Original Article

Outcomes After Rectal Cancer Surgery: A Population-Based Study Using Quality Indicators

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ABSTRACT

Quality indicators are increasingly being used to measure the safety of cancer treatments. We examined factors associated with poorer outcomes after major resection for rectal cancer over time. We linked population-based cancer registry and cancer-related procedure data for rectal cancer cases over a 15-year period. Multivariable logistic regression models were used to examine factors associated with 30- and 90-day postoperative mortality, and overall survival (OS) was estimated using the Kaplan–Meier survival function. The study included 9,222 patients who had major resection for invasive rectal cancer. Thirty-day and 90-day mortality were 2.1% and 3.8%, respectively. Risk of 30-day mortality was elevated in older patients ($p < .001$); patients with ≥2 comorbidities ($p < .001$); and those admitted as an emergency ($p < .001$). An approximate 45% reduction in 30-day mortality ($p = .01$) was observed over time. Two-year OS was 81.5%, again with significant improvements observed over time ($p < .001$). No significant association was observed between hospital volume and mortality or 2-year survival. A reduction in rates of postoperative mortality and improved 2-year OS were observed over time. Quality indicators are a valuable tool to monitor clinical outcomes over time and as a means of improving clinical care for all patients.

Keywords: rectal cancer, patient outcomes, quality indicators, population-based

Introduction

There is growing interest in the use of quality indicators (QIs) that provide information on safety and quality of cancer treatments.[1,2] Several groups have developed quality assessment tools to examine outcomes after cancer surgery.[3-5]

For the most part, surgery is the mainstay of cancer treatments, and for some cancer sites, surgical procedures can be more complex, such as that for rectal cancer.[6] Centralization of some complex cancer surgical procedures has been recommended across several jurisdictions.[7-9] These recommendations have followed from studies showing complex surgical procedures, when conducted in a high-volume hospital, results in improved patient outcomes.[10,11] Although some studies have also shown both high-volume hospital and high-volume surgeon are associated with better outcomes after surgery for rectal cancer,[6,12,13] others report no association between hospital volume and postoperative mortality, survival, or recurrence.[14,15] With improvements in surgical techniques and patient selection, 30-day mortality is now very low, and it has been suggested that 90-day mortality (in conjunction with 30-day mortality) should also be reported.[16]

Rectal cancer is the seventh most common cancer in Australia with an age-standardized rate of 18.8/100,000.[17] The aim of this study, conducted in the Australian state of Queensland where the age-standardized rate of rectal cancer is 19.2/100,000,[18] was to examine rates of in-hospital, 30- and 90-day mortality over time. The study additionally included an examination of factors associated with postoperative mortality and 2-year surgical survival after complex surgery for rectal cancer using an established set of QIs.

Methods

This retrospective population-based study used linked data obtained from the state-based oncology repository. The oncology repository consolidates patient information on a state-wide basis and contains data on cancer diagnoses and deaths from the cancer register as well as hospital admission data, surgery, radiation therapy, and intravenous systemic therapy from public and private facilities.

Study Population

The study included individuals diagnosed with a new case of invasive cancer of the rectum or rectosigmoid

Journal for Healthcare Quality, Vol. ■■■, No. ■■■, pp. 1–11

The authors declare no conflicts of interest.

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DOI: 10.1097/JHQ.0000000000000200

junction (International Classification of Diseases for Oncology [third edition] site codes C19 and C20) between 2000 and 2014. We excluded 139 cases with an overlapping lesion of the rectum, anus, and anal canal. Cancer-related procedures were identified from the Australian Classification of Health Interventions (ACHI) *International Classification of Diseases* (*ICD-10-AM*) ninth edition, 2015. Procedures were reviewed by expert clinicians and included abdominoperineal resection (AP), anterior resection, colectomy, Hartmann's procedure, and total proctocolectomy.

