Original Article

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Long-term survival following elective colon cancer surgery in the aged. A population-based cohort study

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Abstract

Aim The number of colorectal cancer patients increases with age. Long-term data support personalized management due to heterogeneity within the older population. This registry- and population-based study aimed to analyse long-term survival, and causes of death, after elective colon cancer surgery in the aged, focusing on patients who survived more than 3 months postoperatively.

Methods The data included patients ≥ 80 years who had elective surgery for Stage I–III colon cancer in four Finnish centres. The prospectively collected data included comorbidities, functional status, postoperative outcomes and long-term survival. Univariate and multivariate Cox regression analysis were conducted to determine factors associated with long-term survival.

Results A total of 386 surgical patients were included, of whom 357 survived over 3 months. Survival rates for all patients at 1, 3 and 5 years were 85%, 66% and 55%, compared to 92%, 71% and 59% for patients alive 3 months postoperatively, respectively. Higher age, American Society of Anesthesiologists (ASA) score ≥ 4, Charlson Comorbidity Index ≥ 6, tumour Stage III, open compared to laparoscopic surgery and severe postoperative complications were independently associated with reduced overall survival. Higher age (hazard ratio 1.97, 1.14–3.40), diabetes (1.56, 1.07–2.27), ASA score ≥ 4 (3.27, 1.53–6.99) and tumour Stage III (2.04, 1.48–2.81) were the patient-related variables affecting survival amongst those surviving more than 3 months postoperatively. Median survival time for patients given adjuvant chemotherapy was 5.4 years, compared to 3.3 years for patients not given postoperative treatment.

Conclusions Fit aged colon cancer patients can achieve good long-term outcomes and survival with radical, minimally invasive surgical treatment, even with additional chemotherapy.

Keywords Colon cancer, surgery, aged patients, long-term outcome

What does this paper add to the literature?
This register-based cohort study shows that aged colon cancer patients who are physically and functionally fit to survive surgery can achieve acceptable long-term outcomes and survival with radical surgical treatment and additional chemotherapy.

Introduction

Colorectal cancer is the second most diagnosed malignancy in Finland, and the third most diagnosed in the world [1,2]. The age-standardized incidence of colorectal cancer has globally increased 9.5%, and in Finland 17.3%, between the years 1990 and 2017. The global burden of colorectal cancer is expected to grow by 60% by 2030, to more than 2.2 million new cases and 1.1 million deaths [2]. As the population ages, older people are increasingly diagnosed with colorectal cancer [3]. Between 2013 and 2017, 26% of Finnish colorectal cancer patients were aged 80 years or older at the time of diagnosis [1].

Surgery is the cornerstone of treatment for colorectal cancer [4]. The increased number of older people results in more operations for colorectal cancer in this group [5]. Current studies show comparable disease-specific long-term survival rates for all age groups,

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which advocates for surgery with curative intent [5–7]. Conversely comorbidities, disability and the occurrence of severe postoperative complications are strongly associated with reduced short-term survival after surgery [8]. Thus, heterogeneity within the older population and differences in physical and cognitive condition make it impossible to base decision-making only on chronological age; some will survive just as younger adults, whereas others experience increased postoperative morbidity and reduced overall survival [9].

If patients survive the first year after surgery, they have reasonably good long-term survival [10]. Patients with more comorbidities have compromised postoperative outcomes [11,12]. Older patients value outcomes with good quality of life [13]. In a recent study from Italy, the authors call for studies focusing on long-term functional outcomes, to provide reliable information to patients on what to expect from cancer surgery [14]. This is important because informing older patients of the risk factors for postoperative morbidity, and diminished long-term outcomes, is essential for shared decision-making regarding surgical and non-surgical treatments [15].

The aim of this study was to analyse the long-term survival and causes of death in a consecutive population-based cohort of aged patients having colon cancer surgery. Because postoperative complications are a major risk factor of short-term mortality [8], the focus in this study was especially on the patients who survived at least 3 months after surgery.

Patients and Materials

Colon cancer patients aged 80 years and older at the time of surgery and operated in four Finnish public hospitals during 2005–2016 were included. Two of the hospitals were tertiary referral centre hospitals and two were small volume secondary care hospitals. These hospitals are responsible for colon cancer surgery in their catchment areas (100 000–250 000 inhabitants, total 750 000 inhabitants). As all colon cancer surgery in Finland is performed in public hospitals independent of social class or insurance status, the materials can be considered representative at population level.

