



Original Research

Closure of mesenteric defects is associated with a higher incidence of small bowel obstruction due to adhesions after laparoscopic antecolic Roux-en-y gastric bypass: A retrospective cohort study

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ABSTRACT

Introduction: Small bowel obstruction (SBO) is a frequent complication after laparoscopic Roux-en-y gastric bypass (LRYGB).

Objectives: We wanted to evaluate the effect of closure of the mesenteric defects on the incidence of SBO and postoperative complications after LRYGB. Furthermore, we wanted to identify possible risk factors for SBO.

Methods: This study was a retrospective cohort study of 1364 patients who underwent a LRYGB between July 2003 and October 2015. Cohort 1 contained 724 patients in whom mesenteric defects were not closed. Cohort 2 contained 640 patients in whom mesenteric defects were closed. Main outcome parameters were the incidence of SBO and postoperative complications as well as potential risk factors for SBO.

Results: Closure of the mesenteric defects was associated with a reduction in the incidence of SBO due to internal herniation (4.8% vs. 5.5, $p = 0.02$) but resulted in a higher incidence of SBO due to postoperative adhesions (4.8% vs. 1.7%, $p = 0.004$). Multivariate analysis identified smoking as a risk factor for SBO ($p = 0.0187$). We observed a higher incidence of late postoperative pain in cohort 2 (5.3% vs. 2.1%, $p = 0.007$).

Conclusion: Although closure of the mesenteric defects is associated with a lower incidence of SBO due to internal herniation, this effect is countered by a higher incidence of SBO due to postoperative adhesions. Smoking is an independent risk factor for SBO after LRYGB. Closure of the mesenteric defects is associated with a higher incidence of late postoperative pain.

1. Introduction

Laparoscopic Roux – en – y gastric bypass (LRYGB) is considered as the gold standard in the surgical treatment of morbid obesity and its metabolic complications. In 2014 an estimated 229,455 LRYGB procedures were performed worldwide [1]. This number is expected to rise even further in the future. Small bowel obstruction (SBO) after LRYGB is a common complication with a reported incidence of 1.5%–16% [2,3]. The majority of episodes of SBO are due to internal herniation (IH) of the small bowel through the mesenteric defect at the jejunojejunostomy (JJ) site or in Petersen's space (PS) (Fig. 1). Whether or not to close the mesenteric defects perioperatively has been, and still is, a

major topic of debate. Several studies have clearly demonstrated the beneficial effect of perioperative closure of the mesenteric defects on the incidence of internal herniation [2,4–6]. Skeptics however argue that closure of the mesenteric is associated with a higher rate of postoperative complications such as pulmonary complications and kinking of the small bowel [7]. Others have described that rapid weight loss and decrease of the mesenteric fat content results in secondary re-opening of a substantial fraction of the perioperative closed defects [8–10]. In light of these findings some consider primary closure of the defects as an ineffective intervention which unnecessarily prolongs the operative procedure.

Until 2010 mesenteric defects were not closed during LRYGB

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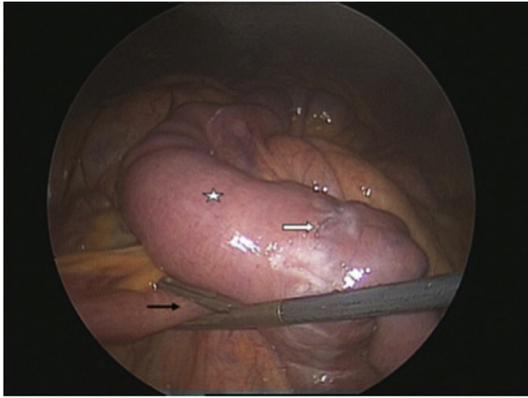


Fig. 1. Perioperative view of SBO due to IH: retrograde reduction of small bowel (black arrow) from underneath the JJ (white arrow) with secondary dilatation of the Roux-limb (white star) (photo courtesy of Dr. M. Abasbassi).

procedures in our hospital. A review article by one of the co-authors (MA) in 2011 showed a relatively high incidence of SBO in our LRYGB series of 9.6% [3]. Hereafter we routinely started closing the mesenteric defects during LRYGB. The primary objective of this study was to determine the effect of this measure on the incidence of SBO. Also, we wanted to investigate whether or not this measure was associated with a higher incidence of postoperative complications. Finally, we wanted to determine possible risk factors for SBO in patients in whom mesenteric defects were closed.