Variables Included

We included age, sex, cancer type, indigenous status, type of hospital (public or private), and admission type (elective or emergency). Socioeconomic status (SES) was assigned according to the Bureau of Statistics Socio-Economic Indexes for Areas (SEIFA), a census-based measure of social and economic well-being.[19] Residence at the time of diagnosis was categorized into metropolitan or rural, based on national geographical classification.[20] Cancer site, histology, and stage were extracted from the state-based cancer register and categorized as primary tumor localized, regional, or metastatic spread. Charlson comorbidity score[21] was derived from hospital admission data and included any comorbid condition in the period 1 month before, and up to 12 months after surgery. American Society of Anaesthetic (ASA) physical status classification was categorized as normal/mild (ASA score 1–2), severe (3–6), and unknown. Information on radiation therapy and intravenous systemic chemotherapy received before surgery was obtained from hospital admission data. Study variables additionally included Multidisciplinary Team Review (MDT). We calculated the average annual volume of rectal resections for each hospital over the 15-year period and categorized them based on tertiles and these included high (>30 rectal resections/year); medium (15–30/year) and low (<15/year). Year of surgery was grouped into 3 periods (2000–2004; 2005–2009; and 2010–2014).

Analysis

The statistical significance of bivariate comparisons between 30-day and 90-day mortality, and various sociodemographic and clinical factors were estimated using the chi-square or Kruskal–Wallis test. We then constructed a series of multivariable logistic regression models to examine factors independently associated with each outcome of interest. For each model, we began with a full logistic model including all variables relating to the outcome of interest including sex, age, residential location, SES, comorbidities, ASA, type of admission, neoadjuvant therapy before surgery, hospital volume, type of hospital, stage at diagnosis, and year of surgery. All models were adjusted for within-hospital clustering. Observed 2-year and 5-year postsurgical survival was estimated using the Kaplan–Meier survival function. The log-rank test was used to assess differences in survival according to hospital volume, year of surgery, type of hospital, and stage. In addition, multivariable analyses were performed with a shared-frailty Cox proportional hazards regression model to examine factors associated with the risk of death within 2 years of surgery. All analyses were conducted using Stata V15.1 (Stata Corp, College Station, TX).

Ethical approval was not required for this study as data were deidentified.

Results

From 2000 to 2014, 12,952 individuals were diagnosed with an invasive cancer of the rectum or rectosigmoid junction, of whom 11,965 received surgery. Patients having either a local excision, polypectomy, enter/enterocolostomy, explorative surgery, or stoma surgery only (n = 2,743) were excluded. Of the remainder, 9,222 underwent one of the included surgical procedures and were included in this analysis.

Mean age was 65 years (range 15–98 years), 64.2% were male patients and 58.4% had localized disease. Of the cohort, 33.1% (n = 3,048) had received radiation therapy or chemotherapy (or a combination) before their surgery (Table 1). The most common procedure was anterior resection (63.7%), and 33.7% were treated in a high-volume hospital.

Thirty- and 90-Day Mortality

Overall, 184 (2.0%) in-hospital deaths occurred. Thirty-day mortality was 2.1% and 90-day mortality was 3.8% (n = 349) with 152 of those deaths (43.5%) occurring from 31 to 90 days after surgery (90-day conditional mortality). We observed a significant reduction for each of the three mortality outcomes over time despite an increase in the number of resections (Figure 1). For example, 30-day mortality more than halved from 3.0% in the period 2000–2004 to 1.3% from 2010 to 2014 ($p < .001$).