Patients with metastatic or recurrent disease and palliative or emergency surgery were excluded. Data were extracted from prospective local colorectal databases and completed from hospital records. The dates and causes of death were obtained from the Death Certificate Register of Statistics Finland, which registers all deaths in Finland [16]. The duration of survival was calculated from the date of surgery to the date of death or to the closure of follow-up on 31 December 2018.

Recorded variables included age, living and functional status, comorbidities, modified Charlson Comorbidity Index (CCI) [17], surgical and postoperative outcomes, colon cancer recurrences or metastasis, overall survival and, for those who survived > 3 months after surgery, date and cause of death. Details of the patients' baseline characteristics and operative variables included in the study have been presented previously [8]. The diagnosis of colon cancer, operative treatment and postoperative surveillance were performed according to the standards of the study hospitals and national guidelines [18]. The postoperative complications were graded with Clavien–Dindo classification [19]. Clinical follow-up was continued for 5 years after surgery, or until death. Personal follow-up was arranged for patients considered too unfit or frail to attend a routine follow-up programme.

The data analysis focused on those patients who survived more than 3 months after the primary cancer operation, intended to exclude the effect of early postoperative mortality. The primary outcome measure was overall survival, reported separately for all patients and for those who survived over 3 months after the primary treatment.

Associations between the categorical variables were tested with the chi-squared test or the Fisher exact test, as appropriate. Survival and recurrence rates were calculated from the time of primary surgery using the Kaplan–Meier method. Log minus log plots were used to validate the proportional hazard assumption. Univariate and multivariate analyses of the factors influencing overall survival were carried out using binary logistic regression. All variables that were statistically significant in the univariate model were included in the multivariate model. Statistical analyses were performed using SPSS version 23 (IBM, Armonk, NY, USA).

The study was approved by the ethics committee of Pirkanmaa Hospital District, Tampere, Finland (R18188).

Results

A total of 386 patients fulfilled the inclusion criteria. Their median age was 83 years (range 80–96 years) and 56.2% were women. Most of the surgeries were right-sided hemicolectomy ($n = 261$, 67.6%), and two-thirds of the surgeries were laparoscopic ($n = 252$, 65.3%). 154 patients (40%) had postoperative complications with 92 (24%) patients having surgical and 62 (16%) non-surgical complications. According to the Clavien–Dindo classification, 69 (18%) patients had severe complications (Grades III–V). Reoperation was needed in 39 patients (10%), most commonly due to anastomotic

leakage ($n = 19$). Three per cent of patients who lived at home before surgery were discharged to nursing homes. Postoperative adjuvant chemotherapy was given to 80 patients (21%), the majority of whom ($n = 67$, 84%) had Stage III disease. Of patients with Stage II tumour, 7.3% (13/176) received adjuvant treatment mainly due to a pT4 tumour. The detailed data of patients' baseline and clinical characteristics as well as complications and early postoperative outcomes have been described elsewhere [8]. Of the study population, 29 patients died within 3 months after surgery, mainly due to cardiovascular causes or surgical complications. The baseline and clinical characteristics of the 357 patients who survived over 3 months after surgery are shown in Table 1.

Follow-up and survival

Of the whole cohort, a total of 232 patients (60.1%) died during the follow-up period (median follow-up 6.3 years, ranging from 1 day to 14 years). Therefore, the overall survival rate was 39.9%. The 1-year survival rate was 85% (327/386), and the 3- and 5-year rates were 66% (255/386) and 55% (211/386), respectively. The median overall survival time was 5.4 years (95% CI 4.72–6.08). For patients who survived the first 3 months after surgery ($n = 357$), the 1-, 3- and 5-year survival rates were 92%, 71% and 59%, respectively. The median survival time for these patients was 5.9 years (95% CI 5.31–6.48). Age-related survival for patients who survived over 3 months after surgery is presented in Fig. 1. The overall median survival time for patients with no complications was 5.9 years (95% CL 5.30–6.50), with mild complications 5.2 years (3.87–6.49) and with severe complications 1.8 years (0.18–3.34). The survival analysis of complications in patients who survived over 3 months after operation is shown in Fig. 2, and the respective survival proportions at 1, 3 and 5 years are shown in Table 2.

