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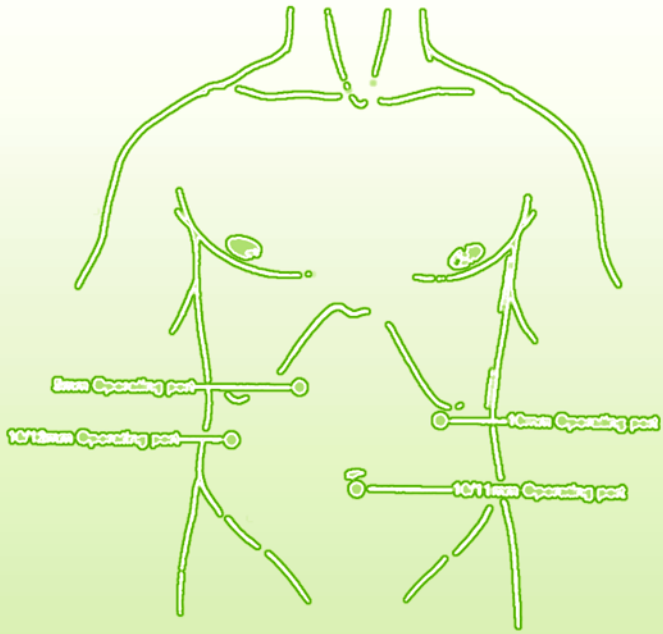
# Endosurgery for Cancer



Steve Eubanks, Ricardo Cohen, Riad Younes and Fredrick Brody

VADEMECUM

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# Dedication

**To Carol, Gui and Regina; reasons for my efforts.**

*Ricardo Cohen*

**To Michael E. Burt, MD, PhD**

*Riad Younes*

**To Sandy, Alicia, Bethany, and Austin; with gratitude for your constant love and support.**

*Steve Eubanks*

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# Foreword

The field of general surgery has changed dramatically over the last ten years with the acceptance of laparoscopy as an extension of the scalpel. Once ridiculed by most academic centers, laparoscopy has revolutionized the management of biliary tract disease and has led to a critical reassessment of how patients with other general surgical problems are managed. The rapid advancement and acceptance of laparoscopy as a part of general surgery is apparent today since most academic centers have laparoscopic sections and many offer laparoscopic fellowships.

The overlap between laparoscopy and other well defined areas of general surgery, such as surgical oncology, is still evolving. Indeed as laparoscopy has undergone its own rapid expansion, so has the field of surgical oncology. The realization that the management of most cancer patients is a multimodality process frequently involving complex surgical procedures has led to the growing acceptance of surgical oncology as its own distinct section of general surgery. Just as in the field of laparoscopy, most academic centers now have sections of surgical oncology and several offer surgical oncology fellowships.

The creation of separate specialty areas such as laparoscopy and surgical oncology, while attesting to their importance, can also lead to the creation of territories or fiefdoms that sometimes prevents physicians from seeing how much intermixing exists between the two fields. *Endosurgery for Cancer* brings together the writings of many internationally renowned individuals in the fields of laparoscopy and surgical oncology, demonstrating how significant laparoscopy has become in managing the oncology patients.

This book covers the whole spectrum of laparoscopy in cancer patients. Initial chapters are devoted to general concepts of laparoscopy and the physiologic alterations associated with it. There are also chapters devoted to the use of the hand assist device. Complications and controversies, are also extensively discussed. The remainder of the text examines the role of laparoscopy in staging and treating specific malignancies. These chapters focus not only on general surgical tumors like pancreatic cancer, colorectal cancer, hepatobiliary tumors, gastric cancer, and lymphoma but also cover adrenal tumors, kidney tumors, pediatric tumors, and thoracic malignancies.

*Endosurgery for Cancer* critically analyzes, in a clear and refreshingly objective way, what has been done, what is being done, and what is being developed in this field. As a result, the practitioner will be better able to understand where laparoscopy might fit into cancer patient management. The book will also be invaluable in answering patients' questions and in dealing with those who demand minimally invasive procedures. The editors have provided a unique and comprehensive overview of a timely subject for which they should be commended.

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# Preface

The fields of surgery involving surgical oncology and endosurgery are rapidly evolving independent of one another. The rate of change that has occurred in the past decade where these fields overlap is remarkable. There currently exist numerous controversies regarding the appropriate role of endosurgery in the diagnosis and treatment of malignancies. Some areas of conflict persist due to tradition and dogma despite evidence that endosurgery has an established role. In other areas, a lack of sufficient evidence exists to draw conclusions regarding the appropriate role of endosurgery. Finally, there are situations where logic and documented experience indicate that an endosurgical approach offers no benefit over the traditional open surgical technique.

This book was chosen to be developed in a handbook form in order to bring this material to the reader in a timely manner due to the rate at which new concepts and knowledge are evolving. The contributors are to be commended for adhering to a tight publication timeline while providing the reader with quality information. Extensive literature searches and complete bibliographies accompany some chapters, whereas others must be based upon current perspectives and authors' experiences due to the paucity of published material.

The list of contributors includes representatives from several continents and numerous countries. This international flavor provides the reader with a broad perspective of the appropriate applications of endosurgical techniques in the cancer patient. Due to numerous factors, certain endosurgical procedures have been more fully developed and more frequently applied in various parts of the world. The editors have attempted to select authors with large personal experiences without regard to their country of origin.

This handbook is intended to serve as a useful resource for general surgeons and surgical oncologists. It is hoped that medical students and surgeons in training will find this information educational and provocative. Most importantly, it is the desire of the editors that this work will result in improved surgical care of those patients afflicted with cancer.

# Surgical Oncology: Role of Videolaparoscopy

*Yoshikazu Noguchi, Kuniyasu Fukuzawa, Takiki Yoshikawa, Riad N. Younes*



## INTRODUCTION

Since the introduction of laparoscopic cholecystectomy in 1987 by Mouret et al[1] laparoscopic surgery has been widely accepted and applied to a variety of diseases including malignant lesions. Laparoscopic procedures for benign lesions reduce pain and enhance early postoperative recovery compared to open surgery. Recently, more than 1,300 papers on laparoscopic surgery have been published in English literature, of which 11% involved malignancy (Table 1.1). Although there have been many technical advances in surgery, the nature of cancer has not changed.

***Table 1.1. Trends of laparoscopic surgery for malignant lesions (number of papers listed in the Index Medicus)***

| year | malignancy (cancer) /laparoscopic surgery | Stomach | Colon | Rectum | Liver | Pancreas | Gall-bladder |
|---|---|---|---|---|---|---|---|
| 1996 | 30(59/82 | 8(5)/39 | 11(2)/41 | 2(0)/16 | 3(3)/30 | 2(3)/8 | 1(0)/6 |
| 1995 | 52(92)/1,801 | 11(5)/48 | 17(8)/72 | 5(4)/29 | 10(3)/53 | 3(1)/12 | 4(5)/21 |
| 1994 | 57(88)/1,282 | 6(4)/51 | 23(12)/86 | 10(3)/44 | 1(5)/49 | 2(1)/9 | 2(1)/16 |
| 1993 | 15(22)/511 | 0(0)/12 | 4(2)/24 | 1(1)/6 | 1(0(/6 | 0/4 | 0(1)/5 |
| 1992 | 1(0)/6 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/1 |
| total (%) | 155(261)/3782 4(7)% | 25(14)/150 17(9)% | 55(24)/223 25(11)% | 18(8)/95 19(8)% | 15(11)/138 11(8)% | 7(5)/33 21(15)% | 7(7)/49 14(14)% |

*Endosurgery for Cancer,* edited by Steve Eubanks, Ricardo V. Cohen, Riad N. Younes, Frederick Brody.

*Table 1.2. Laparoscopic bowel resection (* a randomized study)*

| Authors | number of cases cancer/total | procedure | op time | bowel movements after surgery | complication rate %(n) | mortality rate | hospital stay (range) | data (benign/ malignant) |
|---|---|---|---|---|---|---|---|---|
| Jacobs[12] (1991) | 11/20 | assisted | 170 min | | 3/11 | | 3-8 days | not separated |
| Phillips[13] (1992) | 24/51 | assisted | 2.3 hrs | | 8% | 1/51 | 4.6 days | not separated |
| Scoggin[14] (1993) | 2/20 | assisted | 210 min for r-colectomy | 1.9 days | 20% | 0% | | not separated |
| Peters[15] (1993) | 13/28 | assisted | | 2.7 vs 4.0 days | 13% | 0% | | not separated |
| Senagore[10] (1993) | 9/38 | assisted | 2.9 ± 00.2 hrs | 3.0 ± 0.3 days | 15% | | | not separated |
| Guillou[16] (1993) | 59 | assisted | 233 min r-hemicol (140-340) | 3 days (liquid) | 12/59 | 5.8% | 7 days | malignancy |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Plasencia[7] (1994) | 18/31 | assisted | | by 4th p.o. | 3/32 | 0% | | not separated |
| Jansen[17] (1994) | 31/51 | assisted | 2.5 hrs (1.5-4.0) r-colectomy | | 20.5% | 1.9% | 9.1 days (4-29) | not separated |
| Zucker[18] (1994) | 39/65 | assisted | | | 4/65 | | 4.4 days | not separated |
| Dean[19] (1994) | 59/122 | assisted | 129 min | 4.6 days | 11% | 0% | | not separated |
| Tucker[20] (1995) | 49/114 | assisted | 172 ± 77 min | 3.8 days | 6% | 0% | 4.2 days | separated |
| Lacy•[21] (1995) | 25/51 | assisted | 149 ± 46 min vs 110 ± 49 | 36 ± 16 hrs vs 71 ± 34 | 8% vs 31% | 1/25 | 5.2 ± 1.2 days vs 8.1 ± 3.8 | |
| Lumley[22] (1996) | 103/240 | assisted | 150-280 min | 2-3 (1-9) | | 1.6% | 5-8 days (median) | not separated |
| Lord[23] (1996) | 55/76 | assisted | | | 25% | 2/55 | 5.8 days | malignancy |
| Kwok[24] (1996) | 83 | assisted | 180 min (median) | 4 days (normal diet) | 12% | 2/83 | | malignancy |

Data of reference # 10 and 21 compared with those of open procedure.

1

Laparoscopic oncologic surgery must conform to the principles of open oncologic surgery which entails wide excision of the tumor-bearing area and associated lymphatics. The major controversies regarding laparoscopic procedure for potentially curable cancer include the potential risk of tumor dissemination and inadequate resection. This chapter reviews the current indications and limitations of laparoscopy for oncologic surgery.

## PRINCIPLES OF ONCOLOGIC SURGERY

There is substantial agreement among surgeons that no-touch isolation[2] and en bloc resection of the primary tumor with clear surgical margins are essential to oncologic surgery. However, the extent of lymph node dissection needed, remains controversial. Some investigators advocate wide nodal dissection while others perform limited nodal sampling. Margins of resection and lymph node basin remain controversial as well. Heald[4,5] summarized several oncologic principles in 1988. He stressed a clearly defined surgical margin circumferentially with proximal ligation of the vascular pedicle. Heald also emphasized early ligation proximally and distally of luminal tumors. Finally, all specimens should be protected during removal from the wound. The learning curve for laparoscopic assisted colectomies requires at least 35-50 procedures in order to obtain a short and reproducible operative time (156 min).[6-9] In addition, Senagore et al[10] reported a 25% decrease in pulmonary complications with a reduction in operative times. The conversion rate and time to first oral intake were also decreased with increasing experience. Laparoscopic procedures for cancer entail a steep learning curve in order to maintain patient safety.

The benefits of laparoscopic procedures for malignant lesions include reduced blood loss, early return of bowel function, shorter hospital stay, and quicker return to daily activities.[11,25,26] Several studies of laparoscopic management of colonic tumors document these advantages.[21,27] However, Wexner et al[28] noted a 34% overall morbidity in their colonic series with increased operative times and overall expense.[27-29] Open conversion of these laparoscopic procedures increased operative times as well as the morbidity rate from 33-50%. The morbidity included an anastomotic leak rate from 8-25%.[30-32] Length of hospital stay was not significantly different following open conversion versus the laparoscopic groups.

### Morbidity

Guillou et al[16] also noted an increased rate of thromboembolic complications following laparoscopic colorectal surgery for malignancy. Despite deep venous thromboses (DVT) prophylaxis, two cases of clinically overt (DVT) and one pulmonary embolism from a pelvic vein thrombosis developed. These complications were attributed to prolonged operative times and the Lloyd-Davies position. The exact incidence of thromboembolic complications following laparoscopic oncologic surgery is not known but may be higher as operative times are longer and intra-abdominal insufflation alters venous return. Fusco et al[3] demonstrated that patients undergoing laparoscopic-assisted procedures had a lower incidence of postoperative wound infections versus open surgery (3.6% vs 7.9%). Smaller incisions and preservation of immunological status may explain the lower rates of infection.[34-36] Laparoscopic surgery, based on normal IL-6 concentrations, maintains immune function within the normal range as opposed to open surgery. Other inflammatory changes are significantly decreased as well in laparoscopy. In an already immune-compromised cancer patient, laparoscopy could be an invaluable diagnostic or therapeutic modality.[34,37,38]

## ROLE OF LAPAROSCOPY IN ONCOLOGICAL SURGERY

### Stomach

#### Diagnosis and Staging

Preoperative evaluation of gastric cancer is extremely difficult. Nodal enlargement is easily detected by preoperative CT; however, more than 30% of nodal metastases occur in nodes smaller than 3 mm in diameter.[39] The lower limit for detecting hepatic metastases is 5-10 mm in diameter by either CT scan or by ultrasound. Furthermore, peritoneal metastases are usually undetected by conventional CT or ultrasound. The efficacy of preoperative laparoscopic examination on the resectability of stomach adenocarcinoma has been documented in many reports.[40-42] Laparoscopy is especially effective in diagnosing peritoneal dissemination versus ultrasound or CT.[42] Laparoscopy with peritoneal lavage may provide a predictive value of 100% with regards to peritoneal carcinomatosis.

Staging of gastric carcinoma requires assessment of lymph node involvement, depth of the primary tumor and metastases. Analysis of retrospectively accumulated data reveals nodal metastases are either elevated-type mucosal carcinoma (Type I or IIa) of less than 2 cm in diameter or superficially depressed (IIc)-type mucosal carcinoma of less than 1 cm.[43] Early gastric cancer (T1 ir T2 lesions) can be completely cured surgically with adequate resection.[44]

#### Relative Indication

Nodal metastasis from gastric cancer by location is shown in Table 1.3.[45] With mucosal lesions nodal involvement is only 2-4% and is limited to N1 nodes. N2 nodal involvement occurs in only 0.4-1.6% of all early gastric carcinomas. Once gastric tumor invades the submucosal layer, the frequency of positive nodes increases to 8.3-25.1% with 3-6% with N2 involvement.[46,47] Open resection for N2 disease results in 30-50% 5-year survival rate. Laparoscopic gastric resection should provide similar prospective survival data.

#### Laparoscopic Partial Resection

Partial resection of a gastric lesion can be completed intracorporeally or extracorporeally via a minilaparotomy.[48] This technique is useful for anterior wall or greater curvature lesions. In either case, intraoperative endoscopy is useful for locating the lesion. Endoscopy can also confirm adequate surgical margins and prevent incomplete resections.

1

*Table 1.3. Lymph node metastasis of advanced gastric cancer (%) (Data modified from Maruyama et al)*

| | | Location of tumor | | |
|---|---|---|---|---|
| **Lymph node group** | **Total** | **Upper third** | **Middle third** | **Lower third** |
| | | | | % |
| r-cardiac | 19.9 | 33.2 | 20.6 | 10.9 |
| l-cardiac | 7.2 | 18.0 | 5.4 | 2.2 |
| Lesser curvature | 44.5 | 39.7 | 48.4 | 43.5 |
| Greater curvature | 32.7 | 17.6 | 37.5 | 37.4 |
| Suprapyloric | 7.7 | 2.4 | 7.1 | 11.6 |
| Infrapyloric | 30.5 | 8.4 | 25.5 | 49.1 |
| 1-gastric a. | 27.6 | 24.8 | 29.7 | 27.2 |
| Common hepatic a. | 21.2 | 12.3 | 18.8 | 29.2 |
| Celiac axis | 17.0 | 16.4 | 16.5 | 17.9 |
| Splenic hilum | 6.4 | 13.9 | 7.2 | 1.0 |
| Splenic a. | 8.6 | 13.2 | 8.1 | 6.3 |
| Hepatoduodenal lig. | 5.2 | 2.4 | 3.6 | 8.6 |
| Retropancreatic | 1.7 | 0.7 | 0.9 | 3.1 |
| Mesenteric root | 2.0 | 1.7 | 1.5 | 2.8 |
| Middle colic | 1.1 | 1.7 | 0.5 | 1.2 |
| Para-aortic | 5.3 | 5.8 | 5.3 | 5.1 |
| Cases | 1754 | 416 | 666 | 672 |

* Results from the National Cancer Center for 1754 evaluable cases with extensive lymph node dessection.

**Intraluminal Laparoscopic Resection**

Laparoscopic endogastric surgery entails direct access into the gastric lumen. This technique enables local resection of mucosal lesions too big for endoscopy.[49] Intraluminal (endogastric) as well as extraluminal (laparoscopic) dissection can be completed during the same anesthetic.

**Gastric Resection by Billroth I and II with D1 Nodal Dissection**

Billroth I and II gastric resections were initially reported by Goh[50] and subsequently by Barlehner[51] and Llointier.[52] A five-trocar technique for laparoscopic distal subtotal gastrectomy, omentectomy and division of the left gastric artery and short gastric vessels with D1 nodal dissection was successfully performed in 10 cases by Lopez.[53] The gastric stump is inspected for vascular integrity and a gastrojejunostomy is reconstructed. Kitano et al[54] reported a laparoscopically assisted Billroth I gastrectomy by combining laparoscopy and a small minilaparotomy. The efficacy of nodal dissection using laparoscopy compared to open surgery needs further evaluation. D2 nodal dissection for gastric cancer was reported using a laparoscopic-assisted technique.[56] Laparoscopy reduces the size of the abdominal wound. However a similar retroperitoneal nodal dissection is performed.

### Sarcoma

Less than 2% of all gastric neoplasms surgically resected are histologically smooth muscle in origin. Gastric leiomyomas and leiomyosarcoma are difficult to differentiate. These tumors rarely spread via the lymphatics and occasionally are good candidates for laparoscopic excision. Cases of gastric leiomyoma resected laparoscopically have been reported.[57,58] Simultaneous endoscopy locates the lesion and prevents encroachment of the gastroesophageal junction during resection of lesions located at the cardia.

**Palliative Procedures**

***Laparoscopic gastrostomy or jejunostomy for obstructive lesions***

During the past decade minimally invasive procedures have been utilized for the palliation of inoperable gastric, pancreatic and biliary cancers. Since the first percutaneous endoscopic gastrostomy (PEG) by Gauderer and Ponsky in 1981,[59] many modifications of the original technique have been published. There are a variety of advantages of PEG compared to a surgical gastrostomy. When a endoscope cannot be introduced into the stomach or when abnormal anatomic relationships exist between the stomach and adjacent organs due to adhesions from the previous operations, routine placement of a PEG may be unsafe resulting in colon perforations, small bowel enterotomies, or injuries to other structures. Laparoscopic or combined laparoscopic-endoscopic gastrostomies may be safer.[60,61] Edelman et al[62] performed five laparoscopic gastrostomies utilizing a 5 mm laparoscope under local anesthesia. The mean operative time was less than 30 min. Murayama et al[63] also noted decreased morbidity using four T-fasteners placed into the stomach with cotton bolsters versus the open method.

***Laparoscopic gastroenterostomy for duodenal obstruction***

After performing gastroenterostomies, Nagy et al[64] reported a significant decrease in postoperative discomfort as well as the technical ease of the operation. Similar results with early recovery and discharge are reported by other investigators.[65,66]

***Synchronous multiple cancers***

The incidence of synchronous gastric cancers is approximately 13%. If one lesion is located in the lower or middle third of the stomach, there is a 50% chance of another lesion in the same area. However, upper third lesions only have 26% chance of a second lesion. Thorough evaluation of the entire stomach is necessary to exclude the possibility of synchronous lesions.[67]

### Colon and Rectum

The current management of colon and rectal cancer is characterized by continued exploration of less radical and less invasive treatment methods.[68] Colon cancer is a disease that may be surgically curable in up to 50% of cases. Consequently, any possible benefit in terms of cosmesis, reduced pain scores, shortened hospital stay and accelerated return to normal activity must be balanced against the possibility of reduced cure rate.[69] In 1991 the American Society of Colon and Rectal Surgeons (ASCRS)[70] stated that laparoscopic colorectal surgery should only be undertaken in a setting in which meaningful prospective data retrieval is possible.

1

The laparoscopic Bowel Surgery Registry summarized in 1995, revealed that the most common indication for laparoscopic colon surgery was cancer (453/763 patients).[71] According to the questionnaires of Wexner et al[72] given to the members of the American Society of Colon and Rectal Surgeons, 71% of those responding (196) attempted laparoscopic colorectal surgery for carcinoma, 55% used it only for early lesions and 35% for palliation. However, their responses indicated they were reluctant to apply the new technique to themselves.

**Diagnosis and Staging**

***Intraoperative staging of peritoneal dissemination, nodal metastasis (retroperitoneal) and blood borne metastasis to the liver and ovary***

The main limitations of laparoscopic surgery and diagnostic laparoscopy are the loss of the surgeon's tactile feedback and the inability to make a complete internal evaluation of solid parenchyma. Peritoneal dissemination is usually detected by visual inspection. This can be done more effectively by laparoscope than other currently available modalities. Mesenteric nodal involvement may be more easily assessed by palpation. Para-aortic, pelvic or retroperitoneal nodes may be missed by laparoscopic examination unless the peritoneum is incised and the retroperitoneal tissue is dissected for nodal adenopathy. By doing so, the nodes at the root of the origin of the vessel can be assessed by intraoperative frozen section diagnosis. Probes for laparoscopic sonography have been introduced to compensate for the limitations of laparoscopic surgery and to increase diagnostic efficacy. Some nodes deeply situated in the parenchyma of the liver can be more accurately evaluated for metastases; the technique was described by Bezzi et al.[73] Colonoscopic confirmation of the location of the lesion may be necessary to prevent excision of the wrong segment. Laparoscopic examination of the intestinal organs should be as accurate as open procedure in detecting other lesions. One patient who underwent laparoscopic cholecystectomy and had a colectomy for an obstructing cancer of the colon 1 month later has been described.[74]

**Curative Resection**

The anatomy of the colon is such that the mesentery is at the midline with avascular windows between the major vessels. The colon can be brought to the midline by being moved away from the left or right peritoneal reflections, up from the pelvis or from its attachments to the omentum. Resection of the colon can then theoretically proceed in a conventional manner through a very small incision. This is the rationale for laparoscopic-assisted colectomies.[75] Theoretically, laparoscopic colectomy must consist of the same operative resection as in the open colectomy; tumor-free margins and lymph node recovery must be similar for both approaches. Curative colon resection with limited margins and lymphadenectomy outside of a clinical trial, which includes informed consent, should be discouraged.[76,72]

*Technical Feasibility*

**Laparoscopy-Assisted Colectomy and Low Anterior Resection.** Extensive mobilization of the involved bowel is performed under laparoscopic control, and a minilaparotomy is used for resection and anastomosis. The dissected bowel is exteriorized, resected, anastomosed and returned to the peritoneal cavity. This technique is defined as laparoscopy-assisted colectomy."[76]

**Complete Intracorporeal Procedure.** Dazi et al[77] demonstrated the technical feasibility of a totally laparoscopic, left-sided colon resection, transanal specimen delivery and intracorporeal colorectal anastomosis. Technical problems include the potential for tumor implantation and sphincter damage. Cohen et al[72] concluded that transanal extraction of the resected colon is not the ideal situation for two reasons: the unphysiological dilatation of the anal sphincter necessary to deliver the left colon and its attendant mesentery and the possibility of tumor seeding throughout the rectum. The division of the tumor for the purpose of transanal delivery is contraindicated in oncologic surgery.

**Is There any Benefit of a True or Complete Intracorporeal Laparoscopic Colon Resection?** Bernstein et al[78] concluded that intracorporeal division of the mesentery and anastomosis confer no advantage over the laparoscopic assisted procedure. Data were prospectively collected on 102 consecutive laparoscopic colon resections. There were no statistically significant differences in length of hospital stay or duration of postoperative ileus, regardless of whether intracorporeal or extracorporeal mesenteric division and anastomosis were undertaken.

**Low Anterior Resection.** Low in the pelvis, the view may be better using the laparoscope as it allows excellent anatomical definition and meticulous dissection.[79,16,80] The middle rectal vessels can also be clipped and divided, and dissection of the anterior rectal wall down to the pelvic musculature can readily be accomplished.[16] However, it is also possible to stray into the mesenteric fat and create bleeding that can render accurate dissection impossible.[81] Access to the "holy plane" of rectal surgery can readily be achieved posteriorly and anteriorly, but staying in the plane laterally can be difficult.[4]

Despite being able to satisfactorily mobilize the mesorectum in selected patients, there is no linear cutter currently on the market that will enable a precise low rectal division, especially in the narrow pelvis. Therefore, some surgeons prefer to perform a low anterior resection as an open procedure after laparoscopic dissection of the mesorectum.[22] Ramos[82] overcame this difficulty by using the pull-through technique on a very low anterior resection. He described two techniques: one for small tumor (the classic abdominoperineal endoanal pull-through resection and immediate single stapler colonic anastomosis) and the second for tumors > 4 cm (endoanal circumferential transection of the rectum, pull-through of the sigmoid colon and excision of the redundant colon after 15 days). The same problems as stated above are found here.

***"No-touch" isolation***

Turnbull[2] described the "no-touch" isolation technique in patients who underwent colon resection for malignancy and compared his results with those of historical controls. Turnbull advocated his technique and believed that it offers a survival benefit. However, a more recent multicenter, prospectively randomized trial failed to show any significant difference between the technique of lymphovascular ligation prior to mobilization and conventional resection techniques.[83] The fundamental principle of no-touch isolation of the tumor, especially when the tumor is exposed to the serosal surface, should be maintained. The division of the excised specimen into smaller pieces for tumor retrieval may increase the tumor spillage into the peritoneal cavity and should not be attempted.

***Surgical margin***

The surgical margin most closely correlates with the risk of anastomotic recurrence.[23,24,31,79] Laparoscopically similar margins can be obtained as documented by Lord et al[23] with the closest average tumor margin of 4.5 cm when completed laparoscopically versus 4.8 cm when converted to an open procedure. Unless tumor is located very low in the pelvis, sufficient tumor margin can be obtained by freely dissecting the colon from the peritoneal attachment and mesocolon. For rectal cancer, radial margin clearance probably has a more direct bearing on the rate of local recurrence. It is possible to carry out an equally radical excision using the laparoscopic technique (0.5 mm on average, ranging from 0.1-1.5 mm) as by open surgery (0.9 mm, ranging from 0.1-3.6 mm).[80] Crushing of the tumor by the stapler must be avoided to prevent suture line recurrence. A fall in suture line recurrence rates from 9.9% to 0% after introduction of luminal irrigation and cleansing with sodium hypochloride was reported.[84] Luminal washout of viable exfoliated luminal cells may be effective.[85]

***Nodal status and nodal dissection (the extent of mesenteric resection)***

**Local Excision.** Several groups recently deliberately set out to treat small carcinoma by local excision.[86-88] Banerjee et al[89] advocated local excision by enumerating its indications. Absolute indications for potentially curative local excision include mobile T1 tumors (assessed by ultrasonography), well or moderately differentiated histology (determined by biopsy) and tumor size less than 3 cm. According to Japanese data, most mucosal lesions are node negative. However, once the submucosa is invaded more than one third (sm2 or sm3), 13-25% of cases may have nodal metastases.[90] Additional bowel excision is recommended when there is: (1) massive vascular involvement; (2) poorly differentiated or undifferentiated adenocarcinoma; and (3) massive tumor invasion close to the surgical margin.[91] Local excision should be limited to lesions without nodal involvement.

**Lymph Node Harvest.** What passes for "adequate" resection in open colectomy varies widely between regions, institutions and individual surgeons. The adequacy of oncologic surgery is very often measured by the number of harvested nodes in the mesentery. Unfortunately, the quantity of lymph nodes identified in each specimen is highly variable from institution to institution and from pathologist to pathologist (Table 1.4). The higher average number of nodes in laparoscopically resected specimens compared with those obtained by open colectomy may reflect this bias.[93] Therefore, lymph node yield should be considered a crude criterion by which to judge the adequacy of resection. As stated previously, this depends largely upon where the mesentery was resected. The point should not be whether the resection of the mesentery was done intra- or extracorporeally,[94] but whether or not the mesenteric root was well visualized and the nodes were dissected.

*Table 1.4. Number of lymph node harvested by laparoscopic surgery*

| Authors | year | number of patients | location | number of harvested nodes laparoscopic | conventional |
|---|---|---|---|---|---|
| | | | | mean (range) | |
| Peters[15] | 1993 | 13.28 | right | 9/0 | 8.5 |
| | | | sigmoid | 7.3 | 4.7 |
| Bleday[75] | 1993 | 7 vs 2 | right | 10.6 | 9.5 |
| | | 4 vs 3 | igmoid | 8.0 | 11.0 |
| Tate[25] | 1993 | 11 vs 14 | | 10(2-14) | 13(2-18) |
| Guillou[16] | 1993 | 59 | | 9(5-21) | |
| Zucker[18] | 1994 | 39 | right | 28.4(18-35) | |
| | | | sigmoid | 8.0(6-10) | |
| | | | low anterior | 7.3(5-11) | |
| Lacy[21] | 1995 | 25 vs 51 | | 13 ± 5.4 | 12.5 ± 7.7 |
| Saba[92] | 1995 | 25 vs 25 | | 6(0-21) | 10(2-27) |
| Lord[23] | 1996 | 41 vs 14 | | 9.1 | 7.1(converted to open) |
| | | | | (1-31) | (0-34) |
| Kwok[24] | 1996 | 83 | | 12.8 ± 7.0 | |

**Mesenteric Resection.** There are some who feel the exact same mesenteric clearance as obtained in open surgery is feasible.[22,23,95] However, during resections for malignant disease, the site of mesenteric resection differs greatly depending on the surgeon, even through all ligate mesenteric vessels at their bases.[18,96] The base should be at the root of the vascular pedicles or at the origin from the aorta or SMA. The vascular linear stapler may not achieve an adequate mesenteric margin[97] (Figs. 1.1a, 1.1b and 1.1c ). It is crucial to dissect the nodes and is hard to believe this has been achieved by most procedures, especially by extracorporeal resection.[98]

Miles' theory held that a wider mesenteric dissection removed more lymph nodes that contained metastatic disease and thereby increased the chance for a cure.[99] Lymphatic spread is more often a centripetal and stepwise process. The "skip" lymph node metastases supported Miles' theory that a wide lymphadenectomy maximized the chance for a cure. Survival advantage over a regional mesenteric node dissection (segmental colectomy) was estimated as 5% by Sugarbaker and Corlew.[100] Bleady et al[75] questioned the necessity of the high ligation of the mesenteric vessels citing two papers: (1) colon and rectal cancer were shown to almost always metastasize to each level of nodes in an orderly fashion without "skip" metastases[101] and (2) it was not clear whether an extremely high ligation of the feeding artery and vein to a certain part of the colon is absolutely necessary for an increase in survival.[75]

Theoretically, extended lymphadenectomy should result in a higher survival (Figs. 1.2a, 1.2b),[102] but retrospective data has not supported the survival benefit of an extended mesenteric resection. In a prospective, randomized study of segmental colectomy versus radical hemicolectomy for descending colon carcinoma, the French Association for Surgical Research[103] found no difference in survival.

1

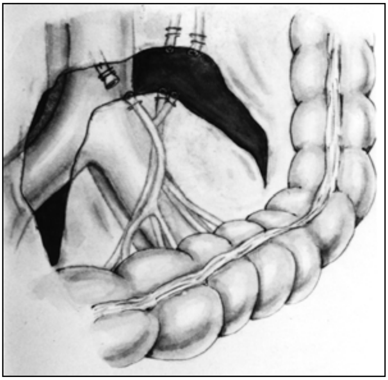


Fig. 1.1a.

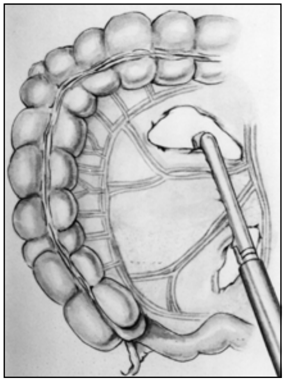


Fig. 1.1b.

Figs. 1.1a, 1.1b and 1.1c. Differences in the mesenteric resection line. Fig. 1.1a, dissection of the nodes at the root of the inferior mesenteric artery. Fig. 1.1b, excision at the level of the main feeding artery, but the nodes around and in proximity to the root are not dissected. Fig. 1.1c, dissection only of the nodes along the marginal artery.

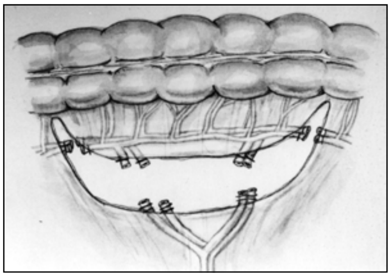
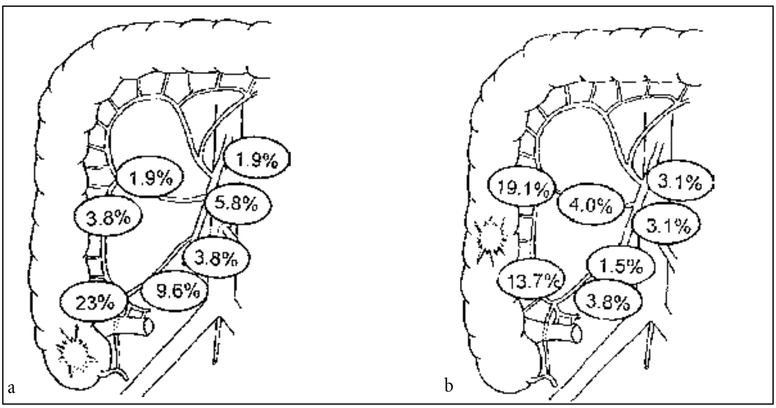


Fig. 1.1c.




Figs. 1.2a and 1.2b. Frequency of lymph node metastases, stratified by the lymph node basin. A star indicates the location of the main tumor, cecal cancer (Fig. 1.2a) and ascending colon cancer (Fig. 1.2b). Data from Yoshida et al.[104]

Pezion and Nicholla[104] found no survival difference with conventional surgery between a high and low ligation of the inferior mesenteric artery.[104] In rectal disease, lateral spread may also be present. Lateral spread is more frequently seen in the lesions at the rectum below the peritoneal reflection, and tumor invades through the muscularis propria or subserosal layer. The frequency of lateral nodal involvements ranges from 4.5-18.2%, with upstream nodal involvement ranging from 27.3-45.5%. The most frequently involved nodes are those at the root of the middle rectal artery and nodes along the internal iliac artery.[105,106] Extended abdominal iliac lymphadenectomy and adequate lateral and mesocolon margins have been proposed for rectal carcinomas. However, again there is little if any survival advantage when compared to historical controls.[72,107] Heald[5] obtained excellent results by using a total mesorectal excision for rectal cancer. The local recurrence rate was below 10%.

Whether one should regard nodal metastasis as a governor of survivor or just as an indicator[108] needs to be clarified in a randomized fashion similar to the discussion of using open or laparoscopic surgery. Some agree that although laparoscopic colon resection is usually a segmental colectomy, it is unlikely that it will compromise patient survival.[109,110] Local recurrence of colorectal cancer after "curative" surgery is seen in approximately 10-40% of patients who underwent curative surgery. Local recurrence may either be a consequence of inadequate removal of the primary tumor and its lymph node metastases or be caused by intraoperative spill of tumor cells.[111] Although the survival advantage may be only 5%, this difference is difficult to obtain by other currently available therapeutic modalities. However, it should not be concluded that segmental resection will satisfy the principles of colon cancer resection.

**Palliative Resection**

Because the advantages and disadvantages of laparoscopic resection with curative intent are not yet delineated, some authors limit their indications to palliative procedures. In patients with multiple metastases, removal of a short segment bearing the primary tumor with clear margins is often accomplished as long as the primary tumor is not too bulky and is not attached to the surrounding organs and tissue.[112] Vara-Thorbeck et al[113] limited the indications of laparoscopic colon resection to patients either with distant metastasis or over 70 years old and American Society of Anesthesia (ASA) III-IV with a high operative risk using standard surgery. They did not report any increase in morbidity (28%) or mortality in those high risk patients having laparoscopic colon resection.

**Fecal Diversion.** Laparoscopy may be well suited for fecal diversion procedures because no resection and minimal tissue dissection is required.[114] Ludwig et al[115] performed 16 loop ileostomies, 6 end sigmoid colostomies, 1 transverse and 1 sigmoid loop colostomies in an average of 60 minutes each (range 20-120 min) with only one major complication (pulmonary embolism). Fuhrman and Ota[116] reported their experience on 17 patients: 7 with their stoma as part of a laparoscopic abdominoperineal resection, 6 with palliative colostomy for an obstructing tumor of the rectum and 4 with proximal protecting fecal diversion for rectal excision. They concluded that although laparoscopic stoma formation does not compromise the surgeon's ability to choose the stoma's location or impair intestinal mobilization and preparation for exteriorization, it requires the same caution as open surgery to prevent stenosis, hernia and prolapse of the stoma i.e., obtaining sufficient dissection of the intestine and adequate excision of the skin at the stoma site.[116,117]

**Other Procedures.** Other procedures where laparoscopy may be used for oncological colorectal problems include reversal of Hartmann's procedure and several techniques described to facilitate localization of the rectal pouch.[118-120]

**Problems**

*Port site recurrence*

Reports of trocar extraction site tumor recurrences following laparoscopic colectomy raise the concern that such recurrence may be more frequent with laparoscopic than with open colectomy. This type of recurrence is not specific to colon cancer but is also observed in other types of cancer such as ovarian,[121,122] gastric,[123] hepatocellular,[124] gall bladder[125,126] and pancreatic cancers.[127]

**Frequency.** A review of 1711 open colon resections for cancer at the Mayo Clinic by Reilly et al[128] found 11 cases (0.6%) with wound recurrence. Only four were diagnosed clinically, and only two of these had isolated recurrence. Hughes' series of cases[129] also demonstrated a similar incidence of wound recurrence (0.68%). Although likely underestimated, incisional recurrence after open colectomy is uncommon, and its occurrence is usually a harbinger of diffuse intra-abdominal disease.[128] Series incidence for laparoscopic colectomy ranges from 0-1.6% (Table 1.5). More than 30 cases with colorectal carcinoma recurrence at the trocar, incisional and drain sites after laparoscopic colectomy have been published in the last few years (Table 1.6). This complication was generally associated with advanced stages of Dukes B or greater, but Dukes A lesions were not exempt. In more than 50% of cases it was manifested as a part of peritoneal dissemination. The interval between the primary laparoscopic operation and wound recurrence was 10.5 ± 10.3 months.

**Location.** Tumor recurrence was frequent at the trocar or incision sites where the tumor was extracted. However, this is not always the case. Recurrence within trocar sites where neither the instrumentation nor the wound edges were directly

*Table 1.5. Port site seeding*

| | Author | total cases | wound recurrence | frequency |
|---|---|---|---|---|
| Open | | | | |
| | Reilly[128] | 1711 | 11 | 0.6% |
| | Hughes[129] | 1603 | 17 | 1.0% |
| Laparoscopic | | | | |
| | Ramos[180] | 208 | 3 | 1.4% |
| | Sugarbaker[100] | 440 | 7 | 1.6% |
| | ASCR[70] | 504 | 6 | 1.2% |
| | Hoffman[31] | 130 | 1 | 0.8% |

exposed to the cancer specimen is not rare. (An asterisk in the Table 1.6 indicates recurrence at the tumor extraction site.)

**Causes.** Several possible mechanisms for abdominal wound recurrence are as applicable to open laparotomy as to laparoscopic resection. These include adherence of intravascular tumor cells to areas of local tissue trauma,[143] local hyperemia,[144] surgically induced depression of host immune mechanisms and release of growth factors.[145] Gross spillage of tumor cells occurs during laparoscopic dissection and tearing of the tissue. Manipulation of the cancer specimen may cause exfoliation of viable tumor cells into the lumen of the colon[146] as well as the free peritoneal cavity.[147] These cells can remain viable in the peritoneal cavity.[148] Repeated contact between contaminated instruments and port sites and passage of tissue through an unprotected incision may promote tumor cell implantation. The wound healing process, in which there is high production of growth factors

*Table 1.6. Recurrence of colorectal carcinoma at trocar, incisional and drain sites*

| | Dukes stage | recurrence site | primary tumor | carcinomatosis | interval |
|---|---|---|---|---|---|
| | | | | | (months) |
| Alexander[131] | C | incision* | As colon | | 3 |
| Fusco[33] | C | 2 cm above port | Hepatic fl | isolated metastasis | 10 |
| O'Rourke[84] | B | ports | cecum | multiple metastases | 2 |
| Walsh[132] | D | port | cecum | | 6 |
| Berends[133] | B | paraumbilical* | | | < 3 years |
| | C | paraumbilical* | | | < 3 years |
| | D | port | | | < 3 years |
| Wilson[134] | ? | port | ? | | ? |
| Cirocco[135] | C | posts & incision | As colon | | 9 |
| Lauroy[136] | A | port | sigmoid | | 9 |
| Guillou[16] | C | port* | rectum | carcinomatosis | ? |
| Nduka[137] | C | port* | rectum | | 3 |
| Ramos[130] | C | port* | colon | carcinomatosis | 6 |
| | C | port* | colon | carcinomatosis | 8 |
| | C | incision* | colon | | 21 |
| Prasad[138] | B | | | | 6 |
| | A | | | | 26 |
| Boulez[139] | | | | | 3.2 |
| Cohen[78] | B | | | | 3 |
| | B | | | | 6 |
| | C | | | | 6 |
| | C | | | | 9 |
| | C | | | | 12 |
| Fingerhut[140] | A | | | | 3.3 |
| | B | | | | – |
| | B | | | | – |
| Jacquet[141] | B | incision | cecum | carcinomatosis | 10 |
| | B | port | r-colon | carcinomatosis | 9 |
| | C | port | | carcinomatosis | |
| 1Federa[142] | C | port | sigmoid | isolated metastasis | 7 |

near laparoscopic incisions, may provide a favorable environment for tumor progression.[146,149] Local gas concentration induced by $CO_2$ pneumoperitoneum may provide local conditions favorable for tumor cells implantation and growth. The optimal gas content for colorectal cancer cell lines is a 10% $CO_2$/90% air mixture,[150] and the addition of pneumoperitoneum will triple the occurrence of tumor implantation at the trocar site without changing the incidence of lung and liver metastases.[151]

**Prevention and Treatment.** Minimal manipulation of the tumor-bearing area, occlusion of the intestinal segments, placement of the specimen into an impermeable endoscopic bag and a large enough specimen extraction site may minimize tumor-seeding.[110,112] Sugarbaker[152] recommended routine administration of intraperitoneal chemotherapy with mitomycin C and 5-fluorouracil after laparoscopic colectomy for cancer. Gasless technique[153] or helium pneumoperitoneum[154] may be beneficial.

**Unrecognized synchronous cancer.** The importance of synchronous multiple cancers should not be overlooked, especially when the tumor is nearly obstructing the lumen and the proximal colon cannot be sufficiently evaluated. Manual examination is not possible, and intraoperative endoscopic examination of the remaining colon may not be suitable because of air insufflation. The diagnostic false negative rate of colonoscopy may be 3-8%, and the incidence of synchronous multiple cancers is around 2-8%. Often a metachronous tumor actually represents the missed synchronous one.[155,156]

## Pancreas

### Diagnosis and Staging

Diagnostic laparoscopy is the most reliable technique for staging and assessment of resectability in patients with pancreatic cancer.[157-159] Cushieri et al first recommended diagnostic and staging laparoscopy of pancreatic cancer as early as 1978.[160] Conlon et al[161] reported a series of 108 patients with pancreatic carcinoma and demonstrated a positive predictive index of 100%, a negative predictive index of 91% and an accuracy of 94%. Laparoscopy failed to identify hepatic metastases in five patients and portal venous encasement in one patient. Mesenteric vascular encasement, extrapancreatic/peritoneal involvement, and celiac or portal lymphatic metastases were effectively detected. These values have subsequently been replicated by other authors and are significantly higher than those obtained by CT or angiography.[159,162-164]

### Curative Resection

A laparoscopic pylorus-preserving pancreaticoduodenectomy was successfully performed for chronic pancreatitis localized to the head of the pancreas.[165] Laparoscopic excision of the distal pancreas for an insulinoma was also reported utilizing localization with laparoscopic ultrasound.[166] Laparoscopic pancreaticoduodenectomy has been reported. However the survival benefit is currently unknown.[167]

**Palliative**

***Bilio-enteric bypass***

Palliation for patients with inoperable pancreatic carcinoma can be accomplished by ERCP and a biliary stent in 90% of cases.[168] Laparoscopic bypass may be indicated for stent blockage, duodenal obstruction, or when endoscopic stenting is not possible.[169] These indications are similar for conventional open procedures.[170] Palliation of malignant obstructive jaundice by laparoscopic cholecystojejunostomy should be completed after demonstrating a patent hepatocystic biliary system above the malignant process.[171] Laparoscopic choledochojejunostomy may be utilized as well for palliation.

### Hepatobiliary Tract

**Diagnostic and Staging**

If a patient appears to have a resectable hepatic lesion, laparoscopy performed just prior to hepatic resection.[172] However, visualization of the liver surface is possible in 70% of cases because of the coronary and triangular ligaments and bare area. Visualization of the caudate lobe is also difficult. The addition of laparoscopic ultrasound to staging and evaluation of liver lesions has greatly enhanced the accuracy of this technique.[173,174]

***Biopsy***

Laparoscopic liver biopsy has now become a routine technique at several institutions. This approach not only increases accuracy in obtaining abnormal tissue through direct visualization but also allows a careful examination of the remainder of the abdominal cavity.[172] The false negative rate has decreased from 24% by blind biopsy to 9% by laparoscopic biopsy.[173]

**Curative Resection**

Reports of laparoscopic liver resection have recently appeared in the literature. A large hepatic adenoma in segment 4 was successfully excised.[175] Rau et al[176] reported five cases of laparoscopic liver resection for five tumors in the left lobe and one in segment 6. These included three cases of focal nodular hyperplasia, two cases of hemangioma and one metastatic lesion. Nonanatomical resection of segment 5 for hepatocellular carcinoma was reported by Hashizume[177] as well as a 4 cm superficial metastasis in segment 4, four years after mastectomy for a pT2N0M0 ductal carcinoma. Laparoscopy for anatomical resection of segments or lobes of the liver or the resection of large tumors is not currently recommended.[172] The potential for uncontrolled bleeding and the large size of the resected specimen are two limiting factors.[178] Air embolisms through dissected liver veins secondary to elevated intra-abdominal pressure have also been described.[177,179] Isolation and clipping of vessels is critically important during these dissections.

**Palliation**

***Hepatic cryotherapy for liver tumors***

Cushieri et al[180] developed a hepatic cryosurgical unit which was applied laparoscopically to six patients and laparoscopically-assisted in four patients. The probes were carefully placed under direct vision. Laparoscopic ultrasound can

1

help localize placement for posteriorly located lesions of the right lobe. The current limitations of hepatic cryotherapy are largely due to incomplete tumor destruction. The use of insulated laparoscopic cryoprobes should enhance the therapeutic efficacy of cryotherapy for both primary and secondary hepatic tumors.

***Intra-arterial catheter placement***

Laparoscopic intra-arterial catheter implantation in the gastroduodenal artery for regional chemotherapy of liver metastasis has been documented.[181] Ligating the right gastric artery and any accessory arteries from the hepatic artery distal to the origin of the gastroduodenal artery are performed as the open approach.

### Staging of Lymphoma and Second Look Procedures

Greene et al[182] noted that the staging of lymphoma via laparoscopy has virtually replaced the open technique. Staging requires bilateral hepatic wedge resections and needle biopsy, splenectomy and retroperitoneal and iliac node dissection. Laparoscopic staging altered approximately 19% of patients.[183] Using a laparoscopic approach to the retroperitoneum, celiotomy was avoided in 16 of 19 patients.[167]

Patients with ovarian cancer have benefitted from second look laparotomies for residual disease. Marti-Vincente et al[184] reported that 49% of 72 ovarian cancer patients had residual tumor. It can be handled laparoscopically if adhesion is not severe. The role of laparoscopy in CEA-directed second look procedures for patients with colon cancer continues has been reported as well.[185,186]

## FUTURE DIRECTIONS

Laparoscopy should not be viewed as a "stand alone" technology but as an adjunct to well-established diagnostic and therapeutic modalities. In the future, palliative applications will expand, and staging and diagnostic procedures will continue. Using laparoscopic oncologic surgery for curative intent must be critically evaluated. Oncologic principles should not be violated or altered when using laparoscopy.

The use of laparoscopic surgery in oncology will continue to increase through technical advances in instrumentation and surgical expertise. Long-term follow-up is essential to justify equivalent results in utilizing laparoscopy for oncologic purposes.

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# Physiologic Alterations Associated with Laparoscopy

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## INTRODUCTION

With the advent of laparoscopic cholecystectomy, a wide range of procedures is now performed laparoscopically. As experience continues to grow investigators are finding new applications. With broader indications, a closer look at the physiologic alterations associated with this procedure is required.[1-4] Inherent to the procedure is the necessity to expand the abdominal cavity and convert a potential space into an arena for diagnostic and therapeutic procedures. Traditionally, this has been accomplished with $CO_2$ although alternatives have been investigated. This chapter will focus on the physiologic consequences associated with pneumoperitoneum with documentation from animal and human studies.

## CARDIOVASCULAR AND HEMODYNAMIC

Most of the cardiovascular and hemodynamic changes seen during laparoscopy are related to the mode of abdominal expansion and the type of gas used for insufflation. The most common method of abdominal expansion is with $CO_2$ insufflation. Alternatives are nitrous oxide ($N_2O$) and Helium (He). Gasless expansion is accomplished by mechanically separating the abdominal wall from the viscera with a variety of support structures. A number of studies have examined these alternatives in animals.

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## MODE OF ABDOMINAL EXPANSION

Davidson et al examined the effects of He insufflation, abdominal wall lifting and $CO_2$ insufflation on wedge pressure, cardiac output and arterial blood gases in anesthetized pigs.[5] The investigators demonstrated that abdominal wall lifting did not alter any of the hemodynamic parameters from baseline throughout the laparoscopic procedure. Helium insufflation resulted in modest acidosis but little change in $pCO_2$. In addition to acidosis, there was a significant rise in arterial $CO_2$ in animals undergoing $CO_2$ insufflation. This study concluded that abdominal wall lifting or helium insufflation may provide safer exposure than $CO_2$ insufflation and would be especially helpful and economical in those patients with preexisting cardiac or pulmonary disease. McDermott et al examined the hemodynamic response to $CO_2$ insufflation versus abdominal wall lifting in 12 anesthetized pigs.[6] Increases in heart rate, mean arterial pressure and $PaCO_2$ with concomitamt decreases in $PaO_2$ were documented again with $CO_2$ insufflation. These effects were not seen in pigs undergoing mechanical wall retraction. In this study the cardiac output and stroke volume were noted to increase during hypercarbia. Although quality of exposure was never assessed in abdominal wall lifting, this study concluded that abdominal wall retraction may be useful in the patient with marginal cardiorespiratory function.

Woolley et al examined the effect of gasless abdominal distension, $CO_2$ pneumoperitoneum and positive end expiratory pressure (PEEP) on hemodynamic and blood gas alterations in six anesthetized swine.[7] Control animals were monitored with pulmonary artery and arterial line catheters. Animals were then assigned a course of variable PEEP with either $CO_2$ pneumoperitoneum or abdominal wall lifting. Baseline values without PEEP were obtained for both groups. Abdominal wall lifting was associated with increased $PaO_2$ and decreased central venous pressure (CVP), pulmonary aretry pressure, pulmonary wedge pressure (PCWP) and $PaCO_2$ compared to $CO_2$ pneumoperitoneum. Similarly, abdominal wall lifting abolished the adverse hemodynamic effects (increased CVP, PAP and PCWP) associated with PEEP that were seen with $CO_2$ pneumoperitoneum. However, abdominal wall lifting was associated with increased systemic vascular resistance compared to baseline and $CO_2$ pneumoperitoneum. Cardiac function significantly decreased in all groups as the PEEP was raised from 0-20 mm $H_2O$. The study demonstrated that overall abdominal wall lifting may be less hazardous in patients requiring elevated PEEP and a laparoscopic procedure.

These three studies suggest that abdominal lifting may induce fewer physiologic alterations in the anesthetized animal. The otherwise healthy patient will likely have minimal problems with standard $CO_2$ insufflation. However, abdominal wall lifting may provide an alternative which requires further study in the patient with compromised cardiopulmonary function. It is unclear at this time whether patients with cardiopulmonary disease require less monitoring during abdominal wall lifting as general anesthesia is still required.

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## TYPE OF GAS UTILIZED

The type of gas used for pneumoperitoneum will also incur hemodynamic changes. Preliminary studies by Ho et al examined the effect of laparoscopic cholecystectomy on multiple parameters in eight anesthetized pigs.[8] As $CO_2$ accumulated, a decrease in stroke volume and a compensatory rise in heart rate were demonstrated. These changes also resulted in pulmonary hypertension. These results verified a linear relationship of the severity of cardiac depression to the amount of $CO_2$ accumulated. Subsequently, eight pigs were used to assess changes in hemodynamics with $CO_2$ and $N_2O$ for the purpose of determining the etiology of hypercarbia and acidemia associated with laparoscopic surgery. Metabolic function was followed with a metabolic cart, acid-base with arterial blood gases (ABGs) and hemodynamics with a pulmonary artery catheter.There was evidence of $CO_2$ absorption and systemic build-up as pulmonary excretion of $CO_2$ increased which was not seen in the group insufflated with nitrogen. $PaCO_2$ rose and pH declined for the first hour of insufflation but reached a steady state after that time, as was seen with pH. This was felt to be due to the compensatory increase in pulmonary excretion with the steady state between $CO_2$ absorption and excretion. In individuals with minimal reserves a persistent hypercapnia and acidemia might prove problematic. $CO_2$ insufflation resulted in a 15% decrease in stroke volume which persisted until the $CO_2$ excess in the body stores was cleared. $CO_2$ excess was measured through a metabolic cart. Cardiac index was maintained by a compensatory tachycardia. Additional alterations that were demonstrated in the $CO_2$ group included elevated pulmonary aretry pressures and mean arterial pressure. These changes were not appreciated in the $N_2O$ group.

