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ORIGINAL ARTICLE

Anastomosis technique and leakage rates in minimally invasive surgery for right-sided colon cancer. A retrospective national cohort study

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Abstract

Purpose The aim of this study was to describe the different techniques currently used in Denmark to construct right-sided ileocolic anastomoses in minimally invasive surgery, and investigate, compare and analyse the anastomotic configurations and their anastomotic leakage (AL) rates.

Methods This was a retrospective register-based, study design using prospectively collected data from the Danish Colorectal Cancer Group (DCCG) database. All patients aged 18 years or older with a malignant colorectal tumour in Denmark in the period of 1 February 2015 until 31 December 2019, and who had an elective, curative, minimally invasive right hemicolectomy (MIRH) with ileocolic anastomosis, were included.

Results Three thousand three hundred ninety-eight patients were included. The most commonly used anastomotic approach was the extracorporeal (EC) hand-sewn anastomosis (HA) with end-to-end configuration (59%) and the second most used was the EC stapled anastomosis (SA) side-to-side configuration (20%). The latter had a higher AL rate compared with the hand-sewn technique (3.8% vs. 1.3%), and had significantly higher odds ratio (OR) (OR: 2.85, 95% CI: 1.56–4.92, $p<0.0001$) for AL in the adjusted regression model. The least used technique was the end-to-side HA which also had a significantly higher OR (OR: 3.05, 95% CI: 1.30–7.15, $p=0.010$) compared with the end-to-end HA. Smoking was an independent factor associated with higher OR for AL.

Conclusion The ileocolic end-to-end HA was the most commonly used technique and had the lowest AL rate in MIRH for colon cancer. The EC SA technique and tobacco smoking were independent risk factors for leakage of the ileocolic anastomosis.

Keywords Anastomosis · Colon cancer · Extracorporeal · Ileocolic · Intracorporeal · Laparoscopic

Introduction

Anastomotic leakage (AL) is a grave complication in colorectal surgery, associated with both morbidity and mortality [1, 2]. Approximately one third of all colorectal resections are right hemicolectomies (RH) [2], and the AL rate after RH amounted to 8% in the largest and most recent international snapshot audit [1]. The standard approach to RH nowadays is minimally invasive surgery (MIS) with construction of an ileocolic anastomosis to restore bowel continuity. Traditionally, the ileocolic anastomosis is constructed outside the abdomen as either a hand-sewn (HA) or stapled (SA) extracorporeal anastomosis (EC), but recent technical improvements have made intracorporeal (IC) anastomosis possible.

What does this paper add to the literature? This paper reports in detail the types of ileocolic anastomoses used in Denmark over the years 2015–2019 in an attempt to elucidate any association between the construction technique and subsequent anastomotic leakage.

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The relative safety of the SA and HA anastomosis is debated. A Cochrane review from 2011 found a significantly lower AL rate in ileocolic SA (2.5%) than in ileocolic HA (6.0%) [3]. On the other hand, the European Society of Coloproctology (ESCP) made an international snapshot audit in 2015 describing ileocolic anastomoses and showed a significantly higher AL in SA (8.5%) compared with HA (7.4%) [1], a finding also reported by others [4, 5].

Several series from dedicated centres using the IC anastomosis technique have been published. No difference in the relative risk of AL was found in IC and EC anastomoses in a recent systematic review of laparoscopic RH for both benign and malignant diseases including 3755 patients [6]. In another recent systematic review [7], however, the IC technique had a significantly lower overall complication rate, including a significantly lower AL rate with 1.3% in the IC group versus 2.9% in the EC group.

The primary aim of this study was to describe the different techniques used to construct right-sided ileocolic anastomoses in MIS in Denmark over a 5-year period, and their leakage rates. The secondary aim was to investigate possible factors associated with AL.

Method

Study design

This was a retrospective register-based study design using prospectively collected data from the Danish Colorectal Cancer Group database (DCCG). Since 2001, the DCCG database has prospectively registered more than 95% of all patients ≥ 18 years with an incident colorectal cancer in Denmark [8]. Details concerning the anastomotic technique, surgical approach and anastomotic configuration have been registered since 1 February 2015. Data from the DCCG database were received in January 2021.

