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# Impact of intracorporeal anastomosis on surgical time and anastomotic leak rate in patients undergoing Videolaparoscopic Ileocolectomy

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## Abstract

**Introduction:** Advances in surgical instruments and surgeon proficiency have facilitated the adoption of completely laparoscopic procedures, enhancing the benefits of minimally invasive surgery. Intracorporeal (IC) anastomosis demands a higher level of technical skill, a steeper learning curve, and extended training. While some published studies suggest the superiority of IC anastomosis, the existing evidence is inconclusive with heterogeneous conclusions. Thus this study aims to evaluate the impact of the IC anastomosis on surgical time, anastomotic leak (AL) rate in patients undergoing laparoscopic right colectomy.

**Methods:** Retrospective cohort study with 234 patients who underwent laparoscopic ileocolectomy between January 2014 and March 2021. Patients were categorized into two groups: IC anastomosis and extracorporeal (EC) anastomosis and analyzed for: Surgical time, AL rate in patients after laparoscopic right colectomy.

**Results:** Surgical time was significantly shorter in the extracorporeal anastomosis group (198 min vs. 260 min; p<0.001). The overall AL rate after ileocolic anastomosis was 3.1%, with a notably higher incidence in the IC anastomosis group (7.2% vs. 1.3%, p=0.021). Univariate analysis identified IC anastomosis as the sole independent risk factor for AL (OR: 6.13, p=0.033).

**Conclusions:** Patients undergoing ileocolectomy with intracorporeal anastomosis exhibited prolonged surgical times and a higher incidence of AL compared to those undergoing EC anastomosis.

**Keywords:** Surgery; Robotic surgery; Intracorpoeral anastomosis; Ileocolectoly; Laparoscopic surgery

## Introduction

The minimally invasive surgery reduces surgical trauma and the inflammatory tissue response, allowing a faster postoperative recovery with less complications rate. This approach is associated with earlier return of the bowel function, reduction of the postoperative pain and of the length of stay (LOS) compared with conventional open approach[1-3]. The use of videolaparoscopy (VDL) to treat colorectal pathologies brought the same mentioned benefits and was widely adopted in many colorectal surgery units all around the world [4,5]. The surgical instruments enhancement and the development of the surgeon's abilities, allowed the conduction of

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completely VLP intra-abdominal procedures, with complex intracorporeal (IC) anastomosis, augmenting more the benefits achieved. IC anastomosis, especially in colorectal surgeries, demands a higher technical ability, learning curve and a longer practicing time [5-7].

In VLP ileocolectomy, the ileocolic anastomosis for the bowel transit reconstruction can be made either extracorporeal (EC) or IC. In the VLP ileocolectomy with EC anastomosis, the vessel sealing, dissection and mobilization of the colon are performed laparoscopically and the anastomosis is made outside of the abdominal cavity while during the IC anastomosis, the whole procedure is conducted laparoscopically [8]

The EC technique requires greater colon mobilization and mesenteric traction besides a larger incision, usually transumbilical, to externalize the colon for anastomosis [4]. In contrast, theoretically the IC technique offers advantages such as less colon mobilization and smaller mesenteric traction, both of which reduce the surgical trauma and the inflammatory response, making the postoperative results better and reducing the incisional hernia rate. However, due to the required technical abilities, especially during suture and the learning curve to a safe anastomosis execution, less than 10% of the laparoscopic right colectomies are performed with IC anastomosis [5-7].

Recent studies evaluated the safety and effectiveness of EC vs IC anastomosis and yielded inconsistent results[7,9]. With two recent meta-analyses examining the short-term outcomes, morbidity, mortality and postoperative recovery parameters, showing discordant results regarding these aspects. Therefore, the advantages of the IC anastomosis during the laparoscopic right colectomy remain uncertain.

Investigations comparing EC vs IC anastomosis were mainly performed in European and United State colorectal units with conflicting results. The aim of this study was to assess the impact of the IC anastomosis regarding: surgical time and AL rate of patients undergoing laparoscopic right colectomy at a colorectal unit in a tertiary hospital in Belo Horizonte, Brazil.