Volz et al[10] studied the effects of pneumoperitoneum on hemodynamics in 25 pigs. Animals were divided into air versus $CO_2$ insufflation at both 14 and 18 mm Hg for a three-hour period. Both groups demonstrated increases in mean arterial pressure, heart rate, wedge pressure and mean arterial pressure. As seen in other studies there was an increase in minute ventilation at a steady rate until approximately two hours where they stabilized at high levels. It appeared that higher pressure (18 mm Hg) were associated with significant acidosis from $CO_2$ absorption. This study concluded that host responses included increases in minute ventilation, peak airway resistance and $CO_2$ production. These were primarily seen at higher pressures (>18 mm Hg). Normal intra-abdominal pressures alone or $CO_2$ at low pressures did not lead to changes in respiratory mechanics or acid-base balance. All of these studies support that $CO_2$ insufflation at high pressures is associated with acidosis because of absorption.

The direct effect of elevated $CO_2$ on myocardial contractility has been examined in anesthetized dogs. Atalay et al examined the hemodynamic effect of abdominal insufflation with $CO_2$.[11] They reported insufflation was associated with a decrease in right ventricular contractility. They speculated that this was due to a direct effect of $CO_2$ on the myocardium and that similar changes may be occurring in the left ventricle under similar conditions.

Similar hemodynamic alterations in the young host have been documented in the animal model. Liem et al examined the hemodynamic effects of abdominal insufflation in four 6 week old swine at pressures of 10 and 15 mm Hg in order to demonstrate the effects in a pediatric animal model.[12] During abdominal insufflation arterial pH significantly decreased, mean $pCO_2$ significantly increased, and arterial $pO_2$ significantly decreased. There was no change in right atrial pressures while inferior vena cava pressure changed commensurate with the level of abdominal pressure. This study showed similar responses to $CO_2$ insufflation.

In the human, El-Minawi et al[13] examined the effects of $CO_2$ versus $N_2O$ pneumoperitoneum on cardiovascular changes in 50 patients undergoing diagnostic laparoscopy. $CO_2$ insufflation produced an increased incidence of tachycardia as compared to $N_2O$ insufflation. This study suggests that $N_2O$ may be an alternative and should be considered in patients with strict contraindications to tachycardia, i.e., recent MI. These studies demonstrate the adverse effects of $CO_2$ insufflation on hemodynamics. The aberrations primarily appear to be the result of $CO_2$ absorption through the peritoneum. With concurrent pulmonary dysfunction $CO_2$ accumulation may worsen and cardiovascular compromise will be magnified. In these scenarios $N_2O$ should be considered as an alternative source for the peritoneum.

## LAPAROSCOPY IN THE COMPROMISED HOST

The cardiovascular alterations seen with abdominal insufflation as outlined above appear to be most prevalent in those patients with underlying cardiac and respiratory disease. This section will examine the alterations seen in experimental and clinical models of co-morbidity. This first part will examine the addition of PEEP and hemorrhage in animal models undergoing laparoscopy followed by the effects of laparoscopic procedures in humans with underlying cardiopulmonary compromise.

Moffa et al[14] examined the effects of PEEP and $CO_2$ pneumoperitoneum on hemodynamics during mechanical ventilation in anesthetized pigs. The animals were monitored with pulmonary artery catheters while incrementally increasing PEEP. This experiment was then repeated with $CO_2$ pneumoperitoneum to 15 mm Hg. The group with $CO_2$ pneumoperitoneum had significnatly increased central venous pressure, mean arterial pressure, mean pulmonary artery pressure, pulmonary vascular resistance index and stroke index, PEEP $\geq$ 5 cm $H_2O$ combined with $CO_2$ pneumoperitoneum was associated with a significant reduction in stroke index and left ventricular stroke work index. These studies indicated that $CO_2$ pneumoperitoneum increases ventricular afterload by exacerbating the adverse effects of increased PEEP.

However Ekman et al[15] performed hemodynamic measurements in 10 women undergoing laparoscopy for investigation of infertility. This study utilized relatively low abdominal insufflation pressures (5-8 mm Hg) and physiologic PEEP at 3.7 cm $H_2O$. With low pressure insufflation and low PEEP, there were no changes in the end tidal $CO_2$. Based on these two studies, laparoscopy with $CO_2$ pneumoperitoneum may not be tolerated in individuals requiring PEEP in excess of 5 cm $H_2O$, e.g., an ICU patient with calculous cholecystitis.

Ho et al[16] examined the effects of $CO_2$ pneumoperitoneum on hemodynamic parameters in a hemorrhage-shock model in anesthetized pigs. The study demonstrated a reduction in arterial pH and hypercapnia with $CO_2$ pneumoperitoneum and mild hemorrhage. Moderate hemorrhage resulted in severe reduction in arterial pH that was not reversed with crystalloid resuscitation. Stroke volume decreased as a function of blood loss and responded to crystalloid resuscitation. This response quickly disappeared with the institution of $CO_2$ pneumoperitoneum. These authors concluded that $CO_2$ insufflation may be contraindicated in the acute setting where the effects of hypovolemia already compromise hemodynamic stability.

Wittgen et al[17] examined the hemodynamic, blood gas and ventilatory parameters in 20 patients with normal preoperative cardiopulmonary status and compared this to 10 patients with previously diagnosed cardiac or pulmonary disease undergoing laparoscopic cholecystectomy. The patients with preoperative cardiopulmonary disease had significantly increased $PaCO_2$ and decreased arterial pH compared to patients without underlying disease.

Feig et al[18] examined 15 patients with pre-existing cardiopulmonary disease and monitored them with a pulmonary artery catheter and arterial catheter during laparoscopy to determine if monitoring was associated with early detection and intervention of detrimental physiological alterations. Abdominal insufflation caused significant increases in systemic vascular resistance, mean arterial pressure, left ventricular work index, pulmonary capillary wedge pressure and stroke index. This was associated with a concomitant decrease in cardiac index and oxygen delivery. The use of intravenous nitroglycerin returned these values to baseline. There were no intra- or postoperative cardiac or pulmonary complications. The authors concluded that pneumoperitoneum with $CO_2$ is safe in high risk patients with appropriate monitoring and pharmacologic intervention.

In the patients with significant co-morbidity the risks of the physiologic alterations caused by the pneumoperitoneum may outweigh the benefits of minimal access. Short procedures in otherwise healthy people with low PEEP and insufflation pressures do not appear to have long term sequelae. Clearly, prolonged laparoscopic procedures in patients with cardiac or pulmonary reserve may be contraindicated. Whether or not these alterations remain clinically significant in the postoperative period remains to be studied.

## VISCERAL ALTERATIONS

The physiologic alterations of the intra-abdominal organs are related to changes in intra-abdominal pressure with gaseous distension. Ishizaki et al[19] examined 21 dogs for splanchnic responses to increasing intra-abdominal pressure. Blood flow was measured using a combination of ultrasonic flowmeters and direct catheter transduction. Graded increases in intra-abdominal pressure resulted in decreases in cardiac output and increases in systemic resistance. At abdominal pressures of 8 and 12 mm Hg no significant changes were evident throughout the procedure. However, inferior vena caval, portal venous and superior mesenteric arterial flow were significantly decreased at 16 mm Hg. These investigations suggested that longer laparoscopic operative times with $CO_2$ insufflation may result in intestinal ischemia as well as hepatic and pancreatic dysfunction. However this study did not document a definitive adverse clinical outcome.



The effect of pneumoperitoneum on renal function has been evaluated by Chiu et al[20,21] in a swine model. Using a doppler flow probe, decreases in renal cortical blood flow correlated with increases in intra-abdominal pressures (IAP). Blood flow reduction was seen at pressures as low as 15 mm Hg. Urine output was also decreased with this reduction in cortical blood flow. These effects were not seen in gasless laparoscopy. Cortical blood flow returned to baseline with release of IAP. These studies reconfirm that IAP should be maintained at the lowest level possible. Adequate patient hydration is critical, as hypovolemia and high IAP would exacerbate the reduction in renal cortical perfusion. As laparoscopic procedures increase in complexity and longevity, periods of insufflation in excess of 2 h may further compromise patients with chronic renal insufficiency. Alternatively, as discussed later, the decrease in urine output may be related to increases in the excretion in antidiuretic hormone associated with laparoscopy or any surgical prcedure.

## NEUROLOGIC CHANGES

As laparoscopic surgery becomes more sophisticated, potential uses include evaluation and treatment of patients in the intensive care unit and those with multiple trauma. Many of these patients will have associated intracranial injuries, including space occupying lesions. Neurologic alterations associated with abdominal expansion have been investigated in a limited number of studies.

Schob et al[22] compared He and $N_2O$ pneumoperitoneum versus standard $CO_2$ insufflation while measuring the intracranial pressure (ICP). ICP was monitored with and without a space-occupying lesion to simulate recent head trauma. ICP, intra-abdominal pressure, mean arterial pressure, end-tidal $CO_2$ and arterial blood gases were measured before and during pneumoperitoneum. Similar measurements were made during inflation of an epidural balloon to simulate and intracranial lesion. This study demonstrated significantly elevated ICP with pneumoperitoneum compared to control animals. $CO_2$ inflation was associated with significantly increased $PaCO_2$ and $ETCO_2$ with concurrent decrease in the arterial pH as compared to He and $N_2O$. The investigators suggested that increases in ICP and $CO_2$ insufflation were due to increased cerebral perfusion and that may be a safer insufflation gas for laparoscopy in the patient with possible closed head trauma.

Jospeh et al[23] looked at this question in swine model with simulated closed head injury. They found that independent of changes in blood pressure and arterial blood gases, the presence of pneumoperitoneum increased ICP. They concluded that in patients with potential head injury or those at risk for cerebral ischemia pneumoperitoneum should have avoided.

Pneumoperitoneum with $CO_2$ seems to be related to increased ICP which should be avoided in patients with potentially significant closed head injuries or space-occupying lesions. Alternative gases or gasless laparoscopy may play a role in this type of patient in the future.

## ENDOCRINE METABOLIC EFFECTS

Data examining endocrine and metabolic alterations in the patient undergoing laparoscopy are sparse. Ortega et al[24] randomized 20 women with uncomplicated, asymptomatic cholelithiasis to open versus laparoscopic cholecystectomy. Hormonal responses were measured and compared for adrenocortical (serum ACTH, cortisol, urinary free cortisol), adrenomedullary (plasma and urinary epinephrine and norepinephrine), thyroid (TSH, thyroxine and triiodothyronine) and glucose (serum glucose, glucagon and insulin) homeostatic axes. Operative time and hospital length of stay were not different between the groups. Pain scores were significantly less in the laparoscopic group. There were no differences in the response of the adrenocortical, adrenomedullary, thyroid and glucose measures. The laparoscopic group had elevated antidiuretic hormone levels during the procedure and postoperatively. Open cholecystectomy was associated with elevated glucose and insulin levels primarily in the postoperative period. This study concluded that statistically higher levels of epinephrine, ADH and glucose were seen during laparoscopic cholecystectomy. Alternative, glucose and insulin levels were greater during the first 24 h after open cholecystectomy suggesting that laparoscopic cholecystectomy is more stressful intraoperatively but less postoperatively.

Glerup et al[25] examined the urea synthesis rate, functional hepatic nitrogen clearance and stress hormonal response to laparoscopic cholecystectomy compared to open cholecystectomy. Laparoscopic cholecystectomy produced a significantly smaller increase in functional hepatic nitrogen clearance (a measure of the postoperative catabolic state) versus open cholecystectomy. Moreover, laparoscopic cholecystectomy failed to produce cortisol or glucagon serum levels. Based on these results the authors concluded that laparoscopic cholecystectomy produced a significant decrease in postoperative hepatic clearance response.

Melville et al[26] studied 11 women undergoing exploratory laparoscopy and evaluated them for elevation in vasopressin. Intra-abdominal pressures (IAP) were increased to maximum (45 mm Hg) for one minute and then decreased to 14 mm Hg. Two of the patients were inflated to 45 mm Hg and held for 5 min. Vasopressin levels were measured with peaks following IAP peaks by about 4 min. This data suggested that vasopressin elevations were due to either direct stimulation from stretch receptors in the abdominal wall or from the hemodynamic changes induced by the pneumoperitoneum. A second study of 12 patients undergoing open, upper abdominal operations showed vasopressin elevations following simple manipulation of the peritoneum.[27] Regardless of the final pathogenesis, vasopressin is elevated following pneumoperitoneum.



In conclusion, laparoscopy induces multisystem changes. $CO_2$ absorption is associated with the majority of these changes. However, alternative gases and gasless laparoscopy can alter the consequences of $CO_2$ absorption. Yet the ease and relative safety of $CO_2$ pneumoperitoneum suggest that these changes may not be clinically significant in the normal host undergoing relatively short laparoscopic procedures. Advanced laparoscopic procedures or laparoscopic procedures in the compromised host may require alternative modes of abdominal expansion.

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# Laparoscopic Diagnosis and Treatment of Ascites and Peritoneal Malignancies



*Frederick L. Greene*



From its inception, the laparoscope has been an important tool in the assessment of causes of fluid collection in the abdomen as well as in the diagnosis and subsequent management of peritoneal malignancies.[1] Although most cases of ascites result from benign conditions worldwide, it is important to understand that benign and malignant conditions may occur concurrently and that a focused approach to the etiology of ascitic collection is mandatory for appropriate treatment strategies. Among the non-malignant causes of ascites in cancer patients are cirrhosis, nephrosis, congestive heart failure and peritonitis secondary to pyogenic organisms and tuberculosis (Table 3.1). History, physical examination, and diagnostic paracentesis with cell counts, cytology, protein, lactate dehydrogenase determinations, and culture will usually provide the diagnosis. Malignant ascites is seen most commonly in patients with ovarian, endometrial, breast, colon, gastric and pancreatic cancer (Fig. 3.1). The management of malignant ascites may include systemic chemotherapy, instillation of radioisotopes or chemotherapy drugs into the peritoneal fluid and peritoneal-venous shunting procedures.

The collection of intraperitoneal fluid in those with known abdominal cancer is most commonly a sign of significant intraperitoneal spread of disease. If neoplastic cells are demonstrated in the abdominal fluid collection, the term "malignant ascites" is used. The recognition of small quantities of intraperitoneal fluid may have staging and prognostic significance and may help in determining whether a conservative surgical approach, in combination with systemic therapy, should be considered rather than extensive radical procedures. Laparoscopic evaluation helps significantly in determining such a course of action. Symptomatic large collections of peritoneal fluid may be a sign of disseminated carcinomatosis or of underlying cirrhosis associated with hepatoma. These findings may indicate end-stage disease and reflect a survival pattern that is in the range of weeks to months. Palliative procedures such as peritoneo-venous shunting may be considered. Laparoscopic evaluation in these patients may help in determining etiology of disease by assessing peritoneal implants for histologic evaluation. In particular situations, malignant ascites may be associated with advanced disease but may yet indicate

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*Table 3.1. Causes of ascites*

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| Extravascular fluid accumulation |
| Chronic renal failure |
| Nephrotic syndrome |
| Right-sided heart failure |
| Constrictive pericarditis, cardiac tamponade, tricuspid stenosis or insufficiency |
| Malnutrition |
| Fluid overload |
| Intra-abdominal causes |
| Acute liver disease.—viral hepatitis, acute hepatic necrosis |
| Chronic liver disease.—cirrhosis, Budd-Chiari Syndrome |
| Pancreatic ascites |
| Chylous ascites |
| Malignancy.—ovarian, colon, breast |
| Tuberculosis |

Fig. 3.1. Diffuse gastric carcinoma with implants on surface of liver. A small amount of ascitic fluid is noted in sub-hepatic area.

situations where aggressive tumor debulking or systemic therapy have efficacy. Such is the case with intra-abdominal lymphoma or ovarian cancer. Stage-III ovarian cancer may be palliated effectively by extensive intra-abdominal debulking of tumor sites greater than 2 cm in diameter with a concomitant use of either intraperitoneal or systemic chemotherapy.[2]

Laparoscopic evaluation of malignant ascites has become an integral part ofthe armamentarium of the team approach to abdominal tumor. Therapeutic approaches used to treat patients with malignant ascites may be utilized for reduction of abdominal tumor bulk as well as the relief of abdominal fluid collection. These have included surgical debulking in preparation for local or systemic chemotherapy, intra-abdominal chemotherapy with or without hyperthermia, abdominal instillation of biologic response modifiers,[3] intra-cavitary isotopes, and, in some cases, intra-abdominal irradiation therapy or whole abdominal external beam radiation therapy.

## DIAGNOSIS AND WORK-UP OF MALIGNANT ASCITES



The finding of ascitic fluid in patients with known abdominal malignancy is usually secondary to the tumor itself. Many times, however, patients present with increasing abdominal girth without other sequelae or prior diagnosis of malignancy. Non-neoplastic causes of ascites include congestive heart failure, cirrhosis, renal disease or pancreatic disease, hypoproteinemia, infectious processes such as spontaneous bacterial peritonitis or tuberculosis (Fig. 3.2). In addition, benign gynecologic conditions such as endometriosis may be associated with ascitic collection. A small amount of ascitic fluid noted on imaging studies in the pelvis or lateral gutters of an asymptomatic patient with known intraperitoneal malignancy does not need to be aspirated because in most instances it can be assumed that the fluid collection is secondary to the malignancy itself. Paracentesis is indicated when a definitive diagnosis of malignant ascites is necessary for staging purposes or when planning surgical resection of malignant disease. In these situations, laparoscopic evaluation with inspection of visceral and parietal peritoneum is extremely helpful to rule out small tumor implants.

When abdominal paracentesis is performed, routine studies include a chemistry profile of the fluid, cell count and differential, gram stain as well as stains for tuberculous organisms and routine culture of bacteria, fungi and mycobacteria. In addition, ascitic fluid should be sent for cytologic evaluation. Generally, 500 cc of abdominal fluid are sufficient to collect enough cells for cytologic evaluation. These studies should be routinely requested when fluid is removed during laparoscopic evaluation. The character of the ascitic fluid may be indicative of the underlying diagnosis since malignant collections are most likely bloody or serosanguineous whereas collections from underlying liver or renal disease or as a result of cardiac disease may be serous in nature. Pancreatic ascites may also give serous fluid collections.[4] The specific underlying malignancy may also have characteristic ascitic fluid. An example of this would be peritoneal mesothelioma which has

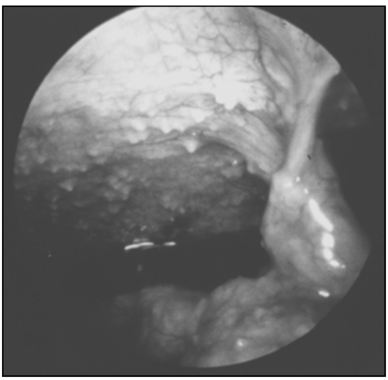

Fig. 3.2. Whitish nodules and ascitic fluid in patient with tuberculous disease of the abdomen.

a very thick whitish ascitic fluid high in hyaluronidase levels.[5] Frequently, in the evaluation of patients with extensive intraperitoneal malignancy, small quantities of fluid may be secondary to lymphatic obstruction and may represent chylous fluid collections which have resulted from obstruction of retroperitoneal lymphatic channels (Fig. 3.3) or from the lower portion of the thoracic duct. In addition, patients may develop chylous ascites who have previously undergone external beam abdominal radiation since the lymphatics may be obstructed secondary to this treatment.[6]

When evaluating ascitic fluid either by laparoscopy or paracentesis, adequate quantities of abdominal fluid must be obtained in order to allow appropriate diagnostic testing (Table 3.2). It is to be remembered that only a minority of all causes of ascitic fluid collections are malignant. This is especially true in the pediatric age group where approximately one-third of patients with known malignancy will have non-malignant causes of ascites.[7] Malignant abdominal effusion is most likely present when an elevated ascitic/serum ratio of protein (more than 0.4) or lactic dehydrogenase (more than 1.0) is seen. Increased elevations of

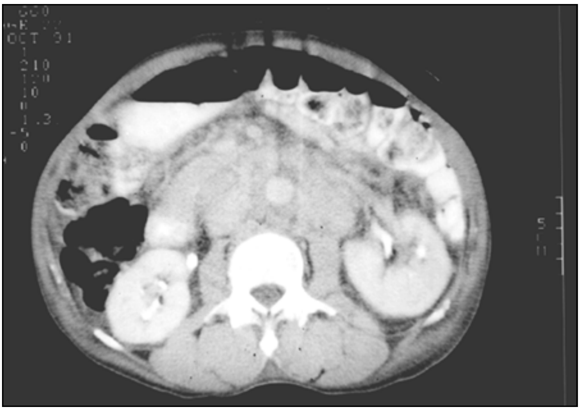

Fig 3.3. Computerized tomographic scan showing large retroperitoneal lymphoma which was associated with chylous ascites.

*Table 3.2. Testing to evaluate malignant ascites*

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| Ascites/serum ratio for protein |
| Cell count |
| Cultures |
| Lactate dehydrogenase |
| Carcinoembryonic antigen |
| CA.—125 |
| Detection of cytokines and cytokine receptors |
| Endoscopic ultrasound guided biopsy |
| Laparoscopic directed aspirate and biopsy |

carcinoembryonic antigen (CEA) or CA-125 favor neoplasia.[8] Cell counts of the ascitic fluid may be important, especially when it is noted that 10,000 erythrocytes per microliter and more than 1,000 leukocytes per microliter are characteristic of malignant effusion. In this instance, it is necessary to rule out spontaneous bacterial peritonitis by doing appropriate cultures.



## PATIENT SELECTION AND TECHNIQUE

In selecting patients for laparoscopy, it is important to consider the overall plan for the patient with malignant disease which would include the possibility of surgical extirpation, chemotherapy or radiation. In patients who present with ascites, the opportunity for curative resection becomes less although appropriate treatment strategies may be undertaken if the etiology of the ascitic fluid becomes known. While laparoscopy itself may be the prime mode of detection and confirmation of malignancy, more often patients who undergo laparoscopic examination have had a previous histologic confirmation by gastrointestinal endoscopic techniques or peripheral node biopsy. Every physician-endoscopist undertaking laparoscopy should have a clear understanding of the benefits offered by the procedure and should be willing to recommend avoidance of the technique if there is no defineable gain for the patient.

Diagnostic laparoscopy in the assessment of ascites or peritoneal malignancy may be undertaken using general anesthetic techniques or local infiltration with intravenous sedation in the awake patient. While some have favored the local anesthetic approach,[9] the necessity for creation of pneumoperitoneum and careful intra-abdominal assessment with biopsy may require prolonged periods of examination which can only be accomplished under general anesthetic techniques. While small laparoscopic cameras and instrumentation have become available for utilization outside the operating room setting, patients undergoing diagnostic laparoscopy may also need immediate celiotomy as the next step in full diagnosis or therapy. In our experience, therefore, these techniques are best performed in the operating room setting.

Patients who have had previous abdominal procedures should be evaluated carefully for alternate sites of placement of the initial puncture for establishing pneumoperitoneum. As the skill of the endoscopist increases, patients having previous operations for both benign and malignant processes may be approached, especially to satisfy the need for a "second look" rather than a formal celiotomy. In order to establish a safe pneumoperitoneum in a patient with a previously operated abdomen, open techniques using a Hasson cannula and adjunctive methods using ultrasound have been recommended to avoid inappropriate trocar placement. The location for placement of the Veress needle to establish a pneumoperitoneum may be determined by the site of the previous incision or by characteristics revealed by the abdominal ultrasound or computed tomography scan.

Selection of patients and the technique utilized for laparoscopy in the assessment of patients with ascites and potential peritoneal malignancy depend heavily on the information to be gained from the study. In patients with significant cardiac and respiratory disease who would not be candidates for open abdominal procedures because of the requirements for general anesthesia, laparoscopy may in fact prove hazardous because of the need for both general anesthesia and a significant pneumoperitoneum. Distention of the abdomen may in fact reduce cardiac output and enhance arrhythmias and may be considered a contraindication in those with severe coronary artery disease.[10] Similarly, profound problems in coagulation should encourage either correction of clotting problems preoperatively or abandonment of techniques that would increase bleeding. In patients with ascitic collection from both cirrhosis and hepatoma for instance, (Fig. 3.4) these coagulation problems must be corrected with fresh frozen plasma or vitamin K prior to any diagnostic procedure. In any patient with ascitic collections, a thorough history and physical examination are required to evaluate a patient for diagnostic laparoscopy and should be prerequisites to determine the appropriateness of this procedure.

One of the most important current utilizations of diagnostic laparoscopy is in the assessment of patients who may have metastatic disease to the liver. These patients may present with ascitic collections and have negative radiographic studies. Since most involved lymph nodes and metastatic deposits less than 1.5 centimeters are not routinely evident on CT scanning,[11] the laparoscope may be important in uncovering these implants. The full assessment of these patients must be performed using a complement of laparoscopy and imaging techniques since the laparoscope is only able to visualize surface lesions, even though these implants may be quite small. Similarly, it is difficult to assess the retroperitoneum

Fig. 3.4. Advanced cirrhosis and hepatoma diagnosed by directed laparoscopic biopsy after correction of coagulation defects.

fully using laparoscopic means, but these techniques are improving because of the addition of newer technology such as laparoscopic-assisted ultrasonography.[12] In the diagnostic evaluation of patients with ascites, consultation with radiologic colleagues is important to define whether computed tomography, magnetic resonance imaging, percutaneous ultrasound, or nuclear medicine studies should be performed to complement laparoscopic evaluation.



Ascitic fluid collection is most often seen in the presence of hepatic cirrhosis, but other causes of benign peritoneal fluid collection do occur. Traditional paracentesis has been used as a diagnostic and therapeutic maneuver, but relies on "blind" approaches to the abdominal cavity which may produce intestinal, biliary, or vascular complications. Since fluid obtained in this manner is studied by cytological methods, false negative determinations occur secondary to sampling and interpretative limitations. If examination of ascites supports underlying benign liver or renal disease, there may be little additional role for laparoscopic evaluation. Direct evaluation of the peritoneal cavity is indicated when the etiology of ascites is unclear or when imaging studies indicate findings in addition to cirrhosis alone.

Infectious causes of ascites may warrant examination beyond percutaneous aspiration of fluid. In many countries around the world, tuberculosis and parasitic infestation may be associated with ascites and may actually mimic malignant cachectic processes. In the United States, tuberculous peritoneal involvement has been seen to increase in populations that are immunosuppressed. These patients present difficult diagnostic dilemmas because of the frequent spectre of cancer associated with immunocompromised states. Evidence in both the laboratory and in human studies supports laparoscopic evaluation rather than open celiotomy because of the reduced effect of minimal access maneuvers on the immune system.[13]

The evaluation of patients with ascitic fluid collections should be as rigorous for laparoscopic procedures as those performed for major surgical resections. As stated above, general anesthesia is frequently required because of the need for performance of pneumoperitoneum, abdominal relaxation and length of intra-abdominal examination required to avoid missing small occult lesions. Assessment of cardiac and pulmonary function is important to avoid post-procedure complications. Radiographic evaluation of the chest is mandatory to determine whether pleural effusion is present along with abdominal fluid collections. Diagnostic or therapeutic thoracentesis should be performed when necessary with full radiologic evaluation afterward to insure that pneumothorax has not resulted. Pre-laparoscopic determination of coagulation abnormalities, especially in patients with underlying hepatic disease is important. Assessment of prothrombin time and partial thromboplastin time as well as platelet count should be routinely performed.

Technical issues relative to laparoscopic evaluation of ascitic fluid are important, especially to avoid the unwanted complication of infected ascites or post-procedure ascitic leak. Prior to laparoscopic evaluation, it is helpful to perform a paracentesis to reduce the amount of intra-abdominal fluid and the potential problem noted when carbon dioxide is placed intra-abdominally. This could result

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in the unwanted phenomenon of bubbling as a result of gas instillation which will interfere with the visual interpretation needed for laparoscopy. An important technical point is to position the patient in reverse Trendelenburg when placing a Veress through a midline infra-umbilical approach. This will allow the abdominal contents, especially loops of intestine, to float on the top of the ascitic fluid collection and, therefore, reduce the potential hazard of intestinal puncture when the Veress needle is directed toward the pelvis. This is opposite to the traditional method of positioning the patient in Trendelenburg position which allows the gravity to help keep intestinal contents out of the pelvic region when routine laparoscopy is performed.

Careful assessment of the entire intra-abdominal area is important to find small implants which may give valuable information as to the cause of the ascitic collection. One confounding problem is the appearance of tuberculous peritonitis which may mimic small implants seen frequently in pancreatic or gastric cancer.[14] Biopsy of implants using cupped biopsy forceps with the application of cautery is necessary during the procedure. In addition, wedge or needle biopsy of suspicious hepatic lesions must be performed. One must remember not to allow cautery application to destroy the architecture of small implants, thereby limiting histologic assessment. Pre-laparoscopy evaluation of coagulation parameters, as noted above, is important prior to any hepatic biopsy.

At the conclusion of the laparoscopic evaluation, careful closure of abdominal trocar sites is mandatory. Fascial and subcutaneous approximation as well as secure skin closure should be performed routinely in order to reduce leakage of peritoneal fluid. Since the development of trocar site recurrence from malignancy is increased in this setting,[15] careful irrigation of all trocar sites utilizing both saline and sterile water is recommended. The water will hopefully lyse isolated malignant cells in the abdominal wound areas.

## LAPAROSCOPY FOR ASCITES AND PERITONEAL MALIGNANCY–RESULTS

The benefit of laparoscopic evaluation is highlighted especially in patients with ascitic fluid collections that are found clinically to be unassociated with other signs of malignancy. The majority of these collections are from benign sources. Chuet al[16] recently reviewed 129 patients having malignant ascites of unknown origin. Seventy-eight (60.5%) were found to have visual manifestations of peritoneal carcinomatosis on laparoscopic evaluation. Peritoneal biopsy revealed malignancy in 67 of 76 cases which were biopsied and showed that a majority of these were adenocarcinoma followed by lymphoma and mesothelioma. In 14% of the laparoscopic studies, no definitive diagnosis could be made whereas peritoneal tuberculosis accounted for 20% of the cases and cirrhosis in 5%. Overall, laparoscopy with peritoneal biopsy was able to establish the cause of ascites in 86% of cases. Approximately 75% of women who present with malignant ascites of unknown origin have a gynecologic cause of the fluid collection while another 10% have associated gastrointestinal malignancy. In men, gastrointestinal cancer accounts for the predominant cases of malignant ascites. Even though rigorous laparoscopy may be performed, a small percentage may still have no identifiable cause for the ascitic collection.[17] It is important to note that ascitic fluid can result from certain treatment regimens utilized in the management of cancer. This is especially true with fluorouracil and N-phosphonacetyl-L-asparate.[18]



The use of laparoscopy must be considered paramount for the complete assessment of patients who present with intra-abdominal malignancy with or without ascites. Most intra-abdominal cancers may be associated with ascitic collections and small implants on the peritoneal surface. In addition, extra-abdominal malignancies such as breast and melanoma may have significant intra-abdominal presentations with both ascites and peritoneal implants.

The benefit of laparoscopy is realized both in the ability to make a diagnosis when cancer is unsuspected as well as the direct evaluation of the abdominal cavity in patients who have diffuse carcinomatosis. Utilizing both fluid for cytology and biopsy of tumor nodules, the surgeon-laparoscopist can play a major role in treatment planning. Although the visual effect of diffuse peritoneal cancer is usually not subtle, interpretation is important and proper biopsy techniques are mandatory in order not to worsen an already advanced situation. Recent addition of intra-abdominal ultrasound and isotopic markers may enhance the visual and histologic information to be garnered from laparoscopy.[19]

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# Lymphoma Staging: Basic Features

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Non-Hodgkin's lymphoma (NHL) and Hodgkin's disease (HD) are two distinct groups of lymphoid neoplasms. Treatment of both depends on pathologic staging and histologic classification. In general, radiation therapy is the treatment for stages I and II NHL and HD, while stages III and IV are treated with multiagent chemotherapy. This chapter will review the staging procedures for both HD and NHL that are essential to proper patient management.

## HODGKIN'S DISEASE (HD) STAGING

The histological diagnosis of HD is based on an excisional or incisional biopsy of a lymph node or more rarely of an extranodal site. Needle aspiration of lymph nodes is inadequate for initial diagnosis because lymph node architecture is essential for histological classification. Accurate staging of HD distinguishes patients requiring radiation therapy alone from those requiring chemotherapy or multimodality therapy.

The Ann Arbor system (Table 4.1), established in 1970, defines the basic parameters for patient staging. Contiguous involvement of adjacent organs is not considered dissemination. These cases are staged based on the extent of lymph node involvement (stages I, II, or III) followed by the subscript E, for direct extension. Splenic involvement is denoted by the subscript S. Patients are also classified as A or B based on constitutional symptoms. The B classification includes temperature > 38°C for three consecutive days, night sweats and 10% loss of body weight during the previous six months.

The majority of patients diagnosed with HD have radiographic evidence of intrathoracic involvement. Therefore, anterior-posterior and lateral chest x-rays should be ordered on all patients. Mediastinal or hilar adenopathy should be evaluated with computed tomography (CT) of the chest.

Intra-abdominal staging of HD is more difficult. CT scanning, ultrasound, lymphography, magnetic resonance imaging (MRI) and gallium scanning have all been utilized for abdominal staging. Bipedal lymphangiography (LAG) provides information about lymph node architecture and may be superior to CT scanning when evaluating patients with HD with inguinal or femoral adenopathy. On the

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*Table 4.1. Ann Arbor staging system*

| Stage | Description |
|---|---|
| Stage I | Involvement of a single lymph node region (I) or a single extralymphatic organ or site (IE) |
| Stage II | Involvement of two or more lymph node regions on the same side of the diaphragm (II) or localized involvement of an extralymphatic organ or site (IIE) |
| Stage III | Involvement of lymph node regions on both sides of the diaphragm (III) or localized involvement of an extralymphatic organ or site (IIIE) or spleen (IIIS) or both (IIISE) |
| Stage IV | Diffuse or disseminated involvement of one or more extralymphatic organs with or without associated lymph node involvement |

other hand, CT scanning is superior when evaluating celiac, splenic, porta hepatic and splenic foci. LAG and CT scanning are complementary techniques for staging, but few institutions perform LAG. Most centers rely on CT scanning for intra-abdominal staging since it is faster and technically easier.

Bone marrow biopsy is also a part of the initial staging procedure. However, the marrow is rarely involved (less than 1%) in stages 1A or 2A. The bone marrow biopsy is particularly important when evaluating patients with bone lesions, bone pain, elevated serum alkaline phosphatase, and clinical documentation of stages 3A or 4A.

## OPERATIVE PROCEDURE

Staging laparotomy includes exploration of the abdominal cavity, splenectomy, liver biopsies and para-aortic, splenic, porta hepatic and celiac lymph node biopsies. Oophoropexy is occasionally performed if pelvic irradiation is indicated. With operative staging, 30% of clinically staged (CS) 1A and 2A patients and 35% of CS 1B and 2B patients with HD will have occult nodal involvement.

Vaccination with anti-pneumococcus. Hemophilus and meningococcus should be performed in all patients prior to splenectomy.

## NON-HODGKIN'S LYMPHOMA STAGING

The Ann Arbor staging system originally developed for HD is currently used for NHL patients as well. The pattern of disease spread in NHL is different from HD and prognostic variables for staging have been identified. The International Prognostic Index (IPI) incorporates age, LDH serum level, performance status, extranodal sites, and the Ann Arbor system for staging purposes. The IPI system effectively predicts survival for intermediate and low grade NHL. NHL is such a diverse group of lymphoid neoplasms with unique natural histories and patterns of presentation that a systematic approach cannot be established. NHL diagnosis is essentially similar to HD.

# Laparoscopic Management of Lymphomas

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## INTRODUCTION

In 1832 Thomas Hodgkin initially described malignant lymphomas as lymphadenopathy of noninflammatory origin.[1] It was not until the late nineteenth century, however, that the histologic criteria for the diagnosis of lymphomas was developed.[2,3] Since that time, the diagnosis and treatment of lymphomas have undergone much change with current management relying on a multi-disciplinary approach involving medical oncologists, therapeutic radiologists, pathologists, and surgeons. The primary goals of this team approach are accurate diagnosis, proper staging, and effective treatment.

A definitive diagnosis is usually provided with an excisional lymph node biopsy. While this procedure has remained a constant, the role of subsequent staging laparotomy continues to evolve. Laparoscopy is simply one more step in this evolution.

## HODGKIN'S AND NON-HODGKIN'S LYMPHOMA

Lymphomas are a heterogeneous group of malignancies arising from the lymphoreticular component of the reticuloendothelial system. They are derived from the native cells of lymphoid tissue (i.e., lymphocytes and their precursors) and are monoclonal in origin.[4] Treatment consists of radiation therapy and/or chemotherapy with surgical resection as a therapeutic tool in a minority of cases. Lymphomas can be subdivided into either Hodgkin's or non-Hodgkin's disease.

### Hodgkin's Disease

Hodgkin's disease is characterized by the presence of multinucleated giant cells, termed Reed-Sternberg cells. It accounts for approximately 40% of lymphomas

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with about 7,500 new cases each year in the United States. The disease process has a bimodal age incidence that first peaks in the mid to late 20s and peaks again in late adulthood. The male to female ratio is 1.3:1.[5]

Hodgkin's disease typically presents with painless lymphadenopathy above the diaphragm. The cervical nodes are the first reported in 60-80% of patients. Constitutional symptoms such as night sweats, weight loss, and fevers are noted in 33% of patients. Additional symptoms may include pruritus, malaise, and alcohol-induced pain in affected areas.

The disease spreads through lymphatics to contiguous lymph nodes or visceral organs with a significant lymphoid component. The characteristic path involves axial nodal groups (cervical, mediastinal, and para-aortic).[6,7] This predictable metastatic pattern provides accurate staging followed by appropriate treatment.



### Non-Hodgkin's Lymphoma (NHL)

Non-Hodgkin's lymphoma is more variable than Hodgkin's disease and is divided into diffuse or nodular subgroups. There are approximately 50,000 new cases in the United States yearly and the peak incidence occurs sometime shortly after age 50. There is a slight male predilection at 1.4:1.[8]

The signs and symptoms of NHL are secondary to disseminated disease rather than local lymphadenopathy; 20-35% of patients present with extra-nodal disease.[9] Constitutional symptoms such as fever, night sweats, and weight loss are less common in NHL.[10]

NHL is considered to have a variable natural history with an irregular pattern of spread. This unpredictable metastatic pattern may be secondary to hematogenous spread.[9] As will be discussed further, because of this unpredictable pattern of spread, NHL rarely warrants surgical staging beyond the initial diagnostic biopsy. Finally, it is not uncommon for patients to develop leukemic features.

## SURGICAL MANAGEMENT

The surgical management of lymphomas has been well described Glatstein et al in 1969.[12,13] It is imperative to understand the traditional indications and open techniques for surgical management of Hodgkin's and non-Hodgkin's disease prior to discussing the laparoscopic management of lymphomas.

### Hodgkin's Disease (HD)

Hodgkin's disease presents with local lymphadenopathy in approximately 85% of patients making a lymph node biopsy the most common means of diagnosis. The treatment of HD, however, necessitates precise anatomical staging of the extent of abdominal disease. The staging laparotomy historically has provided that information and was performed in approximately 85% of patients as recently as 1980.[12] However, with the application of sensitive computerized tomographic (CT) scanning, lymphangiography, and percutaneous biopsy techniques, open laparotomy for staging is much less common.

The traditional staging procedure begins with a midline incision and general inspection of the entire peritoneal cavity. This is followed by hepatic wedge and needle biopsies, en bloc resection of the spleen and its hilar nodes, retroperitoneal and aortoiliac node dissection and bone marrow biopsy. An oophoropexy in young women completes the procedure.[14] While the staging laparotomy provides no therapeutic benefit, it definitively establishes the extent of abdominal disease. Therefore, it should be performed only when the information obtained will alter the treatment plan.

The value of staging is moot with some centers forgoing the procedure altogether.[15-17] Patient selection should be based on the degree of probability the procedure will alter therapy, the relative toxicities and side effects of chemotherapy and radiation, and the operative risk.

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The University of Alabama-Birmingham used a multifactorial analysis to demonstrate that histologic subtype, number of symptoms, and gender were significant predictors of risk of abdominal disease. This risk stratification revealed subgroups of low, intermediate, and high probability of intra-abdominal disease. They concluded that only the intermediate group undergo surgical staging.[18] Diagnostic laparotomy can change the stage in as many as 35-40% of patients with 20-25% being upstaged and 10-15% being downstaged.[15] Thus, staging laparotomy can potentially prevent both under- and over-treatment of Hodgkin's disease. This of course is not trivial since under-treatment leads to decreased survival and increased recurrence, while over-treatment induces the iatrogenic complications from unnecessary local radiation and systemic chemotherapy. Two of the most commonly cited serious complications following treatment for HD are second neoplasms (acute nonlymphocytic leukemia) and infertility.[19-22]

### Non-Hodgkin's Disease

As opposed to HD, the surgeon's role in NHL commonly begins and ends with an excisional lymph node biopsy. The disseminated nature of NHL precludes extensive surgical intervention and relies heavily on radiologic diagnosis. Staging laparotomy is rarely required and is indicated only for a patient who presents with localized diffuse histiocytic lymphoma in whom radiation is the proposed curative therapy.[10,23]

NHL of the gastrointestinal tract is the most common site of extranodal lymphoma. The stomach is most commonly involved accounting for 50-60% of gastrointestinal lesions.[4] Isolated gastric lymphoma is treated primarily with surgical resection followed by radio- and chemotherapy.[14] Small and large intestine involvement with obstruction, hemorrhage, or perforation often require emergent celiotomy.

## LAPAROSCOPIC STAGING OF ABDOMINAL LYMPHOMAS

The indications for surgical staging of abdominal lymphomas, regardless of approach—laparoscopic or open—remain similar. The components of the laparoscopic staging procedure, principally the splenectomy, remain unchanged from conventional open methods. However, as discussed below, this issue is currently being debated.

A standard evaluation of biopsy proven HD begins with a thorough history and physical examination. The history should determine the presence or absence of constitutional symptoms and evaluate symtomatology involving the gastrointestinal tract, central nervous system and musculoskeletal system. The physical exam is directed towards the various nodal basins as well as the presence of hepatosplenomegaly. Laboratory data include renal and liver function tests, complete blood count, erythrocyte sedimentation rate, serum lactate dehydrogenase, and alkaline phosphatase. Radiological studies include posteroanterior and lateral chest x-rays with chest CT when standard films are abnormal. An abdominal/pelvic CT should complete the standard work-up. Lymphangiography is a complementary diagnostic tool if equivocal deep inguinal or iliac adenopathy is present.[32,48]



### Liver Biopsy

Liver biopsy remains an essential tool to confirm suspected hepatic involvement with HD. The surgical evaluation of the liver begins with general visual and bimanual inspection and biopsy of all obvious and accessible lesions. Liver biopsy is then performed with a specialized needle that allows deep core biopsy under laparoscopic guidance. A wedge biopsy can be taken from the left lateral segment of the liver utilizing an endoscopic stapling device.[24] The harmonic scalpel and electrocautery can also be utilized to obtain adequate biopsy specimens from both lobes. Laparoscopic biopsy of the liver is safe and reliable,[24,25] and the mild to moderate coagulopathy present in many oncologic patients does not preclude its performance.[26] A full evaluation for possible coagulation abnormalities should be performed prior to the procedure.

### Splenectomy

Lymphoma is the most common splenic tumor and its involvement affects both the stage and therapy in patients with HD.[4,28] The spleen is involved in as many as 40% of patients undergoing open laparotomy with HD, yet it remains very difficult to evaluate clinically, with an overall accuracy rate of only 64%.[29] Thus, providing splenic histology is a primary objective for the surgeon. Traditionally, this has been accomplished through a midline incision.

Currently, several recent series have documented the efficacy of laparoscopic splenectomy.[30,31] Splenic extraction is usually completed through disruption of the splenic parenchyma. However, morcellation may prevent accurate histologic analysis of the organ's architecture. This may ultimately alter a patient's final stage and treatment. Many centers recommend preservation of splenic architecture by extracting the organ through a small counter incision.[30] This method does not negate the benefit of the laparoscopic approach.[30] Other invasive approaches are currently being investigated. These include a variety of biopsy techniques, with and without diagnostic ultrasound.[34,35] However, splenectomy allows a reduction in the radiation portal fields decreasing the possibility of radiation nephritis and pneumonitis.[12] Furthermore, postsplenectomy patients have an improved tolerance of chemotherapy manifested by a lower incidence of thrombocytopenia, leukopenia, and anemia[37] (Table 5.1). The advantage of splenectomy must be balanced by the occurrence of overwhelming postsplenectomy sepsis and the increased rate of leukemia in patients over 40 years following chemotherapy.[29,38]

Relative contraindications for laparoscopic splenectomy include portal hypertension, massive splenomegaly (generally considered when splenic length is greater than 20 cm), morbid obesity, and enlarged hilar lymph nodes that obscure adequate vision of the splenic hilum.[39,51] The cardiopulmonary consequences of the pneumoperitoneum may also exclude certain patients from undergoing laparoscopy (Table 5.2).



### Lymph Nodes

Moynihan, stated that "...surgery of malignant disease is not surgery of organs, it is the anatomy of the lymphatic system".[40] This is especially true for HD which commonly begins in the lymph nodes above the diaphragm and travels inferiorly to contiguous nodes. Although improved radiologic imaging techniques such as lymphangiography, spiral CT, and magnetic resonance imaging can identify abnormal lymph nodes, histologic evaluation of lymph nodes continues to be the "gold standard". Therapeutic decisions should not be based on indirect techniques, but on histopathologic information which requires excisional lymph node biopsies.

*Table 5.1. Splenectomy for lymphoma staging: Advantages versus disadvantages*

| Advantages | Disadvantages |
|---|---|
| Complete pathology | Physiologic insult |
| Decrease in radiation nephritis and pneumonitis | Risk of pneumococcal sepsis |
| Improved chemotherapy tolerance | Risk of treatment-related leukemia |
| | Wound problems |
| | Potential surgical complications |

*Table 5.2. Contraindications to a laparoscopic approach[51]*

| Absolute | |
|---|---|
| Generalized Peritonitis | |
| Uncorrectable Coagulopathy | |
| **Relative** | |
| Adhesions (Prior Abdominal Surgery) | Bowel Distention |
| Not Able to Tolerate General Anesthesia | Portal Hypertension |
| Pregnancy | Massive Splenomegaly |
| Morbid Obesity | Enlarged Hilar Nodes |
| Abdominal Wall Sepsis | |

Laparoscopic inspection and biopsy of abdominal lymph nodes was first reported in 1978 by Meyer-Burg and Ziegler.[41] Salky and associates[42] later identified and laparoscopically biopsied 19 patients with retroperitoneal disease. The biopsies were positive in 17 of 19 patients and 16 of these patients avoided open laparotomy. More recently, Rhodes et al[43] reported success in 21 of 23 patients undergoing laparoscopic lymph node biopsy with a > 90% diagnostic yield. The lymph node dissection is performed by obtaining biopsies from celiac, mesenteric and aortoiliac areas with special attention being paid to any nodes appearing abnormal on lymphangiogram.[44,45] Intraoperative radiological studies may be utilized to confirm complete excision of all abnormal lymph nodes.



### Additional Procedures

The staging laparotomy includes oophoropexy in young women to protect the ovaries from the inverted-Y radiation field. This historically decreased the amount of infertility and avoided premature menopause in many females.[46,47] However, oophoropexy is currently rarely recommended due to the decreasing use of pelvic irradiation.[48] In one reported series, only 3 of 27 patients who received oophoropexy subsequently required pelvic radiation.[49] The procedure, when indicated, can be performed laparoscopically by suturing the ovaries to the posterior wall of the uterus.[50] An iliac crest bone marrow biopsy completes the staging procedure and is performed using standard techniques. It is important that biopsies, not aspirates, be obtained as HD of the marrow is often spotty and associated with fibrosis. Hodgkin's disease is found in the bone marrow of approximately 1% of patients undergoing laparotomy. Therefore, it may be reserved for patients with B symptoms, bone pain, or an increased alkaline phosphatase.[48]

Laparoscopic staging of abdominal lymphomas has been well documented in the literature.[27,30,34,44,45] It has the advantages of decreasing postoperative pain, reducing hospital stay and enhancing postoperative rehabilitation. These advantages allow earlier administration of definitive therapy. While it remains a technically difficult procedure, laparoscopic staging is a useful technique in the management of patients with suspected abdominal lymphoma.

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# Videolaparoscopy and Pancreatic Cancer

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## INTRODUCTION

For patients with adenocarcinoma of the pancreas the outlook remains bleak despite recent advances in diagnosis and treatment.[1-2] The American Cancer Society has estimated that 27,000 new cases will be diagnosed in the United States during 1997.[3] The majority of these patients will die of their disease within a year of diagnosis, making it the fourth leading cause of cancer death in men and the fifth in women. Non-specificity of symptoms, advanced disease at presentation, lack of effective adjuvant and systemic therapy help explain this grim prognosis. At present, surgical resection for localized disease offers the only chance for long-term survival.[2,4-7]

Unfortunately, the majority of patients continue to present with advanced disease.[8,9] Due to the inability of sophisticated diagnostic modalities such as computerized tomography (CT), magnetic resonance imaging (MRI) and ultrasound (US) to accurately assess the extent of disease, many of these patients will still undergo surgical exploration for accurate staging or palliation.[8,9] For those in whom an open palliative procedure is not warranted, exploration confers no benefit, and may be associated with significant morbidity and mortality affecting both the quality and duration of survival.[10,11]

It has been recently argued that minimal access surgical techniques have much to offer patients with adenocarcinoma of the pancreas from both the diagnostic/ staging and palliative perspective. This chapter will review the role of laparoscopy in both of these areas.

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## RATIONALE FOR LAPAROSCOPIC STAGING

The goal of clinical oncological staging is to accurately define the extent of disease, direct appropriate therapy and avoid unnecessary intervention. Minimal access surgery offers a new approach to this problem. In theory, decreased surgical morbidity, reduced hospital stay, shorter recovery, and potentially improved quality-of-life would be of benefit to the patient expected not to live longer than a few months.

Recent reports have suggested that laparoscopy can play an important role in the staging of abdominal malignancy.[12-19] Laparoscopic examination can visualize the primary tumor, identify hepatic metastases, diagnose regional nodal metastases, and detect small volume peritoneal disease unappreciated by other noninvasive staging modalities such as computerized tomography, magnetic resonance imaging, or ultrasonography.



The concept of utilizing laparoscopy for cancer staging is not new. B.M. Bernheim of the Johns Hopkins University who reported the first clinical laparoscopic procedure in the United States in 1911, believed that the technique "..may reveal general metastases or a secondary nodule in the liver, thus rendering further procedures unnecessary and saving the patient a rather prolonged convalescence".[20] Despite this early promise, poor optics and inadequate instrumentation confined the acceptance of the procedure to a few enthusiasts.[21] It was not until the more recent development of video technology, better instrumentation, and the description of operative procedures such as laparoscopic cholecystectomy that surgeons have incorporated laparoscopy into their oncological practice.

In the late 1980s, Cuschieri from Dundee University[13] and Warshaw from the Massachusetts General Hospital[22] demonstrated that small hepatic or peritoneal implants could be detected with considerable accuracy by laparoscopy alone (Table 6.1). A recent update from Warshaw's group confirmed the utility of preoperative laparoscopy. One hundred and fourteen patients with localized pancreatic cancer were examined.[23] Metastases were identified in 27 patients (11 liver, 5 peritoneum/omentum, 11 multiple sites). None of these patients required open

*Table 6.1. Results of laparoscopic staging**

| Author (Ref) | Number of patients | Liver/peritoneal metastases (%) | % resected after a negative laparoscopy |
|---|---|---|---|
| Cuschieri (13) | 73 | 70 | 44 |
| Warshaw (22) | 32 | 36 | 42 |
| Maffei-Faccioli (24) | 56 | 55 | 40 |
| John (25) | 40 | 45 | 46 |
| F del Castillo (23) | 114 | 24 | 37 |
| Conlon (30) | 115 | 19 | 91 |

* excludes the use of laparoscopic ultrasound

exploration. Tumors in the body and tail of the pancreas were more likely to have metastases. A further 42 patients were excluded from further surgery by angiography, and 40 came to open operation, of which 30 were resected. Maffei-Faccioli and coworkers performed laparoscopy on 56 patients considered to have resectable disease following radiological evaluation.[24] Evidence of disseminated disease was found at laparoscopy in 31 cases. However, only 40% of the remainder who underwent open exploration were resected. Similar results were reported by John and colleagues, who demonstrated unsuspected metastatic spread in 14 of 40 patients (35%) considered to have resectable disease prior to laparoscopy.[25] Laparoscopy alone failed to identify intra-abdominal dissemination in 3 patients and locoregional disease in a further 12 cases, resulting in a specificity of only 50% in predicting tumor resectability.

In an effort to improve the ability to determine resectability, John and colleagues also investigated the role of laparoscopic ultrasonography (LUS).[25] Laparoscopic ultrasonography has the potential to partially overcome the lack of tactile sensation present in standard two-dimensional laparoscopy. Initially developed for the assessment of hepatic disease, it has been recently utilized in benign biliary disease.[26] John and colleagues were able to obtain satisfactory images of the primary tumor in 82% of cases. The LUS examination added information regarding tumor stage in 20 patients. This information changed the decision regarding resectability in 10 patients, resulting in an accuracy in predicting tumor resectability of 89%. Other authors have also suggested that LUS may have utility in the staging process. Machi et al described a technique which allows complete examination of the liver and pancreas.[27] Bemelman and coworkers also used LUS in combination with diagnostic laparoscopy for staging patients with stage I cancer of the pancreatic head.[28] Metastatic disease was demonstrated in 21 of 70 patients (30%). Patients without histological proof of malignancy proceeded to exploration. In those without metastatic disease, 21 of 22 patients considered to have resectable disease after LUS were resected compared to 6 of 13 with equivocal results and 2 of 14 with "irresectable" disease. The sensitivity and specificity of LUS in determining resectability was 67% and 96% respectively. LUS was found to be particularly useful by van Delden and colleagues for staging patients with extrahepatic proximal bile duct obstruction.[29] In a prospective series of 35 patients, LUS provided additional diagnostic or staging information in 8 (23%) and avoided laparotomy in 3 patients (9%).