Recurrences and adjuvant chemotherapy

The recurrence rate for the whole study population was 17.6% (68 patients). Distant recurrence rate was 15%, involving liver (27 patients), lung (12 patients), peritoneum (17 patients) and pelvis (two patients). Local recurrence rate was 2.6% (10 patients). According to the Union for International Cancer Control stages, recurrences developed in 8.2%, 8.4% and 32.9% of Stage I, Stage II and Stage III tumours, respectively. The recurrence rate was 8.5% (33 patients) at 1 year, 14.7% (57 patients) at 3 years and 16.1% (62 patients) at 5 years. The median survival times with tumour Stages I, II and III in the whole study cohort were 5.9 (95% CI 4.16–7.58), 6.5 (4.67–8.37) and 3.5 years (2.04–5.01), respectively. The comparable figures for patients who survived over 3 months postoperatively were 5.9 years (95% CI 4.65–7.15) for Stage I, 7.5 years (5.89–9.19) for Stage II and 4.4 years (3.03–5.75) for Stage III.

Patients with Stage III disease who received postoperative adjuvant chemotherapy had a median survival time of 5.4 years, compared to 2.3 years for those who did not receive postoperative chemotherapy ($P = 0.001$, log-rank). The respective figures for patients who survived over 3 months after surgery were 5.4 and 3.3 years ($P = 0.025$, log-rank). The survival analysis for patients who survived over 3 months with different tumour stages (I–III) is shown in Fig. 3.

Causes for death

The most frequent causes of death within 3 months after surgery ($n = 29$) were cardiopulmonary (55%) and surgery-related (24%) factors. Of the deaths that occurred after 3 months of surgery ($n = 203$), 30% were due to colon cancer, 44% due to cardiopulmonary reasons and 10% due to dementia. The causes of death within and after 3 months of surgery are shown in Fig. 4.

Factors influencing survival

Univariate Cox regression analysis showed that higher age, living in a nursing home, diabetes, coronary disease, congestive heart failure, chronic renal insufficiency, American Society of Anesthesiologists (ASA) score ≥ 3, CCI score ≥ 6, open compared to laparoscopic operation, tumour stage and severe postoperative complications were associated with poor survival after surgery. Multivariate Cox regression survival analysis showed that higher age [hazard ratio (HR) 1.08, 95% CI 1.04–1.13, $P < 0.001$], living in a nursing home (HR 1.54, 1.03–2.30, $P = 0.034$), ASA score ≥ 4 (HR 2.62, 1.32–5.21, $P = 0.006$), CCI score ≥ 6 (HR 1.47, 1.07–2.01, $P = 0.018$), tumour Stage III (HR 1.88, 1.40–2.52, $P < 0.001$), open compared to laparoscopic surgery (HR 1.41, 1.05–1.88, $P = 0.020$) and severe postoperative complications (HR 2.11, 1.49–2.99, $P < 0.001$) were independently associated with diminished overall survival in the whole cohort. For patients who survived over 3 months after surgery these same patient-related variables, except chronic renal insufficiency and type of surgery, were significant in univariate Cox regression analysis. In multivariate Cox regression analysis age ≥ 90 years, living in a nursing home, diabetes, ASA score ≥ 4 and tumour Stage III were independently associated with diminished survival. Detailed

Table 1 Baseline and clinical characteristics of patients who survived at least 3 months after surgery.

	n, median	% (range)
Gender ratio (female/male)	205/152	57/43
Age (years)	83.0	(80–96)
80–84	233	65
85–89	96	27
≥ 90	28	8
Type of living		
Home	313	87.7
Nursing home	31	8.7
Not known	13	3.6
Aid at home		
No	145	40.6
Yes	109	30.5
Not known	103	28.9
BMI (kg/m^2)	25.0	15.4–40.6
< 25	150	42.0
25–29.9	102	28.6
30–	45	12.6
Not available	60	16.8
ASA score		
2	34	9.5
3	248	69.5
4	70	19.6
Not known	5	1.4
CCI (modified)		
4–5	227	63.6
7–12	130	36.4
Procedure		
Right-sided colectomy	250	70.0
Left-sided colectomy	93	26.0
Other colonic resection	14	4.0
Type of surgery		
Open	120	33.6
Laparoscopy	204	57.1
Conversion	33	9.2
Postoperative complications		
None	229	64.1
Minor complications (CD I–II)	83	23.2
Major complications (CD III–V)	45	12.6
Length of hospitalization (days)	7	2–58
Reoperation	32	9.0
Readmission	23	6.4
TNM stage		
1	46	12.9
2	176	49.3
3	135	37.8
Number of lymph nodes	15	0–71
Postoperative adjuvant therapy	80	22.4
Stage III (n = 135)	67	43.3

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; CD, Clavien–Dindo classification.

analysis data of patients who survived over 3 months are shown in Table 3.