After adjustment, a higher risk of 30-day mortality was observed for male patients, compared with

Table 1. Multivariable Logistic Regression Model[a] Examining Factors Associated With 30- and 90-Day Postoperative Mortality

	30-day mortality		90-day mortality	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Sex		.03		.02
Female (*n* = 3,297)	Reference		Reference	
Male (*n* = 5,925)	1.40 (1.02–1.9)		1.39 (1.05–1.84)	
Age group		<.001		<.001
<65 years (*n* = 4,209)	Reference		Reference	
65–74 years (*n* = 2,802)	1.71 (1.09–2.67)		1.60 (1.16–2.20)	
≥75 years (*n* = 2,211)	4.26 (2.75–6.59)		4.35 (3.17–5.99)	
Socioeconomic status		.43		.71
Affluent (*n* = 1,283)	Reference		Reference	
Middle (*n* = 5,838)	1.04 (0.70–1.55)		1.12 (0.79–1.59)	
Disadvantaged (*n* = 2,101)	1.27 (0.79–2.05)		1.21 (0.77–1.90)	
Residential location		.55		.44
Metropolitan (*n* = 5,347)	Reference		Reference	
Rural (*n* = 3,875)	0.91 (0.66–1.25)		0.91 (0.71–1.16)	
Charlson comorbidity score		<.001		<.001
0 (*n* = 6,476)	Reference		Reference	
1 (*n* = 1,554)	1.76 (1.17–2.63)		1.58 (1.28–1.94)	
2+ (*n* = 1,193)	2.39 (1.58–3.63)		2.15 (1.68–2.76)	
ASA		<.001		<.001
Normal/mild disease (*n* = 4,179)	Reference		Reference	
Severe disease (*n* = 2,557)	3.60 (2.16–6.00)		2.93 (2.06–4.17)	
Unknown (*n* = 2,486)	3.06 (1.69–5.52)		2.18 (1.57–3.08)	
Extent of disease[b]		.02		<.001
Localized (*n* = 5,384)	Reference		Reference	
Regional (*n* = 2,525)	0.96 (0.67–1.36)		1.18 (0.87–1.59)	
Distant (*n* = 1,015)	1.90 (1.18–3.07)		3.58 (2.56–4.99)	
Type of admission		<.001		<.001
Elective (*n* = 8,461)	Reference		Reference	
Emergency (*n* = 761)	2.94 (2.10–4.12)		2.80 (2.08–3.77)	

Table 1. Multivariable Logistic Regression Model[a] Examining Factors Associated With 30- and 90-Day Postoperative Mortality *(Continued)*

	30-day mortality		90-day mortality	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Neoadjuvant therapy		.66		.58
No (n = 6,349)	Reference		Reference	
Yes (n = 2,873)	0.90 (0.53–1.50)		1.16 (0.76–1.65)	
MDT[c] documented review		.08		.15
Yes (n = 1,417)	Reference		Reference	
No (n = 7,805)	1.71 (0.93–3.14)		1.55 (0.86–2.78)	
Type of procedure		<.001		<.001
Anterior resection (n = 5,879)	Reference		Reference	
AP resection (n = 1,378)	1.32 (0.79–2.20)		1.31 (0.86–2.00)	
Colectomy (n = 1,443)	2.32 (1.40–3.87)		2.24 (1.61–3.12)	
Other[d] (n = 522)	3.06 (1.80–5.18)		2.55 (1.73–3.75)	
Year of surgery		.01		.04
2000–2004 (n = 2,879)	Reference		Reference	
2005–2009 (n = 3,133)	0.81 (0.61–1.07)		0.92 (0.72–1.16)	
2010–2014 (n = 3,192)	0.55 (0.37–0.82)		0.68 (0.50–0.93)	
Type of hospital		.002		.09
Private (n = 4,878)	Reference		Reference	
Public (n = 4,483)	1.69 (1.21–2.36)		1.26 (0.96–1.65)	
Hospital volume		.22		.24
High (>30/year) (n = 3,110)	Reference		Reference	
Medium (15–30/year) (n = 2,929)	0.89 (0.65–1.23)		1.03 (0.77–1.37)	
Low (<15/year) (n = 3,183)	0.71 (0.47–1.06)		0.80 (0.56–1.15)	

[a] Model adjusted for clustering within hospitals.
[b] Stage missing for 298 (3.2%) of patients.
[c] Multidisciplinary team.
[d] "Other" includes Hartmann's procedure and total proctocolectomy.
CI = confidence interval; OR = odds ratio.

