Intraoperative air leak test reduces the rate of postoperative anastomotic leak: analysis of 777 laparoscopic left-sided colon resections

DOI:10.1007/s00464-018-6421-8

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INTRAOPERATIVE AIR LEAK TEST REDUCES THE RATE OF POSTOPERATIVE ANASTOMOTIC LEAK: ANALYSIS OF 777 LAPAROSCOPIC LEFT-SIDED COLON RESECTIONS

Marco Ettore Allaix, MD,[1] Adriana Lena, MD,[1] Maurizio Degiuli, MD,[1]

Alberto Arezzo, MD,[1] Roberto Passera, PharmD, PhD,[2]

Massimiliano Mistrangelo, MD,[1] Mario Morino, MD[1]

[1]Department of Surgical Sciences, University of Torino

[2]Division of Nuclear Medicine, University of Torino

Correspondence:

Dr. Marco Ettore Allaix

Department of Surgical Sciences

University of Torino, Corso A. M. Dogliotti, 14 – 10126 Torino, Italy

Phone: +39-0116313159

Fax: +39-011-6312548

email: meallaix@gmail.com

Paper presented as a Podium Presentation at the 16th World Congress of Endoscopic Surgery, Seattle, WA, United States, April 11-14, 2018.

No funds, grants or support was received to complete the study.

Original article. The material is previously unpublished.

Running title: Air leak test and laparoscopic colorectal resection

Abstract

Background: The evidence supporting the use of the air leak test (ALT) after laparoscopic left-sided colon resection (LLCR) to test the colorectal anastomosis (CA) integrity aiming at reducing the rate of postoperative CA leakage (CAL) is not conclusive. The aim of this study was to challenge the use of ALT after elective LLCR.

Methods: It is a retrospective analysis of a prospectively collected database including all patients undergoing elective LLCR with primary CA and no proximal bowel diversion between January 1996 and June 2017. The decision to perform the ALT was based on the individual surgeon routine practice. A multivariate analysis was performed to identify independent risk factors for CAL.

Results: A total of 777 LLCR without proximal diversion were included in the analysis: the CA was tested in 398 patients (ALT group), while intraoperative ALT was not performed in 379 patients (No-ALT group). The two groups were similar in demographic characteristics, indication and type of procedure. Intraoperative ALT was positive in 20 (5%) patients: a stoma was created in 14 (70%) patients, while 6 (30%) patients had a suture repair alone. Overall, postoperative CAL occurred in 32 patients (4.1%): the postoperative CAL rate was lower in ALT patients (2.5% vs. 5.8%, p=0.025). A reoperation was needed in 87.5% of cases. No CAL occurred in the 20 patients with intraoperative positive ALT. Multivariate analysis showed that ASA score 3-4 (OR ~~4.91~~5.39, 95% CI 2.~~17~~53-11.~~11~~51, p<0.001) and male sex (OR 3.~~87~~96, 95% CI 1.~~62~~66-9.~~2~~43, p=0.002) were independent risk factors for postoperative CAL, while intraoperative ALT independently reduced the postoperative CAL rate (OR 0.~~39~~40, 95% CI 0.18-0.~~86~~88, p=0.~~019~~022).

Conclusion: Intraoperative ALT allows to detect AL defects after LLCR that can be effectively managed intraoperatively, leading to a significant lower risk of postoperative CAL.

Key words:

Air leak test, laparoscopic, left hemicolectomy, anastomotic leakage, colorectal cancer, diverticulitis

Introduction

Anastomotic leakage after colorectal resection is burdened by significant early postoperative morbidity and mortality and adverse long-term oncologic outcomes [1,2]. Even though several patient-related variables and operative factors have been associated with increased risk of colorectal anastomotic leak (CAL) [3,4], and some prognostic indexes have been developed [5,6], the prediction of the occurrence of CAL is challenging.