2. Materials and methods

2.1. Study population

This study is a retrospective cohort study and is compliant to the STROCCS-criteria [11]. All patients who underwent an antecolic antegastric laparoscopic Roux-en-Y gastric bypass at the AZ Groeninge hospital, Kortrijk, Belgium, between January 2010 and October 2015, were registered in a prospective database. This database was then compared with a previously established retrospective database containing all patients who underwent the same procedure from July 2003 till January 2010. Based on whether or not the mesenteric defects were closed, the patient population was categorized into two different cohorts: cohort 1, including all patients in whom the mesenteric defects were not closed (January 2003–January 2010, retrospective database population) and cohort 2 including all patients in whom mesenteric defects were closed (January 2010–October 2015). Cohort 2 was further divided into cohort 2a including patients by whom only the mesenteric defect at the JJ site was closed and cohort 2b including all patients in which the mesenteric defect both at the JJ-site and PS was closed.

2.2. Study protocol

All patients included in the prospective and retrospective database were eligible for bariatric surgery as stated in the national institute of health criteria. A standardized pre-operative work-up was performed including complete blood count, electrolyte and urine analysis, glucose tolerance test, chest x-ray, ecg, abdominal ultrasound and gastroscopy. Postoperative follow-up was organized after 1, 3, 6, 12, 18 and 24 months. Patients without a single follow-up consultation were excluded from the study. All medical files of the selected patients were reviewed from an online medical database (KWS). The following parameters were imported into the database: age at the time of operation, sex, pre-operative BMI, smoking at the time of operation, co-morbidities (arterial hypertension, cardiac co-morbidity, dyslipidemia, pulmonary co-morbidity, diabetes, sleep apnea, thyroid co-morbidity, osteoarthritis,

dyspnea, psychiatric disorder), whether or not the mesenteric defect at the JJ site and PS was closed, type of suture used to close the defect and postoperative weight and BMI at 1, 3, 6, 12, 18 and 24 months. Furthermore, the presence of early (< 30 days) postoperative surgical (bleeding, anastomosis ulcer, anastomosis leakage, peritonitis, internal herniation, incarcerated hernia, infected intra-abdominal hematoma) as well as non-surgical (cardiac complications, fever of unknown origin, pulmonary complications, hypoglycemia, deep venous thrombosis, pulmonary embolism) complications were registered. Also, the incidence of late (> 30 days) postoperative complications (anastomosis ulcer, gastro-gastric fistula, stenosis, pain with negative investigations, malabsorption, intestinal perforation, incisional hernia) were retrieved from the medical database. Pain with negative investigations was defined as complaints of abdominal pain, with negative additional imaging, exploratory laparoscopy and/or biochemical evaluation. Finally, the incidence of SBO was registered. SBO was defined as an obstruction of the small bowel diagnosed by laparoscopy. SBO was further categorized as caused by an internal herniation, adhesions or incarcerated incisional hernia according to the perioperative assessment made by the surgeon. This study protocol was approved by the ethics committee at the investigational site (B396201837691). This study complies with the principles of the declaration of Helsinki and was registered at <https://researchregistry.com> (UIN: research registry 4863).

2.3. Surgical protocol

Over the course of the years (2003–2015) the LRYGB procedure was performed in a standardized fashion by the same two surgeons, based on the cut omega loop technique as described by Olbers et al. [12]. All patients were operated laparoscopically with a pneumoperitoneum at 15 mmHg. The gastric pouch was created using a 45 mm stapler (Echelon, Ethicon, Johnson & Johnson, Cincinnati, OH, USA or EndoGIA, Medtronic, Minneapolis, MN, USA) in a horizontal direction and two or three additional 45–60 mm staplers in a vertical direction towards the angle of His. The gastroenterostomy was created using a 25 mm circular stapler (PCEEA, Covidien, USSC, Norwalk, CT) with the anvil introduced transorally or transabdominally depending on the surgeon. The gastro-enterostomy was oversewn with interrupted sutures PDS 2/0. A possible leak was tested by means of a ‘bubble’ test.

