



Prevention and management of anastomotic leakage after colorectal resection: evolving trends among Italian surgeons. A SICCR survey

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Abstract

Anastomotic leakage (AL) remains one of the most feared complications after colorectal resection. Although several strategies have been introduced in the fields of AL prevention, diagnosis and management, their application in clinical practice is still to be assessed. A 26-item-questionnaire was administered between December 2023 and March 2024 to residents in general surgery and surgeons to analyse the actual clinical practice in Italy, in general and with respect of surgical experience in colorectal surgery. A total of 414 responses were analyzed. Most respondents were general surgeons/residents working in public or university hospitals; over one-half had limited surgical experience (<50 colectomies). Regarding low colo-rectal anastomosis techniques, Knight-Griffen technique (44.0%) and hand-sewn colo-anal anastomosis (37.4%) were the most commonly reported. “Preventive” measures included reinforcement sutures (29.7%) and dog-ear avoidance procedures (21.7%); among intraoperative tests, hydropneumatic leak test (94.9%), “rings” check (87.9%) and indocyanine green fluorescence (61.8%) were widely used. Protective stomas were created selectively in 52.4% of cases, with ileostomy largely preferred (93.9%). Despite ERAS recommendations, drains were frequently placed, particularly after anterior resection (73.7%). In the case of paucisymptomatic leak, conservative management was preferred (73.4% for ileo-colic, 65.9% for colorectal), at times associated with endoscopic procedures (15.2%). Decisions regarding diverting stomas or Hartmann’s procedures were mainly driven by clinical presentation rather than AL size. Endoscopic treatments, especially intracavitary “sponge” placement, have gained widespread acceptance. This survey highlights partial adoption of current guidelines. Although traditional practices, including drainage placement, persist, conservative and endoscopic approaches are increasingly adopted in the management of AL.

Keywords Anastomotic leak · Diagnosis · Management · Colorectal surgery

Introduction

Anastomotic leakage (AL) is a specific, feared early complication of colorectal resection and is responsible of significant morbidity and mortality, ranging 20–35% [1, 2], and 2–16% [2–5] respectively.

AL occurrence and its severity have been associated with several factors, including operative setting (election/emergency), surgical indication, type of resection and site of the anastomosis (right colectomy, transverse colectomy, sigmoidectomy-left colectomy, anterior resection) [6–10], comorbidities and systemic therapy, including

immunosuppression/diabetes, and voluptuous behaviours, such as cigarette smoking [3, 9, 11, 12].

With the purpose of reducing AL rate, procedures and maneuvers aimed at verifying the appropriateness of the anastomosis’ technique and the correct vascularization of anastomotic stumps have been introduced, including the administration of indocyanine green [13, 14].

Anastomosis technique has also evolved through years, with an increasing role played by mechanical stapling [15–17], and still nowadays a preminent role is played by double stapling procedure, so-called Knight-Griffen technique [18]. Several techniques, manoeuvres and tricks have been proposed to reduce AL rate [19–22].

Moreover, the use of perianastomotic drains achieve an AL early diagnosis and to potentially temper its consequences, is nowadays challenged by recently introduced fast track protocols, including ERAS [23], but is seemingly still largely adopted.

In the case AL eventually occurs, its management is also evolving, with several options alternative to traditional re-do or salvage surgery such as mini-invasive laparoscopic lavage/drainage, imaging-guided radiologic techniques [24–29] and endoscopic procedures, including trans-anastomotic drain positioning, stenting, and suturing/clipping [30–32]. Last, colonic transit diversion by (ileal or colonic) stoma has still a pivotal role in left-sided colorectal resections, as it is traditionally seen as mean of AL “prevention” if performed intraoperatively (mostly in anterior resections) or as a possible treatment of significant but not major post-operative AL [9, 29, 33, 34].

Although all those efforts, AL did not find any definitive solution over the past five decades and remains the main issue of colorectal resective surgery [35, 36], as AL is still reported in 3–8% of cases overall [37, 38], and with even higher rate after low rectal resections [9, 39].

In the last two decades, guidelines [40–42] and scoring systems [9, 43–45] have been proposed in order to define the correct preparation, technique and management of colorectal surgery, and to identify patients at high risk of developing an AL, to be possibly managed differently. Unfortunately, surveys based on national registry databases [46–49] show that clinical practice is not evolving as generally recommended, probably also owing to several factors, including difficult AL multidisciplinary management in an emergency setting, unavailability of latest technology in peripheral hospitals, and an increasing trend towards defensive medicine by general surgeons during their duties.

The present survey is aimed at an appraisal of actual clinical practice in AL prevention, diagnosis and management in the early 2020s, in order to verify the real spread of recent recommendations and the progressive abandonment of nowadays unjustified behaviors. As a secondary purpose, the present analysis is aimed at identifying different attitudes associated with clinical experience, by stratifying survey responders in young (residents/within 5 years from residency) and expert surgeons.

Methods

The survey was carried out between December 2023 and March 2024 by the Colorectal Emergency Section of the Italian Society of Colorectal Surgery (SICCR) and the data were collected using an online questionnaire by Google Forms. This survey, named “Taboos in emergency colorectal

surgery – Section: anastomotic leak”, aims to explore surgeons’ attitude in AL prevention, diagnosis and management, either in an elective or emergency setting, in real life, regardless of the currently available guidelines and recommendations. The purpose of the survey was explained to all respondents with a brief introduction, and respondents were asked to sign a privacy policy consent on a voluntary basis. Both general surgery residents and certified surgeons with various experience in general and colorectal surgery were considered eligible for the survey.

Responders were invited to answer a 26-item-questionnaire divided into six sections: General Information, workplace and personal experience in colorectal surgery (Q1-Q10); Technique of low anastomosis (Q11); Intraoperative “tricks & checks” for leak prevention (Q12-Q13); Indication and technique for stoma (Q14-Q16); Drain management (Q17-Q19); Leak management (Q20-Q26) (Table 1).

Answering to all questions was mandatory to complete the survey. Survey administration to surgeons was performed by mailing lists, instant message services, and the official social media accounts of the Italian Society of Colorectal Surgery (Società Italiana di Chirurgia ColoRet-tale, SICCR) on Facebook, Instagram, and LinkedIn. A reminder was mailed two, four and six weeks after the first mailing. All respondents were informed that the results of the survey would have been used for further statistical evaluation and scientific publication. Anonymity was guaranteed by study design. After the closing date for questionnaire submissions, results were downloaded as a comma separated values (CSV) and analysed by using Excel (Microsoft Corporation, Redmond, USA). Results of the survey were reported according to the Checklist for Reporting Results of Internet ESurveys (CHERRIES) guidelines [50].

