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# Propensity-Matched Analysis of Sigmoidectomies for Diverticular Disease

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## ABSTRACT

**Background and Objectives:** The role for the robotic-assisted approach as a minimally invasive alternative to open colorectal surgery is in the evaluation phase. While the benefits of minimally invasive colorectal surgery when compared to the open approach have been clearly demonstrated, the adoption of laparoscopy has been limited. The purpose of this study was to evaluate clinical outcomes, hospital and payer characteristics of patients undergoing robotic-assisted, laparoscopic, and open elective sigmoidectomy for diverticular disease in the United States.

**Methods:** This is a retrospective propensity score–matched analysis. The Premier Healthcare Database was queried for patients with diverticular disease. Patients with diverticular disease who underwent robotic-assisted, laparoscopic, and open sigmoidectomy for diverticular disease from January 2013 through September 2015 were included. Propensity-score matching (1:1) facilitated comparison of robotic-assisted versus open approach and robotic-assisted versus laparoscopic approach. Peri-operative outcomes were assessed for both comparisons.

**Results:** There were several outcomes advantages for the robotic-assisted approach when compared to laparoscopic and open sigmoidectomy for diverticular disease that included significantly fewer conversions to open ($P = .0002$), shorter hospital length of stay, fewer postoperative complications—ileus, wound complications, and acute renal failure—and more patients discharged directly to home.

**Conclusions:** The robotic-assisted minimally invasive approach to elective sigmoidectomy for diverticular disease results in favorable intra-operative and postoperative outcomes when compared to laparoscopic and open approaches.

**Key Words:** Diverticulosis, Diverticulitis, Sigmoidectomy, Robotic-assisted, Laparoscopy.

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## INTRODUCTION

Colonic diverticular disease describes a spectrum of conditions ranging from asymptomatic diverticulosis to symptomatic acute diverticulitis to chronic inflammation of the colon resulting in recurrent clinical episodes, obstruction, or fistulas. Characterized by the development of false diverticula or herniation of the mucosa and submucosa through weakened areas of the colonic wall, diverticular disease is estimated to be present in up to 60% of patients by the age of 60 years, and the incidence continues to increase with age.[1]

Approximately 10%–25% of patients with diverticulosis will develop an acute episode of diverticulitis, with 15% of these patients requiring urgent operative management.[2] In the setting of colonic perforation and sepsis, emergency surgery is most commonly performed by conventional open techniques. It is estimated that more than 85,000 elective sigmoid resections are performed annually in the United States, with close to 88% managed with an open approach.[3]

Surgery for diverticular disease is technically challenging because of the inflammatory nature of the condition, which may result in thickened bowel wall and mesentery and dense adherence to the bladder, pelvic side-wall, and retroperitoneum. Though the advantages of minimally invasive surgery for colorectal resection that include shorter hospital length of stay, less postoperative pain, and better cosmesis have been clearly demonstrated, minimally invasive surgery has not been widely adopted for the surgical treatment of diverticular disease.[4] This slow adoption has been partly attributed to the limitations in laparoscopic equipment available to meet the challenges of complicated diverticulitis. Robotic-assisted surgery (RS) for colorectal disease has significantly increased because of technological advantages that include 3D visualization, a stable camera platform, wristed instruments, and immunofluorescent capabilities.[5] While feasibility and safety of robotic-assisted sigmoidectomy has been demonstrated, the clinical advantages when compared to laparoscopic surgery (LS) and traditional open surgery (OS) are still under study.[6,7]

The goal of this study was to use the real-world hospital data to test the hypothesis that patients who have undergone elective robotic-assisted sigmoidectomy have better perioperative outcomes compared to patients who have undergone elective LS and OS sigmoidectomy for diverticular disease.

