The Role of Minimally Invasive Treatments in Surgical Oncology

Mark S. Choh, MD\textsuperscript{a,b}, James A. Madura II, MD\textsuperscript{c,d,*}

\textbf{KEYWORDS}
\begin{itemize}
\item Laparoscopy
\item Endoscopy
\item Cancer
\item Minimally invasive surgery
\end{itemize}

Surgical extirpation of malignancy remains the only hope for cure and the best means of palliation for many forms of cancer. The evolutions of anesthesia, blood product transfusion, and reconstructive techniques enable the modern surgeon to resect nearly anything. But at what cost and what benefit? How many times has a perfectly executed surgical procedure been rebuked by unfavorable tumor biology in the form of early and extensive recurrence? The true revolution of minimally invasive intervention for cancer will occur as the genetic and cellular mechanisms of malignancy are revealed, allowing directed therapy at this level. In the mean time, minimally invasive is synonymous with laparo-endoscopic surgical techniques. These techniques have altered the way surgery is performed for both benign and malignant diseases radically.

Since the introduction of fiber-optic endoscopy in the 1960s and the widespread introduction of laparoscopic cholecystectomy in the 1980s, there has been a huge increase in the use of minimally invasive surgical modalities in clinical practice. The incorporation of these techniques into routine practice has led to the innovation and development of surgical endoscopic techniques in other fields, such as thoracoscopy and transanal endoscopic microsurgery (TEM), and more recent developments, such as robotic surgery and natural orifice transluminal endoscopic surgery (NOTES).

The implementation of these techniques for oncologic indications in surgical practice has progressed at a much slower pace, however. In general, the surgical community has been hesitant to use minimally invasive techniques as part of cancer...
treatments, because of concerns that a minimally invasive surgical approach will compromise the oncologic principles of the treatment. For most of the malignancies addressed, these issues deal with the adequacy of resection of the primary tumor, along with the ability to perform a similar extent of lymphadenectomy to an open case. Although many laparoscopic or thoracoscopic operations for benign disease have shown a clinical benefit in terms of improved cosmesis, less postoperative pain, shorter return of bowel function, shorter length of hospitalization, and quicker return to normal activity, those benefits are minimized if it means a lesser cancer operation is performed or if tumor dissemination occurs as a result of pneumoperitoneum.

Although it is established that diagnostic laparoscopy is beneficial in improving diagnosis and patient outcomes in certain malignancies, there are only a handful of examples where the minimally invasive surgical treatment of cancer has been accepted widely. Colon cancer is the most notable, with several large, prospective, multicenter randomized control trials demonstrating similar oncologic outcomes with its corresponding open surgical treatment. No other malignancy has had trials of the magnitude of the Clinical Outcomes of Surgical Therapy (COST) and Conventional versus Laparoscopic-Assisted Surgery in patients with Colon Cancer (CLASICC) trials to demonstrate the efficacy of minimally invasive techniques to treat cancer. The oncologic outcomes with video-assisted thoracic surgery (VATS) lobectomy for early stage lung cancer have been similar to those with open thoracotomy with reduction in pain and debility; however, thoracic surgeons have been slow to adopt VATS lobectomy into their practice.

For many malignancies, however, there is a paucity of literature examining minimally invasive treatments. For some, such as adrenal cortical carcinomas, the rarity of the disease itself prevents the development of a large enough study to adequately compare the two treatments. For others, such as pancreatic cancer, the technical difficulty of the laparoscopic treatment would preclude most surgeons from incorporating the operation into practice. And just as with any disease process and subsequent treatment, there exist regional differences on a local, national, and international level that make it difficult to generalize data. As technology continues to expand with new techniques and applications, one must measure these interventions against the results of standard therapy. Can new technology achieve the same, or better results and what is the real benefit and cost to patients and the system?

COLON CANCER

Colorectal cancer is the third most commonly diagnosed cancer and the second leading cause of cancer-related death for both men and women in the United States. Most patients diagnosed with colorectal cancer undergo surgical resection as the primary modality of treatment. In 1991, Jacobs and colleagues reported the first laparoscopic resection of a sigmoid colon cancer. From then on, experience with laparoscopic techniques for colon resection increased rapidly.

Reports of port site recurrences, including one series that reported port site metastases in 3 of 14 patients, led to hesitancy on the part of surgeons to use laparoscopy for oncologic resections, however. This led to several randomized controlled trials comparing the oncologic outcomes of the use of laparoscopic-assisted and open resections for colon cancer. The results of these trials have quelled initial fears of using laparoscopy for colon cancer, and provide some of the strongest evidence for the use of minimally invasive techniques for oncologic indications.

Studies examining short-term outcomes of laparoscopic colectomy for cancer have been consistent, demonstrating longer operative times, but less blood loss, less postoperative pain and use of narcotic analgesia, quicker return of bowel function, and
shorter length of hospitalization. These studies also have shown equivalent perioperative morbidity and mortality rates and in some cases, improved results, especially with higher-volume centers. Studies assessing the adequacy of oncologic resection, such as lymph node harvest, margins, and length of vascular pedicle also showed no significant difference between open and laparoscopic resections.

Lacy and colleagues first published the results of a single-institution randomized controlled trial of 219 patients undergoing laparoscopic-assisted and open colon resections in 2002. This trial from Barcelona actually demonstrated a significant improvement in cancer-related survival (91% versus 79%, \(P = .03\)) and a trend toward improvement in overall survival (82% versus 74%, \(P = .14\)) at 5 years. This difference in survival was explained by an improvement in survival among resections in patients who had stage 3 tumors.

The Barcelona trial led the way to three larger multicenter randomized controlled trials comparing laparoscopic and open resections for colon cancer. The most recognized is the COST trial, which enrolled and randomized 872 patients to undergo resection by 66 surgeons from 48 institutions in North America. The initial report of outcomes of the COST trial revealed no difference in 3-year overall survival (86% in laparoscopic group versus 85% in open group, \(P = .51\)) and recurrence rates (16% versus 18%, \(P = .32\)). A more recent report of 5-year outcomes revealed similar outcomes for disease-free 5-year survival (69.2% versus 68.4%, \(P = .94\)), overall 5-year survival (76.4% versus 74.6%, \(P = .93\)), and recurrence rates (19.4% versus 21.8%, \(P = .25\)).