Statistical analysis

Collected data were processed, and results were summarized as frequencies (no.) and percentages (%), separately for each question. A further stratification of the outcomes was obtained dividing the responses into one class of experience according to number of colectomies performed (≤ 50 vs. ≥ 51). All the data were reported in contingency tables for subsequent inferential analysis. Statistical analyses were performed using the commercial software “SPSS” (IBM SPSS Statistics for Windows [Version 28]. Armonk, NY: IBM Corp.), the open source statistical system “R” (R Core Team. (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: <https://www.R-project.org/>), and the freeware package of statistical programs for epidemiologists “Winpepi” (Abramson, J. H. (2016). WinPepi: Computer

Table 1 Questions of the survey

General Information, personal experience and workplace workload in colorectal surgery	Q1	Gender
	Q2	Years of experience
	Q3	Workplace activity (colorectal resections per year)
	Q4	Setting of workplace
	Q5	Hospital with emergency (ER, emergency surgery) activities (Y/N)
	Q6	Hospital with intensive care unit (Y/N)
	Q7	Hospital with interventional radiology (Y/N)
	Q8	Workplace region in Italy
	Q9	Number of colectomies performed as operating surgeon
	Q10	Number of laparoscopic procedures performed as operating surgeon
Technique of low anastomosis	Q11	Ultra-low anastomosis (≤ 2 cm from the dentate line): which surgical technique?
Intraoperative “Tricks & Checks” for Leak Prevention	Q12	Prevention of colorectal fistula: which strategy?
	Q13	Prevention of colorectal fistula: which intra-operative leak test?
Indication and technique for stoma	Q14	Protective ileostomy/colostomy after ‘ideal’ mechanical anterior resection (Knight–Griffen technique)
	Q15	After anterior resection with mechanical colorectal anastomosis (Knight–Griffen), a ostomy is planned. Which technique?
	Q16	After anterior resection with mechanical colorectal anastomosis (Knight–Griffen), beyond the distance from the anal verge, which other factors influence the decision to perform a protective ileostomy/colostomy?
Drain management	Q17	Placement of drain(s) after right hemicolectomy
	Q18	Placement of drain(s) after left hemicolectomy
	Q19	Placement of drain(s) after anterior resection of the rectum
Leak Management (in the absence of stump ischemia, in an immunocompetent patient in good general condition)	Q20	Ileo-colic anastomosis with a paucisymptomatic clinically drained leak
	Q21	Reoperation for an ileo-colic anastomotic leak up to 2 cm with localized peritonitis
	Q22	Colorectal anastomosis with a paucisymptomatic clinically drained leak
	Q23	Colorectal anastomosis with a drained colorectal leak: when should a diverting ileo-colostomy be considered?
	Q24	Leak on postoperative day 6 after laparoscopic anterior resection of the rectum with mechanical colorectal anastomosis (Knight–Griffen). A salvage ostomy is planned. Which technique should be used?
	Q25	Colorectal anastomosis with a drained leak: when should a Hartmann’s procedure be considered?
	Q26	Colorectal anastomosis with a drained leak involving up to one-third of the circumference: when should endoscopic treatment be considered?

Q=Question; Y/N=Yes/No

Table 2 Setting of the hospital

Question	Answer	No.	(%)
Type of hospital	Private hospital	2	0.5
	Semi-private hospital	20	4.8
	Public non-University hospital	194	46.9
	University hospital	198	47.8
No. of colectomies per year	0–50	275	66.4
	51–100	73	17.6
	> 100	66	16.0
Emergency activities	Yes	377	91.1
	No	37	8.9
Interventional radiology unit	Yes	321	77.5
	No	93	22.5
Intensive care unit	Yes	400	96.6
	No	14	3.4

No.=Number

programs for epidemiologists. [Version 11.65]. (Retrieved from <http://www.brixtonhealth.com/pepi4windows.html>).

The contingency tables obtained from each question were analyzed using the chi-squared test and the Fisher’s exact test, as appropriate, in order to assess the potential difference between experience groups. The results were considered statistically significant for a p-value below 5% ($p < 0.05$).

Results

General information, workplace and experience in colorectal surgery (Tables 2, 3 and 4; Figs. 1, 2 and 3)

Five hundred and ten questionnaires were correctly completed. After excluding 96 double reports from the same responders, questionnaires from 414 different respondents were considered eligible for the final analysis. Overall, 286 (69.1%) respondents were men and 128 (30.9%) women. Almost all the interviewees worked in public hospitals (one half of them in University hospitals (198; 47.8%) (Fig. 1). In most environments, an intensive care unit (400; 96.6%) and a regular activity of emergency surgery (377; 91.1%) and interventional radiology (321; 77.5%) were present (Table 2). Table 3 highlights the Italian working regions of the respondents to the survey (Table 3). Concerning surgical experience, more than half of interviewed surgeons (115; 27.8%) were in training program or within 5 years from the end of residency, whereas 122 (29.5%) had more than 10 years of surgical experience (Table 4-Figure 2). 66.4% (275) had performed fewer than 50 colonic resections and 23.7% (98) had performed more than 200 laparoscopic procedures (Table 4; Fig. 3).

Table 3 Working regions of respondents

Region	Survey participants	
	No.	%
Abruzzo	10	2.4
Basilicata	1	0.2
Calabria	4	1.0
Campania	29	7.0
Emilia-Romagna	66	15.9
Friuli-Venezia Giulia	6	1.5
Lazio	50	12.1
Liguria	17	4.1
Lombardia	74	17.9
Marche	4	1.0
Molise	8	1.9
Piemonte	30	7.2
Puglia	19	4.6
Sardegna	10	2.4
Sicilia	8	1.9
Toscana	45	10.9
Trentino-Alto Adige	3	0.7
Umbria	4	1.0
Valle d'Aosta	2	0.5
Veneto	24	5.8
Total	414	100

No.=Number

Table 4 Surgeon's experience

Question	Answer	No.	%
Years of surgical experience	Resident	115	27.8
	< 5 y	126	30.4
	From 6 to 10 y	51	12.3
	> 10 y	122	29.5
Colectomies performed as operating surgeon (No.)	0–50	275	66.4
	51–200	73	17.6
	> 200	66	16.0
Laparoscopic procedures performed as operating surgeon (No.)	0–50	227	54.8
	51–200	89	21.5
	> 200	98	23.7

No.=Number; y=Years

Technique of low anastomosis (Question 11; Table 5)

Overall, the most frequently performed procedure was the Knight-Griffen technique (44.0%), followed by manual colo-anal anastomosis (37.4%). Less common approaches included pull-through procedures (8.7%), Transanal Transection and Single-Stapled Anastomosis (TTSS) (8.0%), and other techniques (1.9%). When stratified by surgical experience, no significative differences were observed. Among less experienced surgeons (0–50 colectomies), the Knight-Griffen technique was reported in 47.3% of cases, while manual colo-anal anastomosis accounted for 36.0%. In the expert group (> 50 colectomies), manual

colo-anal anastomosis was slightly more frequent (40.3%) than Knight-Griffen (37.4%). The rate of pull-through and TTSS procedures, rarely used overall (10.8% vs. 7.6%, and 9.3% vs. 7.3%, respectively) was similar in the two groups. The comparison between groups did not show statistically significant differences ($p=0.391$) (Table 5).