Patients and variables

All patients with right-sided colon cancer, and who had an elective, curatively intended minimally invasive right hemicolectomy (MIRH) with ileocolic anastomosis, were available for inclusion. The study period was 1 February 2015 until 31 December 2019. Patients with conversion to open surgery and patients receiving a stoma were not of interest. Patients with missing information regarding the anastomosis, or with obvious misclassification of their anastomotic configuration, were excluded. Furthermore, we focused on the five most common anastomosis configurations (HA end-to-end, HA end-to-side, HA side-to-side, EC SA side-to-side and IC SA side-to-side) and excluded patients with other configurations. The number of patients in the DCCG database during the study period determined the sample size.

The quantitative variables were defined by the DCCG, and categorical variables included were surgical operative approach (laparoscopic or robotically assisted), procedure (RH or extended-RH), anastomotic technique (HA or SA), anastomotic approach (IC or EC) and anastomotic configuration (end-to-end, end-to-side, side-to-side). Data on patient characteristics such as sex (male or female), age (in years), tumour location (caecum, ascending colon, right colonic flexure or transverse colon), tobacco use (never or former, active smoker), alcohol consumption (≤ 14 or > 14 units per week), American Society of Anesthesiologists (ASA) score (I, II, III or IV) and World Health Organization (WHO) performance status (0, 1, 2, 3 or 4) were extracted from the database.

Important definitions used in this study

AL was defined as a failure in the integrity of the anastomosis. The severity of AL was graded and registered in the database according to the impact on clinical management, as proposed by the International Study Group of Rectal Cancer [9]. Grade A is a subclinical or radiological AL with no change of management, grade B is a clinical AL with local peritonitis managed without operation, and grade C is a clinical AL with diffuse peritonitis managed operatively. All grades were coded as AL in our study.

Anastomoses were classified as SA or HA based on the technique used when joining the enterotomies. Furthermore, it was assumed that all HA were extracorporeal and all IC were stapled. Patients registered in the database as 'functional end-to-end', i.e. EC SA, were classified as EC SA with side-to-side configuration [10].

Statistical methods

Data are presented in tables and text as number of observations and proportions in percent. The Clopper and Pearson method [11] was used to calculate the 95% confidence interval (95% CI) for all AL rates which are presented in text. Comparison between categorical patient characteristics and AL were analysed with the chi-square (χ^2) test or the Fisher's exact test depending on expected observation size as appropriate. The distribution of continuous data (age and body mass index) was visually determined by histograms, and comparison was analysed with the Mann–Whitney *U* test (2 independent groups) and with the Kruskal–Wallis test (if more than 2 independent groups). The number of unknown observations, if any, is presented in tables for each variable. Imputation was not done, and unknown values were included in statistical analysis regarding AL in order not to reduce the number of observations with the outcome in

further regression model building. Baseline characteristics associated with AL in the univariable analysis with a significant level ≤ 0.10 were included as independent variables to AL in a multivariable logistic regression model. The fit of the final model was tested with the Hosmer and Lemeshow test [12], and the area under the receiver operating characteristic (ROC) [13]. Results from regression analysis are presented as odds ratios (OR) with 95% CI. p values < 0.05 were considered statistically significant. Statistical analysis was performed using Stata version 17/BE (StataCorp, 4905 Lakeway Drive, College Station, Texas, USA).

This report was written according to the STROBE guidelines [14].

Results

In total, 3690 patients were identified in the DCCG database as subjected to curatively intended MIRH with an anastomosis, and 3398 patients were included according to the eligibility criteria. Exclusion of patients is shown in Fig. 1.

The median age was 73 years, and the majority of the patients were non- or former smokers, drank less than 14 units of alcohol per week, were classified as WHO performance status 0–1 and the median body mass index (BMI) was 26 kg/m^2. The conventional laparoscopic technique was the most frequent surgical approach. All details are listed in Table 1.