## MATERIALS AND METHODS

### Data Sources and Study Sample

This is a retrospective review of the Premier Healthcare Database that includes administrative data for payers from over 700 community and academic hospitals in various geographic locations and represents 20% of all inpatient hospital discharges in the United States.[8] The database is aggregated, deidentified, and HIPAA-compliant, therefore no institutional review board approval was required. Cases that met the following criteria were included: age ≥18 years, inpatient elective sigmoidectomy for diverticular disease (ICD-9-CM diagnosis codes: 562.10, 562.11, 562.12, 562.13) performed via RS, LS, and OS approaches from January 1, 2013 through September 30, 2015. Emergency cases were excluded, as were operative times less than or equal to 1 hour and greater than 8 hour, and hospital length of stay less than 2 d and greater than 30 days. Physician specialty was limited to colorectal and general surgery. International Classification of Diseases, ninth Revision, Clinical Modification (ICD-9-CM) procedure codes 17.36 and 45.76 were used to identify different surgical approaches. The identification of robotic-assisted procedures was performed by searching for the presence of robotic-assistance codes (17.4x). In addition, Premier charge Masterfile was utilized to identify the different approaches.[9] ICD-9-CM codes were used to identify conversion to OS (V64.41) and intraoperative complications and postoperative complications up to 30 days.

Analyzed data included baseline patient characteristics such as age, gender, race, Charlson Comorbidity Index[10]; hospital characteristics that include census region, urban or rural location, teaching status, and number of beds; and perioperative outcomes that include operating room time, conversion to open, blood transfusion, discharge status, hospital length of stay, and complications. Complications were assessed at various time points: intraoperative period, postoperative to discharge and 30 days after surgery.

### Statistical Methods

To mitigate the potential for selection bias across surgical approaches, propensity-score matching was performed using the nearest neighbor approach.[11] Two different comparisons were performed: RS versus OS and RS versus LS. Case matching was performed one-to-one with caliper size of 0.01. RS versus OS matching resulted in 1049 patients in each matched cohort and RS versus LS with a sample of 1209 patients in each matched cohort. Eleven covariates were used for the propensity matching. These included patient characteristics of age, gender, race, Charlson Comorbidity Index, payer type, and hospital characteristics of census region, number of beds, hospital teaching status, hospital location, physician specialty, and the year of sigmoidectomy. Univariate analysis was performed before and after propensity score–matching to compare RS, OS, and LS using the Wilcoxon rank-sum test for continuous variables and $\chi^2$ test or Fisher's exact test for categorical variables. Two-sided $P$ values $<.05$ were considered statistically significant. Sample selection and creation of analytic variables were performed using Instant Health Data platform (Boston Health Economics, Inc., Waltham, Masachusetts, USA). Statistical analyses were undertaken with R-statistical software, version 3.2.1, R Foundation for Statistical Computing, Vienna, Austria.

## RESULTS

A total of 40,548 sigmoidectomy patients were identified from the Premier Healthcare Database during the study period. Of these, 12,652 patients met inclusion criteria for this analysis (**Figure 1**). The distribution of the surgical approaches consisted of 10% RS, 29% OS, and 61% LS. Unmatched patient characteristics are summarized in **Table 1** and show statistically significant differences in age, race, and Charlson Comorbidity Index between RS and OS groups. There were no significant differences in patient characteristics between RS and LS groups. Unmatched payer and hospital characteristics are demonstrated in **Table 2**. There were statistically significant differences between RS and OS groups with respect to payer type, hospital characteristics of census region, location, teaching status, number of beds, physician specialty, and year of sigmoidectomy. All of these characteristic categories were also significantly different between unmatched RS and LS cohorts except for payer type. After propensity-score matching, there were no significant differences between RS and OS, and RS and LS cohorts, in any of the patient, payer, and hospital characteristics. Patients in both matched cohorts who underwent sigmoidectomy due to diverticular disease were more likely to be over the age of 45 years, female, and Caucasian in this dataset. Significantly more patients had commercial insurance and were cared for at hospitals that were large, community based, and located in urban settings in the South of the United States. There were significantly more sigmoidectomies done by general surgeons than colorectal surgeons.