Intraoperative “Tricks & Checks” for leak prevention (Questions 12–13; Table 6)

Regarding leak prevention, the most common approach was to avoid any specific measures (38.9%), followed by anastomosis' reinforcement sutures (29.7%) and techniques to prevent dog-ears (21.7%). Less frequently, surgeons reported the use of glue (5.6%) or other methods (4.1%). Considering surgical experience, although difference between groups did not reach statistical significance ($p=0.098$), surgeons with > 50 colectomies were more likely to avoid any leak prevention measure (45.3% vs. 35.6%), whereas reinforcement sutures (32.0% vs. 25.2%) and dog-ear prevention (23.6% vs. 18.0%) were more frequent among less experienced surgeons. The use of glue remained uncommon in both groups, while other strategies were slightly more frequent among highly experienced surgeons.

Concerning intraoperative leak checks, the hydropneumatic leak test was the most widely used method (94.9%), followed by the rings' check (87.9%) and indocyanine green (ICG) fluorescence (61.8%). Only a minority of surgeons reported performing no test (0.7%) or using other techniques (4.3%). No relevant differences were observed between groups in terms of the hydropneumatic leak test or omission of testing. Rings' check and ICG use showed roughly the same rate among more experienced surgeons (89.2% vs. 87.3% and 67.6% vs. 58.9%, respectively). No statistically significant differences were observed between the two groups overall ($p=0.866$) (Table 6).

Indication and technique for stoma (Questions 14–16; Table 7)

In patients undergoing anterior resection with double-stapling mechanical, colorectal anastomosis (Knight-Griffen technique), the majority of surgeons reported a non-systematic approach, performing a protective stoma only when indicated by local or patient-related conditions (52.4%). Systematic protection was reported in 25.9% of cases when the anastomosis was < 4 cm from the anal verge, in 15.2% when < 8 cm, and in 6.0% when < 12 cm. Only 0.5% of respondents reported to never perform a protective stoma. When stratified by surgical experience, less experienced surgeons more frequently opted for a non-systematic approach

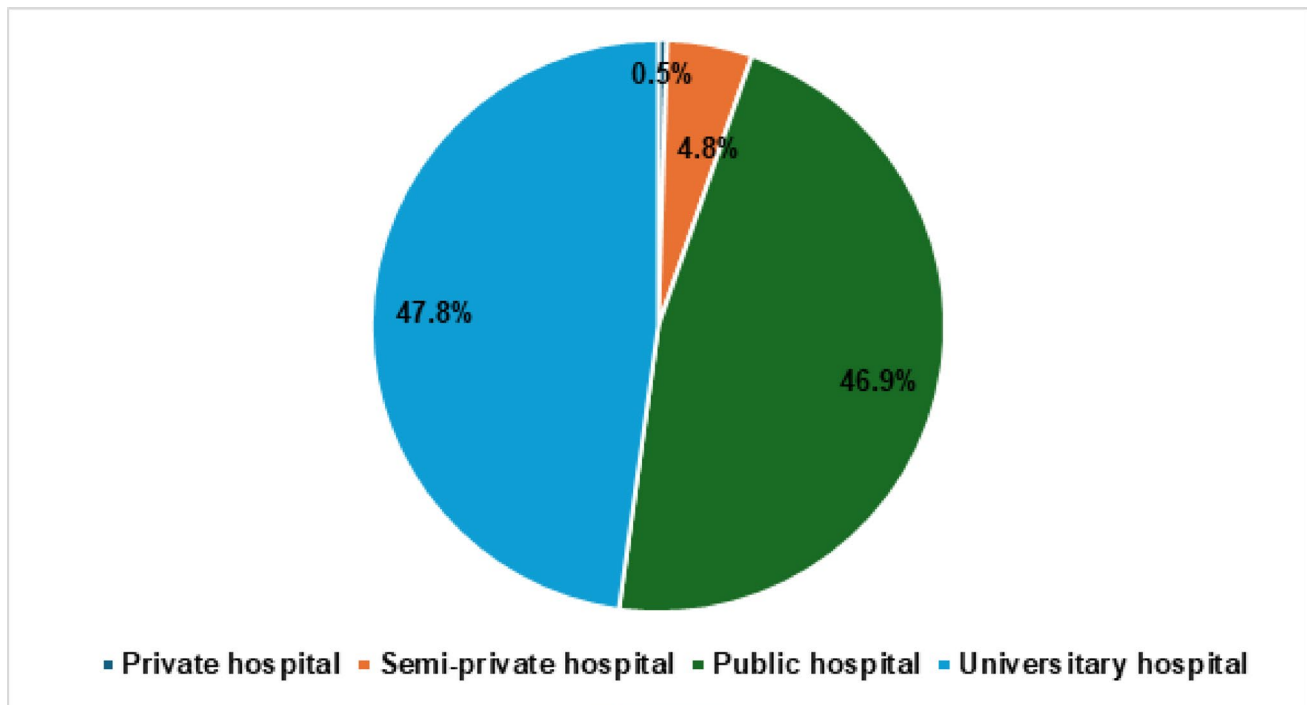


Fig. 1 Type of hospital. Distribution of the various hospital settings among the respondents.