## Methods

### Study design and participants

This retrospective, observational study was conducted in a tertiary hospital in Belo Horizonte, Brazil from January 2014 to March 2021. The study included patients above the age of 18 years underwent VLP ileocolectomy to treat colon cancer or neoplastic benign lesions that were non-resectable endoscopically located in the cecum, ascending colon or proximal transverse colon.

This study was approved by the Research Ethics Committee of the institution. CAAE: 48386915.0.0000.5125.

The exclusion criteria included patients who underwent surgery due to synchronic neoplasm, primary pathologies of the appendix, endometriosis, inflammatory bowel disease and surgical resections which included other bowel segments besides the right colon or the proximal transverse colon.

The patients were divided into two groups. The EC group, constituted by patients with EC anastomosis, and the IC group, composed by patients underwent IC anastomosis. The chosen technique (IC vs EC) was by surgeon's preference and experience.

To assess similarities, both groups were compared considering their age, gender, physical state classification according to the American Society of Anesthesiologists (ASA), body mass index (BMI), and surgical indication. The variables investigated were surgical time, LOS, postoperative AL rate, postoperative ileum, intra-abdominal abscess, surgery site infection, hospital readmission rate and death in a 30-day postoperative period.

Every patient received prophylactic antibiotics with ceftriaxone (2g) and metronidazole (1.5g) one hour before anesthetic induction, as by institutional protocol. An orogastric tube was positioned during the anesthetic induction, and removed at the end of the procedure. Additionally a indwelling urinary catheter, was inserted and removed within 24-hour maximum postoperative period.

The procedure began with the confection of pneumoperitoneum via umbilical punction with a Veress needle and position of the other trocars. Four or five portals were used according to the surgeon's preference. After the positioning of the trocars and performing diagnostic laparoscopy, the colon was mobilized in a medial-lateral direction in the avascular plane of the mesocolon, until the adequate identification of the duodenum, the pancreas and the ileocolic vessels which were isolated and their origin ligated. Then, the right colic vessels, when present, were identified and ligated, as well as the right arterial branches and the middle colic vein. The ascending colon, the hepatic angle, the proximal transverse colon and the terminal ileum were adequately mobilized.

Patients who underwent EC anastomosis, transumbilical incision was performed for the exteriorization of the terminal ileum and distal colon. Then, the side-to-side antiperistaltic ileocolic anastomosis was performed with a linear stapler. In the IC group an endostapler was used to sectionate, close and perform the anastomosis. The colon and the ileum were closed in the location of the stapler insertion with continuous suture in single or double layers according to the surgeon's preference. The specimen was then extracted through a Pfannenstiel incision with wound protection.

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## Statistical analysis

To analyze the data, exploratory statistical techniques were used to enhance the visualization of the general characteristics. Quantitative variables were presented as mean with standard deviation, median, and/or interquartile range, according to the normal distribution. Qualitative variables were presented as absolute value and percentage .The progressive data was tested regarding Normality through the Kolmogorov-Smirnov test and adequate tests were used to distribute it. As the progressive variables did not present Normal distribution, non-parametric tests were utilized. A Mann-Whitney test was applied to compare the progressive variables considering the type of anastomosis. The Chi-square, Fisher and Monte Carlo Simulation tests were used to compare the categorical data regarding the type of anastomosis. The univariate analysis was calculated for the AL risk factors and the variables considered included age (Q1xQ3, <65y vs >=65y), gender, ASA, BMI (Q1xQ3, BMI>=30 x BMI<30), surgical indication (Neoplasm vs unresectable polyp), anastomosis type (IC vs EC) and surgical approach (conversion vs VLP vs Robotic). Statistical significance was considered for $p<0.05$ and the utilized software was SPSS version 25.0.

## Results

A total of 234 patients, who underwent right laparoscopic colectomy at the coloproctology unit of Felício Rocho hospital from January 2014 to March 2021 were included. EC anastomosis was performed in 161 patients (EC group) and IC anastomosis was conducted in 73 patients (IC group).

Both groups were similar in terms of age, BMI, gender, ASA, surgical approach and modality (Table 1). The average age of patients who underwent laparoscopic surgery IC and EC anastomosis were 63.9 and 66.9, respectively. The average BMI was 26.2 for both groups. Right colon malign neoplasm was the main indication to perform surgery (163 patients, 69.7%).