Two other large, multi-institution, randomized controlled trials from Europe have helped support the short- and long-term results of the COST trial. The 3-year outcomes of the COLOR trial, a multicenter randomized controlled trial from Europe, have yet to be published. The CLASICC trial included 794 patients from 27 United Kingdom centers and was unique in that it included patients with both colon and rectal cancer. In addition, it randomized patients at a ratio of 2:1 laparoscopic to open. When examining the 413 patients in the colon cancer group only, there was no difference at 3 years in local recurrence (8.6% in laparoscopic group versus 7.9% in open group, \(P = .76\)), distant recurrence (15.2% versus 14.3%, \(P = .74\)), overall survival, or disease-free survival. The data in the rectal cancer group will be discussed in a separate section.

Although early reports noted port site recurrences as high as 4%, port site and wound recurrences reported in the large randomized studies were low (0.9% to 1.9%) and comparable to historical rates of abdominal wall recurrences in open resections. Various methods have been used to prevent wound implants during specimen retrieval, such as wound protection, gasless laparoscopy, wound excision, peritoneal irrigation; none have been studied extensively in human trials.

Available data support the use of laparoscopic resections for colon cancer. That being said, surgeons must approach each patient on a case-by-case basis. Indications for resection must remain the same as with open surgery, and accurate preoperative localization by means of barium enema, CT colonography, or endoscopic tattooing is imperative, because palpation of the tumor is not as reliable with laparoscopy. Adherence to oncologic principles of proximal ligation of the primary arterial supply, adequate margins, and a lymphadenectomy of at least 12 lymph nodes are mandatory. Failure to achieve these oncologic principles during laparoscopic resection mandates conversion to an open resection.

In addition, laparoscopic colon resection must be performed by surgeons comfortable with laparoscopy if the results from these clinical trials are to be expected. The surgeons in both the COST and COLOR trials had performed at least 20 colon resections. The number of cases required to become competent depends on the individual surgeon and his or her prior laparoscopic experience.
Although proximal tumors of the intraperitoneal rectum can be approached similarly to a distal colon cancer, most rectal cancers are a separate entity, with different preoperative staging and operative and treatment strategies. Therefore, the applicability of minimally invasive techniques to rectal cancer also must be examined separately. Advances in the treatment of rectal cancers such as the standardization of total mesorectal excision (TME), the introduction of TEM, and the use of neoadjuvant chemoradiation therapy have improved outcomes; however, surgical resection remains the mainstay of curative treatment for rectal cancer. Similar to colon cancer, there is a growing body of literature supporting the use of laparoscopy and TEM as acceptable and possibly preferred methods of surgical resection for rectal cancers.

**Laparoscopic Resection of Rectal Cancer**

In 2004, Leung and colleagues published results of a randomized trial comparing 403 laparoscopic and open resections of sigmoid and proximal rectal cancers, excluding tumors less than 5 cm from the dentate line. Findings with short-term outcomes were similar to those in the colon cancer literature with significantly longer operating room times (189.9 versus 144.2 minutes, \( P < .001 \)), but less blood loss (169 versus 238 mL, \( P = .06 \)), postoperative narcotic use, and shorter time to first flatus, bowel movement, and oral intake (all \( P < .001 \)) noted in the laparoscopic group. Hospital stay and time to resumption of normal activity were also significantly shorter. Conversion occurred in 23.2% of patients, with immediate conversion in the 34 cases where local invasion was noted. There was no significant difference in the rates of postoperative mortality or complications. Of note, direct costs were higher in the laparoscopic group ($9297 versus $7194, \( P < .001 \)). Short-term outcomes data from the CLASICC study mentioned previously support these results.

Short-term measures of the adequacy of oncologic resection in these studies raise some concerns. Although distal margins in the Leung trial were similar between the laparoscopic and open groups, there was a trend toward a lower lymph node yield in the laparoscopic group (11.1 versus 12.1, \( P = .18 \)). Similar results were found in a more recent prospective, nonrandomized analysis by Strohlein and colleagues; the lymph node harvest in the laparoscopic group was significantly less than in the open group (13.5 versus 16.9, \( P = .001 \)), although this may be explained partially by a slightly higher rate of the use of neoadjuvant therapy in the laparoscopic group (20.2% versus 14.2%). In addition, a higher, although statistically nonsignificant rate of positive circumferential margins was found in the CLASSIC trial among patients undergoing anterior resection (12% versus 6%, \( P = .19 \)).

These short-term markers of resection adequacy, however, have not resulted in differences in long-term oncologic outcomes. In the Leung study, there were no differences in 5-year overall survival (76.1% in laparoscopic group versus 72.9% in open group, \( P = .61 \)), disease free survival (75.3% versus 78.3%, \( P = .45 \)), or local recurrence (6.6% versus 4.1%, \( P = .37 \)). Similarly, the higher rates of positive radial margins with the laparoscopic anterior resection group in the CLASICC study did not result in a higher rate of local recurrence as initially hypothesized (7.8% versus 7.0%, \( P = .70 \)). In addition, 3-year overall survival and disease-free survival rates were similar in the laparoscopic and open groups.

In the Strohlein study, similar results were noted; however, a significant improvement in 5-year survival was noted in patients undergoing laparoscopic deep anterior resection (\( P = .035 \)). Some authors have postulated that the improved magnification of the endoscopic camera allows for a more precise dissection of the mesorectum
with better preservation of the autonomic nerve plexus and other structures.\textsuperscript{7,11} This is supported by the higher proportion of complete TME resections in the CLASICC study (77\% versus 66\%).\textsuperscript{7} A recent Cochrane systematic review of the literature comparing laparoscopic versus open TME resections\textsuperscript{20} found similar long-term outcomes in the two groups.

Most of literature does not include patients who underwent neoadjuvant radiation as part of their treatment, and the presence of postradiation changes may make a laparoscopic dissection more difficult. More recent literature supports similar short-term outcomes with laparoscopic TME after neoadjuvant therapy;\textsuperscript{19,21} however, long-term oncologic outcomes for patients in this group are still pending.

