Laparoscopic Surgery for Cancer Patients

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Introduction

Minimally invasive techniques such as laparoscopy are now being used frequently in nearly all fields of surgery. The explosion of these procedures can be traced to the development of high-resolution video monitors in the early 1980s. Previously, only one surgeon could view the abdominal cavity through the laparoscope. With a high-resolution monitor and a camera attached to the end of the laparoscope, the surgeon and all assistants can comfortably view a high-quality magnified image, and they can perform surgical procedures using delicate laparoscopic instruments. The potential benefits to the patient include less pain, decreased hospitalization, and earlier return to normal activities.

Concern exists, however, about the rapid application of minimally invasive surgery to a wide variety of procedures. Adequate training, patient selection, unforeseen complications, and appropriate credentialing are some of the issues that have arisen. The use of these procedures in the cancer patient is the subject of increasing excitement and controversy.

Laparoscopic surgery dates back to the 1900s. Before the turn of the century, instruments were developed to look into human organs such as the stomach and bladder. The first minimally invasive abdominal examination, cystoscopic examination of the abdominal cavity of a dog, was reported in 1901 by Kelling. In Russia during the same year a German physician performed the first laparoscopic procedure on a human. Ten years later, Jacobaeus used thoracoscopy and laparoscopy to diagnose several disease states, including malignancy.

A variety of experiences reported in the 1920s revealed that the abdominal cavity could be viewed through a scope in numerous patients without morbidity and that the procedure could be done under local anesthesia without a hospital stay. In the 1930s, Fervers recommended the use of carbon dioxide to establish pneumoperitoneum, and Veress suggested the spring-loaded needle that is used today for insufflation of the abdomen. During this period Ruddock reported on the first significant series of laparoscopic procedures, 500 laparoscopies (including 39 biopsies) over a 4-year period.

The slow development of laparoscopic technology over the next several decades inhibited the adoption of minimally invasive techniques by the surgical community. During the 1960s, however, laparoscopy was widely used by gynecologists, mainly as a diagnostic tool. During this time Semm, a German gynecologist and engineer, developed an automatic insufflation device for monitoring gas flow and intraabdominal pressure. He and others developed a variety of laparoscopic instruments.

In 1982 Semm was the first to report on performance of a laparoscopic appendectomy. In 1985, with the aid of the endoscopic camera and video monitor, the first laparoscopic cholecystectomy was performed by Muhe in Germany, and in
### Table 1
Results of Diagnostic Laparoscopy for Staging Abdominal Cancer

| Reference            | Type of Cancer          | No. Patients | Laparoscopy Successful | Disease Status | Correctly Predicted Resectability (%) | Avoided Laparotomy |
|----------------------|-------------------------|--------------|------------------------|----------------|---------------------------------------|-------------------|
| D’Ugo et al 16        | Gastric                 | 70           | 70                     | 18             | 52                                    | 100.0             | 18/70 (25.7%)     |
| Lowy et al 17         | Gastric                 | 71           | 69                     | 16             | 53                                    | 38                | 71.7             | 15/71 (21.1%)     |
| Burke et al 18        | Gastric                 | 104          | 103                    | 32             | 71                                    | 65                | 91.5             | 24/104 (23.1%)    |
| John et al 19         | Hepatic                 | 52           | 50                     | 32             | 18                                    | 13                | 72.2             | 35/52 (67.3%)     |
| Molloy et al 20       | Gastric/esophageal      | 244          | 244                    | 92             | 152                                   | 85                | 55.9             | 103/244 (42.2%)   |
| Bemelman et al 21     | Pancreatic              | 73           | 72                     | 12             | 58                                    | 29                | 50.0             | 13/73 (17.8%)     |
| Babineau et al 22     | Hepatic                 | 29           | 29                     | 14             | 15                                    | 11                | 73.3             | 12/29 (41.4%)     |
| John et al 23         | Pancreatic              | 40           | 40                     | 24*            | 14                                    | 12                | 85.7             | 18/40 (45.0%)     |
| Bemelman et al 24     | Gastric/esophageal      | 56           | 55                     | 3              | 53                                    | 47                | 88.7             | 3/56 (5.4%)       |
| Hemming et al 25      | Hepatic, pancreatic,    | 162          | 162                    | 58             | 104                                   | 84                | 80.8             | 58/162 (35.8%)    |
| Possik et al 26       | Gastric, colon          | 352          | 345                    | 123            | 222                                   | 111               | 50.0             | 123/352 (34.9%)   |
| Reed and Mustafa 27   | Hepatic, pancreatic     | 26           | 26                     | 6              | 20                                    | 18                | 90.0             | 6/26 (23.1%)      |
| Callery et al 28      | Hepatobiliary, pancreatic | 50           | 50                     | 22             | 28                                    | 26                | 92.9             | 17/150 (11.3%)    |

*One patient had disease that was found to be unresectable at laparoscopy but resectable at laparotomy.
1987, a series of laparoscopic cholecystectomies was begun in France.8 By the end of the decade, laparoscopic cholecystectomy had begun to spread throughout the general surgical community in the United States.9 The widespread adoption of laparoscopic cholecystectomy may have been more rapid than that of any other health care technology in history.10

Inevitably, the expansion of minimally invasive procedures soon included diagnosis and treatment of malignancies. Although minimally invasive techniques have been used for treating cancers of the colon, lung, upper gastrointestinal tract, pelvic organs, and other organs, reports have been published expressing concern about the safety of these procedures11 and even about the safety of insufflation of the abdominal cavity in the patient with an abdominal malignancy.12

This review discusses several minimally invasive techniques for diagnosis and treatment of malignancies by the general surgeon and explores some of the controversies that have arisen from these procedures. Focal points include the use of laparoscopic surgery for diagnosis and staging of abdominal malignancies, therapeutic resection by laparoscopy, and laparoscopic procedures for palliation. Laparoscopic colon resection, laparoscopic adrenalectomy, and laparoscopic cholecystectomy in a patient with unsuspected carcinoma are reviewed individually. A look at the future of laparoscopic surgery and issues such as training and credentialing concludes this review.