When analyzing the LOS based on the type of anastomosis (Table 2), the median of IC anastomosis was 4 days. In contrast, the median LOS of EC anastomosis was 5 days. This difference was not statistically relevant.

When analyzing the surgical time variable, the EC anastomosis group demonstrated shorter surgical time compared to the IC anastomosis group (Median 198 minutes vs 260 minutes; $p<0.001$) (Table 2) (Figure 1).

The surgical time analysis over the years of this study for patients who underwent IC anastomosis, did not show a statistically significant difference ($p=0,802$). (Figure 2).

The AL rate after ileocolic anastomosis was 3.1%, being significantly higher in the IC anastomosis group. (7.2% vs 1.3%; $p=0.021$). (Table 3) No significant difference was

**Table 1:** Operatory and demographic characteristics compared between IC and EC anastomosis.

| Variables | | IC | EC | Total | p-Vaule |
|---|---|---|---|---|---|
| Age | | 64.0 (55.0, 75.0) | 68.0 (59.0, 77.0) | 67.0 (57.5,76) | 0.136* |
| Median (Q1,Q3) | | | | | |
| BMI | | 25.7 (22.9, 23.2) | 25.4 (23.2, 27.9) | 25.4 (23.2, 28.1) | 0.923* |
| Median (Q1,Q3) | | | | | |
| Gender | Female | 39 (53.4%) | 105 (65.2%) | 144 (61.5%) | |
| N (%) | Male | 34 (46.6%) | 56 (34.8%) | 90 (38.5%) | |
| ASA | I | 10 (15.4%) | 17 (11.7%) | 27 (12.9%) | 0.396** |
| N (%) | II | 44 (67.7%) | 111 (76.6%) | 155 (73.8%) | |
| | III | 11 (16.9%) | 17 (11.7%) | 28 (13.3%) | |
| Surgical Indication | Neoplasm | 54 (74.0%) | 109 (67.7%) | 163 (69.7%) | 0.334** |
| N (%) | Unresectable Polyp | 19 (26.0%) | 52 (32.3%) | 71 (30.3%) | |
| Surgical approach | Conversion | 1 (1.4%) | 5 (3.1%) | 6 (2.6%) | |
| N (%) | VLP | 69 (95.8%) | 155 (96.9%) | 224 (96.6%) | 0.075*** |
| | Robotic | 2 (2.8%) | 0 (0%) | 2 (0.9%) | |

*Mann-Whitney Test, **Chi-Square Test; ***Monte Carlo Simulation.

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**Table 2:** LOS and surgical time compared between IC and EC anastomosis.

| | | IC n=61 | EC n=161 | p-Value* |
|---|---|---|---|---|
| LOS (days) | Mean ± SD | 7.6 ± 10.3 | 6.0 ± 5.5 | 0.993 |
| | Median | 4 | 5 | |
| | Minimum | 2 | 2 | |
| | P25 | 4 | 4 | |
| | P75 | 6 | 6 | |
| | Maximum | 67 | 45 | |
| Surgical time (min) | Mean ± SD | 273.4 ± 58.5 | 199.6 ± 46.4 | <0.001 |
| | Median | 260 | 198 | |
| | Minimum | 120 | 85 | |
| | P25 | 240 | 166.5 | |
| | P75 | 310 | 228.5 | |
| | Maximum | 480 | 360 | |

*Mann-Whitney Test.

observed between groups in the postoperative ileus rate (22.9% vs 17.6%), intra-abdominal abscess (4.3% vs 3.1%) and surgical site infection (SII) (1.4% vs 3.8%). Additionally, there was no difference in the hospital readmission rate (5.8% vs 1.3%) and mortality rate (4.3% vs 1.3%) (Table 3.) .

In the univariate analysis (Table 4) for the AL only the IC anastomosis showed as an independent risk factor (OR: 6.13, p= 0.033). The OR of the surgical approach could not be calculated because there were no AL cases during converted and robotic surgeries. The multivariate analysis for the AL risk factors was not calculated due to only a single anastomotic variable having a significant association.