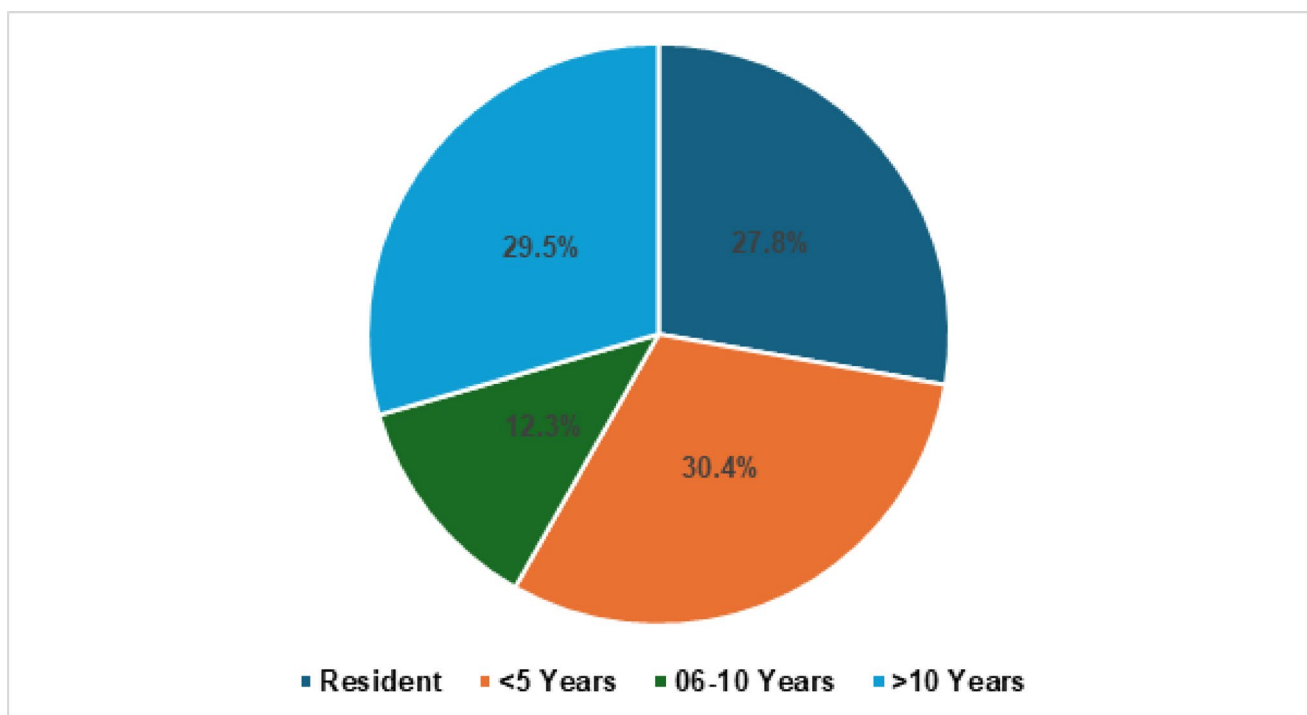


Fig. 2 Surgeon personal experience (years). Years of experience among the respondents.

(57.1% vs. 43.2%), whereas more experienced surgeons showed a preference for systematic protection in the case of anastomosis performed at <8 cm (21.6% vs. 12.0%). The difference between groups reached statistical significance ($p=0.023$) (Question 14; Table 7).

Regarding ostomy technique, ileostomy 15 cm from the ileocecal valve (ICV) was the most performed (53.1%), followed by ileostomy 30 cm from the ICV (40.8%). Other techniques such as left colostomy (2.7%), right transversostomy (2.2%), and other approaches (1.2%) were rarely

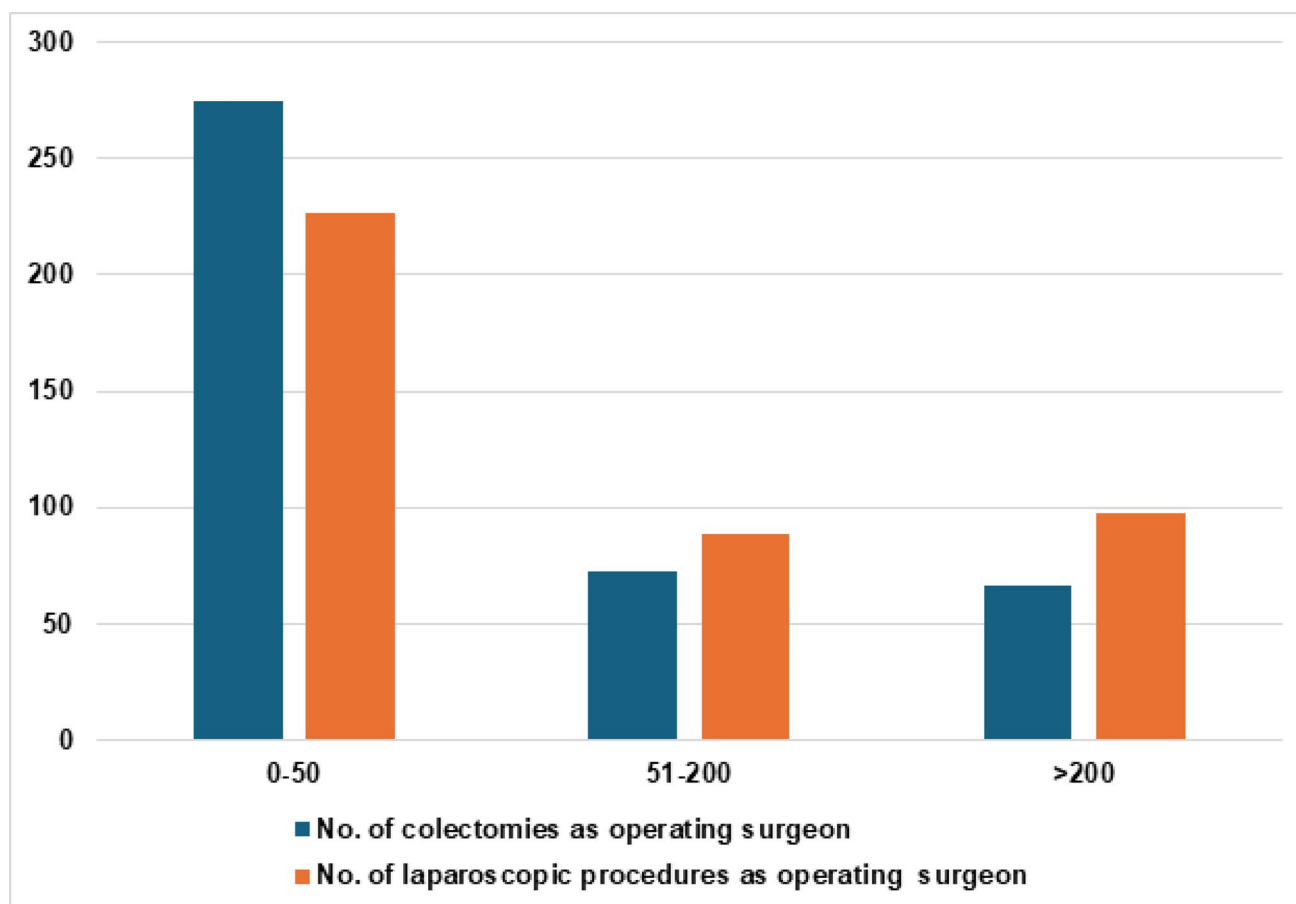


Fig. 3 Surgeon's operative experience (colorectal, laparoscopy). Number of colectomies and laparoscopic procedures performed by respondents.

Table 5 Technique of low Anastomosis

Question	Answer	Total (No. 414)		Surgeon's no. of performed colectomies				p
		No.	%	0-50 (No. 275)		>50 (No. 139)		
				No.	%	No.	%	
Ultra-low anastomosis (≤2 cm from the dentate line): which surgical technique?	Manual colo-anal anastomosis	182	44.0	130	47.3	52	37.4	0.391
	Knight-Griffen (double-stapling)	155	37.4	99	36.0	56	40.3	
	Pull-through (various approaches)	36	8.7	21	7.6	15	10.8	
	TTSS	33	8.0	20	7.3	13	9.3	
	Other	8	1.9	5	1.8	3	2.2	

adopted. No significant difference was observed between surgeons with different levels of experience ($p=0.212$) (Question 15; Table 7).

Other than the anastomosis' distance from the anal verge, several clinical and technical variables influenced the decision-making process. The most frequently reported factors were local conditions such as tissue inflammation (84.5%), preoperative radiotherapy (84.1%), and the quality of the anastomosis (70.3%). Additional criteria included other comorbidities (61.8%), BMI (49.3%), type II diabetes mellitus (40.6%), and smoking habits (30.4%). Although no differences were observed between groups, type II diabetes mellitus, when evaluated alone, resulted as being more

considered by less experienced surgeons (57.5% vs. 7.2%), with a statistically significant difference ($p<0.001$) (Question 16; Table 7).

