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Real-world impact of laparoscopic surgery for rectal cancer: a population-based analysis

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ABSTRACT

Background Randomized trials have demonstrated equivalent oncologic outcomes and decreased morbidity in patients with rectal cancer who undergo laparoscopic surgery (LapSx) compared with open surgery (OpenSx). The objective of the present study was to compare short-term outcomes after LapSx and OpenSx in a real-world setting.

Methods A national discharge abstract database was used to identify all patients who underwent rectal cancer resection in Canada (excluding Quebec) from April 2004 through March 2015. Short-term outcomes examined included same-admission mortality and length of stay (LOS).

Results Of 28,455 patients, 82.4% underwent OpenSx, and 17.6%, LapSx. The use of LapSx increased to 34% in 2014 from 5.9% in 2004 ($p < 0.0001$). Same-admission mortality was lower among patients undergoing LapSx than among those undergoing OpenSx (1.08% and 1.95% respectively, $p < 0.0001$). On multivariable analysis, the odds of same-admission mortality with LapSx was 36% lower than that with OpenSx (odds ratio: 0.64; $p = 0.003$). Median LOS was shorter after LapSx than after OpenSx (5 days and 8 days respectively, $p = 0.0001$). The strong association of LapSx with shorter LOS was maintained on multivariable analysis controlling for patient, surgeon, and hospital factors.

Conclusions For patients with rectal cancer, shorter LOS and decreased same-admission mortality are associated with the use of LapSx compared with OpenSx.

Key Words Colorectal cancer, laparoscopy, mortality, length of stay

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INTRODUCTION

Colorectal cancer is one of the most common malignancies, affecting approximately 6% of the Canadian population[1]. Recently, as with other surgical procedures, the use of laparoscopic surgery (LapSx) for rectal cancer has attracted interest. Several multicentre randomized controlled trials (RCTs) have established noninferior rates of disease-free survival, overall survival, and local recurrence in patients undergoing LapSx for rectal cancer compared with patients undergoing open surgery (OpenSx)[2–7]. Although two recent RCTs (ALaCaRT[8] and ACOSOG Z6051[9]) showed lower rates of "pathologically complete excision" in patients undergoing LapSx compared with OpenSx, resulting in some concern about the widespread adoption of LapSx for rectal cancer, the recent publication of 2-year follow-up data failed to identify a difference between LapSx and OpenSx in terms of disease-free survival and local recurrence[10].

Randomized controlled trials have consistently demonstrated decreased morbidity, including less blood loss, less narcotic use, and quicker return of bowel function in patients undergoing LapSx[11–13]. Although trials have failed to demonstrate a statistically significant difference in length-of-stay (LOS) or same-admission mortality, trends favouring LapSx were observed.

Despite some controversy in the literature about the oncologic safety of LapSx for rectal cancer, an increase in its use has been noted in several countries[14–16]. Although LapSx has clearly been implemented as a standard of care in many settings, population-based results of LapSx use are

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lacking, and it remains unclear whether the benefits of LapSx seen in randomized trials have been realized in the "real world." The purpose of the present study was to compare short-term outcomes in all patients undergoing LapSx and OpenSx for rectal cancer in Canada.

METHODS

Data Source

This population-based analysis used data obtained from the nationwide Discharge Abstract Database (DAD) held by the Canadian Institute for Health Information. The DAD is a national database that captures administrative, clinical, and demographic information about hospital separations (admissions, discharges, deaths, sign-outs, and transfers). All provinces, except Quebec, are required to report those data to the DAD. Since 2004–2005, all diagnostic and therapeutic records in the DAD have been reported using codes from the *International Statistical Classification of Diseases and Related Health Problems,* Tenth Revision, Canada (ICD-10-CA) and the *Canadian Classification of Health Interventions.*

Patient Population

All adult patients with a Canadian postal code who underwent radical rectal resection for rectal cancer between 1 April 2004 and 31 March 2015 were included in the analysis. Diagnostic codes for rectal cancer included the ICD-10-CA codes C19 (malignant neoplasm of the rectosigmoid junction) and C20 (malignant neoplasm of the rectum). Table I lists procedural codes used to identify radical rectal resections; any procedures performed laparoscopically, laparoscopically assisted, laparoscopically hand-assisted, or begun laparoscopically but subsequently converted to open were categorized as LapSx. The relevant diagnostic and procedural codes had previously been validated by ICES[17].