After IC anastomosis emerged as an AL risk factor, a detailed analysis of these patients was conducted (Table 5). The aim was to explore differences in technique, such as the number of reinforcement lines for anastomosis closure, and the surgeon's experience in VLP. No significant differences were observed in AL rates based.

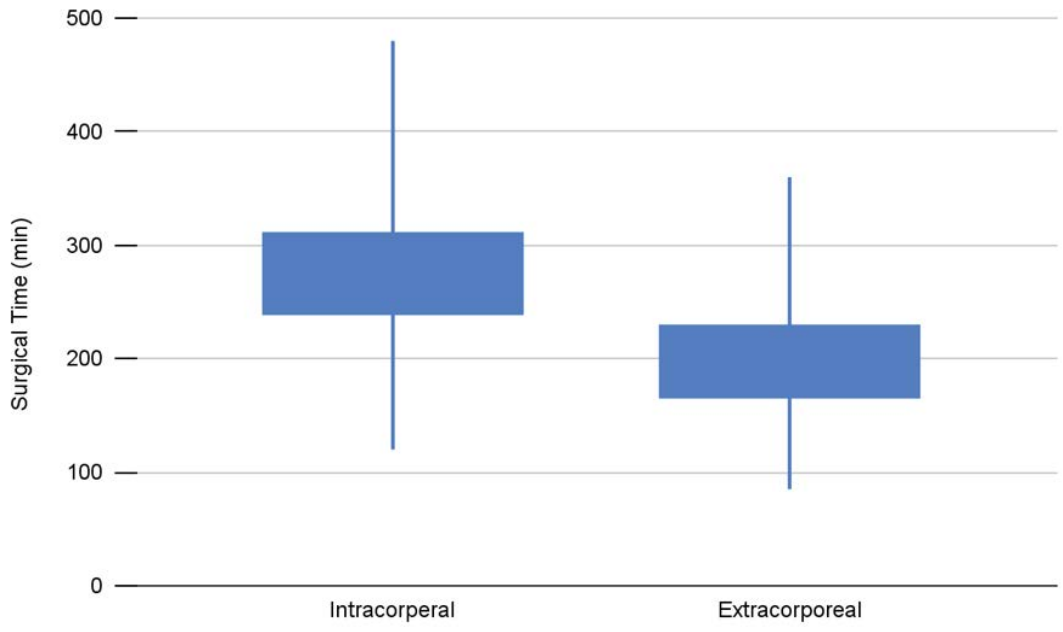


**Figure 1:** Comparison of the surgical time in relation to the anastomosis type (p<0.001).

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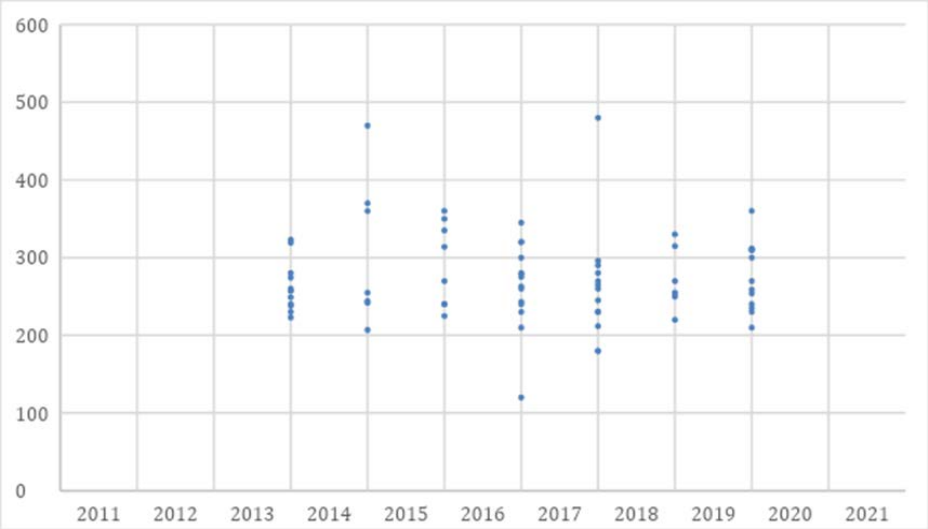


