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Robotic *versus* standard laparoscopic elective colectomy: where are the benefits?

Audrey S. Kulaylat, MD,[a] *Katelin A. Mirkin, MD,*[a] *Frances J. Puleo, MD,*[a] *Christopher S. Hollenbeak, PhD,*[a,b] *and Evangelos Messaris, MD*[a,*]

[a] *Department of Surgery, The Pennsylvania State University, College of Medicine, Hershey, Pennsylvania*
[b] *Department of Public Health Sciences, The Pennsylvania State University, College of Medicine, Hershey, Pennsylvania*

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ABSTRACT

Background: Robotic approaches for colorectal surgery have been growing in popularity as experience with the new technology develops, but are frequently associated with longer operative time. It is unclear whether prolonged operative duration in robotic cases translates to increased morbidity. This study aims to compare the outcomes of non-emergent laparoscopic and robotic colon resections.

Methods: Patients undergoing non-emergent laparoscopic (LC) or robotic (RC) colon resections were identified in National Surgical Quality Improvement Project (2013-2015). Patients were matched 1:1 between cohorts using propensity score matching. To account for the prolonged operative time associated with robotic cases, operative times were stratified into approach-specific (LC or RC) tertiles (low, medium, and high) as covariates in the matching algorithm.

Results: RC increased significantly over time and had lower conversion rates (6.0% among RC versus 11.5% among LC, $P < 0.001$). RC cases were longer (226 min versus 178 min, $P < 0.001$). Unadjusted complication rates were higher in the LC cohort (17.5% versus 15.2%, $P < 0.001$). After propensity score matching, RC was not associated with a significant difference in postoperative morbidity (15.2% among RC versus 15.9% among LC, $P = 0.434$). The robotic approach was associated with a one-half day shorter length of stay (4.6 d versus 5.2 d, $P < 0.001$), but similar 30-day readmission rates (8.9% versus 8.3%, $P = 0.368$).

Conclusions: After controlling for operative duration and patient covariates, RC was associated with similar rates of postoperative morbidity, but decreased conversion rates and shorter length of stay. Further studies examining costs are needed to evaluate whether these benefits offset the increased costs associated with robotic approaches.

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Introduction

Over the past few decades, minimally invasive approaches for colon resections have emerged and may soon surpass open procedures as the dominant approach for elective colorectal surgery.[1] Robotic-assisted minimally invasive surgeries have garnered substantial attention since its approval in 2000,[2,3] particularly within the fields of gynecologic and urologic surgery, with a mounting opinion that the robotic platform offers improved accessibility in the pelvis.[4,5] Other technical benefits

* *Corresponding author*. Department of Surgery, The Pennsylvania State University, College of Medicine, 500 University Drive, P.O. Box 850, H137, Hershey, PA 17033. Tel.: +1 717 531-5164; fax: +1 717 531-0646.
E-mail address: emessaris@pennstatehealth.psu.edu (E. Messaris).
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associated with robotic approaches include greater instrument precision and fine motion scaling, three-dimensional visualization, and more stable camera platform.[4] These benefits often occur at the expense of prolonged setup time and increased hospital costs, however, which may temper the enthusiasm for this emerging technology.[2]

Although the evidence comparing the clinical outcomes of laparoscopic and robotic colon resections is conflicting,[4-15] it has been suggested that most patients elect to pursue the newer technology when given an option.[4] Therefore, it is necessary for surgeons to continue assessing this new modality as experience with the new platform grows, to fully quantify the risks and benefits to patients seeking minimally invasive options. Large, prospective studies directly comparing the two approaches are currently limited, and even these may be subject to bias: one study initially randomized patients to either robotic or laparoscopic approaches, but later abandoned randomization because it was felt that the laparoscopic approach was disadvantageous in the cases with low mesorectal dissections.[5] While this finding was useful in itself, occurrences such as these propagate the challenges in comparing the two modalities directly.