Since the subjective surgeon's clinical assessment of the anastomotic integrity at the end of the operation has a low predictive accuracy for CAL [7], intraoperative colorectal anastomosis (CA) testing after left-sided colon resection (LCR) is recommended to help the surgeon identify a CA at increased risk of a subsequent leakage [8]. Several objective and reliable intraoperative tests have been developed, including intraoperative endoscopy, air leak test (ALT), saline and methylene blue leak tests, and, more recently, the near infrared fluorescence (NIRF) angiography with indocyanine green (ICG) [9].

While commonly used in the United States to test the integrity of a CA [10,11], intraoperative endoscopy is not widely performed in Europe, where other tests such as ALT and, more recently, NIRF angiography with ICG are preferred. However, large comparative studies are needed to validate NIRF with ICG as valuable technique to reduce the risk of CAL [12] and the current evidence supporting the use of ALT aiming at reducing the rate of postoperative CAL is not conclusive [13].

The aim of this study is to challenge the use of ALT in a consecutive series of patients undergoing elective laparoscopic LCR (LLCR) for both benign and malignant diseases.

Materials and Methods

This is a retrospective analysis of a prospectively collected, institutional review board-approved database. Consecutive patients referred for surgical management at our Institution between January 1996 and June 2017 and undergoing elective LLCR with primary CA and no planned proximal bowel diversion for sigmoid diverticulitis, large colon adenoma or cancer of the descending colon, sigmoid colon or the upper rectum were identified. Exclusion criteria were: mid-lower rectal tumors, preoperative or intraoperative evidence of distant metastases in cancer patients, acute bowel obstruction, tumor perforation, synchronous colorectal cancers, and previous history of colon surgery. Patients undergoing LLCR with no primary CA were also excluded.

Preoperative mechanical bowel preparation (MBP, polyethylene glycol solution 4 L 48 hours before LLCR, followed by a liquid diet) was administered to all patients until December 2004; then, according to the findings of the meta-analysis published by Slim et al. [14] MBP was abandoned, with all patients having only a rectal enema the night before surgery.

Perioperative management was standardized. Preoperative oral antibiotics were not routinely administered. Intravenous antibiotics (cephalosporin or gentamycine in case of known allergy to cephalosporin and methronidazole) were administered before starting LLCR. Subcutaneous injection of low molecular weight heparin and pneumatic compression stockings were utilized to achieve deep venous thrombosis prophylaxis. Postoperative patient management (analgesia, nausea and vomiting prophylaxis, urinary catheter removal, patient mobilization and oral intake) was standardized. Patient was discharged after recovering mobilization and bowel function, in the absence of complications, with pain being successfully controlled by oral medications and adequate oral food intake with no need for parenteral nutrition.

All LLCRs were performed by surgeons with extensive experience in colorectal and laparoscopic advanced surgery, and completed the same surgical training program at the same academic institution. All LLCRs were completed by the attending surgeons following the same surgical steps.

The surgical technique was standardized, with intracorporeal splenic flexure mobilization, sigmoid mesocolon dissection, inferior mesenteric vessels division, and distal sigmoid colon transection by using a laparoscopic linear stapler. Distal bowel transection was performed distal to the rectosigmoid junction in patients with diverticulitis; partial mesorectal excision with transection of the rectum and the mesorectum at least 5 cm below the distal tumor margin was performed in patients with cancer of the upper rectum. The bowel was exteriorized through a protected suprapubic incision, the descending colon was divided and the anvil of a circular stapler introduced into the lumen of the proximal colon. The colon was then returned into the abdomen and a laparoscopic transanal intracorporeal double-stapled CA was performed. After removal of the stapler, integrity of the anastomotic doughnuts was routinely checked. However, we did not report in this study the data about the completeness of the doughnuts, since this information was not available in all surgical reports.

The decision to perform the ALT was not based on the intraoperative subjective surgeon's evaluation of the CA quality, but on the individual surgeon routine practice: AA and MaMo routinely performed ALT, while MD and MaMi did not routinely perform ALT. All ALTs were performed by insufflating 60 cc of air into the rectum through a syringe inserted into the anal canal, with the CA under irrigation of saline and the colon occluded proximal to the CA. ALT was not performed with air insufflation into the rectum through an endoscope.

