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A comparison of trends in operative approach and postoperative outcomes for colorectal cancer surgery

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ABSTRACT

Background: Data-assessing trends and perioperative outcomes relative to surgical approach for colorectal cancer (CRC) surgery are lacking. We report national trends of CRC surgery and compare postoperative outcomes by surgical approach.

Methods: A total of 261,886 patients undergoing surgery for CRC were identified using the Nationwide Inpatient Sample from 2009 to 2012. Trends in surgical approach were assessed using the Cochran–Armitage test of trends. Multivariable logistic and linear regression analyses were performed to compare length of stay (LOS), postoperative complications, and cost by surgical approach.

Results: At the time of surgery, 57.5% underwent an open procedure, whereas 42.4% underwent either a laparoscopic (39.9%) or robotic (2.5%) colorectal surgery. The use of minimally invasive surgery increased over time (2009 *versus* 2012: 37.3% *versus* 46.8%; $P < 0.001$). Postoperative morbidity was 15.9% and was higher after open surgery (open *versus* laparoscopic *versus* robotic: 18.4% *versus* 12.4% *versus* 13.3%; $P < 0.001$). Patients who underwent a minimally invasive surgery had shorter LOS (laparoscopic: OR, 0.55, 95% CI, 0.52-0.58; robotic: OR, 0.58; 95% CI, 0.49-0.69; both $P < 0.001$). Robotic surgery was consistently associated with the highest mean costs followed by laparoscopic and open surgery ($P < 0.001$).

Conclusions: Patients undergoing minimally invasive colorectal surgery had a lower postoperative morbidity and shorter LOS compared with patients undergoing open colorectal surgery.

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Introduction

Colorectal cancer (CRC) is the third leading cause of cancer and the second leading cause of cancer-related death in the United States.[1] Given improved cancer screening and recent advances in the treatment of CRC, the number of deaths per 100,000 has steadily decreased. However, it is still expected that in 2016 over 49,190 patients will die from CRC.[2] Surgical resection remains the mainstay for treatment of CRC with the extent of surgery and the need for chemotherapy and radiation varying by stage and disease presentation.[3,4] Recently, there has been a shift from a traditional open colorectal resection to the adoption of minimally invasive surgical approaches such as laparoscopic, and most recently, robotic surgery. Of note, prospective single-center clinical trials have demonstrated minimally invasive surgery (MIS) to be associated with improved short-term outcomes, including a decreased length of stay (LOS), improved postoperative pain control, decreased postoperative morbidity, and lower hospital cost.[5,6]

Moving to an era of greater financial accountability, there is an increasing interest to evaluate data comparing trends and outcomes relative to the method of operative approach. More specifically, as postoperative outcomes are an important determinant of hospital and physician reimbursement, data comparing postoperative clinical and financial outcomes by operative approach are critical to quality improvement efforts. Data-evaluating national trends in the use of minimally invasive *versus* open surgery after 2009, however, remain largely unknown. The limited number of reports assessing trends and outcomes after surgery are limited to single-center or multicenter studies and are therefore unable to report on national trends. Furthermore, to the best of our knowledge, no study has explicitly compared the use of open, laparoscopic, and robotic surgery using a nationally representative data set. Given this, the aim of the present study was to report on national trends in operative approach for the primary surgical resection of CRC. In addition, we sought to compare postoperative clinical and financial outcomes between patients who underwent either an open, laparoscopic, or robotic surgery for CRC.

Methods

Data source and patient population

This retrospective, cross-sectional study was performed using the Healthcare Cost and Utilization Project National Inpatient Sample (HCUP-NIS) database from January 1, 2009 to December 31, 2012. The HCUP-NIS is the largest, nationally representative, all-payer, in patient database in the United States. The NIS represents 20% of all hospital discharges and is collected from over 7 million annual hospital discharges. For each patient record, sociodemographic characteristics including age, sex, race, and insurance status were collected. In addition, each patient record included diagnostic and procedure codes, coded using the *International Classification of Disease, Ninth Revision, Clinical Manifestation* (ICD-9-CM) lexicon. Patient comorbidity was defined according to the Charlson comorbidity index (CCI), categorizing patients into three groups as per their CCI score; CCI $\leq$2, CCI = 3, and CCI $\geq$4. Patient socioeconomic status was determined using predefined income quartiles as specified within the HCUP-NIS which are estimated using the median household income of residents within the patient's ZIP code.[7] Hospital level characteristics recorded within the data set included number of hospital beds, hospital location, and hospital teaching status. Hospitals were categorized as either small, medium, or large using the predefined NIS region-specific hospital bed size classification.[8] As all data collected within the NIS are deidentified and compliant with the Health Insurance Portability and Accountability Act of 1996, this study was deemed exempt from review by the Johns Hopkins University Institutional Review Board.

Patients undergoing a colon or rectal surgery were identified using relevant ICD-9-CM procedure codes (Supplemental Table 1). Only patients with a primary diagnosis of colon or rectal cancer were included in this study (Supplemental Table 2). Patients were then categorized into one of three groups according to the operative approach: open surgery, laparoscopic surgery, and robotic surgery. Patients were categorized on an "intention-to-treat" basis whereby patients who underwent an initial laparoscopic or robotic operation, which was converted to an open surgery, were categorized within the laparoscopic or robotic cohort, respectively. Exclusion criteria included emergency operations and records with missing information for age, sex, insurance status, hospital bed size, income quartile by ZIP code, hospital location, and hospital teaching status.

Primary outcomes: LOS, postoperative complications, and total costs

The primary outcomes evaluated were LOS, development of a postoperative complication, and total inpatient hospital costs. LOS was calculated from the date of index admission to the date of index discharge. For ease of analysis, LOS was dichotomized as an "extended" *versus* an "expected" LOS using the 75th percentile for the LOS (8 d).[9,10] Similarly, additional sensitivity analyses were also performed using the value for LOS representing the 90th percentile (12 d). Postoperative morbidity was defined by the development of one or more postoperative complications identified using previously validated ICD-9-CM diagnosis codes (Supplemental Table 3). Specific postoperative complications included urinary tract infection, myocardial infarction, respiratory failure, pneumonia, venous thromboembolism, systemic inflammatory response syndrome, surgical site infection (SSI), acute renal failure, and cellulitis.[11] For each patient record, the NIS collects total charges submitted, which represent the total amount charged by hospitals for an inpatient episode of care and therefore include perioperative and hospital charges.[12] Using hospital-specific cost-to-charge ratios, total costs for each episode of care were estimated. Cost-to-charge ratios represent the ratio between the total charges submitted and the actual costs of care and are calculated by the Agency for Healthcare Research and Quality using data collected under