female patients (p = .03), and among older, (≥65 years) compared with younger (<65 years) patients (p < .001) (Table 1). Patients with a greater comorbidity burden, those with a high ASA and those admitted as an emergency, were all at significantly higher risk of 30-day mortality. Patients treated in a public compared with a private hospital were about 70% more likely to die within 30 days of their surgery {odds ratio (OR), 1.69 [95% confidence interval (CI) 1.21–2.36]}. Furthermore, risk of 30-day mortality was significantly elevated for patients undergoing a colectomy compared with anterior

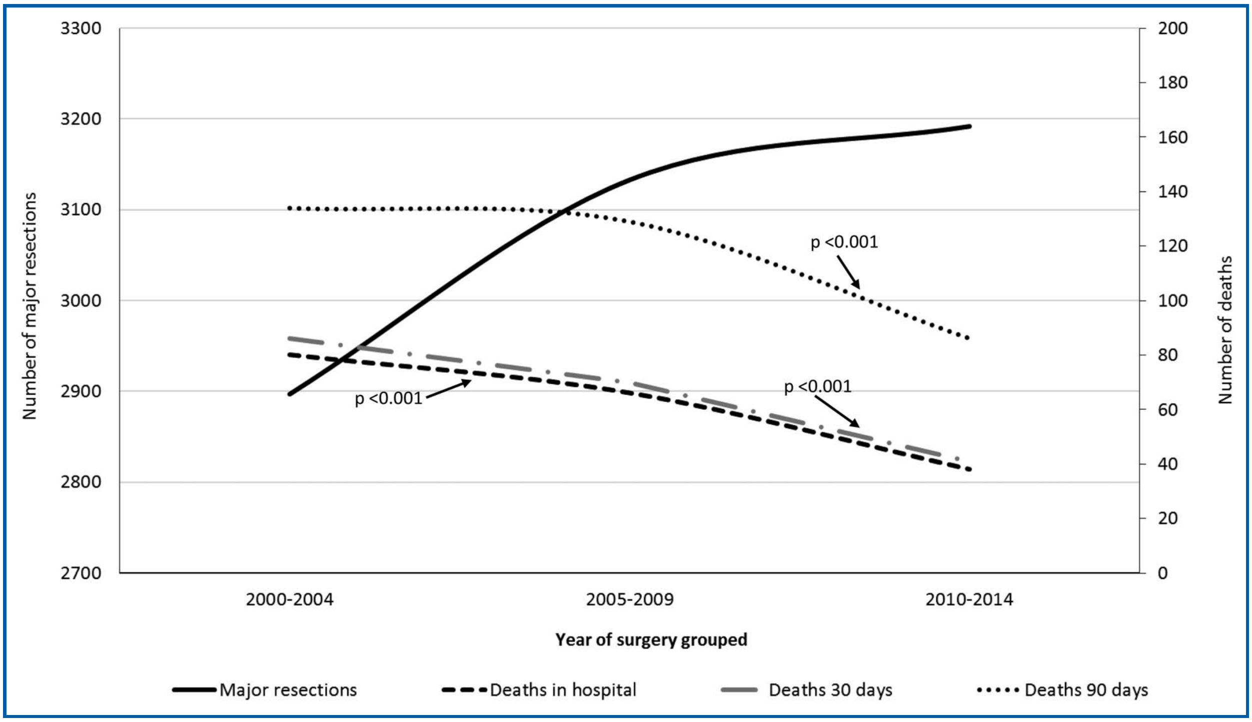

Figure 1. Major resections and number of deaths in-hospital, and within 30 and 90 days over 3 periods.

resections (OR, 2.32, [95% CI, 1.40–3.87]). The risk of 30-day mortality was about 45% lower for surgery performed more recently (2010–2014) compared with 2000–2004 (OR, 0.55, [95% CI, 0.37–0.82]) (Table 1). We observed similar findings when we used 90-day mortality as the outcome of interest (Table 1) and for 90-day conditional mortality (data not shown).