## MEMORIAL SLOAN-KETTERING EXPERIENCE

At Memorial Sloan-Kettering Cancer Center (MSKCC) we believe that laparoscopy is an integral component of the preoperative assessment of patients with peri-pancreatic malignancy.[30,31] In our practice, patients with a suspected peri-pancreatic malignancy have a contrast-enhanced, dynamic CT of the abdomen with 5 mm cuts of the pancreas. This examination has been shown to have a high sensitivity in determining local regional extension and vascular encasement.[32]

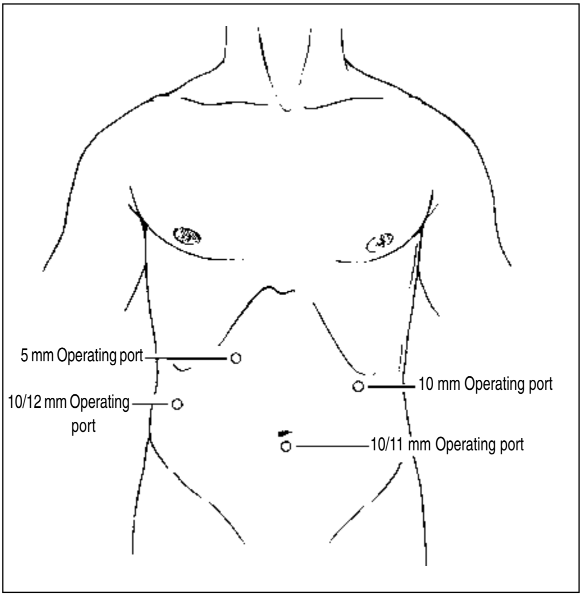


Fig. 6.1. Position of the operating ports for laparoscopic staging. Reprinted with permission from: Conlon KC et al. Ann Surg 1996; 223:134-140.

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Those patients who are considered to have “radiologically” resectable disease undergo laparoscopic staging prior to open exploration.

We perform all of our laparoscopic studies under general anesthesia. A multiport technique was developed which attempts to replicate the standard surgical assessment of resectability. Following creation of the pneumoperitoneum, a 30° angled telescope is placed through the umbilical port. Trocars are placed in the right (10 mm, 5 mm) and left (5 mm) upper quadrants (Fig. 6.1). A systematic examination of the peritoneal cavity, liver, porta hepatis, duodenum, transverse mesocolon, lesser sac, and celiac and portal vessels is performed.[30] Cytological washings are taken from the upper abdomen. Suspicious peritoneal deposits (Fig. 6.2), hepatic lesions (Fig. 6.3),or enlarged celiac, portal or peri-pancreatic nodes are biopsied and sent for frozen section.

Our criteria for unresectability are listed in Table 6.2. Unresectability is determined if one or more of the following are confirmed histologically (i) hepatic, serosal/peritoneal, or omental metastases, (ii) extrapancreatic extension of tumor (i.e., mesocolic involvement), (iii) celiac or portal nodal involvement by tumor, or (iv) invasion or encasement of the celiac axis, hepatic artery, or superior mesenteric artery. Patients in whom histological proof of unresectability is not obtained or who are found to have portal or mesenteric vein encroachment by tumor are considered potentially resectable and thus undergo exploratory laparotomy.

Using such an approach in 108 patients, we demonstrated that laparoscopic staging had a positive predictive index, negative predictive index and accuracy of 100%, 91%, and 94% respectively.[30] We have recently updated our experience.[31] In

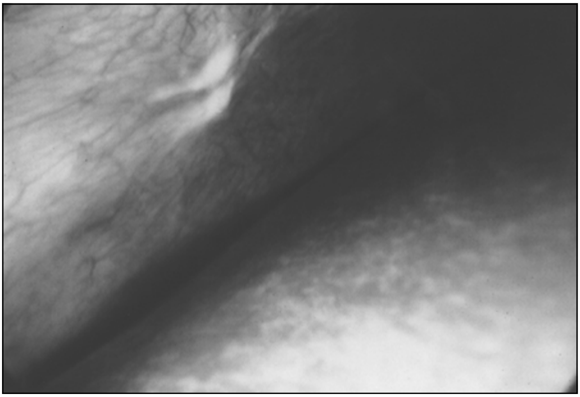

Fig. 6.2. Peritoneal deposit seen at laparoscopy



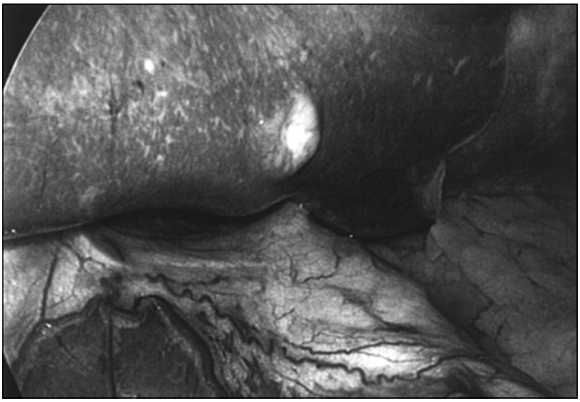

Fig. 6.3. Hepatic metastases in a patient with carcinoma of the head of the pancreas.

*Table 6.2. Criteria for unresectability at laparoscopy*

| |
|---|
| Hepatic, serosal / peritoneal or omental implants |
| Extrapancreatic extension of tumor |
| Celiac or portal nodal involvement by tumor |
| Invasion or encasement of the celiac axis, hepatic artery, or superior mesenteric artery |
| Involvement of the entire retro-pancreatic portal vein / superior mesenteric vein |

the current report, 220 patients with radiologically "resectable" peri-pancreatic tumors underwent laparoscopic staging. Of these, 79 patients were noted to have unresectable disease. The predominant cause for unresectability was hepatic metastases, followed by extrapancreatic spread, vascular invasion and nodal spread. Unresectability was confirmed histologically in all cases. One hundred and forty-one patients were considered to have resectable disease and a resection was ultimately performed in 129 (91%) patients. Of the patients with unresectable disease 64% had a laparoscopic procedure only. None of this group has required a subsequent open operation for palliation. Twelve patients considered to have resectable disease at the end of laparoscopy were not resected. In two cases benign disease was found at laparotomy and no resection performed. For the remainder, the failure to appreciate hepatic metastases was the commonest reason for the false negative result. In no case was eventual unresectability the result of vascular invasion, confirming the utility of contrast-enhanced CT scanning in this regard.

We have also had preliminary experience with laparoscopic ultrasonography (LUS). Currently we are using semiflexible 10 mm laparoscopic ultrasound probes which utilize linear array technology and have a high frequency performance with a range in frequency of 6-10 MHZ (Aloka SSD-2000, Tokyo, Japan). These probes with duplex Doppler and color flow Doppler capability allow detection of lesions as small as 0.2 cm. Hepatic metastases can be seen (Fig. 6.4) and portal and mesenteric vessels imaged (Fig. 6.5). In a initial study of 20 patients, LUS was felt to have given additional information in 7 cases, and altered the surgical approach in 6 patients.[33] This early experience suggests that LUS may have a role to play in the diagnostic algorithm, however, the true assessment of the utility of this modality awaits further study.

## LAPAROSCOPIC BILIARY AND GASTRIC BYPASS

The ideal palliative procedure for biliary obstruction should be effective in relieving jaundice, have minimal morbidity, be associated with a short hospital stay, have a low symptomatic recurrence and maintain quality-of-life. In patients with malignant distal biliary obstruction, there has been a trend recently towards

Fig. 6.4. Ultrasound image of an hepatic metastasis. Aloka SSD-2000, 7.5 MHz linear array probe.

Fig. 6.5. The portal vein as visualized by laparoscopic ultrasonography. Note the proximity of the tumor to the vein (arrowed).



nonoperative biliary drainage by either the endoscopic or transhepatic routes.[34-41]

Randomized trials have demonstrated a reduced hospital stay and similar early morbidity and mortality with endoscopic stent placement compared to surgical bypass.[42,43] However, long term complications appear increased, with recurrent jaundice due to occluded or dislodged prosthesis and cholangitis occurring in 13-60% of cases.[34,35,44,45] In patients who are expected to live longer than a few months these complications may make endoscopic palliation less than optimal.

Prior to the advent of minimal access surgery (MAS), open surgical drainage was the only palliative option to endoscopic or transhepatic stenting. Surgical drainage provides excellent relief of jaundice.[10,11,45] Despite extensive controversy in the literature.[10,11,34,36,45] both choledocho-enteric and cholecysto-enteric bypasses, if selected appropriately, have similar results with regards to reducing serum bilirubin. In a recent analysis of our experience, we were not able to demonstrate any difference between these two methods of biliary diversion.[11] Both procedures were associated with considerable morbidity with complications occurring in 18%. Others have reported similar figures.[10,38] It is our clinical impression that particularly after a complicated postoperative course some patients never regain their preoperative performance status and commence a slow inexorable slide in their quality-of-life until death.

We perform a cholecystojejunostomy in selected patients. Patients with a patent cystic duct and at least 1 cm clearance from the upper extent of the tumor are candidates for this procedure. However, if it is determined that a cholecystojejunostomy would not be appropriate (i.e., prior cholecystectomy, diseased gallbladder, blocked cystic duct, low insertion of cystic duct, tumor encroachment on cystic duct or gallbladder), a standard surgical bypass to the common hepatic duct is performed.

### Animal Experience with Laparoscopic Biliary Bypass

The first series of animal experiments were reported by Nathanson and coworkers who utilized a sutured cholecystojejunostomy in a pig model.[46] An intracorporeal anastomosis was performed in six animals, five of whom subsequently underwent ligation of their common bile duct. In all cases, 4 weeks following this procedure the bilioenteric anastomosis was noted to be patent and bilirubin less than 5 mol/l. A combined biliary and gastric operation in a porcine model was examined by Patel and colleagues.[47] They demonstrated the feasibility of such a procedure. A similar study by Rhodes et al[48] showed that there is a 0% anastomotic stricture formation at 12 weeks if a 6 cm anastomosis was created. A combined biliary and gastric bypass procedure was investigated by Schob et al, who performed a double Roux-en-Y loop cholecystojejunostomy and gastroenterostomy in 10 pigs.[49] On completion of the study only one animal was noted to have an anastomotic failure.



### Clinical Experience with Laparoscopic Bypass

Cuschieri's group from Dundee University in 1992 was the first to report a series of biliary bypass procedures performed laparoscopically.[50] In 5 patients with advanced pancreatic cancer a cholecystojejunostomy was performed. Four patients had an excellent result, recovering from the procedure with minimal morbidity and complete relief of their biliary obstruction. The authors felt that this procedure had merit in selected patients and may avoid the hazards of endoscopic stenting such as recurrent biliary obstruction or cholangitis. Fletcher and Jones also in 1992 reported a case in which they had used the endoscopic linear stapler to construct the complete anastomosis.[51] At follow-up one month following the procedure the patient was neither icteric or symptomatic. Hawasli described a similar technique in two patients both of whom were discharged within 4 days following their procedure.[52]

The first report of laparoscopic gastroenterostomy for malignant duodenal obstruction was by Wilson and Verma from Edinburgh, Scotland.[53] They reported on two cases in which duodenal obstruction was successfully relieved by means of an antecolic gastrojejunostomy. The nasogastric tube was removed on the first post-operative day and a regular diet was achieved by the forth day. Brune and Schonleben in 1992 reported their initial experience in two patients using a stapled anastomosis.[54] They emphasized the operative complexity, need for expensive instruments and skilled surgical technique. Rangraj and coworkers reported a similar technique in 1994.[55] In their case they used the laparoscopic stapler to complete the entire anastomosis rather than suturing the initial enterotomy/gastrotomy.

Combined biliary and gastric bypass was performed by Rhodes and coworkers on a series of 16 patients who presented with gastric outlet obstruction (n=8), an occluded endoscopic stent (n=4), or were found at staging laparoscopy to have metastatic disease (n=4).[56] A cholecystojejunostomy was performed in 7, gastroenterostomy in 5, and a combined procedure in the remaining 3 patients. Median operative time was 75 minutes, and 14 patients were discharged from hospital within a week of surgery. One patient following a biliary bypass required a further surgical procedure for recurrent jaundice. The authors suggest that laparoscopic bypass is a viable option particularly for the patient with an occluded stent, duodenal obstruction, or in whom endoscopic stenting is not possible.

We believe that the indications for a laparoscopic cholecystojejunostomy are similar to the indications for the equivalent open procedure. Currently, we use the laparoscopic ultrasound to assess the relationship of the tumor to the cystic duct/common bile duct. Those patients who are considered unsuitable for a laparoscopic procedure are converted to an open procedure and a standard bypass performed. If a laparoscopic bypass is performed the trocars used in the staging laparoscopy can be utilized. In order to accommodate a linear stapler the right upper quadrant 10 mm trocar is converted into a 12 mm trocar.



The procedure mimics the standard antecolic cholecystojejunostomy. A suitable loop of jejunum approximately 30 cm distal to the ligament of Treitz is brought to the gallbladder. Using an intracorporeal suturing technique, the jejunum is approximated to the gallbladder. Small incisions (0.5 mm) are made in the gallbladder and jejunum. Enteric leakage is minimal due to the increased intra-abdominal pressure enteric leakage is minimal. By using an EndoGIA/30 mm stapler (U.S. Surgical Corp. Norwalk, CT) inserted through the 12 mm RUQ port, and manipulated into the gallbladder and jejunum an anastomosis is created. The resultant enterotomy can be closed by using either a completely intracorporeal or laparoscopically-assisted approach. This technique allows for the construction of a 2.5 cm cholecystojejunal anastomosis without any bowel narrowing.

The technique for fashioning a laparoscopic gastrojejunostomy is similar. A proximal loop of jejunum which is brought in an antecolic position to the stomach. The left upper quadrant 5 mm laparoscopic trocar is converted to a 12 mm trocar. Enterotomies are made in both stomach and jejunum, an EndoGIA 30 mm stapler (U.S. Surgical Corp. Norwalk, CT) is inserted through the 12 mm LUQ port, and manipulated into both enterotomies. The instrument is positioned and fired. The stapler is removed and reloaded, being returned into the anastomosis and refired. This creates an anastomosis approximately 5 cm in length. The anterior defect then can be closed in a similar fashion to the cholecystojejunostomy. Any defects in the anastomosis can be repaired with individual 3/0 sutures.

To date, we have used the techniques described above in 12 patients with unresectable pancreatic cancer. Five patients underwent a cholecystojejunostomy, 2 underwent a gastrojejunostomy and 2 received both a biliary and gastric bypass. Eleven patients had a satisfactory result. In one patient with obstructive jaundice who underwent a cholecystojejunostomy, bilirubin levels did not decrease postoperatively. An endoscopic stent was subsequently placed. The ERCP demonstrated a long biliary stricture with an occluded cystic duct. At the time of the original procedure, the cystic duct and common bile duct junction were not identified and laparopscopic ultrasonography was not available.

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## CONCLUSION

We believe that currently the combination of contrast-enhanced dynamic CT imaging of the pancreas with videolaparoscopy is an effective, safe, and cost-efficient method of staging patients with pancreatic cancer. These investigations avoid unnecessary operation while not precluding exploration and resection for those who would potentially benefit.

However, the true role of laparoscopic bypass remains to be defined. Early reports have demonstrated their feasibility, but their place in our armamentarium is unclear. Further clinical trials are required before this question can be resolved.

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# Laparoscopic Assessment of Tumors of the Pancreatic Head

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## INTRODUCTION

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Pancreatic cancer has the worst prognosis of all gastrointestinal malignancies. According to the National Cancer Institute, only 3% of all patients will be alive five years after diagnosis. Preoperative staging is therefore mandatory in order to carefully select those few patients who may be operated with a likelihood of cure[1,2] and accurate staging will allow selection of patients for palliative treatment without the need for an exploratory laparotomy.

Twenty years ago, Cuschieri[3] demonstrated that diagnostic laparoscopy (DL) was an efficient method of diagnosing and staging patients with pancreatic cancer. DL permits detailed inspection of the peritoneal cavity including the lesser omental sac, and also allows guided biopsy and abdominal cytology to determine possible metastases. Warshaw[4] clearly demonstrated the shortcomings of radiological imaging in pancreatic cancer staging. Although CT scanning will provide information on the primary tumor size, only DL can accurately detect the small hepatic surface metastases and small-volume peritoneal deposits which are so typical of this type of cancer.

Radiological assessment of pancreatic tumors, however, still remains the primary and most important modality for preoperative staging. According to Conlon et al,[5] CT imaging must focus on:

- tumor size and location,
- intrahepatic or peritoneal metastases (or ascites),
- lymph node enlargement (i.e., coeliac, periportal and peripancreatic nodes),
- extra-pancreatic tumor extension, and
- vascular encasement.

Absolute radiological criteria for unresectability are the presence of hepatic or peritoneal metastases and definite vascular encasement or obstruction. DL will not be necessary in these patients. The presence of visible lymph nodes, minimal ascites or appearance of vascular encroachment are generally considered to be

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relative criteria of unresectability. It is especially this group of patients who are ideal candidates for a DL.

Diagnostic laparoscopy plays a very important role in surgical decision-making for pancreatic tumors. It has the unique ability to detect peritoneal deposits and small metastases on the liver surface which are so often missed on preoperative imaging. DL is able to visualize the regional (N3) lymph nodes, and allows biopsy to determine involvement. A more accurate visualization of tumor extension outside the pancreas in the surrounding structures (i.e., mesocolon, duodenum and hepatoduodenal ligament) is possible.

## DIAGNOSTIC LAPAROSCOPY

Diagnostic laparoscopy for pancreatic tumors can be performed in three different categories, depending on the intentions and experience of the surgeon. These categories are (in increasing grade of difficulty):

a) Diagnostic laparoscopy "scan",
b) Extensive staging laparoscopy, and
c) Comprehensive laparoscopy with laparoscopic ultrasonography.



### Diagnostic Laparoscopy "Scan"

Diagnostic laparoscopy "scan" is the most simple and shortest procedure and can be performed as a separate operating session or immediately prior to the planned laparotomy for a pancreaticoduodenectomy. It entails the simple inspection of the peritoneal cavity, including the surface of the liver, hepatoduodenal ligament, duodenum, mesocolon and coeliac axis. No additional investigation is done and the entire procedure will take approximately 15 minutes to perform. Exploration requires a maximum of three trocars; infraumbilical for the laparoscope and one or two 5 mm subcostal ports for retraction and biopsy. It is simple and reliable to interpret.

In our experience with DL, performed in 32 patients with a potentially resectable pancreatic head tumor, small liver or peritoneal metastases were detected in 12 cases while another 2 had obvious extension through the duodenal wall. Therefore, an unnecessary laparotomy could be avoided in 43% of patients. Of the 18 patients who were explored by laparotomy, 6 (18%) were found to be unresectable due to invasion of the portal vein (5 patients) or inferior cava (1 patient). The remaining 12 patients (40%) underwent pancreaticoduodenectomy.

### Extensive Staging Laparoscopy

Extensive staging laparoscopy involves obtaining cytology washings and opening the lesser omental sac to allow careful examination of the coeliac axis, hepatoduodenal ligament and inferior aspect of the mesocolon. It usually requires rather extensive dissection and mobilization to provide sufficient access to allow adequate visualization. Extra trocars are needed, as is adequate experience in laparoscopic techniques, especially when taking representative biopsies of possibly infiltrated lymph nodes. The procedure takes more time to perform, and may require a separate operating session to allow efficient operating room planning. Despite the extent of the staging laparoscopy, in our experience, it remains very difficult to accurately determine local extension of the primary tumor and possible vascular encasement or infiltration (although Conlon et al[5] suggest otherwise).

Fernandez del Castillo et al[7] performed staging laparoscopy in a series of 114 patients with pancreatic cancer (89 pancreatic head and 25 boy or tail). All were deemed resectable after preoperative CT imaging. Metastases were found in 27 patients (24%) and as expected, intra-abdominal spread was more frequent in tumors of the body or tail (44%) than of the pancreatic head (18%). These patients were treated by palliative stenting when necessary. Of the 87 patients without metastases on laparoscopy, 42 were found to have clear vascular invasion by angiography and they were offered radiation therapy. A total of 40 patients were surgically explored with the intent to perform a curative resection. This was ultimately accomplished in 30 patients (75% of those undergoing laparotomy or 26% of the total group who had laparoscopy done). The sensitivity of laparoscopic staging was therefore 93%. This study once again demonstrates the value of laparoscopy in detecting unsuspected intra-abdominal spread. The prevalence is, however, lower than in the previous reports from the same authors[4] in an earlier period (24% versus 41%), and this may reflect earlier diagnosis and improved resolution of radiological imaging modalities. Others have reported accuracy rates of laparoscopy varying from 39-73%.[5,8,9]

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### Comprehensive Laparoscopy with Laparoscopic Ultrasonography

This form of investigation involves the addition of laparoscopic ultrasonography (LUS), supplemental to the above described extensive staging diagnostic laparoscopy. What additional value can the use of laparoscopic ultrasonography offer in the staging of pancreatic cancer?

It has the potential to provide extra information regarding three aspects:

a) detection of small intrahepatic metastases, not visible on the surface,

b) determining local invasion of the portal vein and superior mesenteric vein, and

c) assessment of N3 lymph nodes, not accessible visually.

Sonographic appearances will help to determine tumor status, but biopsies to prove tumor infiltration are essential if laparotomy is to be avoided, and this may be performed using forceps or needles under ultrasonography guidance, although this is extremely difficult to achieve.

Bemelman et al[10] studied the value of diagnostic laparoscopy with laparoscopic ultrasonography in the staging of pancreatic head cancer in a group of 73 patients. All were considered to be resectable following preoperative examination, including ultrasonography and Doppler imaging. Of the 21 patients with metastases, 16 were diagnosed by laparoscopy and ultrasonography; 49 patients underwent laparotomy and trial dissection and 29 (41%) were ultimately resected. The positive predictive value of LUS in determining local vascular invasion was

93%. Laparotomy was avoided in 19% of patients and the preoperative stage was altered in 41%.

An interesting point is the predictive value of LUS in assessing local vascular invasion: 22 patients were shown to have no tumor contact with the large vessels and 21 of them were actually resected. In 13 other cases, resectability was considered to be probable due to visible tumor-vessel contact on LUS but only 7 could be resected at laparotomy. Finally, 2 of 14 patients considered to be unresectable on LUS (tumor infiltration or loss of the dividing white plane) did undergo a radical resection. The authors concluded that visualization of local tumor extension with regard to vascular separation is technically demanding, while LUS-guided biopsies are difficult to perform because the LUS-probes are not equipped for accurate puncture direction. We agree with the authors that surgical exploration and trial dissection must be carried out unless histological proof of metastatic disease is obtained. Comparable results with LUS for pancreatic tumors have been reported by others.[6,11,12] In their series of 40 patients, John et al[12] found unsuspected peritoneal and/or liver metastases in 14 patients (35%). LUS was responsible for upstaging of the disease to an unresectable status in 10 patients (25%).



## CONCLUSIONS

Diagnostic laparoscopy is mandatory for accurate staging of patients considered to be candidates for surgical resection of pancreatic cancer. The expertise and equipment required is currently so widely available that all surgeons involved with pancreatic resections should be able to perform diagnostic laparoscopy.

We have subdivided the procedure into three categories, which represent different grades of difficulty in interpretation and performance. The simple diagnostic scan is well within the reach of every general surgeon. Extensive staging by laparoscopy requires considerably more time and dissection, often with little added information to a quick laparoscopy. Interpretation and accuracy of LUS is difficult, while an exploratory laparotomy is frequently required regardless of the findings. However, increasing experience will allow LUS to provide important supplemental information regarding surgical decision-making in the future. The development of specially designed LUS targeting devices will help to obtain the histological proof necessary to avoid trial dissection. On the other hand, indiscriminate biopsy, particularly of the primary tumor, should be avoided to prevent tumor spill or port-site metastases.

Modern developments in radiological imaging must not be overlooked. The noninvasive techniques, such as MRCP (magnetic resonance cholangiopancreatography) and possible the PET (positron emission tomography) scanning, will certainly provide more accurate preoperative staging. Endoscopic and endovascular ultrasonography are other techniques which may prove to be informative. Despite these and other improvements small volume peritoneal deposits or small liver surface metastases will remain undetectable for any form of radiological imaging.

The use of minimally invasive surgical techniques to perform palliative bypass procedures has been reported for several years,[13,14] but it still resides in the domain of dedicated laparoscopic surgery. Studies on the efficacy of laparoscopic cholecystojejunostomy and gastroenterostomy have not been done, while patient benefit is speculative. In this setting, endoscopic with and without percutaneous stenting is still the mainstay of improving the quality of remaining life for these unfortunate patients.



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# Laparoscopy in the Diagnosis and Treatment of Hepatobiliary Malignancies

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## INTRODUCTION

Surgical resection offers the only hope of cure for patients with hepatobiliary malignancies. Traditionally, potential candidates for resection underwent exploratory laparotomy to determine the exact extent of their disease. A high percentage of these patients were found to be incurable due to the unsuspected spread of tumor beyond the limits of a feasible resection. The salvage rate for patients with hepatobiliary malignancies is low, and this highlights the need for accurate preoperative staging to prevent unnecessary surgical exploration.[1] Unlike most gastrointestinal malignancies, liver tumors generally do not require palliative surgical procedures. The only therapeutic option available is complete surgical resection, although there are increasing reports of experimental non-resectional therapies, such as (regional) intra-arterial chemotherapy, immunization schemes and local ablative procedures.

Radiological imaging modalities have greatly improved in their ability to detect primary or secondary hepatic tumors. Despite recent advances in the various techniques available, the limitations in resolution inherent to the different modalities continue to frustrate the surgeon dealing with hepatobiliary malignancies. Too often he is faced with a marked discrepancy between preoperative staging and the findings at laparotomy, resulting in unnecessary surgical explorations and causing considerable morbidity to the patient, both physical and psychological. Precious time is lost and the costs involved are high. Laparoscopy and the evolving techniques of minimally invasive surgery have the potential to play an

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increasingly important role in the careful selection of patients with hepatobiliary malignancies.[2]

This chapter will focus on the problems encountered in selecting the various tumors for surgical resection and will describe the limitations of available imaging modalities particularly with regard to the surgical decision making process. The advantages of modern videoendoscopy will be discussed, and current indications and surgical technique will be described in detail. Our current experience will be presented and compared to the results reported by others.

## SURGERY OF HEPATOBILIARY MALIGNANCIES

Complete surgical resection holds the only realistic hope of long-term survival for patients with hepatobiliary malignancies. However, there are distinct criteria for determining resectability, and each type of tumor has specific problems concerning (preoperative) patient selection.

### Metastatic Liver Tumors



#### Colorectal Cancer

There is ample evidence that resection of colorectal liver metastases has the potential to achieve long-term cure in selected patients.[3-5] Even repeat resection may be feasible. Although the percentage of patients actually benefiting from resection is low, the high incidence of colorectal cancer in the West makes metastases the most common reason for performing liver resection. The intensive surveillance of patients following resection of a colorectal primary, together with the decreasing morbidity of major liver surgery, has led to a liberalization of the criteria for operation. However, surgical enthusiasm should be curtailed to maintain acceptable rates of negative laparotomy and disease recurrence. Approximately 40% of patients with colorectal liver metastases selected for surgery will be found to be unresectable at laparotomy. Suitability for resection depends upon the exact number of intrahepatic lesions, the precise segmental localization(s), tumor size and relationship to vascular structures. But above all, the absence of extrahepatic tumor spread or locoregional recurrence is an essential prerequisite.

#### Neuroendocrine Liver Metastases

Neuroendocrine liver metastases are rare and seldom solitary. The most common type of tumor is carcinoid. Surgical removal may be curative in some cases, and is usually effective in relieving symptoms caused by hormone producing metastases.[6] Contrary to other types of tumors, palliative debulking or cytoreductive surgery of liver secondaries may be worthwhile.

#### Noncolorectal, Nonendocrine Liver Metastases

Noncolorectal, nonendocrine liver metastases have a dismal prognosis. Experience with hepatic resection remains anecdotal, although there are isolated reports of long-term survivors from a wide variety of primary tumors.[7] Overall 5 year survival is infrequent, suggesting a very selective approach to hepatic resection outside of investigational protocols.

## Primary Liver Malignancies

### Hepatocellular Carcinoma (HCC)

Hepatocellular carcinoma (HCC) is the most frequent primary liver malignancy, although it is relatively uncommon in Northern Europe. As elsewhere, it is typically recognized at an advanced stage and is generally associated with chronic liver disease. Extensive aggressive surgery is justified as it remains the treatment of choice. Associated cirrhosis (present in over 80% of cases) and chronic hepatitis constitute a significant obstacle to performing major hepatectomy, and only about 20% of all patients with HCC are considered resectable at initial presentation. Although recurrence will develop in approximately 70% of patients after curative resection, a 5-year survival rate of 35% can be achieved.[8,9] Early detection by screening high-risk groups and the use of parenchyma-preserving segmental resections are the main reasons for an increase in the number of patients undergoing curative surgery. Specific problems relate to the initial recognition and diagnosis of tumor within cirrhotic liver tissue and the differentiation of satellite lesions from regeneration nodules. Only small (3-4 cm) encapsulated tumors are generally suitable for resection. Actuarial survival rates approach 90% at 3 years, making the early recognition of these so-called "minimal" HCC's an important imaging challenge. However, HCC tends to be highly aggressive with local extension leading to portal vein invasion in 25-40% of cases. Also, the frequent formation of daughter or satellite nodules has obvious implications limiting surgical resectability.

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The fibrolamellar variant is typically seen in patients under 40 years of age with no underlying liver disease. This rare subtype of HCC is usually a slow-growing, solitary, well-circumscribed mass between 6 and 20 cm in size. Resection results in cure in 40% of patients.

### Intrahepatic Cholangiocellular Carcinoma (ICC)

Intrahepatic cholangiocellular carcinoma (ICC) is the second most common primary hepatic neoplasm. Despite a particularly poor prognosis, surgery again represents the only definitive treatment for this relatively infrequent tumor.[10] ICC is often multicentric, requiring major extended hepatectomy. Advanced bilobar disease and regional lymph node involvement at presentation, however, often preclude resection.

## Biliary Malignancies

### Gallbladder Cancer

Gallbladder cancer is notoriously difficult to diagnose and is frequently only discovered at laparotomy, or incidentally following laparoscopic cholecystectomy for symptomatic gallstones.[11,12] Gallbladder cancer is very aggressive and is frequently incurable due to local extension, hepatic lymph node involvement and early peritoneal spread.

### Proximal Bile Duct Carcinoma

Hilar cholangiocarcinoma (Klatskin tumor) is uncommon, but the early onset of biliary obstruction may allow a timely diagnosis and this increases the possibility of resection. Excision, with or without hepatic resection, may be achieved in

20-40% of patients. Local extension with intrahepatic bile duct involvement and portal vein invasion are the principal causes of unresectability.

## RADIOLOGICAL IMAGING MODALITIES

Preoperative radiological imaging is the primary diagnostic and staging modality for hepatobiliary tumors, and still plays an essential part in the decision-making process regarding surgical resection. However, overall false negative rates lie between 40% and 70% depending upon the technique used and the type of tumor examined.[13,14] There is a wealth of information concerning the efficiency of the many radiological imaging methods, but substantial differences in resolution, costs and availability of the various techniques have led to conflicting statistics when comparing alternative modalities. It is not the object of this chapter to provide a complete description of all the available modern imaging techniques, but rather to put the standard modalities at our disposal in perspective of the current practice of hepatobiliary surgery.



### Conventional Imaging Techniques

#### Ultrasonography (US)

By virtue of its simplicity and availability, transabdominal US still plays a crucial role in detecting and evaluating liver malignancies. Variations in contrast within abnormal liver tissues and between solid or cystic tumors are ideally suited to detection with US. It provides multiplanar imaging with excellent spatial resolution, while hepatic vascular anatomy and patency can be accurately displayed using color Doppler flow techniques.[15] US is, however, highly operator dependent and easily restricted by patient habitus or interference by bowel gas and the concealing rib cage. Although sensitivity as high as 94% has been reported for the detection of small hepatomas, results are generally much more variable with sensitivities ranging from 20-76% in the detection of colorectal liver metastases.[16,17] Nevertheless, US is suitable for the screening of liver metastases during the follow-up of colorectal cancer, and the development of HCC in patients with known cirrhosis or chronic hepatitis.

#### Computed Tomography (CT)

The principal imaging methods used in the preoperative assessment of liver tumors are based on CT scanning.[18] Various enhancement techniques exist including dynamic contrast bolus, delayed scanning and arterial portography (CTAP). Conventional CT will detect hepatic involvement in 90% of cases, but only approximately 70% of actual individual lesions are reliably documented. CT is unable to characterize smaller lesions due to the partial volume effect, while nodules under 1 cm in size remain undetected. Another problem is the limited accuracy in demonstrating small peripheral surface lesions, especially in the left liver lobe where they may be obscured by artifacts caused by cardiac motion or contrast in the stomach. Rapid spiral CT scanning optimizes contrast dynamics and will increase sensitivity to well over the present 85%. CTAP appears to be even more sensitive, but it is an invasive and cumbersome technique. Furthermore, laminar flow perfusion defects cause pseudo-lesions, resulting in false positive rates as high as 30-40%.[16,19,20] CT with arterial iodinated oil emulsions may offer advantages in detecting HCC in cirrhotic livers.

Because of its ability to rule out residual primary disease, local recurrence or secondary tumor deposits at remote sites (such as lung and mediastinum) while simultaneously evaluating intrahepatic tumor, CT remains the primary imaging modality for the staging of patients with hepatobiliary malignancies.

**Magnetic Resonance Imaging (MRI)**

Magnetic resonance imaging (MRI) is increasingly available and is particularly useful for characterizing certain benign tumors (e.g., hemangiomas) and for detecting and staging HCC.[13,14,21] Faster, dynamic MRI with gadolinium contrast and enhancement with super paramagnetic iron oxide (SPIO) are promising new techniques, but detection accuracy rates have yet to be defined.

## Problems in Liver Imaging

**Lesion Threshold**

Inherent to the resolution of the imaging technique used, there is a threshold size for the ability to both detect and discriminate the nature of liver mass lesions. Both US and CT are unable to delineate tumors under 1 cm. Although MRI can detect smaller lesions, these subcentimeter "nuisance nodules"[21] are frequently too small to exhibit distinctive morphologic features or allow guided biopsy.

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**The Hepatic Substrate**

Coexistent abnormalities in the substrate of the liver parenchyma complicate the radiologic assessment of suspect liver tumors. The high incidence of silent, incidental benign tumors in the adult population is the most frequent cause of diagnostic dilemmas. Small, often multiple, cavernous hemangiomas are especially difficult to differentiate but also cysts, focal nodular hyperplasia and liver adenomas may be a cause for concern. Their significance lies in confusion with metastatic disease, particularly when the lesions are under 15 mm in size.

Parenchymal disease, especially cirrhosis, reduces the sensitivity and accuracy of radiologic imaging. Initial recognition of tumor and differentiation from regeneration nodules are seriously affected. Fatty infiltration of the liver is another common occurrence and lowers the attenuation of hepatic parenchyma. Although usually diffuse, focal areas may be spared of fat and retain their normal density, mimicking a tumor. Alternatively, the fatty deposit itself may appear as a focal lesion indistinguishable from metastatic disease.

**Requirements for Surgical Decision Making[1]**

Deficiencies in current radiologic imaging mean that only 30-50% of candidates for curative surgery will be found to be resectable at laparotomy. The main reason for unresectability is unsuspected extrahepatic disease (i.e., small volume peritoneal seeding or hepatic lymph node involvement) found in two thirds of cases. In the remaining one third, undetected local intrahepatic conditions (i.e., extra deposits, proximity to major vascular structures or degree of cirrhosis) are the reason for unfruitful laparotomy.

Existing standard imaging techniques (US, CT, MR) have overall sensitivities and specificities of between 60-85%. A comprehensive preoperative assessment will therefore require a combination of different imaging modalities, with considerable time and costs involved.

## INTRAOPERATIVE ULTRASONOGRAPHY (IOUS)

Once the diagnosis of focal intrahepatic tumor has been established, suitability for surgical resection depends on the exact number of lesions, their precise segmental localization and their relationship to the major portal and hepatic venous structures. The inadequacy of preoperative investigations when considering curative liver resection has led to the wide spread employment of intraoperative imaging using US.[22] There are two important roles for IOUS.

### Detection and Differentiation of Occult Tumors

Direct contact with the liver surface allows the use of higher frequency US transducers, providing superb high resolution images, even of subcentimeter nodules.[23-25] Lesions as small as 3-5 mm in size can be detected and characterized. Real-time images and multiplanar views provide a more accurate assessment of the size and shape of the target lesion and its relationship to the surrounding structures. Recent addition of (color) Doppler imaging allows the demonstration of vascular flow patterns and also "motion marking" during needle biopsy.



### Mapping Intrahepatic Vascular Anatomy to Guide Resection

Systematic US scanning provides accurate delineation of the segmental anatomy of the liver parenchyma, which is necessary to determine the exact tumor location and proximity to major vessels. Knowledge of vascular anatomy is essential when performing complicated tissue-sparing or subsegmental resections.[26,27]

There are many reports claiming superiority of IOUS when compared to various preoperative imaging techniques. However, estimates of its utility or value vary greatly and depend on the quality of preoperative assessment. Nevertheless, IOUS has become an indispensable tool for deciding optimal strategy during modern liver surgery. IOUS has repeatedly been shown to have a sensitivity as high as 94-98%. Additional information leading to a change in operative procedure is obtained in 22-49%.[28-30]

**Diagnostic Laparoscopy (LS)**

The value of laparoscopy in diagnosing intra-abdominal malignancies has been understood since its introduction at the beginning of this century. Sixty years ago, Ruddock[31] reported his experience with "peritoneoscopy" in 500 patients, achieving a diagnostic accuracy of 91.7%. He also beautifully described a technique for using laparoscopy to stage and determine operability in gastric cancer, concluding that "the physician must share the responsibility for a fruitless diagnostic laparotomy". Although some hepatologists and gastroenterologists continued to perform laparoscopy for diagnosing liver disease, its use decreased with the advent of modern radiological imaging, and it was not until the late 1970s that reports reappeared on the value of laparoscopy in the preoperative assessment of intra-abdominal malignancies.[32-34] Since the era of minimally invasive surgery, there have been an increasing number of articles on the rediscovered potential of diagnostic laparoscopy for cancer.[35-38]

### Advantages of Laparoscopy

The specific advantages of laparoscopy are a result of the detailed, magnified visual inspection of free (intra-) peritoneal surfaces:

1) It has the unique ability to detect small-volume peritoneal implants and small superficial liver deposits, which are missed by all types of radiological imaging.
2) Accurate assessment of the degree of liver cirrhosis is only possible by direct visual examination, allowing an estimation of the residual functional capacity when contemplating resection.
3) Visual guidance increases the yield and accuracy of tissue biopsies, especially if there is associated liver disease.[39-40]

### Limitations of Laparoscopy

The limitations of laparoscopy are due to the inherent loss of direct tactile sensation; only indirect "palpation" is possible. Less obvious, deep-seated parenchymal lesions, such as in the liver, will escape attention. Less accessible retroperitoneal organs and lymph node regions cannot be visually explored.



## LAPAROSCOPIC ULTRASONOGRAPHY (LUS)

### History of LUS

Combining the advantages of diagnostic laparoscopy with those offered by intraoperative ultrasonography seems a logical development, particularly for the assessment of liver tumors.[2] The first report of a technique combining LS with US dates back to 1963, when Yamakawa[41] described A-mode US scanning of a gallbladder cancer under LS guidance. But it was not until 1981[2] that Ohta[42] and Oda[43] reported their pilot studies using laparoscopic real-time B-mode scanning techniques. In 1983 Frank et al[44] constructed a new "sonographic probe" with a 7 MHz linear transducer integrated in a laparoscope. A year later, Okita[45] reported their experience with an "ultrasonic laparoscope" in 20 patients. A 3.5 and 5 MHz linear array was incorporated in a 13 mm laparoscope with a flexible tip. They found it to be especially useful for detecting small HCC deep in the right liver lobe and to diagnose early stage pancreatic cancer. In 1992, Miles et al[46] inventively described the use of a rigid, 5 MHz endorectal US probe, passed through a (20 mm) large-bore trocar. They obtained unexpected findings in 6 out of 7 patients with hepatic tumors. At about the same time, Cuesta et al[47] reported promising results, using a similar transducer, in 25 patients with hepatobiliary and pancreatic malignancies. Several different LUS probes have since been developed, from rigid to semi-flexible (tip) to fully-flexible designs, with 5 and/or 7.5 MHz transducers, and from 9-13 mm in diameter. These technical refinements have now yielded several commercially available LUS systems.

### Patient Selection-Indications and Contraindications

When selecting patients for LUS it is important to consider the overall plan of management. There must be a clear understanding of the potential benefits offered by the procedure. The patient who is unable to tolerate a diagnostic laparoscopic procedure due to his/her general condition is unlikely to be a candidate for more extensive surgery.

**Contraindications:**

a) The principal contraindication to performing LUS is when the information that might be gained will not be meaningful in making therapeutic decisions.

b) Another reason is when open abdominal exploration is inevitable regardless of the possible findings of LUS.

c) Finally, there will be some cases where the liver and biliary tract are inaccessible due to adhesions or altered anatomy following previous surgery.



**Indications**

There are three goals to performing diagnostic laparoscopy with ultrasonography in patients with hepatobiliary tumors: to establish the correct diagnosis, to provide an accurate staging of the disease, and to determine the appropriate treatment (i.e., surgical resectability). These goals are usually complementary, but each may be individually applied to three different categories of patients.

***Diagnostic***

The diagnosis of intrahepatic lesions incidentally discovered during abdominal imaging (e.g., US for gallstones or pregnancy) which are suspicious but cannot be accurately differentiated externally.

***Staging***

The differential diagnosis of intrahepatic lesions detected during the workup or staging of malignancies;

i) non-gastrointestinal tumors (e.g., breast cancer), where the correct diagnosis is essential to decide appropriate therapy.
ii) gastrointestinal malignancies (e.g., esophageal or lower rectal cancer), where the correct diagnosis will influence the extent of surgery required or where other palliative procedures are available (e.g., endoscopic stenting or cryosurgery).
iii) uncertain lesions detected during follow-up for colon cancer, or raised CEA levels without obvious metastatic or recurrent tumor.

***Treatment***

To determine resectability and surgical strategy in all patients planned to undergo curative resection of a hepatobiliary malignancy.

i) liver metastases from colorectal or other primary tumors, (synchronous or metachronous). The exact number, size and segmental localization will determine suitability for resection. Extrahepatic disease, particularly peritoneal implants and hepatic nodal involvement, can be excluded.

ii) primary liver malignancies. Exact size and location, the presence of satellite lesions, extension into surrounding structures (e.g., diaphragm, vena cava, duodenum) or intrahepatic vascular invasion (esp. portal vein) and the state of the hepatic parenchyma (cirrhosis) may all be assessed. Evaluation of candidates for liver transplant is another indication.

iii) gallbladder and proximal bile duct cancer. To determine the extent of local invasion, nodal or hepatic involvement, and exclude peritoneal spread.

## Surgical Technique

There are several excellent monographs on various techniques of performing LS and LUS.[48-52] The following is a detailed description of the procedure we use to stage potentially resectable hepatobiliary tumors.

### General Aspects

Diagnostic laparoscopy with laparoscopic ultrasonography is usually planned as a separate procedure as this allows the most efficient planning of operating theater time, and may have psychological advantages when discussing therapeutic options with the patient. Alternatively, it may be done directly before laparotomy. The operation is preferably performed under general anesthesia as this permits the greatest freedom for a complete and precise examination. The entire procedure takes approximately 40 minutes. Patients may be discharged after several hours making it possible to use "day-care" facilities if available. Performing the LUS examination in collaboration with a radiologist is certainly advisable during the learning phase. It also provides an independent observer for interpreting the US images, one who is less likely to be biased by a motivation for resection.

### Positioning of the Patient and Trocars

The patient is placed in a supine position and supported to allow tilting of the operating table as necessary. The surgeon stands on the left side with the radiologist opposite. Video monitor and ultrasound screen are on the upper right side (Fig. 8.1). Many patients will have a history of previous abdominal surgery, certainly those coming for the evaluation of colorectal metastases. The placement of trocars obviously depends on existing abdominal scars, but also on the type of surgery the patient has undergone. Although creative improvisation is necessary, there are certain guidelines for safe and effective positioning (Fig. 8.2). Abdominal insufflation may often be achieved using blind puncture with a Veress needle in the right upper abdomen (after left colonic surgery) or left subcostal region (after right-sided colon resections), with the patient placed in anti-Trendelenburg position. It is also possible to visualize intra-abdominal adhesions with transcutaneous ultrasound by observing the so-called "visceral slide". The safest technique, however, is through open placement of a Hasson trocar. Once the laparoscope has been introduced, secondary trocars are placed under visual control, which may require taking down adhesions. It is preferable to use disposable 10/11 mm ports to avoid damaging the LUS transducer surface with metallic valves. In the absence

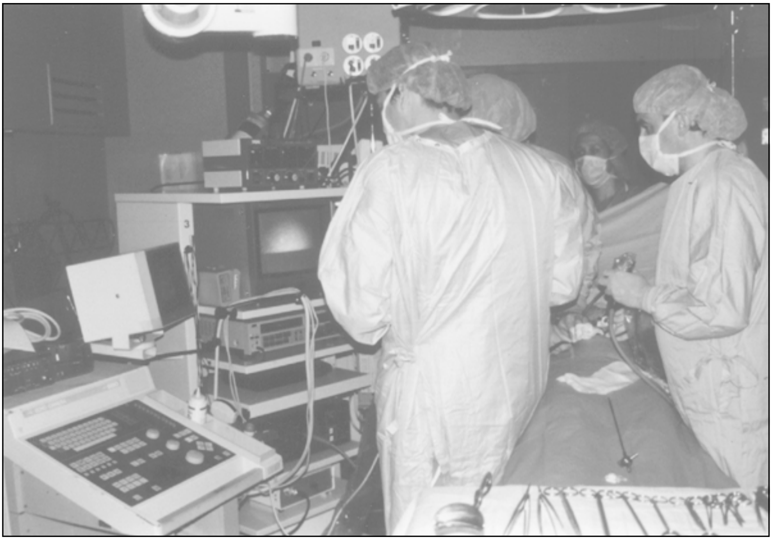

Fig. 8.1. Operating room view during laparoscopic staging. (Ultrasound on the lower left, next to the laparoscopy monitor).

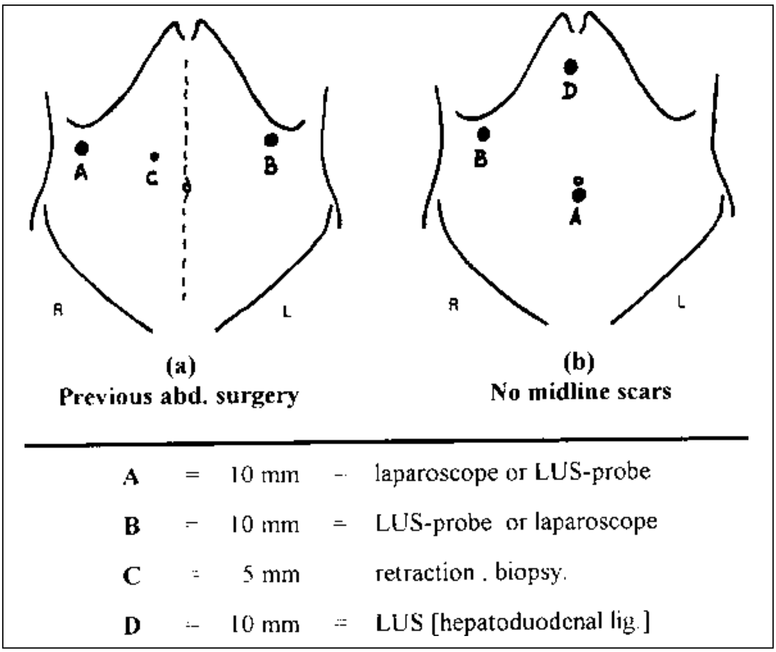


Fig. 8.2. Positions for cannula placement during laparoscopy with laparoscopic ultrasonography for hepatobiliary tumors.

of midline scars, the umbilical position is usually favored for establishing pneumoperitoneum and laparoscope placement. LUS examination of the liver requires access from the right subcostal region when using a (semi-)rigid probe, introduced laterally, between the midclavicular and anterior axillary lines. A second port is needed for full examination, preferably in the left subcostal or infra-umbilical areas. For LUS of the hepatoduodenal ligament, the transducer needs to be placed longitudinally and this requires access from the subxiphoid region. Usually two ports are sufficient although a third 5 mm trocar is useful for manipulation or retraction and for taking biopsies.

**Diagnostic Laparoscopy**

A systematic, thorough and unhurried visual exploration of the abdominal cavity is essential, and all peritoneal surfaces must be carefully examined to detect possible deposits. The undersurface of the diaphragm, the hepatic round ligament and the omentum require particular interest. Using a palpator and tilting the patient, the entire surface and all edges of both liver lobes must be closely scrutinized for evidence of metastatic disease. Lymph nodes in the hepatoduodenal ligament are examined for visible enlargement. Finally, the quality of the liver parenchyma with regard to the degree of cirrhosis or steatosis can be assessed.

**Laparoscopic Ultrasonography (LUS)**

We favor a slender (9 mm diameter, length 40 cm) rigid probe with a 7.5 MHz (38 mm) linear array transducer for ultrasound examination of the liver and bile ducts (Aloka UST- 5521-7.5, Tokyo, Japan) (Fig. 8.3). Fully-flexible endoscopes are more difficult to maneuver systematically over the liver surface. Although a



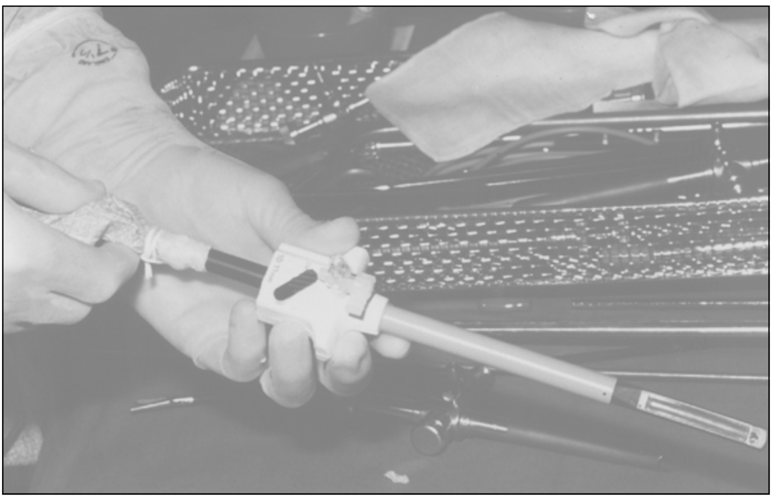

Fig. 8.3. Laparoscopic ultrasound probe: rigid, 9 mm, linear array transducer. Sterile-packed probe passes through a 10 mm trocar.

flexible tip may be useful, we do not find this to be essential. Curved array transducers provide distorted images of target lesions and are generally have a shorter field of view. The 7.5 MHz transducer provides superb resolution and, in our experience, has sufficient penetration depth of the liver parenchyma to allow complete imaging. In large right lobes, it may be helpful to place the probe on the undersurface of the liver. Ultrasound scanning is mainly done by direct contact with the liver surface. To achieve better contact between the rigid probe and the convex liver the abdomen is temporarily desufflated when necessary. Approximately 500 ml of normal saline solution is routinely installed in the upper abdomen to provide an acoustic window along the edges of the liver lobes and to improve contact in the case of (macronodular) cirrhosis. This also allows the standoff scanning technique necessary for examination of the structures of the hepatoduodenal ligament.

***LUS of the liver***

LUS of the liver is performed systematically in the same fashion as open IOUS and experience with the latter is essential. The smaller size of the LUS transducer compared to those used in IOUS requires consideration. The LUS probe is also more difficult to handle due to its limited maneuverability. However, the main difference is that LUS is done in a more longitudinal direction as opposed to the transverse orientation in IOUS. The laparoscope and LUS probe must be interchanged between the two ports to provide different views of the liver and to accommodate the varying placement of the probe on the liver surface. Creating a window in the falciform ligament allows the probe to be almost in a transverse plane facilitating orientation of the liver segments (Fig. 8.4). This may also be useful when there are dense midline adhesions preventing access to the left or right lobes. It is important to use gradual movements and gentle angulation or rotation of the LUS probe to provide clear images. Maintaining visual guidance of the probe's position on the liver with the laparoscope aids in orientation.



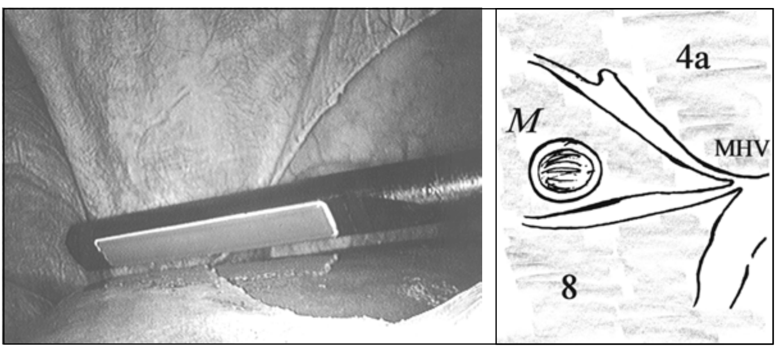


Fig. 8.4. Window in the falciform ligament allows transverse placement of the US probe on the liver surface (shown from left to right).

The first step in examination of the liver is to become acquainted with its segmental anatomy (according to Couinaud). The primary point of orientation is the convergence of the hepatic veins into the inferior vena cava (Fig. 8.5a). By following each of the individual right, middle and left veins peripherally the different segments are identified. Next, the portal vein confluence is found (Fig. 8.5b) by placing the probe on the anterior surface of the quadrate lobe (segment IV), and its right and left branches are followed. The caudate lobe (segment I) is seen between the portal vein and vena cava.

The second step in examination is the systematic, patient search for intrahepatic lesions. The high resolution and ability to evaluate areas of interest in real time are the strengths of LUS. Not only is the interpretation of the acoustic shadowing more detailed, it is also possible to determine size and shape more accurately. The exact localization and relation to vascular structures is clearly defined (Fig. 8.6).

