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Outcomes following major resection for colorectal cancer in patients aged 65+ years: a population-based study in Queensland, Australia

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Abstract

Background: The risk of developing colorectal cancer (CRC) increases with increasing age. As surgery is the primary treatment for CRC, our aim was to examine outcomes following major resection for CRC in a cohort of individuals aged ≥65 years.

Methods: This population-based retrospective study included 18 339 patients aged ≥65 years diagnosed with CRC from 2007 to 2016. Multivariate logistic regression was used to examine factors associated with the likelihood of having major resection, 30-day mortality and laparoscopic surgical procedure. Cox proportional hazards was used to examine factors associated with risk of death at 2 years post-surgery.

Results: Overall, 77.8% (n = 14 274) of patients had a major resection. Males and patients ≥75 years were significantly less likely to have a major resection ($P < 0.001$ and $P < 0.001$, respectively). Thirty-day mortality was 3.1% and 2-year overall survival was 78.7%. After adjustment, factors such as increasing age (≥75 years), ≥2 comorbidities, emergency admission, open surgical procedure and treatment in a public hospital were all independently and significantly associated with poorer outcomes. The likelihood a patient had a laparoscopic procedure was significantly lower for those from a disadvantaged area ($P < 0.001$), emergency admission ($P < 0.001$) as well as for those treated in a public versus private hospital ($P < 0.001$).

Conclusions: Post-operative mortality increased, and 2-year survival decreased after age 75 years. The finding of significantly lower rates of laparoscopic surgery for patients from disadvantaged areas and those treated in a public hospital requires further investigation.

Introduction

Colorectal cancer (CRC) is one the most common cancers diagnosed in developed countries and Australia has some of the highest rates in the world. Rates of CRC rise with increasing age with nearly 70% of cases diagnosed in those aged ≥65 years.[1,2]

CRC is primarily treated with surgical resection of the primary tumour[3] and the majority require major resection. Some studies have reported patients ≥65 years who undergo major resection are at higher risk of extended hospital stay, in-hospital mortality as well as 30- and 90-day post-operative mortality. Older age is also associated with a higher likelihood of re-admission following surgery,[4–6] and is a risk factor for poorer post-operative survival.[4,7,8] However, surgical complications are not necessarily more common in older patients.[9,10] Poorer post-operative outcomes are more common for patients who have emergency, rather than elective surgery.[4,11] The proportion of older patients requiring emergency surgery is higher than that for patients under 65 years.[12]

International recommendations suggest pre-operative assessment including the physiological effects of ageing, physical abilities, mental cognition and the availability of social support be undertaken for patients aged ≥65 years.

Our aim was to examine the frequency of major resection for CRC over time and to identify factors associated with poorer post-operative outcomes in patients aged ≥65 years.

Methods

This retrospective population-based study used linked data from the Queensland Oncology Repository (QOR). QOR collates and matches data from the Queensland Cancer Register together with public and private hospital admissions, surgery, radiation therapy, intravenous systemic therapy, MDT records (primarily in the public sector) and mortality data.

Study population

The study included 18 339 individuals aged ≥65 years diagnosed with a new case of invasive colorectal cancer (ICD-10 AM codes C18-20) from 1st January 2007 to 31st December 2016. Cancer-related procedures were identified and reviewed by expert clinicians and categorized. Procedures included abdominoperineal resection, anterior resection, colectomy, Hartmann's procedure and total proctocolectomy. In addition, per anal excision of lesion or tissue was regarded as being equivalent to a major resection (in that it is a 'treatment' procedure) if there has been no preceding major resection nor a following major resection within 30 days.

Variables included

We included age, sex, Indigenous status, type of hospital (public or private), admission type (elective or emergency), cancer site, histology and stage. Socioeconomic status (SES) was assigned according to the Australian Bureau of Statistics Socio-Economic Indexes for Areas (SEIFA), a census-based measure of social and economic well-being.[13] Residence at time of diagnosis was categorized into major city, inner regional, outer regional and remote/very remote based on the Australian Geographical Classification.[14] Comorbidity was derived from hospital admission data and included any comorbid condition in the period 1 month prior to, 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. We calculated the average annual hospital volume of CRC resections over the 10-year period and categorized them as low (< 20/year), medium (20–50/year) and high (>50/year). Year of surgery was grouped into two periods 2007–2011 and 2012–2016.