Overall Survival

One-, 2-, and 5-year postsurgical overall survival (OS) was 89.8%, 81.6%, and 66.9%, respectively. Crude 2-year Kaplan–Meier survival curves by hospital volume, hospital type (public vs. private), year of surgery, and stage are presented in Figure 2. Based on log-rank test, significant differences were observed in OS according to hospital type ($p < .001$), year of surgery ($p < .001$), and stage ($p < .001$). In multivariable Cox regression analysis, factors associated with a higher risk of death within 2 years of surgery (Table 2) included older age ($p < .001$); living in an area of disadvantage ($p = .04$); greater comorbidity burden ($p < .001$); and presence of regional or distant disease at diagnosis ($p < .001$). In addition, an increased risk of death was observed for patients whose admission was emergency {Hazard Ratio (HR) = 1.87, [95% CI, 1.66-2.11]}; and for patients undergoing abdominoperineal resections (HR, 1.66, [95% CI, 1.45–1.91]), colectomy (HR, 1.69 [95% CI, 1.48–1.93]), or other procedures (such as Hartmann's or total proctocolectomy) (HR, 1.88 [95% CI, 1.59–2.22]) compared with anterior resection ($p < .001$). Other factors associated with an increased risk of death at 2 years after surgery included not having an MDT review ($p < .001$), treatment in a public compared with private hospital ($p < .001$), and emergency admission ($p < .001$). A significantly lower risk of death was observed for patients whose surgery was performed more recently (2010–2014) compared with the earliest period (2000–2004) (HR, 0.63 [95% CI, 0.54–0.73]). Similar results were observed for 5-year survival (data not shown).

Limitations

Some potential limitations should be considered. Although coding errors may have occurred for both disease and procedures, extensive validation checks are routinely conducted with our data sets. In addition, we did not include type or rate of complications that would likely have an impact on factors predictive of postoperative mortality. Finally,