HA (72%) was the most commonly used technique, and end-to-end was the most preferred (59%) configuration followed by the side-to-side configuration (35%). AL was seen in 73 patients (2.1%, 95% CI: 1.7–2.7), and four had grade A (5%), five had grade B (7%) and 68 (88%) of them had a grade C leakage. The anastomoses were broken down in 57 patients (78%). The median time from surgery to leakage was 6 days (interquartile range: 3–11). The 90-day postoperative mortality was significantly higher in the group with AL (14.7%) compared to the group without AL (1.9%) ($p < 0.0001$).

EC HA with end-to-end configuration had the lowest leakage rate (1.3%, 95% CI: 0.8–1.9). In contrast, EC SA with side-to-side configuration, which was the second most used anastomosis (20%), had the highest leakage rate (3.8%, 95% CI: 2.5–5.5). Only 8% of the anastomoses were configured as IC SA side-to-side. The leakage rate in this group was 2.5%, 95% CI: 1.0–5.2, and was similar to that seen in EC HA with side-to-side configuration (2.6%, 95% CI: 1.0–5.6). EC HA end-to-side configuration had a high leakage rate of 3.7% (95% CI: 1.5–7.4) (Table 2). In a pooled analysis, no difference in AL rates was seen between all EC HA (1.64, 95% CI: 1.2–2.2) compared with IC SA (2.54, 95% CI: 1.03–5.20) ($p = 0.282$) nor between EC (2.1%, 95% CI: 1.6–2.7 and IC (2.5%, 95% CI: 1.0–5.2) ($p = 0.643$). The annual trends of the different anastomosis approaches, techniques and configuration are illustrated in Fig. 2.

Current smokers had a higher leakage rate (3.7%, 95% CI: 2.2–5.7) compared with non-smokers (1.7%, 95% CI: 1.2–2.2), and smoking status was associated with AL ($p = 0.001$). None of the other patient characteristics were significantly associated with AL, except for the anastomosis configuration ($p = 0.002$) (Table 2). Both the EC SA side-to-side configuration (OR: 2.85, 95% CI: 1.65–4.92,

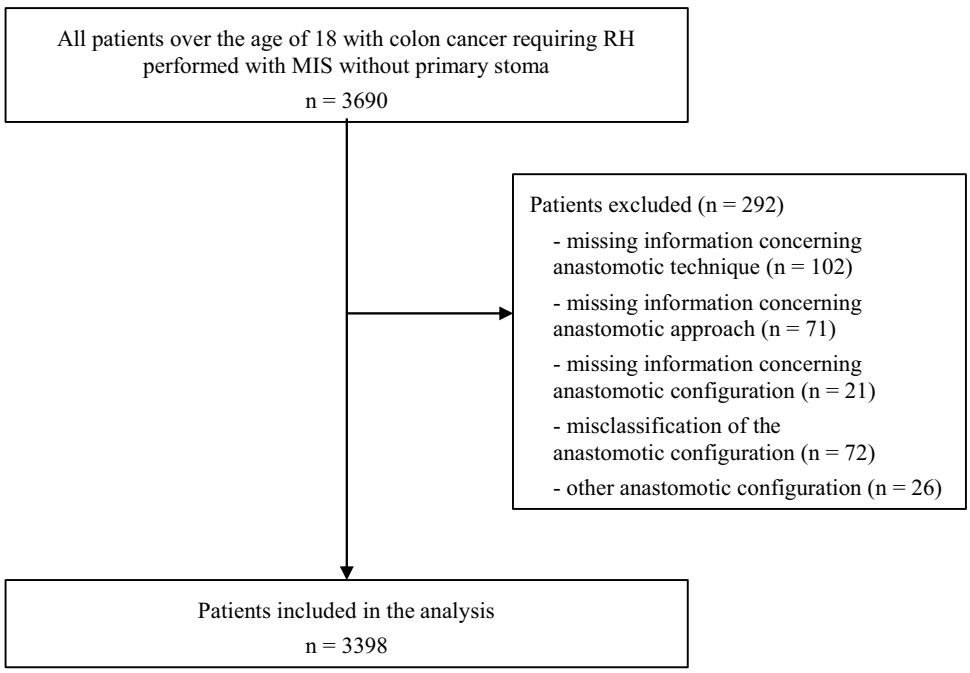

Fig. 1 Flow diagram showing the inclusion of patients with right-sided colon cancer in Denmark requiring right hemicolectomy (RH) performed as minimally invasive surgery (MIS) without a primary stoma in the years 2015–2019