Clinical outcomes are depicted in **Table 3**. RS had significantly longer operative times than both OS and LS groups, the former by an average of 59 minutes ($P <$ .0001) and the latter by an average of 42 minutes ($P <$ .0001). The conversion-to-open rate was significantly less for the RS group than for the LS group (7.9% vs. 12.5%, $P =$ .0002). The hospital mean length OF stay was significantly shorter for RS by 2 days when compared to OS

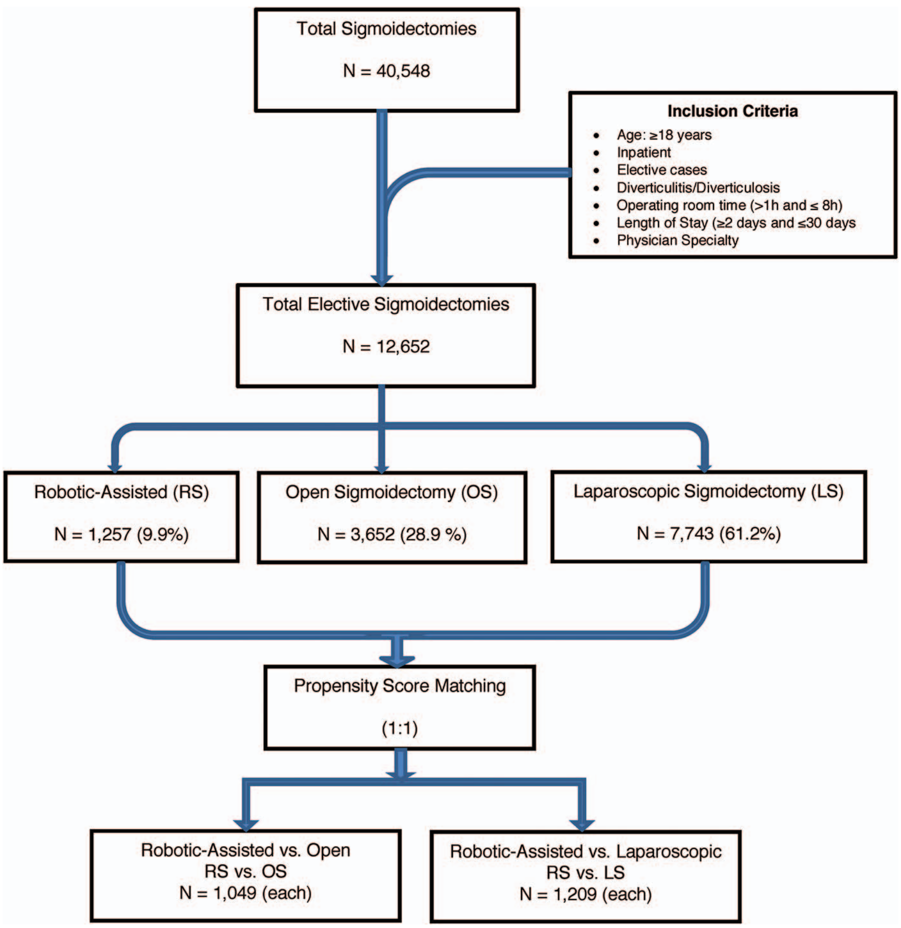


**Figure 1.** Flowchart for propensity score matching analysis.

**Table 1.**
Unmatched Patient Demographics and Baseline Characteristics

| Characteristic | Robotic-Assisted (RS) N = 1257 | Laparoscopic (LS) N = 7743 | Open (OS) N = 3652 | *P* Value RS vs OS | *P* Value RS vs LS |
|---|---|---|---|---|---|
| Age, years (mean ± SD) | 56.5 ± 12.3 | 57.0 ± 12.5 | 60.1 ± 13.0 | <.0001 | .23 |
| Age categories, n (%) | | | | <.0001 | .74 |
| 18–34 years | 49 (4.0) | 294 (3.8) | 112 (3.1) | | |
| 35–44 years | 165 (13.1) | 1003 (13.0) | 368 (10.1) | | |
| 45–64 years | 702 (55.8) | 4227 (54.6) | 1747 (47.8) | | |
| >65 years | 341 (27.1) | 2219 (28.6) | 1425 (39.0) | | |
| Gender, n (%) | | | | .12 | .79 |
| Female | 689 (54.8) | 4210 (54.4) | 2096 (57.4) | | |
| Male | 568 (45.2) | 3533 (45.6) | 1556 (42.6) | | |
| Race, n (%) | | | | .0003 | .16 |
| Black or African American | 72 (5.7) | 399 (5.1) | 221 (6.0) | | |
| White or caucasian | 1003 (79.8) | 6332 (81.8) | 2908 (79.6) | | |
| Hispanic | 13 (1.0) | 46 (0.6) | 6 (0.2) | | |
| Other | 169 (13.5) | 966 (12.5) | 517 (14.2) | | |
| Charlson Comorbidity Index (mean ± SD) | 0.3 ± 0.7 | 0.3 ± 0.7 | 0.5 ± 1.0 | <.0001 | .34 |

OS, traditional open surgery; RS, robotic-assisted surgery; SD, standard deviation of the mean.