The method of repair of an intraoperative AL was left to the discretion of the operating surgeon: suture repair alone, diverting stoma with or without leak suturing, re-resection and redo CA. After AL suture repair, a further ALT was done to verify the integrity of the CA.

A prophylactic drain was routinely placed in the abdominal or pelvic cavity after LLCR in those patients who had positive ALT, otherwise it was used selectively (i.e intraoperative bleeding, severe pelvic inflammation).

The definition of postoperative CAL was clinical: in the presence of fever, signs of local or generalized peritonitis, discharge of gas, pus or stools from the drainage tube, patients underwent a CT scan to confirm the diagnosis. Patients were not screened for asymptomatic CAL.

A prospective protocol was designed to evaluate the following parameters: patient's characteristics [age, sex, body mass index (BMI), comorbidities evaluated using the Charlson Comorbidity Index (CCI) [15], American Society of Anesthesiologists (ASA) score, indication for LLCR], operative variables (type of LLCR, type of anastomosis, reason for conversion, operative time, estimated blood loss), and short-term (within 30 days from surgery) outcomes (morbidity according to Dindo classification [16], resumption of gastrointestinal function, length of hospital stay).

A colonoscopy with gastrografin enema was obtained in all patients who had a diverting ileostomy at the index LLCR in case of positive ALT or as treatment of a postoperative CA to rule out the presence of CA stenosis or CA fistula, before scheduling the stoma closure.

Statistical analyses

Quantitative data are given as median and range and categorical data are expressed as percentages. Statistical analysis among the groups was performed using χ^2 test or the Student's *t* as appropriate. A multivariable analysis to identify independent risk factors for CAL was performed by the binary logistic regression model. A full series of 14 univariate binary regression logistic models was initially estimated; only the exploratory variables being statistically significant in the previous series were included in the multivariate model. The following variables were considered: age, sex, BMI, type of disease, ASA score, CCI, level of albumin, use of preoperative MBP, operative time, intraoperative complications, conversion to open surgery, type of anastomosis, use of a prophylactic drain, and ALT. Results are reported as odds ratio (OR) with 95% confidence intervals (CI).

All statistical analyses were performed on an ''intention-to-treat'' basis: patients converted to an open procedure were included in the study. All p values were 2-sided. A level of 5% was set as the criterion for statistical significance. The statistical analysis was performed using SPSS version 19 (Copyright © SPSS Inc., 2000).

Results

A total of 777 patients undergoing elective LLCR with primary CA and no diverting stoma were included. The CA was tested in 398 patients (ALT group), while intraoperative ALT was not performed in 379 patients (No-ALT group). The two groups of patients were comparable in age, sex, BMI, ASA score, comorbidities, CCI and indication for LLCR (**Table 1**). No patient with upper rectal cancer underwent neoadjuvant chemoradiation therapy. Median height of CA was 13 cm (range, 7-22) in the ALT group and 14 cm (range, 7-23) in the No-ALT group (P=0.340).

Intraoperative results

The type of procedure and the type of CA performed are listed in **Table 2**.

Overall, median operative time was 120 (range, 45-330) minutes in the ALT group and 115 (range, 70-345) minutes in the No-ALT group (p=0.191). Median estimated blood loss was 60 (range, 30-300) ml in the ALT group and 50 (range, 50-200) ml in the No-ALT group (p=0.052).

No significant differences were observed in the conversion rate to open surgery between the two groups: 10.8% vs. 7.9% (p=0.209). Main reasons of conversion were bulky colon cancer, adhesions and morbid obesity in both groups of patients. The types of CA did not differ between the two groups (**Table 2**).

Intraoperative ALT was positive in 20 (5%) patients. A stoma was created in 14 (70%) patients, while 6 (30%) patients had a suture repair alone. A complete reconstruction of the CA was performed in 2 of these 20 patients.