Discussion

Treatment decisions for colon cancer in the aged population have become extremely important as the number of these patients rises due to increased life expectancy. The results of this register- and population-based cohort study of 386 electively operated, non-metastatic colon cancer patients aged ≥ 80 years suggest that, for physically and cognitively fit patients, surgical treatment with curative intent can lead to similar long-term survival as for younger patients. This is especially true when the patients survive the critical first 3 months after surgery.

The study hospitals had standardized protocols for treatment and follow-up based on national evidence based medicine guidelines [18], and the nationwide registers ensured comprehensive death records. There were no statistical differences in patients' baseline characteristics, operative outcomes and tumour characteristics between the four operating hospitals. Considering the older population, it was valuable that we could identify preoperative morbidity and living arrangements, although functional ability could not be clarified in detail. Supporting earlier observations [20,21], postoperative complications were common (40%) and almost half of them (45%) were severe (Grade III–V according to the Clavien–Dindo classification). As complications are a major predictor of short-term mortality [8], we intended to analyse their continued effect among the patients who survived the early postoperative period, through longer-term follow-up. Among all patients with severe complications (Clavien–Dindo III–V), 1-year and overall survival were 45% and 27.5%. However, those who survived the first three postoperative months had survival rates comparable to those with no or mild complications. Thus, preventing complications through preoperative health evaluation is essential, especially for high-risk patients [8].

In 2018, the median life expectancy for Finns aged 80 years and over was 9.9 years for women and 8.2 years for men [22]. In our study (with an average age of 83 years), the overall median survival time was 5.4 years, increasing to 5.9 years when early postoperative deaths were excluded. The 5-year survival rates (54.7% in the whole cohort and 59.1% in patients who survived over 3 months after surgery) are comparable or slightly higher than the figures reported in the EUROCARE-5 study (49% for colon cancer patients aged 75 years or older and 57% for all ages) [23]. The large SEER database study from the USA shows similar

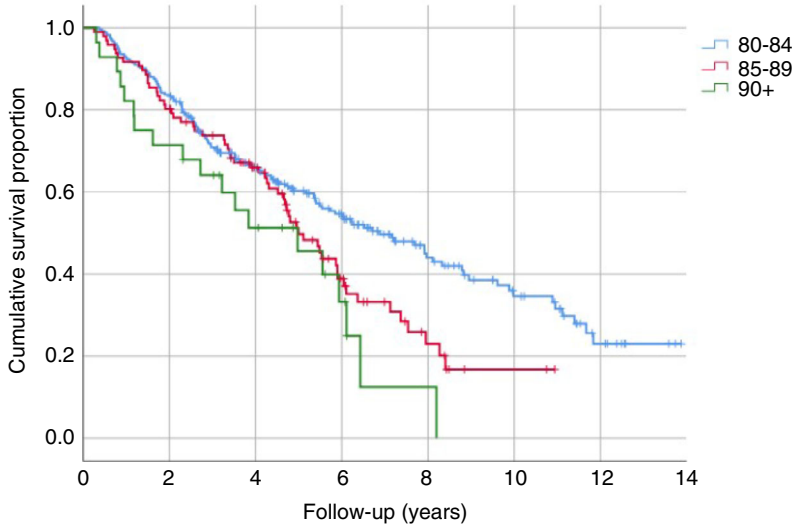

Figure 1 Kaplan–Meier analysis of age-related overall survival in patients who survived at least 3 months after surgery ($P = 0.005$, log-rank).

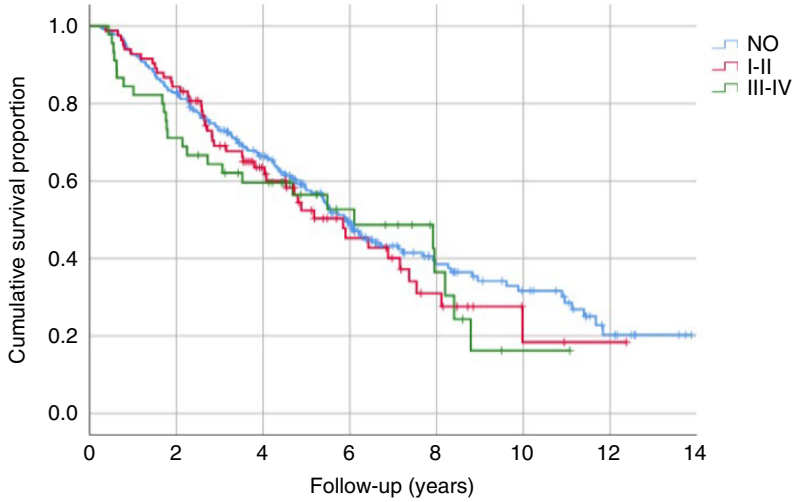

Figure 2 Kaplan–Meier analysis of overall survival in patients who survived at least 3 months after surgery with and without complications graded with Clavien–Dindo classification ($P = 0.575$, log-rank).