Analysis

The statistical significance of bivariate comparisons between 30- and 90-day mortality and various sociodemographic and clinical

Table 1 Sociodemographic and clinical factors associated with likelihood of having major resection for colorectal cancer

	Had major resection *N* (%)	Adjusted OR† (95%CI)	*P*-value
Sex			<0.001
Female (*n* = 8390)	6591 (78.6)	Ref	
Male (*n* = 9949)	7683 (77.2)	0.86 (0.79–0.92)	
Age group			
65–69 (*n* = 4004)	3325 (83.0)	Ref	<0.001
70–74 (*n* = 4186)	3452 (82.5)	0.94 (0.83–1.06)	
75–79 (*n* = 3949)	3239 (82.0)	0.90 (0.80–1.02)	
80–84 (*n* = 3315)	2508 (75.7)	0.62 (0.55–0.70)	
85+ (*n* = 2885)	1750 (60.7)	0.32 (0.28–0.36)	
Indigenous status‡			0.43
Non-Indigenous (*n* = 18 170)	14 153 (77.9)	Ref	
Indigenous (*n* = 160)	121 (75.6)	0.86 (0.58–1.26)	
Socioeconomic status			<0.001
Affluent (*n* = 2269)	1808 (79.7)	Ref	
Middle (*n* = 11 841)	9232 (78.0)	0.86 (0.76–0.97)	
Disadvantaged (*n* = 4229)	3234 (76.5)	0.76 (0.65–0.87)	
Residential location			0.01
Major city (*n* = 11 399)	8870 (77.9)	Ref	
Inner regional (*n* = 4622)	3639 (78.7)	1.10 (1.00–1.21)	
Outer regional (*n* = 1994)	1530 (76.7)	0.97 (0.86–1.10)	
Remote/very remote (*n* = 324)	235 (72.5)	0.73 (0.56–0.95)	
Multidisciplinary team review			<0.001
No (*n* = 14 204)	10 804 (76.1)	Ref	
Yes (*n* = 4135)	3470 (83.9)	1.45 (1.31–1.60)	
Charlson comorbidity score			<0.001
None (*n* = 10 264)	8229 (80.2)	Ref	
One (*n* = 4361)	3344 (76.7)	0.88 (0.80–0.96)	
Two or more (*n* = 3714)	2701 (72.7)	0.75 (0.68–0.82)	
Primary site			<0.001
Colon (n = 13 404)	10 731 (80.1%)	Ref	
Rectum (*n* = 4935)	3543 (71.8%)	0.55 (0.51–0.60)	
Stage at diagnosis			<0.001
Stage I/II (*n* = 7967)	7017 (88.1)	Ref	
Stage III/IV (*n* = 3312)	2683 (81.0)	0.58 (0.52–0.66)	
Stage unknown (*n* = 7060)	4574 (64.8)	0.23 (0.21–0.26)	
Diagnosis period			<0.001
2007–2011 (*n* = 8872)	7020 (79.1%)	Ref	
2012–2016 (*n* = 9467)	7254 (76.6%)	0.63 (0.58–0.68)	

†Odds ratio.

‡Indigenous status unknown for 10 patients.

factors were estimated using the chi-squared or Kruskal–Wallis test. We then constructed multivariate logistic regression models to examine factors independently associated with each outcome of interest. Multivariable Cox proportional hazards regression was used to examine factors associated with risk of death within 2 years of surgery. An additional logistic regression model was used to examine the relationship between clinical and sociodemographic factors and surgical approach (laparoscopic compared to open). For

Table 2 Multivariate model of factors associated with 30-day mortality and risk of death within 2 years of major resection