Postoperative results

The first bowel movement and resumption of solid diet occurred quicker in the ALT group: on postoperative day 4 (range, 2-13) vs. postoperative day 5 (range, 2-11), and on postoperative day 3 (range, 2-16) vs. postoperative day 4 (range, 2-10) (both p<0.001). ~~Median postoperative length of stay was shorter in the ALT group: 7 (range, 4-46) days and 8 (range, 4-58) days (p=0.006).~~

Overall 30-day morbidity rates did not differ between the two groups: 13.3% vs. 13.5% (p=0.962). The severity of complications according to Dindo classification was similar between the two groups (**Table 3**). Mortality rate was 0.3% in the ALT group and 0% in the No-ALT group.

Overall, postoperative CAL occurred in 32 out of 777 patients (4.1%), while a pelvic abscess was observed in 2 (0.5%) ALT patients and in 1 (0.3%) No-ALT patient (p=0.962). No significant differences in CAL rate were observed before and after changing preoperative MBP protocol (5.2% vs. 3.4%; P=0.23). The postoperative CAL rate was significantly lower in ALT patients than in No-ALT patients: 10 CAL (2.5%) vs. 22 CAL (5.8%), respectively (p=0.025). The median time between surgery and the occurrence of a postoperative CAL was 6 days (range, 4-15) in the ALT group and 4 days (range, 2-8) in the No-ALT group (p=0.026). A reoperation was needed in 28 (87.5%) of 32 patients, while a conservative approach was used in 4 (12.5%) patients. Among the 28 patients who underwent a reoperation, 10 (35.7%) patients underwent proximal diverting loop ileostomy (in 1 case with suture of the CA defect), while 18 (64.3%) patients had takedown of the CA, creation of Hartmann stump and end colostomy.

The postoperative course was uneventful in all 20 patients with intraoperative positive ALT. ~~;~~ A colonoscopy with gastrografin enema, obtained before stoma reversal in all patients who had a diverting stoma because of positive ALT or postoperative CAL, found a CA stenosis requiring endoscopic dilatation in 3 (21.4%) of the 14 ALT patients who had a stoma creation at the index LLCR, without any evidence of persistent anastomotic fistula.” ~~however, a CA stenosis requiring endoscopic dilatation was detected by a colonoscopy performed before stoma reversal in 3 (21.4%) of the 14 ALT patients who had a stoma creation at the index LLCR.~~

The multivariate binary logistic model showed that ASA score 3-4 (OR 45.~~91~~39, 95% CI 2.~~17~~53-11.~~11~~51, p<0.001) and male sex (OR 3.~~87~~96, 95% CI 1.~~62~~66-9.~~24~~43, p=0.002) were the independent risk factors for postoperative CAL, while intraoperative ALT independently reduced the postoperative CAL rate (OR 0.~~39~~40, 95% CI 0.18-0.~~86~~88, p=0.~~019~~022) (**Table 4**).

Discussion

Postoperative CAL is associated with significant early morbidity and mortality, need for stoma creation, and poor functional and oncologic outcomes [17-19]. Even though several risk factors for CAL have been identified and some prognostic indexes have been developed, it is very difficult to predict the occurrence of CAL. Unfortunately, the predictive accuracy of the surgeon' judgement for CAL is poor. Karliczek et al. [7] asked 191 surgeons to predict the risk of clinically CAL on a visual analogue scale at the end of each surgical procedure. Median predicted CAL rate was 7.1% for CA constructed more than 15 cm from the anal verge and 9.5% for CA within 15 cm from the anal verge. CAL occurred in 26 (13.6%) patients. Sensitivity and specificity were low for both CAs: 38% and 46% for high CA and 62% and 52% for low CA. Interestingly, sensitivity and specificity did not significantly differ between assistant and staff surgeons.

