Laparoscopic General Surgery: State of the Art

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The rapid acceptance of laparoscopic cholecystectomy into surgical practice has been followed by the extension of laparoscopic treatment to many other surgical problems. While the role of laparoscopic surgery for some conditions is now well established, its applicability in other situations requires further evaluation. This review summarizes our current understanding of the laparoscopic management of common surgical disorders involving the gallbladder and bile ducts, groin hernias, appendix, colon, stomach, and esophagus.

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Removal of the gallbladder, appendix, or colon, and repair of groin hernias are among the most common operations in the United States. General surgeons have been well versed in performing these procedures through standard abdominal incisions. In recent years, however, the way in which these familiar operations are performed has been radically transformed by the use of videolaparoscopy. Guided by the image provided by a miniature video camera attached to a laparoscope and displayed on a video monitor, operations can be accomplished through abdominal puncture holes or small incisions, that is, "minimal-access" surgery.

The modern era of therapeutic laparoscopy was heralded by laparoscopic cholecystectomy, which was first reported in 1986, first performed in the United States in 1988, and then rapidly assimilated into surgical practice between 1989 and 1991.[1–4] With similar velocity, laparoscopic techniques were soon extended to the treatment of a wide range of general surgical problems, including disorders of the esophagus, stomach, small and large intestine, liver, bile ducts, pancreas, adrenal glands, spleen, and abdominal wall.[5] The swift development of laparoscopic general surgery was propelled in varying proportions by medical advantages, both real and perceived, by patient demand, by technologic advancements, and by the entrepreneurial interests of industry and medical care providers.

Certain benefits of minimal-access surgery, such as rapid convalescence following laparoscopic cholecystectomy, have been readily apparent. In other instances, the utility of laparoscopic approaches is not as well established. The widespread implementation of laparoscopic operations in the absence of randomized prospective comparisons with conventional surgery and evaluation of long-term outcomes has fostered skepticism. Additional concerns have been raised about potential complications of laparoscopic surgery. In the initial experience with laparoscopic cholecystectomy, for example, the rate of bile duct injury was about 0.5%, which is two to five times higher than the rates generally cited following open cholecystectomy.[3,6] Since most bile duct injuries occurred early in a surgeon's experience, the adequacy of training and credentialing mechanisms was called into question. In 1992, acting on what it perceived to be an unusually high number of complications from laparoscopic cholecystectomy, the New York State Department of Health issued a memorandum calling for strict and specific credentialing criteria for the procedure.[7]

Surgeons themselves were the first to recognize the need for appropriate training and credentialing. The swift embracement of therapeutic laparoscopy created an unprecedented demand for postgraduate education of practicing surgeons. The requisite skills, instrumentation, and techniques were sufficiently new and substantially different from those of conventional open surgery. Relatively few surgeons had received formal laparoscopic training

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during their residency. An estimated 15,000 US surgeons were trained in laparoscopic cholecystectomy between 1990 and 1992.[8] Among surgical organizations, the Society of American Gastrointestinal Endoscopic Surgeons (SAGES) took the lead by publishing guidelines for the clinical application of laparoscopic cholecystectomy and for granting privileges in laparoscopic general surgery.[9,10] In response to the rapidly developing field of laparoscopic general surgery, these guidelines have been revised and have been supplemented by a comprehensive document on postresidency surgical education and training.[11]

The level of experience necessary for a surgeon to safely and successfully perform laparoscopic surgery depends on the difficulty of the operation and the frequency with which it is performed. Cholecystectomy, appendectomy, and inguinal herniorrhaphy are high-volume procedures that generally do not require advanced laparoscopic techniques. These operations can be accomplished by most surgeons with proper laparoscopic training. There is a learning curve to every laparoscopic operation, however, and optimum outcome is related to the regularity with which a surgeon performs a particular procedure. Laparoscopic skills must be practiced to be maintained. Operations that require more complex laparoscopic techniques should be performed only by surgeons who have undertaken additional training and developed the requisite skills. Likewise, less common operations, if they are to be accomplished laparoscopically, warrant referral to physicians or centers that have established experience in their management. Laparoscopic Nissen fundoplication, adrenalectomy, and splenectomy are not for the occasional laparoscopic surgeon. Some laparoscopic procedures, such as colon resection for regionally confined cancer, might still be considered investigational. Accordingly, such procedures are appropriately performed in the setting of clinical trials that are equipped to monitor long-term outcome and provide useful data.