**Figure 2:** IC anastomosis surgical time distribution (min) according to the year of the surgery.

**Table 3:** Postoperative complications compared between IC and EC anastomosis.

| Variables | IC | EC | Total | Value p |
|---|---|---|---|---|
| Postop ileus | 16 (22.9%) | 28 (17.6%) | 44 (19.2%) | 0.353* |
| Abscess | 3 (4.3%) | 5 (3.1%) | 8 (3.5%) | 0.701** |
| SII | 1 (1.4%) | 6 (3.8%) | 7 (3.1%) | 0.678** |
| AL | 5 (7.2%) | 2 (1.3%) | 7 (3.1%) | 0.021** |
| Readmission | 4 (5.8%) | 2 (1.3%) | 6 (2.6%) | 0.070** |
| Death | 3 (4.3%) | 2 (1.3%) | 5 (2.2%) | 0.168** |

*Chi-square test; **Fisher Test.

**Table 4:** Univariate results of the AL association analysis.

| Variable | Anastomotic leak | | OR | IC95%OR | Value-p |
|---|---|---|---|---|---|
| | Yes n=7 | No n=221 | | | |
| Median Age | 55 | 67 | 0,982 | 0,93 ; 1,04 | 0,548 |
| (Q1;Q3) | (53.0; 76.0) | (57.5; 76.0) | | | |
| Elderly | | | | 0,12 ; 2,49 | 0,434 |
| No (<65 anos) | 4 (57.1) | 93 (42.1) | 1 | | |
| Yes ( >=65 anos) | 3 (42.9) | 128 (57.9) | 0,55 | | |
| Gender n (%) | | | | | |
| Female | 3 (42.9) | 135 (61.1) | 1 | 0,46 ; 9,58 | 0,341 |
| Male | 4 (57.1) | 86 (38.9) | 2,09 | | |
| ASA n (%)* | | | | | |
| I | 0 (0.0) | 27 (13.4) | - | - | - |
| II | 5 (100.0) | 147 (73.2) | | | |
| III | 0 (0.0) | 27 (13.4) | | | |

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| | | | | | |
|---|---|---|---|---|---|
| Median BMI | 28.4 | 25,5 | 1,08 | 0,92 ; 1,27 | 0,373 |
| (Q1 ; Q3) | (23.2; 32.7) | (23.1; 28.1) | | | |
| Obese | | | | | |
| Yes (>=30) | 3 (42.9) | 64 (29.0) | 1,84 | 0,40 ; 8,45 | 0,433 |
| No (<30) | 4 (57.1) | 157 (71.0) | 1 | | |
| Surgical indication n (%) | | | | | |
| Neoplasia | | | | | |
| Unresectable Polyp | 6 (85.7) | 151 (68.3) | 2,78 | 0,33; 23,54 | 0,348 |
| | 1 (14.3) | 70 (31.7) | 1 | | |
| Anastomosis | | | | | |
| n (%) | | | 6,13 | 1,16; 32,43 | 0,033 |
| Intra | 5 (71.4) | 64 (29.0) | 1 | | |
| Extra | 2 (28.6) | 167 (71.0) | | | |
| Surgical Modality n (%)* | | | | | |
| conversion | | | - | - | - |
| Video | 0 (0,0) | 7 (3,2) | | | |
| Robotic | 7 (100,0) | 211 (95,9) | | | |
| | 0 (0,0) | 2 (0,9) | | | |

*Variables whose estimation was not possible, Odds ratio (OR), as they had 0 frequency in the categories.

**Table 5:** Variables assessment in relation to the AL in the IC anastomosis.

| Variables | AL N (%) | | Value p |
|---|---|---|---|
| | Yes (n=5) | No (n=69) | |
| Anastomosis lines | | | |
| One | 1 (20%) | 16 (25%) | 1.000 * |
| Two | 4 (80%) | 48 (75%) | |
| VLP experience | | | |
| Higher | 2 (40%) | 42 (65.6%) | 0.334 * |
| Lower | 3 (60%) | 22 (34.4%) | |

*Fisher Test

## Discussion

Minimally invasive surgery has proven to reduce surgical trauma, postoperative metabolic response, and their associated consequences, enabling faster recovery [11]. In colorectal surgery, the creation of intracorporeal (IC) anastomosis may further decrease surgical trauma by reducing the need for extensive colon mobilization and allowing specimen extraction through smaller, aesthetically preferable incisions.

