Hypothesis: A review of the literature will show that laparoscopy is safe and effective for the treatment of surgical diseases in elderly patients.

Data Sources: An electronic search using the PubMed and MEDLINE databases was performed using the term laparoscopy in elderly patients. Literature published in the English language in the past decade was reviewed. Pertinent references from articles and books not identified by the search engines were also retrieved. Relevant surgical textbooks were also reviewed.

Study Selection: All relevant studies that could be obtained regardless of the study design were included.

Data Extraction: All studies that contained material applicable to the topic were considered. Data on patient characteristics and surgical outcomes were abstracted.

Data Synthesis: Sixteen studies evaluated laparoscopic cholecystectomy in the elderly. Compared with open cholecystectomy, elderly patients undergoing the laparoscopic procedure had a lower incidence of complications and a shorter hospitalization. In the 4 studies reporting the results of laparoscopic antireflux surgery in the elderly, the morbidity, mortality, and length of hospital stay were similar to those of younger patients. The elderly had equally good postoperative symptom relief. Ten reports of laparoscopic colon resection in the elderly demonstrated earlier return of bowel function, shorter hospitalization, and less cardiopulmonary morbidity.

Conclusions: Despite underlying comorbidities, individuals older than 65 years tolerate laparoscopic procedures extremely well. Complications and hospitalization are lower than in open procedures. Surgeons need to inform primary care physicians of the excellent result of laparoscopic procedures in the elderly to encourage earlier referrals.

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Background

Physiologically, aging is associated with a gradual loss of reserve capacity, even in individuals without obvious underlying comorbidities. This becomes most apparent during periods of increased metabolic demand, such as surgery, which reduces the older patient’s ability to tolerate stress. Age greater than 70 years is an indepen-
dent predictor of increased postoperative complications and in-hospital mortality, as well as longer hospital stay.\textsuperscript{2} In addition, concomitant disease tends to become more prevalent in older patients.\textsuperscript{2,3} Consequently, the American Society of Anesthesiology score is often 2 or greater in elderly patients, a known prognostic factor for increased complications and death.\textsuperscript{2,4} Morbidity and mortality are higher after laparotomy than nonabdominal operations in the aged.\textsuperscript{4,5} Therefore, surgical interventions for abdominal disease in the elderly carry a higher risk for complications and death than in younger patients.

Before the performance of the first laparoscopic cholecystectomy (LC), gynecologists had been performing laparoscopy for many years, predominantly on healthy young women. Therefore, the hemodynamic and respiratory effects of carbon dioxide (CO\textsubscript{2}) pneumoperitoneum on older patients with possible underlying cardiopulmonary compromise were unknown.\textsuperscript{6,7} Thus, when general surgeons began performing laparoscopic procedures, only individuals at low risk for cardiopulmonary morbidity were considered operative candidates, preventing many older patients from enjoying the benefits of minimally invasive operations.\textsuperscript{8}

Carbon dioxide pneumoperitoneum raises concern because of the mechanical effects of increased intra-abdominal pressure and the metabolic effects of CO\textsubscript{2}. Pneumoperitoneum decreases functional residual capacity and lung compliance and may also increase peak airway pressures.\textsuperscript{9,10} Fine tuning of minute ventilation will prevent these changes from causing any deleterious effects in most patients. However, patients with underlying pulmonary compromise may not tolerate these respiratory changes.

Intraperitoneal insufflation of CO\textsubscript{2} causes hypercapnia and acidemia, due to absorption of CO\textsubscript{2} across the peritoneal membrane. Adjustments in ventilation can obviate these changes.\textsuperscript{7,11} Healthy individuals are usually not affected, but serious derangements in pH and CO\textsubscript{2} values may develop in those with pulmonary disorders.\textsuperscript{7,10} Mechanical and metabolic effects can inhibit cardiac performance by influencing preload, afterload, and myocardial contractility. This may be problematic for patients with limited cardiac reserve.\textsuperscript{7,10,12}

Initially, these changes were a cause for concern in offering laparoscopy to elderly patients with known cardiopulmonary disease. However, a decade of successful laparoscopic procedures in older patients has reduced fears of pneumoperitoneum-related complications.\textsuperscript{15} Even octogenarians, the fastest growing segment of the population in the industrial world,\textsuperscript{14} seem to benefit from laparoscopic procedures. This review will investigate the studies of minimally invasive surgery in the elderly to determine whether this approach offers a better option for this important and growing group of patients. Although the definition of elderly is somewhat arbitrary, this review will focus on studies performed in patients 65 years and older. The term extreme elderly includes those individuals 80 years and older.