Several intraoperative CA assessment methods are used to evaluate in a simple, reproducible and more objective fashion the integrity of a CA, including the ALT test, the methylene blue leak test, endoscopy and microperfusion tests. Inadequate blood supply and poor surgical technique are widely considered the most likely leading causes of AL [20]. Since the early 1990s, several efforts have been done to investigate the role of blood perfusion in determining a CAL; however, the evidence from some experimental studies, based on laser Doppler flowmetry [21,22] and local oxygen tension assessment [23], is controversial and is not sufficient to define the threshold of blood flow that is necessary for CA healing. More recently, (NIRF) angiography with ICG has emerged as a promising tool for the intraoperative evaluation of tissue perfusion during LLCR [12]; however, even the current imaging systems that are used for NIRF with ICG do not quantify the perfusion of the CA and therefore do not help provide a quantitative definition of adequate anastomotic perfusion.

While endoscopy is widely used in the United States, ALT is the most frequently adopted method in Europe to evaluate the CA integrity during LLCR; however, the current evidence is controversial, with only two randomized controlled trials (RCTs) [24,25], one retrospective nonrandomized comparative study [26] and a few small retrospective case series being published in the literature [27-32]. These studies are heterogeneous, some do not report the definition of AL, while others have a small sample size or report the data incompletely. The only RCT that showed a significantly lower risk of postoperative CAL when intraoperative ALT was performed (4% vs. 14%, p=0.043) is that published back in 1990 by Beard et al, who analyzed 143 consecutive patients undergoing open urgent or elective colorectal resection with CA. A total of 73 patients were randomized to ALT and 71 patients to no-ALT [24]. A trend towards a higher rate of CAL in patients who did not have ALT was also observed by Ivanov et al. in a small RCT [25]. They enrolled 60 patients (30 patients randomized in each group) and reported a 10%-rate of CAL in the ALT group and 20%-rate in the no-ALT group. However, the extremely high reported rates of positive intraoperative ALT (25% and 23%) and postoperative CAL (14% and 15%) in both RCTs raise concerns about the surgical technique and do not allow to draw conclusions. Furthermore, very few data have been published in the laparoscopic era.

We reviewed the outcomes in 777 patients (398 ALT patients and 379 No-ALT patients) undergoing LLCR with primary CA without planned diverting proximal stoma for both benign and malignant colon diseases. Performing an intraoperative ALT did not significantly prolonged the operative time of the index LLCR. ALT was positive in 5% of patients; postoperative CAL was less likely to occur if an intraoperative ALT was performed: 2.5% vs. 5.8% (p=0.025). These results are consistent with those reported in the retrospective comparative study by Ricciardi et al., who compared the outcomes in 825 patients with tested CA and 173 patients who had the CA not tested. ALT resulted to be positive in 65 (7.9%) tested patients. Postoperative CAL rate was 3.8% in the tested group with negative ALT and 8.1% in the non-tested group (p<0.05), suggesting the usefulness of ALT. However, the interpretation of these results is limited, since selection criteria were not clearly stated and information about others factors that might have a role in developing postoperative CAL, including patients' diagnosis and the urgency of the index operation, were not available in their database [26]. We were able to assess the role of intraoperative ALT in a multivariate analysis, showing that ALT was independently associated with a lower rate of postoperative CAL (OR 0.3940, p=0.019022). As a consequence, we also showed that the length of hospital stay was significantly shorter in the ALT group (7 vs. 8 days, p=0.006).

Wu et al. [13] have argued that ALT might not be useful in reducing the rate of postoperative CAL, since a positive ALT is still associated with a substantial rate of postoperative CAL, regardless of the intraoperative strategy used to manage the leak. However, several limitations of the studies considered in their systematic review and meta-analysis of the literature, including selection bias (in most series, ALT was selectively performed only in case of surgeon concern about of the CA integrity) and heterogenous methodology to test the CA, bias the interpretation of the current evidence. To date, the optimal management strategy of an intraoperative AL is poorly studied [26,33] and not defined, since it depends on the level of the CA, the entity of the AL defect and the skills of the operating surgeon.