### Laparoscopy for Diagnosis and Staging of Cancer

Laparoscopy is now considered an effective tool for diagnosis and staging of malignancies, one that adds to the information provided by other noninvasive diagnostic modalities, especially when combined with laparoscopic ultrasonography.13-15 It is a less invasive alternative to laparotomy for staging of intraabdominal malignancies.

Many authors have advocated the use of diagnostic laparoscopy in conjunction with other diagnostic modalities. Laparoscopy has been shown to decrease significantly the incidence of unnecessary laparotomy for unresectable disease in up to 67% of patients with abdominal malignancies (Table 1). Many of these studies were done with early-generation computed tomography (CT) scans as part of the noninvasive work-up. Lowy et al17 and Burke et al,18 however, have shown that diagnostic laparoscopy continues to have significant advantages in preventing unnecessary laparotomy in patients with gastric cancer even when current-generation CT scanning is used in the diagnostic work-up.

One concern in using diagnostic laparoscopy for the staging of abdominal tumors is the invasiveness of the technique, which currently requires general anesthesia, and the potential complications and costs related to it. The use of diagnostic laparoscopy for staging as a separate procedure is controversial, especially for abdominal tumors in which the diagnostic yield of laparoscopy is low (e.g., colorectal and lower esophageal cancers).

Many studies, especially recent ones, used laparoscopy immediately before a planned laparotomy.16-18,22,27,28 In these studies, all patients had been found to have resectable tumors based on preoperative noninvasive studies, and laparoscopy was used for diagnostic staging.

**Laparoscopic staging of an abdominal malignancy should be done at the same time as a planned laparotomy.**
staging at the same time that laparotomy was to be performed. When laparoscopy is performed at the time of laparotomy, the unnecessary performance of laparoscopy is less of a concern. Laparoscopic evaluation of the abdomen can be performed in as little as 10 to 15 minutes, and such evaluation eliminates the need for laparotomy in many patients. Thus, it is recommended that diagnostic laparoscopy for staging an abdominal malignancy be performed at the time of planned laparotomy.

Many authors have stressed the importance of laparoscopic ultrasonography during diagnostic laparoscopy for abdominal malignancy.\textsuperscript{14,19,23,24,28} Ultrasonography during laparoscopy gives the surgeon information that otherwise would not be obtained from laparoscopic visual exploration. Ultrasonography can identify lesions deep in the parenchyma of an organ, especially in solid organs such as the liver and pancreas. It can evaluate invasion of a tumor into other structures, such as major vessels, thus determining that the tumor is not resectable in a patient who otherwise might undergo laparotomy.

John et al\textsuperscript{19} evaluated patients who had potentially resectable liver tumors with laparoscopy and laparoscopic ultrasound. In 14 of 43 patients (33%), laparoscopic ultrasound detected liver tumors missed upon laparoscopic inspection alone. Laparoscopic ultrasound provided more information about tumor resectability than did laparoscopic inspection alone in 18 of 43 patients (42%).

In a study of patients with pancreatic cancer, John et al\textsuperscript{23} used laparoscopic ultrasonography to determine resectability. Factors confirming nonresectability were shown by laparoscopic ultrasonography in 23 patients (59%). In 20 of 38 patients (53%), laparoscopic ultrasonography identified information relevant to the assessment of tumor stage that was not apparent during laparoscopic inspection.

In another study using laparoscopic ultrasonography, Bemelman et al\textsuperscript{21} found that 21 of 22 pancreatic tumors staged as resectable at laparoscopy actually were resectable. Thirteen of 14 patients thought to have unresectable tumors at laparoscopy actually did have unresectable tumors.

Laparoscopy’s ability to visualize directly intraabdominal areas and structures gives it a significant advantage over other diagnostic modalities. Direct visualization has been used to characterize abdominal lesions. For example, specific diagnostic and characteristic features have been identified for hepatocellular carcinoma.\textsuperscript{29,30}

Much of the abdominal cavity can be viewed on initial introduction of the laparoscope. Areas obscured from the initial view often can be seen with the use of instruments introduced through accessory ports for retraction and dissection and adjustment of the table for appropriate patient positioning. Entering the lesser sac, for example, requires dissection and retraction as well as reverse Trendelenburg positioning to most adequately and easily expose the anterior surface of the pancreas.

Obtaining biopsies of organs, lymph nodes, and suspicious lesions during laparoscopy is an important part of the diagnosis and staging of malignancies. Laparoscopic guidance of liver biopsy has been shown to be a safe and effective alternative to open liver biopsy, and it significantly decreases hospital stay.\textsuperscript{31} A skilled laparoscopic surgeon should be able to perform biopsies of most intraabdominal areas and organs and recognize suspicious lesions that require biopsy to rule out malignancy.

The principles of minimally invasive surgery for diagnosing and staging malignancy also have been applied to children with thoracic and abdominal cancers. Holcomb et al\textsuperscript{32} showed that the success rate of tissue biopsies was high (99%) and morbidity was minimal with no mortality. Laparoscopy also has been used in patients with cancers outside the abdom-
inal and thoracic cavities who had abdominal symptoms. Laparoscopic diagnosis and management of these patients was a safe, effective alternative to an open procedure.33,34

**ESOPHAGOGASTRIC CANCER**

Primary carcinoma of the lower esophagus and stomach can be cured by surgical resection if it is found early. Unfortunately, these tumors often have spread by the time the diagnosis is made. Preoperative ultrasonography and CT scanning have been shown to be poor predictors of resectability in patients with lower esophageal or gastric cancers, especially when small-volume peritoneal and hepatic metastasis are present.35,36 Many authors, therefore, have advocated the use of diagnostic laparoscopy in addition to noninvasive modalities to assess these patients for metastatic disease.24,26,36