Literature currently supports the use of laparoscopy for the resection of rectal cancer. Surgical principles that apply to open resections must still be followed, however; these include removal of the blood and lymphatics up to the origin of the superior rectal artery or inferior mesenteric artery, a distal margin of 1 to 2 cm, and total mesorectal excision. As with colon cancer, surgeon experience must be adequate to tackle laparoscopic resection of rectal tumors. In addition, unique patient factors such as pelvic anatomy, obesity, and the possibility of a bulky uterus may prohibit laparoscopic intervention from a technical standpoint.

**Transanal Endoscopic Microsurgery**

TEM, a technique used as an extension of local transanal excision, was developed by Karl Buess in the mid-1980s.\textsuperscript{22} The system consists of a 40 mm diameter proctoscope, an optical stereoscope, and an insufflation mechanism to create a pneumorectum working space, along with four working ports for instrument access (Fig. 1). This results in superior visualization and maneuverability that allows surgeons to access lesions in the rectum that previously were inaccessible with conventional transanal excision techniques.

TEM initially was used for the excision of benign polyps that were unresectable by means of colonoscopy; since then, numerous series have examined the use of TEM...
for rectal cancer as an alternative to a major abdominal operation, particularly in T1 tumors. The rationale behind local excision of these tumors is that they have an extremely low risk of nodal involvement. A review by Hermanek and colleagues23 of 1588 rectal tumors revealed that well differentiated to moderately differentiated pT1 tumors had a 3% risk of positive lymph nodes; therefore, a major resection involving lymphadenectomy is unlikely to provide additional benefit. Endorectal ultrasound or MRI using endorectal coils, however, can identify suspicious lymph nodes preoperatively, with 60% to 92% accuracy, and these should be used as part of a routine preoperative work-up.24,25

It is clear that in experienced hands, TEM can be performed safely with low morbidity rates. In comparing TEM with traditional anterior resection, Winde and colleagues26 found significantly less blood loss, lower operative times, use of analgesia, and shorter length of hospitalization in the TEM group. Most complications are minor and include self-limiting bleeding, tenesmus, fecal soilage, and urinary retention. In a review of 334 patients undergoing TEM, Mentges and colleagues27 reported a 0.3% mortality rate and a 5.5% rate of major complications such as hemorrhage requiring intervention, entry into the peritoneum causing sepsis, and rectovaginal fistula. Studies examining functional results after TEM have shown short-term dysfunction when measured by either manometry or surveys, but improvement in these symptoms over the long term.28,29

With respect to oncologic outcomes, most authors report good-to-excellent results, with low recurrence rates, and long-term survival numbers similar to those of open resection. Duhan-Floyd and Saclarides30 reported a series of 53 patients undergoing TEM for pT1 rectal cancers, with a 7.5% recurrence rate. All patients underwent open resection of their recurrences, and no disease-related deaths were noted. Winde and colleagues26 conducted a small prospective, randomized controlled trial of 52 patients with uT1N0 rectal cancer who were randomized to undergo either TEM-assisted resection or open anterior resection. Although local recurrence rates were higher in the TEM group (4.2% versus 0%), there was no difference in 5-year survival. With respect to more advanced tumors, Lezoche and colleagues31 randomized 40 patients with T2N0 rectal carcinomas who underwent neoadjuvant chemoradiation therapy to either TEM or laparoscopic anterior resection. They found two recurrences in each group, with no cancer-related mortality in the TEM group. A meta-analysis of 22 studies by Suppiah and colleagues32 examining local recurrence rates after TEM for rectal cancer reported a 6% local recurrence rate for 552 patients who had pT1 cancer, 14% for 174 patients who had pT2 cancer, and 20% for 56 patients who had pT3 lesions.

Most authors conclude that indications for TEM in rectal cancer include uT1N0 lesions that are well differentiated to moderately differentiated, with no evidence of lymphovascular invasion. There remains some debate regarding its use in higher-risk T1 and well differentiated T2 lesions. More advanced tumors should not be resected with TEM for curative intent; however, it can be a feasible option in these patients if significant comorbidities precluding a major abdominal resection are present. Salvage resection of local recurrences can result in excellent long-term disease-free survival rates; therefore diligent follow-up of patients undergoing resection by means of TEM is mandatory.

ESOPHAGUS

Esophageal cancer is a significant problem worldwide; it is the seventh most common cause of cancer death, and 13,900 new cases are diagnosed in the United States each year.33 Surgical resection is the only hope for cure; however, a large proportion of
patients is unresectable at the time of presentation. Even with resection, prognosis is poor, with 40% of patients dying in the first year after surgery and 5-year disease-free survival rates of 27%.34,35

It can be difficult to assess the potential benefits and outcomes of minimally invasive approaches to esophageal resection, since there is no consensus on the optimal open approach to esophageal resection. Some larger studies have shown an improvement in perioperative morbidity with the transhiatal approach to esophagectomy,36,37 and other studies have shown no significant difference.36 Data from other centers suggest that the transthoracic approach results in a more complete lymphadenectomy.34 In addition, studies have shown that outcomes may be related more to hospital and surgeon volume than the surgical approach.39 Because no agreed-upon standard of resection has been determined for the traditional open approach to esophagectomy, it is difficult to evaluate outcomes after minimally invasive approaches to esophageal resection.

A myriad of minimally invasive techniques for esophagectomy have been described. An initial report by McAnema and colleagues40 in 1994 described the thoracoscopic-assisted mobilization of the esophagus combined with an open abdominal approach. Following this, DePaula and colleagues41 in 1995 demonstrated the feasibility of laparoscopic transhiatal esophagectomy. Since then, numerous approaches to minimally invasive esophagectomy have been described, including thoracoscopic-assisted esophageal resection, laparoscopic transhiatal resection, hand-assisted laparoscopic transhiatal resection, and three-field, combined thoracoscopic/laparoscopic resection.42–47

Examination of short-term outcomes after minimally invasive esophagectomy (MIE) has demonstrated different approaches to be safe and feasible with outcomes equivalent to traditional open approaches. In a series of 46 patients undergoing MIE, mostly by means of a three-field technique, Nguyen and colleagues44 demonstrated a mortality (4.3%), major complication (17.4%), and anastomotic leak (8.7%) rates that were similar to those of historical controls.48 In a retrospective review comparing 332 MIE cases (309 thoracoscopic-assisted with open laparotomy, 23 total MIE) with 114 open cases, Smithers and colleagues49 demonstrated less blood loss, less time in the thorax, and a shorter length of stay with the minimally invasive approaches, with no increase in lymph node harvest, complication rates, or mortality.