This article reviews the current state of the art regarding laparoscopic treatment of common general surgical conditions. In some situations, such as cholecystectomy, the role of minimal-access surgery is now well established. The laparoscopic treatment of other problems, such as inguinal hernia, gastroesophageal reflux, and colon cancer, remains under evaluation. For a wide variety of other surgical disorders, the possibilities and practicality of minimal-access approaches are being actively investigated.

Laparoscopic Treatment of Gallstones

Laparoscopic cholecystectomy is typically performed with the placement of four cannulas 5 to 10 mm in diameter through the abdominal wall after a pneumoperitoneum has been established by insufflation of carbon dioxide to an intraperitoneal pressure of 15 mm Hg. The operative field is displayed on a monitor from images generated by a miniature video camera attached to the laparoscope. After dissection to identify the anatomy, the cystic duct and artery are ligated and divided. Intraoperative cholangiography should be performed to facilitate anatomic definition of the extrahepatic biliary tree and to detect stones in the common bile duct (Figure 1). The gallbladder is dissected free from the liver and extracted through a cannula located at the umbilicus (Figure 2). Dissection can be accomplished with either electrocautery or laser as a thermal energy source; the vast majority of surgeons currently use electrocautery.

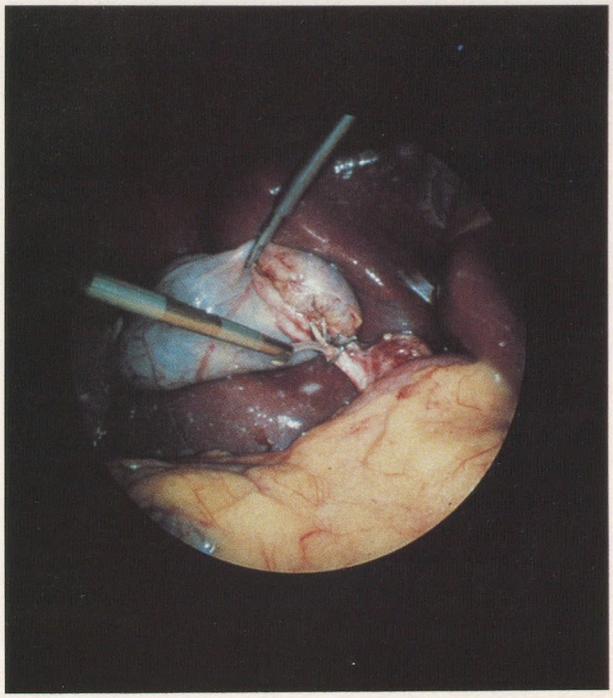

Figure 1. Intraoperative cholangiography during laparoscopic cholecystectomy. Catheter is in cystic duct. Cystic artery above has been clipped. Courtesy of George Berci, MD.

The 1992 National Institute of Health (NIH) Consensus Development Conference on Gallstones and Laparoscopic Cholecystectomy concluded that laparoscopic cholecystectomy is "a safe and effective treatment for most patients with symptomatic gallstones" and the treatment of choice for many patients.[8] Compared with open cholecystectomy, laparoscopic cholecystectomy has been associated with less postoperative discomfort, earlier hospital discharge, and earlier return to normal activity.[2,12,13]

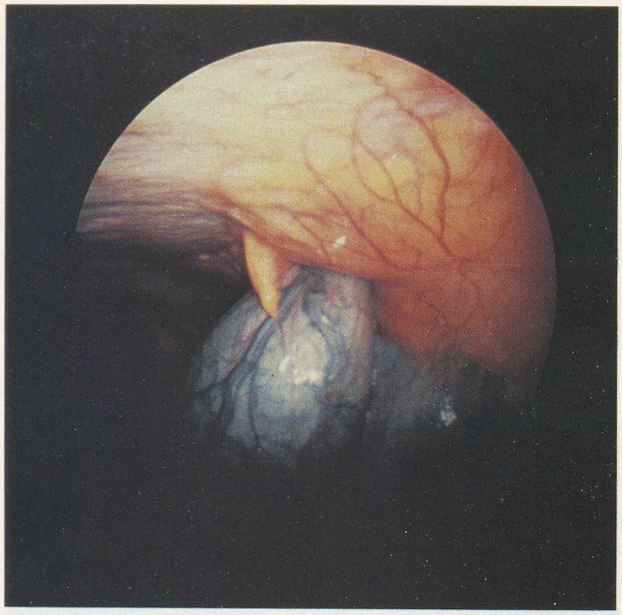

Figure 2. Gallbladder at peritoneal surface of umbilicus just before extraction. Courtesy of George Berci, MD.