***LUS of the gallbladder and proximal bile ducts***

LUS of the gallbladder and proximal bile ducts is commenced by placing the probe on the anterior surface of segments IV and V, using the liver as an acoustic window. Imaging is performed in a variety of planes, with subtle rotary movements of the probe. The use of Doppler flow sampling helps to identify the different vascular structures. Scanning the gallbladder towards its neck will identify the



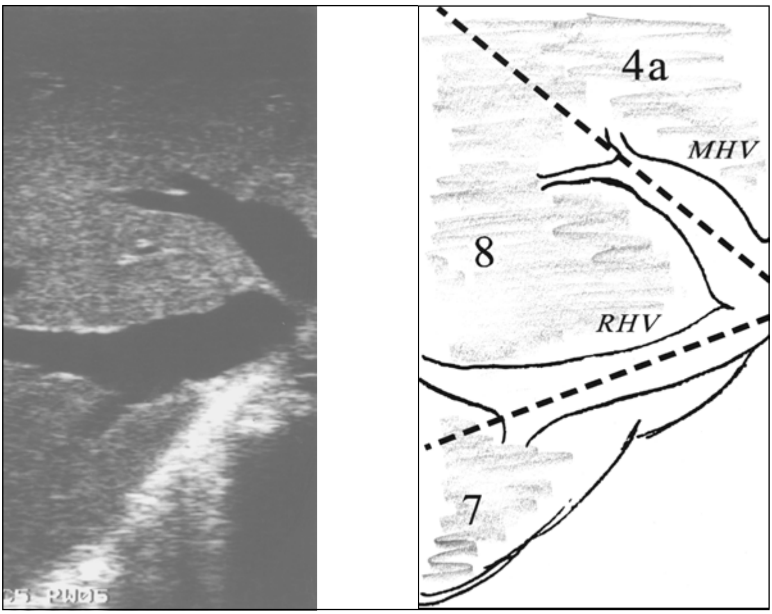


Fig. 8.5a. Hepatic vein confluence with segments 7, 8 and 4a. (MHV = middle hepatic vein; RHV = right hepatic vein.

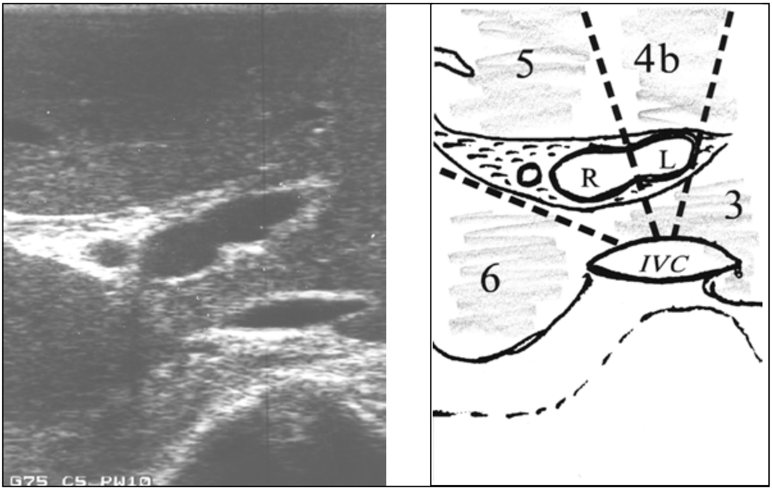


Fig. 8.5b. Portal vein bifurcation with segments 6, 5, 4b and 3. (RPV = right portal vein; LPV = left portal vein; IVC = inferior vena cava)



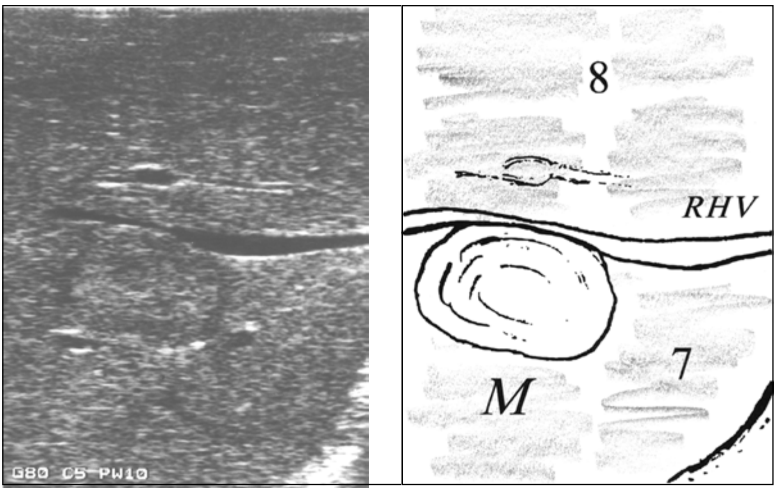


Fig. 8.6. Colorectal metastasis (M), 3 cm diameter, located in segment 7 with compression of the right hepatic vein (RHV).

cystic duct. Intrahepatic bile ducts are recognized by their hyperechoic walls (resembling tram-lines) and lie along corresponding hepatic artery and portal vein branches. These can be traced to reach the confluence of the left and right duct systems in the porta hepatis. The readily identified portal vein bifurcation is a convenient reference point. The portal vein exhibits a laminar flow which is low pressure and high velocity, in contrast to the pulsatile hepatic artery flow. The supraduodenal portion of the extrahepatic biliary tree is best examined with the probe longitudinal, through an umbilical port, and perpendicular to the hepatoduodenal ligament, through a subxiphoid port. Transverse imaging provides the characteristic "Mickey Mouse" appearance of the common duct, hepatic artery and portal vein (Fig. 8.7a). The intrapancreatic portion of the common bile duct is identified by placing the probe over the head of the pancreas and first part of the duodenum. The subhepatic space should be filled with saline in order to create a better acoustic coupling.

Lymph nodes in the hepatoduodenal ligament are imaged directly, by the standoff technique, or through the left liver lobe. Their size, shape and echogenic structure are noted (Fig. 8.7b), which will suggest possible tumor infiltration.



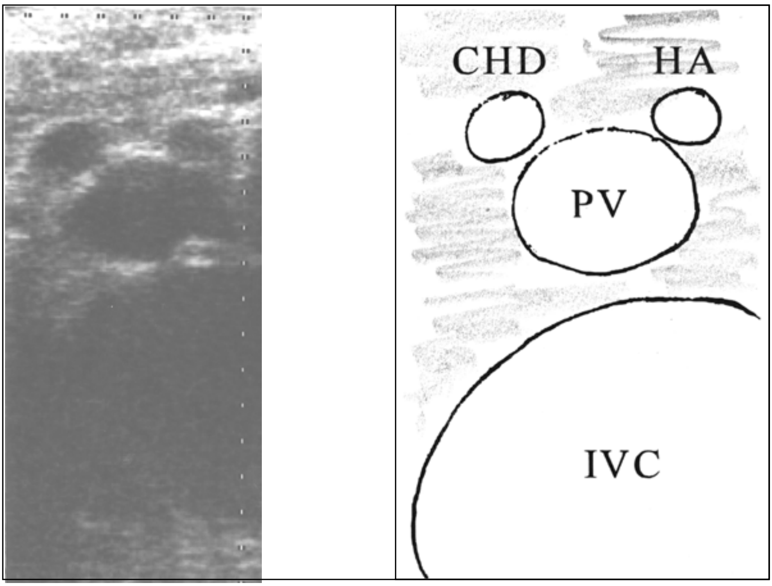


Fig. 8.7a. Typical "Mickey Mouse" formation of the portal vein (PV), common hepatic duct (CHD) and hepatic artery (HA) seen on transverse imaging of the hepatoduodenal ligament. (IVC = inferior vena cava)

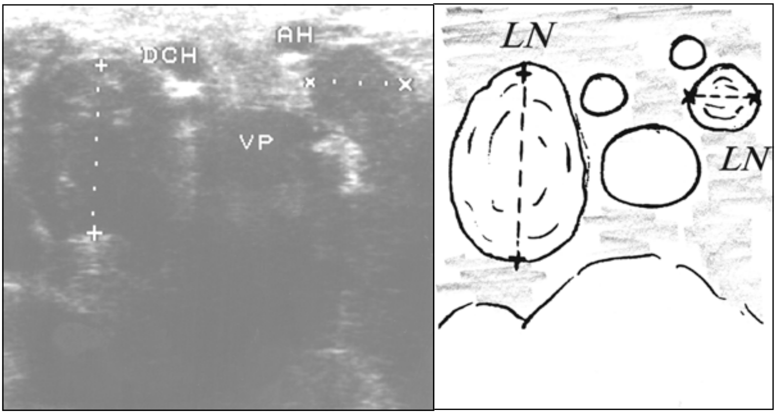


Fig. 8.7b. Lymph nodes (LN), 2 cm and 1.3 cm in diameter, in the hepatoduodenal ligament surrounding the portal vein (VP), common hepatic duct (DCH) and hepatic artery (AH).

8

**Diagnosing Lesions/Biopsy Techniques:**

*Visual aspect*

All peritoneal deposits are best considered to be suspect and require biopsy to exclude malignancy (Fig. 8.8). Occasionally, benign mesothelial proliferations may appear as multiple peritoneal metastases. The degree of liver cirrhosis is determined. The visual aspect of lesions seen on the liver surface is often diagnostic. Cysts are greenish-blue in appearance when visible at the surface. Small metastases are usually easily identified and larger ones have a typical umbilicated or crater appearance. One pitfall is the "von Meyenburg complex", a small benign tumor which may appear as a nodule on the surface. It is indistinguishable from a metastasis visually, and often misleadingly diagnosed as malignant on frozen section. The recognition of satellite lesions is difficult when there are regeneration nodules in a cirrhotic liver. Visually guided (fine needle or core) biopsy is often unavoidable.

*Ultrasonographic Aspect*

While most intrahepatic lesions can be characterized by their specific sonographic appearance, very small (< 5 mm) solid benign tumors cannot be differentiated from metastases. Hepatic cysts are a common finding (10% of the normal population) and can usually be defined preoperatively. However, smaller cysts (less than 1 cm) escape detection or cannot be differentiated externally. The typical US features are a smooth, often spherical, thin-walled lesion, sonolucent with posterior acoustic enhancement (Fig. 8.9a). Hemangiomas are also frequent and appear as dense echoic areas with minimal shadowing, and do not produce distortion of the surrounding tissue structures (Fig. 8.9b). Compressibility is a characteristic feature. Focal nodular hyperplasia (FNH) is often confused with metastatic disease although there may be a typical bright hyperechoic center in a hypoechoic, well-defined lesion. Adenomas are usually diagnosed preoperatively

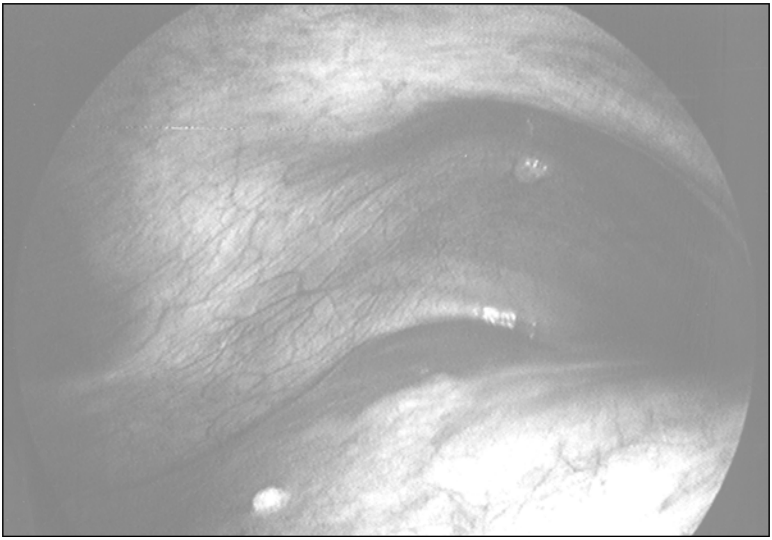

Fig. 8.8. Small peritoneal deposit visible on the undersurface of the right diaphragm and two superficial metastases on the surface of the right liver lobe.

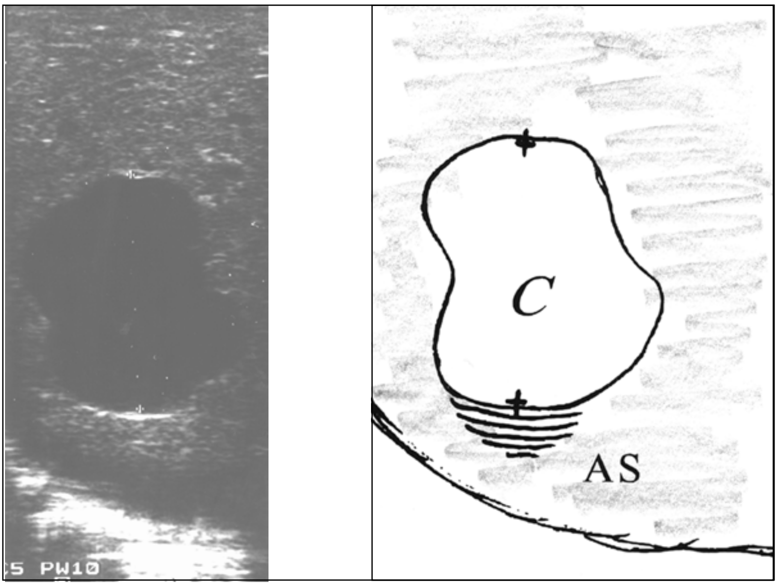


Fig. 8.9a. Typical hepatic cyst (C) = echo-lucent with posterior shadowing (AS).

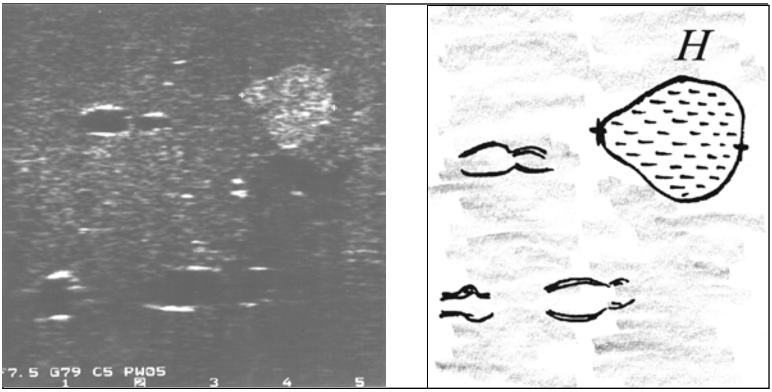


Fig. 8.9b. Typical hemangioma (H) = hyperechoic with no mass-effect on surrounding tissue and no acoustic shadow.



by their well-defined, hyperechoic, homogenous appearance. In cirrhosis regenerating nodules are difficult to differentiate from hepatoma. US-targeted biopsy is indispensable in obtaining a correct diagnosis. Fatty infiltration usually results in a uniformly increased acoustic impedance of the hepatic parenchyma. Occasionally, there may be discrete focal areas of steatosis, typically surrounding vascular structures and against the gallbladder bed. Alternatively, within the fatty infiltration there can be focal areas of "non-steatosis". Hepatocellular carcinoma is typically a hyperechoic, irregular mass surrounded by an echolucent rim. Within the cirrhotic liver it may appear to be isoechoic and its presence is only apparent by the distortion and displacement of local structures. Tumor thrombus in a portal vein branch may be the only visible evidence. Liver metastases have extremely variable appearances on ultrasound, but they usually show similar features within the same liver. Colorectal metastases are classically described as having a "bull's-eye" appearance with a fairly well-defined border, a hypoechoic rim around a hyperechoic center (Fig. 8.10a). Larger lesions can have a calcified center with accompanying posterior shadowing. Smaller lesions, less than 1 cm, are often relatively hypoechoic. Some tumor metastases undergo cystic degeneration, others are hyperechoic (Fig. 8.10b).

***Biopsy***

Biopsy of suspicious lesions can be performed under US guidance[53] (Fig. 8.11), but should be reserved for those cases when the pathological diagnosis is necessary to decide appropriate therapy. It is important to realize that indiscriminate biopsy may result in intra-abdominal spill and needle-tract or port-site metastases.[54,55] Biopsy must be avoided when there is a possibility of performing curative surgery. Small, deep-seated lesions are very difficult to biopsy; LUS puncture-direction devices still need to be designed. (The determination of CEA levels in bile, obtained by gallbladder aspiration, may be an alternative method of diagnosing indeterminate lesions in patients with a history of colorectal cancer.[56]

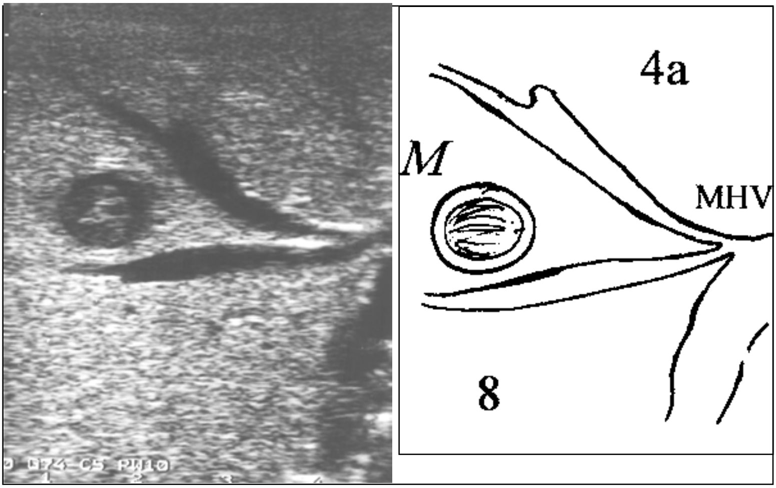


Fig. 8.10a. Metastasis (M), 1 cm diameter, with "bull's eye" appearance, lying in segment 8, between branches of the middle hepatic vein (MHV).



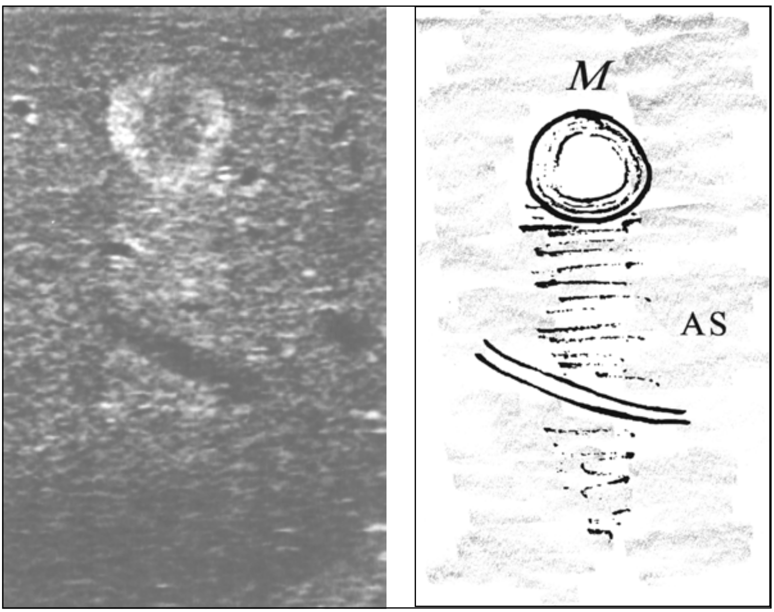


Fig. 8.10b. Hyperechoic metastasis (M), 16 mm diameter, causing acoustic shadowing (AS).

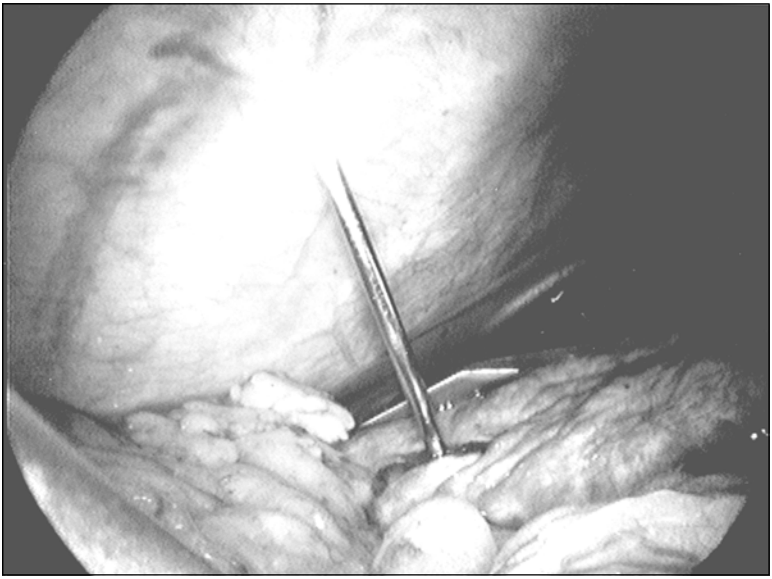



Fig. 8.11. Percutaneous core biopsy of a suspicious nodule within a cirrhotic liver, performed under LUS-guidance.

## Determining Resectability

### Liver Tumors

Both laparoscopy and LUS can provide essential information regarding the possibility of performing a curative resection. The exclusion of extrahepatic disease (particularly peritoneal deposits), accurate delineation of the number and (segmental) localization of hepatic tumor and the quality of the (residual) liver parenchyma contribute to the decision making process.

### Cholangiocarcinoma

The level of biliary obstruction may be assessed and the involvement of primary and secondary biliary confluences determined. Invasion of the liver (including the caudate lobe) can be delineated, although this may be difficult if the lesion is diffuse or sclerotic and isoechoic with the surrounding liver tissue. Vascular involvement and displacement is frequent, as is nodal spread. The detection of peritoneal and hepatic metastases is especially important.

## Results of Laparoscopic Staging of Liver Tumors

### Literature

Most authors report promising results, although definite conclusions about the value of laparoscopic staging cannot be drawn from these preliminary data. In 1990 we started to perform diagnostic laparoscopy with laparoscopic ultrasonography in patients with intra-abdominal malignancies, and we reported our initial experience in 1993.[47] Using a 16 mm 5 MHz probe, additional information leading to a change in surgical strategy was obtained in 20 of 25 patients with hepatobiliary and pancreatic cancer. Babineau et al[57] performed laparoscopic staging prior to planned laparotomy in 29 patients with hepatic malignancies. Fourteen of these (48%) were determined to be unresectable by laparoscopy alone. In 4 of 29 (14%) patients laparoscopy was falsely negative and tumors were found to be unresectable at laparotomy. Laparoscopy proved to be particularly useful in identifying unexpected cirrhosis and peritoneal seeding. John et al[51] gave a detailed description of their technique of staging laparoscopy with laparoscopic ultrasonography and reported its value in the preoperative assessment of 52 patients with liver tumors. They were able to achieve a significantly higher resectability rate after laparoscopic staging (93%) compared with those in whom operative assessment was undertaken without laparoscopy (58%). LUS provided information in addition to that derived from laparoscopy alone in 18 out of 43 patients (42%). There was only one false positive case. Goletti et al[58] subjected 36 patients with various gastrointestinal cancers to LUS, screening them for metastases. LUS was 100% accurate in detecting liver metastases compared to 60% sensitivity of preoperative diagnostic means and laparoscopy. LUS sensitivity in detecting nodal metastases was lower (96%) with only 67% specificity. The treatment plan was altered in 8 of 35 patients (23%) as a result of the LUS findings. Hünerbein et al[59] used laparoscopy to stage 40 patients with upper gastrointestinal tumors. In 16 (40%) patients additional information by LS alone changed the preoperative staging. In 7/20 cases LUS provided extra findings supplementary to LS alone, meaning that LS with LUS changed the stage in 23/40 patients (57%). Surgery was abandoned in 16, while down-staging allowed subsequent resection in another 7 patients. Feld et al[60] compared the accuracy of LUS to CTAP in 13 patients. Surgical management was directly influenced in 4 cases (31%) and additional information was obtained in another 3 patients. Recently, Barbot et al[61] have reported their results with laparoscopic intraoperative ultrasound for staging liver tumors. In 24 patients, nonresectability was predicted in 6 of 8 unresectable patients. Laparoscopy alone had a specificity of 40%, but with the addition of LUS this was increased to 75%. They concluded, as has been suggested earlier,[2] that laparoscopic ultrasonographic evaluation should be a prerequisite to definitive laparotomy with the objective of avoiding unnecessary surgery.



**Current Personal Experience**

Laparoscopy with laparoscopic ultrasonography has been performed in a total of 88 patients. Their ages varied from 29-82 years (average age 62). All had a suspected or confirmed malignant hepatobiliary tumor based on preoperative imaging using transabdominal US and conventional CT, while a few also had MRI. All 88 patients were planned to undergo laparotomy to establish an exact diagnosis or staging (group 1), or to undergo a supposedly curative resection (group 2). Fifty-three percent of patients had previously undergone abdominal surgery. There were no complications attributable to the laparoscopic procedure.

**GROUP 1 (20 PATIENTS): (TABLE 8.1)**

**Diagnosis**

In 6 patients liver tumors were incidentally discovered during abdominal US for evaluating abdominal pain (2 patients), gallstone disease (3 patients) and during pregnancy (1 patient). A definitive diagnosis was obtained in all 6 patients; 4 had benign lesions (hemangioma, FNH) of which 2 were resected laparoscopically, and in 2 patients the tumors were found to be malignant (carcinoid, undifferentiated carcinoma) and not suitable for resection.

**Staging**

In 14 patients with known malignancies, liver tumors were detected during staging of the primary disease. Five patients had breast cancer and even needle biopsy had failed to provide a diagnosis; 2 were shown to have metastases, in 3 they were benign lesions. Four patients had a GI-tract primary; 3 lower rectal and 1 esophageal cancer; only 1 had metastases. The remaining 5 patients were in follow-up after colorectal cancer; 3 were proven to have metastases. In all 14 cases a diagnosis was confirmed and this altered the disease stage in 9 patients (64%), leading to alteration in the choice of therapy.

**GROUP 2: TREATMENT (68 PATIENTS) (TABLE 8.2)**

In an ongoing prospective study we evaluated the impact of LS with LUS on the selection of patients with hepatobiliary malignancies for surgical resection. All patients were deemed to have potentially resectable disease based on the standard preoperative radiologic imaging. The efficacy of LS-LUS was determined, paying particular attention to the additional information obtained and how this affected the planned surgical strategy.

**Hepatic Metastases (46 patients)**

This constitutes the largest and most important group of patients considered for liver resection. The majority had colorectal cancer metastases (41 patients), while 5 had had different primary tumors; 2 were sarcomas, 1 had a melanoma, 1 a Grawitz tumor and 1 carcinoid syndrome. [In our hospital there is a protocol

*Table 8.1. Final diagnosis of the hepatic lesions in Group 1 (20 patients)*

| GROUP 1 [20 patients] | | Hepatic lesion diagnosis after LS + LUS biopsy | | | |
|---|---|---|---|---|---|
| a) Diagnosis (no) | | – Benign | (4) | — hemangioma | 2 |
| — abdominal pain | 2 | | | — FNH | 1 |
| — gallstone disease | 3 | | | — adenoma | 1 |
| — pregnancy | 1 | – Malignant | (2) | — carcinoid | 1 |
| | | | | — undiff.carcinoma | 1 |
| b) Staging (no) | | – Benign | (8) | — hemangioma | 4 |
| — breast cancer | 5 | | | — hepatic cyst | 3 |
| — GI-tract primary | 4 | | | — neurofibroma | 1 |
| — colorectal cancer | 5 | – Metastases | (6) | — breast cancer | 2 |
| (follow-up) | | | | — esophageal ca. | 1 |
| | | | | — colorectal cancer | 3 |

***Table 8.2. Decision made after LS-LUS and final treatment received in Group 2 (68 patients) with potentially resectable hepatobiliary tumors***

| **GROUP 2 [68 patients]** | | **Decision after LS-LUS (no)** | | **Treatment received (no)** | |
|---|---|---|---|---|---|
| a) Hepatic metastases : (46) | | — failed LS / LUS | 5 | — Not resected | 22 |
| — colorectal cancer | 41 | — Unresectable | 17 | (intra-art.catheter | 12) |
| — other primary tumor ** | 5 | — Resectable * | 24 | —Resected | 24 |
| b) Primary liver cancer | 14 | — Unresectable | 11 | —Not resected | 11 |
| | | — Resectable | 3 | —Resected | 3 |
| c) Gallbladder cancer | 5 | — Unresectable | 5 | —endoscopic stent | 5 |
| Prox.bile duct cancer | 3 | — Resectable | 3 | —Resected | 3 |

* 3 false negative (i.e., Not resected)
** includes 3 failed LS/LUS.

Accuracy of LS with LUS in predicting irresectability of primary and secondary liver tumors [55 patients].

| | Laparotomy | | | |
|---|---|---|---|---|
| LS + LUS | Not Resected | | Resected | Total |
| Unresectable | 28 | 0 | 28 | |
| Resectable | 3 | 24 | 27 | |
| total | 31 | 24 | 55 | |

| | | | | |
|---|---|---|---|---|
| Sensitivity | = | 28 / 31 | = | 90% |
| Specificity | = | 24 / 24 | = | 100% |
| Pos.predic.value | = | 28 / 28 | = | 100% |
| Neg.predic.value | = | 24 / 27 | = | 89% |
| Accuracy | = | 52 / 55 | = | 95% |

| LS and LUS | Most important Add.Information | (no.pts) |
|---|---|---|
| Laparoscopy | - peritoneal / extrahepatic deposits | 11 |
| (visible disease) | - small superficial liver nodules | 7 |
| | - degree of cirrhosis / rest liver | 4 |
| Laparosc.Ultrasound | - number of metastases / satellites | 14 |
| (supplemental info.) | - nature of lesions / extra benign | 11 |
| | - anatomical localization | 5 |

| Group I | LS-LUS diagnosis (+ biopsy) | | | |
|---|---|---|---|---|
| a) Diagnosis | - abdominal pain | 2 | Benign | 4 |
| | - gallstones | 3 | Malignant | 2 |
| | - pregnancy | 1 | | |
| b) Staging | - breast cancer | 5 | Benign | 8 |
| | - GI tract primary | 4 | Metastases | 6 |
| | - follow-up colon ca. | 5 | | |

| Group II | Treatment | | | |
|---|---|---|---|---|
| a) Hepatic metastases | - colorectal | 41 | resected | 24 |
| | - other | 5 | irresectable | 22 |
| b) Primary liver cancer | | 14 | resected | 3 |
| | | | irresectable | 11 |
| c) Biliary cancer | - gallbladder | 5 | resected | 3 |
| | - prox.bile duct | 3 | irresectable | 5 |

8

for regional intra-arterial chemotherapy. All patients with unresectable (intrahepatic) colorectal metastases, without extrahepatic disease, were offered this treatment. The subsequent laparotomy for placement of the catheter allowed confirmation of nonresectability of the tumors, as determined by LS-LUS, in 12 patients.]

In 5 patients LS failed or LUS was incomplete due to dense adhesions from previous abdominal surgery; in 3 cases the liver metastases were ultimately resected. LS-LUS did not provide any additional information in 8 patients. During laparotomy, however, 2 of these patients were found to be unresectable due to a small superficial metastasis in one and hilar lymphadenopathy in the other, which had been missed on LS (i.e., false negatives). In 33 of the 41 successful LS-LUS procedures (81%), additional information was obtained. In 14 cases this did not alter the planned treatment; the number of metastases changed in 8 while in 6 patients extra benign lesions were discovered. In one of these latter patients a lesion was (mis)interpreted as a hemangioma but at subsequent laparotomy it was determined to be a metastatic nodule (i.e., false negative). In 19 patients (46%) supplementary findings at LS-LUS changed the surgical plan. Multiple bilobar tumor deposits and unsuspected peritoneal implants precluded a curative resection in 10 patients. The exact localization of the metastases with regard to the major vascular structures altered the surgical strategy in 5 cases. Finally, in 4 patients the suspected liver malignancy was (histologically) diagnosed as a benign tumor, obviating the need for resection. The value of laparoscopic staging in the 46 patients with liver metastases is illustrated in Figure 8.12. Including the failed procedures, 24 of the 46 patients (52%) had their metastases resected. LS-LUS correctly predicted resectability in 21 of 24 cases (88%), with 3 false negatives.



**Primary Liver Cancer (14 patients)**

Additional information was obtained in all 14 patients and in only 2 cases this did not affect therapy; in one an extra benign tumor was found while in the other a small satellite lesion was detected which could be included in the resection. In 12 patients (86%) the further information derived directly altered the preoperative plan; peritoneal spread and multiple satellite tumors in 5, local extension or vascular invasion in 3, advanced cirrhosis preventing major surgery in 3, while 1 patient had a benign tumor (FNH) instead of the suspected HCC. Only 3 of the 14 patients (21%) ultimately underwent resection; all were correctly diagnosed by LS-LUS.

The results for all 60 patients with liver tumors (groups 2a+2b) are shown in Figure 8.13 and Table 8.3. The resectability rate for primary and secondary liver tumors was increased from 24/55 (44%) to 24/27 (89%) after LS-LUS. Sensitivity in determining unresectability was 90%, with 89% predictive value and an overall accuracy of 95%.

**Biliary Tract Tumors (8 patients)**

Our experience with LS-LUS for gallbladder and proximal bile duct cancers is limited. LS is a necessity for establishing the correct diagnosis; in 2 of our patients the presumed Klatskin tumor was in fact a gallbladder cancer. In 5 patients attempts at curative resection were deferred due to previously undiagnosed liver

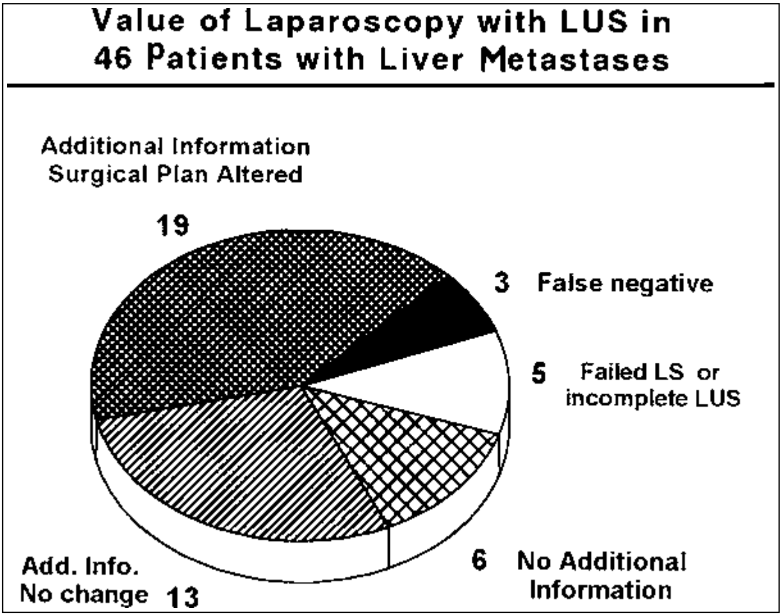


Fig. 8.12. Value of laparoscopy with laparoscopic ultrasonography in 46 patients with liver metastases.

metastases (4 cases), infiltration of the hepatoduodenal structures and lymph node involvement (2 cases). Palliation was achieved by endoprosthesis in all 5.

The value of LS-LUS in all 68 patients with hepatobiliary tumors (group 2) is illustrated in Figure 8.14. The most important additional information was obtained by the LS alone in 22 patients. The visible disease included peritoneal deposits or other extrahepatic tumor (11), small superficial liver nodules (7) and cirrhosis (4). As we strived for a practical approach, LUS was omitted in 8 patients as it was unnecessary after the obvious LS findings of extrahepatic spread. LUS provided exclusive supplemental findings in 30 patients concerning the number of metastases or satellite lesions (14), nature of lesions (11) and localization of intrahepatic lesions (5) (Table 8.4).

## THERAPEUTIC LAPAROSCOPY (MINIMALLY INVASIVE SURGERY)

### Resection of Liver Tumors

The use of modern laparoscopic surgical techniques for the resection of hepatobiliary tumors is still in the stage of an exciting new adventure. There is

8

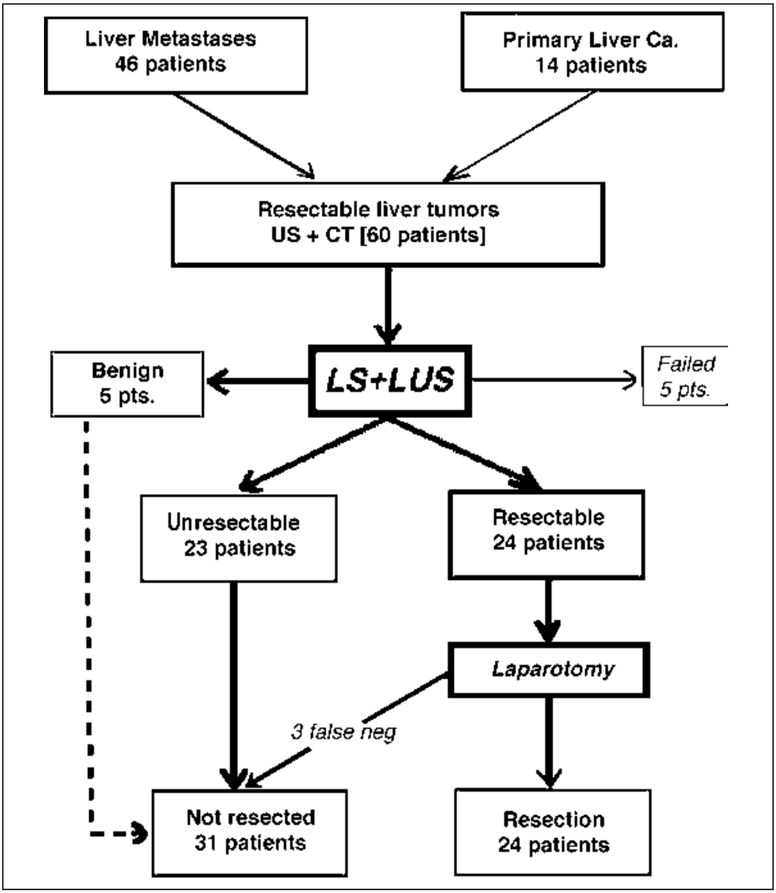


Fig. 8.13. Results of LS-LUS in 60 patients with potentially resectable liver tumors.

*Table 8.3. Accuracy of LS with LUS in predicting unresectability of primary and secondary liver tumors (55 patients)*

| | Laparotomy | | |
|---|---|---|---|
| LS + LUS | Not Resected | Resected | total |
| Unresectable | 28 | 0 | 28 |
| Resectable | 3 | 24 | 27 |
| total | 31 | 24 | 55 |

Sensitivity = 23/31 = 90%
Specificity = 24/24 = 100%
Pos. predic. value = 28/28 = 100%
Neg. predic. value = 24/27 = 89%
Accuracy = 52/55 = 95%

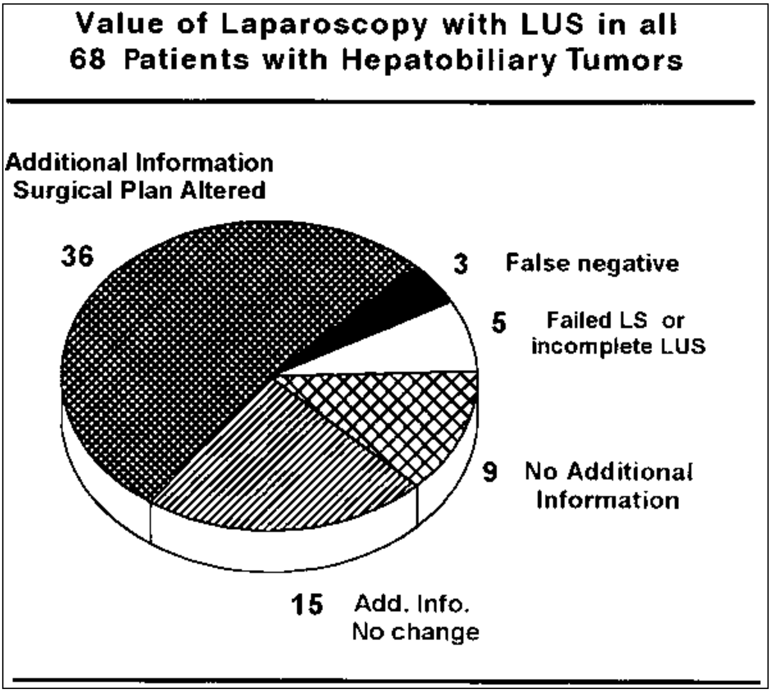


Fig. 8.14. Value of laparoscopy with laparoscopic ultrasonography in all 68 patients with hepatobiliary tumors.

*Table 8.4. Most important additional information obtained by laparoscopy and laparoscopic ultrasonography*

| SL and LUS | Most important Add. Information | (no. pts) |
|---|---|---|
| Laparoscopy (visible disease) | —peritoneal/extrahepatic deposits | 11 |
| | —small superficial liver nodules | 7 |
| | —degree of cirrhosis/rest liver | 4 |
| Laparosc. Ultrasound (supplemental info.) | —number of metastases/satellites | 14 |
| | —nature of lesions/extra benign | 11 |
| | —anatomical localization | 5 |

only limited experience available with sporadic reports to date.[62,63] Small, readily accessible tumors along the free liver edge may be resected fairly easily, and we have performed a left (segment 2 and 3) lobectomy. Hüscher et al[64] recently described their success with five right hemihepatectomies and one right lobectomy. They rightfully warn of the difficulties and dangers involved in performing major resections laparoscopically. It is extremely complicated and demanding surgery, requiring highly sophisticated equipment and advanced technical skills. LUS is mandatory, while use of the laparoscopic CUSA or harmonic scalpel and Argon coagulator facilitate the parenchymal dissection. It remains to be seen whether this approach will become popular and if there are any advantages to be expected for the patients.

#### Nonresectional Treatment

If resection of the hepatic malignancy is not feasible, the destruction of tumor tissue by alternative methods may be contemplated. Local ablation can be achieved using laser hyperthermia, cryosurgery freezing or (in the case of HCC) ethanol injection.[65-67] That this may be possible under LS-LUS guidance seems obvious, although it is still in an experimental stage of development.

#### Palliative Procedures

The implantation of an intra-arterial catheter for regional chemotherapy to the liver has been done laparscopically.[68] Bilio-digestive bypass surgery for proximal bile duct tumors is probably too complicated to perform laparoscopically. Inventive alternatives are being explored,[69] but endoscopic or percutaneous methods will remain the first choice of palliation.



## CONCLUSIONS

The potential role of laparoscopy in the (surgical) treatment of hepatobiliary malignancies still needs to become apparent before general recommendations can be made. Much depends upon the individual patient and his/her disease, while the surgeon is limited by technical (cap-) abilities.

On the contrary, the role of laparoscopy in diagnosis and staging has now become well established, and it should become an integral part of routine preoperative work-up. The value of laparoscopic staging in selecting patients with hepatobiliary malignancies for (curative) surgical resection will largely depend on the quality of the preoperative imaging modalities used. The additional information provided by LS-LUS will steadily decrease as the resolution of modern radiologic imaging increases. However, there can be no doubt that laparoscopic staging has the potential to provide essential supplementary information that would otherwise only become apparent during laparotomy. LS has the unique ability to detect peritoneal implants and small superficial hepatic nodules, and it is the only method of accurately assessing the degree of liver cirrhosis. LUS supplies the same accuracy in detecting intrahepatic lesions and provides the same anatomical information as IOUS, which has become indispensable for determining surgical strategy during liver resections.

The clinical implications of LS-LUS underline the surgeons responsibility in obtaining accurate preoperative staging to prevent a fruitless laparotomy. There may be a considerable financial impact as laparoscopic staging obviates the need for extensive sophisticated radiological imaging which is not only less accurate, but also more costly, personnel intensive and time consuming. The improved staging accuracy of LS-LUS will also lead to better stratification schemes for future studies on (neo-) adjuvant therapy. Above all, diagnostic laparoscopy with laparoscopic ultrasonography is a safe, simple and reliable procedure which can substantially reduce both physical and psychological morbidity by avoiding unnecessary exploratory laparotomy, and it should become a prerequisite to the definitive treatment of hepatobiliary malignancies.

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# Laparoscopic Treatment of Colorectal Malignancies

*Morris E. Franklin Jr., Jorge Balli*



9

## INTRODUCTION

Laparoscopic bowel surgery began in the early 1980s when Semm reported a large series of laparoscopic appendectomies in Germany.[1] The vast majority were for benign disease and, in fact, many of the appendices were histologically normal. Although poorly documented, Rich subsequently reported repair of a bowel perforation in 1989.[2] Substantial laparoscopic surgery for benign disease was described by Jacobs, Placencia, Fowler, and Franklin in 1990.[3-5] Jacobs performed primarily right hemicolectomies with lateral mobilization followed by exteriorization of the involved segment and an extracorporeal anastomosis. In 1990 Fowler also performed similar procedures for the left colon. The first total intracorporeal resection was performed by Franklin et al in 1990 as well. Laparoscopic oncologic resections were first performed by Phillips and Franklin in 1991 and their preliminary results were reported in 1992.[6]

The principles of open surgery for colon malignancies are well known but not well documented. Although each expert refers to a gold standard, the standards are not well published. The principal factors involved in colonic resections for malignancies include a tissue diagnosis of carcinoma with preoperative staging for a definitive oncological procedure. Accepted surgical techniques for colonic malignancies include:

- intraoperative staging
- early vascular control and
- minimal handling of the tumor.

Early or late ligation of the mesenteric vasculature results in similar survival and recurrence rates. However, no randomized, prospective studies comparing early or late vascular ligation have been performed. The surgical specimen should include a proximal margin of at least 10 cm, except for low rectal tumors which

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require only a 2 cm distal margin. Rectal tumors also mandate a wide lateral mesorectal resection with nerve preservation.[8,9] Ligating the proximal and distal ends of the specimen with umbilical tapes has been recommended, but there is no advantage in survival or recurrence rates. The colonic specimen should include its lymphatic drainage for pathologic staging. The specimen is removed and the anastomosis is performed while maintaining vascular supply proximally and distally. Blood loss should be kept at a minimum as blood transfusions are associated with increased recurrence as well as postoperative complications.[10] Controversy still exists regarding drainage of the colonic anastomosis. Currently most surgeons do not drain the anastomosis, however, recent studies for rectal carcinomas have shown that drainage reduces the incidence of abscess and fistula formation within the pelvis. Surgical resection also includes adjacent structures if contiguous with the tumor. Colonic and peritoneal irrigations with and without tumoricidal agents have been utilized to reduce tumor recurrence as well.[11,12] The above maneuvers provide a set of criteria resulting in known and accepted survival and recurrence rates. Laparoscopic colonic procedures should yield equivalent results.

## TECHNIQUE OF LAPAROSCOPIC COLON RESECTION



All principles of open oncologic colon surgery must be observed. No surgeon should embark upon laparoscopic colon resections without a thorough understanding of these principles. Additionally, the laparoscopic colon surgeon must be familiar with the special precautions regarding oncologic laparoscopic surgery. Furthermore, the surgeon should be experienced in laparoscopic colon resection for benign disease. Laparoscopic surgical skills including two-handed technique, intracorporeal stapling, knot tying and suturing are strongly recommended.

## TECHNIQUE OF LAPAROSCOPIC COLON SURGERY, PATIENT SELECTION

Initially laparoscopic colon resection should be attempted on patients with relatively small tumors and no prior abdominal procedures. The preoperative work-up should include a thorough history and physical examination with an emphasis on cardiovascular and pulmonary status. The work-up includes standard blood studies as well as an EKG, chest x-ray and barium enema. Colonoscopy with or without tumor marking is extremely helpful. Bowel preparation includes a decreased bulk diet for three days preoperatively followed by clear liquids for 2 days and finally purgatives. Golytely or polyethylene glycol is a stressful preoperative preparation and tends to leave a tremendous amount of fluid in the small and large bowel. Finally, the bowel preparation includes oral antibiotics and enemas. Intravenous antibiotics are given approximately 1.5 h prior to surgery.

Laparoscopic colon resection entails meticulous intraoperative planning regarding operating room set-up and potential equipment as well as the actual procedure. A three-chip camera and a reliable light source are vital to the procedure. A colonoscope should be available.

Patient positioning requires tucking both arms to the side, taping the shoulders to the operating room table and placing the lower extremities in the modified lithotomy position. Anal access must be available, especially for left colon, lower anterior and abdominoperineal resections. Bony prominences and their accompanying nerves on the arms and legs are protected with soft padding.[14] Temperature loss is controlled with thermal blankets, heated respiratory gases, fluid warming and extremity wrapping. Two monitors as well as a separate monitor for the colonoscope are placed for maximal viewing. Finally, nasogastric and foley catheter placement are performed following the induction of general anesthesia.

## OPERATIVE PROCEDURE

The surgeon stands on the contralateral side of the involved segment, the left-hand side for right colon lesions and the right-hand side for left colon lesions. The surgeon stands between the legs for transverse colon lesions and for total colectomies. The camera holder stands on the same side as the surgeon while the assistant surgeon may be on the same side, the opposite side or between the legs.

Following abdominal access with either the Hasson or the Verres technique, a pneumoperitoneum with $CO_2$ is obtained at 14 mm Hg. Alternative sites of abdominal access are utilized when the patient has had prior abdominal surgery. Trocars are then placed under direct vision in a semicircle around the colonic pathology. A 30° laparoscope is crucial for colonic resections.



The lesion is localized by either direct visualization or by identifying a preoperative marking of India ink or Congo red. Intraoperative colonoscopy can be utilized for tumor localization, however, proximal clamping of the colon or small intestine must be performed to prevent intestinal distension.

The involved segment is mobilized with vascular control obtained early in the operative procedure. The right and left ureters should be identified in all lower anterior, sigmoid and abdominoperineal resections. If both ureters cannot be identified during these dissections, the case should be converted to open laparotomy. Dissection proceeds with proximal and distal ligation of the colonic specimen. The specimen is then placed in a reinforced bag prior to abdominal extraction.[17] Alternatively, a wound protector can be placed if a reinforced bag is not utilized. The specimen is removed either transanally, transvaginally or transabdominally depending on the size and location of the tumor and the experience of the surgeon. The specimen is then opened for tumor verification prior to colonic anastomosis. The colonic anastomosis must be tension-free and have a good blood supply. Finally the anastomosis is checked for leaks in every case with a colonoscope. Approximately 10% of all anastomoses require some type of cauterization for bleeding. A protective ileostomy may be used for low anterior resections in patients with borderline vascular status, a high cancer load, malnutrition or neoadjuvant radiotherapy. Upon completion of the procedure, the abdominal cavity is washed with 10% Betadine or 5-FU and suctioned dry. The abdomen is irrigated thoroughly with normal saline and deflated. The abdomen is then reinsufflated and hemostasis is verified. The abdomen should be irrigated again with normal saline while the trocars are irrigated with a cytotoxic solution of 5-FU or Betadine prior to removal. Pelvic drains are placed in all low anterior, abdominal perineal and sigmoid resections.

Postoperatively the nasogastric tube is removed in the recovery room. Liquids are started when bowel sounds are present, and the patient is advanced to solids with flatus or bowel movement. After tolerating a solid diet the patient is discharged when bowel function has returned. Results of several series appear in Table 9.1. Several authors have noted the immunological advantage of laparoscopic colon surgery for carcinoma.[18-20] These advantages include low infection rates and delayed tumor recurrence.

## CONCLUSIONS

Laparoscopic colon resection for cancer is safe and the results are comparable to open resection. Currently, five-year survival rates from several large series are pending, but preliminary data indicates survival and recurrence similar to those after open surgery. When performed laparoscopically, colonic resections for carcinoma lead to shorter hospitalizations, preservation of immune function and quicker recovery times. Early reports of carcinomatosis and trocar site implants

9

*Table 9.1. Analysis of laparoscopic colon resection for cancer*

| Author | # of Cases | Avg. Length of Stay (days) | Complication Rate (%) | Trocar Recurrence # | Trocar Recurrence % |
|---|---|---|---|---|---|
| Larach | 150 | 5 | 4.6 | 0 | 0 |
| Franklin | 285 | 4.7 | 9 | 0 | 0 |
| Gayet | 100 | 6 | 5 | 1 | 1 |
| Leroy | 150 | 5 | 3.3 | 1 | 0.6 |
| Felding | 200 | 6 | 8 | 2 | 1 |
| Kim | 220 | 6 | 9 | 1 | 0.4 |
| Petelin | 106 | 4 | 7 | 0 | 0 |
| Phillips | 80 | 6.5 | 8 | 0 | 0 |
| Milson | 35 | 4.8 | 9 | 0 | 0 |

resulted from inexperience with poor specimen extraction techniques. Several large series from experienced surgeons have provided excellent results in terms of survival and recurrence while documenting a negligible if not nonexistent trocar site recurrence rate.

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# Laparoscopy and Gastric Cancer: Perspectives and Controversies

*Demetrius E.M. Litwin, Peter C. Willsher*



## INTRODUCTION

The laparoscopic surgery revolution has resulted from the development of new techniques and technologies which allow the performance of increasingly complex procedures. While gastric resection for cancer has not been embraced with such enthusiasm as removal of other abdominal viscera, this may be a reflection of the relative rarity of this disease in the West. However, a number of groups have undertaken subtotal or total gastrectomy, albeit in small series of patients. Goh et al[1] surveyed advanced laparoscopic surgeons and identified a total of 118 laparoscopic gastrectomies performed prior to November 1994. In 46 (38%) of these cases, the indication for surgery was gastric cancer. This report included our early cases and established the feasibility of laparoscopic gastrectomy. This chapter outlines our appraisal of the current role of laparoscopy—both diagnostic and therapeutic—in the management of gastric cancer.



## LAPAROSCOPIC APPROACH TO GASTRIC CANCER

Clearly, surgical resection is the only means of curative treatment for gastric cancer, and the differences between the extent of resection as practiced in Japan and in Western countries is widely appreciated. The Japanese approach is generally not used in the West because randomized prospective trials comparing extensive with less extensive resections for adenocarcinoma of the stomach do no demonstrate a survival benefit.[2-5] Furthermore three of these trials[2-4] show that extended resections are associated with increased perioperative morbidity. It has

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been suggested that this increase in morbidity is associated with the performance of splenectomy and distal pancreatectomy, and the majority of North American surgeons do not routinely perform this.[6,7] Although resections of any extent could be carried out via the laparoscope, Japanese classification R3 resections would be difficult and lengthy procedures,[8] but the less extensive operations are more readily performed laparoscopically.

### Duration of the Procedure and Initial Surgical Outcome

Laparoscopic gastrectomy can be technically difficult and time consuming, and in general, the operative duration is currently longer than anticipated for open surgery. Our preliminary experience with laparoscopic gastric resection is demonstrated in Table 10.1. The average operating time for total gastrectomy was 6.5 hours and 4 hours for subtotal gastrectomy. In the cases identified by Goh et al[1] (which included benign resections, total and subtotal gastrectomy) the mean operative duration was 3.5 hours. In the 10 cases of subtotal gastrectomy reported by Ballesta-Lopez et al[9] the mean duration was similar to ours at 4 hours and 10 minutes. The authors of this report claim that the duration was decreasing with experience. This phenomenon has been seen in other advanced laparoscopic procedures and one would anticipate operative times may approach those of open surgery. In many respects the stomach is actually better suited to laparoscopic resection than the colon. There is more room to operate in the upper abdomen, and the stomach is more fixed in position. This makes the stomach easier to dissect, place in a bag and extract.