survival rates for Stage II rectal cancers for patients aged 80 years or over treated with resection and neoadjuvant therapy as for younger patients [24], and patients treated non-operatively had lower survival than those who underwent surgery. In an English study, which included non-operatively treated Stage I–III colorectal cancer patients over 80 years, the average life expectancy following diagnosis was 1.5 years, and only 20% of patients survived over 3 years [25]. The non-operative outcomes are as essential as surgical outcomes to patients. The authors thus suggested that cancer surgery is not beneficial for frail aged patients and has higher risks for postoperative morbidity and reduced survival than for physically and mentally fit patients. Conversely, in a recent case series study from the UK, elective surgical management of carefully selected nonagenarian (over 90 years) patients enabled the majority to return to the same functional level of care following discharge [26].

Altogether, our data and previous reports show that elderly patients who are fit enough to survive the early perioperative period have similar overall survival times to younger patients. On the other hand, severe ill-health, living in a nursing home and the occurrence of complications considerably impair long-term survival. Generally, chronic conditions and multiple morbidities increase mortality and prolonged hospitalizations in the

Table 2 Survival proportion at 1, 3 and 5 years of patients who survived at least 3 months after surgery.

	Survival proportion (%)							
	n	%	1 year	*P* value	3 years	*P* value	5 years	*P* value
Gender								
Male	152	42.6	93.4	0.337	69.7	0.556	59.2	1.000
Female	205	57.4	90.2		72.7		59.0	
Age								
80–84	233	65.3	92.7	0.163	71.2	0.605	62.2	0.238
85–89	96	26.9	91.7		74.0		54.2	
≥ 90	28	7.8	82.1		64.3		50.0	
BMI (kg/m^2)								
< 25	150	42.0	91.3	0.966	70.7	0.972	55.3	0.516
25–29.9	102	28.6	92.2		70.6		61.8	
≥ 30	45	12.6	91.1		68.9		62.2	
Type of living								
Home	313	87.7	92.0	0.729	72.2	0.098	60.1	0.051
Nursing home	31	8.7	90.3		58.1		41.9	
Aid at home								
None	145	40.6	93.8	0.751	84.1	< 0.001	73.1	< 0.001
Relatives	58	16.2	91.4		58.6		44.8	
Other	51	14.3	92.2		58.8		41.2	
Hospital admissions								
< 6 months								
No	266	74.5	91.4	0.643	70.3	0.499	58.6	0.977
One or more	85	23.8	92.9		74.1		58.8	
ASA score								
2	34	9.5	97.1	0.463	76.5	0.001	76.5	0.002
3	248	69.5	90.7		76.2		61.7	
4	70	19.6	91.4		54.3		42.9	
CCI (modified)								
4–6	302	84.6	92.1	0.434	73.8	0.023	61.9	0.016
7–12	55	15.4	89.1		58.2		43.6	
Type of operation								
Laparoscopy	204	57.2	94.1	0.140	74.5	0.312	61.8	0.282
Conversion	33	9.2	87.9		69.7		63.6	
Open	120	33.6	88.3		66.7		53.3	
Postoperative complications								
None	229	64.1	92.6	0.180	73.4	0.451	59.8	0.933
CD I–II	83	23.2	92.8		69.9		57.8	
CD III–V	45	12.6	84.4		64.4		57.8	
Tumour stage								
I	45	12.9	95.7	0.031	78.3	< 0.001	58.7	0.003
II	176	49.3	94.3		79.0		67.6	
III	135	37.8	86.7		59.3		48.1	
Postoperative adjuvant therapy (Stage III)								
No	68	50.4	83.8	0.449	51.5	0.080	39.7	0.059
Yes	67	49.6	89.6		67.2		56.7	

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; CD, Clavien–Dindo classification.

elderly [27], and severe complications are more common in patients who have preoperative hospitalizations and who live in nursing homes [28]. Complications and older age [29] are associated with lower health-related quality of life after cancer surgery. Thus, careful preoperative assessment of physical and cognitive fitness, and