($P < .0001$) and by 0.3 days when compared to LS ($P < .0001$). Index hospital ileostomy and colostomy rates were significantly lower for RS when compared to OS (2.3% vs. 4.4%, $P = .01$; and 1.5% vs. 8.1%, $P < .0001$, respectively), and there was no significant difference between RS and LS groups. Discharge status was significantly different between the RS and the OS groups with more patients discharged to home in RS compared to OS (98.0% vs. 94.2%) rather than to a health facility (1.6% vs. 5.4%, $P < .0001$). There was a similar trend in the RS and LS comparison with more patients discharged to home in the RS group compared to the LS group (98.2% vs. 97%) and fewer patients discharged to a health care facility (1.5% vs. 2.8%, $P = .06$), though this difference was not statistically significant. There was no significant difference in RS mortality rates when compared to LS and OS groups.

Complications in the matched cohorts are shown in **Table 4**. RS was associated with significantly lower postoperative complication rates when compared to both OS (10.6% vs. 18.1%, $P < .0001$) and LS (9.5% vs. 12.7%, $P = .02$) groups. In addition, when compared to the OS group, RS had significantly fewer complications through 30 days postoperatively (17.7% vs. 24.8%, $P < .0001$). There was no significant difference in intraoperative complications between RS and both OS and LS groups. There was also no significant difference in RS and LS with respect to 30 days (16.5% vs. 18.5%, $P = .20$) complications.

With regard to specific complications, the RS group had significantly less ileus than both OS (7.3% vs 12.8%, $P < .0001$) and LS (6.6% vs. 9.9%, $P = .004$) groups. When compared to the OS group, RS had significantly fewer wound complications (0.8% vs. 2.1%, $P = .02$), fewer wound seromas (0.3% vs. 1.1%, $P = .03$), and less acute renal failure (1.1% vs. 2.6%, $P = .02$). The RS cohort had similar rates of intraoperative bleeding compared to OS; however, OS had significantly higher intra-operative blood transfusions (2.1% vs. 0.2%, $P < .0001$). Postoperative bleeding (5.0% vs. 8.4%, $P = .002$), and postoperative transfusions (2.3% vs. 4.3%, $P = .01$;) were significantly lower for the RS cohort compared to the OS cohort. Peri-operative bleeding and transfusion rates were comparable between the RS and LS groups. There was no significant difference in the remaining complications between RS and OS groups. Except for ileus, there were no significant differences in specific complications between RS and LS groups.

## DISCUSSION

This large propensity score–matched database analysis representing 12,652 patients undergoing sigmoidectomies