Table 1 Patient characteristics of 3398 patients over the age of 18 who had a right-sided hemicolectomy performed as minimally invasive surgery due to colonic cancer in Denmark in 2015–2019. Patients are grouped by the configuration of their anastomosis

	Extracorporeal				**Intracorporeal**		
	Hand-sewn			**Stapled**	**Stapled**		
	End-to-end $n=2011$	**End-to-side** $n=191$	**Side-to-side** $n=230$	**Side-to-side** $n=690$	**Side-to-side** $n=276$	***p***	**All patients** $n=3398$
Age in years, median (IQR)	72 (67–79)	75 (67–79)	73 (67–80)	72 (66–78)	73 (68–78)	0.333	73 (67–79)
Body mass index, kg/m^2 median (IQR)	25 (23–29)	26 (23–30)	25 (23–29)	25 (23–28)	26 (23–30)	0.047	26 (23–29)
Unknown body mass index (*n*, %)	24 (1.2)	1 (0.5)	5 (2.17)	26 (3.8)	5 (1.8)		61 (1.8)
Sex, *n* (%)							
Male	890 (44.3)	94 (49.2)	107 (46.5)	298 (43.2)	145 (52.5)	0.055	1534 (45.1)
Female	1121 (55.7)	97 (50.8)	123 (53.5)	392 (56.8)	131 (47.5)		1864 (54.9)
Tumour location, *n* (%)						0.005	
Coecum	739 (36.7)	68 (35.6)	99 (43)	282 (40.9)	105 (38.0)		1293 (38.1)
Ascending colon	838 (41.7)	92 (48.2)	99 (43)	262 (38.0)	111 (40.2)		1402 (41.3)
Right colonic flexure	236 (11.7)	12 (6.3)	21 (9.1)	82 (11.9)	44 (15.9)		395 (11.6)
Transverse colon	198 (9.8)	19 (9.9)	11 (4.8)	64 (9.3)	16 (5.8)		308 (9.1)
Smoker, *n* (%)						0.301	
Current	294 (14.6)	26 (13.6)	36 (15.7)	120 (17.4)	36 (13.0)		512 (15.1)
Non-smoker (including former smoker)	1586 (78.9)	162 (84.8)	178 (77.4)	530 (76.8)	226 (81.9)		2682 (78.9)
Unknown[a]	131 (6.5)	3 (1.6)	16 (7.0)	40 (5.8)	14 (5.1)		204 (6.0)
Alcohol consumption, *n* (%)						0.758	
< 14 beverages weekly	1673 (83.2)	170 (89.0)	196 (85.2)	575 (83.3)	235 (85.1)		2849 (83.8)
> 15 beverages weekly	210 (10.4)	15 (7.9)	24 (10.4)	72 (10.4)	26 (9.4)		347 (10.2)
Unknown[a]	128 (6.4)	6 (3.1)	10 (4.3)	43 (6.2)	15 (5.4)		202 (5.9)
ASA, *n* (%)						0.125	
I	382 (19.0)	31 (16.2)	36 (15.7)	131 (19.0)	33 (12.0)		613 (18.0)
II	1082 (53.8)	107 (56.0)	129 (56.1)	391 (56.7)	158 (57.2)		1867 (54.9)
III–IV	537 (26.7)	53 (27.7)	64 (27.8)	164 (23.8)	82 (29.7)		900 (26.5)
Unknown[a]	10 (0.5)	0 (0.0)	1 (0.4)	4 (0.6)	3 (1.1)		18 (0.5)
WHO performance status, *n* (%)						0.007	
0	124 (61.7)	138 (72.3)	169 (73.5)	434 (62.9)	159 (57.6)		214 (63.0)
1	486 (24.2)	36 (18.8)	44 (19.1)	182 (26.4)	74 (26.8)		822 (24.2)
≥ 2	190 (9.4)	15 (7.9)	12 (5.2)	62 (9.0)	33 (12.0)		312 (9.2)
Unknown[a]	95 (4.7)	2 (1.0)	5 (2.2)	12 (1.7)	10 (3.6)		124 (3.6)
Operative approach, *n* (%)						< 0.0001	
Laparoscopic	1832 (91.1)	190 (99.5)	193 (83.9)	635 (92.0)	167 (60.5)		3017 (88.8)
Robotically assisted	179 (8.9)	1 (0.5)	37 (16.1)	55 (8.0)	109 (39.5)		381 (11.2)
Procedure, *n* (%)						< 0.0001	
Right hemicolectomy	1592 (79.2)	165 (86.4)	197 (85.7)	582 (84.3)	195 (70.7)		2731 (80.4)
Extended right hemicolectomy	419 (20.8)	26 (13.6)	33 (14.3)	108 (15.7)	81 (29.3)		667 (19.6)