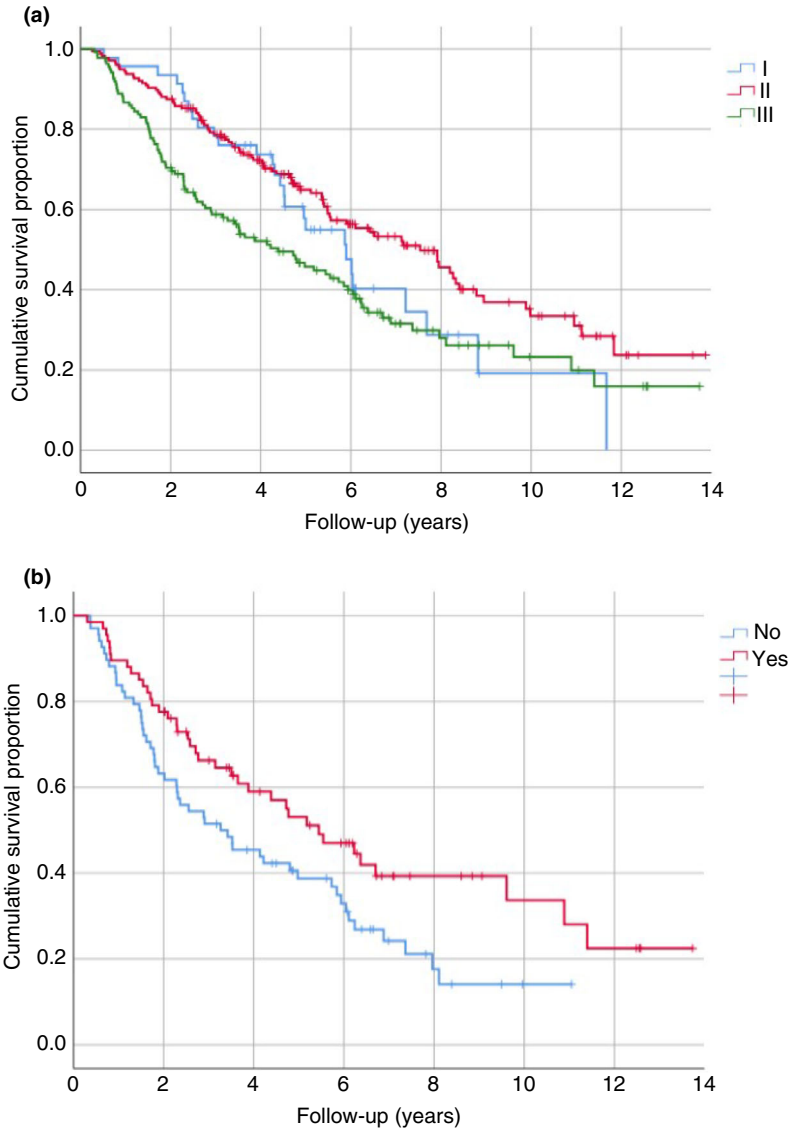

Figure 3 Kaplan–Meier analysis of overall survival in patients who survived at least 3 months after surgery, according to (a) tumour stage ($P = 0.002$, log-rank) and (b) adjuvant therapy ($P = 0.025$, log-rank).

the provision of accurate and clear information about treatment options, allows patients to participate in management decisions and contributes to good outcomes and long-term patient satisfaction and quality of life.

The leading causes of death in our cohort were cardiovascular (31%), colon cancer (28%), pulmonary (14%) and dementia (8.6%). Noticeably, colon cancer is not the most frequent cause of death in these older cancer patients. Diabetes, coronary artery disease and congestive heart failure were important predictors of mortality in very old age in a large Finnish follow-up study [27]. The same factors were significantly associated with reduced survival in our data. In the total study population, only 3.9% of patient deaths were directly related to surgery, although patients with severe surgical complications had greatly reduced median survival (3.7 months) compared to patients with cardiopulmonary causes (2.9 years) [8]. However, those patients with severe surgical complications who survived more than 3 months had similar long-term outcomes to those without or with minor complications. In contrast, a Dutch study reported that severe postoperative complications were most predictive of diminished long-term survival [30].