**Table 2.**
Unmatched Payer and Hospital Characteristics

| Characteristic | Robotic-Assisted (RS) N = 1257 | Laparoscopic (LS) N = 7743 | Open (OS) N = 3652 | *P* Value RS vs OS | *P* Value RS vs LS |
|---|---|---|---|---|---|
| Payer, n (%) | | | | <.0001 | .24 |
| Commercial | 765 (60.9) | 4,518 (58.3) | 1,616 (44.3) | | |
| Medicaid | 68 (5.4) | 387 (5.0) | 223 (6.1) | | |
| Medicare | 360 (28.6) | 2,392 (30.9) | 1,574 (43.1) | | |
| Other | 64 (5.1) | 446 (5.8) | 239 (6.5) | | |
| Hospital | | | | | |
| Census region n (%) | | | | <.0001 | .0007 |
| Midwest | 183 (14.6) | 1,507 (19.5) | 793 (21.7) | | |
| Northeast | 313 (24.9) | 1,823 (23.5) | 522 (14.3) | | |
| South | 610 (48.5) | 3,522 (45.5) | 1,877 (51.4) | | |
| West | 151 (12.0) | 891 (11.5) | 460 (12.6) | | |
| Location, n (%) | | | | <.0001 | <.0001 |
| Urban | 1,177 (93.6) | 6,979 (90.1) | 3,094 (84.7) | | |
| Rural | 80 (6.4) | 764 (9.9) | 558 (15.3) | | |
| Teaching status, n (%) | | | | .001 | .025 |
| Academic | 520 (41.4) | 2,943 (38.0) | 1,320 (36.1) | | |
| Community | 737 (58.6) | 4,800 (62.0) | 2,332 (63.9) | | |
| Number of beds, n (%) | | | | <.0001 | <.0001 |
| 1–200 | 139 (11.1) | 1671 (21.5) | 812 (22.2) | | |
| 201–400 | 460 (36.6) | 2630 (34.0) | 1530 (41.9) | | |
| 401–600 | 337 (26.8) | 1740 (22.5) | 766 (21.0) | | |
| >600 | 321 (25.5) | 1703 (22.0) | 544 (14.9) | | |
| Physician specialty, n (%) | | | | <.0001 | <.0001 |
| Colorectal Surgery | 467 (37.2) | 1,636 (21.1) | 378 (10.4) | | |
| General Surgery | 790 (62.8) | 6,107 (78.9) | 3,274 (89.6) | | |
| Year of sigmoidectomy, n (%) | | | <.0001 | <.0001 | |
| 2013 | 390 (31.0) | 3,137 (40.5) | 1,463 (40.1) | | |
| 2014 | 459 (36.5) | 2,762 (35.7) | 1,313 (35.9) | | |
| 2015 | 408 (32.5) | 1,844 (23.8) | 876 (24.0) | | |

LS, laparoscopic surgery; OS, traditional open surgery; RS, robotic-assisted surgery.

for diverticular disease demonstrates several significant outcomes advantages for the RS approach. RS is associated with significantly shorter hospital length of stay, significantly fewer postoperative complications, and significantly less ileus than both OS and LS groups. In addition, when compared to OS, RS was associated with significantly fewer stomas and fewer discharges to a health facility other than home. When compared to LS, RS was associated with significantly fewer conversions to open. Operating times were significantly longer in the RS group when compared to both OS and LS groups.

A recent population-based study showed that the incidence of diverticular disease has increased by 50% since the year 2000, especially in patients younger than age 50 years.[12] Our study confirmed the findings of other studies that demonstrate trends in demographics for patients who present with symptomatic diverticulitis to be Caucasian,

**Table 3.**
Clinical Outcomes after Propensity Score-Matching (1:1)

| Variable | Robotic-Assisted (RS) N = 1049 | Open (OS) N = 1049 | *P* Value RS vs OS | Robotic-Assisted (RS) N = 1209 | Laparoscopic (LS) N = 1209 | *P* Value RS vs LS |
|---|---|---|---|---|---|---|
| Operating room time, minutes (mean ± SD) | 256.5 ± 75.2 | 197.6 ± 74.3 | <.0001 | 254.4 ± 74.8 | 212.2 ± 75.0 | <.0001 |
| Conversion to open, n (%) | 90 (8.6) | NA | | 95 (7.9) | 151 (12.5) | .0002 |
| Length of hospital stay, days | | | <.0001 | | | <.0001 |
| Mean ± SD | 5.5 ± 2.8 | 7.5 ± 3.9 | | 5.4 ± 2.7 | 5.7 ± 2.8 | |
| Median | 5 | 6 | | 5 | 5 | |
| Index hospital ileostomy rates, n (%) | 24 (2.3) | 46 (4.4) | 0.01 | 27 (2.2) | 25 (2.1) | .89 |
| Index hospital colostomy rates, n (%) | 16 (1.5) | 85 (8.1) | <.0001 | 17 (1.4) | 28 (2.3) | .13 |
| Discharge status, n[a] (%) | | | <.0001 | | | .06 |
| Health facility | 17 (1.6) | 57 (5.4) | | 18 (1.5) | 34 (2.8) | |
| Home | 1,027 (98.0) | 987 (94.2) | | 1,186 (98.2) | 1,173 (97.0) | |
| Deceased | 4 (0.4) | 4 (0.4) | | 4 (0.3) | 2 (0.2) | |
| Mortality[b], n (%) | | | | | | |
| Index hospital | 4 (0.4) | 4 (0.4) | 1.00 | 4 (0.3) | 2 (0.2) | .68 |
| 30-day | 4 (0.4) | 4 (0.4) | 1.00 | 4 (0.3) | 2 (0.2) | .68 |