Although some studies of intraperitoneal chemotherapy for patients with gastric cancer and peritoneal seeding suggest that gastric resection and perioperative intraperitoneal chemotherapy may be appropriate, laparoscopy still may be of benefit in these gastric cancer patients. Watt et al37 showed that laparoscopy was more effective than CT scan and ultrasonography in assessing nodal involvement among esophageal and gastric cancer patients. The sensitivities of laparoscopy, CT scan, and ultrasonography were 72%, 57%, and 52%, respectively. The addition of laparoscopy to the preoperative evaluation has increased resectability rates at the time of laparotomy to a range of 56% to 100% in several studies.16-18,20,24,36 In lower esophageal cancers, when resectability is still in question after noninvasive studies and laparoscopy, diagnostic thoracoscopy of the right chest may be performed.38

**HEPATOBILIARY CANCER**

Laparoscopy aids significantly in the assessment of suspected primary or metastatic hepatobiliary malignancy. Radiographic studies such as ultrasonography, CT angiography, and magnetic resonance (MR) imaging are helpful in determining the diagnosis and resectability of hepatobiliary cancers. Laparoscopy, however, has opened the door to further evaluation, allowing direct visualization of the entire abdominal cavity and access to several areas for biopsy. In addition, laparoscopic ultrasound and laparoscopic-guided biopsy can distinguish between benign and malignant hepatic disease and can identify small peritoneal metastases (less than 1 cm) that might be missed on noninvasive studies.

When a hepatobiliary malignancy is diagnosed, staging by laparoscopy can be safe and beneficial. Hemming et al25 studied 168 patients who underwent laparoscopic staging for malignant tumors (chiefly hepatobiliary tumors) in the abdomen. They reported a 1.8% overall complication rate and no mortality. Several studies have shown that laparotomy can be avoided in a significant number of patients with hepatobiliary cancer when laparoscopy shows that the disease is not resectable.19,22,25,28 Avoiding laparotomy can decrease hospital stay, which averages 5.6 days after laparotomy compared with 1.5 days after laparoscopy.

**PANCREATIC CANCER**

Although pancreatic cancer has a resectability rate of 5% to 10%, laparotomy for pancreatic tumors was justified in the past. Laparotomy provided histologic diagnosis of the primary tumor or showed extrapancreatic spread and allowed for a palliative procedure for obviously unresectable tumors.39,40

With the current capabilities of radiologic and endoscopic techniques, including biopsy, most pancreatic tumors can be diagnosed and palliated without surgery. In patients whose tumors still appear resectable after noninvasive studies, laparoscopic evaluation is being used for diagnosis and staging so that laparotomy can be avoided, if possible. Studies have
shown that laparoscopic biopsy of extra-pancreatic tissue suspected of harboring metastatic disease and complete abdominal evaluation, including peritoneal washings for cytologic studies, can prevent a significant number of unnecessary laparotomies.41,42

Although laparoscopy has been shown to predict nonresectability reliably, thereby eliminating the need for laparotomy, it does not necessarily predict resectability reliably. In a series of 73 patients with pancreatic cancer, Cuschieri40 found that only four of nine tumors thought to be resectable upon laposcopic examination actually were resectable at laparotomy.

LYMPHOMA
Surgery for lymphoma has been limited to procedures that help in the diagnosis and staging of the disease. In Hodgkin’s disease, staging laparotomy can alter the treatment strategy in some groups of patients by changing the stage of the disease to a later one than that determined by noninvasive means. Studies have shown that after laparotomy, a change in stage can be expected in 20% to 30% of patients with clinical stage I and II disease.43,44

Laparoscopic biopsy of the liver and spleen combined with imaging studies can decrease the need for staging laparotomy by 70% in patients with clinical stage I or II Hodgkin’s disease.44,45 Now that more laparoscopic splenectomies are being performed, case reports of laparoscopic staging for Hodgkin’s disease have been published. These reports show that the entire procedure (including paraaortic lymph node dissection, bilateral liver biopsies, splenectomy, and oophoropexy) can be performed laparoscopically.46,47

Although only a few patients with Hodgkin’s disease are considered candidates for staging laparotomy, the use of laparoscopy for staging is a significant advantage for them. Patients have less postoperative pain and a shorter hospital stay and postoperative recovery period after staging laparoscopy than they do after staging laparotomy.

Laparoscopy has a limited role in non-Hodgkin’s lymphoma. It is used primarily to obtain a sufficient amount of tissue to aid in diagnosis. The addition of laparoscopic-guided biopsy doubles the diagnostic yield compared with that obtained by percutaneous biopsy alone.48

The importance of sampling the liver and spleen in cases of lymphoma makes direct visualization during biopsy a distinct advantage over other modes of percutaneous biopsy. Visualization of the parenchyma of the liver and the spleen after biopsy can help the operator avoid prolonged bleeding from the biopsy site. Any increased bleeding can be controlled laparoscopically with direct pressure, electrocautery, argon laser coagulation, application of hemostatic material, or suturing.