Drain management (Questions 17–19; Table 8)

The survey investigated surgeons' practice regarding drain placement after various operations including colectomies and anterior rectal resection.

After right hemicolectomy, most surgeons reported not to place a drain (36.7%), followed by placing a

Table 6 Intraoperative “Tricks & Checks” in leak prevention

Question	Answer	Total (No. 414)		Surgeon’s no. of performed colectomies				p
		No.	%	0-50 (No. 275)		>50 (No. 139)		
				No.	%	No.	%	
Prevention of colorectal fistula: which strategy?	Nothing	161	38.9	98	35.6	63	45.3	0.098*
	Anastomosis’ reinforcement suture	123	29.7	88	32	35	25.2	
	Any technique to prevent “dog-ears”	90	21.7	65	23.6	25	18.0	
	Glue	23	5.6	18	6.6	5	3.6	
	Other	17	4.1	6	2.2	11	7.9	
Prevention of colorectal fistula: which intraoperative leak test? [#]	Hydropneumatic leak test	393	94.9	261	94.9	132	95.0	0.866*
	Rings’ check	364	87.9	240	87.3	124	89.2	
	ICG	256	61.8	162	58.9	94	67.6	
	Other	18	4.3	7	2.5	11	7.9	
	Nothing	3	0.7	2	0.7	1	0.7	

Table 7 Indication and technique for stoma

Question	Answer	Total (No. 414)		Surgeon's no. of performed colectomies				p
		No.	%	0-50 (No. 275)		>50 (No. 139)		
				No.	%	No.	%	
Protective ileo/colostomy after 'ideal' mechanical anterior resection (Knight–Griffen technique)	Never	2	0.5	0	0.0	2	1.4	0.023
	Non-systematic (depending on local/patient conditions)	217	52.4	157	57.1	60	43.2	
	Always (systematic <12 cm)	25	6.0	15	5.5	10	7.2	
	Systematic <4 cm	107	25.9	70	25.4	37	26.6	
	Systematic <8 cm	63	15.2	33	12.0	30	21.6	
After anterior resection with mechanical colorectal anastomosis (Knight–Griffen), I decide to perform a protective stoma. Which technique?	Left colostomy	11	2.7	7	2.5	4	2.9	0.212
	Ileostomy 15 cm from ICV	220	53.1	147	53.5	73	52.5	
	Ileostomy 30 cm from ICV	169	40.8	116	42.2	53	38.1	
	Right transversostomy	9	2.2	3	1.1	6	4.3	
	Other	5	1.2	2	0.7	3	2.2	
After anterior resection with mechanical colorectal anastomosis (Knight–Griffen), beyond the distance from the anal verge, which other factors influence the decision to perform a protective ileo/colostomy?#	Other relevant comorbidities (cardiac, respiratory, etc.)	256	61.8	161	58.5	95	68.3	0.617*
	BMI	204	49.3	136	49.5	68	48.9	
	Local conditions (tissue inflammation, etc.)	350	84.5	238	86.5	112	80.6	
	Preoperative RT	348	84.1	229	83.3	119	85.6	
	Quality of anastomosis (number of firings with linear stapler, etc.)	291	70.3	194	70.5	97	69.8	
	Type II Diabetes Mellitus	168	40.6	158	57.5	10	7.2	
	Smoking	126	30.4	76	27.6	50	36.0	

retroanastomotic drainage (18.4%) and in the right parietocolic gutter (17.4%). A further 16.2% reported avoiding drainage only in patients following the ERAS protocol, whereas 7.0% placed one drain in the pelvis and 2.9% systematically placed two drains. No statistically significant differences were observed between less and more experienced surgeons ($p=0.401$) (Question 17; Table 8).

After left hemicolectomy, most surgeons opted for a drain in the pelvis (49.0%), followed by no drain at all (17.9%) and drain placement in the left parietocolic gutter (12.8%). Systematic use of two drains (5.1%) and avoidance of drainage in ERAS patients (8.9%) were less common, while only 5.3% of respondents limited drain use to patients with

comorbidities. Surgeons with >50 colectomies were more likely to avoid drains (26.6% vs. 13.5%), with a statistically significant difference between groups ($p=0.044$) (Question 18; Table 8).

After anterior resection of the rectum, the vast majority reported placing a drain in the pelvic cavity (73.7%), followed by the systematic placement of two drains (11.8%). “No drain” was reported by 5.8% of respondents systematically, while 3.4% omitted it only in ERAS patients, and 3.1% limited drain use, to patients with comorbidities. Other strategies and alternative locations were rarely mentioned. No significant differences were found between surgeons with different experience ($p=0.714$) (Question 19; Table 8).

Table 8 Drain management

Question	Answer	Total (No. 414)		Surgeon's no. of performed colectomies				p
		No.	%	0-50 (No. 275)		>50 (No. 139)		
				No.	%	No.	%	
Placement of drain(s) after right hemicolectomy	No drain	152	36.7	95	34.5	57	41.0	0.401*
	One, retroanastomotic	76	18.4	57	20.7	19	13.7	
	One, in the right parietocolic gutter	72	17.4	45	16.4	27	19.4	
	No drain if the patient follows the ERAS protocol	67	16.2	49	17.8	18	13.0	
	One, in the pelvic cavity	29	7.0	17	6.2	12	8,6	
	Two	12	2.9	8	2.9	4	2.9	
	Other	6	1.4	4	1.5	2	1.4	
Placement of drain(s) after left hemicolectomy	One, in the pelvic cavity	203	49.0	142	51.6	61	43.9	0.044*
	No drain	74	17.9	37	13.5	37	26.6	
	One, in the left parietocolic gutter	53	12.8	38	13.8	15	10.8	
	No drain if the patient follows the ERAS protocol	37	8.9	24	8.7	13	9.4	
	One, if the patient has particular comorbidities (diabetes, obesity, etc.)	22	5.3	16	5.8	6	4.3	
	Two	21	5.1	15	5.5	6	4.3	
	Other	4	1.0	3	1.1	1	0.7	
Placement of drain(s) after anterior resection of the rectum	One, in the pelvic cavity	305	73.7	203	73.8	102	73.4	0.714*
	Two	49	11.8	33	12.0	16	11.5	
	No drain	24	5.8	14	5.1	10	7.2	
	No drain if the patient follows the ERAS protocol	14	3.4	10	3.6	4	2.9	
	One, if the patient has particular comorbidities (diabetes, obesity, etc.)	13	3.1	11	4.0	2	1.4	
	Other	5	1.2	1	0.4	4	2.9	
	One, in the left parietocolic gutter	4	1.0	3	1.1	1	0.7	

Leak management (Questions 20–26; Table 9)

The management of anastomotic leaks varied according to clinical presentation and surgeon experience. In the case of ileo-colic anastomosis with a drained clinically paucisymptomatic AL, most surgeons opted for a conservative approach and CT imaging (73.4%), while 15.9% performed laparoscopy, 6.3% chose endoscopic exploration, and only 3.4% preferred laparotomy. Surgeons with ≤ 50 colectomies were more likely to choose a conservative approach (76.7% vs. 66.9%), whereas laparoscopy (20.1% vs. 13.8%) and laparotomy (6.5% vs. 1.8%) were more frequent among experienced surgeons, with a statistically significant difference ($p=0.023$) (Question 20; Table 9).