	30-day mortality		Death within 2 years of surgery	
Factors	OR† (95%CI)	*P*-value	HR‡(95%CI)	*P*-value
Sex		0.19		0.77
Female	Ref		Ref	
Male	1.15 (0.94–1.41)		0.99 (0.92–1.06)	
Age group		<0.001		<0.001
65–69	Ref		Ref	
70–74	1.38 (0.91–2.10)		1.15 (1.01–1.30)	
75–79	2.11 (1.43–3.10)		1.53 (1.35–1.72)	
80–84	2.86 (1.95–4.21)		1.87 (1.64–2.12)	
85+	4.04 (2.69–6.07)		2.35 (2.05–2.68)	
Socioeconomic status		0.40		0.65
Affluent	Ref		Ref	
Middle	1.12 (0.85–1.49)		1.02 (0.91–15)	
Disadvantaged	1.26 (0.90–1.77)		10.98 (0.85–1.13)	
Residential location		0.83		0.04
Major city	Ref		Ref	
Inner regional	1.07 (0.84–1.36)		1.09 (0.99–1.20)	
Outer regional/remote/very remote	1.01 (0.74–1.38)		1.15 (1.02–1.29)	
Charlson comorbidity score		<0.001		<0.001
None	Ref		Ref	
One	2.10 (1.59–2.75)		1.42 (1.30–1.56)	
Two or more	2.99 (2.34–3.81)		2.19 (2.00–2.39)	
ASA score		<0.001		<0.001
1–2	Ref		Ref	
3+	2.29 (1.65–3.17)		1.54 (1.41–1.69)	
Unknown	1.99 (1.32–2.99)		1.33 (1.17–1.50)	
Primary site		0.21		0.77
Colon	Ref		Ref	
Rectum	0.83 (0.61–1.11)		0.99 (0.90–1.08)	
Stage at diagnosis		0.23		<0.001
I/II	Ref		Ref	
III/IV	0.94 (0.69–1.27)		2.78 (2.53–3.05)	
Unknown	0.83 (0.68–1.03)		1.30 (1.18–1.42)	
Type of admission		<0.001		<0.001
Elective	Ref		Ref	
Emergency	3.35 (2.60–4.30)		2.31 (2.12–2.51)	
Surgical procedure		0.007		0.003
Laparoscopic	Ref		Ref	
Open	1.38 (1.09–1.74)		1.23 (1.07–1.41)	
Stoma created at resection		0.003		
No	Ref		N/A	
Yes	1.48 (1.15–1.91)			
Adjuvant chemotherapy§				0.001
No	N/A		Ref	
Yes			1.24 (1.12–1.37)	
Multidisciplinary team review		<0.001		
No	Ref		N/A	
Yes	0.28 (0.18–0.44)			
Hospital type		<0.001		<0.001
Private	Ref		Ref	
Public	1.91 (1.47–2.50)		1.18 (1.10–1.28)	
Hospital volume		0.45		0.02
> 50/year	Ref		Ref	
20–50/year	0.98 (0.78–1.23)		1.12 (1.03–1.22)	
<20/year	0.80 (0.56–1.13)		1.05 (0.92–1.18)	
Diagnosis period		0.07		<0.001
2007–2011	Ref		Ref	
2012–2016	0.77 (0.59–1.02)		0.65 (0.60–0.71)	

†Odds ratio.

‡Hazard ratio; N/A not included in model.

§Intravenous systemic therapy began within 3 months of major resection.

Table 3 Multivariate logistic regression model examining factors associated with likelihood of having laparoscopic versus open surgery for colorectal cancer

Factors	Odds ratio (95%CI)	*P*-value
Sex		0.02
Female	Ref	
Male	1.09 (1.02–1.18)	
Age group		0.91
65–69	Ref	
70–74	0.98 (0.88–1.09)	
75–79	0.96 (0.86–1.07)	
80–84	1.00 (0.90–1.13)	
85+	0.97 (0.84–1.10)	
Socioeconomic status		<0.001
Affluent	Ref	
Middle	0.78 (0.70–0.88)	
Disadvantaged	0.85 (0.74–0.97)	
Residential location		<0.001
Major city	Ref	
Inner regional	1.02 (0.93–1.12)	
Outer regional/remote/very remote	0.79 (0.70–0.90)	
Charlson comorbidity score		<0.001
None	Ref	
One	0.93 (0.85–1.02)	
Two or more	0.80 (0.72–0.88)	
ASA score		
1–2	Ref	<0.001
3+	0.85 (0.78–0.93)	
Unknown	0.83 (0.74–0.93)	
Primary site		<0.001
Colon	Ref	
Rectum	0.66 (0.60–0.72)	
Stage at diagnosis		<0.001
I/II	Ref	
III/IV	0.81 (0.73–0.90)	
Unknown	0.97 (0.89–1.05)	
Type of admission		<0.001
Elective	Ref	
Emergency	0.28 (0.25–0.32)	
Multidisciplinary team review		0.11
No	Ref	
Yes	1.09 (0.98–1.22)	
Hospital type		<0.001
Private	Ref	
Public	0.72 (0.66–0.79)	
Hospital volume		<0.001
>50/year	Ref	
20-50/year	0.72 (0.67–0.79)	
<20/year	0.32 (0.28–0.37)	
Diagnosis period		<0.001
2007–2011	Ref	
2012–2016	2.40 (2.22–2.61)	

each model, we began with a full logistic model including all variables relating to the outcome of interest. All models were adjusted for within-hospital clustering. All analyses were conducted using Stata V15.1 (Stata Corp, College Station, TX).