LAPAROSCOPIC CHOLECYSTECTOMY

The incidence of gallstones and gallbladder diseases increases with increasing age.\textsuperscript{1,14-16} Fifty percent of women and 15% of men 60 years or older are estimated to have gallstones.\textsuperscript{17} Gallbladder disease is the most common indication for abdominal surgery in the elderly.\textsuperscript{14,17,18} Open cholecystectomy (OC) in the elderly is associated with considerable morbidity and mortality, with complication rates reported in the range of 18% to 35%.\textsuperscript{8,13,19,20} and mortality as high as 12.7%.\textsuperscript{8,10,20} Since much of the morbidity of OC relates to the large abdominal incision, LC should result in decreased morbidity in older patients, similar to that already observed in the general population.\textsuperscript{21}

During the past decade, a number of reports have addressed the issue of LC in older patients. The only prospective, randomized, controlled clinical trial comparing LC with OC in the aged patient was quite small and not well designed. However, the study demonstrated that patients undergoing LC tended to have less postoperative pain, a shorter hospital stay, and fewer complications.\textsuperscript{22} Despite the presence of cardiopulmonary disease in most patients undergoing LC, there were no complications related to the CO\textsubscript{2} pneumoperitoneum. Randomization became difficult when the advantages of LC became apparent and the study was terminated for ethical reasons.\textsuperscript{22}

Retrospective and prospective studies comparing elderly patients undergoing LC with similar patients undergoing OC have demonstrated that LC results in a shorter hospital stay and fewer postoperative complications than OC.\textsuperscript{13,23-25} Despite a high incidence of preoperative cardiopulmonary morbidity, few complications related to CO\textsubscript{2} pneumoperitoneum have been reported.\textsuperscript{23,26} Occasionally, pneumoperitoneum resulted in difficulty in ventilation and conversion to OC was necessary.\textsuperscript{27} The reported rate of conversion to OC has ranged from 3%\textsuperscript{28} to 22%,\textsuperscript{8,15,20,25-27} The reasons for conversion include dense adhesions, distorted anatomical features, acute and gangrenous cholecystitis, bleeding, and unexpected common bile duct stones.\textsuperscript{8,14,27-29}

Studies comparing geriatric patients undergoing LC with younger patients undergoing the same procedure have shown that the elderly tend to have more complications, higher conversion rates, and longer hospital stays than younger individuals.\textsuperscript{8,14,15} Because of the higher incidence of previous abdominal surgery in older patients, adhesions are encountered more frequently, sometimes necessitating conversion.\textsuperscript{15,29} Despite the higher complication rate in the elderly, it is still lower than that seen with OC.\textsuperscript{15,22}