Considering the reoperation for ileo-colic AL up to 2 cm with localized peritonitis, the preferred options were ileo-colic re-anastomosis without protective stoma (36.0%) and ileocolic re-anastomosis with stoma (29.5%). Raphia with ileostomy was reported by 23.7%, while terminal stoma creation (7.2%) and simple raphia (2.4%) were less frequent. Although less experienced surgeons more frequently chose re-anastomosis with stoma (32.4% vs. 23.7%) and more experienced surgeons preferred re-anastomosis without diversion (44.6% vs. 31.6%), such differences did not reach statistical significance ($p=0.104$) (Question 21; Table 9).

Concerning patients with colorectal anastomosis with a clinically paucisymptomatic, drained AL, conservative treatment was the most common choice (65.9%), followed by endoscopic exploration (15.2%) and laparoscopy $\pm$ stoma (13.3%), with very few cases managed by open stoma creation (2.7%) or laparotomy (0.5%). No significant differences were observed between groups ($p=0.894$). (Question 22; Table 9).

When asked when to perform a diverting ileo/colostomy in the presence of a drained colorectal AL, most surgeons reported that the decision depended on clinical findings (52.4%). Other criteria included the extent of the leak, with thresholds $>1/3$ (15.2%), $>1/4$ (9.2%), or $>1/2$ of the circumference (8.2%), while 13.5% opted for diversion systematically. More surgeons with >50 colectomies reported to rely on clinical finding (61.1% vs. 48.0%), but the difference was not statistically significant ($p=0.056$) (Question 23; Table 9).

In the case of a leak on postoperative day 6 after low anterior resection with Knight-Griffen anastomosis, the most frequent salvage procedure was ileostomy 15 cm from the ileocecal valve by laparoscopic approach (41.3%), followed by ileostomy 30 cm from the ileocecal valve with laparoscopy (32.4%). Other approaches included right transversostomy (11.9%), ileostomy with open approach (11.6%), and miscellaneous techniques (2.9%). No significant differences

Table 9 Leak management

Question	Answer	Total (No. 414)		Surgeon's no. of performed colectomies				p
		No.	%	0-50 (No. 275)		>50 (No. 139)		
				No.	%	No.	%	
Ileo-colic anastomosis with a clinically paucisymptomatic, drained leak	Conservative approach (observation and CT)	304	73.4	211	76.7	93	66.9	0.023*
	Laparoscopy	66	15.9	38	13.8	28	20.1	
	Colonoscopy (e.g. endoscopic procedures)	26	6.3	18	6.6	8	5.8	
	Laparotomy	14	3.4	5	1.8	9	6.5	
	Other	4	1.0	3	1.1	1	0.7	
Reoperation for ileo-colic anastomotic leak up to 2 cm with localized peritonitis	Ileocolic reanastomosis without ileostomy	149	36.0	87	31.6	62	44.6	0.104*
	Ileocolic reanastomosis with ileostomy or ileo/colostomy	122	29.5	89	32.4	33	23.7	
	Raphia with ileostomy	98	23.7	69	25.1	29	20.8	
	Terminal ileostomy or ileo/colostomy	30	7.2	21	7.6	9	6.5	
	Raphia alone (without stoma)	10	2.4	7	2.6	3	2.2	
	Other	5	1.2	2	0.7	3	2.2	
Colorectal anastomosis with a clinically paucisymptomatic, drained leak	Conservative approach (observation and CT)	273	65.9	183	66.6	90	64.7	0.894*
	Colonoscopy (e.g. endoscopic procedures)	63	15.2	43	15.6	20	14.4	
	Laparoscopy ± Ileo/colostomy	55	13.3	36	13.1	19	13.7	
	Ileo/colostomy with open access	11	2.7	7	2.5	4	2.9	
	Other	10	2.4	5	1.8	5	3.6	
	Laparotomy	2	0.5	1	0.4	1	0.7	
Colorectal anastomosis with a drained leak: when should a diverting ileo-colostomy be considered?	Depends on the clinic	217	52.4	132	48.0	85	61.1	0.056*
	Leak size > 1/3 of the circumference	63	15.2	49	17.8	14	10.1	
	Systematic	56	13.5	40	14.5	16	11.5	
	Leak size > 1/4 of the circumference	38	9.2	27	9.8	11	7.9	
	Leak size > 1/2 of the circumference	34	8.2	26	9.5	8	5.8	
	Other	6	1.5	1	0.4	5	3.6	
Salvage diverting stoma for POD 6 leak after LAR with mechanical colorectal anastomosis (Knight-Griffen): Which technique should be used?	Ileostomy 15 cm from ICV, with LA	171	41.3	115	41.8	56	40.3	0.133*
	Ileostomy 30 cm from ICV, with LA	134	32.4	91	33.1	43	30.9	
	Right transversostomy, with LA	40	9.7	19	6.9	21	15.1	
	Ileostomy 15 cm from ICV, with OA	26	6.3	19	6.9	7	5.0	
	Ileostomy 30 cm from ICV, with OA	22	5.3	18	6.5	4	2.9	
	Other	12	2.9	7	2.5	5	3.6	
	Right transversostomy, with OA	9	2.2	6	2.3	3	2.2	
Colorectal anastomosis' drained leak: when should Hartmann's procedure be considered?	Depending on the clinical symptoms	261	63.1	178	64.7	83	59.7	0.365*#
	Leak size > 1/2 of the circumference	81	19.6	58	21.1	23	16.6	
	Leak size > 1/3 of the circumference	44	10.6	25	9.1	19	13.7	
	Other	20	4.8	8	2.9	12	8.6	
	Systematically	8	1.9	6	2.2	2	1.4	
Colorectal anastomosis' drained leak involving up to one-third of the circumference: when should an endoscopic treatment be considered?	Intracavitary sponge (e.g. endosponge) with stoma	128	30.9	85	30.9	43	30.9	0.820*
	Intracavitary sponge (e.g endosponge) without stoma	104	25.1	72	26.1	32	23.0	
	Endoscopic approach is not considered	80	19.3	48	17.5	32	23.0	
	Clips (e.g. Ovesco) without stoma	51	12.3	33	12.0	18	12.9	
	Clips (e.g. Ovesco) with stoma	21	5.1	15	5.5	6	4.4	
	Endoscopic suture with stoma	21	5.1	15	5.5	6	4.4	
	Endoscopic suture without stoma	9	2.2	7	2.5	2	1.4	

were found between groups ($p=0.133$) (Question 24; Table 9).

