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Short-term outcomes of minimally invasive *versus* open colectomy for colon cancer

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ABSTRACT

Background: Laparoscopic and open approaches to colon resection have equivalent long-term outcomes and oncologic integrity for the treatment of colon cancer. Differences in short-term outcomes should therefore help to guide surgeons in their choice of operation. We hypothesized that minimally invasive colectomy is associated with superior short-term outcomes compared to traditional open colectomy in the setting of colon cancer.

Materials and methods: Patients undergoing nonemergent colectomy for colon cancer in 2012 and 2013 were selected from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) targeted colectomy participant use file. Patients were divided into two cohorts based on operative approach—open *versus* minimally invasive surgery (MIS). Univariate, multivariate, and propensity-adjusted multivariate analyses were performed to compare postoperative outcomes between the two groups.

Results: A total of 11,031 patients were identified for inclusion in the study, with an overall MIS rate of 65.3% ($n = 7200$). On both univariate and multivariate analysis, MIS approach was associated with fewer postoperative complications and lower mortality. In the risk-adjusted multivariate analysis, MIS approach was associated with an odds ratio of 0.598 for any postoperative morbidity compared to open ($P < 0.001$).

Conclusions: This retrospective study of patients undergoing colectomy for colon cancer demonstrates significantly improved outcomes associated with a MIS approach, even when controlling for baseline differences in illness severity. When feasible, minimally invasive colectomy should be considered gold standard for the surgical treatment of colon cancer.

Introduction

Colon resection is the mainstay of treatment for most colon cancers and has traditionally been performed via laparotomy. Laparoscopic colectomy for colon cancer was first introduced in the early 1990s[1-3] but faced early criticism given concerns regarding the oncologic integrity and risk of port-site recurrence.[4] These concerns led to several randomized controlled trials designed to evaluate long-term cancer-related outcomes associated with differing operative approaches.[5-8] A Cochrane review published in 2012 by Kuhry *et al.* concluded that laparoscopic resection yields similar long-term oncologic

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outcomes to that of open colectomy.[9] Similarly, several large prospective trials reported on differences in short-term outcomes between the two approaches. Most notably, the clinical outcomes of surgical therapy (COST) trial,[10] colon cancer laparoscopic or open resection (COLOR) trial,[11] and conventional *versus* laparoscopic-assisted surgery in colorectal cancer (CLASICC) trial[12] all demonstrated marginal short-term benefits in those patients randomized to a laparoscopic approach for the surgical treatment of colon cancer. These trials were largely viewed as a demonstration of noninferiority of a laparoscopic approach but failed to provide compelling evidence for surgeons to alter their practice as a result.

Despite evidence from the aforementioned randomized controlled trials, laparoscopy for the treatment of colorectal cancer has not been universally adopted in the United States. Recent evidence suggests that approximately 50% of colon resections for cancer are still performed open in this country,[13,14] possibly in part reflecting surgeon attitude regarding a lack of substantial benefits with a laparoscopic approach. Randomized trials have been criticized for the lack of clinically significant differences in outcomes, the patient selection, and the context in which these trials were performed wherein open patients were not managed according to newer enhanced recovery protocols. A comparison of these two approaches as used in real-world practice may help to address some of these concerns.

Therefore, we performed a comparative effectiveness study using a standardized, large, national clinical database to assess the differences in short-term patient outcomes between open and minimally invasive colon resection. Using propensity scoring to control for differences in treatment groups, we sought to further support the hypothesis that minimally invasive colectomy is associated with superior short-term outcomes compared to traditional open colectomy in the setting of colon cancer. Secondarily, we aimed to evaluate how outcomes are impacted by conversion from a minimally invasive to open approach.

Materials and methods

Sample selection

Patients undergoing nonemergent colon resection for an indication of colon cancer were selected from the 2012 and 2013 American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) targeted colectomy participant use files. ACS-NSQIP provides a prospectively maintained clinical database that has been previously described. The targeted colectomy database was developed in 2011 and contains data contributed by participating academic and community hospitals throughout the country. Importantly, this database contains variables for operative approach, ileus, anastomotic leak, cancer staging information, and other colon-specific variables. Adult patients undergoing colon resection for colon cancer were eligible for inclusion in the study. Current procedural terminology (CPT) codes included 44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44160, 44204, 44205, 44206, 44207, 44208, and 44210. Right-sided colon resection was identified using CPT codes 44160 and 44205. Both elective and nonelective cases, which is to be distinguished from the "emergency case" variable in NSQIP, were included. In an attempt to exclude critically ill patients, exclusion criteria included emergent operation (defined by ACS-NSQIP as cases reported as emergent by the surgeon and/or anesthesiologist), preoperative ventilator-dependence, preoperative sepsis or septic shock, and ASA class 5 or ASA class not reported. Additional exclusion criteria included surgery performed by a surgical service other than general surgery; operative approach classified as endoscopic, hybrid, natural orifice transluminal endoscopic surgery, other, or missing; and missingness of data for variables included in the statistical models. Finally, a small number of patients were excluded based on extreme propensity score (Fig. 1).

Variable classification

Operative approach was classified as "open" if the procedure was planned and performed open. Minimally invasive surgical (MIS) approach was defined as any operation started as laparoscopic, hand-assisted laparoscopic, robotic, hand-assisted robotic, single-incision laparoscopic (SILS), and hand-assisted SILS. In the primary analysis, cases in which there was an unplanned conversion to open were included in the MIS cohort consistent with the intent-to-treat principle. In the secondary analysis undertaken to evaluate the effect of conversion, three separate groups were defined: open, converted, and cases completed via a MIS approach. Body mass index (BMI) classes were defined as underweight (<18.5), normal (18.5-24.9), overweight (25-29.9), obese (30-39.9), and morbidly obese (40+). Age groups were divided into age <50 y, 50-64 y, 65-79 y, and 80+ y. Prolonged hospital stay was defined as length of stay >7 d.

Endpoints

The ACS-NSQIP database reports on multiple predefined 30-d outcomes, including various complications, mortality, and hospital length of stay. Additionally, the targeted colectomy database contains colorectal-specific variables for prolonged postoperative ileus and anastomotic leak. Complications were grouped into several categories to form composite endpoints. "Infectious complication" included at least one of the following complications: superficial surgical site infection (SSI), deep SSI, organ space SSI, pneumonia, urinary tract infection, sepsis, and septic shock. "Wound complication" included at least one of superficial SSI, deep SSI, and wound dehiscence. "Noninfectious complication" included anastomotic leak, wound dehiscence, reintubation, pulmonary embolism, failure to wean from the ventilator, renal insufficiency, renal failure, cardiac arrest, myocardial infarction, and deep venous thrombosis. As wound dehiscence most commonly occurs in the setting of wound infection but can also be related to surgical technique, it was included in both the wound composite outcome as well as the noninfectious composite outcome. "Any complication" included any of the 30-d complications included in the infectious or noninfectious categories. Ileus, 30-d mortality, mean operative time, mean