IQR interquartile range, *ASA* American Society of Anesthesiologists, *WHO* World Health Organization. [a]Unknown values were omitted from statistical comparison between groups

$p < 0.0001$) and the EC HA end-to-side (OR: 3.05, 95% CI 1.30–7.15, $p = 0.010$) were significantly associated with AL in the logistic regression model adjusting for the patient tobacco use and with the EC HA end-to-end configuration as reference. Tobacco use was also an independent factor in the multivariable logistic regression model (Table 3).

Discussion

There are several possible combinations when deciding the configuration of the ileocolic anastomosis in patients having MIRH. The most commonly used combination in our study was the laparoscopic operative approach with

Table 2 Patient characteristics and association with anastomotic leakage after minimally invasive right-sided hemicolectomy

	Leakage $n=73$	**No leakage** $n=3325$	p
Age in years, median (IQR)	73 (67–79)	73 (67–79)	0.988
Body mass index, kg/m^2 median (IQR)	26 (23–28)	26 (23–29)	0.929
Sex, *n* (%)			0.627
Male	35 (2.3)	1499 (97.7)	
Female	38 (2.0)	1826 (98.0)	
Tumour location, *n* (%)			0.894
Coecum	27 (2.1)	1266 (97.9)	
Ascending colon	31 (2.2)	1371 (97.8)	
Right colonic flexure	7 (1.8)	388 (98.2)	
Transverse colon	8 (2.6)	300 (97.4)	
Smoker, *n* (%)			0.001
Non-smoker (including former smoker)	45 (1.7)	2637 (98.3)	
Current	19 (3.7)	493 (96.3)	
Unknown	*9 (4.4)*	*195 (95.6)*	
Alcohol consumption, *n* (%)			0.222
< 14 beverages weekly	56 (2.0)	2793 (98.0)	
> 15 beverages weekly	10 (2.9)	337 (97.1)	
Unknown	*7 (3.5)*	*195 (96.5)*	
ASA, *n* (%)			0.445
I	11 (1.8)	602 (98.2)	
II	38 (2.0)	1829 (98.0)	
III–IV	24 (2.7)	876 (97.3)	
Unknown	*0 (0.0)*	*18 (100.0)*	
WHO performance status, *n* (%)			0.175
0	38 (1.8)	2102 (98.2)	
1	25 (3.0)	797 (97.0)	
≥ 2	8 (2.6)	304 (97.4)	
Unknown	*2 (1.6)*	*122 (98.4)*	
Operative approach, *n* (%)			0.945
Laparoscopic	65 (2.2)	2952 (97.8)	
Robotically assisted	8 (2.1)	373 (97.9)	
Procedure, *n* (%)			0.842
Right hemicolectomy	58 (2.1)	2673 (97.9)	
Extended right hemicolectomy	15 (2.2)	652 (97.8)	
Anastomotic approach, technique and configuration, *n* (%)			0.002
EC HA end-to-end	27 (1.3)	1984 (98.7)	
EC HA end-to-side	7 (3.7)	184 (96.3)	
EC HA side-to-side	6 (2.6)	224 (97.4)	
EC SA side-to-side	26 (3.8)	664 (96.2)	
IC SA side-to-side	7 (2.5)	269 (97.5)	