In our study, surgical time was significantly longer in the IC anastomosis group (260.0 vs. 198.0 minutes; p<0.001), consistent with findings from the first meta-analysis comparing IC to EC anastomosis [12]. his extended duration may be attributed to the procedure's inherent complexity and the learning curve associated with mastering IC techniques. Despite expectations that increased experience over time would shorten operative times, this was not observed, as shown in figure 2.

The longer surgical time in our study, even among experienced surgeons, suggests that the complexity of the IC procedure is a major contributing factor. The execution of an anastomosis entirely via laparoscopic methods demands advanced technical skills, such as laparoscopic suturing [13,14]. which may explain its lower adoption rate globally. Studies indicate that less than 10% of ileocolic anastomoses are performed intracorporeally, likely due to the perceived

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technical demands compared to EC anastomosis [5-7,15,16]. Although the IC approach was expected to be longer, recent meta-alysis [17] and randomized controlled essays[4] did not demonstrate a significant difference in the procedure time compared to EC.

Emerging technologies like robotic surgery and 3D laparoscopy could potentially address these challenges. For instance, a meta-analysis by Costa et al. demonstrated shorter anastomotic and operative times with 3D laparoscopy compared to 2D laparoscopy. However, the limited number of robotic procedures in our study precluded analysis of 3D technology's impact.

Despite these technological advances, laparoscopic ileocolectomy, whether with IC or EC anastomosis, continues to be associated with significant morbidity, mortality, and anastomotic leak (AL) rates. Our study reported an overall AL rate of 3.1%, aligning with literature, but with a significantly higher rate in the IC group (7.2% vs. 1.4%, $p<0.001$). This finding contrasts with recent studies, such as Hajibandeh et al., 2021, which found no significant difference in AL rates between IC and EC groups (5.5% vs. 4.0%). Additionally, Creavin et al., 2021, reported no significant difference in AL rates between the two techniques (IC 5.5% vs. EC 4%, RR 1.34, 95% CI 0.58-3.13, $p=0.5$).

Our study included surgeons with varying levels of experience in advanced laparoscopic surgery. Many studies[23] highlight the individual importance of the surgeon as a risk factor of AL. Notably, no significant differences in AL rates were observed between more experienced surgeons (over 20 years) and their less experienced counterparts, nor between different IC anastomosis techniques (single- or double-layer suture) (Table 5). Data of Learning curve for IC anastomosis were published by Cuk et al, 2023, showing only a reduction of operative time of the right colectomy with IC anastomosis, with no alteration in the complication or AL rates. These results reinforce the idea that IC anastomosis presents challenges even for experienced laparoscopic surgeons.

The AL rate after colorectal surgery remains significant, and its prevention continues to be a challenge. Studies like EAGLE (ESCP Safe-Anastomosis Programme in Colorectal Surgery) and RALAR (Risk Factors for Anastomotic Leakage After Anterior Resection for Rectal Cancer) have shown promise in identifying AL risk factors, reducing AL rates, and decreasing morbidity after AL. The EAGLE study was a randomized controlled trial involving 64 countries and 3268 patients, where one of the participating hospitals was our own. The study included online training for surgical technique, a digital risk calculator and an in-theater checklist. Although the overall AL rates did not decrease, hospitals with over 80 per cent team engagement experienced reduced leak rates, from 12.2% to 5.1%. This study highlights the importance of team involvement in implementing interventions, which could successfully decrease AL rates regardless of the surgical technique. Another important study in the field of colorectal anastomotic AL is the RALAR study. This study identified nine independent risk factors for colorectal AL, and a nomogram with a risk score (the RALAR score) was developed to predict AL risk at the end of resection and assist surgeons in deciding whether to perform a protective stoma in order to decrease morbidity after AL [26]. These two studies show that properly recognizing the preoperative and intraoperative risk factors related to AL helps surgeons in the decision to perform a stoma.