When asked in which situation a salvage Hartmann's procedure in the setting of a drained colorectal leak, 63.1% of surgeons reported taking their decision based on clinical

presentation, whereas 30.2% of surgeons decided considering leak size: 19.6% for leaks > 1/2 of the circumference and 10.6% for leaks > 1/3 of the circumference. Only 1.9% performed Hartmann's systematically. The overall comparison

did not show any significant difference ($p=0.365$) (Question 25; Table 9).

Finally, considering the management of drained AL involving up to 1/3 of anastomosis' circumference, endoscopic management was preferred by the majority. Endoscopic options included intracavitary sponge placement (56%), associated with (30.9%) or without stoma (25.1%), followed by clips placement (17.4%) and endoscopic suturing (7.3%), whereas 19.3% did not consider any endoscopic approach. No statistically significant differences were observed between groups ($p=0.820$) (Question 26; Table 9).

Discussion

Participants and participants' facilities (Tables 2, 3 and 4; Figs. 1, 2 and 3)

Four-hundred-ten general surgeons/general surgery residents were included in the survey, with a > 50% rate of young surgeons, including 27.8% residents and 30.4% within 5 years from residency program. Experience in both major colorectal resections and laparoscopic surgery reported by survey responders are consistent with the young age of most participants. The geographical distribution of participants is related to the numerosity of population in each Italian region, with slightly higher rates of responders in Lombardia (17.9%), Emilia-Romagna (15.9%), Lazio (12.1%) and Toscana (10.9%), probably also owing to survey promotion activity by the authors (Table 3).

Many responders' hospitals are secondary-tertiary general hospitals, as only roughly 5.3% were private health facilities (22/414), and only 8.9% without emergency surgery activity (37/414). Interestingly enough, almost ¼ of responders' hospitals (93/414) does not have any interventional radiology unit available on site, which may be supposed to affect AL management, in particular in the case of limited peri-anastomotic abscesses potentially suitable of imaging-guided drainage. The number of University hospitals seems over-represented as they account for almost 50% (198/414), whereas the majority of surgical facilities in Italy are non-University institutions. Such a finding seems related to the high rate of residents (115/414; 27.8%), mostly attending University hospitals, completing the survey (Table 2; Fig. 1).

Consistently with those figures, the majority of responders have limited experience in colorectal surgery (275; 66.4% - has < 50 colectomy performed as operating surgeon) and laparoscopy (227; 54.8% - has < 50 performed laparoscopic procedures) (Table 4; Figs. 2 and 3). It is surprising that more than 2/3 of responders are men, since in Italy a recent trend towards a 1:1 gender ratio is ongoing. Since

this trend is recent, this may explain such figures as well as the apparent significantly lesser experience in colorectal surgery reported by women. Age also influences colorectal experience, as the majority of surgeons > 10 years from residency program report to have performed > 50 colectomies, falling to less than 40% in the 6-10-y-span and less than 15% within 5 years from residency program. Those data should lead to some reflections in surgeons' education through their early career, as > 90% of young surgeons with on call duties in hospital with emergency activities responding to the survey seemingly has limited experience in colorectal surgery. Interestingly, no difference emerged in surgeons' colorectal experience by type of hospital (public/private) as well as by presence of third level services (ER, ICU, interventional radiology), showing the spread of colorectal surgery among Italian general surgeons, also outside specialized centres.

Surgical anastomosis and leak prevention techniques (Questions 11–13; Tables 5 and 6)

Technique for very-low colorectal anastomosis (≤ 2 cm from the dentate line)

As expected, surgeons' body is conservative regarding anastomosis' technique: the vast majority of them favours manual or mechanical (Knight-Griffen) colo-anal anastomosis, with less than 10% switching to the recently introduced TTSS [21] or any pull-through technique [51–54], which has been recently re-proposed (preferred by 33 and 36 responders, respectively). Colorectal experience stratified analysis did not show significant differences.

Anastomosis' technical "tricks"

The majority of surgeons add some "tricks" to his approach, mostly a "reinforce" suture (123; 29.7%) and some technical variants in order to avoid the so-called Knight-Griffen's "dog-ears" (90; 21.7%), the lateral parts of double-stapling suture, which are diffusely perceived as the Achilles' heel of that technique due to supposed inadequate vascular supply. There is a trend towards not doing anything after colorectal anastomosis by more expert surgeons, whereas younger colleagues more frequently report technical variants/tricks, maybe because they mostly attend tertiary/University hospitals.

Intraoperative anastomosis' "checks"

Among the manoeuvres performed in order to check the correctness of surgical technique and stumps' blood supply, the hidro-pneumatic test and the so-called "donuts" check are almost universally performed, whereas ICG test is rapidly

spreading and entering surgeons' routine, as at the present time it is already performed by almost 2/3 of surgeons. Colorectal experience associated with stratified analysis did not show significant differences.

Indication and technique for stoma (Questions 14–16; Table 7)

Stoma after anterior resection

Although protective stoma is traditionally performed by Italian surgeons after rectum anterior resection, the result of the survey is somehow surprising, as seemingly only 25 (6%) of surgeons perform a stoma systematically after anterior resection (regardless the distance from the anal verge of anastomosis), whereas more than 1/2 decides based on local findings and general conditions of the patient. To be fair, such a question may have been misleading as, overall, another 170 surgeons reportedly perform a stoma routinely after low anastomosis (<4 or <8 cm), and the answer “not systematically” actually could imply the distance from the dentate line as one of considered criteria.

From the comparison between less and more experienced colorectal surgeons, we may deduce that younger colleagues are more oriented towards a tailored use of protective stoma, as they are more likely to perform stoma “not systematically”, which is coherent with recent literature on the subject [55] whereas experience may induce a more prudent behaviour.

Stoma techniques

Consistently with general recommendations [20, 56–58], ileostomy (389; ~94.0%) is widely preferred to colostomy in order to temporarily protect high-risk colorectal mechanical anastomoses; in half of cases performed 30 cm from the ileocecal valve in order to allow a comfortable closure at a distance from the colorectal resection.

Criteria for stoma

Local conditions such as tissue inflammation and previous radio-therapy are considered by over 80% of surgeons; sub-optimal surgical technique (multiple “firing” by linear stapler) and general comorbidities or obesity are evaluated by 50–75%, whereas DM and cigarette smoking are not considered as factors by the majority of surgeons. This latter data is not consistent with recent literature and recommendations on the subject [8, 9]. Interestingly, DM is significantly more often ignored by more experienced surgeons in deciding whether to perform a stoma or not. Seemingly,

younger colleagues are more up to date with international recommendations [9].

Drain management (Questions 17–19; Table 8)

Overall

Also owing to the spread of fast-track programs (including ERAS), the use of intraabdominal drains after colectomy is progressively reducing especially for right-sided procedures. In fact, considering drain placement with respect of resected segment, a clear anticlockwise trend towards avoiding any perianastomotic drain from rectum anterior resection to left side resections to right colectomy, where it has been abandoned by roughly one half of surgeons.