The advantage of LC compared with OC persists even in the extreme elderly.\textsuperscript{14,20,26,31} Moreover, the number of octogenarians undergoing LC is increasing, in some cases more quickly than the number of younger patients.\textsuperscript{20,31} Despite the higher incidence of advanced gallbladder disease in octogenarians, a large number of these individuals present electively for treatment of biliary disease.\textsuperscript{15,29} The conversion rate in the extreme elderly is higher than in those aged 65 to 79 years, as are morbidity and mortality. The likely reasons for the poorer outcomes in octogenarians are increased comorbidities, more scarring around the gallbladder, and higher incidence of choledochoolithiasis.\textsuperscript{14,28} Although hospital stay in the extreme elderly is higher than in patients aged 65 to 79
years, 47% of patients older than 80 years in one report were discharged on postoperative day 1. Just as important, these patients undergoing LC returned to 100% activity at a mean of 13.9 days after surgery, an important benefit of the minimally invasive approach. Most investigators conclude that, in the setting of uncomplicated gallbladder disease, elderly patients tolerate LC extremely well. When elderly patients undergo LC for acute cholecystitis, the conversion rate, hospital stay, and postoperative morbidity and mortality are all increased compared with the elective setting. 15,20,22,29,30,32,33  Despite the fact that complications due to LC are still fewer than those seen when these patients undergo OC, 15,20,22,29,30,33 elderly patients presenting with acute cholecystitis still may be offered LC less frequently than younger individuals. 33 This could be due to the greater technical difficulty of performing the procedure in the acute setting and the fear of an increased risk for bile duct injury. In addition, patients requiring urgent surgical intervention are often in poorer physical condition. Investigators therefore recommend attempting LC in elderly patients with acute cholecystitis, but advise maintaining a low threshold for conversion to an open procedure. 15,30

Older patients appear to have a more aggressive progression of gallbladder disease and are more likely to have complications of gallstones requiring urgent intervention, including cholelithiasis, acute cholecystitis, pancreatitis, and gallbladder perforation. 15,16,18,27,29,30,34 Two decades ago, surgeons recognized that patients older than 70 years who had complicated gallstone disease requiring urgent operations fared worse than their counterparts undergoing elective biliary tract surgery. 34 Since many of the patients with advanced biliary disease admitted to symptoms of gallstones before development of complications, it could be inferred that elderly patients were not being offered surgical treatment of biliary disease until complications developed, necessitating an urgent operation. There are 2 possible explanations for delayed referral of older patients, especially octogenarians. First, the elderly often have atypical clinical manifestations of gallbladder disease, and the clinician may not consider gallstones as the explanation for the initial symptoms. Second, primary care physicians may believe that the risks associated with general anesthesia and surgery in this population are prohibitive. 14 Earlier referral and elective operation are necessary to minimize morbidity and mortality in the older population. 16,34

As it becomes clear that elderly patients tolerate LC well, especially in the elective setting, primary care physicians should become more comfortable referring their patients for surgical management of biliary tract disease. Because the elderly have variable presentations of gallstones and their symptoms do not always fit the classic description of biliary colic, it is imperative that surgeons educate primary care physicians of the protean manifestations of gallbladder disease in the elderly to ensure the prompt diagnosis of symptomatic gallstones. Furthermore, the safety of electively performed laparoscopic cholecystectomy in this age group must be emphasized to encourage early referral to a surgeon. Ultimately, this should result in improved outcomes in the elderly population.

LAPAROSCOPIC ANTIREFLUX SURGERY

Gastroesophageal reflux disease is extremely common, with approximately 10% of the population experiencing daily heartburn. For most patients, their disease can be managed with lifestyle modifications and medications. However, a subset of patients will require long-term treatment with proton pump inhibitors to relieve symptoms, prevent esophagitis, maintain remission, and prevent complications. 33,36 Medications are costly and have adverse effects. Moreover, complications of reflux, including bleeding, stricture, Barrett esophagus, and reactive airway disease, may develop in individuals with chronic reflux disease, and medications may fail to prevent the progression of disease. 36,37 In addition, proton pump inhibitors may heal esophagitis, but fail to control all symptoms. Surgical therapy, which has proven to be safe and effective, may be indicated in this group of people with reflux disease. 38

The prevalence of reflux disease is higher in the elderly than in younger individuals. 39 The physiological effects of aging, including changes in esophageal motility, gastric emptying, and the lower esophageal sphincter and reduced salivary flow, contribute to the higher prevalence of disease in the elderly. 39,40 Because pathologic reflux and reflux esophagitis are seen more commonly in this population, older patients may present with more advanced reflux disease than younger patients. 36,39-41 Moreover, the extent of mucosal damage may be more severe than their symptoms suggest. 39,41 Without endoscopy, it is difficult to predict the presence of esophagitis in the elderly. Therefore, patients older than 65 years who present with symptoms of reflux should undergo endoscopy early in the workup. When esophagitis is diagnosed in this patient population, it should be treated aggressively. 39,41 Although this generally means intensive medical therapy, elective antireflux surgery should also be considered. 37,39,43