In an attempt to capture only patients who would be eligible for either LapSx or OpenSx, patients who were pregnant, who underwent emergency surgery, or who underwent complex multivisceral resection were excluded. Patients were assigned to the fiscal year of admission for rectal cancer resection and were categorized into the applicable group: LapSx or OpenSx.

Outcomes and Covariates

We evaluated differences in same-admission mortality and LOS in individuals undergoing LapSx and OpenSx. "Same-admission mortality" was defined as death during the admission in which the rectal cancer resection was performed[11]. The LOS was measured from the date of rectal surgery, and the LOS analyses excluded patients who died in hospital.

Patient-level covariates included age, sex, and score on the Charlson comorbidity index (CCI), a comorbidity measure that has been validated in a wide range of patient populations, including patients with colorectal cancer[18–20]. In Canada, the reported in-hospital mortality for patients with a CCI of 0 is 1.5%; it is 28.8% for patients with a score of 6 or more[21]. System-level variables included surgeon and hospital volume, sphincter preservation, province, and year.

It has been well established in the literature that high surgeon volume is associated with improved outcomes in patients with rectal cancer[22–26]; however, the definition of "high-volume" is variable. In Canada, the relationship between surgeon volume and in-hospital mortality is linear, whereby increased surgeon volume has been associated with improved survival[27]. Our analysis tested whether that association would persist if the exposure were to be simplified into a dichotomized variable. We therefore calculated the mean annual number of rectal cancer surgeries for each hospital and surgeon, including only years in which at least 1 rectal cancer surgery was performed. Average annual volumes were dichotomized into high and low, with "high volume" being defined as a volume above the 50th percentile, consistent with prior rectal cancer volume–outcome studies[26,28]. High surgeon volume corresponded to 5 or more rectal cancer surgeries per year, and "high-volume hospitals" were those in which

TABLE I Procedure codes for radical rectal cancer resection

Procedure type	Procedure code[a]	Description
Sphincter-sparing		
Open	1.NQ.87.RD	Partial excision of rectum with colorectal anastomosis
	1.NQ.89.SF	Total excision of rectum with colo-anal anastomosis
	1.NQ.89.KZ	Total excision of rectum with transanal sphincter-sparing total mesorectal excision and colo-anal anastomosis
	1.NQ.87.TF	Partial excision of rectum without anastomosis (colostomy and closure of rectal stump)
Laparoscopic	1.NQ.87.DE	Partial excision of rectum with colorectal anastomosis
	1.NQ.87.DF	Partial excision of rectum with colorectal anastomosis
	1.NQ.89.GV	Total excision of rectum with laparoscopic abdominal approach and transanal sphincter-sparing total mesorectal excision and colo-anal anastomosis
	1.NQ.87.DX	Partial excision of rectum without anastomosis (colostomy and closure of rectal stump)
Non-sphincter-sparing		
Open	1.NQ.89.RS	Total excision of rectum with stoma formation and distal closure (anterior approach)
	1.NQ.89.LH	Total excision of rectum with stoma formation and distal closure
Laparoscopic	1.NQ.89.AB	Total excision of rectum with stoma formation and distal closure

[a] From the *Canadian Classification of Health Interventions.*

20 or more rectal cancer surgeries were performed per year. Sphincter preservation was categorized as present or absent according to procedural codes.

Statistical Analysis

Patient and system characteristics were compared between the LapSx and OpenSx groups using the Student *t*-test for continuous variables and the chi-square test for categorical variables. Univariable logistic regression was used to estimate the unadjusted association of surgical approach (LapSx, OpenSx) with patient and system characteristics and same-admission mortality. The Kruskal–Wallis test was used to compare the unadjusted LOS for patients undergoing LapSx and OpenSx, given the non-normal distribution expected for that outcome. A multivariable logistic regression model was created to estimate the association of surgical approach with same-admission mortality, and linear regression of the logarithmic transformation of LOS was performed to test the association between LapSx and LOS, controlling for patient and system variables. The use of year as a variable in multivariable analysis created a time-trend analysis within this population-based study. Founded on known and expected clinico-demographic differences in the LapSx and OpenSx cohorts, we planned *a priori* to use a forced entry technique to include in the multivariable analysis all patient and system covariates examined.