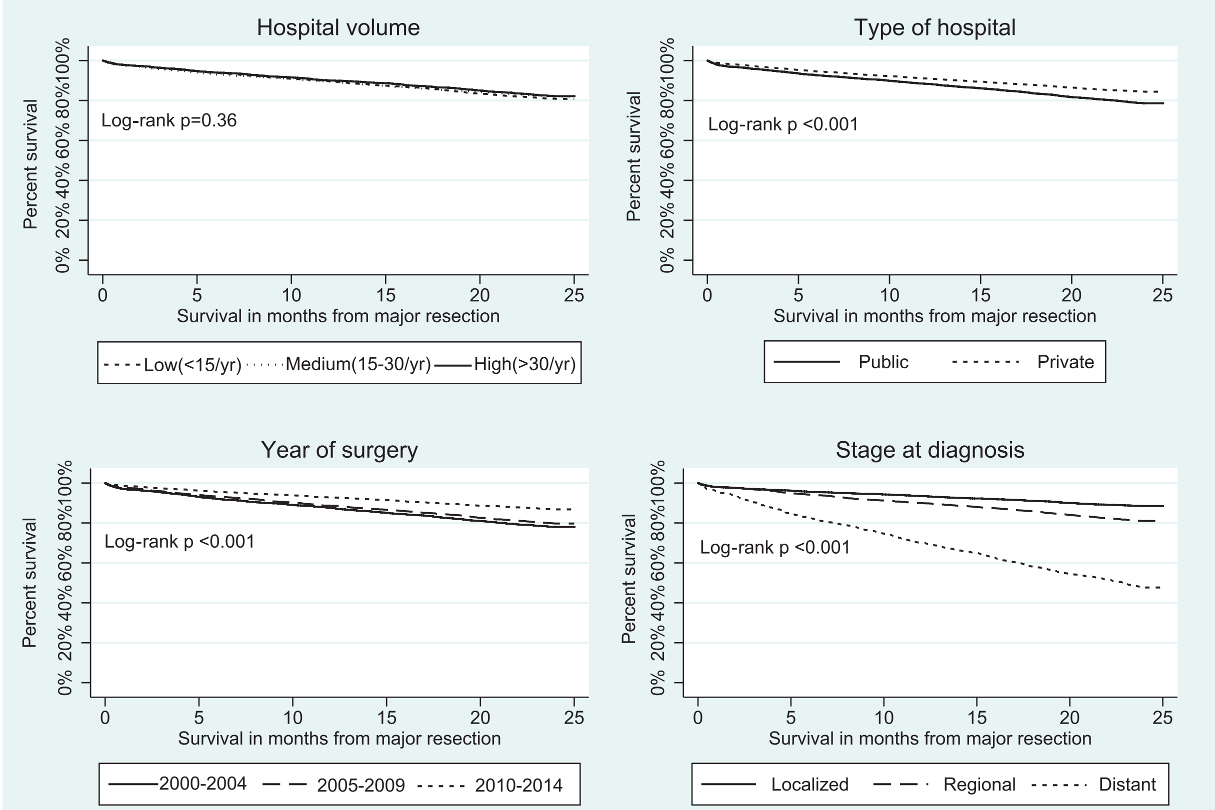

Figure 2. Overall crude 2-year survival after major resection for rectal cancer.

although we analyzed outcomes according to hospital volume, we could not do the same for surgeon volume, which is likely an important factor in outcomes after major resection for rectal cancer. Although we have identified some limitations, our results are consistent with other population-based studies.[12,16,22,23]

Discussion

Reporting on outcomes after cancer surgery using a set of agreed clinical indicators allows for the reviewing, comparing, and sharing of information on the safety and quality of cancer treatments and outcomes. Surgery is a critical component of the curative treatment for rectal cancer, and here, we reported on selected outcomes after complex rectal cancer surgery in a population-based cohort spanning a 15-year period.

Overall, 30-day mortality was low at 2.1%, comparable with rates reported elsewhere. For example, Aquina et al[13] observed a reduction in 30-day mortality from 7.7% to 1.2% over a 10-year period. Similarly, a large Swedish cohort study reported 30-day morality reduced from 2.1% to 1.6% over an 8-year period.[16] We did observe a significant reduction in 30-day mortality over the 15 years of the study with rates decreasing by more than half from 3.0% between 2000 and 2004 to 1.3% between 2010 and 2014. The magnitude of the decrease observed for 30-day mortality was also observed for 90-day mortality. Linear decreases in rates of postoperative mortality have also been reported elsewhere.[13,16] The postoperative mortality reductions likely reflect improvements in surgical procedures as well as better perioperative and postoperative care. Furthermore, changes in patient selection, that is, operating on fewer patients with high-comorbidity burdens may artificially lower postoperative mortality. In our data, we did find fewer patients in later years had two or more comorbidities; however, we found no

Table 2. Multivariable Cox Regression Model[a] Examining Factors Associated With Risk of Death Within 2 Years of Major Resection

	Adjusted 2-year overall survival	
	Hazard ratio[b] (95% CI)	*p*
Sex		.06
Female	Reference	
Male	1.10 (1.00–1.22)	
Age group		<.001
<65 years	Reference	
65–74 years	1.17 (1.03–1.33)	
≥75 years	2.22 (1.97–2.51)	
SES		.04
Affluent	Reference	
Middle	1.17 (0.99–1.37)	
Disadvantaged	1.27 (1.05–1.54)	
Charlson comorbidity score		<.001
0	Reference	
1	1.30 (1.15–1.48)	
2+	1.84 (1.62–2.08)	
ASA		<.001
Normal/mild disease	Reference	
Severe disease	1.65 (1.45–1.87)	
Unknown	1.32 (1.15–1.51)	
Extent of disease		<.001
Localized	Reference	
Regional	1.87 (1.66–2.11)	
Distant	5.94 (5.27–6.70)	
Type of admission		<.001
Elective	Reference	
Emergency	1.82 (1.58–2.09)	
MDT[c] documented review		<.001
Yes	Reference	
No	1.39 (1.17–1.68)	