Luketich and colleagues45 have reported the largest series of total MIE to date. Using a combined thoracoscopic/laparoscopic/cervical three-field technique, he reported short- and long-term outcomes on 222 patients undergoing MIE. Short-term outcomes were also similar to historical series, with a 30-day mortality rate of 1.4% and an anastomotic leak rate of 11.7%. Mean hospital stay was 7 days, however, much less than in open series.48

As with any oncologic indication for minimally invasive surgery (MIS), concerns about adequacy of oncologic resection with MIE exist. There are no randomized trials comparing open and minimally invasive approaches for esophageal cancer; however, reported case series have promising results that suggest that oncologic outcomes after MIE may be similar to those of open series. Braghetto and colleagues39,50 reported a consecutive series of 166 patients undergoing esophagectomy for cancer. Three-year survival rates were 93.8% for stage 1 disease and 54% for stage 2a disease among patients undergoing MIE, and there was no significant difference when compared with patients in the open group. Similarly, in the Smithers group,49 there was no significant difference in survival when the open, thoracoscopic-assisted, and total MIE groups were compared stage for stage for 3-year survival. The Luketich series45 included 185 patients undergoing MIE for cancer, and 3-year survival rates for stage 1, 2a, 2b, and 3 patients were
65%, 41%, 45%, and 17%. The small numbers in all these series make it difficult to make any definitive conclusions; however, the data suggest that survival outcomes with MIE may be similar to those after traditional approaches to resection.

With experience and improved technology, the hope is that minimally invasive approaches may improve short-term outcomes by eliminating the need for either a thoracotomy requiring lung collapse and rib spreading, or a major laparotomy, while providing at least equivalent, if not improved survival outcomes over traditional open approaches. Although further work must be done to determine the optimal approach to esophageal resection, it is clear that minimally invasive approaches to esophageal resection will play a major role in the treatment of esophageal cancer for years to come.

**STOMACH**

Gastric cancer is the second leading cause of cancer-related deaths worldwide; however, it only ranks 13th on the list in the United States. Although it is decreasing in incidence, it continues to be one of the deadliest gastrointestinal malignancies, with over 30% of patients presenting with stage 4 disease, overall 5-year survival less than 40%, and the ability to perform a curative resection in as few as 20% of patients in Western series. Despite the grim prognosis, surgical intervention must be aggressive and attentive to oncologic principles, because an R0 resection is the most important prognostic factor for resectable gastric cancer.

MIS applied to gastric cancer has the potential to improve patient quality of life over traditional open surgery. There is no doubt that upper abdominal surgeries reap great benefit from MIS as documented in cholecystectomy, antireflux and diaphragmatic surgery, splenectomy, and bariatric surgery. Patients experience less pain after MIS compared with open surgeries in the upper abdomen because of the absence of upper abdominal incisions and aggressive, prolonged retraction needed for traditional surgical exposures. This translates to less pulmonary embarrassment and faster recovery, which has been documented after laparoscopic gastrectomy for benign and malignant disease. Endoscopic and laparoscopic resections of benign and low malignant potential lesions (such as gastrointestinal stromal tumors, GIST) have been received with little controversy and are considered preferred approaches in centers where the expertise is available. The same concerns that prefaced the wide acceptance of laparoscopic colon surgery for malignancy have slowed the adoption of MIS approaches to gastric cancer, however; These include: adequate surgical margin, lymph node harvest, effect on pattern of recurrence, and long-term survival data. Facility with advanced endoscopic and laparoscopic techniques and desire of traditional surgical oncologists to adopt new technology likely have roles in the limited widespread application also.

Currently, a range of MIS options for gastric adenocarcinoma are being performed around the world, including endoscopic mucosal resection (EMR), intragastric mucosal resection, laparoscopic wedge resection, and partial and total laparoscopic or laparoendoscopic-assisted gastric resections. Choice of approach should have the patient’s best chance for curative resection in mind.

**Endoscopic Mucosal Resection for Gastric Cancer**

In Asia, where there is a high prevalence of gastric cancer, aggressive screening practices have led to more frequent identification of early gastric cancer (EGC). The gold standard for the treatment of early gastric cancer remains gastrectomy with lymph node dissection, with 5-year survival rates in the 96% to 99% range. Outcomes
after endoscopic resection of early gastric cancers are similar to those after operative treatment in these, mainly Japanese series. One must keep in mind that gastric cancer in North America is thought to be a different entity, often found at a more advanced stage with less favorable histology. Therefore, endoscopic therapy for gastric cancer has not found widespread use in Western centers.

EGC is defined by the Japanese classification system as cancer that does not invade beyond the submucosa (T1) regardless of lymph node involvement. The ideal candidates for EMR within this group are those patients whose risk of lymph node involvement is minimal. Although there have been no prospective randomized trials comparing operative and endoscopic resections for early gastric techniques, large retrospective series have identified commonly accepted indications for EMR: well differentiated, intestinal type carcinoma that is limited to the mucosa. Tumors must have no evidence of ulceration and be 20 mm or less in elevated types and 10 mm or less in depressed or flat types. When these criteria are met, and no lymphovascular invasion is seen on final pathologic examination, incidence of lymph node involvement is less than 0.4%.

More recently, expanded criteria have been proposed, based on large retrospective series examining characteristics of EGC and risk of lymph node metastases. These indications include nonulcerated, well differentiated mucosal tumors of any size and ulcerated mucosal tumors of up to 30 mm. In addition, they include nonulcerated lesions with microscopic (less than or equal to 500 μm) invasion into the submucosa. Survival rates after EMR using the expanded criteria have been excellent; in a series of 714 patients undergoing EMR, 146 (20%) diagnosed using the extended indications, 3-year overall and disease-specific survival rates were 99.2% and 93.7%, respectively.

Numerous methods have been used for EMR of EGC, from fulguration to wide excision using a submucosal technique. The benefit of EMR over fulguration is that it provides a complete pathologic specimen for accurate depth staging and does not exclude the possibility of further surgical therapy should the need for it arise. Endoscopic resection techniques include strip biopsy, double snare polypectomy, and cap-fitted endoscopic resection. More recently, the use of endoscopic submucosal dissection (ESD) techniques has given endoscopists the ability to resect larger cancers as a single specimen, resulting in a higher rate of curative resection in some series. In addition, intragastric mucosal resection techniques using the transgastric deployment of laparoscopic instruments have been described.