To attenuate some of the selection bias associated with retrospectively designed studies, we utilized propensity score matching to match patients on preoperative characteristics, disease types, and operative details in patients undergoing either laparoscopic or robotic colon resections. Within the American College of Surgeons National Surgical Quality Improvement Project (ACS NSQIP) database, colectomy-specific variables became available since 2013, allowing for the identification of operative approach. Using this data, the aim of this study was to compare postoperative morbidity, conversion rates, postoperative length of stay (LOS), and 30-day readmission rates in similarly matched cohorts of patients undergoing elective colectomies.

Materials and methods

Data

Patients undergoing minimally invasive colon resections were identified in the ACS NSQIP Participant Use File and Targeted Colectomy Database from 2013 to 2015. Current Procedural Terminology (CPT) codes were used to identify segmental resections (44140, 44141, 44143, 44144, 44160, 44204, 44205, and 44206), total abdominal colectomies (44150, 44151, and 44210), and resections involving the rectum (44145, 44146, 44147, 44207, and 44208). Included within each cohort were patients who underwent minimally invasive procedures with open assistance and those with unplanned conversion to open procedures. Patients undergoing emergent resections or those with documented sepsis before surgery were excluded to isolate the sample to elective resections. ACS NSQIP and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors. Per institutional policies, this study was deemed exempt from Institutional Review Board review.

Covariates and outcomes

Demographic data used as covariates for analysis included patient age (stratified by groups of 18-49, 50-59, 60-69, and $\geq$70 y), sex, and a body mass index of 30 kg/m^2 or above. Comorbidities used in multivariable analyses included pulmonary (presence of dyspnea, history of chronic obstructive pulmonary disease, or need for ventilation), cardiac (history of congestive heart failure or hypertension), hepatic (presence of ascites), renal (presence of renal failure or need for dialysis), and diabetes. Other conditions used in the analyses included preoperative weight loss, preoperative steroid use, functional status, advanced American Society of Anesthesiology class of three or above, wound classification, hypoalbuminemia, use of mechanical bowel preparation, and smoking history. Receipt of a stoma during the index procedure was identified through either a primary CPT code (44141, 44143, 44144, 44146, 44150, 44151, 44206, 44208, and 44210) or a secondary CPT code (44310). The indication for colon resection was also identified within the database.

Primary outcomes of interest included 30-day postoperative morbidity, defined as the occurrence of any of the standard NSQIP complications (including anastomotic leaks); secondary outcomes included rates of conversion to open procedures, operative duration, postoperative LOS, and 30-day readmission rates.

Statistical analysis

To compare baseline patient and disease characteristics between the robotic (RC) and laparoscopic (LC) colon resection cohorts, Chi-squared and Student's *t* tests were used to compare binary/categorical and continuous variables, respectively. Cases performed robotically or laparoscopically were then divided into tertiles of operative duration (short, medium, and long), based on the tertiles specific for that type of procedure (segmental colectomy, total colectomy, or procedures involving rectal resections) (Table 1). After stratifying patients by both approach (RC versus LC) and procedural duration (short, medium, or long), propensity score matching was performed to select two cohorts of patients who underwent different approaches with similar comorbidity profiles, underlying diseases, procedural duration tertiles, and resection types. In this manner, the outcomes of the "shortest" robotic cases were compared with those of the "shortest" laparoscopic cases, and so on. The psmatch2 routine in STATA was utilized to perform a 1:1 match of patients undergoing LC or RC, without replacement, using a nearest-neighbor approach with caliper restrictions.[16] To account for uncertainty at both the matching and modeling steps, a bootstrapping algorithm with 500 replicates was used to generate confidence intervals for the propensity score results. Values for the average effect of treatment on the treated are presented to estimate the differences in outcomes for patients intended to undergo either robotic or laparoscopic colectomy. All statistical analyses were performed using Stata statistical software, version 12.1 (StataCorp, College Station, TX). Statistical significance was set at $P < 0.05$.

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