The relative safety and efficacy of the procedure have been confirmed by the results of several large prospective studies, including a multi-institutional evaluation of over 2600 patients conducted by SAGES.[3,4,14] The mortality rate is approximately 0.1%. Major complications occur in 1% to 2% of patients. Conversion to a standard open cholecystectomy may be necessary in 3% to 5% of patients. Conversion is more commonly required because of difficulty with the laparoscopic dissection and inability to clearly delineate the anatomy rather than for management of a laparoscopic complication. It should be emphasized that conversion reflects good surgical judgment and is not a complication of the procedure.

Approximately 80% of cholecystectomies in the United States are now being performed laparoscopically.[8] The total number of cholecystectomies being performed has increased since the advent of the laparoscopic approach. Population-based data from Maryland have demonstrated a 28% increase in the annual cholecystectomy rate.[15] The established indications for removal of the gallbladder, however, have not changed. Cholecystectomy is indicated for the treatment of symptomatic gallstones in patients who are able to tolerate general anesthesia. Laparoscopic cholecystectomy has not extended the indications for surgery to include the routine treatment of asymptomatic cholelithiasis. Increases in the cholecystectomy rate may be due to the increased willingness of patients and their primary physicians to accept laparoscopic intervention at a lower symptomatic threshold than for conventional open cholecystectomy.

As experience with laparoscopic cholecystectomy has accumulated and surgical skills have expanded, the contraindications to laparoscopic intervention have decreased. Absolute contraindications include inability to tolerate general anesthesia (although laparoscopic cholecystectomy has been performed with thoracic epidural anesthesia), irreversible coagulopathy, and the existence of a concomitant condition requiring laparotomy. Complicated biliary tract conditions, such as acute cholecystitis, gallstone pancreatitis, and choledocholithiasis, were initially considered relative contraindications to laparoscopic treatment. In the hands of experienced surgeons, these situations are now often amenable to laparoscopic intervention.

Since it minimizes wound and respiratory problems, laparoscopic cholecystectomy is the procedure of choice in morbidly obese patients requiring cholecystectomy.[16] Laparoscopic intervention must still be approached cautiously in the pregnant patient.[17] Although there are multiple clinical reports of successful laparoscopic cholecystectomy performed during pregnancy,[17–19] many surgeons may still be reluctant to perform the procedure on pregnant patients. More information is required on the metabolic and physiologic consequences to the fetus. Limited experimental data have demonstrated fetal arterial hypertension and acidosis during CO_2 insufflation.[20,21] During the third trimester, the procedure may be technically difficult because of the size of the uterus.

Patients with severe cardiopulmonary disease may also pose problems to laparoscopic intervention. A CO_2 pneumoperitoneum produces hypercarbia, decreased arterial pH, and hypercapnia. In fit patients, these changes are minimal and inconsequential. In patients with cardiopulmonary compromise, however, these changes are more pronounced and the ability to compensate more limited.[22] Other potentially important effects of the pressurized pneumoperitoneum include decreased venous return, increased pulmonary airway resistance, decreased cardiac index, increased peripheral resistance, and potentially increased myocardial O_2 consumption.[23] The safe performance of laparoscopic surgery in these patients requires careful fluid and pharmacologic intervention to optimize hemodynamic levels; intraoperative monitoring with arterial blood gases, Swan-Ganz catheter, and transesophageal echocardiography as appropriate; and anticipation of postoperative ventilatory and critical-care support.[24] Despite these potential intricacies, laparoscopic cholecystectomy has been associated with a lower mortality rate and shorter hospitalization than open cholecystectomy in physiologically impaired patients.[25] Compared with open cholecystectomy, laparoscopic cholecystec-

tomy results in less postoperative impairment of ventilatory mechanics.[26] The use of abdominal wall-lifting devices or other gases for intraperitoneal insufflation is being investigated as alternatives to the CO_2 pneumoperitoneum for laparoscopic access.[27,28]

The risk of serious iatrogenic injuries has been a paramount concern since the widespread implementation of laparoscopic cholecystectomy. Injuries to the bile duct, bowel, or major vascular structures are potentially fatal complications. Fortunately, such occurrences have been infrequent. The SAGES prospective multi-institutional study of 1771 patients revealed the following injury rates: bile duct 0.2%, bile leak 0.7%, bowel injury 0.3%, bleeding 0.5%.[14]

In many series, bile duct injury has been the most frequent major complication of laparoscopic cholecystectomy. The typical mechanisms of laparoscopic bile duct injury have been well defined, and technical guidelines for their prevention have been elucidated.[29,30] Current data suggest that the risk of duct injury is related to the surgeon's experience and the use of intraoperative cholangiography. Whether the incidence of these injuries has peaked remains to be determined.