With current laparoscopic capabilities, patients with lymphoma can be accurately diagnosed and staged without laparotomy. The benefits of decreased pain, decreased hospitalization, earlier return to normal activities, and the ability to begin chemotherapy treatments earlier than after laparotomy make laparoscopy an important option in the diagnosis and staging of the patient with lymphoma.49

PELVIC LYMPHADENECTOMY
Most indications for pelvic lymphadenectomy are within the realm of urologic and gynecologic surgery. Several reports evaluating laparoscopic pelvic lymphadenectomy for staging prostate cancer have shown significant benefits, which include decreased pain, decreased hospital stay, and decreased use of laparotomy.50,51 Laparoscopic pelvic and retroperitoneal lymphadenectomies have been used for staging other urologic tumors, such as bladder,52 penile,52,53 and nonseminomatous testicular cancers.54

The large number of laparoscopic surgery for cancer

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pelvic lymphadenectomies performed for prostate cancer raised concerns about the low yield of positive lymph nodes (sometimes less than 5%) and the incidence of port site metastases.55 To avoid unnecessary surgery, patients who are unlikely to have metastatic disease should not undergo laparoscopic staging. Therefore, laparoscopic pelvic lymph node dissection is limited to patients with prostate cancer who have a high likelihood of metastatic disease as predicted by preoperative clinical staging, prostate-specific antigen levels, and Gleason grade.56,57

For gynecologic tumors, laparoscopic pelvic lymphadenectomy has focused primarily on cervical and early endometrial cancers.58,59 Studies have shown that an adequate lymph node sample can be obtained with the laparoscopic approach; compared with open surgery, the hospital stay is shorter, but a

| Reference     | Year | No. of Adrenalectomies | No. Converted to Open Procedures | Hospital Stay (Days) | Morbidity | Mortality |
|---------------|------|------------------------|----------------------------------|----------------------|-----------|-----------|
| Nies et al54  | 1993 | 5                      | 1                                | NR                   | 1         | 0         |
| Suzuki et al55| 1993 | 12                     | 0                                | NR                   | 3         | 0         |
| Matsuda et al56| 1993| 13                     | 2                                | NR                   | 4         | 0         |
| Ono et al56   | 1994 | 5                      | 0                                | 10.0                 | 0         | 0         |
| Fletcher et al57| 1994| 6                      | 0                                | 3.2                  | 0         | 0         |
| Uchida et al58 | 1994| 6                      | 0                                | NR                   | 0         | 0         |
| Naito et al59  | 1994| 17                     | NR                               | NR                   | NR       | NR       |
| Takeda et al50 | 1994| 17                     | 0                                | 11.6                 | 0         | 0         |
| Stoker et al51 | 1995| 6                      | 0                                | 2.0                  | 0         | 0         |
| Hata et al52  | 1995 | 7                      | 2                                | NR                   | 2         | 0         |
| Mandressi et al53 | 1995| 7                      | 1                                | 4.0                  | 0         | 0         |
| Schlinkert et al53 | 1995| 9                      | 3                                | 2.3                  | 1         | 0         |
| Prinz54        | 1995 | 10                     | 1                                | 2.1                  | 1         | 0         |
| Mercan et al54 | 1995| 11                     | 0                                | 3.0                  | 0         | 0         |
| Go et al55     | 1995 | 14                     | 0                                | NR                   | 0         | 0         |
| Guazzoni et al56 | 1995| 20                     | 0                                | NR                   | 0         | 0         |
| Chapuis et al57 | 1995| 25                     | 2                                | NR                   | 0         | 0         |
| Nakagawa et al58 | 1995| 25                     | 0                                | NR                   | 0         | 0         |
| Miccoli et al59 | 1995| 25                     | 0                                | 3.0                  | 0         | 0         |
| Brown et al60  | 1996 | 8                      | 1                                | 2.3                  | 0         | 0         |
| MacGillivray et al61 | 1996| 17                     | 0                                | 3.0                  | 3         | 0         |
| Heintz et al62  | 1996| 20                     | 3                                | 5.0                  | 0         | 0         |
| Brunt et al63  | 1996 | 4                      | 0                                | 3.2                  | 4         | 0         |
| Marescaux et al64 | 1996| 27                     | 5                                | 4.6                  | 2         | 0         |
| Walz et al65   | 1996 | 30                     | 5                                | NR                   | 0         | 0         |
| Fernandez-Cruz et al66 | 1996| 42                     | 2                                | 3.1                  | 0         | 0         |
| Gagner67       | 1996 | 72                     | 2                                | 3.0                  | 8         | 0         |
| Linos et al68  | 1997 | 18                     | 0                                | 2.2                  | 0         | 0         |
| Horgan et al69  | 1997| 19                     | 0                                | 2.9                  | 4         | 0         |

NR = not reported.
low complication rate is maintained. More prospective randomized studies are needed to determine the role of laparoscopic pelvic lymphadenectomy in gynecologic malignancies.

A significant learning curve for laparoscopic pelvic lymphadenectomy has been identified. General surgeons may play a role in the adoption of this procedure because of their familiarity with the laparoscopic pelvic anatomy if their experience includes a significant number of laparoscopic herniorrhaphies. These techniques can be adopted most safely when surgeons familiar with laparoscopic anatomy help other surgeons through their learning curve. Other general surgical applications of laparoscopic pelvic lymphadenectomy are rare and include staging for cutaneous or soft tissue malignancies, especially malignant melanoma.

**Laparoscopic Curative Resection**

The use of minimally invasive techniques for curative resection of abdominal malignancy is controversial. The growth of laparoscopic capabilities has resulted in reports of the resection of most types of abdominal tumors and organs. Although the reports have shown that these procedures can be done, determining when laparoscopic resection of cancer should be performed is difficult.

Because of the concerns surrounding laparoscopic resection of cancer and the difficulty associated with doing these procedures, laparoscopic resection of abdominal tumors rarely has been performed except in two areas. One is laparoscopic adrenalectomy, which is being done increasingly more often. The greater experience with laparoscopic adrenalectomy has been aided by the fact that a significant number of these resections are performed for benign tumors. The other exception is laparoscopic resection for colorectal malignancy. The high incidence of colorectal disease has led to increased experience with laparoscopic colon resection.

**Laparoscopic Gastrectomy**

Laparoscopic curative resection of gastric cancer has been reported. The approaches used depended on the extent of the tumor. For early gastric cancers or smooth muscle tumors, some authors used a technique of laparoscopic intragastric resection or a combined laparoscopic-gastroscopic technique that employed standard laparoscopic ports and instruments to perform a wedge resection of the lesion from within the gastric lumen.