Laparoscopic Resection for Gastric Cancer

Laparoscopic surgery for gastric cancer is the logical extension of nearly 20 years of laparoscopic surgery on the stomach for benign diseases such as peptic ulcer disease, gastroesophageal reflux, and bariatric procedures. Regardless of one’s commitment to lesser or more radical surgical intervention for gastric cancer, all of the proposed operations done in conventional open surgery can be, and have been, performed laparoscopically. The first laparoscopically assisted Billroth I gastrectomy for EGC was performed in 1991 as reported by Katano and colleagues in 1994. The preliminary results of 10 patients undergoing laparoscopically assisted total gastrectomy were reported in 1995 to be equivalent to open surgery with the benefits of less pain and faster recovery. Laparoscopic extended lymphadenectomy and pancreaticosplenectomy subsequently have been published. Data are maturing that confirm the initial impression of equivalent oncologic results and the benefits of the MIS approach. Five-year results of a randomized prospective trial comparing 59 patients subjected to open or laparoscopic subtotal gastrectomy showed no statistical
difference in number of lymph nodes resected, mortality, morbidity, or overall and disease-free survival with the benefits of reduced blood loss, shorter time to resumption of oral intake, and earlier discharge from hospital attributed to the laparoscopic approach.74 The authors’ own data confirm the ability to achieve adequate lymph node retrieval and margins even in advanced gastric cancers.75 MIS techniques now are being applied in palliative resections also. To the authors’ knowledge, none of the early concerns for port site recurrence, dissemination of tumor, or inadequate tumor clearance have materialized.

The technical aspects of MIS gastrectomy involve stapling, multifield procedures, multiple anastomoses, and dealing with unexpected anatomy and challenges. The learning curve is quite shallow (meaning it takes a large number of cases to become proficient). It is therefore likely that the widespread application of MIS to gastric cancer will be slow to occur.

**PANCREAS**

Of all the operations in general surgery, resections of the pancreas are among the most complex, requiring an extensive dissection of a retroperitoneal organ with an intimate relationship with numerous major vascular structures and often a complex reconstruction involving the alimentary and biliary tracts. Performing pancreatic resections, whether at the head or tail, therefore, remains among the most technically challenging operations that can be performed in a minimally invasive fashion. In addition, fewer than 20% of adenocarcinomas of the pancreas are considered resectable for cure,76,77 and the poor prognosis of this disease makes it difficult to assess the clinical benefits of laparoscopy in pancreatic cancer. Although there is generalized support for using diagnostic laparoscopy and laparoscopic ultrasound as a means to assess resectability of pancreatic tumors,78,79 most of the literature involving resections of the pancreas for oncologic indications remains anecdotal.

Both laparoscopic distal pancreatectomy and laparoscopic pancreaticoduodenectomy (LPD) first were reported in 1994.80,81 An early report by Gagner, who performed the first laparoscopic Whipple procedure, questioned the clinical benefit of laparoscopic pancreatic resection, reporting long operative times and high complication rates, with minimal benefit in short-term outcomes, such as hospital stay.82 More recent reports, however, have confirmed the feasibility of laparoscopic pancreatic resections and supported some benefits in short-term postoperative outcomes. Conversion rates for laparoscopic resection have been between 0% and 20%.83–85 Edwin and colleagues83 reported on 32 patients who underwent either enucleation or distal pancreatectomy, with or without splenectomy, with a short median hospital stay (5.5 days) and postoperative need for opioid analgesia (2 days). Complications were reported at 38%; however, most of the complications reported were minor. Mabrut and colleagues84 reported the results of a multicenter, retrospective review of 127 patients undergoing laparoscopic pancreas resections; most (79%) undergoing distal pancreatectomy. Mean operating times were reasonable at 190 minutes, and median postoperative hospital stay was 7 days, which was significantly less when compared with the group undergoing open resection after conversion. Pancreas-related complication rates were 31%, comparable to published results on open resections.86

Similarly, the feasibility of LPD is being supported by recent literature. Various techniques and approaches have been reported, including hand-assisted and robot-assisted techniques, as well as using a minilaparotomy for the reconstructive portion of the operation.82,87–91 Indications and short-term outcomes of currently published case series are listed in Table 1. Although operative times are quite lengthy, there does seem to be a trend toward shorter times with more experience. Hospital stay is difficult to
<table>
<thead>
<tr>
<th>Author</th>
<th>Number of Patients</th>
<th>Operative Details</th>
<th>Conversion</th>
<th>Diagnosis</th>
<th>Operative Time (Min)</th>
<th>Length of Stay (Days)</th>
<th>Complication Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gagner et al, 1997</td>
<td>10</td>
<td>Laparoscopic pylorus-preserving PD</td>
<td>40%</td>
<td>Pancreatic adenocarcinoma–4 Ampullary cancer–3 Chronic pancreatitis–2 Cholangiocarcinoma–1</td>
<td>510</td>
<td>22.3</td>
<td>50%</td>
</tr>
<tr>
<td>Giulianotti et al, 2003</td>
<td>8</td>
<td>Robot-assisted PD</td>
<td>12.5%</td>
<td>Pancreatic adenocarcinoma–3 Mucinous cystadenoma–2 Cholangiocarcinoma–2 Ampullary carcinoma–1</td>
<td>490</td>
<td>NR</td>
<td>37%</td>
</tr>
<tr>
<td>Dulucq et al, 2006</td>
<td>22</td>
<td>13 total laparoscopic 9 laparoscopic-assisted</td>
<td>13.6%</td>
<td>Pancreatic adenocarcinoma–11 Ampullary cancer–3 Chronic pancreatitis–2 Duodenal adenocarcinoma–2 Other–4</td>
<td>287</td>
<td>16.2</td>
<td>32%</td>
</tr>
<tr>
<td>Palanivelu et al, 2007</td>
<td>42</td>
<td>Laparoscopic pylorus-preserving PD</td>
<td>0%</td>
<td>Ampullary Ca–24 Pancreatic adenocarcinoma–9 Pancreatic cystadenoma–4 Cholangiocarcinoma–3 Chronic pancreatitis–2</td>
<td>370</td>
<td>10.2</td>
<td>31%</td>
</tr>
<tr>
<td>Pugliese et al, 2008</td>
<td>19</td>
<td>6 total laparoscopic 7 laparoscopic assisted</td>
<td>31%</td>
<td>Pancreatic adenocarcinoma–11 Ampullary carcinoma–4 Cholangiocarcinoma–3 Mesenchymal tumor–1</td>
<td>461</td>
<td>18</td>
<td>37%</td>
</tr>
</tbody>
</table>