In the days of open surgery, patients older than 60 years undergoing Nissen fundoplication did very well, with the same morbidity rates as their younger counterparts. In the past decade, the minimally invasive approach to antireflux surgery has been enthusiastically embraced, and the number of patients undergoing operative intervention for reflux disease has exploded. 37,38 After successfully performing laparoscopic Nissen fundoplication for several years, investigators began to analyze their results in elderly patients. Despite the increased preoperative comorbidities seen in patients older than 65 years, the older individuals had equivalent postoperative results and no increase in postoperative complications. 37 Specifically, the median length of hospital stay in the older patients was 2 days, which was identical to that in the younger group. Postoperative complications occurred in 7% of the patients in the elderly group and 6% of the patients in the younger group. There were no deaths in either group. Results of postoperative pH studies were normal in both groups. 37

Since this study, additional reports have documented the safety of laparoscopic Nissen fundoplica-
tion in elderly patients. Two studies compared laparoscopic antireflux surgery in patients 65 years and older with patients younger than 65 years.49,55 In both studies, the older patients had higher American Society of Anesthesiology scores than the younger patients, but no difference was seen in postoperative complications. In one report, the hospital stay was longer in the older group,44 but the other study reported equivalent hospitalization for both groups.45 When postoperative symptoms were assessed, the elderly reported degrees of satisfaction and low incidence of symptoms that were similar to those of younger patients.44,45 One group of investigators analyzed their operative results in 30 octogenarians and nonagenarians who underwent laparoscopic Nissen fundoplication for reflux disease or paraesophageal hernia.46 They reported a mean ± SD hospital stay of 2.2 ± 1.0 days, 1 conversion to laparotomy, 2 complications, and no deaths. All but 2 patients were satisfied with their results. These studies illustrate that older patients tolerate laparoscopic antireflux surgery quite well. It is imperative that in this elderly population, patients are appropriately selected and underlying medical problems are properly managed preoperatively.37

As with LC, surgeons need to inform referring physicians of the excellent results of laparoscopic antireflux surgery in the elderly. The proven safety and efficacy of this procedure need to be communicated to prevent a delay in referral of elderly patients with persistent reflux symptoms for surgical management. Appropriate and timely surgical intervention can prevent the development of complications of reflux disease in this population.

**LAPAROSCOPIC COLON RESECTION**

The first reports of laparoscopic operations for benign and malignant colorectal disease appeared in the 1990s.47 Early studies demonstrated that laparoscopic colonic resection was feasible and resulted in decreased postoperative pain, quicker return of bowel function, shorter hospital stay, better cosmesis, and more rapid return to routine activities.47-49 However, this procedure has not been embraced as avidly by surgeons and patients as other laparoscopic operations, partly as a result of the controversy regarding the appropriate use of this modality in patients with malignant disease.47,48,50

Since the incidence of colorectal disease increases with age, a large number of elderly patients will require colorectal surgery.1,10,39 In octogenarians requiring colorectal operations, emergency procedures are more common, blood transfusions, complications and postoperative deaths occur more frequently, and hospital stay is longer.51,52 Underlying cardiopulmonary comorbidities are responsible for the higher incidence of pulmonary and cardiovascular complications. The elderly, therefore, could potentially benefit immensely from minimally invasive techniques that cause less cardiopulmonary stress, earlier rehabilitation, and faster return to independent status.