Studies from Spain and Italy show that laparoscopy is safe in the older population with increased comorbidity and leads to better short-term outcomes than open procedures and equivalent long-term oncological

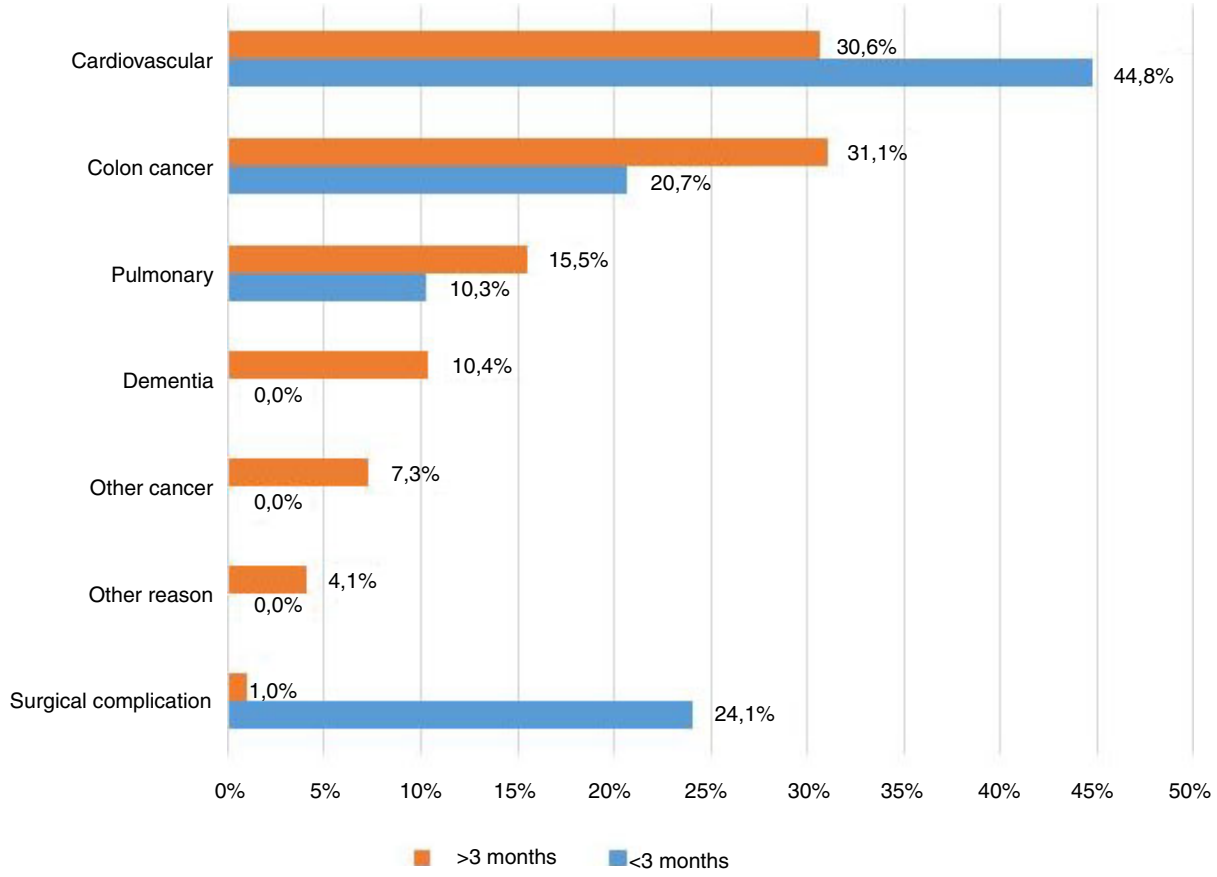

Figure 4 Causes of death within and after 3 months of surgery (n = 29 and n = 193).

outcomes [31,32]. A review article from the UK shows that age is not a risk factor or a limitation for laparoscopic colorectal surgery, and even very old patients may benefit from a minimally invasive approach [33]. In our study the overall median survival time for patients operated with a laparoscopic approach (5.8 years) was significantly better than survival after an open operation (4.4 years). The knowledge of the benefits of minimally invasive surgery has changed our study hospitals' practices, and laparoscopy is now considered the best approach for colon cancer surgery for aged patients.

Besides age, high comorbidity burden and complications, the only significant factor affecting survival was tumour stage. Long-term survival and recurrent disease depend on the stage of tumour [30]. Stage III disease is associated with diminished survival [4,30,34]. The recurrence rate was 17.6%, with Stage I 8.2%, Stage II 8.4% and Stage III 32.9%. The high proportion of Stage I recurrences may reflect the quality of individual pathology reports (lymph nodes counted 10–18 in four Stage I patients) or tumour biology. Otherwise the numbers correspond to recent studies from Sweden and Denmark [35,36]. However, the real rate of recurrences in our series may have been higher, as further investigations and treatment may have been stopped by an unwilling patient or by a physician who considered a patient too frail or unfit. Some of the patients may have died from non-cancer-related causes while having recurrences. In contrast, patients with Stage III disease receiving adjuvant chemotherapy had significantly better overall survival rate compared to patients not having postoperative therapy, comparable to recent studies [37,38]. That finding suggests that, for patients fit enough to survive radical surgery, adjuvant chemotherapy is advisable.