Abbreviations: Ca, cancer; PD, pancreaticoduodenectomy.
analyze because of the wide variation in the approach to postoperative management. That being said, complication rates in the later series seem to be similar to those published in larger studies of the standard open pancreaticoduodenectomy. There have been no studies, however, that specifically have examined long-term oncologic outcomes after laparoscopic pancreatic resections. Palanivelu and colleagues reported the largest series, 42 patients, to date. Of these, 40 were performed for malignant indications with close follow-up. Median survival for the total group was 49 months, and 5-year survival was 30.7% for ampullary carcinoma and 19.1% for pancreatic adenocarcinoma.

It is clear that performing laparoscopic pancreatic resections requires a significant amount of experience and technical expertise. If performed by skilled and practiced surgeons with proper indications, it is definitely feasible; however, the true clinical benefit remains to be seen. As technological advances in endoscopy, robotics, and surgical instrumentation improve, the use of laparoscopy in pancreatic surgery will continue to grow.

LIVER

Like the pancreas, liver resection, whether performed open or laparoscopically, remains one of the more complex operations performed in surgery. Because of significant risks of bleeding, difficulty in obtaining hemostasis, and risk of major morbidity because of bile leakage, incomplete resection, and air embolism, many surgeons have shied away from implementing minimally invasive techniques for resecting hepatic malignancies. Since the first report of a laparoscopic partial hepatectomy by Gagner and colleagues in 1992, however, there has been a steady increase in international experience with wedge resection, minor anatomic resections, and even major hepatic resections for both benign and malignant disease. Technological innovations in intraoperative ultrasound, ultrasonic dissection techniques, and endoscopic linear staplers have made laparoscopic liver resections not only feasible, but also beneficial to patients when performed by surgeons with appropriate expertise and experience.

A recent meta-analysis by Simillis and colleagues examined short-term outcomes of studies comparing laparoscopic hepatic resections (LHR) and open hepatic resections (OHR) for benign and malignant neoplasms. An examination of eight studies comprising 409 hepatic resections (165 [40.3%] laparoscopic, 244 [59.7%] open) found significant decreases with LHR in operative blood loss (-123 mL, 95% CI, -179 to -67 mL, \( P < .001 \)), duration of hospital stay (-2.6 days, 95% CI, -3.8 to -1.4 days, \( P < .001 \)), and period to first oral intake (-0.5 days, 95% CI, -1.0 to 0.0 days, \( P = .05 \)). In addition, there were no significant differences in postoperative mortality or complications. These differences were all similar when studies matched for the presence of malignancy were analyzed.

Most commonly, liver resections for malignancy involve resection of either hepatocellular carcinoma (HCC) or metastases from colorectal cancer (CRM). Although there are only a handful of studies examining the oncologic outcomes of LHR for malignancy, early data suggest comparable survival rates to open resections.

Although controversial, orthotopic liver transplantation may offer the highest recurrence-free survival rates in patients who have HCC. Limited organ availability and strict indications for transplantation, however, limit its availability as a treatment option. Newer techniques such as transarterial chemoembolization (TACE), ethanol injection, and radiofrequency ablation frequently are used in select cases of HCC. Surgical resection, however, remains the primary modality of treatment for many patients. Kaneko and colleagues examined 30 cases of LHR for HCC, all of whom
underwent either left lateral segmentectomy or partial hepatectomy. When compared with 28 control cases based on similar preoperative criteria, there was no difference in 5-year overall survival (61% versus 62%, not significant [NS]) or disease-free survival (31% versus 29%, NS). Vibert and colleagues\(^97\) reported data on 113 laparoscopic liver resections (including major hepatectomies), 65 of them for malignant disease (16 for HCC, 41 for CRM, and 8 for other metastatic disease). With respect to HCC, overall survival and disease-free survival at 3 years were 66% and 68%, respectively, numbers that compare with open results. More recently, Chen and colleagues\(^98\) reported a series of 116 patients undergoing LHR for HCC, including 19 patients undergoing major resection of more than two segments. Five-year overall survival rates were similar in the minor (two or less segments) and major (three or more segments) resection groups (59.4% and 61.7%).

Resection of isolated CRM after resection of the primary tumor has been shown to improve survival rates when appropriate timing and patient selection are employed.\(^99\) In the study by Vibert and colleagues,\(^97\) follow-up data were available in 30 patients who underwent LHR for CRM; all patients underwent adjuvant systemic chemotherapy. Although 14 recurrences were noted, overall survival was excellent, at 87% at 3 years, with a disease-free survival rate of 51% at 3 years.

These data suggest that the use of LHR for malignant neoplasms improves short-term outcomes with similar long-term oncologic results. Because of the increased risk of major bleeding complications and the inability to gain rapid hemostasis with the laparoscopic approach, it is imperative that a surgeon is familiar with the various laparoscopic instruments and techniques that are required for a safe laparoscopic liver resection. In addition, patient-related factors such as cirrhosis, ascites, adhesions, anatomic anomalies, and tumor-related factors such as size, location, and relationship to major vascular structures must be taken into account when selecting candidates for LHR.

ADRENALECTOMY

Although there has not been a large, prospective, randomized controlled trial comparing laparoscopic versus open adrenalectomy, there have been numerous well-designed retrospective and prospective nonrandomized studies demonstrating a dramatic benefit in clinical outcomes such as postoperative pain, cosmesis, return of bowel function, and length of hospitalization, along with no significant increase, and in some cases, a decrease in complication rates.\(^100\)\textendash102 Since the introduction of laparoscopic adrenalectomy (LA) in 1992,\(^103\) data have led to LA becoming the gold standard for resecting benign adrenal lesions and incidentalomas, based on a 2002 consensus statement published by the National Institutes of Health (NIH).\(^104\) The approach to malignant lesions of the adrenal gland is not as straightforward, however.