Regarding other postoperative outcomes, our study found no significant differences between IC and EC anastomosis groups in terms of paralytic ileus, intra-abdominal abscesses, surgical site infection (SII) rates, mortality, or rehospitalization rates (Table 3). Other authors such as T. ALLAIX *et al.*, 2019; BOLLO *et al.*, 2018, 2020, when analyzing the postoperative results in IC anastomosis, observed a shorter time of bowel recovery with a reduction in the occurrence of paralytic ileus, a smaller surgical incision, a reduction in the SII rate, analgesics use, LOS, and a better aesthetic result, showing that this approach is superior to the EC anastomosis. In contrast, HAJIBANDEH *et al.*, 2021, showed that the laparoscopic ileocolectomy with IC anastomosis has a more surgical morbidity comparable to the EC. CREAVIN *et al.*, 2021, also did not report a difference regarding the AL rate, general morbidity or degree of morbidity. These results are more compatible with our study, in which the difference of morbidity in both groups was not observed with the exception of the AL rate (Table 4).

A study by Grieco et al. highlighted that the adoption of IC anastomosis, alongside enhanced recovery after surgery (ERAS) protocols, reduced the use of nasogastric tubes and length of hospital stay (LOS). However, these benefits are likely attributable to ERAS rather than the anastomosis type. In our institution, ERAS protocols were already in place before IC anastomosis adoption, which may explain the lack of significant differences in our findings. Additionally, the study reported longer operation time after the adoption of IC anastomosis.

The IC anastomosis does allow for a smaller and more aesthetically favorable Pfannenstiel incision, associated with lower SII and incisional hernia rates compared to the midline incision typically used in EC anastomosis [13,23]. In our study, the EC anastomosis and the extraction of the specimen were performed through a transumbilical median incision and the specimens of IC anastomosis patients were removed through Pfannenstiel incision. However, our study did not analyze incisional hernia occurrence, and no significant difference in SII was observed.

Regarding the possible benefits of the IC anastomosis in relation to the EC technique during a minimally invasive right colectomy is still limited. Our study showed higher AL rate

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and longer surgical time without demonstrating any benefits in relation to other analyzed aspects such as paralytic ileus, SII and LOS.

The present study is associated with some limitations, which must be carefully interpreted. The main limitations of this study are associated with its non-prospective randomized design, the short follow-up period, and the lack of evaluation of short and long-term oncological aspects. Among the strengths of the study, we can highlight the substantial number of cases presented, the standardization of the technique and data collected from a single tertiary hospital, referenced in Brazil.

The adoption of the technique should be accompanied by periodic audits of the results and the implementation of technical development of the team to improve results. As technology evolve the minimally invasive surgical practice will allow additional refinement of the IC anastomosis techniques, bringing benefits in relation to reduce AL of the patients who underwent VLP ileocolectomy. Future randomized studies should assess the impact of the anastomosis type in terms of the postoperative complications.

## Conclusion

Patients who underwent ileocolectomy with IC anastomosis had longer surgical time and a higher anastomotic leak rate compared to those that underwent EC anastomosis.

## Authors contributions

Conceptualization: M.F.C.; F.L.Q. Data Curation: M.F.C.; J.S.A.V. Formal Analysis: M.F.C.; L.A.B.C Funding Acquisition: All authors Investigation: M.F.C.; L.A.B.C; J.S.A.V. Methodology: M.F.C.; F.L.Q. Project Administration: M.F.C.; F.L.Q. Resources: M.F.C.; F.L.Q. Supervision: F.L.Q. Validation: M.F.C.; R.C.T; H.F.C.A.L;J.M.C Visualization: M.F.C; L.A.B.C; D. M. L. E Writing: M.F.C Writing – Review & Editing: M.F.C; L.A.B.C; D. M. L. E; F.L.Q.

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## Conflict of interest disclosure

The authors have no conflict conflicts of interest to declare.

## Ethics approval statement

This study was approved by the Research Ethics Committee of Hospital Felício Rocho, Belo Horizonte, Brazil. CAAE: 48386915.0.0000.5125.

## Patient consent statement

This is a retrospective, observational study, patient consent was not required in accordance with the Research Ethics Committee of Hospital Felício Rocho.

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## Clinical trial registration

This is a retrospective, observational study, clinical trial registration was not required.

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