IQR interquartile range, *ASA* American Society of Anesthesiologists, *WHO* World Health Organization, *EC* extracorporeal, *IC* intracorporeal, *HA* hand-sewn anastomosis, *SA* stapled anastomosis

an EC HA anastomosis with an end-to-end configuration. The AL rate was overall 2.1% which was lower than reported in two systematic reviews for ileocolic anastomosis [3, 15], however, similar to other more recent studies from Sweden, Denmark and Italy [4, 5, 16]. Risk factors for AL have been studied extensively, and tobacco use, diabetes and SA are considered general risk factors for AL [17, 18].

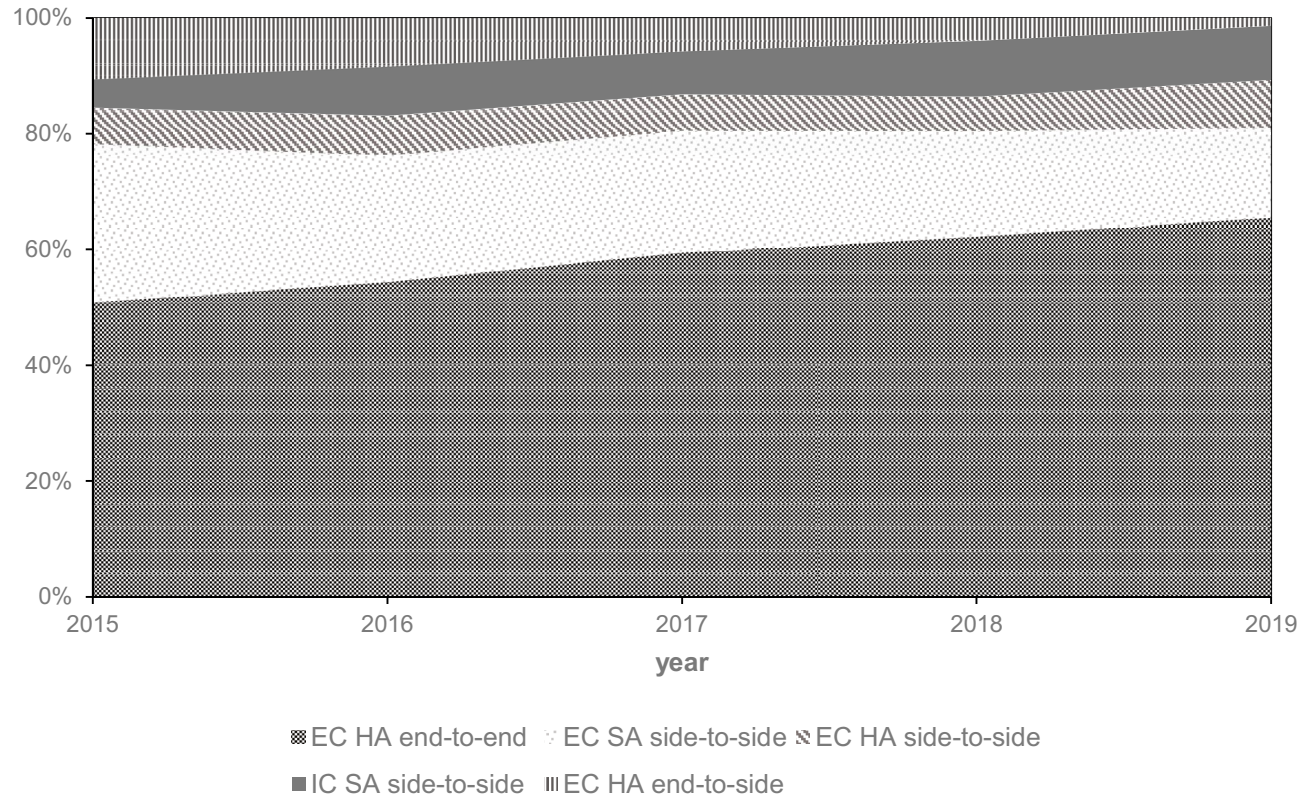

Fig. 2 Trends of the different anastomotic approaches and techniques during the study time. The extracorporeal (EC) hand-sewn anastomosis (HA) has been the most common configuration over time. The usage of the intracorporeal (IC) stapled anastomosis (SA) is slowly increasing over the years, while a decrease of the usage of the EC HA end-to-side and the EC SA side-to-side. The annual percentage of the EC HA side-to-side is rather stable in the study period

Stapled vs. hand-sewn technique

Several studies have investigated the importance of technical aspects related to the surgical approach as well as the construction of the anastomosis itself. A Cochrane review from 2011 concluded that SA had a lower rate of AL compared to HA. However, newer studies have shown the opposite [1, 4, 5]. In 2014, Gustafsson et al. compared AL

Table 3 Results from the univariable and multivariable logistic regression models with anastomotic configuration and smoking status as independent factors to the outcome anastomotic leakage

	Univariable logistic regression				Multivariable logistic regression			
	OR	**Std. Err**	***p***	**95% CI**	**OR**	**Std. Err**	***p***	**95% CI**
Anastomotic configuration								
EC HA end-to-end	1.00				1.00			
EC HA end-to-side	2.80	1.21	0.017	1.20–6.51	3.05	1.32	0.010	1.30–7.15