The indications for adrenalectomy have not changed with the recent popularization of laparoscopic adrenalectomy. Functioning tumors, lesions with an increased risk of malignancy, and in some cases, solitary metastatic lesions to the adrenal gland are indications for resection of the adrenal gland. Lesions greater than 6 cm should be considered for resection, and lesions of intermediate size (4 to 6 cm) should be evaluated on an individual basis based on patient’s age and comorbidities, as well as suspicious features on imaging (irregular borders, heterogenous lesions with calcification or necrosis, and invasion of surrounding structures).

**Adrenal Cortical Carcinoma**

Primary adrenal cortical carcinoma (ACC) is an extremely rare and aggressive tumor. These tumors account for approximately 0.1% of all adrenal lesions and 4% of
surgically resected specimens,\textsuperscript{105} and they have dismal prognosis. Reported 5-year survival rates are between 22\% and 26\%,\textsuperscript{106,107} and locoregional recurrence rates are 30\% after traditional open resection.\textsuperscript{108} Because of the rarity of this tumor, there are only a handful of case series that discuss the role of laparoscopy in resecting primary ACC. An early report by Suzuki and colleagues\textsuperscript{109} discussed a case of peritoneal dissemination and mortality of a patient who underwent laparoscopic adrenalectomy for ACC. Since then, series examining patients with ACC have reported locoregional recurrence rates ranging from 0\% to 100\%; however, a combined examination of these reports resulted in rates of 26\% for local recurrences and 32\% for peritoneal recurrences (Table 2), rates that approximate those from larger open studies. Reported survival rates are also similar; Porpiglia and colleagues\textsuperscript{110} reported a series of 13 patients undergoing resection for malignancy, seven with ACC. At a mean follow-up of 30 months, there was only one death; five patients had no evidence of recurrent disease. Nocca and colleagues\textsuperscript{111} compared nine patients undergoing resection for ACC. Four patients undergoing laparoscopic resection with a mean tumor size of 85 mm had a mean survival of 42.3 months compared with five patients undergoing open resection with a mean tumor size of 122 mm with a mean survival of 29.7 months.

\textbf{Isolated Adrenal Metastasis}

The adrenal glands are a common site of metastasis for several malignancies, including melanoma, colon, renal, and lung cancers. Numerous reports have demonstrated improved survival after resection of solitary adrenal metastases.\textsuperscript{112,113} As surgeons became more comfortable using laparoscopy for resection of benign adrenal lesions, experience began to grow with laparoscopic resections for metastatic disease. An early report by Heniford and colleagues\textsuperscript{114} reported ten patients undergoing laparoscopic adrenalectomy for malignancy, nine with metastatic lesions, with no locoregional recurrences at a mean follow-up of 8.3 months. In a series of 31 patients, Moinzadeh and Gill\textsuperscript{115} reported 26 with adrenal metastasis; 53\% of patients were alive at a median follow-up of 42 months. Five-year estimated Kaplan-Meier survival was 40\%. More recently, Strong and colleagues\textsuperscript{116} from Memorial Sloan Kettering reported their experience with the resection of 94 patients who had isolated adrenal metastases. Laparoscopic resection was used for 31 patients, and there was no difference in local recurrence, margin status, disease-free survival, or overall survival between the open and laparoscopic groups, although the mean size of the laparoscopic tumors was smaller in the open group.

These data suggest that oncologic outcomes after laparoscopic adrenalectomy for primary ACC or metastatic adrenal lesions may be acceptable given appropriate preoperative indications for laparoscopic resection. There does not seem to be a size limitation on laparoscopic resection, as long as adequate local resection and negative margins can be achieved.

\textbf{MINIMALLY INVASIVE THYROID SURGERY FOR THYROID CANCER}

Papillary and follicular carcinomas of the thyroid both have extremely favorable prognosis, with a high definitive cure rate and low mortality.\textsuperscript{117,118} Surgical resection remains the mainstay of treatment, although there is some controversy on the optimal extent of thyroid resection, and the role of central neck dissection without a preoperative suspicion of lymph node metastases. The use of endoscopic techniques in the neck may seem unconventional; however, surgeons are using minimally invasive techniques to perform thyroid resections, for benign and malignant conditions.
<table>
<thead>
<tr>
<th>First Author</th>
<th>Institution/Location</th>
<th>Year</th>
<th>Total with Adrenal Cortical Carcinoma</th>
<th>Local Recurrence</th>
<th>Peritoneal Recurrence</th>
<th>Distant Recurrence</th>
<th>Follow-Up (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ushiyama</td>
<td>Hamamatsu/Japan</td>
<td>1997</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Hamoir</td>
<td>Liege/Belgium</td>
<td>1998</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Foxius</td>
<td>Louvain/Belgium</td>
<td>1999</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Valeri</td>
<td>Firenze/Italy</td>
<td>2002</td>
<td>1</td>
<td>1</td>
<td>NR</td>
<td>NR</td>
<td>8</td>
</tr>
<tr>
<td>Porpiglia</td>
<td>Orbassano/Italy</td>
<td>2002</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>NR</td>
<td>19*</td>
</tr>
<tr>
<td>MacGillivray</td>
<td>Maine Medical Center/United States</td>
<td>2002</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>Henry</td>
<td>Marseilles/France</td>
<td>2002</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>28*</td>
</tr>
<tr>
<td>Kebebew</td>
<td>University of California San</td>
<td>2002</td>
<td>6†</td>
<td>2</td>
<td>NR</td>
<td>1</td>
<td>40†</td>
</tr>
<tr>
<td></td>
<td>Francisco/United States</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zeh</td>
<td>Johns Hopkins/United States</td>
<td>2003</td>
<td>4</td>
<td>1</td>
<td>NR</td>
<td>1</td>
<td>24*</td>
</tr>
<tr>
<td>Prager</td>
<td>University of Vienna/Austria</td>
<td>2004</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>60, 27</td>
</tr>
<tr>
<td>Moinzadeh</td>
<td>Cleveland Clinic/United States</td>
<td>2005</td>
<td>6</td>
<td>2</td>
<td>NR</td>
<td>NR</td>
<td>21</td>
</tr>
<tr>
<td>Gonzalez</td>
<td>MDACC</td>
<td>2005</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>15*</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>39</td>
<td>10/39 (26%)</td>
<td>7/22 (32%)</td>
<td>8/28 (29%)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: NR, not reported; MDACC, M.D. Anderson Cancer Center.