In our initial series (Table 10.1) there were only two significant complications. A 63-year-old male patient with linitis plastica who underwent total gastrectomy developed a duodenal stump leak on the 9th postoperative day. He subsequently developed a gastrointestinal bleed and eventually died on the 47th postoperative day. This patient had been on prednisone and methotrexate for severe rheumatoid arthritis. A 78-year-old patient with severe COPD required prolonged postoperative intubation (9 days), and developed bronchopneumonia. At present follow-up there have been no significant long-term complications. In the series of Goh et al[1] the perioperative morbidity was 11% and mortality was 3%.

In our experience conversion to open surgery was required for three cases. This was carried out because of bleeding from the splenic region in two cases and technical inability to safely complete the operation in one case. In the other reported series the conversion rates were 5%[1] while Ballesta-Lopez et al[9] completed all ten cases laparoscopically.

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*Table 10.1. Initial experience with laparoscopic gastrectomy for gastric cancer*

| | Indication | Total (Conversion to open) |
|---|---|---|
| Total Gastrectomy | Linitis plastica | 4(1) |
| Subtotal Gastrectomy | Malignant ulcer | 9(2) |

The length of hospital stay in our series, ranged from 2-61 days with a median of 6 days. While the median hospital appears favorable the small number of cases and the place on the "learning curve" make it impossible to comment whether hospital stay is reduced in comparison to open surgery.

### Oncologic Adequacy of Resection

A major controversy regarding the applicability of the laparoscopic approach for resection of malignancy are doubts regarding the oncologic adequacy. The discussion has centered around colorectal cancer largely because of reports of port site recurrences, although the same concerns have been raised with respect to gastric cancer.[10] There are three points at issue: 1) the ability to achieve clear resection margins of the primary tumor, 2) the performance of an equivalent lymph node clearance, and 3) the potential for tumor spread to remote sites (port site). The first two points appear to have been clarified to show an equivalence for laparoscopic resection for colorectal cancer,[11,12] but there is little published data from experience with laparoscopic resection for gastric cancer. In our series, all resection margins were histologically clear of cancer. Ballesta-Lopez et al[9] also achieved this result and furthermore were able to obtain a mean of over 30 lymph nodes for each resection. The issue of port site metastases in colorectal cancer has taken on less significance than initially feared. It seems more probable that poor technique or advanced disease have been responsible for the apparent spate of "port site" recurrences reported in the literature.[13] Moreover, the "open" literature demonstrates that incisional tumor recurrence occurs in 1% of patients with colon cancer undergoing resection.[14] Furthermore we must know both the numerator (occasional reports of port site recurrence) and the denominator (total number of cases undergoing laparoscopic resection) before substantiating criticism of the laparoscopic approach to cancer. In our limited experience there have been no port site recurrences, nor have any been reported in the literature.

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With respect to long-term outcome, there is such limited experience and a lack of significant follow-up that no meaningful comment can be made about survival. In spite of this and the apparent fears regarding the use of laparoscopy in the treatment of malignancy, we are confident that with meticulous technique and our ability to assess the extent of resection that philosophical tenets regarding cancer surgery can be maintained.

## LAPAROSCOPIC STAGING OF GASTRIC CANCER

The potential advantages of using laparoscopic assessment of intra-abdominal malignancies have become increasingly evident. In particular the fallibility of preoperative investigations (including CT scan and ultrasound) has been well demonstrated by the ability of laparoscopic examination to detect "occult" metastatic disease in upper gastrointestinal malignancy. A number of reports have shown that between 20-30% of patients considered potentially curative on the basis of preoperative investigations will have metastatic disease detected by laparoscopy.[15,16]

A prospective comparison of laparoscopy, ultrasonography and computed tomography in the staging of gastric cancer, demonstrated that laparoscopy was more sensitive in detecting hepatic, nodal and peritoneal metastases.[17] Ultrasonography and CT were particularly poor at detecting nodal and peritoneal spread. In this study of 103 consecutive patients with gastric carcinoma, 27 were confirmed to have hepatic metastases, of whom 11 (41%) were only detected at laparoscopy.

It would be anticipated that the addition of laparoscopic ultrasound to routine laparoscopic assessment would further improve the detection of metastatic disease. While this has been studied in other upper gastrointestinal malignancies there is little published specifically regarding the role of laparoscopic ultrasound in gastric cancer.[18,19] However, our preliminary experience, and that of others suggests that this modality will further improve the identification of patients likely to benefit from curative resection.[20]

Our current approach is to perform laparoscopy and laparoscopic ultrasound on all patients with potentially curable upper gastrointestinal malignancy. Laparoscopic ultrasound is performed using a 12 mm multifrequency articulating ultrasound probe (B & K). The examination of the liver is facilitated by division of the falciform ligament. Suspected metastatic disease is always confirmed by biopsy and frozen section. Our experience with this approach and the frequency with which occult metastatic disease is detected has prompted us to schedule laparoscopic staging as a separate procedure (usually as an outpatient): with the resection planned at a subsequent time. We have found this allows the most efficient use of operating room resources.

There seems little doubt that the combination of diagnostic laparoscopy and laparoscopic ultrasound allows a significant number of patients to either avoid unnecessary laparotomy, or undergo a less radical resection. We believe that this approach should be undertaken in all cases of gastric cancer where curative resection is contemplated.



## OPERATIVE PROCEDURE, PREOPERATIVE CONSIDERATIONS, PATIENT EVALUATION

A survey of the patient's general condition and nutritional status should be carried out, and the presence of overt metastases be identified by clinical examination and simple investigations. Laparoscopic surgery does not allow palpation, so it is essential that the surgeon knows the exact location of the cancer. Since this is best determined by gastroscopy this investigation should preferably be carried out by the operating surgeon. Furthermore intraoperative gastroscopy should always be available if needed to confirm the site of the lesion.

### Patient Preparation

The stomach must be empty and should be irrigated via a large bore tube if gastric outlet obstruction is present. Prophylactic antibiotics and subcutaneous heparin are routinely administered.

**Positioning and Set Up**

The patient positioning and location of operating staff and apparatus is shown in Figure 10.1. It is important that the patient has both arms extended. Two monitors are positioned near the head of the table. The location and size of laparoscopic ports is shown in Figure 10.2. The surgeon operates from the left side of the table using the two left sided ports (12 and 5 mm). The 12 mm port is the main operating port and the EndoGIA is usually used through this site. A right sided 12 mm port is often required for the EndoGIA. The scrub nurse stands at the left of the operating surgeon. The camera man, who also functions as the first assistant, faces the surgeon on the right side of the table. He operates the telescope which is placed at the umbilicus, and uses the right sided port to provide countertraction. The second assistant stands to the left of the first assistant and elevates the left lobe of liver with a 5 mm palpation probe passed through the epigastric port.

Initially the patient is level during mobilization of the greater omentum, dissection of the greater curvature of the stomach and division of the duodenum. Once the left gastric pedicle has been controlled, the head of the operating table is elevated to facilitate division of the stomach and creation of the anastomosis.

## OPERATIVE TECHNIQUE

The decision to carry out total or subtotal gastrectomy is based on the usual indications determined by the site and size of the tumor.

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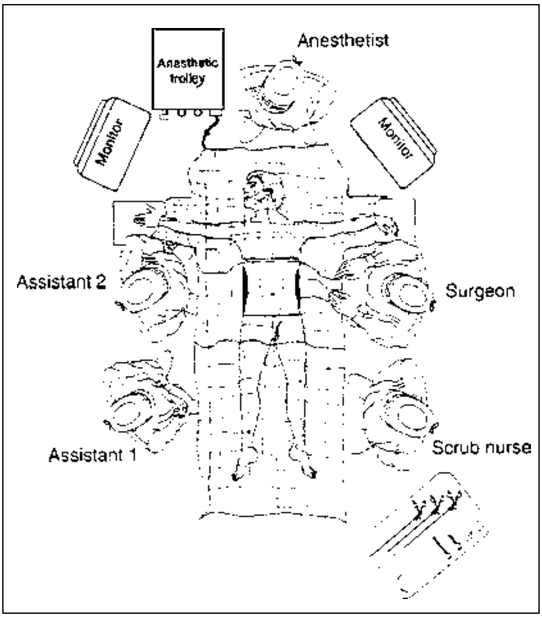


Fig. 10.1. Patient positioning and location of operating staff and apparatus.

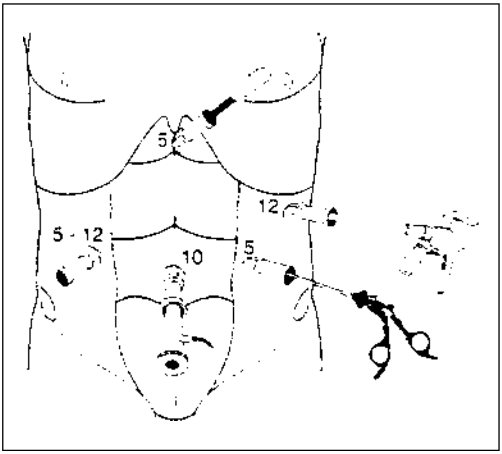


Fig. 10.2. Position and size of laparoscopic ports.

**Subtotal Gastrectomy**

Initial laparoscopic exploration of the abdomen is performed to exclude hepatic and peritoneal metastases. Laparoscopic liver ultrasound is carried out as described earlier. The first step in performing gastric resection is to detach the gastrocolic omentum. This is done either from the transverse colon for curative resection, or divided outside the gastrocolic arcade for palliative or benign resection (Fig. 10.3). If it is detached, the omentum is elevated by the assistant surgeon, and sharp dissection is used to develop the fusion plane between the omentum and the transverse colon. Division of the gastrocolic omentum requires electrocauterization of the vessels and sharp dissection. The dissection should proceed from left to right and should start midway along the body of the stomach where the lesser sac is open. The omentum is separated from the transverse mesocolon, and this dissection is commenced on the left where these structures are less well fused. The dissection is carried to the right until the right gastroepiploic vessels are reached. These vessels are doubly clipped and divided. Following this, the position of the pylorus should be confirmed. This is usually identified by the presence of the prepyloric vein over an area of apparent thickening. However, if there is difficulty in identifying the pylorus, gastroscopy can be carried out. To allow division of the duodenum, the small branches from the pancreatic arcade need to be cauterized and divided. After the duodenum is mobilized it is divided with the EndoGIA–30, which is introduced via the left 12 mm port (Fig. 10.3). In general, one staple cartridge should be long enough to divide it, if this is not sufficient then the position of the stapler must be reconfirmed. The division of the duodenum is an important step in laparoscopic gastrectomy as this allows great mobility of the stomach, so that it can be maneuvered and approached from all sides. In essence, a gastric pedicle has been created. The next step is to divide the right gastric pedicle that usually constitutes a number of vessels which can be clipped and divided as high in the gastrohepatic omentum as practical.

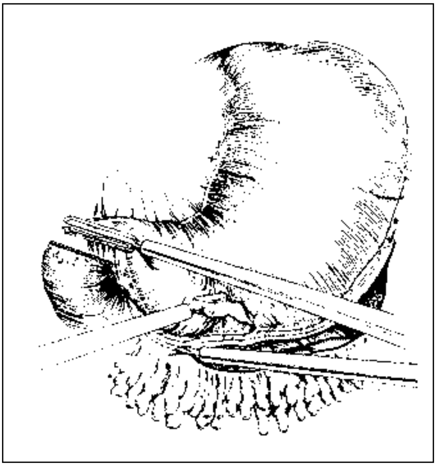

Fig. 10.3. The stomach must be pedicalized by mobilizing the greater curve and dividing the duodenum. This allows the assistant to grasp the duodenum and effectively retract the stomach. In this diagram the gastrocolic omentum is divided outside the gastroepiploic vessels. Modified from

After completion of this part of the operation the mobility of the stomach is such that the first assistant, utilizing the right port, is able to grasp the duodenum and push the stomach toward the left upper quadrant, thus folding the stomach back on itself. This allows division of the posterior attachments of the stomach which are largely avascular and can be divided sharply. Once the left gastric pedicle is reached, the stomach and attached greater omentum are retracted to the right so that the left gastroepiploic and short gastric vessels are placed on a stretch. The dissection and division of these vessels should be carried out as distant from the stomach as possible. For subtotal gastrectomy, approximately 80% of the stomach is removed so that a number of short gastric vessels will need to be doubly clipped and divided. The last step prior to gastric transection is division of the left gastric artery, this is carried out at its origin (Fig. 10.4). This vessel is best controlled and divided with the EndoGIA vascular stapler.

The stomach is then retracted to the right in preparation for transection. The EndoGIA is passed from the left as shown in Figure 10.5. The EndoGIA-30 is used and four or five cartridges are required. We do not favor the 60 mm stapler as it is cumbersome and a larger trocar (15 mm) is required. Once the stomach is divided, the whole specimen is placed in an extraction bag and passed to the right upper quadrant for later retrieval.

Following subtotal gastrectomy there are a number of alternatives for reconstruction. We have preferred a simple gastrojejunostomy as this is the is most easily performed and gives satisfactory results. The Billroth II anastomosis is performed along the greater curve to the proximal jejunum, which is identified by "running" the small bowel distally from the ligament of Treitz. The jejunum is brought up to the stomach in either a antecolic or retrocolic fashion through a small window in the left portion of the transverse mesocolon. A small enterotomy is created at the antimesenteric border of the jejunum, and the left lateral corner

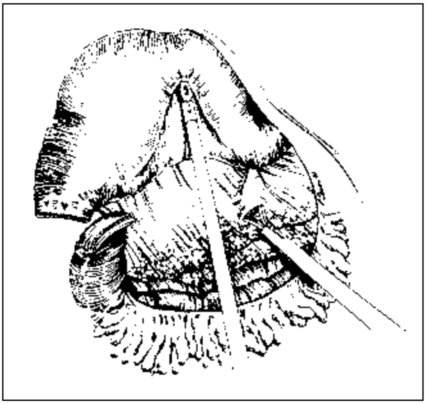

Fig. 10.4. Cephalad retraction of the stomach allows for division of the left gastric artery.

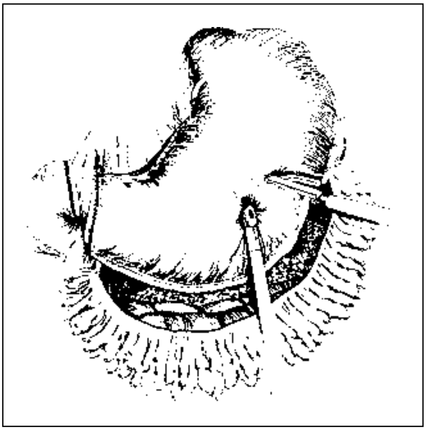

Fig. 10.5. The stomach is easily divided with the EndoGIA 30 stapler passed from the left. Usually 4 or 5 cartridges are required. In this diagram, a partial gastrectomy is depicted, but the stomach can be divided at any level.

of the gastric staple line of the stomach is amputated. The EndoGIA is passed again from the left side and two firings are carried out to create an adequate anastomosis (Fig. 10.6). Subsequent closure of the defect can be by suture, or with the EndoGIA-30 which is best passed from the right side to effect this closure. We have also successfully performed the gastrojejunostomy with a traditional two-layered anastomosis. The specimen is then extracted through the left-sided 12 mm port site. Once the neck of the bag is retrieved, the extraction site can be enlarged to 20 or 30 mm and the specimen can be removed as large pieces. This is usually adequate to allow relatively simple reorientation of the specimen by the pathologist.

**TOTAL GASTRECTOMY**

This is carried out largely as described for subtotal resection, apart from the more proximal mobilization, division and a different mode of reconstruction. For total gastrectomy the dissection along the greater curve is performed to divide all

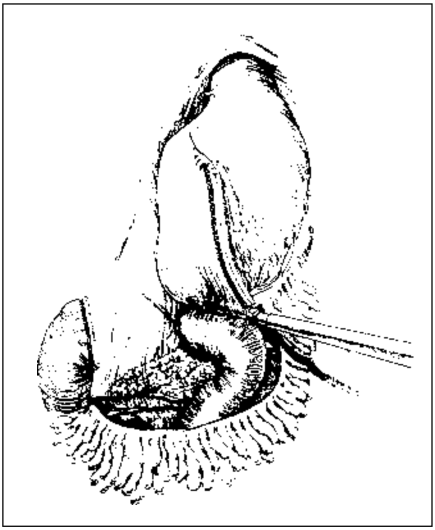

Fig. 10.6. The anastomosis is depicted. This requires two firings of the EndoGIA 30 stapler. It is created on the greater curve or posterior wall of the stomach.

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of the short gastric vessels. The posterior dissection of the stomach up to the esophageal hiatus is predominantly by blunt dissection and is relatively straightforward. To mobilize the distal esophagus the stomach is retracted in a caudad direction and the phrenoesophageal ligament is divided with cautery. Blunt dissection allows identification of the esophagus which is mobilized from the crura by careful blunt dissection. While a nasogastric is often helpful in open surgery to aid identification of the stomach, in laparoscopic surgery it is a hindrance as it makes the esophagus stiff and difficult to retract and maneuver with laparoscopic instruments. Once the esophagus has been encircled, the vagal trunks are divided between clips. Following complete mobilization, the esophagus is transected with the EndoGIA which is best introduced from the right.

Reconstruction following total gastrectomy is more complex. We have tried different approaches but have developed and currently favor a Roux-en-Y esophagojejunostomy as depicted in Figure 10.7. The jejunum is divided at an appropriate point with the EndoGIA-30, and the proximal limb subsequently anastomosed to jejunum. A small antimesenteric enterotomy is made in the distal jejunal limb for the jaw of the EndoGIA-30 stapler. This is used to pass the jejunum up to the esophagus where the other jaw of the stapler is inserted into a small incision in the midpoint of the esophageal transection line. A single firing of the stapler is carried out to perform an adequate posterior anastomosis, which is not narrowed by anterior suture closure. We believe this technique provides a larger anastomosis than that of a circular anastomotic stapler.

More extensive resection can be carried out. En bloc splenectomy and distal pancreatectomy can be performed laparoscopically. Where the tumor has invaded the transverse mesocolon or transverse colon itself the appropriate resection could also be performed.

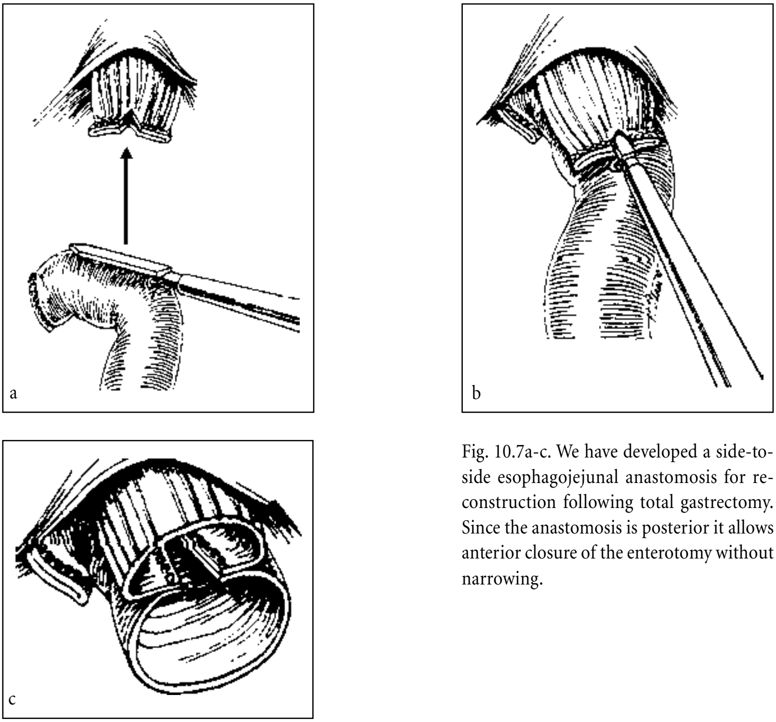


Fig. 10.7a-c. We have developed a side-to-side esophagojejunal anastomosis for reconstruction following total gastrectomy. Since the anastomosis is posterior it allows anterior closure of the enterotomy without narrowing.



## POSTOPERATIVE CARE

The postoperative management of these patients is similar to open surgery. The nasogastric tube remains until the patient passes flatus. The patient is then progressed to a normal diet over two days. When a total gastrectomy was performed, a gastrografin swallow is performed to ensure anastomotic integrity prior to instituting oral intake.

## CONCLUSION

There is no question that there is an important clinical role for laparoscopy in the staging of gastric cancer, as it avoids or modifies resection in up to one third of patients. In addition, the use of laparoscopic ultrasound may be particularly advantageous in this respect. The role of laparoscopic resection for gastric cancer is yet to be clearly defined. While our early experience and that of others demonstrates that laparoscopic resection is feasible, the well recognized advantages of minimal access surgery have not yet been demonstrated. This may be related to the length of time required to undertake this demanding laparoscopic procedure.

The major limiting factor in the development of the laparoscopic approach to gastric resection for gastric carcinoma may be difficulty in gaining significant experience in Western countries. Notwithstanding this, we remain convinced that laparoscopic gastrectomy for gastric cancer will become the approach of choice for the majority of patients. Furthermore we are confident that the oncological outcome will not be compromised.

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# Hand-Assisted Laparoscopic Gastrectomy

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## INTRODUCTION

Advanced laparoscopic procedures can be technically demanding. Historically, they have been criticized for significantly extending the length of standard operating times. Today, we see that even with improved technology and increasing surgical skills, certain laparoscopic cases remain extremely difficult and/or lengthy for most surgeons.

For these reasons, many advanced laparoscopic operations are not attempted. For those advanced laparoscopic procedures that are attempted, many suffer from a high conversion rate or exceedingly long case lengths.



There are many reasons for conversion such as poor visualization and/or surgeon discomfort with the complexity of the dissection. The restoration of orientation and comfort that might prevent conversion and the reintroduction of control could potentially be solved by simply 'getting a hand in there'.

During surgery, the hand functions as the most efficient atraumatic grasper and retractor, and relays critical tactile information. Therefore, handassist devices have been developed to aid in the performance of advanced laparoscopic procedures, and early results are described in recent literature.[1-3,5-7] We have had extensive experience with handassist devices both in the form of early prototype models and those currently on the market. Important principles of handassist devices include ease of use, reliable maintenance of pneumoperitoneum, and hand comfort. In cooperation with industry we have helped to develop a new handassist device which appears to meet all these important principles (HandPort™, Smith & Nephew Endoscopy, Andover, MA).

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The following section describes the Hand-Port's use in assistance of laparoscopic subtotal and total gastrectomy with reconstruction. Gastrectomy cases serve as an excellent model to demonstrate the potential benefits of hand-assistance to advanced laparoscopic surgery. Since an extraction incision is often necessary in gastrectomy and other advanced cases, we simply make use of this incision from the beginning through a properly selected site. Making use of the operator's hand from the start allows continued efficient retraction, blunt dissection, and tactile feedback throughout the case. We have had considerable total laparoscopic gastrectomy experience[4] and believe this device will allow us to perform laparoscopic gastrectomy more safely and efficiently. Our bias is that the well-known benefits to the patient from the laparoscopic approach (less pain, quicker recovery) will, for the most part, be retained.

## PATIENT SELECTION

Standard indications for gastrectomy are utilized. The laparoscopic approach may be used to treat both benign and malignant diseases of the stomach. In view of the current debate over laparoscopic surgery in cases of known malignancy, and, in particular, port site recurrence, caution must be exercised in patients with potentially curative resections. However, most examples of port site recurrence are likely the result of advanced disease or poor technique. We can not overemphasize the need to adhere to the strict surgical principles in which we individually believe. The laparoscopic equivalent should not be a compromise or shortcut procedure.

The major contraindication to this approach, like that for most complex laparoscopic surgery, is poor cardiopulmonary reserve. This is due to the decrease in venous return and increase in pulmonary resistance associated with the pneumoperitoneum. A relative contraindication may include nonelective gastric resection. 

## PATIENT PREPARATION AND POSITIONING

Routine patient specific preoperative preparations are followed. Prophylactic antibiotics are administered in the holding area. Patients are placed on an adjustable operating room table (preferably electric) in the supine position, arms at patient's sides (left may be extended). General anesthesia is administered and a nasogastric tube and Foley catheter are placed. The patient is prepped and draped from nipples to groin. The surgeon stands on the patient's right side with scrub nurse opposite (Fig. 11.1).

The camera operator stands opposite the surgeon and may serve as an assistant during the later course of the subtotal procedure. The first assistant stands on the same side of the surgeon and primarily serves to retract the liver (this assistant may be replaced by a mechanical retracting device attached to the operating room

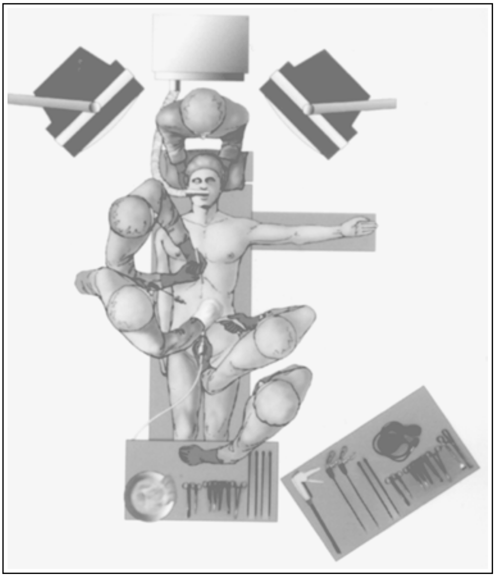

Fig. 11.1. O.R. setup and patient position.

table). The monitor is placed off both sides of the patient's shoulders. A gastroscope should be available.

Pneumoperitoneum may be achieved by Veress needle or open technique. A 10 mm trocar is placed in the umbilicus and a 30° 10 mm laparoscope is used for initial exploration after insufflating to 15 mm Hg.



## HAND-ASSIST PLACEMENT

Choosing a site for placement of assist devices such as the HandPort™ should wait until the abdomen has been insufflated. The distortion of the abdominal wall under pneumoperitoneum changes the ultimate position and length of any incision attempted prior to insufflating. A site is then chosen in the high left upper quadrant just lateral to the rectus abdominus (Fig. 11.2). We believe that the optimal position of the hand is one that allows for triangulation with the other laparoscopic instruments and therefore substitutes for a typical port site in standard laparoscopy.[4] The length of incision correlates mainly with breadth of the palm. This length also approximates the size of the surgeon's glove (for most 7-8 cm). The incision is then carried full thickness. Loss of pneumoperitoneum will occur at this stage.

The HandPort™ consists of three separate parts: the base retractor, bracelet, and sleeve. The following describes in brief the setup necessary for this handassist device. First, the inner ring of the base retractor is placed within the abdominal cavity through the incision created. The outer ring is then inflated (Fig. 11.3).

Next, the right hand is prepared to enter the base retractor. The bracelet should

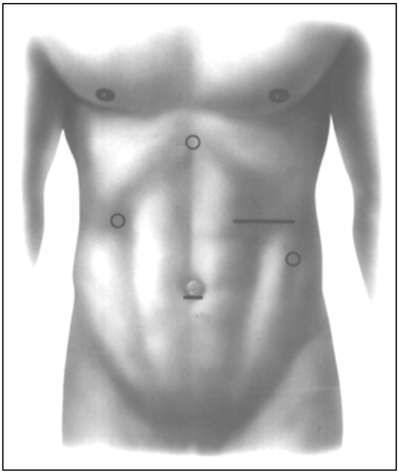

Fig. 11.2. Trocar placement and handassist placement.

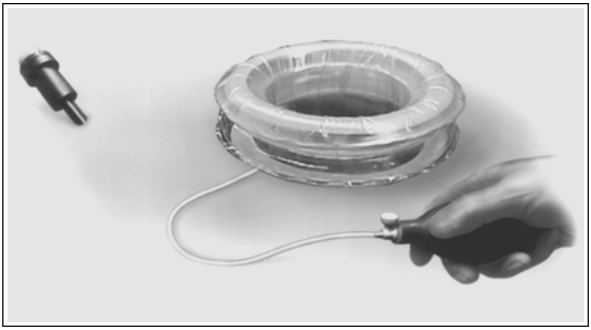

Fig. 11.3. The base retractor of Handport™ is inflated.



have already been placed under sterile conditions to the wrist of the surgical gown if ultimately only one pair of gloves is planned. If the surgeon prefers to double glove then the bracelet may be placed in a sterile manner on the wrist between the two pair of gloves. We have found that wearing brown gloves as the sole or exterior glove reduces glare. The sleeve is then placed over the forearm and its tapered end easily secures to the bracelet (Fig. 11.4). The hand is then introduced through the base retractor and the wider end of the sleeve is secured to the base retractor (Fig. 11.5) and the abdomen re-insufflated. (Note: Many of the operator, incision, and port site positions to be mentioned are what have worked for us. Others may find modifications more comfortable for them, specifically with respect to the ultimate handassist device placement.) In our description, we have chosen to introduce our right hand for hand-assistance and use our left hand to handle laparoscopic instruments. Our team involves both a left-hand and right-hand domi-

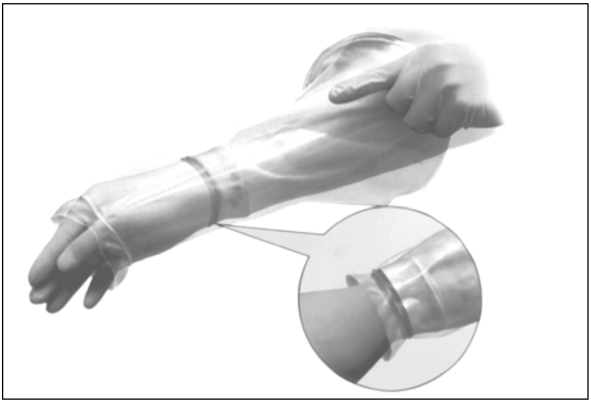

Fig. 11.4. The sleeve is placed and secured to the wrist.

Fig. 11.5.. The sleeve is secured to the base.



nant surgeon, and we have both operated comfortably through the setup provided. Conceptually, a right-handed surgeon may prefer to introduce his/her nondominant hand through a mirror image set up while operating from the patient's left side. Either should allow good exposure and functional assistance. Either would have the potential for conversion if necessary. Also of note, we have experimented with and rejected a vertical, midline, epigastric incision for various reasons including not offering advantageous triangulation to the stomach and because it tends to block the camera view.

With the hand introduced, a combination of visual and tactile exploration may be carried out. Laparoscopic ultrasound is a useful adjunct to the initial exploration in cases of suspected malignancy.

Initial port placement consists of a 5 mm trocar in the epigastric region. This port will be used for dissection and/or left lobe retraction. A 12 mm port is placed several centimeters below the right subcostal margin in the anterior axillary line (Fig. 11.2). It will also be used for dissection and for introduction of linear staplers. For safety, the hand should be retracted into the sleeve above the base retractor whenever introducing trocars.

## SUBTOTAL GASTRECTOMY

Generally, the first maneuver in gastric resection is to enter the lesser sac. This is achieved by dividing an avascular portion of the greater omentum. The hand elevates the stomach to facilitate this maneuver. The extent of omental resection will depend upon the malignant potential of the lesion. For benign disease, once the lesser sac is entered, the omentum is detached directly along the greater curvature outside the gastroepiploic arcade by electrocautery, clips, or ultrasonic scalpel. For more extensive omental resection, the omentum is detached from the transverse colon along the fusion plane either sharply or with electrocautery to again enter the lesser sac. The most distal region of greater curvature is then approached for the identification of the right gastroepiploic artery. Using laparoscopic instruments in the left hand introduced through the 12 mm port, the artery is dissected and divided between endoclips (Fig. 11.6). The hand, throughout the initial and subsequent stages of dissection, is a constantly active participant. The hand can provide blunt dissection, tactile feedback, and a wide range of grasping and retraction options which can continuously change the exposure and



Fig. 11.6. Division of right gastroepiploic artery.

presentation of the tissue to the laparoscope and laparoscopic instruments.

The first goal of laparoscopic gastric resection is to pedicalize the stomach by dividing the pylorus. Once the right gastroepiploic is divided, the retroduodenal dissection is facilitated by upward retraction on the stomach by the right hand. Small feeding vessels to the pylorus can be divided with electrocautery. The hand can feel and choose a site distal to the pylorus for distal transection margin. A linear stapler is introduced through the 12 mm port to transect the duodenum. The hand can then be placed behind the distal stomach segment that is elevated and retracted downward. Dissection along the lesser curve (lesser omentum) is carried out. The right gastric artery is identified and then divided between endoclips (Fig. 11.7). The lesser omentum is divided along the lesser curve to the site of the proximal resection margin. Descending branches of the left gastric will need to be clipped and divided.

While advancing up the lesser curvature, the left lobe of the liver will require retraction. Occasionally this is simply accomplished by using the back of the hand or one extended finger, while the palmar side of the hand can still be engaged in the act of retraction and palpation. Usually, an assistant may hold up the left lobe with a blunt probe introduced through the 5 mm port (Fig. 11.8).

We now turn our attention to identifying a site along the greater curvature to initiate the proximal resection margin. The omentum is cleared from this spot by cautery or ultrasonic scalpel. Additional omental resection (e.g., in cases of malignancy) may similarly be accomplished with electrocautery, clips, or the ultrasonic scalpel. A 12 mm port is placed in the left abdomen, just lateral to the HandPort™ (Fig. 11.2) to allow introduction of the linear stapler in a proper orientation. The stomach will be divided from greater to lesser curvature (Fig. 11.9). The specimen can then be removed through the HandPort™. The base retractor functions as an



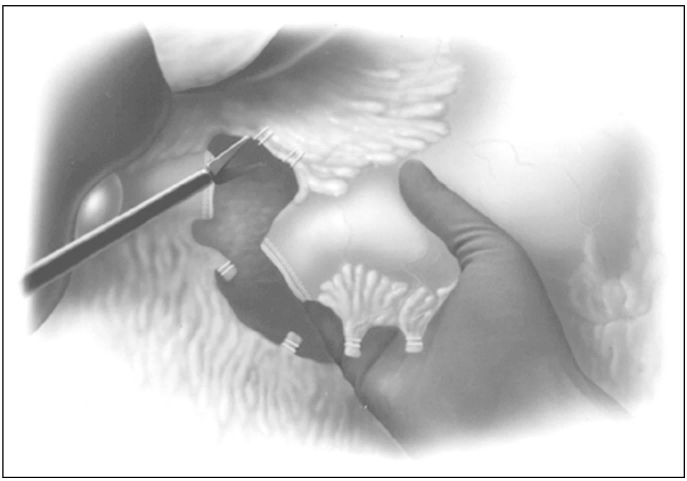

Fig. 11.7. Division of right gastric artery.

excellent wound retractor and wound protector.

Following resection, a gastrojejunostomy will need to be fashioned. The hand is reintroduced and the abdomen insufflated. The jejunum just distal to the ligament of Treitz is selected and brought to the gastric remnant in an ante- or retrocolic position, depending on surgeon's preference. An enterotomy is created

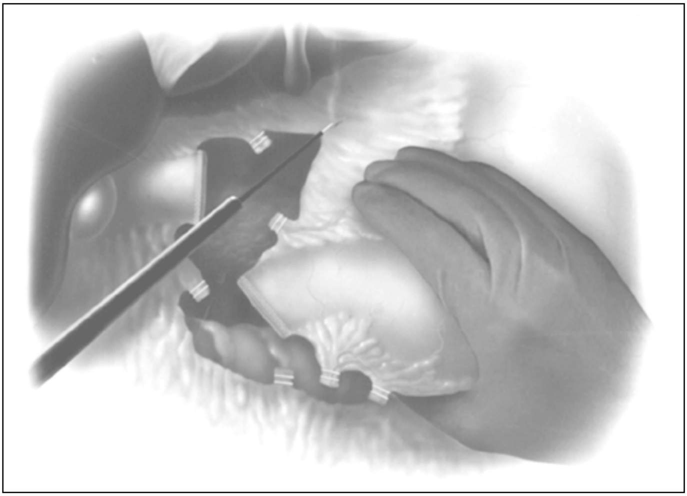

Fig. 11.8. Division of lesser omentum (blunt retractor on left lobe).

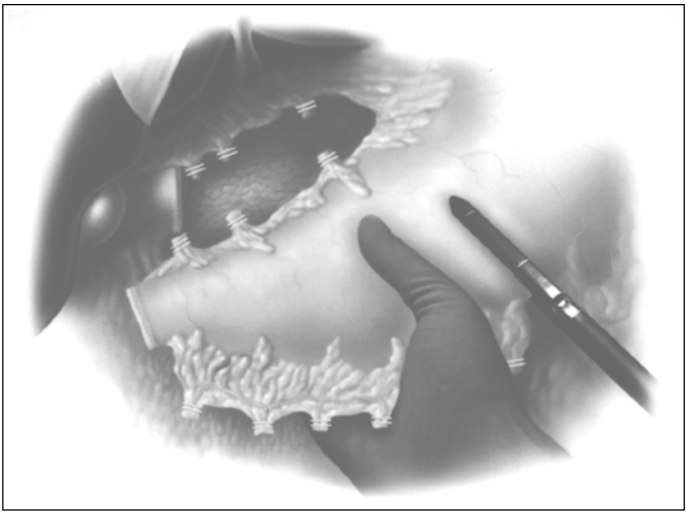

Fig. 11.9. Proximal resection margin is created.

in the antimesenteric portion of small bowel and along the dependent portion of gastric remnant (near the end of the staple line on the greater curvature or posterior wall). Linear staplers are then used to create the anastomosis (two 30 mm firings) through the 12 mm port in the right abdomen (Fig. 11.10). The hand is extremely useful in helping to align and guide this anastomosis. The initial enterotomies are then closed by linear staplers introduced through the 12 mm port in the left abdomen (Fig 11.11). The closure of enterotomies may also be accomplished with sutures placed: 1) totally laparoscopically or 2) by standard open technique (no pneumoperitoneum), if the operative field is exposed through the HandPort™ base retractor after the hand and sleeve are removed.

## TOTAL GASTRECTOMY

The operation begins in the same fashion as for subtotal gastrectomy. The first goal is to pedicalize the stomach. After the right gastric artery is divided, the remainder of the lesser curvature is divided up to the level of the right crus. The left gastric artery is identified while the hand retracts the pedicalized stomach toward the anterior abdominal wall. The left lobe of the liver will need retraction by the assistant with a blunt probe through the epigastric 5 mm port. Once the left gastric artery is divided, the esophageal hiatus is approached. Here the hand is most useful for encircling the esophagus, creating inferior retraction, and bluntly dissecting posteriorly and/or guiding careful electrocautery (Fig. 11.12). The phrenoesophageal ligament is divided, as are both vagus nerves. Before the esophagus is transected, the remaining attachments on the greater curvature are divided (short gastric vessels, left gastroepiploic). The stomach may be retracted medially



Fig. 11.10. The gastrojejunostomy is fashioned.

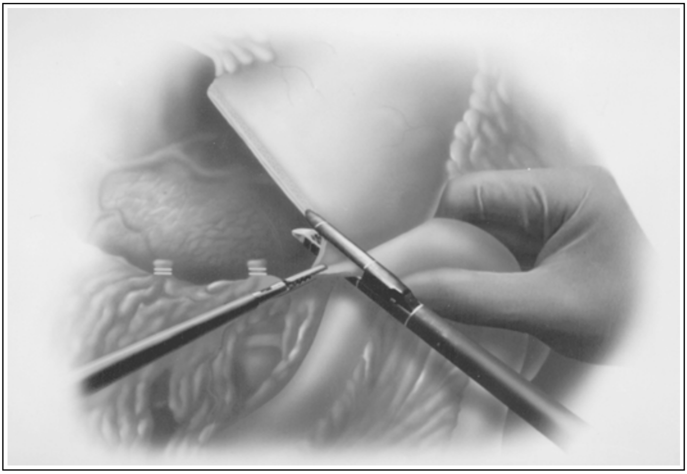

Fig. 11.11. Closure of original enterotomies.

Fig. 11.12. Posterior esophageal window is created.



with aid of the hand or laparoscopic grasping device through the right abdominal ports. The short gastric vessels are divided with the ultrasonic scalpel (Fig. 11.13). The left gastoepiloic is divided between endoclips. The stomach can now be elevated with the hand and any posterior attachments are taken to the level of the hiatus.

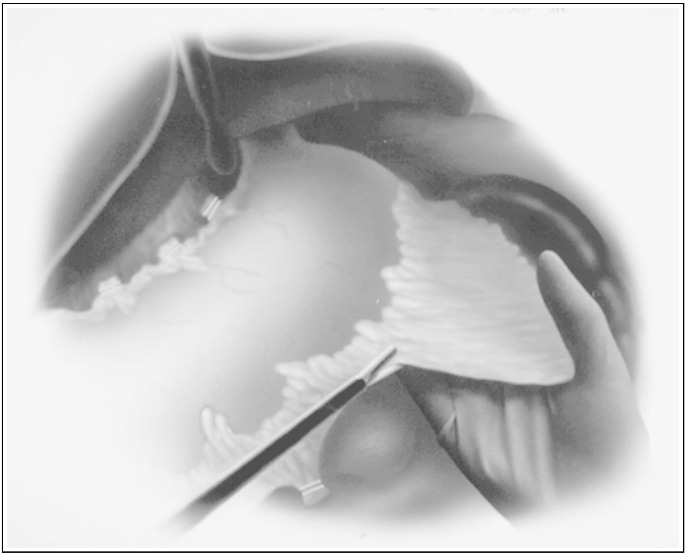

Fig. 11.13. Division of short gastric vessels.



The distal esophagus is then transected with the linear stapler passed through the 12 mm port. The esophagus may be held proximally with a non-crushing 5 mm laparoscopic clamp (DeBakey type) (Fig. 11.14) prior to transection in order to prevent esophageal retraction into the chest (this may be placed through the 5 mm epigastric port). Additional left lobe retraction may be provided by several extended fingers of the hand. The specimen is removed through the base retractor.

Reconstruction at this point may be somewhat surgeon biased, but any choice should be reproducible with the handassist method. Also note that although we favor the reconstruction laparoscopically, a certain degree of the reconstruction may be done open through the exposure created by the base retractor. We prefer to fashion a Roux-en-Y esophagojejunostomy in a side-side technique using laparoscopic linear staplers. Another option would be an end esophagus to side jejunum using a circular stapler (23 mm). In either case an appropriate distal limb of jejunum is chosen and transected. The Roux limb is brought up to esophagus. For the side-to-side technique as originally described by Litwin and Rossi,[4] enterotomies are fashioned in esophagus and Roux limb (Fig. 11.15). A linear stapler is then used to fashion the anastomosis (Fig. 11.16). The original enterotomies are then closed with a linear stapler or by sutures. We have employed the side-to-side technique in six laparoscopic esophagojejunal anastomoses.[4]

If an end-to-side anastomosis is planned (circular stapler), the first step is to remove the staple line sharply from the distal esophagus. A purse string is fashioned either laparoscopically or open through the base retractor (Fig. 11.17). Like-

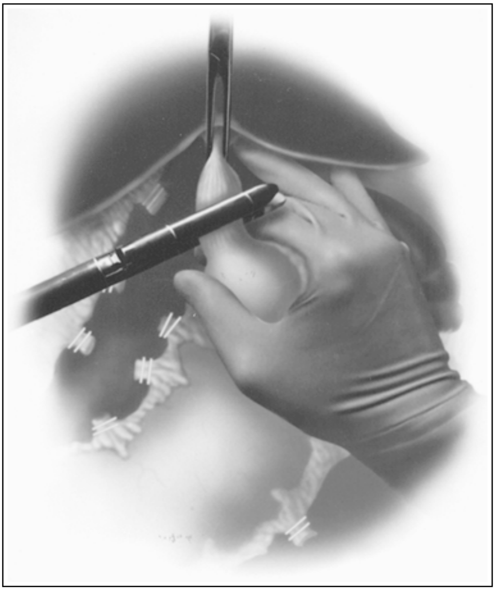

Fig. 11.14. Esophageal transection.

Fig. 11.15. The esophagojejunostomy is prepared.



wise an appropriate Roux limb may be chosen and fashioned through the exposure of the base retractor.

Continuing in either an open or laparoscopic mode, the anvil is placed and the purse string secured. One may find that the completion of the following circular stapling technique is possible through the exposure created in the base retractor.

Fig. 11.16. Esophagojejunal lumen is created.

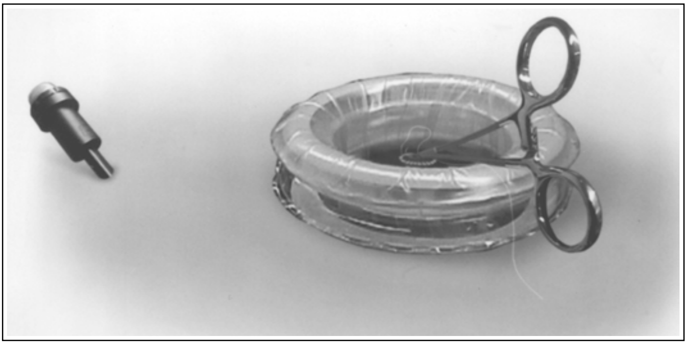

Fig. 11.17. The esophageal purse string formed through the base.

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Frequently, however, it may be difficult to visualize the fashioning of the anvil portion to the receiving pin of the circular stapler high in the epigastrium. In such case, the stapler can then be visualized and fashioned under pneumoperitoneal conditions. The device may be deployed in a makeshift fashion through a separate sleeve of the HandPort™ (note: on later models of HandPort™ there will be caps). These caps will contain variable sized valve mechanisms to allow insertion of instruments rather than a hand while still maintaining the laparoscopic environment). One should be aware that certain models of circular staplers are not airtight and will allow a variable amount of air leak. The remainder follows through the routine deployment of a circular stapler (Fig. 11.18). The distal end of the Roux-en-Y limb is closed with a linear stapler.

The distal entero-enterotomy may be created in a side-to-side fashion also using linear staplers (Fig. 11.19). We have also created this anastomosis with a circular stapling device as an end jejunum to side Roux limb. Here the entero-enterotomy is created before the esophageal anastomosis. The purse string and anvil are placed in the jejunal stump in a similar fashion to that previously mentioned for the esophagus. The stapling device is passed well down the cut end of the Roux limb (> 40 cm) before the receiving pin is deployed through the wall of the jejunum (Fig. 11.20). The circular stapling device is then deployed in the routine fashion.

Wound sites are closed with suture material of surgeon's preference.

## POSTOPERATIVE MANAGEMENT

Pain control in the postoperative period should be governed by symptoms, but may include narcotic and NSAIDS per preference. We treat these patients the same as with conventional gastric surgery. The nasogastric tube remains until the patient passes flatus. Diet is then advanced over the next 48 hrs. We prefer to perform a Gastrografin swallow prior to oral intake for the total gastrectomy patients.

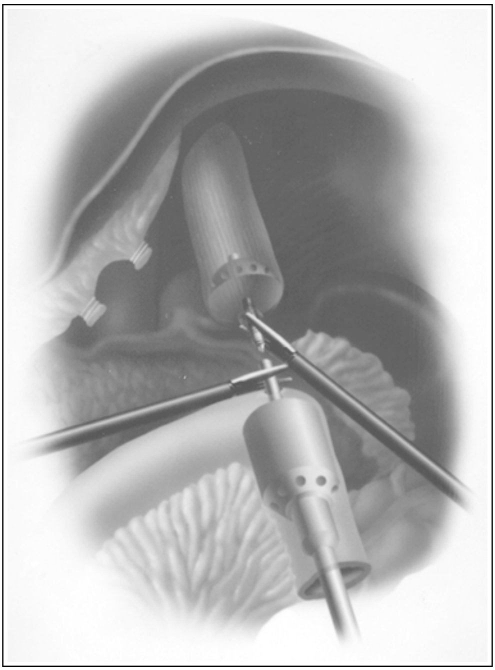

Fig. 11.18. Circular esophagojejunal anastomosis.

Fig. 11.19. Entero-enterotomy created with linear stapler.



Fig. 11.20. Entero-enterotomy created with circular stapler.

## SUMMARY

Our operative times for purely laparoscopic total gastrectomy averaged 6.5 hours, and 4 hours for subtotal gastrectomy.[4] We are fairly confident that hand-assistance will allow us to reduce our operative times substantially (perhaps by as much as 50% or greater). The hand assist method should also allow for greater control that should result in fewer conversions. The other potential benefits of the hand-assisted approach remain to be determined.

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# Laparoscopic Adrenal Surgery

*Sonia L. Sugg, Demetrius E.M. Litwin*



## INTRODUCTION

Since the introduction of laparoscopic adrenalectomy in 1992[1] its use has become increasingly widespread. The advantages of removing adrenal glands laparoscopically are related to the small incisions used in this procedure, resulting in decreased length of stay, decreased utilization of parenteral pain medication, and earlier return to functional status.

In this chapter, we will review the indications for laparoscopic adrenalectomy in surgical oncology, the clinical investigations required, the various surgical techniques, and discuss the controversies specifically related to approaching malignant adrenal lesions laparoscopically.

## PREOPERATIVE EVALUATION



The preoperative evaluation of a patient with an adrenal mass begins with a thorough history and physical exam focusing on the signs and symptoms of excess hormonal secretion (Table 12.1), as well as those resulting from a mass effect of the tumor consisting of abdominal, back, flank pain, and a palpable mass. Symptoms may be episodic, and therefore the history must be carefully elicited. All patients with known adrenal masses must undergo biochemical evaluation for hormonal function. Functional tumors may be clinically occult.[2,3] For example, some pheochromocytomas remain clinically silent until surgical stress or manipulation during surgery, or some asymptomatic cortisol producing adenomas can suppress contralateral adrenal function resulting in Addisonian crises after surgical removal.[3] An initial screening of serum electrolytes, urinary catecholamines, and serum and urinary basal cortisol is indicated in all patients,[4] and additional testing should be pursued as indicated (Table 12.2).

*Endosurgery for Cancer,* edited by Steve Eubanks, Ricardo V. Cohen, Riad N. Younes, Frederick Brody.

*Table 12.1. Symptoms and signs of adrenal hormonal excess*

| Cortisol | Aldosterone | Sex Hormones | Catecholamines |
|---|---|---|---|
| Diabetes | Hypertension | Virilizing (in females) | Sustained or paroxysmal hypertension |
| Truncal obesity | Muscle weakness | -amenorrhea | Palpitations |
| Buffalo hump | Hypokalemia | -hirsutism | Anxiety attacks |
| Moon facies | Metabolic alkalosis | -deepening voice | Flushing |
| Muscle wasting | Polyuria | | Excessive sweating |
| Osteoporosis | Polydipsia | Feminizing (in males) | |
| Mood swings | | -rare | |
| Hypertension | | -gynecomastia | |
| Edema | | -impotence | |

*Table 12.2. Biochemical evaluation of adrenal mass*

| | Cortisol | Aldosterone | Androgens | Catecholamines |
|---|---|---|---|---|
| Screening tests | 1 mg overnight dexamethasone suppression test<br>Urinary free cortisol | Plasma potassium | Plasma testosterone and androstenedione | 12 or 24 hour urinary metanephrines and VMA |
| Detailed testing | AM and PM plasma cortisol<br>Urinary 17-hydroxy-corticosteroid and 17-ketosteroids<br>Plasma corticotropin<br>Exogenous CRH test | Plasma renin and aldosterone levels<br>Saline loading test<br>Postural testing | | Clonidine suppression test |

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The initial imaging test of choice is a computerized tomography CT scan with fine cuts through the adrenal glands.[5] This test will detect with a high degree of accuracy tumors greater than or equal to 1 cm, possible involvement of other organs, metastatic disease, and extraadrenal disease. If there is concern of caval involvement, especially in large tumors suspicious for malignancy, a magnetic resonance imaging (MRI) scan should be obtained to rule out this possibility,[6,7] which would preclude a laparoscopic approach. The functional status of the tumor can be evaluated by scintiscanning. MIBG ($I^{123}$-meta-iodobenzylguanidine) scanning will detect most pheochromocytomas.[8] It is especially helpful in determining the presence of bilateral pheochromocytomas, extraadrenal paragangliomas and metastatic disease. Biopsy will provide imaging of functional cortical adenomas (cortisol and aldosterone producing tumors),[9,10] aid in the diagnosis of bilateral cortical hyperplasia, assess the functional status of the contralateral gland, and provide a guide for determining the malignant potential of a tumor (adrenocortical carcinomas usually display no or very low uptake of iodocholesterol).[7] It may be necessary to perform venous sampling in some cases of hyperaldosteronism to determine the presence of unilateral or bilateral disease.[11]

## INDICATIONS FOR SURGERY

### Adrenal Cortical Tumors

**Functional Adrenal Adenomas—Aldosteronomas and Cortisol Producing Adenomas**

Aldosteronomas, producing the clinical syndrome known as Conn's, usually present between the ages of 30 and 50, and are twice as common in women than in men.[12] Clinical symptoms are moderate to severe hypertension, and those related to hypokalemia such as muscle weakness, intermittent paralysis, and polyuria. Preoperative preparation includes controlling the hypertension and correcting hypokalemia. Spironolactone is commonly used.[13] The tumors are usually small, ranging from 1-3 cm in diameter.[12] Removal results in cure of hyperaldosteronism and hypokalemia. However, patients who are male, older than age 40, and with longstanding hypertension are most likely to have residual persistent elevation in blood pressure.[14]

Cortisol producing adenomas accounts for 10% of Cushing's syndrome. It occurs more frequently in females (3:1 female to male ratio), and commonly presents in the mid-thirties.[15] The tumors usually range in size from 3-5 cm. Tumors larger than 6 cm have an increased likelihood of being malignant.[16] Removal of the adenoma results in 100% cure, and the physical signs of Cushing's syndrome disappear within one year.[17] Postoperative cortisol replacement therapy is required until the hypothalamic-pituitary-adrenal axis recovers, which may require 6-18 months.[17]



**Nonfunctional Adrenal Masses—"Incidentalomas"**

With the increasing use of imaging studies such as ultrasound, CT scanning and MRI, asymptomatic adrenal masses are being discovered with greater frequency, at about a 5% incidence.[18] Most of these masses are benign nonfunctional cortical adenomas. However, the possibility of a functioning or malignant tumor must be ruled out. Possibilities include functional cortical adenomas, cortical carcinomas, pheochromocytomas, cysts, myelolipomas, ganglioneuromas, or adrenal metastasis.[19] A complete biochemical evaluation for adrenal cortical and medullary function must be performed, and functioning tumors should be excised. MRI scanning may help distinguish between tumor types such as cysts, myelolipomas, or pheochromocytomas based on signal intensity.[5] Iodocholesterol or MIBG scanning may detect subclinically functioning tumors.[20] Needle aspiration may be useful in determining the nature of an adrenal cyst by analysis of the cyst fluid for catecholamines or cytology.[21] It may also be useful for diagnosis in cases of adrenal metastasis from other tumors. Before attempting needle aspiration, pheochromocytoma must be ruled out by biochemical studies to prevent precipitation of catecholamine release by the aspiration.[22] There is concern about needle aspiration possibly seeding tumor cells in cases of possible adrenocortical carcinoma, and cytology is unable to distinguish between adrenal adenoma and carcinoma.[23] Therefore needle aspiration should be avoided in solid primary adrenal lesions, especially in operative candidates. The size of a biochemically silent adrenal mass has been used to determine operative strategy.[7] Tumors larger than 6 cm are generally thought to have a higher chance of being malignant and should be removed. Tumors 3 cm or smaller may be followed with serial CT scans and biochemical studies. Enlargement or change in functional status should prompt operation. However, it should be noted that adrenocortical carcinomas as small as 3 cm have been found to metastasize.[24] Management of masses between 3 and 6 cm is controversial, with some surgeons advocating operation in good risk patients,[25] and some preferring observation with interval CT scanning and biochemical testing.[19] However, with the advent of laparoscopic removal, it is likely that a more aggressive approach will be adopted and lesions larger than 3 cm in size will be removed.