Other reports of resection for early gastric cancers describe laparoscopic distal gastrectomy with a primary anastomosis. These resections include a perigastric lymphadenectomy similar to what would be done in an open gastrectomy for cancer. Jagot et al reported on nine patients who underwent laparoscopic gastric mobilization and lymphadenectomy for esophageal cancer. These patients had combined open incisions (six through the right side of the chest and three through the left side of the neck) for esophageal resection and anastomosis. All intraabdominal portions of the procedures were completed laparoscopically. Mean hospital stay was 10.3 days, and no complications occurred.

The patients in these reports of laparoscopic gastric surgery did well with no complications in short-term follow-up; however, all reports included 10 patients or fewer. Using early gastric cancer or gastric lymphoma as an indication, an Italian group performed only 10 laparoscopic gastrectomies in more than 100 patients with gastric cancer in a 4-year period, showing the infrequent use of laparoscopic resection for gastric cancer.

In an international review of laparoscopic gastrectomies, Goh et al sent surveys to many surgeons known to have performed laparoscopic gastrectomies.
Among 118 laparoscopic gastrectomies performed, gastric cancer was the most common indication for the procedure (46 patients).

The indications for laparoscopic resection of gastric cancer must be limited to palliation of advanced gastric cancer and possibly treatment of early gastric cancer. The use of laparoscopy for resection of stage II or III gastric cancers must be evaluated in prospective randomized studies. The infrequent use of laparoscopic resection of gastric cancer, however, makes it difficult to evaluate this technique for future use. Even more difficult is training the inexperienced laparoscopic surgeon to perform and safely adopt this technique.

LAPAROSCOPIC RESECTION OF OTHER UPPER QUADRANT ABDOMINAL CANCERS

Still fewer reports have been published on laparoscopic resection of other upper quadrant abdominal cancers.

Laparoscopic resection of benign liver tumors measuring up to 9 cm in diameter has been reported using electrocautery, ultrasonic dissection, and endoscopic stapling devices to ensure minimal blood loss.\textsuperscript{70} Laparoscopic liver resection for malignant disease has also been reported for smaller lesions.\textsuperscript{71,72} Reports of laparoscopic distal pancreatectomy with splenectomy have shown the benefits of decreased pain and shorter hospitalization compared with open surgery.\textsuperscript{73} Gagner and Pomp\textsuperscript{74} have even reported three pancreateodudenumectomies performed laparoscopically.

However, each case required a significantly prolonged operative time, and the benefits of minimally invasive surgery, such as a decreased hospital stay, were not realized.

Laparoscopic splenectomy has been discussed in the context of staging for Hodgkin’s disease, and many authors have reported good results from laparoscopic splenectomy for a variety of diseases.\textsuperscript{75,76} However, primary or metastatic carcinoma of the spleen would be a rare indication.

Other curative laparoscopic procedures, such as laparoscopic resection of small bowel carcinoma, are feasible, but the reported experience is too limited to be a basis for evaluation. Partially be-
### Table 3
Results of Laparoscopic Colon Resection

| Reference          | Year | No. of Patients | No. Resected for Malignancy | No. Converted to Open Procedures | Hospital Stay (Days) | Complications (No.) | Deaths (No.) |
|--------------------|------|-----------------|-----------------------------|----------------------------------|----------------------|----------------------|--------------|
| Jacobs et al\(^1\) |
| Phillips et al\(^1\) |
| Monson et al\(^1\) |
| Quattlebaum et al\(^1\) |
| Dean et al\(^1\) |
| Jansen\(^1\) |
| Plasencia et al\(^1\) |
| Puente et al\(^1\) |
| Slim et al\(^1\) |
| Zucker et al\(^1\) |
| Fine et al\(^1\) |
| Lacy et al\(^1\) |
| Tucker et al\(^1\) |
| Begos et al\(^1\) |
| Gellman et al\(^1\) |
| Huscher et al\(^1\) |
| Kwok et al\(^1\) |

NS = number of patients not specified, but report acknowledged that some patients were resected for cancer.
mortality (Table 2). Compared with traditional open resection, laparoscopic adrenalectomy has less intraoperative blood loss, a decreased requirement for pain medication, a shorter hospital stay, and an earlier return to normal diet and activities.\textsuperscript{89,93,96,98,101} Although the most common indications for laparoscopic adrenalectomy were pheochromocytoma, primary aldosteronism, nonfunctioning adenoma, and Cushing’s adenoma, cases of primary adrenal adenocarcinoma\textsuperscript{107} and carcinoma metastatic to the adrenal gland were reported.\textsuperscript{108}

The laparoscopic approaches used for adrenalectomy have included transabdominal supine, transabdominal lateral decubitus, and lateral totally extraperitoneal with balloon dissection. The transabdominal supine approach allows for exploration of the entire abdominal cavity, including the opposite adrenal, without repositioning the patient. The transperitoneal lateral decubitus approach is, however, considered the best approach for maximal exposure of the gland.\textsuperscript{109} The totally extraperitoneal approach has yielded excellent results, although the exposure is less than optimal and the learning curve is higher than that of the transabdominal approaches.\textsuperscript{79,110}

The most common complication of laparoscopic adrenalectomy has been hemorrhage, which, combined with poor exposure, was the most common reason for conversion to an open procedure.\textsuperscript{93}

Few other complications or morbid conditions and only one death were reported, although one author emphasized the importance of careful handling of the gland and the use of a specimen bag for removal. Gagner et al\textsuperscript{109} reported a case in which the retrieval bag broke, leaking adrenal fluid into the abdomen, apparently resulting in marked prolonged hypotension that eventually resolved without sequelae.

Most experts consider large size (more than 6 cm) and evidence of invasion of surrounding structures to be contraindications to laparoscopic adrenalectomy, and some consider pheochromocytoma a relative contraindication. For other indications, however, the laparoscopic approach is the preferred method for removal of the adrenal gland if the surgeon is skilled in open adrenalectomy and in advanced laparoscopic techniques.