Table 2. Multivariable Cox Regression Model[a] Examining Factors Associated With Risk of Death Within 2 Years of Major Resection *(Continued)*

	Adjusted 2-year overall survival	
	Hazard ratio[b] (95% CI)	*p*
Type of procedure		<.001
Anterior resection	Reference	
Abdominoperineal resection	1.66 (1.45–1.91)	
Colectomy	1.69 (1.48–1.93)	
Other[d]	1.88 (1.59–2.22)	
Year of surgery		<.001
2000–2004	Reference	
2005–2009	0.91 (0.80–1.03)	
2010–2014	0.63 (0.54–0.73)	
Type of hospital		<.001
Private	Reference	
Public	1.33 (1.14–1.47)	
Hospital volume		.33
Higher (>30/year)	Reference	
Medium (15–30/year)	0.93 (0.80–1.08)	
Lower (<15/year)	0.89 (0.75–1.04)	

[a] Model adjusted for clustering within hospitals and additionally adjusted for residential location.
[b] Hazard ratios greater than 1.0 indicate increased risk of death.
[c] Multidisciplinary team review.
[d] "Other" includes Hartmann's procedure and total proctocolectomy.
CI = confidence interval.

differences in the age distribution of operated patients over time. In addition, we found no significant change in the distribution of procedures over the 15 years of data (except for significantly fewer Hartmann's procedures in later years [$p <$ .001]). When we included type of operation in the multivariable models, patients treated in more recent years continued to have a mortality benefit. It is possible that in more recent years, there were lower rates of complications; however, we were unable to assess that in these data. We found 43% ($n = 152$) of patients who died within 90 days of surgery died within the 31- to 90-day period. This is similar to a Swedish study that found more than half the deaths from 0 to 90 days occurred in the 31- to 90-day period.[16] The authors noted rates of complications for patients dying within 30 days were 90% but remained relatively high at 62% for patients dying in the 31- to 90-day period. The addition of a 90-day postoperative mortality measure to QIs will likely help ongoing quality assurance and research.

For several complex cancer surgeries, the inverse relationship between hospital volume and postoperative mortality is well recognized.[10] However, this relationship is less clear for rectal resection. Both earlier[22,23] and later studies[6,12,15] of hospital volume outcomes report conflicting results. Our study found no mortality benefit for patients treated in a higher volume hospital. A recent large study from the Spanish Society of Surgeons that included 9,809 rectal cancer patients[24] also failed to find any association between mortality and hospital volume, with the same result reported for a Dutch study of 2,095 patients.[15] Our results additionally showed 2-year survival was similar across hospital volume categories. These findings mirror those of others.[12,15,25] There may be several potential reasons why our data did not show an association between hospital volume and the outcomes of interest. In our jurisdiction, about 40% of the population live outside the state capital.[26] Cancer surgery and other cancer treatments are routinely performed in regional hospitals in Australia (where surgical volume is lower), and in the case of more complex surgical procedures, experienced surgeons based at higher volume hospitals do, where the appropriate clinical and infrastructure support is available, perform these in larger regional centers. In addition, the establishment of a Safety and Quality Partnership and the development of, and regular reporting on, a Cancer Quality Index in our jurisdiction have provided the necessary formal structure to reflect on performance and identify areas for improvement.