* Median
† One case converted to open after diagnostic laparoscopy

One of the difficulties in assessing oncologic outcomes with minimally invasive thyroid surgery is the wide variation in techniques used. Techniques described include minimizing incision length to 2.5 to 3.5 cm, video-assisted techniques using a small 1.0 to 1.5 cm central or lateral neck incision, and completely endoscopic techniques by means of the chest, breast, or axilla (on one or both sides). All of these techniques have been examined with or without the use of CO₂ insufflation and skin-lifting techniques. Benefits of these approaches are mainly cosmetic, with reduced incisions that in some cases are moved to more inconspicuous areas. Studies have shown reduced postoperative pain and reductions in postoperative hospital stay when compared with traditional open surgery.

Most surgeons’ indications for endoscopic thyroid surgery are quite strict: thyroid nodules of 3.0 to 3.5 cm or less, no previous neck radiation or operation, and no evidence of thyroiditis. The size or volume of the thyroid appears to be the biggest limiting factor for minimally invasive thyroid surgery. With these indications, however, complication rates have been comparable, with permanent recurrent laryngeal nerve injury rates between 0 and 2.8% and permanent hypocalcemia between 0% and 1.0%, rates that are similar to conventional thyroid surgery.

There have been no reports of long-term oncologic outcome after video-assisted thyroid resections for malignancy. Reports using secondary short-term measures of the oncologic adequacy of resection have shown promising results. Chung and colleagues analyzed 103 patients undergoing endoscopic surgery by means of a bilateral breast and axillary approach and found no difference between 3-month serum thyroglobulin levels when compared with 198 patients undergoing open thyroidectomy. In a small, prospective study of patients undergoing resection for papillary carcinoma, Miccoli and colleagues randomized 33 patients to open or video-assisted thyroid resection and found no postoperative difference in radioactive iodine uptake or mean thyroglobulin level at follow-up.

In addition, smaller case series have demonstrated the feasibility of adding central lymph node dissection in conjunction with video-assisted thyroid surgery for patients who have papillary thyroid carcinoma or positive RET oncogene mutations undergoing prophylactic thyroidectomy, and even a lateral lymph node dissection. The lack of long-term analyses of survival and recurrence rates, however, should lead to hesitancy with labeling these techniques as a definitive oncologic operation. The excellent prognosis and long-term survival for most thyroid cancer patients likely will be unaffected by the application of MIS.

**VIDEO-ASSISTED THORACIC SURGERY FOR LUNG CANCER**

Like many advanced minimally invasive surgical techniques, the use of VATS for lung cancer has been slow to replace open procedures. First described in the early 1990s, it is estimated that only 5% of the 40,000 lobectomies performed each year in the United States are being done using thoracoscopic techniques. The literature has shown, however, that the use of VATS has significant advantages with respect to short-term outcomes, and recent results show the longer-term oncologic outcomes after VATS lobectomy for early nonsmall cell lung cancer (NSCLC) are similar to those after traditional open resection.

Numerous reports have demonstrated that VATS lobectomy is safe and feasible. Perioperative mortality rates are low, between 0.5% and 2.7%, with low conversion rates in the largest series. Complication rates vary based on authors’ experience and definition of complications; however, in the largest published series of 1100 patients undergoing VATS lobectomy, McKenna and colleagues reported
a 15.3% complication rate. The most common complications reported in larger series are similar to those reported in the open literature and include atrial arrhythmias, pneumonia, persistent air leak, and myocardial infarction. Reports of short-term outcomes after VATS lobectomy demonstrate the thoracoscopic approach has resulted in low operative blood loss with no significant change in operative time, less postoperative pain, and earlier return to baseline function in a small retrospective cohort study examining longer-term quality-of-life measures, Suguira and colleagues noted that after at an average of 12 months after surgery, none of the patients undergoing VATS lobectomy complained of post-thoracotomy pain, while 26.7% of those undergoing traditional thoracotomy still were taking narcotics for chest wall pain.

More importantly, long-term oncologic data after VATS lobectomy for lung cancer demonstrate excellent outcomes. The cohort of 500 patients reported by Onaitis and colleagues included 416 patients who had NSCLC, and 2-year survival rates for stage 1 and stage 2 disease were 85% and 77%. Kaplan-Meier survival curves for 976 patients who had NSCLC in the series by McKenna and colleagues are shown in Fig. 2. Although there have been no large multicenter randomized trials comparing VATS lobectomy with open resection, a small, prospective trial by Sugi and colleagues randomized 100 patients who had clinical stage 1a lung cancer to either VATS lobectomy or traditional resection. Two patients in the VATS group were converted to thoracotomy, resulting in 52 patients in the open group and 48 patients in the VATS group. There was no significant difference in 3- and 5-year overall survival rates between the two groups (93% and 85% in the open group, 90% and 90% in the VATS group).

Current data support the use of thoracoscopic techniques for resection of early stage lung cancer. Improved short-term outcomes related to decreased postoperative pain, less blood loss, and a shorter length of hospital stay and return to preoperative function likely are related to the avoidance of a rib-spreading thoracotomy. In addition, studies have shown an immunologic benefit with VATS, resulting in decreased
cytokine release and improved lymphocyte function,\textsuperscript{142,143} although the clinical benefit of these findings has yet to be examined thoroughly. The routine use of VATS should be limited to single lobe resections in patients who have either clinical stage 1 or 2 lung cancer, and appropriate work-up for the presence of locally invasive or metastatic disease is mandatory. More involved resections, such as sleeve lobectomies and pneumonectomies have been reported, but data are sparse, and these operations should only be performed in high-volume, experienced centers with careful monitoring and reporting of outcomes.

**SUMMARY**

Laparoscopic and minimally invasive techniques will continue to penetrate and transform all areas of surgery, including oncology. Long-term data will likely prove that minimally invasive techniques are equivalent in oncologic outcomes without deleterious effects. Physicians must continue to insist that these operations are performed for the same indications and accomplish the same surgical goals as traditional operations while providing significant benefit to patients to justify the inevitable increase in expense. New skill sets and technology demand attention to training and credentialing to assure safe patient outcomes.

**REFERENCES**