LS, laparoscopic surgery; OS, traditional open surgery; RS, robotic-assisted surgery; SD, standard deviation of the mean.
[a]Sample size is 1048 for both groups in RS vs. OS-matched cohort and 1208 for RS group in the RS vs. LS-matched cohort.
[b]Mortality rate was measured from admission to discharge ("Index hospital") and admission to 30 days ("30-day").

female, and 45 years of age or older. Similar to these previous studies, we were also unable to determine the reason for this demographic profile. Many of the sigmoidectomies for diverticular disease in our study were for patients in smaller urban hospitals and hospitals in the South. Patients in the RS and LS groups were more likely to have commercial insurance than the OS group. It is difficult to determine whether these findings are generalizable to other patient populations or if this profile is a limitation of the composition of this database.

Consistent with multiple prior studies, we found RS was associated with a significantly longer mean operating room time compared to both LS (+42 minutes) and OS (+59 minutes).[6,13–15] Increased operating room time in RS is likely multifactorial. Surgeons early in their learning curve, patient positioning, docking, instrument exchange, troubleshooting, and quality of bedside assistant have been postulated as contributors to increased operating room time.[16,17] The utilization of a dedicated RS team has been associated with decreased preoperative setup times, as well as overall length of surgery.[18] Lasser and colleagues[18] demonstrated that operating room staff consistency decreased overall operating room times in 10-case increments through enhanced efficiency prior to the incision. The longer operating times reported in these studies do not appear to be associated with worse outcomes.[13,15,19]

RS was associated with a decreased incidence of conversion to open when compared to LS, and this is consistent with some other studies.[5,6,19–21] Feinberg et al[19] found on multivariate analysis that RS was protective for unplanned conversion to open in colorectal resections. Further studies are warranted to understand the risk factors for conversion to open.

A unique outcome of our study was that RS was associated with significantly lower ileus rates than OS and LS. While most previous studies have shown no difference in postoperative ileus between RS and LS groups, there are exceptions that demonstrate significantly less ileus in the RS group.[19,22–24] The robotic-assisted approach offers technological advantages for more complex tasks often required

**Table 4.**
Complications after Propensity Score-Matching (1:1)

| Complications | Robotic-Assisted (RS) N = 1049 | Open (OS) N = 1049 | *P* Value RS vs OS | Robotic-Assisted (RS) N = 1209 | Laparoscopic (LS) N = 1209 | *P* Value RS vs LS |
|---|---|---|---|---|---|---|
| Complications, n (%) | | | | | | |
| Intraoperative | 37 (3.5) | 34 (3.2) | .81 | 41 (3.4) | 29 (2.4) | .18 |
| Postoperative | 111 (10.6) | 190 (18.1) | <.0001 | 115 (9.5) | 153 (12.7) | .02 |
| 30-day | 186 (17.7) | 260 (24.8) | <.0001 | 199 (16.5) | 224 (18.5) | .20 |
| Bleeding and transfusion n (%) | | | | | | |
| Intraoperative bleeding | 12 (1.1) | 14 (1.3) | .84 | 15 (1.2) | 11 (0.9) | .55 |
| Intraoperative transfusion | 2 (0.2) | 22 (2.1) | <.0001 | 2 (0.2) | 4 (0.3) | .69 |
| Postoperative bleeding[a] | 52 (5.0) | 88 (8.4) | .002 | 57 (4.7) | 56 (4.6) | 1.00 |
| Postoperative transfusion[a] | 24 (2.3) | 45 (4.3) | .01 | 24 (2.0) | 23 (1.9) | 1.00 |
| Gastrointestinal, n (%)[b] | | | | | | |
| Ileus | 77 (7.3) | 134 (12.8) | <.0001 | 80 (6.6) | 120 (9.9) | .004 |
| Fistula | 4 (0.4) | 4 (0.4) | 1.00 | 4 (0.3) | 3 (0.2) | 1.00 |
| Intestinal obstruction | 6 (0.6) | 11 (1.0) | .33 | 6 (0.5) | 5 (0.4) | 1.00 |
| Clostridium difficile colitis | 7 (0.7) | 10 (1.0) | .63 | 10 (0.8) | 10 (0.8) | 1.00 |
| Abdominal wall hematoma | 4 (0.4) | 11 (1.0) | .12 | 5 (0.4) | 2 (0.2) | .45 |
| Wound, n (%)[b] | | | | | | |
| Wound complications | 8 (0.8) | 22 (2.1) | .02 | 7 (0.6) | 13 (1.1) | .26 |
| Wound dehiscence | 5 (0.5) | 11 (1.0) | .21 | 5 (0.4) | 6 (0.5) | 1.00 |
| Seroma | 3 (0.3) | 12 (1.1) | .03 | 2 (0.2) | 7 (0.6) | .18 |
| Superficial SSI, n (%)[b] | 49 (4.7) | 51 (4.9) | .92 | 53 (4.4) | 51 (4.2) | .92 |
| Organ space SSI, n (%)[b] | 62 (5.9) | 73 (7.0) | .37 | 69 (5.7) | 67 (5.5) | .93 |
| Other, n (%)[b] | | | | | | |
| Pneumonia | 13 (1.2) | 19 (1.8) | .37 | 13 (1.1) | 15 (1.2) | .85 |
| Deep venous thrombosis | 4 (0.4) | 9 (0.9) | .27 | 5 (0.4) | 4 (0.3) | 1.00 |
| Urinary tract infection | 10 (1.0) | 20 (1.9) | .10 | 14 (1.2) | 16 (1.3) | .85 |
| Acute renal failure | 12 (1.1) | 27 (2.6) | .02 | 18 (1.5) | 24 (2.0) | .44 |