The inclusion of both rectal cancer (ICD-10-CA code C20) and rectosigmoid cancer (ICD-10-CA code C19) in our cohort was a potential source of heterogeneity such that tumours of the rectosigmoid junction are technically easier to resect than are middle and low rectal tumours. To ensure that those two patient groups were not systematically different, we ran the same-admission mortality and LOS analyses after excluding patients with rectosigmoid tumours and compared those results with the results from the entire cohort.

All statistical analyses were performed using the Stata software application (release 14: StataCorp LP, College Station, TX, U.S.A.). For statistical testing, a 1-tailed *p* value less than 0.05 was deemed statistically significant. Results of the logistic regression analysis are reported as odds ratios (ORs) with 95% confidence intervals (CIs). The study was approved by the Dalhousie University Ethics Board.

RESULTS

From April 2004 to March 2015, 38,010 patients were diagnosed with rectal cancer and underwent radical surgical resection. Of those patients, 28,455 met the inclusion and exclusion criteria (Figure 1) and formed the study cohort. Overall, 5002 patients underwent LapSx (17.6%), and 23,453 patients underwent OpenSx (82.4%). The proportional use of LapSx increased to 34.0% in 2014 from 5.9% in 2004. The LapSx and OpenSx groups showed significant differences in patient demographics and system-related factors (Table II). Patients undergoing LapSx were more likely to be female and younger, and to have fewer comorbidities than patients undergoing OpenSx. They were also more likely to be treated by a high-volume surgeon in a high-volume hospital and to undergo sphincter-sparing surgery.

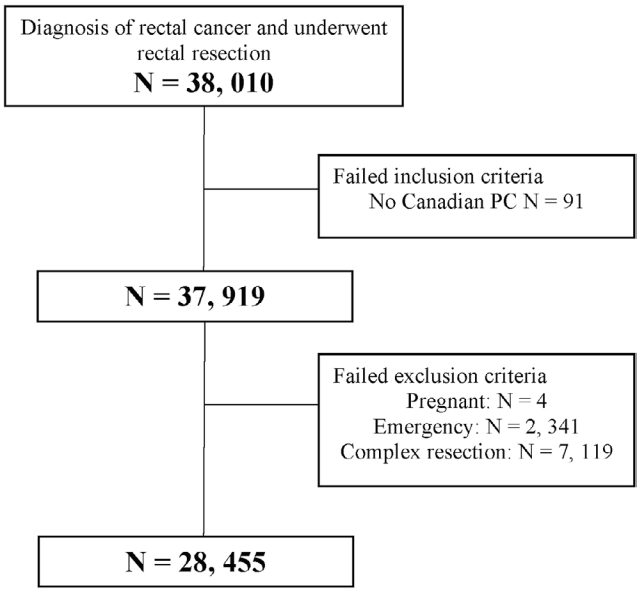

FIGURE 1 Flow chart demonstrating the selection of a cohort of patients who underwent rectal cancer surgery from April 2004 to March 2015 in Canada, excluding Quebec. PC = postal code.

Same-Admission Mortality

The same-admission mortality rate was 1.08% for LapSx and 1.95% for OpenSx ($p < 0.0001$). On multivariable analysis, compared with OpenSx, LapSx was associated with a 36% decrease in the odds of mortality (OR: 0.64; $p = 0.004$; Table III). Age greater than 65 years, male sex, CCI score greater than 0, and low hospital volume were associated with increased odds of same-admission mortality. Year was also associated with same-admission mortality, whereby the odds of death decreased by 3% each year between 2004 and 2014. Surgeon volume, sphincter preservation, and province had no statistically significant association with same-admission mortality after rectal cancer surgery (Table III).

LOS

The median LOS was significantly shorter after LapSx (5 days) than after OpenSx (8 days, $p = 0.0001$; Table IV). The strong association of LapSx with shorter LOS was maintained on multivariable analysis, where female sex, high surgeon volume, sphincter preservation, and specific province were also associated with shorter LOS (Table IV). Conversely, age greater than 50 years, CCI score greater than 0, and high hospital volume were significant predictors of increased LOS after rectal cancer surgery.

After patients with rectosigmoid tumours (C19) were removed from the analysis, the strong association of LapSx with lower same-admission mortality and shorter LOS persisted.