**LAPAROSCOPIC RESECTION OF COLORECTAL CANCER**

Laparoscopic colon resection is one of the most commonly performed advanced laparoscopic procedures. In comparison with open colon resection, the laparoscopic approach offers the patient decreased blood loss, earlier return of bowel function, shorter hospital stay, and lowered hospital costs.\textsuperscript{111,112} Many series of laparoscopic colectomies, including resection for malignant disease, have reported the safety and effectiveness of laparoscopic colon surgery (Table 3). The benefits of minimally invasive colectomy have been shown even in elderly and high-risk patients.\textsuperscript{130,131} Despite these studies, laparoscopic colon resection is still controversial, especially for the management of colon cancer.\textsuperscript{132-134}

One concern about the laparoscopic approach for treatment of colon cancer is whether laparoscopic techniques can achieve true “oncologic” resection (i.e., wide margins and intact resection of areas of lymph node drainage) of the colon. Studies of animal and cadaver models measured the length of divided major arterial supply (i.e., inferior mesenteric artery) and the amount of lymph nodes remaining after resection of the colon to show that laparoscopic techniques could adhere to principles of cancer surgery.\textsuperscript{135,136}

The adequacy of lymphadenectomy has been addressed by several studies, which consistently showed that the number of lymph nodes resected laparoscopically was similar to the number.
retrieved in open colectomy for cancer.\textsuperscript{112,115,116,120,126,128,131}

The technique of laparoscopic colon resection also has been controversial. Some surgeons have performed completely laparoscopic colon resections as opposed to laparoscopic-assisted resections. The laparoscopic-assisted approach involves performing one or more components of the operation (for example, the anastomosis) outside the peritoneal cavity through a small incision. When a completely laparoscopic approach is used, all elements of the procedure are performed within the abdominal cavity.\textsuperscript{132}

Studies comparing these two techniques have shown no significant differences in the strength of the anastomosis, the length of postoperative ileus, or the length of hospital stay.\textsuperscript{137,138}

With the fast spread of laparoscopic techniques, another concern is the means by which a surgeon becomes adequately trained to do a laparoscopic colon resection for cancer. Experts in the field have admitted that the current 1- or 2-day training courses are severely inadequate.\textsuperscript{132} Their contention is supported by studies showing that the learning curve (as measured by operative time, complexity of cases, and percentage of conversions to an open procedure) seems to vary from 10 to 60 cases.\textsuperscript{139-141} Surgeons must try to obtain additional training after these courses and ask for assistance from surgeons who are more experienced with laparoscopic techniques.

Appropriate intraoperative judgment, such as when to convert to an open procedure, is also critical to the safe adoption of the laparoscopic approach for colectomy. Relative indications for converting to an open procedure include tumor invasion into small bowel, adhesions, fistulas, obesity, bulky tumor, bleeding, and thickened or short mesentery.\textsuperscript{112,114,115,120,121,124,126,127,129} It is important to identify the need to convert to an open procedure as soon as possible because this can reduce operative time and overall costs, both of which are significantly increased when conversion to an open technique is required.

**Port Site Metastasis**

Probably the most compelling argument against the use of laparoscopy for resecting colon cancer has arisen from the many reports of early postoperative recurrence in the port site.\textsuperscript{142-145} The exact mechanism of tumor implantation is not clear. Many reported port site metastases have occurred at secondary ports through which specimens were not removed. Ugarte\textsuperscript{146} reported a case in which a patient, 1 month before open resection of a colon cancer, underwent laparoscopic cholecystectomy and subsequently developed a recurrence of the colon cancer in one of the port sites used in the laparoscopic cholecystectomy. Montorsi et al\textsuperscript{143} reported a case of wound site recurrence after laparoscopic colon resection for cancer even after many precautions were taken, such as placing the specimen in a retrieval bag before removing it from the abdominal cavity. Evidence such as this has led to the belief that pneumoperitoneum itself might cause tumor cells to migrate or dislodge and spread throughout the abdomi-
The most likely mechanism of tumor implantation at trocar sites in laparoscopic colectomy seems to be direct implantation. Extraction of the specimen through a very small incision allows for the possibility of tumor cells shedding into the wound. Laparoscopic instruments, especially crushing instruments, can be involved in the direct transfer of tumor cells to abdominal wall trocar sites. Other mechanisms include dissemination of cancer cells in the irrigation fluid, especially with movement of trocars, and hematogenous spread.

Animal studies have evaluated the effects of laparotomy compared with those of laparoscopy on tumor growth and the propensity for abdominal wall recurrences. Most studies indicate that laparotomy has a permissive effect on tumor establishment and growth compared with laparoscopy.

Several animal studies show that the effects of pneumoperitoneum, especially with carbon dioxide, lead to increased implantation of tumor cells in the abdominal wall. Studies of rats undergoing laparoscopic surgery showed a threefold to fivefold increase in the incidence of metastases in the abdominal access wounds of those with pneumoperitoneum compared with those without pneumoperitoneum.

Some surgeons have proposed gasless laparoscopy to alleviate the theoretical concerns of pneumoperitoneum in cancer patients. An added benefit of gasless laparoscopy is that conventional early postoperative intraperitoneal 5-FU was used in an attempt to control the disease. These patients were disease free 1.5 years after this treatment.

Other intraoperative measures proposed to prevent port site metastasis include handling the tumor as little as possible, suturing the ports in place so they cannot move during the operation, irrigating the peritoneal cavity with povidone-iodine, irrigating port sites with sterile water, and deflating the abdomen before removing the trocars.