**Adrenal Cortical Carcinoma**

This is a rare malignancy (0.5-2/million/year) with a poor prognosis (35% 5-year survival). The tumor more commonly affects females (female:male ratio of 2.5 to 1).[24,26] Patients present with symptoms of mass effect, excess hormonal secretion, and systemic symptoms of malignancy. The tumor is generally large, with an average size of 12 cm (range 3-30 cm) and an average weight of approximately 600 gm (range 12-4750 gm).[24,26] Metastasis occur most commonly in the liver, lung, and adjacent organs. Staging is based on the MacFarlane classification. Stages I and II are defined as local disease with no lymph node or distant metastasis, and no local invasion. Stage I tumors are less than 5 cm, and stage II tumors are larger than 5 cm. Regional disease with lymph node spread/local invasion is defined as stage III. Stage IV tumors have distant metastasis. At diagnosis, only 4% of patients have stage I disease. In contrast, approximately 40% are stage II, 26% are stage III and 30% are stage IV. Mean survival times correlate with stage: 34-40 months for stage I and II disease, 22 to 26 months for stage III disease and 8-9 months for stage IV disease. The overall mean survival is 21 months, and the overall 5 year survival rate is 35%.[24,26] The survival rate for patients who underwent curative resection was significantly higher than patients with tumors that were unresectable.[26] The lack of effective alternative therapies including radiation and chemotherapy for adrenal cortical carcinoma makes complete surgical resection the only option for potential cure. For this reason, not only should the initial lesion be aggressively resected, but local recurrence should be treated with reresection if possible. Contiguous organs such as kidney, distal pancreas, colon, and spleen invaded with tumor should be resected en bloc.[7] In patients without systemic metastasis, extension of the tumor into the vena cava may require venovenous or cardiopulmonary bypass for complete removal of the tumor thrombus.[7] In patients with tumors producing significant clinical syndromes, efforts to remove all gross tumor should be attempted. Because of the extensive surgery often required, most surgeons therefore advocate laparotomy instead of laparoscopic surgery for preoperatively diagnosed adrenocortical carcinoma.[27] However, if the diagnosis is made postoperatively by the pathologist, and the tumor has been removed laparoscopically, open re-resection is probably unnecessary if the tumour capsule has not been breached by tumor and a margin exists.

**Pheochromocytoma**

These are catecholamine producing neuroendocrine tumors of the adrenal medulla. Though this is a rare tumor, with an incidence ranging from 1.3/100,000 to 1/500,000, many pheochromocytomas remain undetected until autopsy.[28] Extraadrenal pheochromocytomas, also known as paragangliomas, may be found along the sympathetic chain ganglia. Malignancy occurs in 10-20% of pheochromocytomas.[29] There is an association with familial syndromes, such as multiple endocrine neoplasia II, neurofibromatosis, and Von Hipple Lindau disease.[30,31] Prior to surgery, patients must be prepared by $\alpha$-adrenergic blockade. After $\alpha$-blockade is accomplished, $\beta$-adrenergic blockage may be added if the patient has tachycardia or arrhythmia. Intraoperative blood pressure needs to be monitored by arterial line and volume status by central venous pressure.[32] Pheochromocytomas are usually at least 4 cm in diameter, and can be quite hypervascular with large veins on the surface. During operation, care must be taken to avoid manipulating or compressing the tumor, which can lead to sudden release of catecholamines and subsequent blood pressure fluctuations, even if the patient has been adequately blocked. The laparoscopic approach, with magnification and identification of tissue planes, allows for more gentle handling of pheochromocytomas. Traditionally, central vein clipped first to end efflux of catecholamines and blood pressure fluctuations. We have found it not necessary in most cases with adequate blockade. In our experience, clipping the central vein first often led to engorgement of the tumor with a more difficult resection as a result. Ten percent of pheochromocytomas are multifocal, and an even higher incidence is present in familial syndromes. Although it is possible to explore the potential areas of extraadrenal pheochromocytomas or paragangliomas laparoscopically, it can be time consuming. We recommend a good quality abdominal and pelvic CT scan and/or MIBG scan to screen for additional tumors prior to operation. Potential areas include the opposite adrenal, paraaortic regions from the celiac axis to aortic bifurcation, the organ of Zuckerkandl, and rarely, within the bladder. Postoperatively, patients with pheochromocytomas need to be monitored by urinary catecholamines for the development of malignant disease, which can occur as late as 7-10 years after resection of a primary tumor that appears benign on pathologic examination.[33]



**Bilateral Adrenal Hyperplasia—Cushing's Disease, Ectopic ACTH Syndrome**

Cushing's disease is the most common primary cause of hypercortisolism. Bilateral adrenal cortical hyperplasia is caused by excess adrenocorticotropic hormone (ACTH) secretion by a pituitary adenoma. The treatment of choice is transsphenoidal pituitary surgery or irradiation. Failure of surgery and subsequent medically uncontrollable Cushing's syndrome leads to bilateral adrenalectomy as the last resort, which will result in lifelong cortisol and mineralocorticoid replacement.[34] The surgical complication rate for this group of patients has been higher due to their excess corticosteroid secretion resulting in decreased immune function and delayed wound healing. The patients must be prepared for surgery with control of their diabetes, hypercortisolism, and hypertension. Though there have been no specific studies of laparoscopic adrenalectomy in these patients, the small surgical incisions, quicker mobilization and shorter length of stay associated with the laparoscopic approach should prove beneficial to this group of patients.

Ectopic ACTH syndrome is an uncommon cause of excess cortisol production. In a review of 41 patients by Zeiger et al, the source of ACTH in half of the patients was bronchial carcinoid, followed by pancreatic endocrine tumors, thymic carcinoid, medullary cancer of the thyroid, pheochromocytoma, small cell lung cancer, and occult disease.[35] Bilateral adrenalectomy is indicated in patients with occult disease, or unresectable metastatic pancreatic ACTH producing tumors that fail medical therapy by cortisol-blocking agents.

**Primary Nodular Adrenal Hyperplasia**

This is a rare syndrome of hypercortisolism associated with multiple small hyperfunctioning adrenal nodules. It may be associated with Carney's syndrome with cardiac myxomas, hyperpigmentation of the skin and buccal mucosal and other endocrine disorders such as growth hormone producing pituitary adenomas.[36] The treatment consists of bilateral adrenalectomy.

**Metastasis**

Metastasis to the adrenal glands are relatively common. The most common types are lung carcinoma, renal cell carcinoma and melanoma.[37] In most cases, the metastasis is a component of systemic disease and should not be resected. However, resection may be appropriate in certain cases where the adrenal lesion is the only site of recurrence in an otherwise healthy and disease free patient. The laparoscopic approach is ideal in this instance because it allows for inspection of peritoneal surfaces and intra-abdominal organs for occult metastasis prior to resection of the adrenal gland. Laparoscopic ultrasound may be used as an adjunct.



## SURGICAL TECHNIQUES

In open surgery, there are three approaches to adrenalectomy—anterior, posterior, and lateral. The lateral approach is generally reserved for very large tumors, and may include a thoracic component. The posterior approach was advocated by many for smaller (< 6 cm) adrenal lesions, as the recovery times were less than those of the anterior approach because the peritoneal space was not entered.[38] The anterior approach facilitated exposure and could exclude other tumors, and was preferred for larger adrenal masses and pheochromocytomas. Prinz compared three groups of patients who underwent adrenalectomy via the anterior and posterior open approaches, and lateral laparoscopic approach. The patients undergoing laparoscopic adrenalectomy had a significantly shorter length of stay and required less postoperative analgesia.[39]

Laparoscopically, there have also been three methods advocated which parallel the open approaches. The anterior approach[40] provides difficult exposure to the adrenal glands and is not in widespread use.[27] The lateral approach, developed by Gagner et al, has the advantage of allowing gravity to assist in the exposure by allowing the bowel, spleen, and pancreas to fall away from the operative field.[41] It allows for the removal of very large tumors, and is easier to learn because of familiar anatomical landmarks. In the case of bilateral adrenalectomies, it requires repositioning of the patient, which can add at least 20 minutes to the operating time. We favor the lateral approach and will describe it in the following section.[42] The posterior approach has been described in detail elsewhere. An initial balloon trocar is placed lateral to the 12th rib, and the retroperitoneal space is created by balloon expansion. Insufflation is maintained using $CO_2$. Additional trocars are placed adjacent to the 10th, 11th and 12th ribs[42] or positioned posteriorly between the costal margin and the iliac crest.[27] The adrenal gland is identified, with the help of laparoscopic ultrasound, if necessary, dissected and removed. The advantages of this approach lies in avoiding entering the peritoneum, especially in cases with previous abdominal surgery, and obviating the need for repositioning in cases of bilateral adrenalectomy. Disadvantages include the size limitation of the lesion removed, due to the smaller potential space in the retroperitoneum for manipulation of instruments, occasional difficulty in identifying the gland within the retroperitoneal fat, limited access to the vena cava for vascular control, and a low incidence of postoperative neuralgia secondary to port placement adjacent to the intercostal nerves.[27] Duh et al reviewed their experience with both methods and found them to be comparable in terms of operative time and length of stay.[27] They especially favor the posterior approach for bilateral lesions.

### Lateral Laparoscopic Approach

The patient is placed in the lateral decubitus position with the affected side facing up. The table is flexed for maximum exposure of the space between the costal margin and iliac crest. The patient is secured and pressure points are carefully padded (Fig. 12.1). The surgeon and assistant stands facing the patient. The peritoneal cavity is insufflated with $CO_2$ to 15 mm Hg through a Veress needle placed inferior to the costal margin in the anterior axillary line. An 11 mm trocar is placed at this site and the peritoneal cavity is inspected with a 30°, 10 mm laparoscope. Another 11 mm trocar is placed along the costal margin in the posterior axillary line, and a 5 mm trocar is placed 5-8 cm cephalad to the first trocar also along the costal margin in the epigastrium. This positioning will allow for triangulation. Using forceps and scissors, exposure of the adrenal gland can begin.



On the left, the spleen is mobilized by incising the entire lateral peritoneum of the spleen to the level of the diaphragm. By grasping this edge of peritoneum, the operating surgeon can roll the spleen forward to expose the underlying kidney and adrenal gland. There is loose areolar tissue in this plane which can be both bluntly and sharply dissected. Gerota's fascia should not be entered. The spleen and tail of pancreas must be brought forward in this fashion, since this much mobilization is required to safely dissect the left adrenal vein. The adrenal gland is

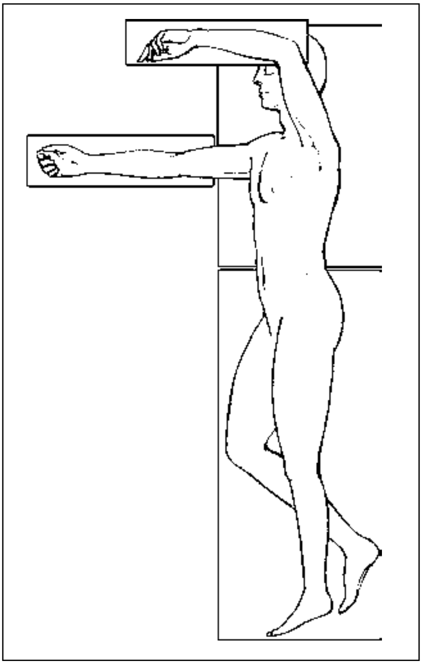

Fig. 12.1. Patient position for laparoscopic left adrenalectomy.

almost always obvious. Usually the dissection begins at the lateral aspect of the gland or the upper pole and numerous small vessels surrounding the gland are divided. Generally electrocautery is sufficient for hemostasis although occasionally clipping is required. Once the dissection around the gland has begun, the edge of the gland becomes obvious and it proceeds without difficulty. The adrenal vein is usually the last structure divided and is at the inferior and medial portion of the gland. It is always clipped prior to division. Rarely, an additional posterior trocar must be placed for retraction of the spleen. On the right, the first three trocars are placed as on the left, and an additional 5 mm trocar is always placed for medial retraction of the liver. The liver is mobilized by dividing the triangular ligament. This will swing the liver forward. The right adrenal is then exposed. It is dissected away from the surrounding perinephric fat in the same fashion as the left. The adrenal vein is identified at the superior and medial portion of the gland and it is doubly clipped and divided at its junction with the vena cava. The medial aspect of the gland is closely applied to the vena cava and care must be exercised separating the gland from that vena cava. The posterior attachments are avascular on both the right and left sides and can be easily and rapidly divided and the gland freed. After hemostasis is established, the adrenal gland or tumor is placed into a thick plastic extraction bag and removed through the anterior 11 mm trocar site. It may be necessary to fragment the tumor or enlarge the trocar site for removal of a large tumor.

### Special Considerations for Malignant/Potentially Malignant Tumors

Malignant adrenal tumors, including pheochromocytomas and adrenocortical carcinoma, often cannot be diagnosed preoperatively. Though these tumors are rare, every pheochromocytoma and adrenal cortical tumor must be handled as if potentially malignant because the consequences of tumor seeding can be fatal. Though there have been documented cases of tumor implantation in laparoscopic colon cancer resections,[43] such cases have not yet been reported with adrenal tumors. The extraction of the adrenal tumor must be carefully done to avoid tumor spillage. A thick and sturdy plastic bag should be employed. If possible, the tumor should be extracted intact to aid in pathologic diagnosis. The difficulty lies in larger tumors, which have the highest chance of being malignant, and yet require fragmentation for removal without a large incision. Fragmentation can destroy histologic features used for the determination of malignancy by the pathologist such as capsular invasion and patterns of necrosis. We attempt to fragment the tumor into several large pieces in order to preserve as much architectural detail as possible. We approach all adrenal lesions laparoscopically unless there is evidence of gross invasion of adjacent organs. With the magnification achieved during laparoscopic examination, we are able to delineate tissue planes and identify gross evidence of tumor invasion. If major organ invasion is present, we advocate an open approach for complete radical resection of the tumor and adjacent invaded soft tissue and organs. Radical resection has been performed laparoscopically,[44] but the increased time required may outweigh the benefits.

### Results

In the past 2 years, we performed 20 right, 17 left, 2 partial and 2 bilateral laparoscopic adrenalectomies in 41 patients. The average patient age was 46 years (range: 15-74 years) and the female to male ratio was 2.7:1. Seventeen patients had Conn's syndrome, 9 had pheochromocytoma, 8 has Cushing's syndrome, 3 had adrenal metastases, and one each had myelolipoma, adrenal cyst, Cushing's disease and ectopic ACTH syndrome. There was one patient with a malignant pheochromocytoma (7 cm) and one case of adrenocortical carcinoma (8 cm) in a patient with Cushing's syndrome. In both cases the tumor was well encapsulated and removed without rupture. Two patients had adrenal metastasis from contralateral renal carcinoma, and one patient had a metastasis from colorectal carcinoma.



The average tumor size in the 41 patients was 3.9 cm (range: 1-10 cm). Our average operating time was 139 minutes and ranged from 80-295 minutes. The operating time correlated with tumor size. The average estimated blood loss was 127 cc (range: 10-400 cc), and did not correlate with tumor size. Intraoperative complications included one liver laceration and one splenic capsular tear, both easily controlled. There were no conversions to open surgery and no blood transfusions. Postoperative complications were minor and no deaths occurred. On average, patients were discharged on POD 2.9 (range: 1-9 days) tolerating a regular diet. Increased length of stay was associated with increased age, but not with increased operating time or blood loss. Our results compare favorably with those of other published reports.

## SUMMARY

Laparoscopic adrenalectomy has rapidly become many surgeons' method of choice for removing adrenal glands or tumors. The benefits of less postoperative pain and earlier discharge and return to functional status are clear. Although the procedure requires a high degree of technical expertise in laparoscopy, it can be performed with minimal morbidity and mortality by trained surgeons. In addition to the technical aspects, resection of adrenal glands and tumors requires detailed knowledge of the endocrine aspects of preoperative diagnosis, intraoperative and postoperative management. The laparoscopic approach is particularly suited to surgical oncology because of its ability to diagnose disease spread prior to resection with minimal morbidity. Malignant tumors may be encountered during laparoscopic adrenalectomy but can be appropriately managed as detailed above. This review covered aspects of laparoscopic adrenalectomy with special attention to its importance in the area of surgical oncology.

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# Videolaparoscopy in Kidney Tumors

*Anuar Ibrahim Mitre, Lísias Nogueira Castilho*



## INTRODUCTION

The European pioneers, Kelling and Jacobeus,[1] first utilized laparoscopic techniques during the early 20th century. However the use of gynecological laparoscopy did not become widespread until the 1950s with the development and enhancement of optical fibers and telescopic lens systems. Laparoscopy blossomed again during the 1970s and 80s with the development of microcameras and special surgical instruments. In 1976, urological laparoscopy developed when Cortesi et al[2] described the laparoscopic treatment of bilateral cryptorchidism. In 1991, Clayman et al[3] performed the first laparoscopic nephrectomy in an 85-year-old woman with a left renal oncocytoma. During the intervening 15 years between Cortesi and Clayman, several other pioneers have developed innovative urologic techniques for laparoscopy.

From 1990 to 1996 about 400 laparoscopic nephrectomies were reported in the literature by a few groups. Each group added or modified specific technical details making the surgical procedure slightly different and in many cases more efficient.[3-37] Several of these authors have documented superior results following laparoscopic surgery versus conventional open surgery in selected groups of patients.[11,32] Currently, laparoscopic nephrectomy is a well-established procedure that unfortunately is only practiced in several centers of excellence. Of the 400 nephrectomies reported since 1991, approximately 80 cases were performed for renal or ureteral cancer.[4,5,7,25,26,33] Although the experience is relatively new and small, the following preliminary data support the use of laparoscopic nephrectomy.



*Endosurgery for Cancer,* edited by Steve Eubanks, Ricardo V. Cohen, Riad N. Younes, Frederick Brody.

## PATIENT SELECTION

Contraindications to laparoscopic nephrectomy include hemodynamic instability, generalized peritonitis, bowel distension, uncorrected coagulopathy, severe cardiopulmonary disease and previous ipsilateral retroperitoneal surgery. Previous ipsilateral retroperitoneal surgery constitutes a contraindication to the laparoscopic approach secondary to the dense adhesions making laparoscopic dissection tedious and dangerous. Previous intra-abdominal surgery is not a contraindication to the laparoscopic approach. Tumors greater than 6 cm (T3bN0M0) have been successfully removed laparoscopically.[26] However the operation is long and technically demanding. The majority of large tumors are treated by formal laparotomy with or without thoracic extension. With the advent of ultrasound, nuclear magnetic resonance and computerized tomography, the number of asymptomatic patients with smaller tumors (T1 or T2N0M0) is growing.[26] These patients are ideally suited for laparoscopic nephrectomies. Similarly, patients with ureteral tumors can also undergo a laparoscopic radical nephrectomy. The indications and contraindications follow the same criteria as for renal carcinoma. Partial nephrectomies and renal wedge resections have also been completed laparoscopically. The international experience with regard to these procedures is small, but these surgical techniques have been established experimentally and clinically.[15,26]

## PATIENT PREPARATION

Initially, patients undergoing laparoscopic nephrectomy were subjected to ipsilateral renal artery embolization, ipsilateral ureteral catheterization and mechanical colon preparation.[3] Since these initial patients and with greater laparoscopic experience, embolization and ureteral catheterization have been abandoned. A colonic preparation is still incorporated.

Following intubation a nasogastric tube and foley catheter are placed and the patient is securely positioned on the operating table. Details regarding positioning are discussed below. Finally, instrumentation for open conversion should be available in the operating room.

13

## RADICAL NEPHRECTOMY

### Surgical Technique

The majority of laparoscopic nephrectomies are performed through a transperitoneal approach, as opposed to a retroperitoneal approach. The endoscopic working space utilized during the retroperitoneal technique is significantly smaller versus the transabdominal approach making dissection, especially of the renal vessels, more difficult. Specimen retrieval through a smaller midline incision is also easier during the transabdominal approach. The kidney is removed through the lumbar region when a retroperitoneal approach is used. The lumbar incision is associated with increased pain and herniation. The basic equipment for either approach is summarized in Table 13.1. At this time a morcellation is not necessary and can potentially alter the pathological staging.[19,31]

**Transperitoneal Route**

The patient is positioned in a modified decubitus position at 45°. Depending upon body habitus, the arm is either tucked to the side or secured to an ether screen. The torso and legs are secured to the operating table with a belt and/or tape as rotational movements are required during the operation. As opposed to a true 90° lateral decubitus position, this modified position provides easy access to the abdomen if emergent vascular control is required.

The surgical team is positioned as shown in Figure 13.1. A Hasson trocar is placed in the midclavicular line at the level of the umbilicus. After creating the pneumoperitoneum, subsequent trocars are placed as depicted in Figure 13.2. Eleven and 12 mm trocars are used in order to facilitate dynamic movement of the laparoscope throughout the procedure as well as the larger clip pliers and vascular staplers currently available. The four basic trocars are utilized for either a right or left nephrectomy with additional trocars placed for either dissection or retraction.

After inspecting the abdomen the colon is mobilized medially from either the hepatic or splenic flexures inferiorly toward the pelvic rim. Adequate colonic

*Table 13.1. Basic equipment for radical videolaparoscopic nephrectomy*

| | |
|---|---|
| 1 | monitor |
| 1 | $CO_2$ automatic insufflator and $CO_2$ line |
| 1 | videocamera |
| 1 | automatic high intensity light source |
| 1 | VCR |
| 1 | light cable |
| 1 | Veress needle |
| 1 | Hasson cannula |
| 1 | 10 mm 0° laparoscope |
| 4 | 10/11 mm trocars with reducers |
| 1 | 12 mm trocar |
| 2 | 5 mm trocars |
| 1 | 5 mm curved electrosurgical scissors |
| 1 | 10 mm fan-type retractor |
| 2 | 5 mm atraumatic grasping forceps |
| 2 | 5 mm traumatic grasping forceps |
| 1 | 9 mm clip applier |
| 1 | 11 mm clip applier |
| 1 | vascular linear stapler |
| 1 | 10 mm right-angle dissector |
| 1 | 5 mm irrigator/aspirator |
| 1 | surgical entrapment sac |
| 1 | 5 mm bipolar cautery |

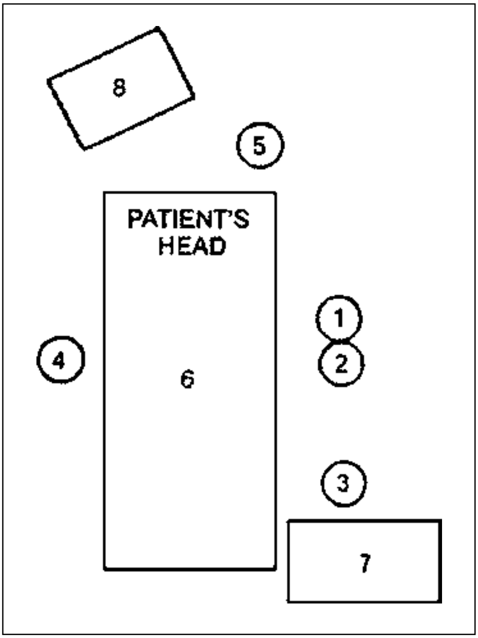


Fig. 13.1. Disposition of basic equipment and personnel in the operative room for right transperitoneal radical nephrectomy or left retroperitoneal radical nephrectomy. 1: Surgeon; 2: Camera assistant; 3: Scrub nurse; 4: Second assistant; 5: Anesthesiologist; 6: Table; 7: Sterile setup table; 8: Monitor, Video cart, Camera box, VCR, Light source, $CO_2$ insufflation

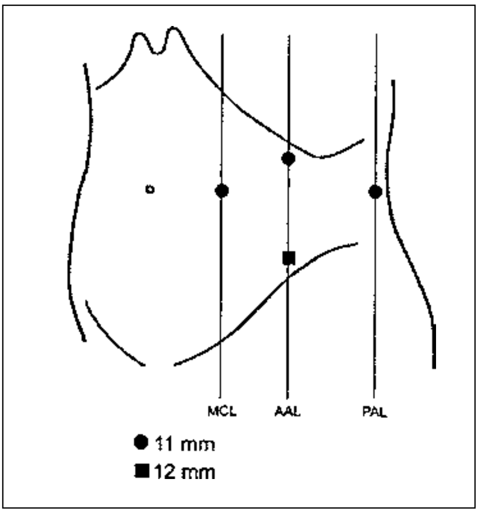


Fig. 13.2. Port sites for transperitoneal radical nephrectomy (MCL-midclavicular line, AAL-anterior axillary line, PAL-posterior axillary line)

mobilization exposes the renal hilum and vessels as well as the ureter. Inferior mobilization is complete when the colon lies below the renal hilum without requiring retraction. Adjusting the operating table to approximately 45° allows the colon to fall further medially and inferiorly. Hilar dissection of either kidney is complicated and prolonged by colonic dilatation, inadequate colonic mobilization or a poorly prepared colon. Our own operative times have significantly decreased through adequate colonic mobilization.

The single renal vein is easily identified and the arterial supply is approached sequentially at its terminal branches or proximally at its main trunk or bifurcation. These vessels can usually be clipped with 9, 11 or 12 mm clips. Three clips are placed at the aortic side and two on the specimen side. A similar approach is used for venous control. If the vein is too large, a vascular stapler can be used. Alternative techniques include extra- and intracorporeal knots and or endoloops combined with clips. Staplers are especially useful during difficult dissections or for urgent vascular control. If a stapler is utilized to secure the hilum en bloc, the risk, albeit small, of an arteriovenous fistula is small.

The body of the kidney is cleanly dissected without violating Gerota's fascia. The dissection plane is as in conventional open surgery. The adrenal glands may or may not be included in the specimen. The gland is currently removed en bloc for upper pole tumors or for involvement documented preoperatively by MRI or CT scan. If the left adrenal gland remains in situ, the left adrenal vein may require ligation depending upon proximal dissection of the left renal vein.

The ureter is ligated with either intra- or extracorporeal knots, clips or endoloops. The ureter can be dissected or ligated early in the procedure for retraction purposes or as the final step in the procedure.

Extensive lymphadenectomy as described by Robson[39] is rarely performed today. Although technically feasible, a radical laparoscopic lymphadenectomy from the diaphragm to the aortic bifurcation increases operative times and does not alter prognosis. Periaortic and pericaval nodes are dissected at the level of the renal hilum for staging purposes.



The surgical specimen is removed en bloc after placing it in a retrieval sac. We use a lower midline incision extended 5-8 cm for removal. The retrieval sac allows for a smaller abdominal incision and prevents malignant implants during removal. Other authors recommend extension of a lateral port site, but we have found greater cosmesis and postoperative comfort with a midline incision. Certain authors have even utilized transvaginal specimen removal.[7] Morcellation has also been recommended. However, subsequent pathologic characterization regarding microinvasion and multicentricity is difficult. At this time we recommended en bloc retrieval of all surgical specimens.[8]

**Retroperitoneal Approach**

The surgical team is arranged as in Figure 13.1 with equipment as outlined in Table 13.1. A Gaur device is required as well.[13]

The patient is placed in a full lateral decubitus position. An initial 1.5 cm incision is made in the posterior axillary line just above the iliac crest. The retroperitoneum is accessed with blunt finger dissection followed by introduction of the Gaur device and creation of the endoscopic retroperitoneal space. Approximately 1 liter of $CO_2$ is used to create an adequate dissection space. Distension is monitored through the laparoscope.

Subsequent trocars are inserted under direct vision as in Figure 13.3. Exact trocar placement is variable and depends upon the surgeon's preference as well as patient anatomy.[9,10,26,29] Additional trocars can be placed as needed for retraction of dissection.

The retroperitoneal dissection is essentially the same as the transperitoneal approach except that arterial ligation precedes venous ligation when approached posteriorly. Again, clips, sutures or staples can be used. The ureter is then secured and the specimen is dissected from the adrenal gland, when required, and all further retroperitoneal attachments. The specimen is retrieved by enlarging a trocar site in the lower lumbar region.

Postoperative care is similar regardless of surgical approach. Oral intake is usually started on postoperative dayÍ (POD) 1 and the patient is quickly advanced to a regular diet as tolerated. Ambulation is encouraged on POD 1 as well. Hospital length of stay varies from 3-7 days and return to activities of daily living is usually faster than after open nephrectomy regardless of the laparoscopic approach employed.[20,22,26,32]

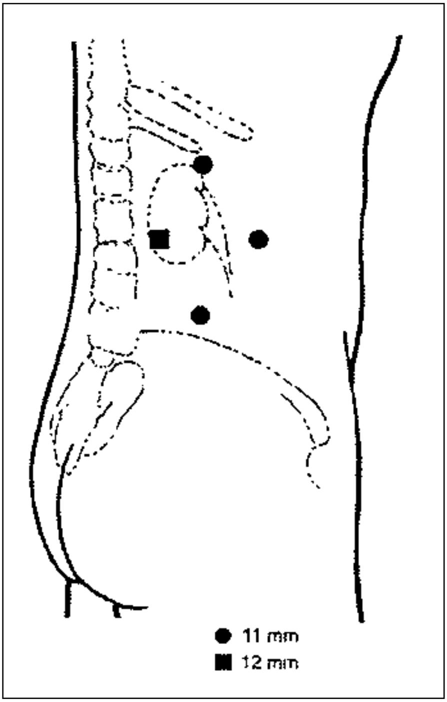


Fig. 13.3. Port sites for retroperitoneal radical nephrectomy.

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### Results

A recent series of 56 retroperitoneal nephrectomies reported operative times of 5-8 h with recovery times of three weeks. At 14 months follow-up, no distant metastases or local recurrences were detected and no operative deaths were reported.

A series of 32 patients from Gill et al[16] in 1995 noted a 10% major complication rate. Complications included a superior mesenteric artery injury requiring open conversion and repair as well as two injuries to the renal vein requiring open conversion. Four cases of cardiac insufficiency and/or myocardial ischemia and one case of acute tubular necrosis were noted also. No late sequelae occurred in any case. Overall five patients (16%) required conversion to open surgery.

Preliminary results are encouraging. However, larger patient cohorts and long-term follow-up are required prior to definitive conclusions regarding laparoscopic nephrectomies.

## PARTIAL NEPHROURETERECTOMY

Although both approaches have been described, the transperitoneal laparoscopic transabdominal technique is easier to learn and is technically less demanding than the endoscopic retroperitoneal approach.[21,33] Currently, we feel that the laparoscopic transabdominal technique provides easier access to the distal ureter and bladder cuff while observing oncologic principles.

The initial steps of trocar placement and pneumoperitoneum are completed as described above. The ureter is dissected distally but not severed. A clip may be placed across its lumen to prevent residual urine from leaking during the procedure. The dissection proceeds distally along the ureter to the bladder. As in conventional open surgery, the median umbilical ligament and the vas deferens, or round ligament, may be divided to access the distal ureter (Fig. 13.4). A groin or lower midline incision is performed and a cuff of bladder is resected. The bladder is closed in two layers with absorbable suture. The bladder resection and repair may be performed laparoscopically; however, we find an open, assisted technique much quicker. The entire specimen—kidney, ureter and bladder cuff—is removed en bloc through the groin or midline incision. Bladder resection and closure have been accomplished with linear staples. Although no clinical cases have been reported, stone formation or recurrent infections are possible with metallic staples left in the bladder wall.[26] Although not currently available, absorbable clips may solve this technical problem.



### Results

Recently 22 cases have been described by five separate authors. The average surgical time was 8 h with a length of hospital stay of five days.[26] One postoperative death secondary to respiratory failure occurred following massive blood transfusions required for vascular injury. One locoregional recurrence was described one year after surgical resection as well. Again, these cohort groups are exceed-

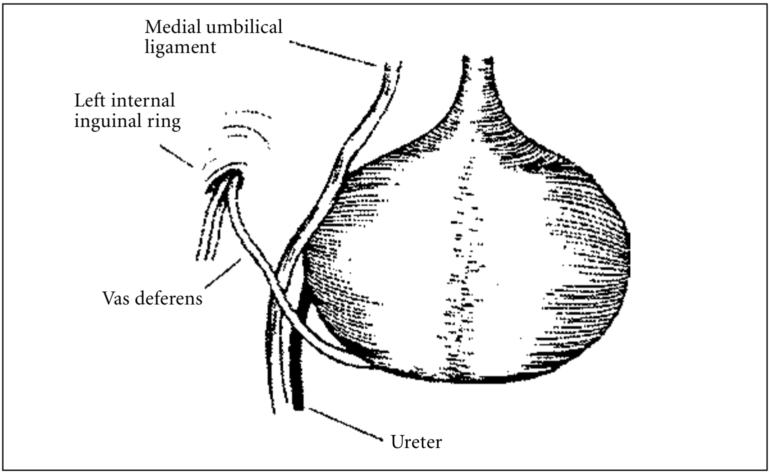


Fig. 13.4. Male anatomy of distal ureter. To perform a complete ureterectomy and excise a bladder cuff, both vas deferens and medial umbilical ligament have to be severed.

ingly small and long-term follow-up is not available to make definitive conclusions regarding this technique.

## PARTIAL NEPHRECTOMY AND RENAL WEDGE RESECTION

Although a radical nephrectomy has been the gold standard for the treatment of renal carcinoma, specific clinical scenarios may allow a partial nephrectomy or even a renal wedge resection. These specific situations usually involve small tumors in individuals with solitary kidneys or chronic renal insufficiency. However these lesser procedures have been performed in patients with tumors less than 3 cm and normal renal function coupled with a normal contralateral kidney.[15]

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The partial nephrectomy follows the initial steps outlined for a transperitoneal radical nephrectomy. However fundamental differences do exist. The main trunk of the renal vein or artery cannot be ligated, and Gerota's fascia is opened for dissection. Segmental ligation of venous tributaries and terminal arterial branches is performed, and the renal parenchyma is resected with an argon beam coagulator or bipolar electrical coagulator. Gill's device (Fig. 13.5) is particularly useful but not essential for hemostasis and retraction.[15] When transected, the collecting system should be closed with intra- or extracorporeal knots. In addition to the preoperatively placed double J stent, external drainage with a Jackson Pratt system or Penrose should always be employed after completing the procedure.

Renal wedge resections are usually reserved for small tumors of the renal cortex without involvement of the collecting system. Recently, two cases, one benign and one malignant, have been described by Nakoda et al.[26] Neither case required suturing of the collecting system.

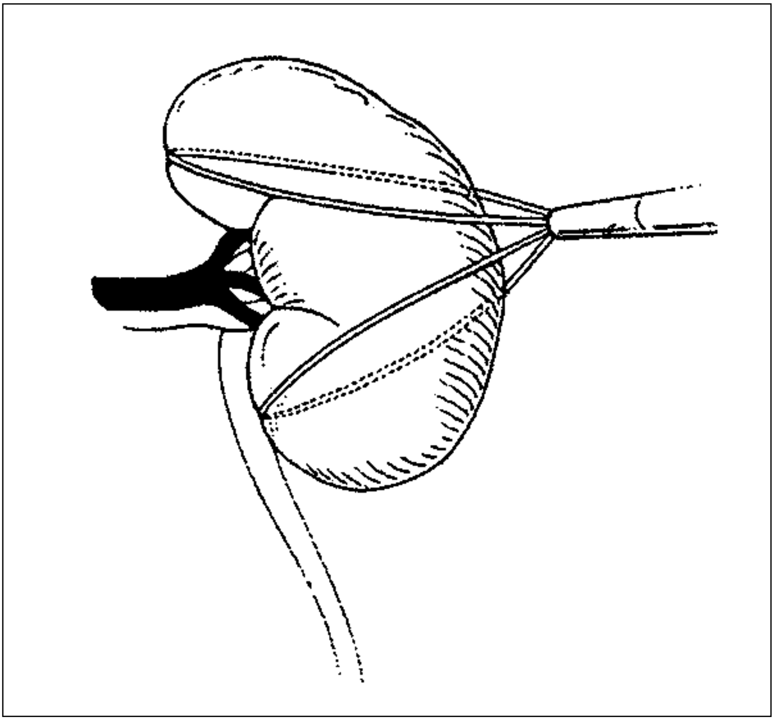

Fig. 13.5. Gill's device.

## CONCLUSION



Utilizing a laparoscopic and an endoscopic retroperitoneal approach, radical nephrectomies, radical nephroureterectomies, partial nephrectomies and renal wedge resections have been performed for excising renal tumors. Although the current cohort is small and long-term follow-up data is not available, the current laparoscopic techniques are feasible, reproducible, and safe. Since its origin in 1990, urologic laparoscopy for renal tumors is expanding, and significant data should be available in the near future.

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# Laparoscopic Surgery in Kidney Cancer

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Renal cell carcinoma is the most common primary renal malignancy, accounting for approximately 25,000 cases annually in the United States and resulting in over 10,000 deaths. It is the tenth most common cancer, constituting 3% of all adult malignancies, and generally occurs in adults between the ages of 50 and 70. Males are affected twice as frequently as females.[1] It occurs bilaterally in 2 to 4% of individuals either synchronously or metachronously. The incidence of renal carcinoma has steadily increased from 1935 to 1989. However, the mortality has decreased over the same interval,[2] suggesting effective treatment or earlier diagnosis.

In recent years, the widespread use of abdominal ultrasonography and computed tomography (CT) has increased detection of real cell carcinoma.[3] Tumors found incidentally are typically smaller than those that produce symptoms and more likely to be resected for cure.[4] CT imaging is the diagnostic procedure of choice when a solid renal mass is seen on ultrasound. Initial staging with CT delineates retroperitoneal adenopathy, perinephric fat invasion, vascular involvement and locoregional extension.

The classic triad of hematuria, pain and a flank mass is associated with renal cell carcinoma. However, the complete triad is present in less that 20% of cases. Hematuria (microscopic or gross) is present in 50% of patients, while flank pain is present in only 40%, and less than 30% have a palpable abdominal or flank mass. Other clinical signs and symptoms of renal carcinoma are broad and nonspecific including fever, hypertension, weakness, hypercalcemia, and anemia. They often are part of a paraneoplastic syndrome.[5]



The most important determinant of survival is the anatomical extent of the tumor. Patients with Stage I or II disease and able to complete surgical resection have better outcomes than those patients with nodal involvement or distant metastases. The Robson staging system[6] is commonly used to define the extent of disease (Table 14.1).

Appropriate treatment of renal tumors is determined almost entirely by the clinical stage at presentation. Surgical resection remains the cornerstone of treatment for renal cell carcinoma. Radical nephrectomy, which includes resection of the kidney, perirenal fat, and adrenal gland was adopted in 1969.[6]

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*Table 14.1. Robson staging system for renal cell carcinoma*

| Stage | |
|---|---|
| I | Confined to renal capsule |
| II | Through renal capsule, confined to Gerota's fascia |
| IIIA | Renal vein involvement |
| IIIB | Lymphatic involvement |
| IVA | Contiguous organ involvement |
| IVB | Metastatic spread |

Several series of laparoscopic nephrectomies and adrenalectomies for benign disease have recently been published.[7,8] Early data indicate that patients undergoing laparoscopic nephrectomy have a significant reduction in hospital stay and postoperative analgesic requirements when compared to patients undergoing conventional open nephrectomy.[7] However, laparoscopic radical nephrectomy is controversial with regard to adequacy of dissection, potential for tumor spillage, and accuracy of pathologic staging.

The first laparoscopic nephrectomy, performed in 1990, was done in a patient with a 3 cm renal tumor that was subsequently diagnosed as a oncocytoma.[9] Since then other laparoscopic total and radical nephrectomies have been performed for renal tumors. To date, this approach is limited to tumors 6 cm or smaller without evidence of renal vein involvement.

## OPERATIVE TECHNIQUE

Laparoscopic radical nephrectomy may be successfully performed utilizing either a transperitoneal, transperitoneal hand-assisted or retroperitoneal approach.

We currently utilize a transperitoneal approach. With the patient in a lateral decubitus position, pneumoperitoneum is established through a 12 mm incision at the umbilicus. A 30° laparoscope is introduced through this trocar and the subsequent trocars are placed under direct visual control. A 12 mm subcostal port along the midclavicular line, a 5 mm port, 3 cm below the umbilicus in the midclavicular line, a 5 mm port in the anterior axillar line at the tip of the $12^{th}$ rib and a 5 mm port in the anterior axillary line at the level of the umbilicus (Fig. 14.1). A total of ten steps are followed during a transperitoneal laparoscopic nephrectomy:

- incision along the line of Toldt;
- dissection and lateral retraction of the ureter;
- renal hilar dissection;
- occlusion and transection of the renal artery, secured with five 9 mm clips;
- mobilization of the lateral surface and superior and inferior poles of the kidney;
- transection of the ureter between two 9 mm clips;

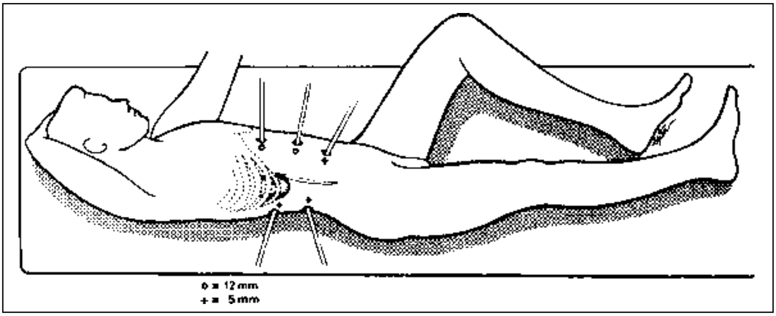


Fig. 14.1. Schematic drawing of port placement for transperitoneal laparoscopic right nephrectomy. The patient is in the lateral position.

- introduction of a 5 x 8 inch impermeable sac into the abdomen and entrapment of the kidney;
- morcellation of the kidney within the sac followed by evacuation of the renal fragments, and sac retrieval;
- removal of the trocar sheaths and closure of the port sites.

## CLINICAL EXPERIENCE

Several institutions have documented only 68 laparoscopic radical nephrectomies for renal carcinoma.[9-14] Mean operative times for laparoscopic radical nephrectomy ranges from 4.5 to 7.5 hours (Table 14.2). McDougall et al recently reported their experience with 17 laparoscopic radical nephrectomies performed for renal tumors smaller that 6 cm.[10] The average operative time was 6.9 hours (range 4.5 to 9) and the average estimated blood loss was 105 ml (range 50-600 ml). The average weight of the surgical specimen was 402 g (range 190 g to 1.100 kg). One patient required conversion secondary to intraoperative bleeding. McDougall et al compared this group of patients with 12 patients undergoing open radical nephrectomy. Both groups were similar with respect to age and ASA score. Operative times for laparoscopic radical nephrectomy were significantly longer versus open radical nephrectomy (6.9 hrs versus 2.2 hrs). However, the laparoscopic group had significantly less postoperative pain (24 versus 40 mg morphine sulphate required for postoperative analgesia, shorter length of hospital stay (4.5 versus 8.4 days) and quicker return to normal activities (3.5 versus 5.1 weeks). Gill reported a multi-institutional review of 185 patients undergoing laparoscopic nephrectomy. Thirty-two of these patients had renal tumors.[11] Their investigators noted a complication rate for laparoscopic simple nephrectomy of 12% and 34% for laparoscopic radical nephrectomy. The complication rate for laparoscopic radical nephrectomy is presently higher versus open radical nephrectomy. Complications encountered during laparoscopic nephrectomy included trocar site hernias, 14

*Table 14.2. Laparoscopic radical nephrectomy; review of the literature*

| Report | # | Mean Operative Time (hrs.) | Mean Blood Loss(ml) | Analgesia (mg morphine) | Hospital Stay (days) |
|---|---|---|---|---|---|
| McDougall[10] | 17 | 6.9 | 211 | 24 | 4.5 |
| Gill[11] | 185 | 5.5 | 471 | – | 10.0 |
| Tschada | 18 | 4.6 | – | – | 8.0 |
| Tse | 4 | 5.0 | – | – | 4.3 |
| Ono | 5 | 6.4 | 430 | – | 11.0 |
| Kavoussi[12] | 8 | 7.5 | 295 | 15 | 5.2 |
| Copcoat | 5 | 4.5 | – | – | 4.8 |

pneumothorax, trocar injury to the kidney, splenic laceration, pulmonary embolus, and congestive heart failure. The majority of these complications occurred during the first 20 cases. As the learning curve progressed their complication rate dramatically decreased for the remaining patients.

Finally, no evidence of metastatic disease or local recurrence has been reported in any of the 68 patients undergoing laparoscopic radical nephrectomy for renal carcinoma.

## CONCLUSION

Laparoscopic radical nephrectomy cannot be adopted as a routine procedure for all patients with renal cell carcinoma. Laparoscopic radical nephrectomy is reserved for patients with small tumors without vascular involvement. Laparoscopic radical nephrectomy may require longer operative times by advanced laparoscopic surgeons. However, laparoscopic radical nephrectomy includes less postoperative pain, shorter length of hospital stay, and a rapid return to normal activities. Based on the current literature, laparoscopic radical nephrectomy does not violate any oncologic surgical principles or compromise patient survival.

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# Endosurgery and Pediatric Oncology

*Paulo Chapchap, Ricardo Frank Coelho da Rocha*



## THE SURGEON'S ROLE IN PEDIATRIC ONCOLOGY

Although pediatric cancer is one of the most common serious diseases among children and adolescents under 16 years of age in developed countries,[1] the most frequent pediatric malignant diseases, leukemias and central nervous system tumors are not in the therapeutic field of the pediatric surgeon. However, pediatric surgeons have always played a leading role in the diagnosis, staging and treatment of solid tumors.

In the past, when treating tumors such as neuroblastomas, Wilms' tumors, lymphomas and soft tissue sarcomas, the only available therapy was complete extirpation. At that time, due to high rates of dissemination by the time of diagnosis, cure was rarely accomplished. Improved therapeutic protocols that addressed distant metastasis with systemic antineoplastic agents were needed.

Modern neoplastic therapy includes surgical excision, radiation therapy, chemotherapy or a combination of these modalities. The choice of therapy will depend on the type, stage and extent of the tumor, delivering cure, palliation or support for the child.

Although surgery remains the cornerstone of treatment of many malignant pediatric solid tumors, the availability of chemotherapy and radiotherapy necessitates treatment planning by a well-trained, multidisciplinary team that ideally involves a pediatric surgeon, a radiation therapist, pediatric oncologist, social workers, pediatric psychologists and nurses.



## PEDIATRIC ENDOSURGERY

Pediatric endosurgery developed as a natural consequence of the evolution of the concept of minimally invasive medicine and after wide acceptance among

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general surgeons. While advantages of minimally invasive access are apparent to most surgeons, acceptance among pediatric surgeons has been slow. Many endosurgery procedures in children, though feasible, are either considered investigational or clinical use has not been proven to be superior to a conventional approach.

As with adults, the main advantages of endosurgery are reduced hospital stay and cost, improved cosmetic results, less postoperative pain and fewer complications. Intra- and postoperative physiological advantages over open procedures have been demonstrated through comparison of numerous parameters during laparoscopic cholecystectomy in adults. Preservation of the systemic immune response is superior during laparoscopic cholecystectomy.[4] Furthermore, there is significantly reduced compromise in pulmonary function and narcotic requirement leading to fewer postoperative pulmonary complications such as atelectasis and hypoxia.[5] Adult laparoscopic instruments are often poorly designed for use in pediatric patients. The length and diameter of many instruments are excessive for small patients. The recent increased application of endosurgical techniques in pediatric surgery has prompted the design and manufacture of better instruments for pediatric use. Likewise, the rising popularity of minilaparoscopy or "needlescopic" surgery has led to the development of excellent instrumentation for use in infants and small children.

Major differences between children and adults are the tolerance to hypothermia and metabolic changes caused by $CO_2$ insufflation, tolerance to intra-abdominal pressure and possible manifestation of inguinal hernias or scrotal subcutaneous emphysema due to a patent processus vaginalis. Additionally, the positions of the trocars must vary according to the size of the patient. Most important is that the procedure be performed by experienced and well-trained surgeons (or appropriately supervised trainees) who will not hesitate to convert to open surgery if the adequacy of the operation or safety of the patient is judged to be compromised by endosurgery.

Definitive resections are rarely indicated as the initial step. Instead, extensive evaluation of the primary tumor, metastatic spread, staging, tissue sampling, evaluation of resectability and treatment response and second-look procedures are increasingly gaining acceptance. Minimally invasive surgery is an important aspect of the surgical armamentarium. The magnitude of surgical trauma is directly related to the metabolic and endocrine responses to injury. Endosurgery potentially could spare an immunologically compromised pediatric oncology patient from major surgical trauma. The potential benefits of endosurgery must be balanced against the potential limited assessment or compromised oncologic procedure when selecting an operative approach.



Although small incisions are one of the main advantages of endosurgery, every effort should be made to avoid traumatic handling and forceful extractions of tumors. Inappropriate handling of tumor may lead to peritoneal and abdominal wall seeding. Enlargement of trocar sites and safe extraction of specimens inside a protective bag should always be considered in order to prevent tumor spillage and implantation.[7]

## DIAGNOSIS, STAGING AND TISSUE SAMPLING

Endosurgery is a valuable diagnostic tool and should be indicated when all other less invasive diagnostic modalities have failed or have been inconclusive. In some cases it might even avoid or exclude further time-consuming, expensive and potentially dangerous diagnostic procedures.

Abdominal tumors in children are most frequently located in the retroperitoneum. Neuroblastoma and Wilms' tumor can be visualized with ultrasonography and/or computed tomography. Other tumors arising within the abdominal cavity include hepatic tumors, non-Hodgkin lymphoma, germ cell tumors and rhabdomyosarcomas. The majority of these tumors have characteristic appearances and are most frequently observed in specific age groups. This simplifies diagnosis. Nevertheless, in many cases the diagnosis is unclear and a more invasive diagnostic procedure is indicated. Furthermore, not only the diagnosis of a specific tumor is important but also the histology and molecular characteristics might prove critical in determining therapy prognosis.

When dealing with retroperitoneal masses, transparietal needle biopsies guided by ultrasound or computed tomography provide a safe and accurate way to obtain specimens for precise diagnosis.

In Hodgkin's disease there is an ever present question related to clinical versus pathological staging. The majority of institutional protocols for Hodgkin's disease in children use combined modality programs with low dose limited field radiation and multiagent chemotherapy. In this setting, clinical staging, although limited for anatomic location of small amounts of disease, is usually satisfactory. For adolescents, when growth and development is not an issue, the alternative is high dose extended field radiation alone. In these cases, since chemotherapy is not used, pathological staging is usually required because abdominal ultrasound and CT scan, even with oral and intravenous contrast, usually underestimate the extent of nodal and visceral disease. Lymphangiogram (LAG), classically used for evaluation of the extent of retroperitoneal adenopathy, is difficult to perform and interpret, does not evaluate mesenteric, porta hepatis, celiac or splenic hilar lymph nodes, and requires sedation or anesthesia. Currently, LAG is not performed routinely by the majority of institutions. Moreover, accurate evaluation of the spleen and liver must be surgical. Therefore some protocols require staging for treatment design. In this setting, laparoscopy is a valid alternative to laparotomy, even when splenectomy is part of the procedure.[9] Oophoropexy can easily be performed in the same procedure when indicated.



Retroperitoneal lymphadenectomy is indicated in paratesticular rhabdomyosarcomas with suspected retroperitoneal node involvement by CT scan[10] and in cases of abdominal or testicular germ cell tumors with persistently increased serum levels of specific tumor markers after resection and no other evidence of disease.[11] Endosurgical lymphadenectomy is feasible and less traumatic. In this case, specimens can easily be removed through 10 mm trocars.

### Intrathoracic Tumors

Thoracoscopy has proven to be an important diagnostic modality in the treatment of intrathoracic tumors in children. It is a much less invasive procedure that eliminates the need for thoracotomies that are extremely painful for the child.

In a recent review of 85 children who underwent 88 endosurgical procedures, there were 63 thoracoscopies and 25 laparoscopies.[12] Thoracoscopies have been more frequently employed and were indicated mainly to evaluate possible metastatic disease since it allows thorough visualization of the pleural cavity. Chest tubes are seldom necessary provided the lungs are fully expanded by the time the trocars are withdrawn.

Lung biopsies can be easil/y performed with the use of linear stapling devices and are essential to rule out malignancies in some cases, e.g., pseudoinflammatory tumors. Intrathoracic masses can also be biopsied with appropriate forceps, laser or electrosurgery. The argon beam coagulator can be helpful in coagulating raw edges of highly vascular tissues such as the lung.

A high degree of diagnostic accuracy can be attained with thoracoscopy in the evaluation of mediastinal masses. Biopsies are taken more safely under direct vision and although resections are feasible, experience is still limited.[13]

As with abdominal masses, any thoracic tumor once resected can be extracted with the help of a tissue morcellator. Mayo endoscopic scissors can also be used to cut the specimen into small pieces to facilitate extraction. Again, forceful extractions and excessive and traumatic handling of tissue should be avoided and placement of specimens inside protection bags is strongly advised.

## EVALUATION AND RESECTABILITY

There are cases where diagnostic imaging methods may be misleading. Minimally invasive access provides a safe and cost-effective way to establish a diagnosis and at the same time assess resectability. In some cases tumors that had been diagnosed as unresectable may be considered otherwise after direct visualization with the help of an endoscope, thereby radically changing the course of therapy.