DISCUSSION

This population-based study of 28,455 patients undergoing radical rectal cancer resection in Canada demonstrated an association of LapSx with lower same-admission mortality

TABLE II Patient and system demographics among patients undergoing laparoscopic and open rectal cancer surgery in Canada (excluding Quebec) from April 2004 to March 2015

Variable	Procedure type						*p* Value
	Overall		Laparoscopic		Open		
	(n)	(%)	*(n)*	(%)	*(n)*	(%)	
Patients	28,455		5,002		23,453		
Mean age (years)	66.3±11.89		65.3±12.2		66.5±11.8		<0.0001
Age group							
≤50 Years	2,750	9.7	582	11.6	2,168	9.2	
51–65 Years	10,369	36.4	1,870	37.4	8,499	36.2	
66–80 Years	11,885	41.8	1,975	39.5	9,910	42.3	
>80 Years	3,451	12.1	575	11.5	2,876	12.3	
Sex							<0.0001
Women	9,263	32.6	1,912	38.2	7,351	31.3	
Men	19,192	67.4	3,090	61.8	16,102	68.7	
Charlson comorbidity index							<0.0001
0–1	19,354	68.0	3,534	70.7	15,820	67.4	
2–5	1,870	6.6	307	6.1	1,563	6.7	
≥6	7,231	25.4	1,161	23.2	6,070	25.9	
Surgeon volume							<0.0001
Low (<5 per year)	14,282	50.2	2,241	44.8	12,041	51.3	
High (≥5 per year)	14,173	49.8	2,761	55.2	11,412	48.7	
Hospital volume							<0.0001
Low (<20 per year)	14,230	50.0	2,308	46.1	11,922	50.8	
High (≥20 per year)	14,225	50.0	2,694	53.9	11,531	49.2	
Sphincter preservation							<0.0001
No	6,959	24.5	579	11.6	6,380	27.2	
Yes	21,496	75.5	4,423	88.4	17,073	72.8	
Year of surgery							<0.0001
2004	2,539	8.9	151	3.0	2,388	10.2	
2005	2,730	9.6	217	4.3	2,513	10.7	
2006	2,593	9.1	281	5.6	2,312	9.9	
2007	2,559	9.0	344	6.9	2,215	9.4	
2008	2,591	9.1	399	7.9	2,192	9.3	
2009	2,749	9.7	439	8.8	2,310	9.9	
2010	2,558	9.0	463	9.3	2,095	8.9	
2011	2,525	8.9	556	11.1	1,969	8.4	
2012	2,611	9.2	622	12.4	1,989	8.5	
2013	2,482	8.7	673	13.5	1,809	7.7	
2014	2,518	8.9	857	17.1	1,661	7.1	
Province							<0.0001
Newfoundland and Labrador	886	3.1	27	0.5	859	3.9	
Prince Edward Island	175	0.6	18	0.4	157	0.7	
Nova Scotia	1,358	4.8	148	3.0	1,210	5.2	
New Brunswick	1,035	3.6	55	1.1	980	4.2	
Ontario	12,943	45.5	2,775	55.5	10,168	43.3	
Manitoba	1,497	5.3	214	4.3	1,283	5.5	
Saskatchewan	1,250	4.4	136	2.7	1,114	4.8	
Alberta	3,519	12.4	470	9.4	3,049	13.0	
British Columbia	5,792	20.4	1,159	23.1	4,633	19.8	

and shorter LOS (as compared with OpenSx) over a period that saw a substantial rise in the use of LapSx (to 34% in 2014 from 5.9% in 2004). Our study outlines the early experience of Canadian surgeons using LapSx for rectal cancer and suggests that in this "real-world setting," minimally invasive surgery was associated with improved short-term

TABLE III Multivariable logistic regression of factors associated with same-admission mortality after rectal cancer resection, 28,455 cases, Canada