Laparoscopic Treatment of Common Bile Duct Stones

Current options for the initial management of common bile duct stones include endoscopic papillotomy and retrograde extraction, laparoscopic removal at the time of cholecystectomy, and conventional open common bile duct exploration. Each of these approaches can be safe and effective. Appropriate management in any given circumstance involves multiple considerations, including stone location and characteristics, biliary anatomy, symptomatology, the patient's physiologic status, and in large part, the expertise available locally.

Endoscopic evaluation of the bile duct should not be performed routinely before laparoscopic cholecystectomy. Most would agree that preoperative endoscopic cholangiography is indicated for patients with jaundice or cholangitis or a visible stone in the common bile duct found by ultrasonography. Other indicators, such as elevated liver enzymes, hyperamylasemia, pancreatitis, or ultrasonographic evidence of bile duct dilatation, are less reliable predictors of choledocholithiasis. Endoscopic cholangiography shows that most patients with these findings do not have stones. For these patients, this study is therefore unnecessary. Additionally, endoscopic sphincterectomy has an associated morbidity rate of 10% and a mortality rate of up to 1%. Endoscopic clearance of bile duct stones is unsuccessful in about 10% of patients, particularly when stones are larger or numerous or when there is an associated stricture of the bile duct. There is also concern about the potential long-term consequences of endoscopic sphincterotomy in young patients, that is, the risk of stenosis and late bile duct problems. For these reasons, preoperative endoscopic cholangiography and stone extraction is reserved for patients with the highest probability of choledocholithiasis and for those in whom conventional open common duct exploration is considered unduly hazardous.

Laparoscopic exploration of the bile duct is applicable to the treatment of both unsuspected common bile duct stones discovered during intraoperative cholangiography and to the management of stones suspected preoperatively based on the results of clinical, laboratory, or imaging evaluations. Because the procedure can be technically demanding, an experienced laparoscopic surgeon is required. Laparoscopic treatment of common bile duct stones is usually performed through the cystic duct rather than by directly incising the common bile duct, as in conventional open common bile duct exploration.[31] Under fluoroscopy, balloon catheters and baskets can be passed through the cystic duct into the common bile duct, and stones can be flushed or pushed into the duodenum or grasped and retrieved through the cystic duct. Ampullary dilatation may facilitate stone clearance in some situations. The cystic duct can be dilated for passage of a small-diameter flexible fiberoptic choledochoscope for direct visualization of the duct and retrieval with a basket passed through the working channel of the choledochoscope. Large or impacted stones may be fragmented by methods of intracorporeal lithotripsy using a pulsed dye laser or electrohydraulic lithotriptor.

The transcystic approach to common bile duct stones is not applicable when stones are larger (>9 mm), located in the proximal biliary tree (common hepatic or intrahepatic ducts), or when the cystic duct is small or has an unusual junction with the common bile duct. If the common bile duct is large enough, laparoscopic removal of common bile duct stones can be accomplished by direct laparoscopic choledochotomy. When exploration has been completed, a T-tube is placed in the common bile duct for drainage. Precise laparoscopic suturing is required to close the opening in the common bile duct. If bile duct stones cannot be completely removed by laparoscopic methods, conversion to a conventional open duct exploration is appropriate, providing that the bile duct is not too small. Obstructing stones must be dealt with at the time of surgery. If the stone defects are small or questionable and there is no obstruction, the operation can be terminated. Endoscopic sphincterotomy can be performed postoperatively if necessary, although it generally is not required.

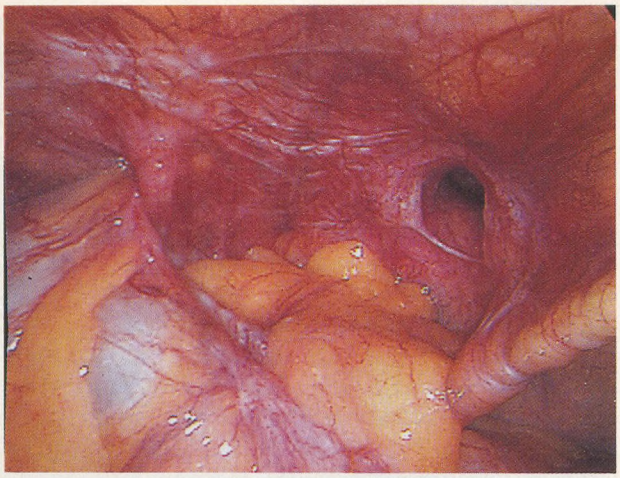

Figure 3. Laparoscopic view of recurrent left inguinal hernia. A direct hernia defect is visible toward the right of the photograph. There is also an indirect hernia alongside the spermatic cord structures on the left of the photograph.