Hepatic tumors are currently being treated with preoperative chemotherapy after a complete evaluation that includes thoracoabdominal computed tomography and biopsy. The International Society of Pediatric Oncology (SIOP) recommends a "small laparotomy" for biopsy, but several centers prefer transparietal needle biopsy. Laparoscopy is an option with the advantages of both procedures: safer and better tissue sampling through a less invasive technique. An additional advantage would be direct visualization of the whole liver for better pretreatment staging and confirmation of adequate hemostasis. After preoperative chemotherapy, computed tomography is not always sufficient to determine whether or not a tumor is resectable. In these cases laparoscopy with direct visualization of the tumor may be useful to guide the surgeon towards a correct decision.

Laparoscopic resection of solid tumors remains controversial since strict adherence to basic principles of oncologic surgery must always be respected in order to avoid tumor spillage and seeding with subsequent alteration of the disease stage. Should resection be attempted, mobilization of the tumor must be achieved with careful and gentle dissection and isolation and clipping of bigger blood vessels. The extraction of solid tumors is usually a difficult task since 10 mm incisions are routinely used to insert the cannulae. For this purpose, once the tumor is placed inside the special bag, a tissue morcellator can be used to cut the specimen into pieces small enough to allow the sac to be withdrawn through the cannula site.[14,15] Controversy still exists however, regarding whether morcellation of the specimen interferes with histological examination of the tumor, especially at the margins.

## OTHER INDICATIONS

### Management of Complications Secondary to Antineoplastic Therapy

One of the most challenging diagnoses a pediatric surgeon has to make is when a child treated for malignancy presents with an acute inflammatory abdominal condition. There is a natural resistance by the surgeon to embark on surgery in these cases since an unnecessary intervention would represent an additional trauma to an often seriously malnourished and immunologically compromised child with a high morbidity rate. Possible diagnoses include appendicitis and neutropenic enterocolitis. Other less frequent conditions are ileocecal intussusception, intestinal obstruction, pancreatitis and peritonitis.

Although the incidence of appendicitis in pediatric cancer patients is low, the consequences of delayed therapy are fearsome. Persistent right lower quadrant abdominal pain and guarding associated with clinical deterioration despite intensive clinical support should always cause a high degree of suspicion. Aside from atypical cases, the diagnosis of acute appendicitis is mainly made on clinical grounds after careful patient monitoring and repeated physical examination.[17,18]

Neutropenic enterocolitis, or typhlitis, is another possibility in children treated for leukemia with chemotherapy-induced agranulocytosis. Intestinal mucosa damage caused by chemotherapy followed by bacterial invasion of the intestinal wall. In some cases, necrosis and perforation of the ileocecal segment where a high concentration of lymphatic tissue is present can occur.[19,20] Again, delayed treatment may lead to increased morbidity and high mortality rates. When it is no longer safe to observe the child, laparoscopy may be useful in making the diagnosis.

The increased susceptibility to bacterial, fungal or protozoal infections is one of the major causes of death in the pediatric cancer patient. These children often develop pulmonary infiltrates or lesions that require accurate diagnosis for specific therapy. Bronchoalveolar lavage is a less invasive option but with a variable diagnostic yield, from 27-71%.[21] Since a negative bronchoalveolar lavage does not rule out infection in neutropenic, febrile cancer patients, a more invasive method is often needed to establish the etiology of a suspicious pulmonary lesion.[22] Endoscopic lung biopsies are frequently used for this purpose with high diagnostic accuracy and low incidence of complications.

### Management of Ventricular Shunts and Tenckhoff Catheter Malfunction

Many children with central nervous system malignancies at some point must undergo ventricular shunting. These shunts frequently cease to function due to a variety of reasons: malposition, debris or thrombotic plugs within the lumen or obstruction by the greater omentum. Likewise, children with chronic renal failure undergoing continuous ambulatory peritoneal dialysis (CAPD) often have some degree of catheter malfunction. Laparoscopic management of these complications is, in most cases, simpler and less invasive than a conventional approach.[23]

### Oophoropexy

Girls who will undergo pelvic irradiation for the treatment of malignancies often have the ovaries fixed behind the uterus for gonadal protection. This is easily accomplished with laparoscopy.[23-25]

### Management of Recurrent Malignant Pleural Effusions and Pneumothorax

Pleural effusion can result from tumor compression of the superior vena cava, local invasion, metastatic spread to the thorax, heart failure, hypoproteinemia or a sympathetic response to thoracic malignancy. Although less frequent, chylous effusions can follow lymphatic obstruction. Small, asymmetric effusions are frequently observed in the initial evaluation of children with a wide variety of malignancies. Thoracocentesis is, in these cases, an important staging procedure.

Many children develop recurrent pleural effusions despite adequate treatment and when there is respiratory compromise or a negative effect on duration and quality of life, chemical pleurodesis might provides some relief. A number of agents can be injected into the thoracic cavity to promote intense inflammation and pleural adhesions.

Holcomb et al reported the use of thoracoscopy for pleurodesis after spontaneous pneumothorax in a child with histiocytosis X and for pleurolysis for intrapleural chemotherapy in a patient with recurrent undifferentiated sarcoma previously submitted to a pulmonary lobectomy.[12]



### Placement of Brachytherapy Needles

In some instances interstitial radiation, also known as brachytherapy, is superior to external radiation. When combined with external radiation, brachytherapy can deliver a higher dose of radiation to the central portion of the infiltrating tumors in children. Careful placement of the needles is critical in order to obtain the best results. The needles can be positioned with the help of ultrasonography, computed tomography or surgery.

When dealing with deeper organs and structures, surgical placement provides a safer and more effective way to position the needles. In this sense, endoscopic surgery could be especially helpful in the treatment of unresectable or incompletely resectable soft tissue sarcomas in the abdominal cavity.[23]

## CONTRAINDICATIONS OF PEDIATRIC ENDOSURGERY

A great difference between children and adults is the tolerance to increases in intra-abdominal pressure. In small infants and neonates, slight changes in abdominal pressure can lead to major impairment in ventilatory mechanics and cardiocirculatory collapse due to diminished venous return. Hence continuous monitoring of ventilatory pressures and cardiopulmonary parameters are mandatory (Table 15.1).

Relative contraindications are previous surgery and peritonitis with adhesions, and depend mostly on the expertise of the surgeon.[26]

## FUTURE PERSPECTIVES

Endosurgery has grown beyond all expectations over the last five years. We are still in the middle of the initial boom where indications for the use of minimally invasive surgery are still being established and evaluated.

One of the most exciting and challenging areas of pediatric surgery, fetal surgery, has already incorporated endoscopic techniques. Counting on ever-increasing accuracy in prenatal diagnosis of fetal disease, fetal therapy will soon be a reality.[27]

In oncology prenatal diagnosis of fetal tumors has had a great impact on many aspects of maternal and child care, changing the course of pregnancy and affecting neonatal outcome.[28] Also it has provided valuable data that will help us to understand the natural history of many tumors such as neuroblastoma, the biological behavior of which never ceases to amaze pediatric oncologists.

Open fetal therapy is a reality, and many fetuses have been operated on for a wide variety of diseases. The resection of a fetal sacrococcygeal teratoma and a cystic adenomatoid malformation are examples of open surgeries already performed.[29] As with other surgical specialties, endosurgery has reached fetal surgery



*Table 15.1. Absolute contraindications for endosurgery*

- coagulation disorders
- respiratory failure
- cardiovascular instability
- massive abdominal wall infection
- huge tumor mass(es)
- marked abdominal and bowel distension

and showed clear advantages over the conventional open approach.[30,31] Still, there are many obstacles to be overcome in fetal surgery, and it will certainly require furthre development before significant positive results allow us to safely apply this new therapeutic modality in our day-to-day practice.

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# Complications of Videolaparoscopy

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*Aldo Junqueira Rodrigues Jr.*

The complication rate for laparoscopic procedures varies between 0.5-5% with a 0.1% mortality. A large majority of these complications occur during abdominal access with either a Veress needle or an open technique. A blind technique with a Veress needle is associated with a 0.3-0.4% incidence of injury to abdominal viscera as well as vascular structures. An open Hassan technique can be used as well to access the abdominal cavity. The Hassan technique is associated with a 0.1% complication rate and essentially a 0% mortality. There are no published studies comparing the two techniques in a randomized prospective fashion.

Along with life-threatening complications, inappropriate placement of the Veress needle may result in extensive subcutaneous emphysema within the peritoneal space, omentum, mesentery or retroperitoneal space. We currently recommend utilizing the Hassan technique especially in patients with prior abdominal surgery. If a Veress needle is utilized, the patient should be placed in the Trendelenburg position at 20° to allow cephalad movement of the abdominal contents. The Veress needle should always be introduced at the level of the umbilicus since the peritoneum is closely adherent at this point. The Veress needle should be introduced at a 30° angle in the midline and directed caudad in the pelvis. The position of the needle is assessed by aspirating with a half-filled syringe of saline solution. This verifies the absence of a bladder or vascular accident. The saline is then emptied by gravity into the abdominal cavity verifying tip location again. The insufflator is connected and the manometer should show a low intra-abdominal pressure indicating proper positioning.

Bleeding from the abdominal wall occurs in 0.05-2.5% of all cases. Most bleeding is associated with the inferior epigastric vessels. Injuries to major vessels occur in 0.03-0.06% of cases and represent the third leading cause of death during laparoscopy. Aortic and iliac injuries are the most frequently injured vessels. Mortality associated with vascular injuries is approximately 15%. Injuries to the gastrointestinal tract are the second most common complication occurring in 0.04%-0.06% of all cases. These injuries should be identified after initial exploration of the abdomen laparoscopically. These injuries should be repaired immediately. Late identification of these lesions results in significant morbidity and mortality. Infection at the port sites is exceedingly uncommon occurring in less than 1% of all laparoscopic procedures. Port site hernias, as well, occur in less than 1% of all laparoscopic procedures. This rate is even smaller when utilizing 5 mm or smaller trocars.



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Other complications are related to the laparoscopic instruments and equipment. All equipment should be routinely inspected, with attention to connections and insulation, before the start of any surgical procedure. Insulation gaps can result in cautery burns to adjacent organs. Electrocautery injuries occur in 0.05%-3.0% of all laparoscopic procedures. Faulty insulation can also produce arcing of the electrical current to remote organs within the abdominal cavity. Inability to maintain adequate pneumoperitoneum should prompt inspection of all trocar sites and valves as well as $CO_2$ cannisters and tubing. If monopolar cautery is used, the cautery unit should be set at 30 watts and the site of bleeding or dissection should be kept under direct vision at all times. Long periods of cauterization should be avoided. Bipolar cautery confines the current between the two poles of the instrument. However, the instrument still generates a substantial amount of heat that can produce injury.

Several physiologic complications occur secondary to the $CO_2$ pneumoperitoneum and hypercarbia. With rising intra-abdominal pressure, venous return decreases and peripheral vascular resistance increases. Cardiac output is reduced and associated with mild arterial hypertension. Furthermore, abdominal insufflation to 15 mm Hg produces a 60% reduction in renal cortical flow secondary to increased abdominal compartment pressures. This diminished renal perfusion translates into a 50% reduction in urine output. Despite pneumoperitoneal evacuation and almost immediate restoration of renal arterial flow, urinary output remains diminished for approximately another 60 min. Other, hormonal factors may be involved such as ADH and aldosterone concentrations. Pulmonary functional volumes are also diminished following insufflation with increased shunting. Peak inspiratory pressures are increased and may interfere with ventilation. This further impairs an already compromised venous return and cardiac output. All of these factors should be considered when evaluating a patient with significant comorbidities for any laparoscopic procedure. These physiologic complications can be overcome with abdominal lift devices. However, these devices can be cumbersome and may inhibit exposure.

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# Role of Laparoscopic Ultrasound in Minimal Access Surgery: Overview

*R. Kolachalam, M.E. Arregui*



## INTRODUCTION

Currently laparoscopic surgeons are involved in the diagnosis, staging, treatment, and palliation of intra-abdominal malignancies. One major drawback of oncologic laparoscopic surgery is the loss of tactile feedback to the surgeon's hand. This hampers the diagnostic and therapeutic capabilities of laparoscopic surgery. Laparoscopic ultrasound (LUS) may compensate for this tactile deficit and in some scenarios may exceed the sensitivities of manual palpation. While laparoscopy alone is a useful tool for staging intra-abdominal malignancies, the addition of LUS enhances the surgeon's capabilities. LUS is thus the "stethoscope" of the laparoscopic surgeon. The currently available LUS probes can be inserted through a 10 mm cannula and range in frequencies from 6-7.5 MHZ. These probes can be used for laparoscopic sonography of the liver, bile ducts, pancreas, retroperitoneum, and hollow viscera such as the colon.



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Fig. 17.1. Picture of laparoscopic ultrasound.

## INDICATIONS FOR LAPAROSCOPIC ULTRASOUND

There continues to be an explosive increase in the applications of LUS in minimal access surgery. Therefore the indications for LUS continue to evolve as different centers continue to report the fine nuances of this emerging technology. In addition to preoperative diagnostic studies or laparoscopy alone, LUS provides additional information regarding the resectability of pancreatic or liver tumors. LUS is also utilized for accurate staging of primary gastrointestinal tumors. Diagnostic laparoscopy with LUS-guided biopsies of intra-abdominal malignancies reduces exhaustive diagnostic work-ups while avoiding unnecessary laparotomies. With a potentially protracted life expectancy, these patients benefit from this diagnostic approach with quicker recovery times. Quicker recovery times and shorter hospital stays translate into substantial cost containment. Finally, combining LUS in the diagnosis, staging and treatment of intra-abdominal malignancies, the laparoscopic conduct of the procedure can uncompromisingly follow the standards of traditional open surgery.

## TECHNIQUE

### General Principles

17

Current laparoscopic ultrasound probes are passed via 10 mm ports. To prevent iatrogenic complications related to placement and maneuvering of the LUS probe, the intra-abdominal manipulation of the probe should always be performed under direct vision. Particular attention should also be paid to placement of the ultrasound display screen. It should be placed in a convenient position in line with the organ to be imaged and the surgeon. Based on contact imaging, LUS depends on direct contact between the organ and the LUS probe. This contact is facilitated by inserting saline directly on the imaged organ and maintaining firm contact. Decreasing the angle of contact enhances ultrasound imaging by increasing the surface area of the probe in contact with the imaged organ. Any other imaging studies incorporated into the preoperative work-up such as CT scans should be available in the operating room for easy reference and clinical correlation with LUS.

Routine use of LUS of liver during laparoscopic cholecystectomy enhances familiarity with the anatomy of the liver and the portahepatis. Our technique has been described by us in a previous publication.[2]

**LUS of the Liver**

Detailed description of hepatic gross anatomy is beyond the scope of this chapter; however, important anatomical concepts pertaining to the liver need to be addressed. The normal liver parenchyma is uniform, containing fine, homogenous echoes, and is either minimally hyperechoic or isoechoic compared to the normal renal cortex. Compared to spleen, liver is hypoechoic. One should be familiar with segmental anatomy and vasculature of the liver. The major hepatic veins are interlobar or intersegmental, coursing between the lobes and segments. Along most of its course the portal vein, on the other hand, is intrasegmental, running within the segments. The only exception is the ascending portion of the left portal vein which runs in the left intersegmental fissure separating the medial segment of the left lobe from the lateral segment. When actually scanning, the portal vein has an

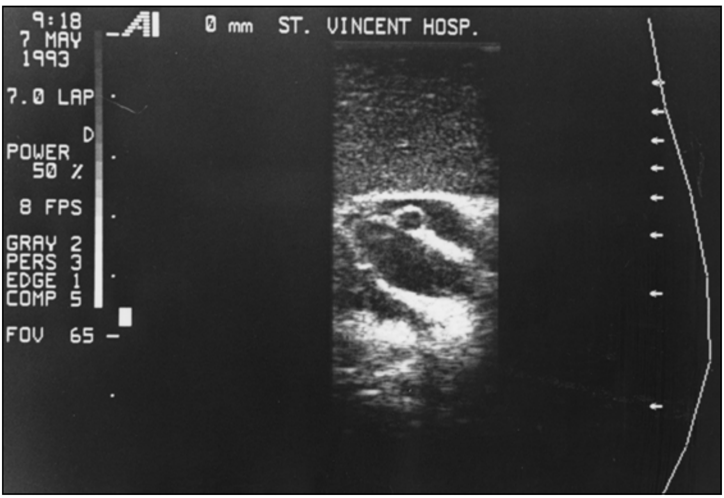



Fig. 17.2. Portal triad showing the relationship of portal vein to common bile duct.

echogenic wall since it is encased by Glisson's capsule. The hepatic veins have thin imperceptible walls.

At the porta hepatis, identification of the portal vein is the key. The bile duct is anterior to the portal vein, has an echogenic wall and does not fluctuate in size with respiration. From the porta, the bile ducts are easily followed throughout the liver parenchyma.

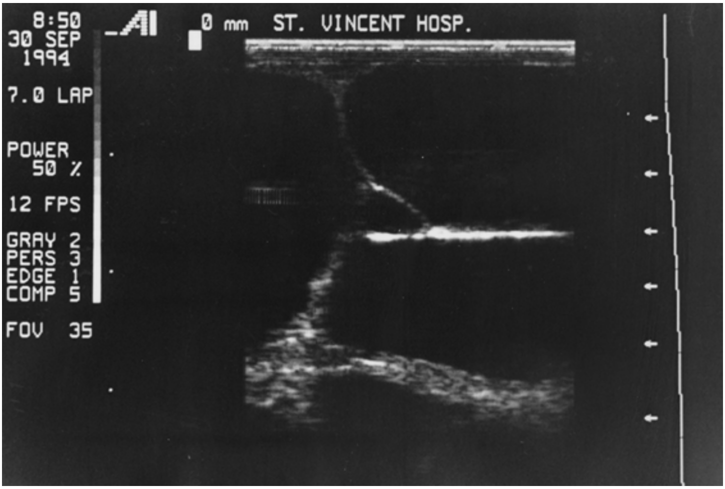
Utilizing a standardized technique, the patient is always approached from the right, facing cephalad. The liver should be scanned from both its superior as well as inferior aspects to thoroughly image the entire thickness of the liver. The LUS probe can be applied directly to a visible mass or used to search for occult lesions. The right lobe is scanned transversely from lateral to medial and then medial toward lateral starting from the dome. It is also scanned craniocaudally. The major hepatic veins form ideal segmental boundaries but are visualized only when scanning the superior aspect of the liver. The LUS probe is passed from the umbilical port or the right upper quadrant.

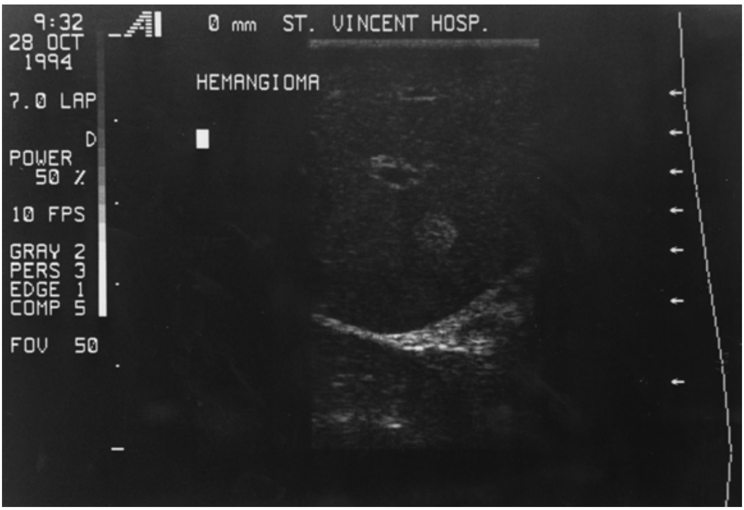
With practice, the more common liver lesions are easily identified. Benign liver cysts are anechoic or hypoechoic, with a well-demarcated thin wall. Cysts are generally rounded or oval, with clearly delineated walls lacking internal echoes. A bright echo immediately deep to the cyst wall is called a posterior acoustic enhancement and is characteristic of a cyst. Abscesses tend to have thick walls, internal septations, fluid interfaces and debris depending on the stage of evolution. Typically, hemangiomas are well defined, homogenous, and hyperechoic whereas the monographic findings of adenomas and focal nodular hyperplasia (FNH) are similar and nonspecific. Adenomas and FNH may be isoechoic, hypoechoic or hyperechoic. A central fibrous scar is suggestive of FNH.

Primary and metastatic lesions can be complex and varied. Small hepatocellular carcinomas are hypoechoic whereas larger lesions are complex or echogenic. Similarly, metastatic lesions may appear echogenic, hypoechoic, calcified, cystic and/or diffuse. LUS can define the relationship of these lesions to the vascular anatomy of the liver and delineate satellite nodules, tumor thrombus, and direct vascular invasion.

## PANCREAS

The pancreas is imaged from port sites in the right upper quadrant or the umbilicus. The acoustic impedance of the pancreas is slightly lower than that of fat, inducing a slightly darker signal than the surrounding retroperitoneal fat. With age, the pancreas may become infiltrated with fat, producing a higher echogenicity. The best views of the pancreatic head and uncinate process are obtained by placing the probe directly over the gland. The body and tail of the pancreas are evaluated by placing the probe on the anterior wall of the stomach and viewing the structure through the gastric wall. Alternatively, the probe can be placed directly on the gland after opening the gastrohepatic or gastrocolic ligaments.




Figs. 17.3-17.4. Showing liver cysts and a hemangioma of the liver.

Surrounding structures such as the pancreatic duct, distal CBD, portal vein, superior mesenteric artery, and celiac axis orient the pancreas. The portal vein runs obliquely behind the body of the pancreas, whereas the CBD tapers as it passes through the pancreatic head passing through the duodenum. The origin of the superior mesenteric artery from the aorta can be visualized and traced longitudinally behind the body of the pancreas.

Acute pancreatitis is associated with a decreased signal secondary to parenchymal edema and an increase in the anteroposterior dimension of the gland (greater than 3 cm). Often the surrounding tissues are also edematous, making the gland more difficult to see. Chronic pancreatitis, in contrast, produces a hypoechogenic signal due to parenchymal fibrosis and calcification. The gland also tends to be asymmetric and associated with a dilated duct (greater than 2 mm).

Pancreatic cysts, like cysts in other parts of the body, are well circumscribed and hypoechoic. Pseudocysts are the most common cystic lesion of the pancreas. These may be difficult to differentiate from simple cysts by ultrasound criteria alone but can usually be differentiated from cystadenomas or cystadenocarcinomas as the latter are usually complex cystic structures. Some pseudocysts may demonstrate internal echoes signifying early formation with intracystic debris. Alternatively these echoes may signify internal hemorrhage or infection.

Pancreatic tumors present as discrete masses in the substance of the gland. Carcinomas are usually hypoechoic with irregular borders. The pancreatic and/or bile ducts may also be dilated secondary to compression. In contrast, islet cell tumors are well circumscribed and hypoechoic compared to the surrounding parenchyma. Biopsies of isoechoic nodules invariably show normal pancreatic tissue.

Peripancreatic adenopathy is not an uncommon finding. Normal lymph nodes, which may be found either surrounding or even in the substance of the gland, are characterized by an isoechoic area surrounded by a rim of hypoechoic tissue. Lacking a rim of hypoechogenicity, pathologic lymph nodes tend to be more hyperechogenic and less circumscribed.

## ROLE OF LUS IN INTRA-ABDOMINAL MALIGNANCY: RESULTS

Jakimowicz reviewed the role of LUS during minimal access surgery in his seminal paper in 1993.[5] In his study of 31 patients undergoing LUS of the liver, unsuspected metastasis were detected in three patients and suspected metastasis were excluded in two patients. Suspected liver pathology was confirmed in four patients and absence of pathology was confirmed by LUS imaging. Based on the intraoperative findings with LUS, Jakimovicz reported a combined false positive and false negative rate of 16% (5 out of 31 patients) for preoperative screening of the liver. This initial illustrates the diagnostic potential for LUS in minimal access surgery for gastrointestinal malignancy.

Garden et al[6] recently reported their experience with staging laparoscopy and LUS of 45 patients with liver tumors. LUS was performed in addition to staging laparoscopy in 43 patients. In 14 (33%) of these patients, LUS demonstrated liver tumors imperceptible by laparoscopy alone. Further information regarding surgical treatment and tumor resectability was obtained in 18 of 43 patients (42%). Seven patients (16%) with a preoperative diagnosis of local disease were diagnosed with unresectable tumors and/or distant metastases following LUS. Despite an extensive diagnostic work-up, including laparoscopy, 16% of these patients required LUS in order to avoid an unnecessary laparotomy. A normal LUS is equally important. Two patients with preoperative documentation of hepatic tumors had normal findings on LUS. Through its positive and negative findings, LUS optimizes surgical decision-making of hepatic malignancies.

Few pancreatic tumors are amenable to surgical excision after the patient is symptomatic. Preoperative staging of pancreatic cancers by radiological tests alone is not 100% accurate. Peritoneal and omental metastases usually are only 1-2 mm in size. These lesions and liver metastasis less than 2 cm are not often identified by any combination of preoperative radiological tests including CT scanning, ultrasonography, magnetic resonance imaging, and selective visceral angiography. These preoperative limitations led to the recommendation by Cushieri and Warshaw[7,8] that routine laparoscopic staging performed in all patients with presumed resectable pancreatic tumors. If preoperative staging with CT, angiography and laparoscopy was normal, resectability approached 80% for tumors in the head of the pancreas.[8] The addition of laparoscopy alone considerably improved the previous resectability rate of less than 25%.

Laparoscopy alone as a staging technique considerably reduces the laparotomy rate. However, due to its retroperitoneal location and its intimate relationship to major vascular structures, the pancreas is difficult to access with laparoscopy. Several investigators have utilized LUS to overcome the diagnostic shortcomings of laparoscopy.

Okita reported his experience with LUS for staging of pancreatic cancer in two patients in 1984.[9] A more detailed analysis of LUS in the management of pancreatic cancer was undertaken by Garden.[10,11] Forty consecutive patients with a diagnosis of potentially resectable pancreatic or periampullary cancer underwent staging laparoscopy with LUS. LUS confirmed unresectability in 23 patients (59%), provided staging information in addition to that of laparoscopy alone in 20 patients (53%), and changed the decision regarding tumor resectability in 10 patients (25%). Laparoscopy with LUS was more specific and accurate in predicting tumor resectability than laparoscopy alone (88% and 89% versus 50% and 65%, respectively). LUS clearly demonstrated local tumor invasion, peripancreatic lymphadenopathy, vascular invasion, and parenchymal liver metastasis not identified by laparoscopy alone.

LUS has found a variety of other applications in minimal access surgery for intra-abdominal tumors. LUS was used to localize a colonic tumor in two patients. In three patients with gastric LUS altered medical therapy by identifying enlarged celiac lymph nodes. Presently, the role of LUS in minimal access surgery is evolving. It combines the advantages of laparoscopy with contact ultrasonography in the evaluation of potentially malignant disease concealed in hollow viscera, solid organs or the retroperitoneum.

### St. Vincent's Results

Stimulated by the experience of European surgeons using ultrasound in the office, the senior surgeon (MEA) started using ultrasound imaging extensively in the office and operative room. Ultrasound imaging was quickly incorporated into laparoscopy at St. Vincent's Hospital in Indianapolis. Initially, LUS was used for evaluating the common bile duct for stones during laparoscopic cholecystectomy. It soon became apparent that LUS was useful staging gastronitestinal tumors. Over the last two years, LUS has been extensively used in both evaluation of common bile duct stones as well as oncologic staging.

We reviewed our experience with LUS in 72 patients undergoing minimally invasive surgery during the last two years. Preoperative data was collected prospectively. Seventy-two patients underwent 73 LUS exams. This was performed using a 7.5 or 10 MHZ probe (Acoustic Imaging Systems 5200, Phoenix, AZ). LUS altered overall medical management in 24 (32%) of patients. Sixteen of the 73 LUS exams (21%) changed surgical management. No additional information was obtained by LUS in 40 exams (Table 17.1). The results for each disease process are discussed below.

## PANCREATIC-BILIARY-(MALIGNANT GROUP)

LUS was used to evaluate 18 patients with pancreaticobiliary malignancies (Table 17.2). In nine of these patients (50%), additional data was obtained and eventually altered surgical treatment in five patients. Undiagnosed hepatic metastases as small as 7 mm were confirmed by LUS-guided biopsy in three of these five patients. An unsuspected liver abscess was identified with LUS in another

*Table 17.1. LUS in evaluating patinets undergoing minimally invasive surgery*

| **Results** | **Number of Patients** | **LUS Added Information** | **Added Information Helped** | **LUS Changed or Could Have Changed Surgery** | **No Additional Information** |
|---|---|---|---|---|---|
| Pancreatic-Biliary Malignancy | 18 | 9 (50%) | 10 (55.5%) | 5 (25%) | 9 (50%) |
| Pancreas-Benign | 10 | 4 (40%) | 2 (20%) | 3 (30%) | 9 (60%) |
| Liver-Malignancy | 6 | 2 (33%) | 2 (33%) | 3 (50%) | 4 (66%) |
| Liver-Benign | 5 | 2 (40%) | 2 (40%) | 2 (40%) | 3 (60%) |
| Colon CA-Staging | 11 | 3 (27%) | 1 (9%) | 1 (9%) | 8 (72%) |
| Unknown Primary | 5 | 1 (20%) | 1 (20%) | 1 (20%) | 4 (80%) |
| Stomach | 3 | 1 (33%) | 1 (33%) | 0 (0%) | 0 (0%) |
| Spleen | 3 | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Adrenal | 1 | 1 (100%) | 1 (100%) | 0 (%) | 0 (0%) |
| Miscellaneous | 11 | 7 (63%) | 4 (36%) | 1 (9%) | 4 (36%) |
| | 73 | 30 (41%) | 24 (32%) | 16 (21%) | 40 (54%) |

patient. Overall, LUS helped in the management of 10 patients (55.5%) with pancreaticobiliary malignancy by confirming or altering preoperative data.

### PANCREAS-BENIGN GROUP

Ten patients underwent LUS of the pancreas for benign conditions. Based on the preoperative work-up and laparoscopy alone, additional information was obtained with LUS in four patients (40%). This information altered management in two patients (20%). In one patient, an insulinoma was identified exclusively by LUS. However, another patient with occult insulinoma on preoperative work-up, LUS failed to identify the insulinoma. Yet, subsequently laparotomy with open operative ultrasound failed to localize the insulinoma as well. By documenting pancreatitis as opposed to a pancreatic mass, LUS helped a third patient avoid a laparotomy. Overall, LUS changed surgical plans in three patients (30%).

### LIVER MALIGNANT GROUP

LUS altered surgical plans in three patients (50%) with hepatic malignancies. Additional information was gained in two patients by adding LUS to laparoscopy and preoperative work-up. The first patient presented with primary colorectal cancer and a rising CEA level. Preoperative work-up with a CT scan failed to conclusively identify any hepatic lesions. Moreover, a preoperative Oncoscan (a radionucleide test) documented false positive activity at the root of the mesentery. LUS, on the other hand, identified a resectable metastatic liver lesion and showed no evidence of metastases at the root of the mesentery. A second patient, with a presumed solitary, resectable liver metastasis, was found to have malignant periportal adenopathy following LUS-guided biopsy. These nodes were not identified by preoperative CT scan. LUS correctly identified a normal liver in a third patient previously diagnosed with a hepatic carcinoid based on a preoperative MIBG scan. LUS did not yield any additional information in three other patients (50%).

### LIVER-BENIGN GROUP

LUS changed surgical plans in two of five patients (40%) with hepatic lesions. One patient with presumed liver lesions by CT scan showed normal liver parenchyma on LUS. In another patient, LUS-guided liver biopsy documented focal nodular hyperplasia of the caudate lobe of the liver. No additional information was added to laparoscopy alone in three other patients (60%).

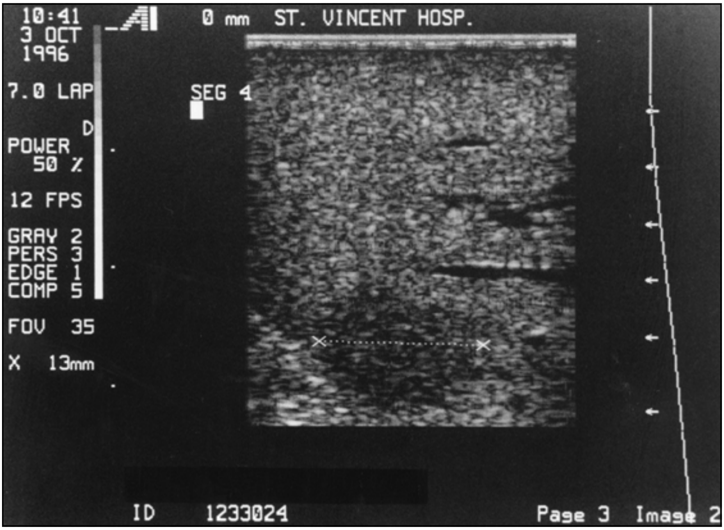


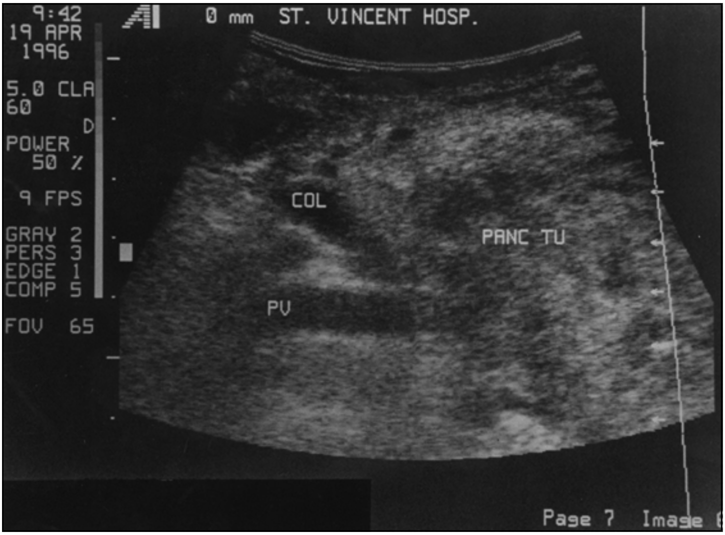

Fig. 17.5. Metastatic lesion in the liver.

## COLON CANCER STAGING

Eleven patients undergoing laparoscopic colectomy for cancer underwent LUS staging of the liver. LUS changed surgical plans in one patient (9%). Preoperatively this patient was diagnosed with metastatic colon cancer based on a CT scan. LUS subsequently showed normal liver architecture without any evidence of metastatic disease. Downstaging of colon lesions was also obtained in several other patients by documenting benign liver cysts and delineating negative margins.

## UNKNOWN PRIMARY

Five patients with unknown intra-abdominal primary malignancies underwent LUS evaluation. LUS-guided biopsy identified metastatic periportal adenopathy not demonstrated on preoperative work-up or laparoscopy alone. LUS did not show any lesions in the solid viscera of this patient. Based on these findings, the patient avoided laparotomy. In the other patients with unknown primary malignancies, LUS did not add any further information to laparoscopy or the preoperative workup.





Figs. 17.6, 17.7. Pancreatic adenocarcinoma and insulinoma pancreas.

*Table 17.2. LUS evaluation of 18 patients with pancreaticobiliary malignancies*

| Pre-op Diagn | Lapar Findings | LUS Findings | Laparoscopic Findings | | | Laparoscopic Ultrasound Findings | | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | Add'n Info | Helped | Changed Surgery | Add'n Info | Helped | Changed Surgery | |
| Resect Panc CA | Resect | Unresect | No | Yes | No | Yes, liver met | Yes | Yes | Liver met, biopsied/LUS |
| Breast Met, Bile Duct | Unresect | Unresect | No | Yes | No | Yes, met to panc | No | No | Choledochojejunostomy |
| Resect Panc CA | Resect | Unresect | No | Yes | No | Yes, portal vein involved | Yes | Yes | Choledochojejunostomy |
| Resect Panc CA | Resect | Resect | No | Yes | No | No | No | No | Choledochojejunostomy |
| Unresect, Panc CA | Unresect | Unresect | Yes, hep art encase | Yes | Yes | No | No | No | Plan for Infusaid pump canceled |
| Resect Panc Cyst* | Resect | Resect | Yes, cystic | No | No | Yes, cystic | No | No | Path benign, misdiagn Panc CA |
| Resect ampullary tumor | Resect | Resect | No | Yes | No | No | Yes looked resect | No | Did not want resection |
| Resect Panc CA | Unresect | Unresect | Yes, peritoneal implants | Yes | Yes | Yes, involved stomach | No | No | Whipple canceled |
| Resect Panc CA | Resect | Resect | No | Yes | No | No | Yes | No | Margins positive for met renal cell |
| Resect Panc CA. | Unresect | Unresect | Yes, liver mets | Yes | Yes | No | No | No | Whipple canceled |
| Resect Panc CA. | Resect | Resect | No | Yes | No | No | Yes | No | Whipple |

| Pre-op Diagn | Lapar Findings | LUS Findings | Laparoscopic Findings | | | Laparoscopic Ultrasound Findings | | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | Add'n Info | Helped | Changed Surgery | Add'n Info | Helped | Changed Surgery | |
| Resect Ampullary Tumor | Resect | Resect | No | Yes | No | No | Yes | No | Whipple, could have done local resection since LUS showed TI lesion |
| Resect Cholangio CA. | Resect | Resect | No | No | No | No | No | No | Refused resection |
| Porcelline GB | Unresect GB, CA. | Unresect | Yes, GB CA. | Yes | Yes | Yes, extent of CA. | Yes | No | Wall stent |
| Resect Cholangio, CA. | Resect | Unresect | No | No | No | Yes, met to LN | Yes | Yes | Biopsy lymph node positive |
| Panc Pseudo st | Unresect Panc CA. | Unresect | Yes, Met. Panc CA. | Yes | Yes | No | No | No | Gastojejun |
| Unresect Panc CA. | Same, could not find abscess | Same, found abscess | No | Yes | No | Yes, found abscess | Yes | Yes | LUS guided drainage of abscess |
| Resect Panc CA | Resect | Unresect | No | No | No | Yes, portal vein | Yes | No, but should have* | By classic staging resect Early in experience. Now would resect. |

*LUS provided information that could have changed surgical plans. This was early in our surgical experience and we felt that this patient was resectable by traditional criteria. CA =Carcinoma, GB=Gallbladder, LUS=Laparoscopically, Met.=Metastases, Panc. =Pancreatic, Resect.=Resectable, Unresect.=Unresectable.

| | | |
|---|---|---|
| Total of 18 patients | LUS added information other than laparoscopy findings | 9 (50%) |
| | The added info from LUS helped | 10 (55.5%) |
| | Info from LUS changed or could have changed surgery | 5 (28%) |
| | No additional information from LUS | 9 (50%) |

## STOMACH, SPLEEN AND ADRENALS

LUS did not alter surgical treatment in three patients undergoing LUS during gastric surgery or splenectomy. LUS helped identify the adrenal vein during a laparoscopic adrenalectomy but otherwise added no further information or altered surgical plans in any way.

## MISCELLANEOUS

Eleven other patients underwent LUS for various reasons including small bowel tumors, diverticulitis, ischemic bowel, endometriosis, chronic abdominal pain, chylous ascites. LUS identified large periportal adenopathy not seen on preoperative work-up in the patient with hepatosplenomegaly of unknown etiology. In this homosexual male, biopsy of the periportal nodes and liver revealed disseminated histoplasmosis. The patient avoided laparotomy by utilizing LUS.

## SUMMARY

Review of our experience at St. Vincent Hospital is similar to that reported by several other authors. LUS does have a learning curve, but it is quickly overcome with routine, frequent use. Experience with transabdominal ultrasound is helpful, but not essential. Based on the above data, LUS has been extremely useful in the evaluation of solid viscera including the pancreas and liver. By showing local invasion, vascular involvement and regional lymphadenopathy, LUS adds vital information to the preoperative work-up and laparoscopy alone. Any suspicious lymph nodes identified by LUS should undergo diagnostic biopsy. However, ultrasound characteristics alone should not be used to distinguish between inflammatory and malignant processes of the pancreas. LUS provides invaluable information regarding hepatic masses with concurrent periportal adenopathy. LUS can thoroughly stage hepatic lesions and may be more accurate than CT scans regarding periportal and peripancreatic lymph nodes. LUS of the liver during laparoscopic colon surgery adequately replaces manual palpation of the liver. However, it should be remembered that surface lesions can be easily missed by intraoperative ultrasound and retroperitoneal structures may go undetected. In summary, our early experience and review of the literature provides ample support for the use of LUS during minimally invasive surgery. Further work is in progress to better define its role as an adjunct to laparoscopy alone in intra-abdominal laparoscopic surgery.

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# Biology of Videothoracoscopy

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## INTRODUCTION

Videothoracoscopy, or video-assisted thoracic surgery (VATS), represents a major advance in thoracic surgery in the last decade. VATS, compared to conventional thoracotomy, produces less postoperative pain, shorter length of hospital stay, quicker return to normal activities and improved cosmesis.[32] Most of these benefits still await well-designed prospective, randomized clinical studies. Despite the lack of data, VATS has been enthusiastically embraced by thoracic surgeons.[22] Conceivably, any thoracic procedure performed by conventional thoracotomy can be completed through VATS.[28] However, the surgeon's enthusiasm must be tempered by the relative cost effectiveness and therapeutic benefit of VATS versus conventional thoracotomy. With the paucity of large clinical trials, VATS for pulmonary tumors must be approached either through a protocol or strict oncologic guidelines. The paucity of clinical trials documenting the efficacy of VATS is only surpassed by the lack of experimental data regarding the biology and pathophysiology associated with this novel technique. This chapter describes several pathophysiologic mechanisms associated with VATS.

## PORT SITE RECURRENCE

Since Ackerman and Wheat reported the first series of port site recurrences, strict oncologic principles have been established to minimize these recurrences.[1] The first report of port site recurrence following laparoscopic surgery was published in 1978 by Dobronte following a laparoscopic biopsy of an ovarian carcinoma.[11] Although rarely encountered, several cases of port site recurrence have been reported in the literature.[4,5,13,19,25,30,33] The actual incidence of tumor implants following laparoscopy or thoracoscopy is currently unknown. There is no difference in the incidence of tumor implantation following laparoscopic or


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thoracoscopic surgery versus conventional open surgery.[3] Currently several institutions are evaluating tumor implantation with prospective, randomized trials.[9] Since 1993 several cases of port site recurrences following VATS for primary or metastatic thoracic tumors have been reported (Table 18.1).

## PATHOPHYSIOLOGY OF TUMOR IMPLANTS

Several experimental studies suggest that surgery promotes cancer spread through mobilization of tumorigenic cells and transient immune suppression.[8,12,17] Murphy et al documented cancer cell implantation and tumorigenesis following intervention.[27] The authors noted that the inflammatory process following surgery initiated a gelatinous structure involving fibrin, fibronectin and platelets. Circulating inflammatory and neoplastic cells are trapped within this gel. The architectural framework is ideal for tumorigenic adhesion. The framework enhances tumorigenic isolation and protection against host defense mechanisms. Growth factors (EGF, PGF) are intimately involved in the normal repair process and inadvertently propagate tumor growth. All of these factors engender a favorable environment for tumor growth at the site of surgical trauma.

Port site recurrences may be secondary to direct tumor implantation. Operative instruments contaminated with malignant cells may contaminate port sites. However, this hypothesis does not explain tumor implants remote from trocar sites.[34]

Other possible mechanisms of tumor implantation include hematogenous dissemination and $CO_2$ insufflation. However, $CO_2$ insufflation with thoracoscopy has been largely abandoned. Regardless of their origin, tumor implants should be treated aggressively with resection and chest wall reconstruction.[7,24,29] Several protective measures should be performed during the initial operation to avoid

*Table 18.1. Tumor implants following VATS*

| Author | Year | Diagnosis | Interval (months) |
|---|---|---|---|
| Thurer | 1993 | Metastasis of endometrial cancer | 4 |
| Fry | 1993 | Lung cancer | 5 |
| Canalis | 1993 | Esophageal cancer | 7 |
| Peracchia | 1993 | Esophageal cancer | 6 |
| Coles | 1994 | Esophageal cancer | – |
| Yim | 1995 | Pleural metastases | – |
| Buhr | 1995 | Lung cancer | 19 |
| Walsh | 1995 | Metastases of sarcoma | 3 |
| Johnstone | 1995 | Lung cancer | 5 |
| Downey | 1995 | Report on 21 cases | – |
| Jancovici | 1996 | Lung cancer | – |
| Sartorelli | 1996 | Metastases of sarcoma | 4 |

tumor implantation. All tissue removed from the thoracic cavity should be placed in reinforced plastic or nylon bags and direct contact with the chest wall should be avoided.

## ACUTE PAIN

Few prospective, randomized studies have evaluated postoperative pain following VATS versus open thoracotomy. In 1996, Gebhart et al[15] reported a randomized study of patients with spontaneous pneumothoraces undergoing VATS or conventional open thoracotomy. The latter group required significantly more opioid analgesia during the first 48 postoperative hours compared of the VATS group. However, no subjective pain evaluations were performed postoperatively. The authors also demonstrated higher concentrations of inflammatory mediators following open thoracotomy versus VATS. Gebhart et al postulated that these higher concentrations correlated with greater surgical trauma and increased postoperative pain. Landreneau et al[21] retrospectively evaluated postoperative pain following VATS versus open thoracotomy for pulmonary resection. Opioid frequency and patient questionnaires were utilized to evaluate postoperative pain. The VATS group had significantly less postoperative pain and opioid use. However, Kirby et al[20] utilized a prospective, randomized trial of VATS versus muscle-sparing thoracotomy for pulmonary resections. The authors found no significant difference in the two groups in terms of length hospital of stay and postoperative pain. Further studies with larger cohorts are required for definitive conclusions regarding postoperative pain utilizing VATS.

## CHRONIC PAIN

Chronic post-thoracotomy pain requires a history of persistent pain for two months postoperatively at the incision site or along the intercostal nerve dermatome.[10] Factors associated with the development of post-thoracotomy pain include intercostal neuromas, rib fracture, local infection, costochondritis, displacement of costochondral joints and local tumor recurrence. The most common cause is an intercostal neuroma secondary to rib spreading from retractor trauma. VATS performed through small incisions with less muscle trauma and little intercostal spreading should theoretically induce less chronic pain.[18] However, careless insertion and manipulation of trocars during VATS can produce severe injuries to intercostal nerves with subsequent pain.[35]

Landreneau et al emphasized meticulous intercostal dissection with minimal cautery to avoid compression and injury to intercostal nerves and rib structure.[5] In a retrospective study comparing VATS to thoracotomy, Landreneau noted a significant reduction in chronic pain following VATS compared to conventional thoracotomy during the first three postoperative months. However, a one year follow-up found no significant difference in chronic pain in the two groups.

## IMMUNE RESPONSE

In 1997 Walker et al reported higher T lymphocyte counts, increased oxidative activity of leukocytes and lower concentrations of inflammatory mediators following VATS versus open thoracotomy for pulmonary lobectomies.[32] Although open thoracotomy produced greater immune suppression, there was no difference in clinical outcome between the groups. However MaKinlay et al[24] noted a trend toward greater disease-free survival rates in patients treated by VATS for pulmonary malignancies. The full impact of immune suppression of VATS for pulmonary malignancies has yet to be determined.[15]

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# Video-assisted Thoracic Surgery for Lung Cancer

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In 1996, 170,000 new cases of lung carcinoma were diagnosed while 156,000 patients died from the disease. Patients diagnosed with localized pulmonary carcinoma are treated surgically. Surgical intervention for pulmonary carcinoma requires at a minimum a lobectomy with mediastinal lymph node dissection. Patients diagnosed with locally advanced disease are treated with either surgery and adjuvant therapy or exclusively with adjuvant therapy. Disseminated disease is treated with chemotherapy alone. Currently, video-assisted thoracic surgery (VATS) has been utilized for diagnosis, staging and treatment of pulmonary carcinoma.

The majority of patients with pulmonary carcinoma present with extensive tumor burden that is centrally located. A minority of patients present with asymptomatic, peripheral tumors. Approximately 37% of solitary lung nodules represent primary lung carcinoma. Therefore these lesions require accurate histological diagnosis for effective treatment. The incidence of lung cancer increases with age and smoking habits. Early diagnosis is imperative as patients with solitary, peripheral lung lesions have the best outcomes following proper treatment.

Several studies have evaluated the effectiveness of noninvasive methods to detect and diagnose malignancy in lung nodules. Old chest x-rays are required for comparison. If a peripheral lesion has remained unchanged for more than two years, there is a very high likelihood that it is benign. Computed tomography (CT) of the chest can evaluate morphology, adenopathy and calcifications. However, fine needle aspiration (FNA) must be incorporated to make the diagnosis of carcinoma. For peripheral lesions, cytology obtained from sputum or bronchoscopy is diagnostic in only 5-30% of patients. Percutaneous transthoracic needle biopsy, guided by fluoroscopy or CT, is highly accurate for pulmonary lesions. Sensitivities approach 90%. However, there is only a 77% specificity. Surgical resection is indicated for histologically indeterminate nodules as well as for malignant tumors. Currently, percutaneous needle biopsy is reserved for high risk patients or patients reluctant to undergo surgery.

Following this initial work-up, VATS is utilized for definitive diagnosis. The involved lung is deflated following double-lumen tube intubation, and three intercostal trocars are placed after verifying the anatomical site of the nodule. The video camera is introduced through the seventh intercostal space in the mid-axillary line. This position provides maximal visualization of the majority of the pulmonary parenchyma. The other ports are usually positioned anterior and posterior

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to a line parallel to the thorascopic port. After thoroughly inspecting the lungs and pleural cavity, an excisional biopsy is performed. Endoscopic staplers are utilized for pulmonary wedge resections in a V or U shape. The surgical specimen is placed in a retrieval bag and removed through an intercostal port. This maneuver decreases contamination of the trocar site with tumor cells from the specimen. Frozen sections are performed on the surgical specimen. The integrity of the stapled pulmonary parenchyma is checked by completely submerging the tissue in irrigation fluid. Positive pressure is applied by the anesthesiologist to determine the presence of air leaks. The entire thoracic cavity is then thoroughly evaluated. Evaluation includes visualization of the parietal and visceral pleura, mediastinal, paratracheal, subcarinal and inferior paraesophageal lymph adenopathy. Mediastinoscopy cannot assess the inferior paraesophageal lymph nodes. Mediastinal dissection with lymph node biopsies can also be completed with VATS. Any hilar adenopathy is sent for frozen section. If N2 or N3 diseases is identified on frozen section, pulmonary resection is aborted and the patient is referred for chemotherapy and radiation. The pleural cavity is then drained with a chest tube, the lung is inflated and the chest wall incisions are closed. VATS provides a 97% diagnostic accuracy for solitary lung nodules with minimal postoperative pain.

Thorascopic localization is difficult for solitary lung nodules located deep within the pulmonary parenchyma. Extension of a port incision for manual palpation, endoscopic ultrasound, needle localization with fluoroscopy, and CT-guided dye injection can facilitate localization of these lesions. Overall VATS provides excellent visualization of the entire thoracic cavity for evaluation of local regional tumor involvement. Utilizing VATS as an initial staging modality decreases the rate of unnecessary thoracotomies due to N2, N3, T3 or T4 disease by approximately 10%.

Most if not all operations performed through conventional thoracotomy are possible using VATS. Although technically more demanding initially, VATS is a reasonable surgical option for pulmonary carcinoma. Without 10-year survival data, many thoracic surgeons believe that VATS should be limited to patients with stage IA or IB tumors (T1N0 and T2N0, respectively). Stages I and II tumors are confined to lung parenchyma without mediastinal or hematogenous spread and no evidence of adjacent organ invasion. These tumors represent localized disease and higher cure rates. Surgical treatment is indicated for patients with adequate pulmonary function. Lobectomy or pneumonectomy are the standard procedures based on tumor position. Complete surgical treatment of lung cancer requires negative margins and mediastinal lymph node biopsies. However, the extent of mediastinal dissection is still unclear. Currently at our institution patients undergo a complete mediastinal lymph node dissection regardless of the extent of lung dissection. Retrospective analysis of these patients shows improved survival rates following a complete dissection regardless of stage. Patients with non-small cell lung cancer (NSCLC) with stage I disease have a five year survival rate of 65-87% (at our institution, 67%). Martini et al followed 598 patients with T1 and T2 lesions at Memorial Sloan-Kettering Cancer Center. T1 lesions were seen in 49% of cases. Overall survival rate was 82% for T1N0 lesions and 68% for T2N0 lesions ($p < 0.0004$). Recurrence rate was 27% with 74% of all recurrences at distant sites. Formal lung resections involving either a lobectomy or pneumonectomy resulted in a 77% five-year survival while wedge resections or segmentectomies resulted in a 59% five-year survival. Local recurrence rates increased to 12-19% following wedge or segmental resections. The majority of these limited resections were performed on patients with significantly limited pulmonary function. Finally, operative mortality rates ranged from 1-3%. Table 19.1 shows the results of limited resections for NSCLC.

Currently the size of the thoracic incision is irrelevant as long as the surgeon performs a formal oncologic resection of the primary tumor. Formal guidelines utilizing VATS for oncologic procedures await long-term results of ongoing, prospective, randomized protocols. Until equal or superior results are documented with VATS, thoracic surgeons should meticulously document every oncologic, thorascopic procedure.

*Table 19.1. Results of limited resection in the treatment of NSCLC - T1/T2*

| Author | year | n | Local recurrence rate (%) | Five-year survival rate (%) |
|---|---|---|---|---|
| Bennett | 1978 | 44 | 40% | 36% |
| McCormack | 1980 | 53 | 19.3 | 35% |
| Errett | 1985 | 100 | — | 69% |
| Miller | 1987 | 32 | 6.2% | 31% |
| Read | 1990 | 107 | 4.4% | 70% |
| Wain | 1991 | 164 | 5% | 46% |
| Temeck | 1992 | 61 | 9% | 29% |
| Warren | 1993 | 74 | 21.6% | 50% |
| Ginsberg | 1994 | 123 | 17.5% | 70% |
| Martini | 1995 | 64 | 22.6% | 59% |
| Landreneau | 1997 | 102 | 20% | 61% |

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# VATS in Malignant Pleural Disease

*Riad N. Younes*



Pleural effusions are frequently observed in patients with pulmonary malignancies as well as in patients with cardiac failure, pulmonary diseases, mediastinal diseases and intra-abdominal diseases. The proper management of pleural effusions depends on accurate diagnosis. Traditionally, pleural diseases are diagnosed by aspirating pleural fluid or transthoracic pleural biopsy using a Cope's needle. Utilizing thoracentesis yields a diagnosis in 66% of patients. The addition of a pleural biopsy increases this value to 75%. Despite those results, 25% of patients are undiagnosed. These patients require further diagnostic and therapeutic interventions. Thoracoscopy provides a diagnostic and therapeutic modality for these patients.