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

Results

Of a total 18 339 individuals aged ≥65 years diagnosed with invasive CRC from 2007–2016, 14 274 (77.8%) had a major resection. In the fully adjusted model (Table 1), factors associated with a reduced likelihood of having a major resection included being male (OR = 0.86, 95% CI = 0.79–0.92); aged ≥75 years ($P < 0.001$), from a middle or disadvantaged area ($P < 0.001$) and residing in a remote/very remote location (OR = 0.73, 95% CI = 0.56–0.95). Furthermore, the odds of having a major resection were lower for patients with one or more comorbidities ($P < 0.001$) and for those with stage III/IV or unknown stage disease ($P < 0.001$). Compared to patients with no record of an MDT review, those with an MDT record were nearly 50% more likely to have a major resection (OR = 1.45, 95% CI = 1.31–1.60).

Outcomes of major resection

30-day mortality

Of 14 274 patients who had major resection, 437 (3.1%) and 771 (5.4%) died within 30 and 90 days of surgery, respectively. Both 30- and 90-day mortality decreased significantly over time across all age groups ($P < 0.001$) (data not shown).

Factors associated with 30-day mortality included older age ($P < 0.001$), one or more comorbidities ($P < 0.001$), ASA score of ≥ three ($P < 0.001$); emergency admission ($P < 0.001$), open surgical approach ($P = 0.007$) and stoma creation at resection ($P = 0.003$) (Table 2). Surgery in a public compared to private hospital was associated with a higher odds of 30-day mortality (OR = 1.91, 95% CI = 1.47–2.50). Patients whose case was discussed at an MDT meeting were about 70% less likely to die within 30 days of surgery (OR = 0.28, 95% CI = 0.18–0.44). Results were similar for 90-day mortality (data not shown).

Overall post-surgical survival

One-, 2- and 5-year postsurgical overall survival (OS) was 87.3%, 78.7% and 63.3%. After adjustment (Table 2), factors associated with a higher risk of death within 2 years of major resection included older age ($P < 0.001$), one or more comorbidities ($P < 0.001$), ASA score 3+ ($P < 0.001$), more advanced stage at diagnosis ($P < 0.001$), emergency admission ($P < 0.001$), open surgical procedure ($P = 0.003$), having adjuvant chemotherapy ($P = 0.001$) and surgery in a public hospital ($P < 0.001$). A reduction in risk of death was observed for patients diagnosed more recently (HR = 0.65, 95% CI = 0.60–0.71).

Surgical approach

Laparoscopic procedure was performed in 41.5% of resections. After adjustment (Table 3), patients were less likely to have laparoscopic surgery if they lived outside an affluent area ($P < 0.001$) or resided in an outer regional/remote/very remote location (OR = 0.79, 95% CI = 0.70–0.90). A reduced likelihood of having laparoscopic surgery was also observed for those with ≥ two comorbidities ($P < 0.001$), ASA score of ≥ three ($P < 0.001$), more advanced disease ($P < 0.001$) and emergency compared to elective admission ($P < 0.001$). Patients were about 25% less likely to have a laparoscopic procedure if their surgery was in a public compared to private hospital (OR = 0.72, 95% CI = 0.66–0.79). Likelihood of a laparoscopic procedure was also reduced for middle and low compared to high volume hospitals ($P < 0.001$). Patients diagnosed more recently (2012–2016) were significantly more likely to have laparoscopic surgery compared to those diagnosed from 2007–2011 ($P < 0.001$).

Discussion

This study included 14 274 patients aged ≥65 years who had a major resection for CRC. Currently, few studies exist reporting outcomes following surgery for CRC in the older population. As CRC is one of the most common cancers diagnosed in older age, focusing on this cohort is important in the context of assessing healthcare outcomes and for healthcare planning.

Just over three-quarters (77.8%) of patients diagnosed with CRC had a major resection. The proportion of patients aged 65–69, 70–74 and 75–79 who had major resection was similar (83%, 82% and 82%, respectively). The reduction in rates appeared to occur at around 80 years of age with a marked drop for those aged 85+ (61%). In a study of older patients with rectal cancer, authors reported 31.7% of patients ≥80 had major resection, [15] lower than the 56.4% we observed for our rectal cancer patients aged ≥80.