Successful clearance of duct stones has been reported in over 90% of patients with laparoscopic common bile duct exploration.[32,33] Operative morbidity and mortality have compared favorably with open common bile duct exploration. A prospective multi-institutional study of 226 patients undergoing laparoscopic common bile duct exploration was conducted by SAGES.[34] Minor complications occurred in 7% of patients with a 0.4% operative mortality. Retained stones were present in 2.6% of patients. Despite the considerable surgical skill required for laparoscopic common bile duct exploration, successful clearance of common bile duct stones by this method allows complete treatment of the patient in one session without the need for endoscopic sphincterotomy and its potential complications. Convalescence following laparoscopic treatment of common bile duct stones is more rapid than that after conventional open common bile duct exploration. Conventional open common bile duct exploration is indicated for the treatment of choledocholithiasis when endoscopic and laparoscopic methods are unavailable or unsuccessful.

Laparoscopic Treatment of Inguinal Hernia

With the introduction of laparoscopic methods for repairing groin hernias, one of the most common surgical conditions has become one of the most controversial. Conventional repair of an inguinal hernia is accomplished through an incision just above the inguinal ligament, followed by reduction or ligation of the hernia sac and closure of the hernia defect by suture approximation of overlying fascial structures or by coverage with a prosthetic patch. An elective repair is typically an outpatient procedure performed with local anesthesia and intravenous sedation. Resumption of full physical activity usually occurs in 4 to 6 weeks. Long-term rates of hernia recurrence range from 2% to 10%.[35]

Laparoscopic inguinal hernia repair is performed under general anesthesia, with cannulas for instruments typically placed at the umbilicus and in the right and left lower abdomen. Several different techniques of laparoscopic repair have been used but no one method has been fully established as superior.[36] The principle of repair is to cover the inguinal floor, including all potential hernia orifices (direct, indirect, and femoral) with a large prosthetic patch (Figures 3 and 4). The patch can be positioned through a transperitoneal or extraperitoneal route. The mesh is usually fixed in position with staples, and any opened peritoneum is closed to prevent intestinal adherence to the mesh.

The perceived advantages of laparoscopic repair as compared with conventional herniorrhaphy include less postoperative discomfort and earlier resumption of full normal activity. At present, there are no comparative data based on the results of randomized prospective trials. Differences between laparoscopic approaches and standard hernia repairs in terms of technical requirements and potential complications have prevented laparoscopic repair from being implemented as widely and as rapidly as was laparoscopic cholecystectomy. Some early methods of laparoscopic repairs, such as use of a mesh plug of the hernia orifice, use of small prosthetic patches, and direct suture repair, were associated with unacceptably high early-recurrence rates and are no longer advocated.[37]

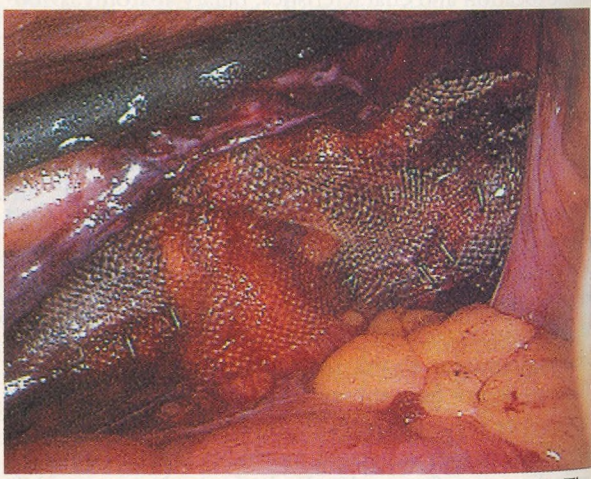

Figure 4. Completed mesh repair of hernia in Figure 3. The peritoneum was subsequently closed over the mesh.