LS, laparoscopic surgery; OS, traditional open surgery; RS, robotic-assisted surgery; SD, standard deviation of the mean; SSI, surgical site infection.

[a]Postoperative bleeding and transfusions that occurred through discharge.

[b]Gastrointestinal, wound, and other complications included complications occurring from admission to 30 days.

during sigmoidectomies for diverticular disease, such as splenic flexure takedown and dissection of a complicated phlegmon adherent to the pelvic side-wall and retroperitoneum. It is possible that performing complicated segments of the procedure with a less traumatic "minimal-touch" technique may result in decreased ileus rates, but the inconsistencies in these findings warrants further study.

Hospital length of stay was significantly decreased in the RS group compared to both LS and OS groups. We recognize that the statistically significant 0.3-day difference between the RS and LS groups may not be clinically significant. Other studies report inconsistent results with respect to this outcome variable. A Michigan Surgical Quality Collaborative risk-adjusted database query comparing LS to RS for colorectal resections also demonstrated a shorter length of stay for both colectomy and proctectomy.[6] Another large health system database analysis of 3248 laparoscopic and 421 robotic-assisted colorectal resections revealed a significantly shorter length of stay for the robotic-assisted approach.[13] In contrast, multiple other authors have reported no significant difference in length of stay when comparing RS and LS.[5,19,20,24,25] The reason for the different outcomes among studies is not clear, but may be related to variations in provider care processes such as Enhanced Recovery Pathways among groups, a variable unable to be evaluated with the data source in our study.

There are several limitations in this study that includes those inherent to a retrospective study design. Our study is limited by reliance upon accurate reporting of intraoperative and postoperative details, surgeon experience with operative approaches, and surgeon bias for a surgical approach. We used a propensity score–matched analysis as a surrogate method to control for these limitations. As with any large administrative database, potential coding errors could not be avoided, but it would likely affect all the surgical approaches equally. The strength of this study is that it provides a large sample size composed of many hospitals of heterogeneous composition and surgeons of varying skill sets, and is therefore generalizable.

The complexity of complicated diverticulitis is not always predictable by clinical presentation and radiographic imaging. Continued advancements in minimally invasive technology are warranted to help reduce complications and improve outcomes for this vexing disease. Further studies to better characterize the role of minimally invasive surgical options are warranted.

## CONCLUSION

This large national database comparison of robotic-assisted, laparoscopic, and open approaches for diverticular disease shows several outcomes advantages for robotic-assisted sigmoidectomy that include decreased conversion to open, decreased postoperative complications and ileus rates, and decreased hospital length of stay at the expense of increased operating times. These data warrant consideration for surgeons choosing between minimally invasive options for diverticular disease.

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