Variable	Cases		Unadjusted analysis			Adjusted analysis		
	(n)	(%)	OR	*p* Value	95% CI	OR	*p* Value	95% CI
Surgical procedure								
Open	23,453	82.4	1.00					
Laparoscopic	5,002	17.6	0.55	<0.0001	0.41 to 0.73	0.64	0.003	0.47 to 0.86
Age group								
≤50 Years	2,750	9.7	1.00					
51–65 Years	10,369	36.4	1.77	0.11	0.89 to 3.58	1.65	0.16	0.82 to 3.34
66–80 Years	11,885	41.8	6.30	<0.0001	3.24 to 12.23	5.41	<0.0001	2.77 to 10.55
>80 Years	3,451	12.1	18.93	<0.0001	9.69 to 36.99	16.36	<0.0001	8.35 to 32.05
Sex								
Men	19,192	67.4	1.00					
Women	9,263	32.6	0.75	0.004	1.10 to 1.63	0.71	0.001	0.58 to 0.87
Charlson comorbidity index								
0–1	19,354	68.0	1.00					
2–5	1,870	6.6	4.62	<0.0001	3.66 to 5.82	3.30	<0.0001	2.60 to 4.18
≥6	7,231	25.4	1.66	<0.0001	1.35 to 2.03	1.67	<0.0001	1.36 to 2.05
Surgeon volume								
Low (<5 per year)	14,282	50.2	1.00					
High (≥5 per year)	14,173	49.8	0.87	0.13	0.73 to 1.04	1.12	0.28	0.91 to 1.36
Hospital volume								
Low (<20 per year)	14,230	50.0	1.00					
High (≥20 per year)	14,225	50.0	0.70	<0.0001	0.59 to 0.84	0.74	0.004	0.60 to 0.91
Sphincter preservation								
No	6,959	24.5	1.00					
Yes	21,496	75.5	0.91	0.36	0.75 to 1.11	1.06	0.58	0.86 to 1.30
Year of surgery			0.96	0.002	0.93 to 0.98	0.97	0.04	0.94 to 0.99
Province								
Newfoundland and Labrador	886	3.1	1.00					
Prince Edward Island	175	0.6	0.84	0.78	0.24 to 2.89	0.63	0.47	0.18 to 2.20
Nova Scotia	1,358	4.8	1.02	0.96	0.56 to 1.85	0.87	0.66	0.47 to 1.60
New Brunswick	1,035	3.6	1.10	0.77	0.59 to 2.04	0.93	0.82	0.49 to 1.76
Ontario	12,943	45.5	0.79	0.34	0.48 to 1.28	0.68	0.13	0.41 to 1.11
Manitoba	1,497	5.3	1.12	0.70	0.63 to 2.00	0.94	0.84	0.52 to 1.70
Saskatchewan	1,250	4.4	1.31	0.37	0.73 to 2.34	1.03	0.93	0.57 to 1.86
Alberta	3,519	12.4	0.79	0.40	0.46 to 1.36	0.77	0.35	0.44 to 1.33
British Columbia	5,792	20.4	0.92	0.73	0.55 to 1.52	0.81	0.42	0.49 to 1.35

OR = odds ratio; CI = confidence interval.

outcomes. To our knowledge, this population-based analysis is the first to look at LapSx for rectal cancer in Canada.

To date, RCTs have failed to demonstrate a statistically significant difference in short-term mortality in patients undergoing LapSx compared with OpenSx; however, nonsignificant trends of reduced mortality after LapSx were seen in the COLOR II, ALaCaRT, and U.K. Medical Research Council's CLASICC studies[2,3,8,11,13]. Similarly, a recent systematic review and meta-analysis of randomized data from 3397 patients failed to reach statistical significance in comparing 30-day mortality after LapSx and OpenSx for rectal cancer (OR: 0.81; 95% CI: 0.50 to 1.32)[6]. In our population-based analysis, we were able to detect a statistically significant reduction in same-admission mortality after LapSx (1.08% LapSx and 1.95% OpenSx, $p < 0.0001$), a relationship that persisted after controlling for age category, CCI score, sex, surgeon and hospital volume, and sphincter preservation. However, given the retrospective nature of our study, the data lack the benefit of the randomization used in RCTs, and a potential for unmeasured confounders and selection bias therefore exists.

The few population-based comparative studies of postoperative mortality after LapSx and OpenSx for colorectal disease seem to align with our findings. Dobbins *et al.*[15] used a large administrative database in Australia to study the uptake and outcomes of LapSx for colorectal cancer. Paralleling our results, they found a significant reduction in 30-day and 90-day mortality after LapSx compared with OpenSx in the rectal cancer cohort. A French series involving more than 84,500 patients with colorectal cancer demonstrated

TABLE IV Multivariable linear regression of factors associated with length of stay after rectal cancer resection, 27,943 cases, Canada