Multicenter trials of laparoscopic preperitoneal prosthetic repairs have reported a recurrence rate of approximately 2%.[38] Although these short-term outcomes are acceptable, long-term efficacy in comparison with standard anterior herniorrhaphy has not been established. Additional concerns pertain to the requirement for general anesthesia, the possibility of intraperitoneal adhesions or visceral complications, and the risk of injury to nerves that are normally outside the field of traditional anterior hernia repair (lateral femoral cutaneous nerve, femoral branch of the genitofemoral nerve, femoral nerve). Serious complications have been infrequent. Nerve injury is avoided by the proper placement of staples. However, when nerve entrapment does occur, it can result in substantial debility.

The initial cost of laparoscopic inguinal hernia repair is higher than that of conventional herniorrhaphy. Assessment of the overall economic impact must include consideration of the cost savings of an earlier return to work. Laparoscopic herniorrhaphy appears to be beneficial to patients desiring an early return to physical activity and employment, and for those with bilateral or recurrent hernias. Additional evaluation of both short- and long-term outcomes is needed before this approach will be more widely accepted.

Laparoscopic Appendectomy

Appendicitis is the most common acute surgical condition of the abdomen. The first substantial experience to document the utility of laparoscopic removal of an inflamed appendix was established in Germany.[39] Subsequent experiences in the United States have confirmed that laparoscopic appendectomy can be accomplished in a high percentage of patients with acute appendicitis, even in the presence of perforation.[40–44] The procedure is generally performed with placement of three cannulas, and on average takes 15 to 25 minutes longer than conventional open appendectomy (Figure 5). Rates of conversion to open appendectomy range from 2% to 12%.

It is not completely clear whether there is an overall advantage to laparoscopic appendectomy over conventional appendectomy performed through a small, right-lower-quadrant incision. Duration of hospitalization and postoperative impairment are already fairly limited following an uncomplicated open appendectomy. In three of four randomized prospective trials, laparoscopic appendectomy was associated with shorter hospitalization than was open appendectomy.[43–46] There is general agreement that laparoscopic appendectomy lessens postoperative pain and results in lower analgesic requirements. Wound infections may also be less common with the laparoscopic approach, since the appendix is removed through a cannula or in a specimen bag and does not directly contact the wound.[41,44,46] In two randomized US trials, patients were able to resume full activity an average of 4.5 and 11 days sooner following laparoscopic appendectomy.[43,44] The cost of laparoscopic appendectomy, as with any laparoscopic procedure, can vary depending on the instrumentation used; it may be similar to or higher than the cost of open appendectomy.[40,42] Any increased expense of instrumentation may be offset by savings resulting from shorter hospitalization, less medication, and an earlier return to work.

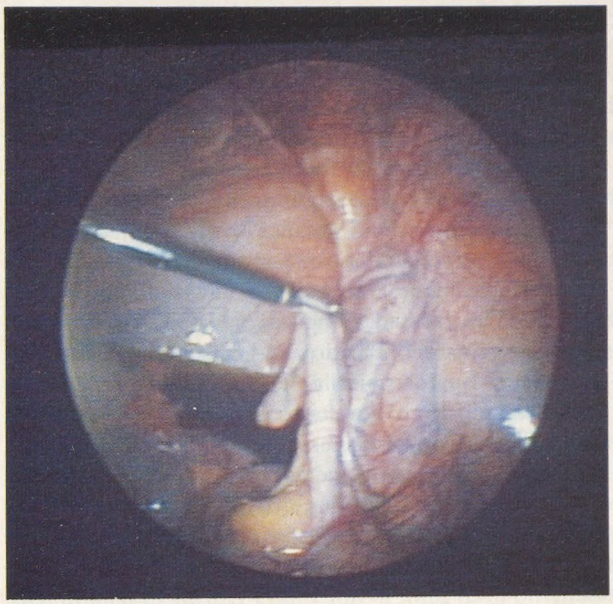

Figure 5. Laparoscopic view of appendix. Free intraperitoneal fluid can be seen in the pelvis. Courtesy of David Easter, MD.

In certain situations, the benefits of laparoscopic appendectomy have been quite apparent. The laparoscopic approach is technically advantageous in obese patients and in patients with an inflamed retrocecal appendix.[40] Laparoscopy also permits a much more thorough examination of the peritoneal cavity than does a small, right-lower-quadrant incision and has obvious merits when the preoperative diagnosis has not been clearly established.