EC HA side-to-side	1.97	0.90	0.138	0.80–4.81	1.94	0.89	0.147	0.79–4.77
EC SA side-to-side	2.88	0.80	< 0.0001	1.67–4.97	2.85	0.80	< 0.0001	1.65–4.92
IC SA side-to-side	1.91	0.82	0.131	0.82–4.43	1.99	0.86	0.110	0.86–4.62
Smoker								
Non-smoker (including former smoker)	1.00				1.00			
Current	1.83	0.62	0.076	0.94–3.56	2.22	0.62	0.004	1.28–3.84
Unknown	2.61	1.11	0.023	1.14–5.99	2.90	1.10	0.005	1.39–6.06

OR odds ratio, *Std.Err* standard error, *95% CI* 95% confidence interval, *EC* extracorporeal, *IC* intracorporeal, *HA* hand-sewn anastomosis, *SA* stapled anastomosis

Model statistics in the final multivariable model: Hosmer–Lemeshow test $p = 0.252$, area under the receiver operating characteristic (ROC), 0.671

rate in 3428 malignant right hemicolectomies in a Swedish population based study. The results showed a significantly higher risk of anastomotic leakage in SA compared to HA (2.4% vs. 1.2%, $p = 0.006$) [5]. Nordholm-Carstensen et al. showed similar results, in a national Danish cohort study, derived from the DCCG database, where 1414 patients were included, showing significantly higher leakage rates in SA (5.4%) compared to HA (2.4%) [4]. Ultimately, Frasson et al. published a prospective observational study, which included 1102 patients that showed that the SA technique was an independent risk factor in grade C anastomotic leakages [2]. A Danish single-centre retrospective study with 445 patients, who had undergone RH for both benign and malignant cause, reported AL in 22 patients (4.9%). SA was associated with an increased AL rate (SA 8.1% vs. HA 3.2%) and almost half of the SA (6 out of 13 patients) became ischemic compared to (one in nine patients) in the HA group [17]. Our study confirmed that an EC SA had a significantly higher leakage rate compared to the commonly used EC HA with end-to-end configuration, also when adjusting for tobacco usage as confounding variable.