One of the first reports to address laparoscopic colon resection in the elderly studied 18 patients with colon cancer who were undergoing palliative resections or were older than 70 years with American Society of Anesthesiology scores greater than 2. The authors reported no intraoperative complications, no conversions to an open operation, and adequate tumor resection. Despite the fact that all patients in this study were older than 60 years, there were no deaths and no morbidity specifically related to the laparoscopic technique.53 A later study evaluated the outcomes of laparoscopic colon resection in 36 individuals 60 years and older and compared the results to procedure-matched patients younger than 60 years. There were no deaths in either group, and morbidity and conversion rates were similar in both groups. Although the lengths of ileus and hospital stay were longer in the elderly group, the difference did not meet statistical significance.54 Additional studies comparing outcomes in older and younger patients demonstrated that operative times, intensive care unit stay, and hospital stay tended to be longer in the elderly.55 Need for conversion and postoperative morbidity were not significantly higher in the elderly groups.54,55 A number of case series of older individuals undergoing attempted laparoscopic colectomy have demonstrated shorter length of stay in patients whose procedures were completed laparoscopically. Morbidity, especially cardiopulmonary morbidity, appeared to be lower than that associated with open colectomy. Conversion rates varied from 11% to 22%.36-38

In a study comparing octogenarians undergoing laparoscopic colon resection with those undergoing open colec- tomy, there were no complications due to the CO2 pneumoperitoneum, despite the length of the procedure and the need for a steep head-down position. Of the 42 cases attempted laparoscopically, 5 required conversion to an open procedure. Morbidity and mortality were similar in both groups. Patients treated laparoscopically tended to have shorter hospitalizations and less need for inpatient rehabilitation or nursing home placement. At 4 weeks after operation, a higher number of patients in the laparoscopic group had returned to their previous level of activity than the patients undergoing open colectomy.59 Other investigators who compared elderly patients undergoing laparoscopic colectomy with those undergoing open colectomy found a lower incidence of cardiopulmonary complications and earlier return of bowel function in the laparoscopic group.35,60-62 Of particular interest in this population was the shorter hospital stay and the higher rate of postoperative independence in the laparoscopic group.61 The significantly lower need for posthospital nursing home placement offers a tremendous advantage for elderly patients. Recently, results of the Clinical Outcomes of Surgical Therapy (COST) study analyzing quality-of-life outcomes in patients undergoing laparoscopic colon resection became available. With the use of a rigorous tool to determine quality-of-life outcomes between open and laparoscopic colon resection, only minimal short-term improvement in quality-of-life scores was found in the laparoscopic group.63 However, even a small, short-term advantage may be beneficial in older patients if the likelihood of postoperative independence is enhanced.60 The studies in elderly patients demonstrate a number of short-term advantages of the laparoscopic approach. However, the long-term survival results of minimally invasive operations for the treatment of malignant disease remain unclear.50 Due to the concern about port
site metastasis. Some investigators strongly advise against performing curative laparoscopic colon resection for malignant disease outside the setting of a clinical trial. Randomized trials addressing the long-term results of laparoscopic colon resection for cancer are currently under way. It may, therefore, be prudent to offer laparoscopic colon resection only to elderly patients with benign colorectal disease until the results of these large, randomized trials are available.

CONCLUSIONS

The elderly are the fastest growing segment of the population in the United States. Surgeons, therefore, must be comfortable treating these individuals. Older patients, healthier and more fit than in previous generations, are able to withstand the stress of surgery. Therefore, denial of surgical treatment of disease should never be based solely on age.

From this review, it is apparent that elderly patients derive the same benefits from laparoscopic procedures as younger individuals. Therefore, minimally invasive procedures should be offered to geriatric patients when clinically appropriate. In fact, the elderly tolerate LC and laparoscopic antireflux procedures better than they do open procedures. The same can be said for laparoscopic colon resection, although the controversies surrounding this procedure for the treatment of malignant disease may continue to make surgeons reluctant to perform it. For benign colorectal disease, laparoscopic colon resection may be the treatment of choice for geriatric patients.

Although even elderly patients with significant underlying comorbidities can tolerate urgent surgical intervention, all patients clearly have better outcomes when procedures are performed in the elective setting. In light of the evidence that laparoscopic procedures are well tolerated in the elderly, primary care physicians should become more willing to refer patients with biliary tract disease, gastroesophageal reflux disease, and colorectal disease for surgical intervention early, before complications develop. It is, therefore, incumbent on surgeons to educate referring physicians about the excellent outcomes that can be achieved when older patients undergo laparoscopic surgery.

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