Laparoscopic Colon Resection

A variety of intestinal operations, including resections of the small or large bowel, adhesiolysis for small bowel obstruction, feeding tube placement, colostomy formation or closure, and abdominoperineal resection, have been accomplished with the assistance of videolaparoscopic techniques. Particular attention has been directed

to laparoscopic colon resection as an alternative to conventional open surgery for selected patients with benign or malignant neoplasms, diverticulitis, inflammatory bowel disease, and other colorectal disorders.[47–53] However, the use of laparoscopy in the treatment of many bowel diseases has been more limited than in the treatment of gallstones. The requirements of intestinal mobilization, mesenteric and vascular division, bowel transection, and intestinal anastomosis present a considerable technical challenge. Most commonly, colon resections have been performed as laparoscopically assisted operations. Intestinal mobilization and mesenteric division are performed laparoscopically, the specimen is removed through a small incision, and an anastomosis is created externally by standard operative methods. Alternatively, resections can be performed with intracorporeal laparoscopic anastomoses, although these are technically more demanding.[48] For left-sided resections, the anastomosis is typically performed transrectally with a stapling instrument.

Initial experience has demonstrated that laparoscopic colectomy can be accomplished with low operative morbidity and mortality rates.[47–51] Operative time is longer than with conventional open resection, but blood loss is less. Conversion to an open procedure has been necessary more often than with laparoscopic cholecystectomy. Postoperative recovery appears to be more rapid following laparoscopic resections. Compared with past or concurrent patients undergoing conventional colectomy, patients with laparoscopic resection have less postoperative ileus, are able to eat sooner, have less postoperative pain and narcotic requirements, require shorter hospitalizations (average total, 5 to 6 days), and can resume normal activity sooner.[48,50,53]

The role of laparoscopic resections for colon cancer has been controversial because of concern about adequate extent of resection. Investigators have found that laparoscopic resections and open procedures yield a similar number of mesenteric lymph nodes[51,53]; however, the adequacy of distal resection margins for lower lying left-sided tumors has been questioned.[54] Additional concern has been raised by reports of early tumor recurrence at laparoscopic cannula sites.[55,56] Currently, there are no data on long-term oncologic outcomes. Clearly, the laparoscopic approach makes sense for patients with advanced disease when the resection is palliative. The results of randomized prospective comparisons between laparoscopic and conventional colon resections are required before the adequacy of laparoscopic resection as a curative cancer operation can be assessed. At present, these procedures should be performed in the context of a prospective controlled trial with the fully informed consent of the patient.

Laparoscopic Treatment of Stomach and Esophageal Disorders

Gastroesophageal reflux, hiatal hernia, peptic ulcer disease, and achalasia are some of the gastroesophageal disorders amenable to the minimally invasive surgical techniques of laparoscopy and thoracoscopy. Most patients with symptomatic gastroesophageal reflux can be adequately managed by medical therapy; however, surgical treatment by gastroesophageal fundoplication is more effective for patients with complicated gastroesophageal reflux.[57] A laparoscopic approach to the surgical treatment of gastroesophageal reflux is attractive because experienced laparoscopic surgeons can accomplish the same operations as with an open procedure without the discomfort associated with a conventional upper abdominal incision. As with cholecystectomy, the availability of a laparoscopic approach to gastroesophageal reflux disease should not change the indications for the operation or the necessary preoperative diagnostic evaluation.

Several variations of gastroesophageal fundoplication have been used laparoscopically. Whereas the technical details of these operations differ and various preoperative considerations may have an impact on selection, the physiologic principle behind these procedures is the creation of a high-pressure zone at the distal esophagus. The Nissen fundoplication has been the most widely used antireflux procedure by both open and laparoscopic approaches. This operation creates a circumferential wrap of stomach around a short segment of the distal esophagus.

Accumulating experience at several specialized centers has demonstrated that laparoscopic fundoplications have clinical and physiologic results similar to those obtained with open procedures.[58–61] Hinder and colleagues[61] have reported 198 patients undergoing laparoscopic Nissen fundoplication for treatment of complications of gastroesophageal reflux disease or failed medical therapy. All patients had a thorough preoperative evaluation, including upper gastrointestinal endoscopy and biopsies, upper gastrointestinal roentgenography, esophageal manometry, and 24-hour esophageal pH monitoring. The operative construction of the wrap was performed in the same way as during an open fundoplication. Only six patients were converted to a standard open procedure. There was one postoperative death and 15 postoperative complications. An important risk is unrecognized perforation of the stomach or esophagus, which occurred in three patients. Notably, there was a minimal incidence of wound or pulmonary complications or deep venous thrombosis, and no patients required splenectomy. The median hospital stay was 3 days, and the median return-to-work time was 3 weeks. These results compare favorably with those of open Nissen fundoplication. One hundred patients had postoperative follow-up of 6 to 32

months, with a median follow-up of 12 months. The clinical and physiologically documented results were similar to those of the open operation. The operation is technically demanding and requires a skilled laparoscopic surgeon.