Right colectomy

After right colectomy, perianastomotic drains are less and less placed by surgeons, roughly reaching 50%, owing to several reasons. First of all, a perianastomotic drain after right colectomy is de facto placed in the middle of peritoneal cavity, where it may easily move for the original perianastomotic position, also owing to the recovery of small bowel peristalsis; [59, 60] second, the liquid state of stools passing through an ileo-colonic leak and diffusing in the middle of the abdomen questions the usefulness of a drain itself as a “therapeutic mean”, as immediate emergency endoscopy/surgery seems the most appropriate management; [61] third, ERAS recommendations suggest to avoid drain placement to enhance recovery after surgery [23].

Left colectomy

After left colectomy, at least one drain is still placed systematically by about ¾ of surgeons against ERAS recommendations. Such a drain is seemingly still nowadays diffusely considered helpful for leak early diagnosis, as well as a therapeutic mean for not severe leakage, possibly managed conservatively (endoscopic procedures, including stenting, sponging, suturing, clipping,...). Interestingly enough, more expert surgeons do not systematically place any drain after left colectomy, as they probably adapt their attitude on a case-by-case basis, in accordance with their experience.

Anterior resection

After anterior resection, the attitude of over 90% Italian surgeons remains to place at least one drain, usually in the Douglas (or perianastomotic) pouch. Significantly, in the case of anterior resection, ERAS recommendations suggesting avoiding abdominal drains are mostly ignored, as they

are followed by just 14 surgeons (3.4%), whereas, on the contrary, as many as 2 drains are left in place by 49 surgeons (11.8%). The actual risk of leak after colorectal anastomosis, as well as the potential role of drain in the conservative treatment of non-severe leakage together with endoscopic management and antibiotic therapy, probably play a role in such an ingrained, die-hard habit.

Leak management (Questions 20–26; Table 9)

Clinically pauci-symptomatic leak of an ileo-colic anastomosis Significantly, a conservative attitude is adopted by roughly $\frac{3}{4}$ of surgeons, in few cases associated with colonoscopy (and potentially endoscopic manoeuvre), whereas in just one out of 5 cases (80/414; 19.3%), surgery (by laparotomy or laparoscopy) is preferred. Significantly, higher percentage on non-conservative management is recorded among older surgeons ($p=0.023$), when experience may suggest a more pondered management.

Emergency surgery for leak of an ileo-colic anastomosis

Interestingly, when surgery is eventually needed for an ileo-colic leakage, 2/3 of surgeons (271; 65.5%) prefer a re-do anastomosis, associated or not with a stoma, rather than a suture of the leak (w/without stoma). Deteriorated tissue conditions due to localized peritonitis caused by ileal leak seemingly plays a role in such an attitude.

Management of a clinically pauci-symptomatic leak of a colo-rectal anastomosis

Significantly, overall, over 80% of surgeons prefer a non-operative management, in just 15.2% (63/414) of cases associated with endoscopic assistance. In the remaining cases a stoma is preferred, mostly after laparoscopic exploration. The confidence in drain placement as an effective management of minor leaks in non-significantly symptomatic patients may be the reason of such persistent habit.

Indication for a stoma in the case of colo-rectal anastomosis leak

Interestingly, regarding the decision to proceed with stoma, surgeons are actually split in two halves, with 217 (52.4%) relying on clinical symptoms, whereas the remaining ones considering AL size (percentage of anastomosis' circumference). Interestingly, less experienced surgeons mostly decide based on leakage size compared to more experienced

ones ($p=0.056$). Probably, those latter ones' experience, other than the recent introduction of various endoscopic techniques, tools and stents, make experienced colleagues more and more conservative even in the case of major leak, if patients are not severely symptomatic.

Stoma technique in case of colo-rectal anastomotic leak

The vast majority (353/414; 85.3%) of surgeons prefer ileostomy as salvage procedure in the case of a colo-rectal AL. Interestingly enough, a laparoscopy-assisted stoma is an increasingly accepted approach among colo-rectal surgeons, as it is used by 83.4% (345/414) of colleagues, including ileal and colonic stomas.

Indication for Hartmann procedure in the case of colo-rectal anastomosis leak

Interestingly, only 1.9% (8/414) of surgeon systematically opt for a Hartmann procedure in the case of colo-rectal anastomosis' leak. On the contrary, almost 2/3 decides based on clinical symptoms (261/414; 63.1%), and 125/414 (30.2%) based on leak's size. Similarly to what reported for the decision to perform a stoma, the severity of clinical symptoms lead the surgical management of colo-rectal anastomosis' leak in most cases nowadays.

Indication for an endoscopic procedure in the case of colo-rectal anastomosis leak

Endoscopy has seemingly entered clinical practice, as less than 20% (80/414) of surgeons does not include endoscopy among colo-rectal anastomosis' leak treatment options. "Sponge" (56.0%), clips (17.4%) and endorectal suturing (7.3%) are proposed as "endoscopic managements", showing the first one as the preferred endoscopic approach by far. Even if no statistical analysis has been performed in this regard, interestingly, the placement of clips is seemingly considered more effective as non-operative management alone, as more than 70% (51/72; 70.8%) of patients undergoing endoscopic clipping do not undergo stoma, whereas sponge placement and suturing is proposed in association with ileostomy/colostomy in 55.2% (128/232) and 70% (21/30) of cases, respectively.

Conclusions

The present survey represents an effort to define how colorectal leak prevention and management are evolving and how recently introduced techniques/tools and guidelines/recommendations have spread in surgeons' practice.

Idropneumatic test and “donuts” check are universally performed after left-sided procedures, whereas ICG test is rapidly spreading to check anastomotic stumps' blood supply as it has already entered 2/3 of surgeons' routine.

Drain placement is still largely adopted by most surgeons, with a decreasing rate from right (~50%) to left colectomy (~70%) to anterior resection (~90%), mostly ignoring ERAS recommendations.

A conservative management in clinically non-severe cases is spreading, as most surgeons' management is led by leak's symptoms and not size, both concerning the decision to proceed with protective right-sided stoma or Hartmann procedure, with surgeon's experience playing a role in such an attitude.

Operative endoscopy, in particular endoscopic sponge placement, has definitely entered clinical practice as management option for over 80% of surgeons.

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Silvia Curcio
Silvia Negro
Silvia Neri
Simona Ascanelli
Simona Badalucco
Simona Pisicchio
Simone Buccianti
Simone Gargarella
Simone Guadagni
Simone Muratori
Sofia Esposito
Sophia Costacurta
Stefania Bettoni
Stefania Piccioni
Stefano Barbieri
Stefano Carini
Stefano Lafranceschina
Stefano Olmi
Stefano Rossi
Stefano Scabini
Teresa Perra
Tommaso Farolfi
Tommaso Fontana
Tommaso Iaquinta
Tommaso Loderer
Tommaso Violante
Ugo Grossi
Valentina Rampulla
Valentina Zucchini
Vania Silvestri
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