We have shown that no clinical postoperative CAL occurred among the 20 patients with positive ALT: 14 patients had a diverting stoma and 6 had a direct suture repair. The results of our study are similar to those reported by Mitchem et al. [33] who specifically analyzed the outcomes in 119 patients with a positive ALT: 51 had proximal diversion or CA reconstruction, while 68 patients underwent suture repair alone. They reported no clinical postoperative CAL in the group of patients who had a stoma, while CAL occurred in 9% of patients who had a suture repair only. No CAL in patients who had a stoma were reported also by others [26]. Even though the stoma creation seems to be a safe and effective treatment modality of intraoperative positive CAL, this CAL treatment modality is not without drawbacks, since the presence of a stoma is associated with significant morbidity [34] and, as we have reported, a CA stenosis requiring endoscopic dilatation may occur in more than 20% of these patients.

The results of our the unimultivariate analysis confirmed that preoperative MBP does not help prevent postoperative clinical CAL after LLCR. Same findings were observed regarding the use of a prophylactic drainage, that is routinely placed by many surgeons aiming at decreasing postoperative complications, including CAL. In our series, we did not observe a significant difference in the rate of clinical CAL between patients who had a drain in place at the end of the surgical procedure and those who did not. These results confirm the findings of a recent meta-analysis of 11 RCTS, including 1803 patients: no significant differences were observed in terms of clinical CAL, radiologic CAL, mortality and reoperation rates [35].

We acknowledge that our study is not without limitations, that are mainly related to the retrospective nature of the data analysis. In addition, it is a single-center study, with all LLCRs performed by highly experienced surgeons in both colorectal and laparoscopic surgery; as a consequence our results may not be generalized. Furthermore, the differences observed in the outcomes might reflect inter-surgeon variability more than be associated with the use of ALT. However, the perioperative patient management protocol was standardized and not based on the surgeon's preference, without significant changes in hospital care and surgical techniques during the study period. The four attending surgeons involved in this study completed the same surgical training program at the same academic institution and performed all LLCRs following the same surgical steps. In any case, the study period excluded the first 40 LLCRs of each surgeon to avoid the effect of the learning curve [36]. Finally, we did not report the data about completeness of the donuts that were not available for all patients.

Nevertheless, this is the largest comparative study assessing the rate of postoperative CAL after ~~laparoscopic~~ LLCR with or without intraoperative ALT in the laparoscopic era. In addition, electronic medical charts were reviewed in details when patient's characteristics or operative details were missing in the database.

In conclusion, the results of this large comparative study favor the routine use of ALT during LLCR to verify the CA integrity. Even though routine intraoperative ALT with insufflation of 60 cc of air does not prevent the occurrence of postoperative CAL, the CAL rate in patients who have ALT is half of that observed when ALT is not performed. In addition, we feel that a positive ALT allows to intraoperatively manage the AL with no added risk of postoperative CAL.

Disclosures

Drs. Marco Ettore Allaix, Adriana Lena, Maurizio Degiuli, Alberto Arezzo, Massimiliano Mistrangelo, and Mario Morino have no conflicts of interest or financial ties to disclose.

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Table 1 Baseline patients' characteristics.

	ALT (n =398)	No-ALT (n =379)	P value
Sex			
Male, n (%)	217 (54.5)	179 (47.2)	0.050
Age (years)	66 (27-90)	65 (31-91)	0.872
Body Mass Index (Kg/m^2)	25 (16-47)	24 (17-43)	0.156
ASA score, n (%)			0.173
1	23 (5.8)	29 (7.6)	
2	278 (69.8)	236 (62.3)	
3	94 (23.6)	108 (28.5)	
4	3 (0.8)	6 (1.6)	
Charlson Comorbidity Index, n (%)			0.344
0	71 (17.8)	55 (14.5)	
1-2	211 (53)	218 (57.5)	
≥3	116 (29.2)	106 (28)	
Comorbidities, n (%)			
Diabetes	37 (9.3)	35 (9.2)	0.925
Pulmonary	29 (7.3)	31 (8.2)	0.740
Cardiovascular	129 (32.4)	111 (29.3)	0.387
Indications for LLCR, n (%)			0.642
Diverticulitis	57 (14.3)	63 (16.6)	
Adenoma	46 (11.6)	40 (10.6)	
Cancer	295 (74.1)	276 (72.8)	

ALT = air leak test

ASA = American Society of Anaesthesiologists

LLCR = laparoscopic left-sided colon resection

Table 2 Intraoperative results.