Metastatic pleural effusions frequently occur in cancer. It is estimated that 40% of patients with breast cancer will develop a pleural effusion some time during follow-up; 72% of the effusions will be malignant. The interval between primary breast cancer and pleural metastases averages 6 years following tumor resection. Nonmalignant pleural effusions occur in cancer patients secondary to hypoproteinemia, coagulopathy, atelectasis, actinic pleuritis, pneumonia, and venous or lymphatic congestion.

Regardless of the primary tumor, malignant effusions are associated with poor survival. These patients are candidates only for palliative interventions and supportive measures. Pleural effusions significantly diminish the quality of life of these patients. At our institution 73% of patients with metastatic pleural effusions presented with dyspnea, 55% with pain, 42% with persistent cough, and 10% with empyema. Along with diagnosing these effusions, adequate treatment is required to prohibit reaccumulation of thoracic fluid. Currently pleurodesis is performed via a chest tube or thoracentesis needle using tetracycline, bleomycin or both.

Video-assisted thoracoscopic surgery (VATS) has recently been used to diagnose and the treat pleural effusions. VATS enables direct visualization of the thoracic cavity with precise treatment of the entire cavity. Multiple biopsies can be performed simultaneously as well.

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## TECHNIQUE OF VATS FOR PLEURAL DISEASE

Following general anesthesia and selective endotracheal intubation, the patient is placed in a lateral decubitus position. The first port incision is placed in the mid-axillary line in the sixth or seventh intercostal space. Pleural fluid is aspirated, and the videoscope is introduced for inspection of the pleural cavity. A second and third port are placed depending on the pleural findings. Usually one port is placed anterior and one posterior to the thorascope. Biopsy is performed with endoscopic forceps, scissors and electrocautery. Deep biopsies are avoided to decrease the rate of phrenic or intercostal injuries. At the end of the procedure, the anesthesiologist is asked to reinflate the lung after placement of a chest tube through one of the thorascopic ports. If indicated, pleurodesis is performed prior to reinflation under direct vision. VATS provides a 90-96% accuracy for pleural diseases with few complications and a low mortality rate.

## PLEURODESIS

Creating an artificial symphysis of the pleural and visceral linings of the thoracic cavity allows maximal expansion of the underlying pulmonary parenchyma, maintenance of lung capacity, and relief of dyspnea and pain. Pleurodesis is usually accomplished by inducing a strong inflammatory reaction between the parietal and visceral pleura, causing a fibrotic reaction between the two structures. The pleural cavity is obliterated preventing further fluid accumulation. Pleurodesis is accomplished utilizing chemotherapeutic agents, antibiotics, sclerosing agents or mechanical abrasion.

The success rate for eradicating pleural effusions depends on the agent and the method applied. Recently, experimental and clinical studies showed the effectiveness of different sclerosing agents. The average success rates following an initial attempt at pleurodesis were as follows: nitrogen mustard (44%), bleomycin (71%), tetracycline (69%), and talc (96%). Talc has consistently been shown to effectively produce pleural fibrosis with the best early and long-term results. A randomized prospective clinical study showed that talc is equally effective if administered through an indwelling chest tube or thoracoscopically. Thoracoscopy allowed for diagnostic sampling, effective lysis of adhesions, removal of loculations, and uniform distribution of talc. The talc is distributed homogeneously over the entire pulmonary surface. A thin layer will suffice and is made into a slurry by mixing 2-4 grams with normal saline. However, VATS is more expensive and requires general anesthesia.

We followed 145 consecutive patients with malignant pleural effusions treated with either tube thoracostomy (TT-n=95) or thoracoscopy (VATS-n=50). Pleurodesis was performed via tube thoracostomy with bleomycin or talc poudrage via thoracoscopy. Median overall survival of the patients was 8 weeks following pleurodesis. Recurrence rates for just TT patients without pleurodesis was 44% while patients undergoing pleurodesis had a 29% recurrence rate (37%

homolateral). Recurrence rate for thoracentesis alone was 63% (96% homolateral). Recurrence rates for VATS patients was 2% (homolateral). There were no operative deaths; the complication rate was 16% (respiratory insufficiency). We concluded that VATS and talc pleurodesis provided the best management of malignant pleural effusions with acceptable complication and local control rates.

## MESOTHELIOMA

Mesothelioma is the most common primary pleural malignancy with a clear association with asbestos exposure. Certain populations have a higher incidence of this disease due to proximity of shipyards or other related industries with asbestos exposure. Mesothelioma usually presents at 60-70 years of age, and 85% of patients are male. Chest pain, dyspnea, and cough are the most common presenting symptoms.

The diagnosis of mesothelioma requires histopathologic evaluation of the tumor. Thoracentesis with a needle biopsy yields a diagnostic accuracy between 35-70% in most series. However the definitive diagnosis of mesothelioma is difficult due to the frequent resemblance of mesothelioma with adenocarcinoma. Larger tissue samples are often required by the pathologist. Open thoracotomy was previously indicated to confirm tumor histology. However, recent studies showed that VATS achieved a diagnostic accuracy of 95-98%. VATS also allows appropriate staging. Biopsies are easily performed and specifically directed to suspicious lesions.

Localized mesothelioma can be resected utilizing VATS. Contamination of the thoracoscopic ports following resection is prevented by utilizing a specimen bag. Currently there are no long-term studies documenting the results of mesothelioma utilizing VATS. Traditionally, extensive pleuropneumonectomy with adjuvant chemotherapy has been utilized for effective treatment. Preliminary results are encouraging with improved long-term survival rates following surgery and adjuvant therapy.

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# Laparoscopic Approach to Esophageal Cancer

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## INTRODUCTION

The search for a safe and less traumatic procedure for esophagectomy has constantly challenged surgeons. Early attempts at esophagectomy were conducted through an extrapleural approach since thoracotomy was impossible.[1-3] With advances in critical care and anesthesiology, surgeons adopted the thoracic approach as the best alternative for esophagectomy.[4] The high incidence of malnutrition and respiratory insufficiency among patients with esophageal cancer resulted in a revival of esophagectomy without thoracotomy in order to minimize perioperative surgical morbidity.[5-9] With the advent of videoscopic and minimally invasive surgery, thoracic procedures are now being performed via this modality, including esophagectomy. Currently video-assisted esophagectomy is technically feasible; however its advantages as compared to conventional techniques remain questionable. Furthermore several questions regarding operative technique, preservation of oncological principles, postoperative adjuvant management and long-term survival remain unanswered.

## SURGICAL ASPECTS

Video-assisted esophageal resection entails three important surgical techniques. These techniques include the route of access for surgical excision, mobilization and extirpation of the esophagus, and finally reanastomosis of the digestive tract.

The video-assisted technique replicates conventional surgery. For the access to the thoracic esophagus, trocars are placed in the neck, chest, and/or abdomen. Utilizing these ports, dissection and removal of the esophagus as well as mobilization of the stomach is completed. Gastric mobilization includes the transection

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and ligation of the omental vessels, the left gastroepiploic artery, the short gastric vessels and the left gastric artery at its origin. The right gastroepiploic artery and the gastroduodenal artery are preserved to maintain vascular supply to the stomach. An oncological resection should include the gastric cardia within the specimen. Gastrointestinal restoration is achieved with an esophagogastrostomy at the apex of the chest or within the neck following esophageal resection.



## ENDOSCOPIC MICROSURGICAL DISSECTION OF THE ESOPHAGUS (EMDE)

Endoscopic microsurgical dissection of the esophagus (EMDE) was described by Buess et al in 1991.[12] The patient is placed in the supine position with the head turned to the right. The esophageal dissection proceeds with a modified mediastinoscope introduced through a small cervical incision. The space for the endoscopic operation is created by mechanical distraction of tissue planes contiguous with the esophagus. Instruments (clamps, scissors, suction device, coagulating forceps) are manipulated through the working channel of the mediastinoscope and the dissection is performed close to the esophageal wall. The method does not permit a wide en bloc esophageal resection incorporating extensive amounts of lymph nodes. The abdominal portion of the procedure is completed through an upper midline incision. Gastric dissection starts with ligation and transection of the short gastrics, omentum, left gastroepiploic vessels and left gastric artery. Suspicious celiac lymphadenopathy is excised as well. The esophageal specimen, including the gastric cardia, is removed and gastrointestinal continuity is achieved with an esophagogastrostomy in the neck. A pyloromyotomy for drainage is added.

The initial series of Buess et al included 17 patients with esophageal cancer. The operative mortality was 5.9% (1 out of 17 patients). The short follow-up period does not provide an analysis of survival. However the authors suggest that EMDE provides an excellent view of the mediastinum when compared to the blind dissection performed during open transhiatal esophagectomy.

## ESOPHAGECTOMY BY VIDEO-THORACOSCOPY (EVT)

Esophagectomy by video-thoracoscopy (EVT) was proposed by Dallemagne in 1992.[11,12] This operation is carried out in two phases: thoracic via thoracoscopy and an abdominal resection via laparotomy or laparoscopy. Intubation is performed with a double-lumen endotracheal tube to allow one-lung ventilation. The patient is positioned in the left lateral decubitus. The table is tilted 30° to the left lateral to facilitate lung retraction. The operating surgeon stands facing the patient's back with an assistant on each side. The video monitor is placed facing the surgeon. The first 10 mm thoracic trocar is introduced in the 5th or 6th right intercostal space at the midaxillary line. The 0° wide angle laparoscope is introduced in order to inspect the pleural cavity. Four more thoracic trocars are placed under direct vision: two 10 mm trocars along the anterior axillary line and two trocars (10 mm and 12 mm) along the posterior axillary line (Fig. 21.1). The laparoscope is handled alternately by the assistants, depending on the phase of the dissection. The right side assistant manipulates the suction device (inferior trocar) and the left side assistant the lung retractor (superior trocar), both introduced through the anterior axillary line entrance (Fig. 21.2). Division of the triangular ligament down the inferior pulmonary vein allows retraction of the right lung to obtain a better exposure of the esophagus. Resectability is reevaluated by checking the extent of the tumor and evaluating the tumor invasion of intrathoracic and mediastinal structures. The pleura is then incised from the azygous vein superiorly to the esophageal hiatus inferiorly. Resectability is confirmed again after completing the exposure. Esophageal dissection begins at the level of the hiatus and proceeds up to the pleural apex. Again a wide en bloc lymphadenectomy is impossible with this technique.

The gastric dissection is completed through a laparotomy or laparoscopy. Utilizing this approach, the patient is placed in a modified lithotomy position. The surgeon is positioned between the patient's legs with an assistant at either side.

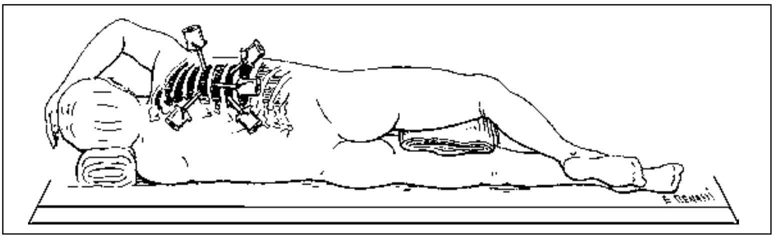
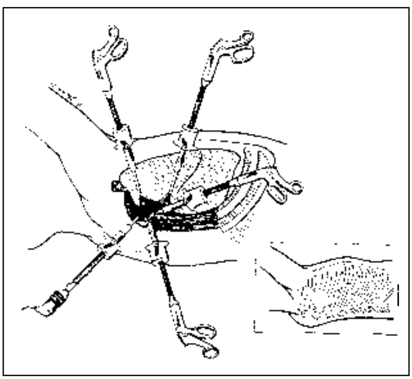


Fig. 21.1. The patient is positioned in the left lateral decubitus The first 10 mm thoracic trocar is introduced in the 5th or 6th right intercostal space at the midaxillary line. The 0° wide angle laparoscope is introduced and four more thoracic trocars are placed under direct vision: two 10 mm trocars along the anterior axillary line and two trocars (10 mm and 12 mm) along the posterior axillary line.

Fig. 21.2. The suction device (inferior trocar) and the lung retractor (superior trocar), are both introduced through the anterior axillary line entrance. Division of the triangular ligament down the inferior pulmonary vein allows retraction of the right lung to obtain better exposure of the esophagus.



Trocars are placed in the left and right upper quadrants for interventions on the upper digestive tract. The esophageal hiatus should not be opened initially in order to maintain the pneumoperitoneum. Gastric transection is performed with a linear endostapler introduced through a 12 mm trocar inserted to the right of the xiphoid appendix. Using successive cartridges, a gastric tube is created. The phrenoesophageal membrane is then opened and the esophagus is released from its hiatal connections.



A left anterolateral cervical incision along the sternocleidomastoid muscle is made and the esophagus is thoroughly exposed. The surgical specimen is removed by the cervical route. The stomach is transposed through the posterior mediastinum and occupies the esophageal bed. In both cases, the surgical specimen includes the upper portion of the stomach (Figs. 21.3 and 21.4). The cervical stage is done by left anterolateral cervicotomy. The operation is completed with an esophagogastric anastomosis at the cervical level.

**TRANSHIATAL ESOPHAGECTOMY BY VIDEOLAPAROSCOPY (THEVL)**

Transhiatal esophagectomy by videolaparoscopy (THEVL) was described by DePaula et al in 1993.[14,18] The patient is placed in a modified supine position with legs spread apart and the head turned to the right side. The operating surgeon stands between the legs of the patient (Fig. 21.5). Pneumoperitoneum is established using $CO_2$. The intraperitoneal pressure is maintained at or below 13 mm Hg. The insufflation needle is usually introduced through a puncture 5 cm above the umbilicus. The first 10 mm trocar is then placed through the same puncture. This trocar is used to introduce the laparoscope. Then, under direct vision, the remaining trocars are inserted through the abdominal wall (Fig. 21.6). The first surgical step is an extramucosal pyloromyotomy. Next, the mobilization of the stomach is performed as described above. All of the abdominal maneuvers must precede the dissection of the thoracic esophagus in order to avoid the loss of pneumoperitoneum. The surgeon proceeds with exposure of the gastroesophageal junction followed by dissection of the phrenoesophageal membrane through a 12 mm trocar.

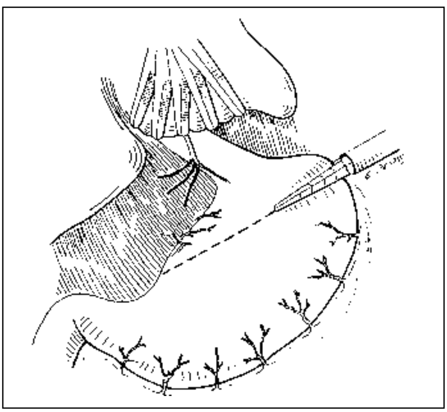


Fig. 21.3. Video-laparoscopic restoration of the digestive tract. The transection of the stomach is performed with a linear endostapler. Surgical specimen including the upper portion of the stomach.

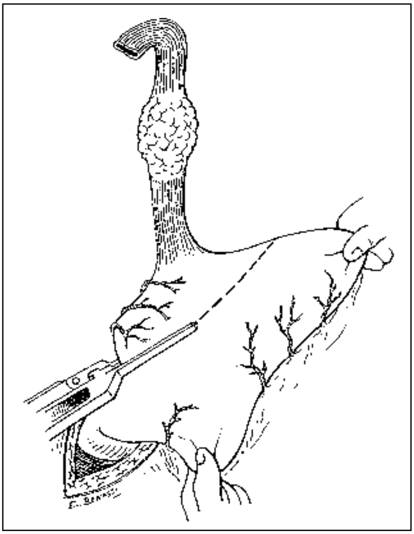


Fig. 21.4. Open route restoration of the digestive tract. Surgical specimen including the upper portion of the stomach in a case of esophageal cancer.

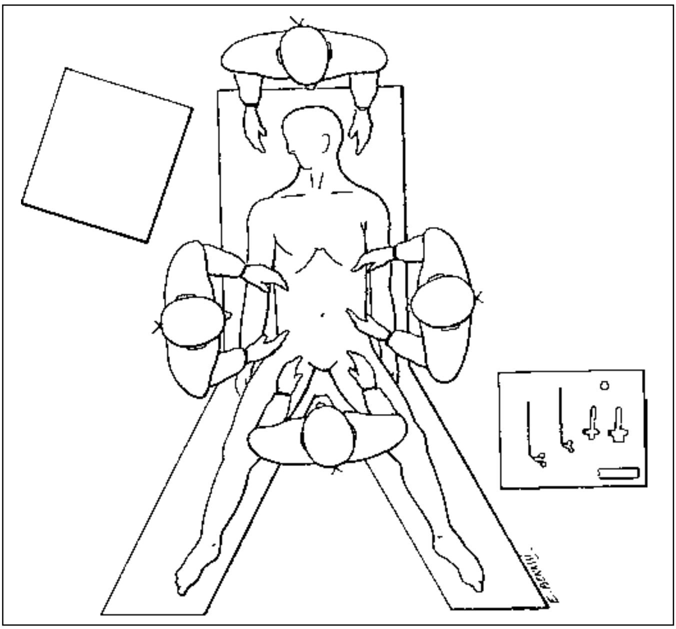


Fig. 21.5. Transhiatal esophagectomy by video-laparoscopy (THEVL). The patient is placed in a modified supine position with legs spread apart and the head turned to the right side. The operating surgeon stands between the legs of the patient.

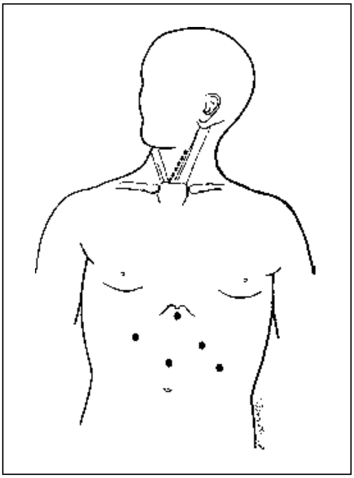


Fig. 21.6. The first 10 mm trocar is introduced through a puncture 6 cm above the umbilicus and is used to introduce the laparoscope. The remaining trocars are inserted through the abdominal wall under direct vision.



In cases of cancer, for oncological reasons, the transection includes the upper portion of the stomach (Fig. 21.4). The distal stump of the surgical specimen is attached to the apex of the stomach by means of a suture so as to facilitate the conduction of the gastric tube to the cervical region during the maneuver. The esophageal specimen is transected with staplers at the appropriate distal margin. Under direct vision, esophageal dissection proceeds cephalad into the chest. Circumferential dissection utilizes blunt and sharp instrumentation. A left anterolateral cervical incision enables identification of the cervical esophagus. The cervical and proximal thoracic esophagus are dissected bluntly through the cervical incision, and the esophageal specimen is extracted through the cervical incision. Prior to extraction, a stitch is placed securing the gastric conduit to the distal aspect of the specimen. The stomach is positioned in the posterior mediastinum and the procedure is completed with the esophagogastric anastomosis.

Forty patients with esophageal carcinoma underwent THEVL with two conversions to EVT and two to thoracotomy. Sixteen patients EVT without conversion. Mean hospital stay following THEVL was 14.2 days and 11.4 days for EVT. This difference was not statistically significant.

## CRITICAL ANALYSIS

Video-assisted surgery must respect the principles of oncological resection. However, in the specific case of esophageal cancer, it is conceivable to palliate dysphagia. Esophageal resection with or without wide lymphadenectomy is controversial, regardless of surgical technique. Akiyama recommends wide lymphadenectomy whereas its value is questioned by Western surgeons.[22,23] It is widely recognized that lymphadenectomy improves pathological staging; however it is much more traumatic. As proposed by Akiyama,[24-25] wide lymphadenectomy includes dissection at three levels: cervical, thoracic and abdominal. This dissection necessitates a conventional right thoracotomy. Video-assisted esophagectomy permits lymph node excision; however fewer nodes are extracted utilizing video-assisted esophagectomy. DePaula et al[23] removed an average of 11 lymph nodes using THEVL and 18 lymph nodes following EVT. The five- or ten-year survival rate or prognostic significance has yet to be determined.

The introduction of video surgery has added a new perspective to the treatment of esophageal carcinoma. The concept of minimally invasive surgery fulfills the palliative as well as the curative needs of patients with esophageal disease.[19,22,23] Nevertheless, morbidity and mortality rates are similar to those of conventional esophageal surgery, and an adequate preoperative work-up with careful oncological staging is exceedingly valuable. Finally, the advantages of video-assisted surgery should meet the expectations of the patient.

The morbidity and mortality associated with esophagectomy is related to the gastroplasty, esophagogastrectomy and surgical incisions. The first two aspects are not modified by video-assisted surgery. However, with smaller incisions the postoperative benefits are more appealing. But obtaining these benefits must not alter overall survival rates. Owing to the short follow-up period, data regarding the survival rate are not yet available. One might add that staging is the most important determinant of survival (Table 21.1), and it is unlikely that the new surgical methods can modify this picture. The available literature does not permit a pertinent conclusion since the series are poorly representative and the samples are not comparable.

The review of the results of surgical treatment of esophageal carcinoma did not indicate that any surgical technique was superior with respect to long term survival. The advantages of the video-assisted techniques lie in the better visual control of the blind steps of the conventional techniques (Fig. 21.7). We believe that the newer techniques can be combined with standard operative techniques so that we can meet the goals of reducing surgical trauma and its subsequent morbidity and mortality.

*Table 21.1. Staging versus 5-yr survival*

| STAGING | TNM | 5-yr survival |
|---|---|---|
| I | T1 N0 M0 | 65% |
| IIA | T2 N0 M0 | |
| | T3 N0 M0 | 45% |
| IIB | T1 N1 M0 | |
| | T2 N1 M0 | 25% |
| III | T3 N0/N M0 | |
| | T4 N0/N M0 | 20% |
| IV | T_ N_ M1 | 5% |

## TECHNICAL MODALITES OF VIDEO-ASSISTED ESOPHAGECTOMY

### EMDE—Endoscopic Microsurgical Dissection of the Esophagus

- supine position; head turned to the right
- cervical dissection of the thoracic esophagus through mediastinoscope
- preparation of the stomach for gastroplasty
- pyloromyotomy
- gastrosplasty
- esophagogastric anastomosis

### EVT—Esophagectomy by Video-Thoracoscopy

- left lateral decubitus position
- placement of the trocars; evaluation of the pleural cavity
- dissection and release of the thoracic esophagus
- preparation of the stomach for gastroplasty
  - laparotomy
  - video-laparoscopy
- pyloromyotomy
- cervical dissection
- exeresis of the specimen (laparotomy or cervicotomy)
- gastroplasty
- esophagogastric anastomosis

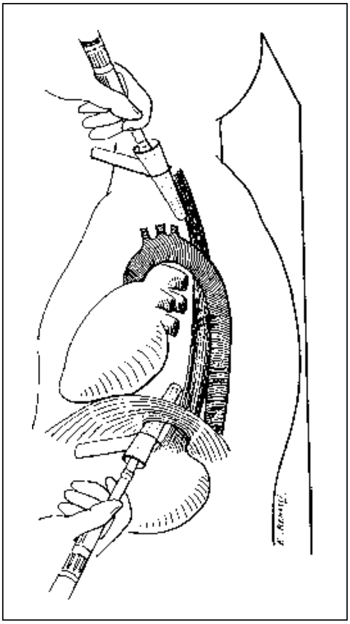


Fig. 21.7. Esophagectomy by video-thoracoscopy. The advantages lie in the better control of the blind steps of the conventional techniques.

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**THEVL—TRANSHIATAL ESOPHAGECTOMY BY VIDEO-LAPAROSCOPY**

- modified lithotomy position; head turned to the right
- pneumoperitoneum; placement of the trocars
- pyloromyotomy
- preparation of the stomach for gastroplasty
- dissection and release of the esophagus
- cervical dissection
- exeresis of the specimen via cervicotomy
- gastroplasty
- esophagogastric anastomosis

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# Videoendoscopy for Mediastinal Cysts and Tumors

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## INTRODUCTION

Mediastinal tumors and cysts represent a heterogeneous collection of pathology derived from different tissue elements, many of which are situated in characteristic anatomical locations. As a result, the mediastinum is often arbitrarily divided into four compartments. The superior compartment lies above a plane extending horizontally from the angle of Louis (manubriosternal joint) to the fourth thoracic vertebral body. The anterior compartment lies in front of the pericardium while the middle compartment consists of the heart and great vessels within the pericardium as well as the more posterior tracheobronchial tree and various lymph nodes. Finally, the posterior compartment lies behind the pericardial sac and includes the paravertebral gutters.

Mediastinal tumors are not rare. While the true incidence of mediastinal tumors may be difficult to ascertain, the increased use of routine chest x-rays and the increased sensitivity of various imaging techniques allow frequent and earlier diagnosis of many diseases.

Mediastinal cysts are included in the discussion because they are often indistinguishable clinically and radiologically from primary mediastinal tumors. Table 22.1 shows the distribution of mediastinal tumors and cysts from 13 series of 2440 patients summarized by Davis et al.[1] Although some differences exist in the relative incidence of neoplasms among various series, the most common mediastinal masses are neurogenic tumors (20%), thymomas (19%), lymphoma (13%) and germ cell neoplasms (10%).

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*Table 22.1. Primary mediastinal tumors and cysts in 2,440 patients (reproduced with kind permission from Davis RD, Oldham HN, Sabiston DC, eds.* The Mediastinum in Surgery of the Chest. *5th edition, Philadelphia: WB Saunders 1990).*

| Type of Tumor | Sabiston & Scott (1952) | Heimburger et al (1963) | Burkell et al (1969) | Fontenelle et al (1971) | Benjamin et al (1971) | Conkle and Adkins (1972) | Rubush et al (1973) | Vidne and Levy (1973) | Ovrum and Birkeland (1979) | Nandi et al (1980) | Adkins et al (1984) | Parish et al (1984) | Davis and Sabiston (1987) | Total | Incidence (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neurogenic tumor | 20 | 21 | 13 | 17 | 49 | 8 | 36 | 9 | 19 | 27 | 8 | 212 | 61 | 500 | 20 |
| Thymoma | 17 | 10 | 12 | 17 | 34 | 11 | 42 | 9 | 10 | 18 | 4 | 206 | 68 | 459 | 19 |
| Lymphoma | 11 | 9 | 12 | 16 | 32 | 10 | 14 | 6 | 11 | 4 | 7 | 107 | 75 | 314 | 13 |
| Germ-cell neoplasm | 9 | 10 | 3 | 7 | 27 | 2 | 14 | 3 | 5 | 7 | 11 | 99 | 44 | 241 | 10 |
| Primary carcinoma | 10 | 11 | 0 | 2 | 0 | 10 | 3 | 2 | 9 | | 5 | 25 | 37 | 114 | 5 |
| Mesenchymal tumor | 1 | 4 | 4 | 0 | 24 | 2 | 10 | 4 | 4 | 2 | | 60 | 29 | 148 | 6 |
| Endocrine tumor | 2 | 8 | 4 | 0 | 24 | 0 | 13 | 2 | 21 | 6 | 2 | 56 | 13 | 155 | 6 |
| Other Cysts | 14 | 0 | 0 | 0 | | | | 1 | 2 | 1 | 1 | 36 | 10 | 65 | 3 |
| Pericardial | 2 | 4 | 4 | 2 | 3 | 0 | 10 | 2 | 7 | 2 | | 72 | 37 | 145 | 6 |
| Bronchogenic | 5 | 12 | 9 | 13 | 11 | 0 | 6 | 2 | | | | 54 | 39 | 151 | 6 |
| Enteric | 2 | 5 | 0 | 4 | 1 | 0 | 2 | 1 | | | | 29 | 11 | 55 | 2 |
| Other | 8 | 3 | 0 | 4 | 4 | 0 | 3 | 3 | 3 | 7 | | 41 | 17 | 93 | 4 |
| Total | 101 | 97 | 61 | 90 | 209 | 43 | 153 | 45 | 91 | 74 | 38 | 997 | 441 | 2440 | 100 |

## ROLES OF VIDEOTHORACOSCOPY

The advent of videothoracoscopy has revolutionized the practice of thoracic surgery. While the treatment of certain benign conditions such as spontaneous pneumothorax is generally accepted, its role in the management of mediastinal tumors remains controversial.

In our practice we utilize videothoracoscopy for the following situations: (1) diagnostic biopsy; (2) to exclude unresectability prior to thoracotomy or sternotomy; (3) as primary treatment with resection of benign cysts, small stage I thymomas and small, well-encapsulated neurogenic tumors; and (4) as an adjunct to open surgery for visualization and illumination.



### Diagnosis

Most mediastinal masses require surgical intervention for either diagnosis or treatment. Although percutaneous fine needle aspiration (FNA) biopsy[3] may occasionally yield a diagnosis, this approach as a primary diagnostic modality is limited for several reasons. Mediastinal masses are, by definition, located close to the heart or major vessels. Therefore, percutaneous biopsy under computerized tomographic (CT) guidance is often difficult and potentially hazardous. Secondly, FNA biopsy seldom yields tissue with cellular architecture adequate to make a diagnosis of lymphoma or germ cell tumor. Since both tumors are both highly responsive to chemotherapy, accurate diagnosis is crucial.[4]

Cervical mediastinoscopy[5] and parasternal mediastinotomy[6] are frequently employed techniques for diagnosing mediastinal disease in the staging of primary lung cancer. These approaches yield adequate specimens for diagnosis, entail minimal surgical trauma and are associated with rapid recovery and short hospital stay. However, they assess a limited operative field while failing to provide information regarding the potential invasiveness of the lesion in question.

Video-assisted thoracoscopic surgery (VATS) provides an effective alternative approach to obtain adequate biopsy specimens and in some cases to assess resectability. Apart from obtaining biopsies for primary histological diagnosis, VATS is also useful to document pathologic remission following chemo- and radiotherapy. In our institution VATS is the preferred approach for histological diagnosis of a solid mediastinal mass. Other modalities are utilized for patients who cannot tolerate one-lung ventilation or who have pleural symphysis.

### Assess Resectability

VATS is useful in excluding patients with pleural metastases in order to avoid unnecessary thoracotomy or sternotomy. It is routine at our institution to performs VATS exploration on all patients with known intrathoracic malignancy even though in the majority of cases an open procedure is planned.[7] VATS exploration usually takes only a few minutes (including set-up of the camera), and the morbidity approaches zero in experienced hands. In view of the increased morbidity of thoracotomy, we prefer to avoid unnecessary thoracotomy by routine VATS exploration. We identified two patients with unexpected pleural metastases out of 39 (5.1%) with documented intrathoracic malignancies. These two patients avoided unnecessary thoracotomies.

On rare occasions VATS exploration can also confirm unresectability by showing tumor invasion of major vessels. However, in the vast majority of cases, VATS alone is not a good approach to detect vascular invasion as this requires careful assessment with bimanual palpation and dissection of the hilum.

#### Primary Resection

VATS is a viable, alternative approach to the resection of various benign mediastinal cysts and tumors. In our experience, mediastinal masses that have been successfully resected include the thymus,[8,9] neurogenic tumors, bronchogenic cysts (Fig. 22.3a), esophageal duplication cysts and pericardial cysts.[10-12] In the majority of cases the anatomical planes are well-preserved and endoscopic dissection is usually not difficult.

It is now generally accepted that VATS, in its current stage of development, should not be used as the primary approach for resection of invasive mediastinal malignancies. Exceptions are benign tumors or tumors associated with a low biological grade.[8,13] During the resection of a thymoma, evidence of invasion into adjacent tissue planes is an indication for conversion to an open procedure.

#### Adjunct to Open Surgery

The thoracoscope is an excellent device for visualization and illumination of the thoracic apex which is difficult to evaluate through conventional thoracotomy. As an adjunct to open surgery, the thoracoscope is particularly useful when a mediastinal mass has to be approached through a thoracotomy. The thoracoscope overcomes blind dissection at the thoracic apex. Although this is not thoracoscopy by definition, the use of the thoracoscope as an adjunct should not be disparaged.

## SURGICAL TECHNIQUES AND STRATEGIES

Under general anesthesia with selective one-lung ventilation, the patient is placed in a lateral decubitus position and the table flexed at 30° to open up the intercostal spaces.[14] A 0° telescope is placed through the fourth or fifth intercostal space in the posterior axillary line (Fig. 22.1). For anterior mediastinal masses, the instruments are introduced through the second or third intercostal spaces in the posterior axillary line. Extra ports for lung retraction are placed as needed. On the other hand, for posterior mediastinal masses, the thoracoscope is placed along the anterior axillary line with its exact position determined by the level of the mass (Fig. 22.2). Instruments are placed on either side of the thoracoscope in a "triangular" fashion.[15]

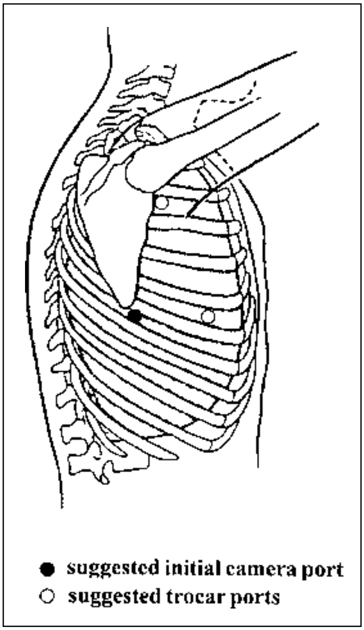


Fig. 22.1. Commonly used access positions for resection of anterior mediastinal masses (thymectomy).

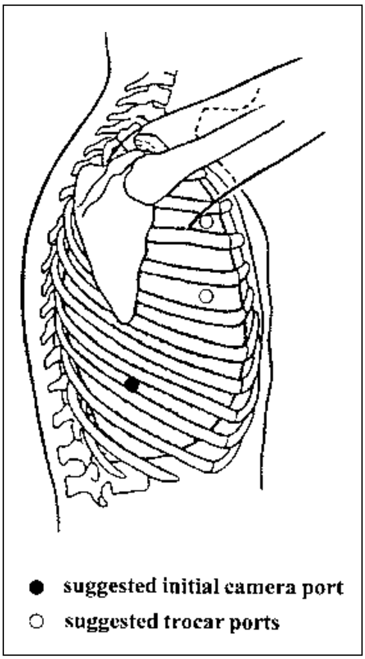


Fig. 22.2. Commonly used access positions for resection of posterior mediastinal masses (neurogenic tumor).

## THYMECTOMY

VATS thymectomy is an established, viable alternative to the median sternotomy or transcervical approaches. This is usually performed for patients with myasthenia gravis, but the technique has also been successfully employed in patients with stage I thymomas.

We advocate a right-sided approach in order to clearly visualize the confluence of the brachiocephalic veins forming the superior vena cava.[3] The procedure begins by inserting a 0° laparoscope in the fifth intercostal space along the posterior axillary (Fig. 22.1). Additional ports are placed for lung retraction as necessary.

The entire hemithorax is carefully examined with particular attention to the mediastinum. The mediastinal pleura is carefully incised along the superior vena cava. The incision is carried cephalad and caudad over the mediastinum from the thoracic inlet to the diaphragm. The right inferior horn of the thymus is identified and dissected off the underlying pericardium. Dissection extends onto the aorta in a cephalad manner until the left brachiocephalic vein is exposed. Blunt dissection with a pledget is utilized to identify the vascular supply of the thymus. The two or three thymic venous tributaries draining into the left brachiocephalic vein are identified, clipped and divided. It is important to obtain vascular control prior to further manipulation of the thymus. Dissection is then carried behind the sternum. With gentle traction on the thymus, the left anterior horn is identified and dissected up to the thymic isthmus. The most difficult part of the operation is the dissection of the superior horns. However, with gentle and deliberate inferior thymic traction, the superior horns are dissected free from their fascial attachments. Occasionally the superior horn may pass behind instead of in front of the brachiocephalic vein. The thymus is placed in a plastic bag and removed through the most anterior port as the intercostal spaces are widest anteriorly. The specimen is resected to confirm complete resection.

## MEDIASTINAL CYSTECTOMY

Mediastinal cysts usually result from congenital anomalies and consist of a heterogeneous group that include thymic, pericardial, esophageal duplication and dermoid cysts. Presentation occurs at any age from infants[16] to the elderly.[17] Operative technique and strategy depend on the nature of the cyst and its location. Superior mediastinal cysts are closely related to the great vessels while inferior mediastinal cysts are usually related to the pericardium. In the latter case, identification of the phrenic nerve is essential prior to any dissection. In most cases the cyst can be drained early to facilitate manipulation and dissection. In the majority of cases, the anatomical planes are well-preserved for endoscopic dissection. However, esophageal duplication cysts (Figs. 22.3b and 22.3c) may be firmly adherent to the esophagus with no identifiable dissection plane. Under these circumstances the cyst is opened and its content aspirated. The cyst wall is then excised except for a small island which is left intact on the esophagus. The mucosa of the cyst is then

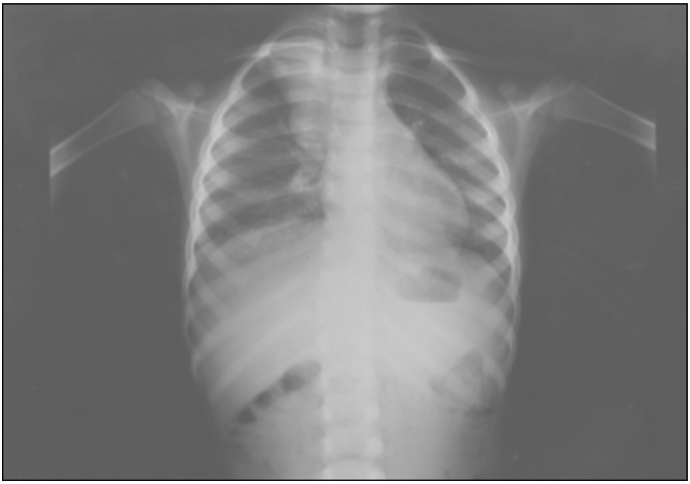

Fig. 22.3a. 2-year-old female incidentally discovered to have a right mediastinal mass.

cauterized. In situations where the esophagus is difficult to identify, a flexible endoscope is passed to transilluminate and insufflate the esophagus. This maneuver facilitates dissection and verifies the absence of perforation after flooding the field with irrigant. In the absence of a continual stream of air bubbles, a perforation has not occurred.

## RESECTION OF NEUROGENIC TUMORS

Neurogenic tumors, found in any mediastinal location, are most commonly located in the posterior compartment. They often arise from either the intercostal nerves (neurofibroma, neurolemma and neurofibroma), the sympathetic ganglia (ganglioma, ganglioblastoma and neuroblastoma), or paraganglia cells (paraganglioma).[1] Of all neurogenic tumors, neurolemma is the most common. Preoperative staging with magnetic resonance imaging is required to exclude intraspinous involvement ("dumbbell-tumor").[18]

Trocar placement is shown in Figure 22.2. VATS is applicable to the resection of small, encapsulated neurogenic tumors with well-preserved tissue planes. We recommend conversion to an open procedure if there is any evidence of tumor invasion into adjacent planes which is suggestive of malignant degeneration into neurosarcolemma. A thoracotomy with video assistance should be performed if the tumor is larger than 4 cm in diameter.

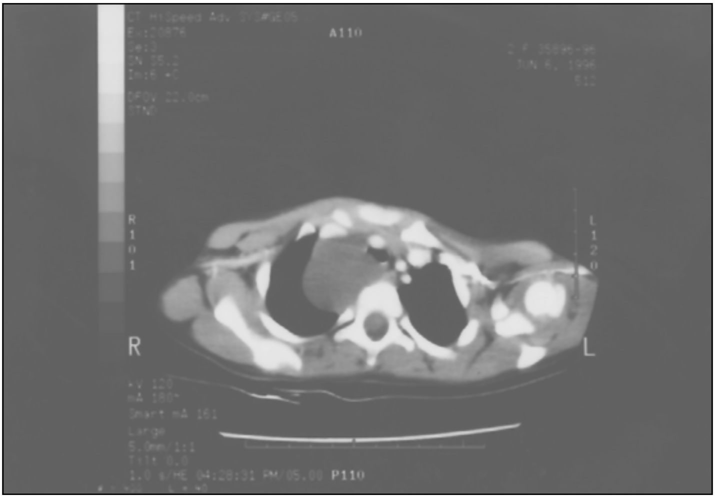


Fig. 22.3b. CT scan showed a right mediastinal cyst closely related to the esophagus and trachea. (Oral contrast study showed no communication between the esophagus and the cyst).

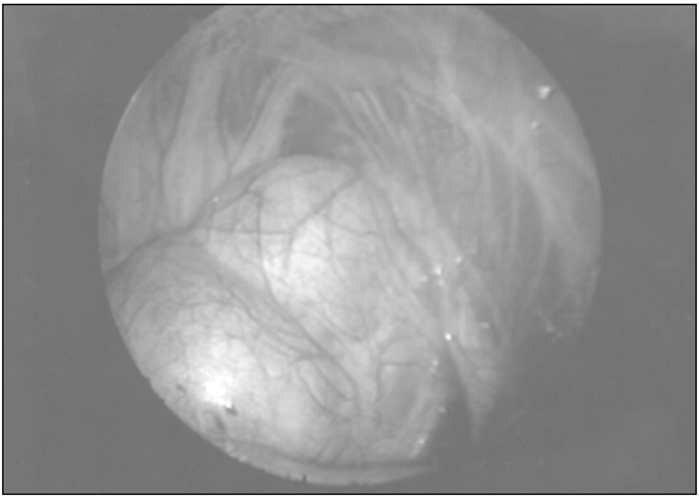

Fig. 22.3c. Thoracoscopic view of a multiloculated cyst. Pathology subsequently revealed an esophageal duplication cyst.

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## MEDIASTINAL MASS BIOPSY

Mediastinal biopsies are performed to establish a primary diagnosis as well as to evaluate neoadjuvant treatment of mediastinal masses. Although complete resection may not be possible, the goal of surgery is to obtain an adequate biopsy for histology to guide further management. In a few cases, complete excisional biopsy may be possible. In other cases, the mass is either too large or firmly attached to adjacent vascular structures for safe dissection. Under these circumstances, generous and often multiple biopsies are usually taken for frozen section analysis. If these prove inadequate, a formal thoracotomy should be performed for diagnosis as well as treatment. As mentioned earlier, VATS alone is not the best approach for staging mediastinal disease. It should be used as an adjunct to mediastinoscopy. It is a viable alternative to the Chamberlain procedure (or parasternal mediastinotomy) in order to biopsy nodes in the aortopulmonary window (level 5).

## CONCLUSION

VATS represents a viable alternative approach to the management of mediastinal masses in selected patients. If used properly, complications are relatively infrequent.[19,20] However, limitations of this approach in its present form must be appreciated.

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# Video-assisted Thoracic Surgery for Malignant Pericardial Effusion

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Pericardial effusions frequently develop in patients with advanced metastatic cancers. Breast and lung cancers account for nearly 70% of the primary sources.[1-3] Small to moderate asymptomatic effusions can be treated medically for a considerable period, but large effusions with hemodynamic consequences of tamponade require an effective drainage procedure.[4,5] Pericardiocentesis can provide effective decompression when acute tamponade is present in hemodynamically unstable patients. However, these effusions recur rapidly and require definitive surgical drainage.[6-9] Recurrent pericardiocentesis increases the risk of injury to the myocardium, coronary arteries, and other intrathoracic and intra-abdominal organs.[10,11]

Surgical options available for pericardial decompression include the traditional approaches of anterior thoracotomy, median sternotomy, and subxiphoid pericardiotomy. All are associated with considerable morbidity and mortality in debilitated patients.[12,13] The recent widespread experience with video-assisted thoracic surgery (VATS) provides another treatment option with less operative trauma for these patients.[14-16]

## PATIENT SELECTION

The patient's general condition and life expectancy determine the appropriate method of surgical decompression of the pericardium.[11,17] Many of these patients are terminally ill, with advanced metastatic disease, and are unable to undergo even general anesthesia. This group can be palliated effectively by a simple subxiphoid or left anterior thoracic approach under local anesthesia.[3,18] Some patients remain relatively healthy and active with early evidence of a pericardial effusion.[19] These patients are excellent candidates for VATS pericardiectomy.

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## ANESTHETIC AND SURGICAL TECHNIQUE OF VATS PERICARDIECTOMY

The technique of VATS pericardiectomy is similar to most other intrathoracic VATS procedures. A double-lumen tube or a single-lumen tube with a bronchial blocker is used for all anesthetic intubations. Hemodynamic monitoring with an arterial line is helpful. Following intubation, tube position is confirmed by bronchoscopy. Pericardial access is usually determined by the extent of concomitant pleural disease but may be obtained from either side. We commonly utilize a left thoracoscopic approach.[8,20,21]



The patient is placed in the right lateral decubitus position, and the entire left chest is prepped and draped as for an open thoracotomy. The first port is usually placed in the sixth or seventh intercostal space in the posterior axillary line. This posterior position avoids injury to the heart and pericardium which are usually massively dilated filling the anterior hemithorax.[22,23] Preliminary exploration of the entire thoracic cavity is performed including any biopsies sent for frozen section. Two other ports are then placed in an inverted pyramid technique with the working ports anterior and the camera port posterior. Lung retraction generally is not needed.[24] If the pericardium is markedly distended and tense, it may be necessary to perform a percutaneous pericardiocentesis under direct vision so that enough pericardium can be grasped to incise the sac.[21,25]

The phrenic nerve is easily identifiable and is scrupulously protected. Large pieces of pericardium are taken both anteriorly and posteriorly to the phrenic nerve, leaving a bridge of pericardium of approximately 1 cm under the nerve for support. A larger pericardiectomy precludes recurrence. With extensive pericardial inflammation, scissors with electrocautery are utilized for hemostasis. Obviously, the pericardium is retracted away from the heart when using the cautery to avoid dysrhythmias.

Visualization is comparable to an open thoracotomy and significantly better than a subxiphoid approach. All adhesions can be visualized and lysed with the electrocautery scissors. Multiple intercostal blocks in the appropriate interspaces using 0.25% bupivacaine hydrochloride (Marcaine) with epinephrine are administered. Finally, a 28 F chest tube is placed, and the anterior sites are checked for bleeding before closure with 3-0 Dexon subcutaneously and 4-0 Dexon subcuticularly.

Malignant pericardial effusions can induce myocardial irritability. However, the incidence is lower than in pericarditis. Some centers apply external defibrillator patches. However, the presence of an external defibrillator in the operating room is generally considered a satisfactory safety back-up measure.[25,26] Endoshears are used to initially incise the pericardium and then selectively cauterize the bleeding edges as it tents away from the heart.

Bradyrhythmia can also occur during this procedure, especially during resection of the superior portion of the pericardium near the hilum. Manipulation of the pericardium over the atrium and atrial appendage is the most common area of concern. Careful administration of atropine and cessation of the local stimulation usually control this situation.[27]

Postoperative management is generally the same as that for other VATS operations. Pain is usually controlled by intraoperative intercostal blocks and oral agents. Intramuscular or intravenous narcotics usually are not needed. The chest tube is generally removed on the second postoperative day unless sclerosis for malignant pleural effusion is required.

## THE AUTHOR'S EXPERIENCE



From December 1990 to April 1997 we treated 52 patients with significant pericardial effusions and tamponade in whom pericardiocentesis had failed. Twenty-one of these patients, with a life expectancy of 6 months or more, underwent VATS pericardial resection (Table 23.1). There were no hospital deaths, and the average hospital length of stay was 4 days. Pleural sclerosis was performed in five patients without sequelae. In the remaining 31 patients, a subxiphoid approach or left anterior transthoracic pericardiectomy under local anesthesia was employed. As shown in Table 23.1, the latter patients were older and had a considerable 30-day mortality and increased hospital length of stay.

Pericardial disease requiring surgical intervention has increased dramatically in the past 10 years. This is primarily due to the development and use of more effective chemotherapeutic agents, increasing patient survival. However, this often leads to more difficult aspects of disease control.

Our experience with pericardial effusion and tamponade in patients with metastatic cancer demonstrates two well-defined groups of patients. The first is composed of patients who are essentially moribund with a pericardial effusion with tamponade that is a preterminal event. These patients are best treated, albeit palliatively, by either a subxiphoid pericardial window or pericardial window done through a small anterior thoracotomy. Both approaches can be performed under local anesthesia with satisfactory results. Very few recurrences develop because the life expectancy of these patients is so short.

*Table 23.1. Treatment of 52 patients with malignant pericardial effusion*

| Procedure | Number of Patients | Average Age of Patients (years) | Mortality | Average LOS (days) |
|---|---|---|---|---|
| VATS pericardiectomy | 21 | 51 | 0 | 4 |
| Subxiphoid pericardiectomy | 5 | 65 | 1 | 9 |
| Left anterior thoracotomy | 26 | 61 | 4 | 10 |
| TOTAL | 52 | | | |

LOS = hospital length of stay

The second group of patients have a life expectancy of at least 6 months with a pericardial effusion early in the course of their disease. This group of patients fulfill our criteria for VATS pericardiectomy.

If an operation can be performed as well with VATS as with open techniques, VATS is employed since it is less invasive with comparable complication rates. This policy is utilized for pericardiectomy as well and is based on minimal morbidity and low complication rates.

## SUMMARY



The treatment of malignant pericardial effusion with tamponade entails two different techniques depending on the condition and disease status of the patient. Minimally invasive transthoracic or subxiphoid pericardiectomy under local anesthesia can provide palliation of this emergency quite satisfactorily in patients who are essentially at the end of life. VATS pericardiectomy can be employed in patients with a life expectancy of at least 6 months and a pericardial effusion early in the course of their disease. As our experience and the world literature demonstrates, the VATS approach is becoming the preferred technique.

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# Complications in Video-Assisted Thoracoscopy

*Riad N. Younes*

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Complications following video-assisted thoracic surgery (VATS) are similar to complications encountered during conventional thoracotomy.[1,6,21] These include intercostal nerve and artery injuries, chest wall hematomas, infections and air leaks. Other complications such as trocar perforations of lung parenchyma and the diaphragm are unique to VATS.

Lung perforations following trocar introduction are unique to VATS. These perforations are easily avoided by adhering to several guidelines. First, single lung ventilation should be performed for either case. Second, all trocars should be introduced under direct vision after incising an adequate opening within the intercostal space. The index finger is then inserted through the chest wall and any parenchymal adhesions are bluntly lysed. Finally, all trocars should be introduced with blunt introducers as opposed to the cutting sheaths utilized during laparoscopy. These guidelines will prevent parenchymal injuries during trocar introduction. If parenchymal injuries do occur, they usually result in bleeding or airleaks. The majority of these lesions are treated with direct pressure, suture ligation or stapling. Lung perforation following trocar introduction is rare, occurring in less than 1% of VATS cases.[8,11]

Trocar insertion can also produce intercostal arterial injuries.[22] These injuries result in troublesome bleeding from retracted vessels with the intercostal musculature. This complication is usually recognized immediately during the operative procedure. However, significant blood loss can occur in oncologic patients with underlying anemia.[10] If the intercostal vascular injury is not recognized, a large hematoma can form at the trocar site. These sites heal slowly and have an increased risk of infection and air leak.

Diaphragmatic injuries with concurrent intra-abdominal injuries have also been described in the literature following trocar introduction.[4] This is an exceedingly rare complication that occurs during blind introduction of an inferiorly placed trocar. Again, trocars are always placed under direct vision after probing the chest wall for adhesions.

Intercostal nerve injuries occur during trocar insertion or instrument manipulation through the chest wall.[14] Incision size should be kept to a minimum and instrumentation should be smooth and precise if the chest wall is not protected by trocar.

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Trocar site infections are treated with local drainage of purulent collections and antibiotics for gram positive organisms. The skin surrounding the trocar site can become desiccated and ischemic during a lengthy operation. All port sites are kept moist during lengthy procedures and nonviable tissue is resected at the time of trocar site closure. Currently there are no prospective studies defining the role of prophylactic antibiotics for VATS. However, first generation cephalosporins are usually administered to patients prior to VATS. The overwhelming majority of trocar site infections are self-limited with minimal cellulitis or small abscesses. Rarely, a patient may present with an associated empyema requiring protracted treatment and hospitalization.

Air leaks are frequent in thoracic surgery, regardless of the method of access. Usually air leaks are small and respond to chest tube suction. The incidence of significant air leaks or bronchopleural fistulae is slightly increased in patients undergoing VATS versus conventional open thoracotomy. Intraoperative underwater testing of pulmonary parenchyma for air leaks following positive pressure ventilation is essential for diagnosis.[13] Adequate drainage of the thoracic cavity postoperatively is essential for resolution of air leaks and prevention of tension pneumothoraces.

Currently there is a higher incidence of postoperative empyemas following VATS versus open thoracotomy.[3] However, this incidence is rapidly decreasing. Initially, longer operative times with uncontrolled contamination accounted for the higher incidence of empyemas. This difference is slowly decreasing as operative times for VATS are reduced and operative interventions with steep learning curves are increasingly performed by thoracic surgeons.

Port site recurrences have been reported following VATS. Most reports have occurred in patients with advanced intrathoracic malignancies (stage III and IV).[5,18,20] Most investigators theorize that increased local trauma at the port sites enhances tumor recruitment and adhesion.[2] Meticulous technique with port site protection with wound protectors is recommended for every oncologic procedures and all specimens should routinely be placed in reinforced polypropylene bags.[16] These maneuvers should prevent port site recurrences. Prospective studies are certainly needed to evaluate the incidence and pathophysiology of tumor seeding.[17]

Proponents of VATS have noted inadequate oncologic procedures utilizing thoracoscopy. However VATS maintains the oncologic principles of clear margins, no-touch technique , en bloc resection of tumor and lymph node basins, and avoidance of tumor spillage. Long-term results following prospective studies of VATS versus open thoracotomy are currently pending. Regardless of the eventual results, VATS should never compromise any of the previously mentioned oncologic principles. The indications and extent of the thoracic procedure utilizing VATS should be exactly the same for an open thoracotomy. Conversion of VATS to open thoracotomy is not a complication, rather a surgical judgement intended to maintain oncologic principles.[19]

Finally, trocar incisions are usually larger than the diameter of a chest tube. This small difference between the chest tube and chest wall orifice results in subcutaneous emphysema. It is usually self-limited unless accompanied by a persistent bronchopleural fistula. Subcutaneous emphysema can be avoided by securing a careful placed U-stitch sealing the skin surrounding the chest tube.



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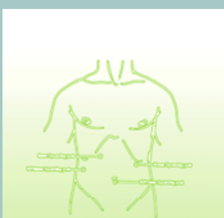

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