Although we set our high volume at more than 30 patients annually, this may be considered lower volume for other jurisdictions; however, our categories were based on tertiles and reflect the actual volume of colorectal cancer patients receiving major surgery in our study population. Furthermore, although we adjusted for other factors such as comorbidities and stage, we did not have access to surgical complications, margins, or lymph node status. That said, other recent studies that have included such factors have also failed to find an association between hospital volume and mortality or survival.[15,24,25]

Our findings indicated several factors were strongly and independently associated with higher 30-day mortality and lower 2-year postoperative survival. Higher burden of comorbidity and more severe ASA scores were both associated with an approximate 2-fold increased risk of death at 30 days and at 2 years. These findings are similar to results of other recent studies[6,13,15] and highlight the importance of identifying patients who may be at risk of poorer outcomes in the perioperative and postoperative phase. Although patients admitted as an emergency had a significantly increased risk of death within 30 days of surgery, the frequency of emergency admissions for rectal cancer was relatively low at about 8% compared with the 20–25% observed for colon cancer.[27] The findings here highlight the need to identify how to better manage this group of patients. We did observe a slight reduction in the number of patients presenting as an emergency over time, and this may in part be due to increased awareness of the symptoms of colorectal cancer with the introduction of Australia's national bowel screening program.

We also observed higher mortality both at 30 days and 2 years postoperatively in patients attending public, compared with private hospitals. Although our model adjusted for other possible confounders (such as more severe disease according to ASA, comorbidity burden, and receipt of neoadjuvant therapy), it is possible that public hospitals (particularly large teaching hospitals) treat more complex cases. It is also likely there remain some unmeasured differences in casemix between patients within public and private facilities.

Our findings also indicated a higher risk of postoperative mortality and risk of death at 2 years for patients who did not have an MDT review. The primary role of MDT meetings is to discuss and develop a plan of treatment for individual patients.[28] Although results of studies examining the efficacy of MDTs for outcomes such as survival have been inconsistent,[29] there is good evidence that MDTs result in improved decision-making, effective coordination of quality patient care, and better treatment.[30] Documented MDT activity within our data was significantly lower in earlier years. Although our final models were adjusted for year of surgery, there remained a strong interaction effect between MDT activity and year of surgery. The development of a web-based tool by our group is now increasingly used by clinicians (primarily in the public system) to support MDT meetings. Although MDT meetings occur within the private health system, currently we are unable to capture all activity.

The strengths of this study are its population base and the inclusion of all cases of rectal cancer in Queensland where a major resection was performed from 2000 to 2014. A further strength is the linking and inclusion of data from several clinical and administrative sources into a central repository. Clinical teams of specialists provide guidance and advice on the collection and management of data in this repository including routine data checks and validation.

Conclusions

In this large population-based study, we found 30- and 90-day postoperative mortality for patients after a major resection for this population-based cohort was low. We found no association between postoperative outcomes and hospital volume over the 15-year study. We did identify a subgroup of patients for whom the risk of poorer outcomes was significantly elevated.

Implications

Quality indicators are a valuable tool for measuring outcomes over time. These tools can be used to identify and quantify subgroups of patients at risk of poorer outcomes and thus inform the implementation of strategies to continue to improve clinical care for all patients. Comparison of performance by each hospital with deidentified peers has led to practice improvements, including case selection that better suits hospital capability.

Authors' Biographies

Philippa Youl, PhD, MPH, is a data analyst with Cancer Alliance Queensland. Her primary responsibilities are in the analysis and interpretation of cancer data. She has conducted epidemiological cancer research for over 25 years in both the government and not-for-profit sector.

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David E. Theile, AO, FRACS, is the Chair of the Queensland Cancer Control Safety and Quality Partnership for Cancer Alliance Queensland. He has a long and distinguished career in clinical practice as a general surgeon and District Chief Executive Officer. Prof Theile has led the development of the Queensland Quality Index and in the reporting of outcomes after cancer treatment throughout Queensland public and private hospitals.

Acknowledgments

The authors thank members of the Colorectal Cancer Subcommittee of the Queensland Cancer Control Safety and Quality Partnership for their valuable contributions to ongoing audits of colorectal cancer surgery. The authors also thank the Queensland Cancer Control Analysis Team who maintain the Queensland Oncology Repository and conduct analysis including John Harrington, Neal Rawson, Danica Cossio, Nathan Dunn, and Tracey Guan.

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