The likelihood of having a major resection was lower for patients living in a middle or disadvantaged socioeconomic area and about 25% lower for those from a remote/very remote location. While our model was fully adjusted for other potential confounders (such as stage, primary site, comorbidities), geographical and socioeconomic variations in the management of CRC patients have been reported previously. [16]

Thirty- and ninety-day post-operative mortality was 3.1% and 5.4%, respectively. Others have reported 30-day mortality rate of 7.1% in patients aged ≥70 years, [10] and 4.9% in those aged ≥75 years.[17] When we restricted our analysis to the same two age groups, our rates were 3.6% and 4.5%, respectively. We observed a 1% and a 1.5% reduction in 30- and 90-day mortality over time with the most significant reduction observed for those aged 65–74.

The association between higher postoperative mortality and age appeared to begin after 75 years with patients aged 70–74 years having no increased risk compared to those aged 65–69 years. A high comorbidity burden, high ASA score and emergency admission have all been shown to be risk factors for postoperative mortality. [18,19] In this study, 15% of patients were admitted as an emergency with the proportion increasing significantly as age increased. Other studies have reported similar results.[10,15] Causes of emergency admission may include obstruction and bleeding. While we were unable to examine the reasons for emergency admission, females and those with later stage disease were more likely to present as an emergency. Our results are similar to others.[20] These findings highlight the need to better understand the reasons why older patients in particular are more likely to present as an emergency.

Increased mortality risk was observed for patients having surgery in a public compared to private hospital. The reasons for this differential are largely unknown. While our model adjusted for other casemix variables (such as age, stage at diagnosis, type of procedure), it is possible there remains some underlying differences in patient casemix. While we did find a decreased risk of 30-day postoperative mortality for patients discussed at an MDT, we found no such association with 2-year post-operative survival. A similar finding has been reported in a review of MDT care and cancer survival. [21] Despite this, there is some evidence suggesting MDTs may be beneficial in decision making and coordination of patient care, [22] and these advantages may well be greater for an older population.

Two-year post-surgical OS among this cohort was 78.7%, ranging from 86.3% for patients aged 65–69 to 64.4% for those aged 85+ years. OS in this study was similar to others.[17,23] Apart from increasing age and advanced stage at diagnosis, factors such as a higher comorbidity or ASA score, emergency admission and open surgical procedure were all independently associated with an increased risk of death. These results are similar to other studies in both elderly and all age populations, [24,25] and highlight the importance of preoperative assessment and ongoing post-operative care. We observed an increased risk of death within 2 years of surgery for patients who received adjuvant chemotherapy. While our model was fully adjusted including age, comorbidities and stage, some residual confounding may have been present. When we stratified by age and risk of death, approximately 18% of patients who received adjuvant chemotherapy died within 2 years of surgery, increasing to 22%, 28%, 37% and 55% for those aged 70–74, 75–79, 80–84 and 85+, respectively.

Laparoscopic compared to open surgery has been shown to result in better short-term outcomes.[26,27] However in the elderly, this approach is less likely to be performed due to the presence of comorbidities, high ASA score and longer surgical times.[28] While we found patients with a higher comorbidity burden were about 20% less likely to have laparoscopic surgery, the rates observed in this study are comparable to those where all ages were included.[4,29] Patients treated in a public or low volume hospital were however significantly less likely to have a laparoscopic procedure. There are several possible explanations for this finding. Lower volume hospitals are more likely to be staffed by generalist rather than specialist surgeons who are more familiar and experienced in this procedure. Furthermore, public hospitals have a large proportion of more junior doctors who would be less experienced in laparoscopic techniques.

Limitations

While this was a large population-based study, some limitations should be considered. We were unable to include type and rate of complications in our analysis which has been shown to impact surgical outcomes across all age groups. Our group are however, currently testing methods to enable inclusion of the Clavien–Dindo classification system to our population-based linked data. Our study included hospital volume, however, we were unable to include surgeon speciality or surgical volume. Furthermore, our capture of MDT activity was primarily limited to the public sector and is therefore likely to be underreported.

Conclusions

Three-quarters of patients aged ≥65 years received a major resection for CRC. Higher post-operative mortality and lower 2-year OS was evident after age 75 years. The finding of significantly lower rates of laparoscopic surgery for patients from disadvantaged areas as well as those treated in a public hospital requires further investigation.

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Author contributions

Philippa Youl: Conceptualization; formal analysis; methodology; writing-original draft. **David Theile:** Conceptualization; writing-review and editing. **Julie Moore:** Data curation; project administration; writing-review and editing. **John Harrington:** Data curation; project administration. **Shoni Philpot:** Conceptualization; project administration; writing-review and editing.

Conflicts of interest

The authors have no conflicts of interest to declare.

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