	ALT (n =398)	No-ALT (n =379)	P value
Operative time (min)	120 (45-330)	115 (70-345)	0.191
Intraoperative blood loss (ml)	50 (30-300)	50 (40-200)	0.052
Reasons for conversion, n (%)	43 (10.8)	30 (7.9)	0.209
Tumor related			
locally advanced tumor	20	11	
Non-tumor related			
Obesity	10	7	
Adhesions	11	9	
Others	2	3	
Surgical procedure, n (%)			0.247
Left hemicolectomy	102 (25.6)	105 (27.7)	
Sigmoidectomy	183 (45.9)	152 (40.1)	
Anterior resection with PME	113 (28.5)	122 (32.2)	
Colorectal anastomosis, n (%)			0.349
End-to-end	361 (90.7)	335 (88.4)	
Side-to-end	37 (9.3)	44 (11.6)	
Prophylactic drain, n (%)	51 (12.8)	41 (10.8)	0.453

ALT = air leak test

PME = Partial Mesorectal Excision

Table 3 Postoperative results.

	ALT (n =398)	No-ALT (n =379)	P value
First bowel movement (days)	4 (2-13)	5 82-11)	<0.001
Oral intake (days)	3 (2-16)	4 (2-10)	<0.001
Length of hospital stay (days)	7 (4-46)	8 (4-58)	0.006
Complications, n (%)			
Overall	54 (13.6)	51 (13.5)	0.952
Grade 1	11	8	0.687
Grade 2	25	17	0.347
Grade 3	17	24	0.261
Grade 3a	1	1	0.501
Grade 3b	16	23	0.253
Grade 4	0	2	0.458
Grade 5	1	0	0.980

ALT = air leak test

Table 4 Univariate and multivariate analysis of risk factors for anastomotic leak.

Variable	Univariable analysis		Multivariable analysis	
	OR (95% CI)	**P value**	**OR (95% CI)**	**P value**
Age[a] <66 ≥66	1 1.45 (0.71-2.98)	0.312		
Gender Female Male	1 3.60 (1.54-8.43)	0.003	1 3.96 (1.66-9.43)	0.002
BMI ≤30 >30	1 1.15 (0.44-3.06)	0.773		
Cancer No Yes	1 1.99 (0.76-5.25)	0.162		
ASA score 1-2 3-4	1 5.58 (2.64-11.78)	<0.001	1 5.39 (2.53-11.51)	<0.001
CCI 0-2 ≥3	1 2.29 (1.13-4.68)	0.022		
Level of albumin ≥3.5 g/dl <3.5 g/dl	1 1.45 (0.59-3.52)	0.435		
Preoperative MBP No Yes	1 1.47 (0.84-2.59)	0.230		
Operative time <180 min ≥180 min	1 1.49 (0.72-3.06)	0.301		
Intraoperative complications No Yes	1 1.68 (0.21-13.22)	0.620		
Conversion to open surgery No Yes	1 1.27 (0.28-2.25)	0.809		
Type of anastomosis Side-to-end End-to-end	1 1.78 (0.42-7.59)	0.436		
Prophylactic drain No Yes	1 0.88 (0.26-2.97)	0.843		
Air leak test No Yes	1 0.42 (0.19-0.89)	0.025	1 0.40 (0.18-0.88)	0.022

[a] Median age of the study population
OR = Odds Ratio; 95% C.I. = 95% Confidence Interval
BMI = Body Mass Index; ASA = American Society of Anaesthesiologists; CCI = Charlson Comorbidity Index; MBP = mechanical bowel preparation