Intra- vs. extracorporeal construction

No significant difference in AL rates (IC 3.7% vs. EC 3.0%) was reported in laparoscopic ileocolic IC and EC anastomoses in a meta-analysis from 2016 including 1492 colon cancer patients. The IC anastomoses were all performed as SA; however, EC anastomosis were SA or HA [19]. A recent prospective multicentre study compared IC side-to-side with EC side-to-side ileocolic anastomoses in 1225 patients undergoing MIS. No difference in AL was reported (EC 1.6% vs. IC 2.4%) [16]. This is in line with the findings from a multicentre retrospective propensity score-matched comparison of IC and EC anastomoses for benign and malignant MIRH. Lower complication rates in the IC group were reported; however, no difference in the AL rates between IC (0%) and EC anastomoses (0.9%) was found [20]. In our study, no significant difference was found in AL between IC SA side-to-side compared to the EC HA end-to-end, nor between IC SA compared to EC HA.

Robotic vs. traditional laparoscopy

A recent systematic review and meta-analysis, including 15 studies and 2280 patients, investigated AL rates in laparoscopic (3.1%) versus robot-assisted (1.7%) colon resections (both right and left-sided colon cancer). A significant difference favouring the robot-assisted technique was found. This was also consistent in a supplementary meta-analysis including information regarding whether the anastomosis was made IC or EC, and also in a subgroup analysis with data from nine studies with only RH patients. The AL rate in the nine studies varied between 0–4.5% and 0–10% in robotic and laparoscopic RH procedures, respectively [21]. We did not find any difference in AL rate when comparing laparoscopic (2.2%) vs. robot-assisted (2.1%) RH. Differences in patient population, study design and definition of outcome may explain these conflicting results.

Time trends

Considering the growing interest in intracorporeal anastomoses [22, 23], it was somewhat surprising that this technique constituted less than 10% of the anastomoses constructed, and with only a very limited increase over the 5 years studied (Fig. 2). Use of the most traditional technique—end-to-end EC HA—on the other hand, increased steadily over the years. This may be to the benefit of the patients, since our study suggested this anastomosis technique to be the safest in terms of leakage. Formal comparisons of IC and EC approaches have shown conflicting results, however.

Another trend seen was the decrease in the usage of EC HA end-to-side in 5-year study period, with only 12 (1.5%) patients having this type of anastomosis in 2019. We believe this is positive, since our data suggest that the EC HA end-to-side had a significantly higher OR of AL compared to the EC HA end-to-end configuration.

Strengths and limitations

A strength of this study was the register-based design with a nationwide cohort with literally all patients diagnosed with colon cancer in Denmark during the study period. This has resulted in a rather large cohort compared with other studies, improving statistical power and minimizing selection biases. On the other hand, the statistical analyses were challenged by the overall low AL rates in our study population. Information regarding whether the side-to-side anastomosis configuration was iso- or antiperistaltic was not available in the DCCG database and thus not investigated in this study. Nonetheless, this has not been shown to be associated with AL in the ileocolic anastomosis as reported by others [16]. Statistically significant differences between the anastomosis configuration groups regarding tumour location and performance status were found (Table 1), but none of these variables were significantly associated with AL or with the risk factors for AL found in the adjusted analysis. This would argue against any bias due to these differences. Finally, incomplete follow-up after discharge from hospital or underreporting of complications by the treating hospitals may potentially be the most important limitations

of this study among other well-known limitations related to national database studies. However, a validation of the DCCG database was published in 2020 showing 97% data completeness of surgical complications such as AL [24], and thus, we believe our results are trustworthy.

Conclusions

The most commonly performed ileocolic anastomosis in patients undergoing MIRH for colon cancer in Denmark between 2015 and 2019 was the EC HA with end-to-end configuration. This was the anastomosis with the lowest frequency of AL. EC SA and tobacco smoking were independent risk factors for AL in ileocolic anastomosis.

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Declarations

Ethics approval There were no ethical considerations in this register study. The study was approved by the Danish Data Protection Agency in Regional committee with journal number 19/26020.

Patient consent Not relevant.

Permission to reproduce material from other sources Not relevant.

Conflict of interest The authors declare no competing interests.

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