A more limited experience has been established with laparoscopic treatment of peptic ulcer disease. Variations of gastric vagotomy (highly selective, posterior truncal vagotomy and anterior highly selective vagotomy, posterior truncal vagotomy and anterior seromyotomy) have been accomplished with acceptable early results.[62] Long-term follow-up is obviously required before a legitimate comparison can be made with the results of open methods of highly selective vagotomy. In addition to the elective surgical treatment of peptic ulcer disease, experience with emergent laparoscopic closure of a perforated duodenal ulcer has been reported.

Esophageal achalasia, although a less common entity, can also be managed by laparoscopy or thoracoscopy. Initial experience with esophageal myotomy using minimally invasive methods has yielded good results.[63]

Other Applications of Laparoscopy in General Surgery

Before the current era of therapeutic laparoscopy, the utility of diagnostic laparoscopy in the evaluation of abdominal pain, intra-abdominal malignancy, and abdominal trauma had been well established. Subsequent clinical experience and technical developments have expanded and refined the role of laparoscopy for the investigation of these surgical problems. Diagnostic laparoscopy has been useful for the detection or exclusion of disease in patients with chronic abdominal pain and has provided clinically important information in the majority of patients evaluated for acute abdominal pain.[64,65] The accuracy of diagnostic laparoscopy in patients with acute abdominal pain is close to 90%, and its use decreases the rate of negative laparotomies. In the evaluation of malignant disease, the diagnostic and staging information provided by laparoscopy can be a critical determinant of subsequent therapy.[66] Laparoscopy can detect small hepatic metastases and peritoneal spread of tumor that otherwise can be identified only at laparotomy. Laparoscopy has been a valuable method for evaluating both blunt and penetrating abdominal trauma. It is well suited to the detection of peritoneal penetration in patients with stab or gunshot wounds.[67] In the evaluation of blunt trauma, diagnostic laparoscopy may result in fewer negative laparotomies than diagnostic peritoneal lavage.[68,69]

The therapeutic horizons for minimally invasive general surgery are seemingly endless. At the present time, virtually every standard abdominal operation has been approached, at least experimentally, using minimal-access methods. In clinical practice, many operations have been successfully accomplished by laparoscopic techniques, including resection of solid organs (pancreas, spleen, adrenal gland, kidney) and partial hepatectomy, hysterectomy, biliary and gastric bypass for unresectable malignancy, unroofing of cysts of the liver, spleen, and kidneys, and internal enteric drainage of pancreatic pseudocysts.[5]

The use of laparoscopy for the treatment of certain conditions is likely to increase in the near future. Laparoscopic fundoplication can be expected to be performed more widely as increasing numbers of surgeons master the requisite skills and as more gastroenterologists acknowledge the benefits of the procedure. Similarly, laparoscopic removal of the spleen or adrenal gland will be performed more commonly since it confers the advantages of minimal-access surgery and achieves the same therapeutic goal as open surgery. The extent to which laparoscopic repair of groin hernias will evolve will be determined by further evaluation of long-term outcomes and overall cost. Based on accumulating experience, it is reasonable to assume that for certain patient subpopulations, laparoscopic herniorrhaphy will prove beneficial, whereas among other groups, conventional repair will be preferable. Laparoscopic-assisted colon resection will be performed more frequently for benign indications. If long-term studies substantiate its efficacy for treatment of colon cancer, a resurgence of interest in laparoscopic treatment of this common condition will be realized. Such data are at least several years away.

Laparoscopic operations demand technical proficiency. Increasing numbers of surgical residents are now being trained in advanced laparoscopic techniques. Specialized fellowships in laparoscopic surgery are also being initiated throughout the country. Practicing surgeons have been honing their therapeutic laparoscopic skills for several years now, and many have become expert. Well-trained surgeons will be available to perform these operations.

There are technical and practical limitations to minimal-access surgery, and important issues, such as cost and the appropriate application of laparoscopic techniques in relation to conventional approaches, have not been completely resolved. Nonetheless, it is clear that the maturation of laparoscopic skill, technology, and judgment has benefited and will continue to benefit large numbers of patients who have general surgical problems formerly amenable only to laparotomy.

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