Current Recommendations
Some early reports of prospective or randomized studies comparing laparoscopic colectomy with open colectomy specifically for colon cancer have found more favorable results with the laparoscopic approach. However, the American Society of Colon and Rectal Surgeons currently recommends that curative resection of colorectal cancer not be performed laparoscopically except as part of a prospective, controlled clinical trial.
Society of Colon and Rectal Surgeons currently recommends that curative resection of colorectal cancer not be performed laparoscopically unless it is part of a prospective, controlled clinical trial. Most experts agree with this cautious approach and recommend that for colon cancer, the laparoscopic approach be limited to either palliative resection of advanced lesions or curative resection of early lesions. However, it is difficult to identify lesions that are early cancers by laparoscopic evaluation alone, and trocar site metastases from early colon cancers have been reported in patients who were treated with laparoscopic resection.

Laparoscopy for Palliation of Cancer

The use of laparoscopic techniques for palliation of abdominal cancer may be one of the best applications of minimally invasive surgery. In patients who no longer have the hope of cure but are plagued by the complications of an unresectable tumor (such as obstructive jaundice or intractable pain), palliation should be attempted by the least invasive means possible. Minimally invasive techniques, including laparoscopic surgery, offer a great advantage over open surgery in patients whose life expectancy is limited because of cancer.

Laparoscopic choledochojejunostomy and gastrojejunostomy are technically feasible for the palliation of malignant duodenal or biliary obstruction. The most common tumor associated with these conditions is an unresectable cancer of the pancreas. Laparoscopic bypass of the duodenum, with the use of endoscopic stapling devices and endoscopic suturing techniques, can be done in about the same amount of time as the open procedure with little morbidity and mortality.

Laparoscopic choledochojejunostomy also has been shown to be effective, although it requires a patent cystic duct with no impending obstruction from cancer and a gallbladder free of stones. Benefits of the laparoscopic approach for choledochojejunostomy or gastrojejunostomy over the open procedure include decreased postoperative hospital stay and earlier return to regular diet. Morbidity, mortality, and survival rates in patients treated laparoscopically are similar to those of patients treated with open bypass.

Tarnasky et al studied the opportunity to use laparoscopic bypass for biliary obstruction. Over a 2-year period, these investigators assessed cholangiograms in patients with malignant biliary obstruction and found that nearly half the patients were ineligible for choledochojejunostomy because of previous biliary surgery (29%) or hilar tumors (17%). For patients with more proximal malignant obstructions (common bile duct or hilar), Soulez et al reported a technique of hepaticogastrostomy using fluoroscopic, endoscopic, and laparoscopic guidance for biliary decompression. Appropriate patient selection is essential for the achievement of good re-
sults with minimally invasive procedures for palliation of malignant obstructive jaundice.

The use of laparoscopic techniques to assist in the treatment and palliation of hepatic tumors offers significant advantages compared with open surgery. With the assistance of laparoscopic ultrasound, hepatic cryotherapy has been used to treat patients with unresectable malignancy metastatic to the liver and for treatment of primary liver carcinomas.\textsuperscript{163,164} Although the evaluation of hepatic cryotherapy for survival advantage is ongoing, the laparoscopic approach can significantly lessen the pain and reduce the postoperative recovery period compared with open surgery.

A laparoscopic technique also has been described for the implantation of an intraarterial catheter for regional chemotherapy of unresectable liver metastasis in patients without evidence of extrahepatic metastatic disease.\textsuperscript{165} The potential benefits of decreased postoperative pain, faster recovery, and possibly, reduced immunosuppressive effect compared with open surgery are significant advantages in this patient group. Laparoscopic colon resection can be performed concomitantly in these patients if the liver metastases are synchronous lesions.

Laparoscopic colectomy for palliation is an accepted procedure that allows patients to avoid the trauma of open surgery. With the decreased recovery time after minimally invasive surgery, patients can return to normal activities faster and may begin adjuvant therapies much sooner than they would after an open colon resection. These benefits are especially important to patients and their families when life expectancy is limited.

Another role for endoscopic techniques in palliation of cancer was described by Melki et al.\textsuperscript{166} Thoracoscopic splanchnicectomy was used to relieve intractable abdominal pain caused by unresectable pancreatic cancer. Subsequent reports showed the effectiveness of thoracoscopic denervation for the relief of upper abdominal cancer pain.\textsuperscript{167,168} Takahashi et al\textsuperscript{169} described a group of patients who underwent this procedure, all of whom had immediate pain relief postoperatively.

In patients such as these, who are usually in the last stages of their disease, a minimally invasive procedure that can significantly relieve pain may make the remaining days or weeks of life tolerable.

**Carcinoma of the gallbladder is found in about 1% to 2% of all cholecystectomies performed.**

**Laparoscopic Cholecystectomy: Unsuspected Carcinoma of the Gallbladder and Trocar Site Metastasis**

Laparoscopic cholecystectomy is by far the most commonly used therapeutic laparoscopic procedure in all of general surgery. In a short time, laparoscopic cholecystectomy has become the procedure of choice for most gallbladder diseases.

Despite some early reports of increased bile duct injuries and deaths resulting from the laparoscopic ap-
laparoscopic cholecystectomy has been shown to be safe and effective when performed by skilled laparoscopic surgeons. We have done more than 3,000 laparoscopic cholecystectomies at our institution and have encountered only one bile duct injury, which was successfully repaired over a T-tube.

Although the benefits of laparoscopic cholecystectomy have been impressive, the rare occurrence of an unsuspected carcinoma of the gallbladder and reports of subsequent metastasis to abdominal wall trocar sites have raised some concern. Carcinoma of the gallbladder is found in about 1% to 2% of all cholecystectomies performed.

The percentage of carcinomas of the gallbladder in relation to cholecystectomies performed may be decreasing, and the gallbladder cancers found may be at an earlier stage with the advent of laparoscopic cholecystectomy. With this minimally invasive approach, more patients are electing to have surgery earlier for symptomatic cholelithiasis, and more surgeons feel comfortable proceeding with laparoscopic cholecystectomy in patients whose age or medical condition precludes open surgery.