There are some limitations to our study. Due to its retrospective nature, detailed information on daily physical and cognitive functional activity as well as the severity of the comorbidities could not be documented. Thus, patients with better health status were likely to be selected for operative treatment. Exact long-term data of cancer recurrences was not complete, as invasive investigations may not have been performed for physically and cognitively unfit patients. However, our

Table 3 Factors influencing survival with patients who survived at least 3 months after surgery (Cox regression analysis).

	Univariate			Multivariate		
	HR	95% CI	*P* value	HR	95% CI	*P* value
Age (years)						
80–84	1					
85–89	1.45	1.06–1.99	0.020	1.29	0.91–1.83	0.148
> 90	1.96	1.20–3.20	0.007	1.97	1.14–3.40	0.015
Gender						
Female	1					
Male	1.12	0.84–1.48	0.450			
Type of living						
Home	1			1		
Nursing home	1.76	1.17–2.65	0.006	1.56	1.01–2.43	0.047
Hospital admissions ≤ 6 months						
No	1					
Yes	1.06	0.76–1.46	0.746			
BMI (kg/m^2)						
< 25	1					
25–29.9	0.89	0.63–1.25	0.506			
> 30	0.89	0.57–1.40	0.616			
Diabetes						
No	1			1		
Yes	1.45	1.05–2.01	0.026	1.56	1.07–2.27	0.022
Hypertension						
No	1					
Yes	1.06	0.80–1.41	0.672			
Coronary heart disease						
No	1			1		
Yes	1.50	1.11–2.01	0.008	0.98	0.69–1.38	0.890
Congestive heart failure						
No	1			1		
Yes	1.65	1.04–2.63	0.033	1.24	0.69–2.21	0.470
Arteriosclerosis obliterans (ASO)						
No	1					
Yes	0.710	0.22–2.27	0.563			
Renal failure						
No	1					
Yes	1.61	0.97–2.69	0.067			
Celebral stroke						
No	1					
Yes	1.49	0.99–2.26	0.057			
Atrial fibrillation						
No	1					
Yes	1.28	0.93–1.76	0.130			
Chronic pulmonary disease						
No	1					
Yes	1.38	0.61–3.11	0.442			
Rheumatic diseases						
No	1					
Yes	1.24	0.61–2.51	0.554			
Dementia						
No	1					
Yes	1.22	0.79–1.89	0.378			

Table 3 (Continued).

	Univariate			Multivariate		
	HR	95% CI	*P* value	HR	95% CI	*P* value
Other cancer						
No	1					
Prostate	1.35	0.77–2.39	0.297			
Breast	1.02	0.45–2.32	0.957			
Colorectal	1.35	0.66–2.76	0.404			
Urinary tract	0.68	0.17–2.73	0.583			
Gynaecology	0.77	0.25–2.41	0.652			
Other cancer	1.68	1.02–2.77	0.043	0.94	0.51–1.75	0.849
ASA score						
2	1			1		
3	2.22	1.23–4.02	0.008	1.93	0.99–3.75	0.053
4	3.92	2.05–7.48	< 0.001	3.27	1.53–6.99	0.002
CCI (modified)						
4–5	1			1		
6–12	1.68	1.26–2.22	< 0.001	1.52	0.99–2.34	0.055
Tumour stage						
1–2	1			1		
3	1.61	1.23–2.12	0.001	2.04	1.48–2.81	< 0.001
Type of operation						
Laparoscopy/conversion	1			1		
Open	1.35	1.02–1.78	0.038	1.37	1.00–1.88	0.051
Postoperative complications						
CD 0–II[b]	1					
CD III–V	1.17	0.78–1.77	0.450			
Surgical complication						
No	1					
Yes	1.23	0.88–1.71	0.228			
Non-surgical complication						
No	1					
Yes	1.04	0.71–1.54	0.836			

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; CD, Clavien–Dindo classification; HR, hazard ratio.

findings propose that surgery in aged patients diagnosed with colon cancer can lead to acceptable long-term outcomes, comparable with younger patients.

In conclusion, this study extends our earlier findings [8] and suggests that aged colon cancer patients who are physically and functionally fit to survive surgery can achieve acceptable long-term outcomes and survival with radical surgical treatment and additional chemotherapy. Further prospective studies are required to identify patients who are at risk of complications and able to recover from them as well as the effects of colon cancer surgery on the quality of life in long-term follow-up.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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