Variable	Cases		Regression type					
	(n)	(%)	Simple linear			Multiple linear		
			Coeff.	*p* Value	95% CI	Coeff.	*p* Value	95% CI
Procedure type								
Open	22,995	82.3	Reference					
Laparoscopic	4,948	17.7	−0.473	<0.0001	−0.49 to 0.45	−0.394	<0.0001	−0.41 to 0.38
Age group								
≤50 Years	2,741	9.8	Reference					
51–65 Years	10,309	36.9	0.063	<0.0001	0.04 to 0.09	0.040	0.001	0.02 to 0.06
66–80 Years	11,644	41.7	0.198	<0.0001	0.17 to 0.22	0.159	<0.0001	0.14 to 0.18
>80 Years	3,249	11.6	0.411	<0.0001	0.38 to 0.44	0.372	<0.0001	0.34 to 0.49
Sex								
Men	18,816	67.3	Reference					
Women	9,127	32.7	−0.099	<0.0001	0.08 to 0.11	−0.069	<0.0001	−0.08 to 0.06
Charlson comorbidity index								
0	19,103	68.4	Reference					
1–5	1,763	6.3	0.273	<0.0001	0.24 to 0.30	0.208	<0.0001	0.18 to 0.23
≥6	7,077	25.3	0.076	<0.0001	0.06 to 0.09	0.059	<0.0001	0.04 to 0.07
Surgeon volume								
Low (<5 per year)	14,008	50.1	Reference					
High (≥5 per year)	13,935	49.9	−0.043	<0.0001	−0.06 to 0.03	−0.026	0.001	−0.04 to 0.01
Hospital volume								
Low (<20 per year)	13,930	49.9	Reference					
High (≥20 per year)	14,013	50.1	−0.012	0.09	−0.03 to 0.01	0.022	0.004	0.01 to 0.04
Sphincter preservation								
No	6,825	24.4	Reference					
Yes	21,118	75.6	−0.272	<0.0001	−0.29 to 0.26	−0.200	<0.0001	−0.22 to −0.18
Year of surgery			−0.021	<0.0001	−0.02 to 0.02	−0.010	<0.0001	−0.01 to −0.01
Province								
Newfoundland and Labrador	868	3.1	Reference					
Prince Edward Island	172	0.6	−0.016	0.75	−0.11 to 0.08	0.012	0.80	−0.79 to 0.10
Nova Scotia	1,330	4.8	−0.134	<0.0001	−0.19 to 0.08	−0.100	<0.0001	−0.15 to −0.05
New Brunswick	1,012	3.6	0.005	0.87	−0.05 to 0.06	0.040	0.12	−0.01 to 0.09
Ontario	12,735	45.6	−0.214	<0.0001	−0.26 to 0.17	−0.128	<0.0001	−0.17 to −0.09
Manitoba	1,463	5.2	−0.019	0.46	−0.07 to 0.03	0.026	0.27	−0.02 to 0.07
Saskatchewan	1,217	4.4	−0.024	0.37	−0.08 to 0.03	−0.010	0.69	−0.06 to 0.04
Alberta	3,462	12.4	−0.114	<0.0001	−0.16 to 0.07	−0.048	0.02	−0.09 to −0.01
British Columbia	5,684	20.3	−0.201	<0.0001	−0.24 to 0.16	−0.126	<0.0001	−0.17 to −0.09

CI = confidence interval.

significantly lower mortality rates after LapSx than after OpenSx (2% LapSx and 6% OpenSx, $p < 0.0001$), a result that was maintained on multivariable analysis[29]. A similar study in England found that the unadjusted in-hospital mortality rates after LapSx and OpenSx for rectal cancer were 2.2% and 3.3% ($p = 0.043$) respectively[30].

Shorter LOS after LapSx was demonstrated in the COLOR II trial (8 days LapSx and 9 days OpenSx, $p = 0.036$), but other RCTs failed to show a statistically significant difference between the open and laparoscopic groups[8,9,12,11]. However, pooled data and meta-analyses of randomized data from those trials demonstrated a 2- to 3-day shorter LOS after LapSx, supporting the findings of our large population-based study[6,31]. Reduced LOS after LapSx is likely related to the aggregate effect of the physiologic benefits of minimally invasive surgery, including less narcotic use, less blood loss, and quicker return of bowel function[8,9,11,13,32,33]. Interestingly, the median LOS after LapSx in our study was shorter than those reported in RCTs, suggesting that, in carefully selected patients, the effect of LapSx in everyday practice might exceed that observed in the clinical trial setting[8,9,11,13,33].