In one large series, Yamaguchi et al reported that the incidence of unsuspected carcinoma of the gallbladder detected during pathologic study was less than 1% (24 of 2,616 laparoscopic cholecystectomies). Abdominal wall metastasis occurred in three of the 24 patients.

The literature has many more case reports of trocar site metastasis from unsuspected carcinoma of the gallbladder. Approximately half of all trocar site metastases reported are from carcinoma of the gallbladder.

MANAGEMENT OF UNSUSPECTED CARCINOMA OF THE GALLBLADDER AND TROCAR SITE METASTASIS

The possibility of gallbladder carcinoma should be entertained in all patients undergoing laparoscopic cholecystectomy, especially the elderly, because this entity may be difficult to diagnose preoperatively.

Preoperative findings that suggest gallbladder carcinoma include the presence of a fixed mass inside the gallbladder, a thickened posterior gallbladder wall with no distinct plane between the gallbladder and the liver, and a mass effect within the gallbladder invading adjacent organs. These may be found on ultrasound or CT scan.

Signs of gallbladder carcinoma during laparoscopic surgery include difficulty in dissecting the gallbladder from the gallbladder bed of the liver; increased size of the gallbladder; a thickened, whitish wall; and neovascularization of the wall.

When gallbladder carcinoma is suspected preoperatively or intraoperatively, conversion to an open procedure should be considered. Jacobi et al reported a case of laparoscopic cholecystectomy that was converted to an open procedure because of technical problems. A microscopic adenocarcinoma was diagnosed at final pathologic study. Two
months after the operation, the patient developed metastases to the abdominal wall at two trocar sites, but the paramedian laparotomy incision was free of tumor. This finding supports the recommendation that open laparotomy be performed when cancer is suspected.

If the laparoscopy is not converted to an open procedure when cancer is suspected, a laparoscopic retrieval bag should be used when the gallbladder is removed from the abdomen.
Some surgeons have recommended laparoscopic cholecystectomy as the primary therapy when a tumor of the gallbladder is believed to be noninvasive. Porter et al. have reported the use of laparoscopic cholecystectomy as curative treatment for a noninvasive carcinoid tumor of the gallbladder. Other cases have been reported in which laparoscopic cholecystectomy was used for preoperatively suspected gallbladder carcinoma. Because of the small number of patients and the limited follow-up, however, the role of laparoscopic cholecystectomy for definitive therapy has not yet been established.

A gallbladder removed laparoscopically from a patient who was suspected of having gallbladder cancer preoperatively should be opened and undergo biopsy before the patient is awakened. If an invasive cancer is diagnosed on frozen section, an open resection of the liver and excision of port sites, especially the umbilical port site, should be considered.

Unfortunately, gallbladder carcinoma is sometimes not diagnosed until the final pathology report is made. In patients with in situ carcinoma or T1 lesions without invasion of the lymphatic, venous, or perineural spaces, no further resection is indicated. However, when an invasive tumor is diagnosed, another operation is recommended for resection of the liver covering the gallbladder bed. The excision of trocar sites also should be considered. As was mentioned earlier, the umbilical trocar site is especially at risk for metastasis because the gallbladder is typically removed through this incision. Microscopic metastasis in the umbilical trocar site has been documented as early as 8 days after the initial laparoscopic cholecystectomy. A trocar site used for drain placement is also at high risk for metastasis.

A high index of suspicion for gallbladder carcinoma must be maintained, especially in patients with the previously mentioned preoperative and intraoperative signs of malignancy. Although laparoscopic cholecystectomy may be curative for noninvasive gallbladder carcinoma, conversion to an open operation should be considered if invasive gallbladder carcinoma is suspected. The finding of invasive gallbladder carcinoma is treated by segmental liver resection to include the gallbladder bed and excision of all laparoscopic port sites.

**Conclusion**

After the long hibernation of laparoscopic surgery, in the last decade modern technology has created a spate of laparoscopic techniques and procedures. This new technology coupled with rapidly increasing surgical experience has made laparoscopy a viable tool in the diagnosis and management of abdominal malignancy (Figure). For patients devastated by a diagnosis of malignancy, avoiding open surgery with concomitant benefits such as decreased pain and shorter hospitalization can be a bright spot in the battle against cancer.

Laparoscopy, however, has not undergone such rapid development without significant costs. Many surgeons, under economic and competitive pressures, have begun to perform laparoscopic procedures without adequate training or monitoring. Increases in major complications and many deaths have resulted. Credentialing of laparoscopic procedures has varied and is sometimes based only on the experience gained at a 1- or 2-day course. Only when thorough training and preparation are required and strict credentialing is mandated can the risk of complications from laparoscopic surgery can be minimized.

The problem of adequate training and monitoring has been recognized, and improved methods of training (such as multimedia interactive computer-based training and virtual reality simula-
tion) are being developed. For surgeons who cannot find appropriately trained physicians to monitor or assist them during the learning curve for laparoscopic procedures, the use of high-bandwidth telecommunications, or telemedicine, is being studied to provide expert laparoscopic surgeons for proctoring worldwide.

Minimally invasive technology continues to advance at a rapid pace, and now “needle scopes” and other instruments less than 3 mm in diameter are being used. Many laparoscopic procedures for diagnosis and staging of malignancy may soon be done in the physician’s office under local anesthesia. The concurrent advances in oncologic research such as immunoscintigraphy and radioimmune-guided surgery will undoubtedly be used with minimally invasive techniques to improve the care of the cancer patient.

The future of laparoscopic surgery for the management of malignancy holds exciting prospects. However, this bright future is in jeopardy if scientific evaluation, including prospective studies, of these new procedures, especially those for attempted curative resection, is not carried out to determine which procedures benefit the patient. Although surgeons, with pressure from patients, hospitals, and equipment companies, are happy to perform laparoscopic procedures offering their patients less pain and earlier return to normal activities, they must remember first to do no harm.

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