Our study also demonstrated a significant association of our primary outcomes with specific patient, hospital, and system variables. Compared with younger, healthier patients, those of older age or with a higher comorbidity score had worse same-admission mortality rates and longer LOS. The association between increased CCI score and increased postoperative morbidity has previously been described[34]

and might explain increased same-admission mortality in that population. Similarly, older age has previously been described as a predictive factor for in-hospital mortality after colorectal surgery[35].

Interestingly, we found an association of high hospital volume with longer LOS. That relationship might be explained by the centralization of patients with more medically complex needs and technically challenging rectal cancers to high-volume hospitals for surgical treatment. High surgeon volume was associated with shorter LOS, a relationship that has previously been documented in population-based studies of patients undergoing rectal cancer resection[26].

Our study is strengthened by its large patient cohort, its population-based design, and an ability to examine LapSx for rectal cancer in the real-world setting. The 28,000-patient sample size powered the study to detect a small, but potentially meaningful difference in the same-admission mortality rates after LapSx and OpenSx for rectal cancer; it is possible that the nonsignificant trends observed in RCTs would have reached statistical significance had the sample sizes been larger.

But the use of administrative data lends itself to the introduction of selection bias. Although we attempted to control for important factors associated with same-admission mortality and LOS, we cannot account for confounding by other unmeasured variables. The study also cannot clarify the decision-making that went into selecting the surgical approach (LapSx or OpenSx); it can control only for several patient and system factors in a cohort of patients felt to eligible for both LapSx and OpenSx. Patients with unmeasured favourable characteristics could possibly have been more likely to undergo LapSx than OpenSx, potentially overestimating the true benefit attributable to LapSx. That consideration is supported by two findings in the study data:

- The more-favourable measured confounders (younger age, lower CCI scores) in the patients undergoing LapSx in general
- The smaller magnitude of the association of LapSx with our primary outcomes on multivariable compared with univariable analysis

Furthermore, our analysis detected a small but significant association between increasing year and lower same-admission mortality and shorter LOS. That observation further supports the potential for confounding in our analysis, because improvements in hospital and system factors might also explain a reduction in mortality and LOS over time. Examples of potentially relevant unmeasured confounders not captured in the DAD include body mass index, tumour size or location, previous abdominal surgery, increased community resources to facilitate expedited hospital discharge, and use of "enhanced recovery after surgery" protocols.

In addition, our description of "laparoscopic surgery" lacks clinical granularity, such that we are unable to subclassify cases that were completely laparoscopic, laparoscopic-assisted, converted to open, or hand-assisted. The study therefore more accurately describes the association between laparoscopically attempted surgery and short-term outcomes, and potentially suggests that, compared with OpenSx, even partial or attempted minimally invasive surgery for rectal cancer is associated with short-term benefits. Our study also does not capture patients who underwent robotic rectal surgery; however, the uptake of that surgical approach in Canada has been slow, and our data precede many of the publications supporting its use[36–39].

Finally, as a primary outcome, we chose to use same-admission mortality, which does not capture early deaths after discharge or readmission. Thus, true 30-day or 90-day mortality rates were not reported. Although studies vary in measuring mortality after rectal cancer, same-admission mortality rates have commonly been used in randomized trials[11] and population-based studies[35] alike. Although further research about differences in re-admission rates and 30- and 90-day mortality rates are important, our results suggest that the mortality benefits of LapSx might be realized as early as the initial postoperative period. The present study also does not measure other important non-oncologic short-term outcomes, including rates of re-admission and complications. Future research into those outcomes is important to further evaluate the safety of LapSx for rectal cancer in real-world populations.

CONCLUSIONS

This pan-Canadian study demonstrated that, after LapSx (compared with OpenSx), same-admission mortality is lower and LOS is shorter. Although our study is limited by the potential for confounding by variables that could influence patient selection for LapSx, the overall safety of rectal cancer surgery in Canada, in terms of short-term outcomes, has been demonstrated. Those findings are encouraging, given that the current role for LapSx in rectal cancer is under question. Collectively, the results of RCTs suggest that survival and recurrence rates are improved with high-quality surgery that achieves negative margins, regardless of surgical technique (LapSx or OpenSx). Surgeons should therefore consider patient characteristics, tumour size and location, and their own skills and experience before performing LapSx. Our results do not suggest any reason for concern, in terms of short-term outcomes, with respect to the current use of LapSx for rectal cancer in Canada.

CONFLICT OF INTEREST DISCLOSURES

We have read and understood *Current Oncology*'s policy on disclosing conflicts of interest, and we declare that we have none.

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