An alimentary limb of 120 cm was measured from the gastro-enterostomy and a side-to-side jejunojunctionostomy was created with a 60 mm stapler. The enterotomy defect was closed with interrupted sutures PDS 2/0, V-lock or Fill-bloc depending on the surgeon's preference. Since 2010, the mesenteric defect at the jejunojunctionostomy site was systematically closed. Over the course of the years several sutures were used ea. Ethibond 0, Ethibond 2/0, Ethibond 3/0, V-lock non-resorbable, Ticron 2/0, Ticron 3/0, PDS 2/0, Endohernia® stapler, Filbloc, and Vicryl. Since 2013, one surgeon also systematically started closing the defect at Petersen's site. Postoperative intake was gradually increased from water to mashed foods and patients were discharged on POD 2 or 3.

2.4. Statistical analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) Analysis on the incidence of small bowel obstruction was performed using the Fisher's Exact Test. Pearson Chi-square test was used for analysis of the relative incidence of IH, SBO due to IH and incarcerated incisional hernia. Multivariate analysis of possible risk factors was performed using a logistic regression analysis (LOGISTIC procedure, SAS Institute Inc., Cary, NC, USA). Statistical analysis on the incidence of early and late postoperative complications was performed using a Mantel-Haenszel Chi Square Test. A p-value of 0.05 was considered as statistically significant.

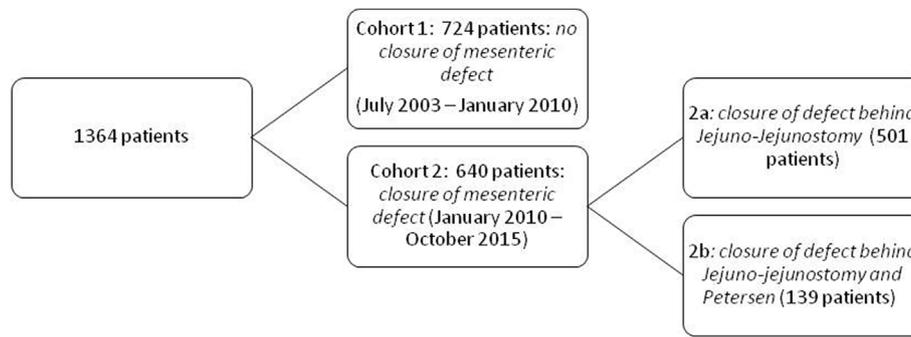


Fig. 2. Flowchart of patient population.

3. Results

3.1. Study group

A total of 1364 patients were included in the study. Cohort 1 consisted out of 724 patients in which the mesenteric defects were not closed. Cohort 2 contained 640 patients in which the mesenteric defects were closed. Cohort 2 was then further subdivided in cohort 2a and cohort 2b. Cohort 2a included 501 patients in which only the mesenteric defect behind the JJ was closed. Cohort 2b consisted out of 139 patients in which both the defect behind the JJ and the defect at PS were closed. A flowchart of the patient population is illustrated in Fig. 2.

3.2. Patient demographics

In the general study population, the mean age was 39.8 (± 11.6) years with a male to female ratio of 27.6/72.4%. Age was distributed equally over the different cohorts with 39.7 (± 11.2), 39.7 (± 12.3) and 41 (± 10.9) years over cohort 1, 2a and 2b respectively. Overall mean pre-operative BMI was 41.9 (± 4.6) kg/m². BMI in cohort 1 and 2a was 42.3 (± 5.6) and 42 (± 5.3) kg/m² respectively. Mean BMI in cohort 2b was slightly lower with 40.3 (± 4.6) kg/m². A total of 524 (38.4%) of patients suffered from arterial hypertension and 203 (14.9%) patients had diabetes. An overview of the baseline characteristics of the study population in general and per cohort are shown in Table 1.

3.3. Follow-up to the consultations

Attendance to the follow-up consultation at 1, 3, 6, 12, 18 and 24 months was respectively 89,5% (n = 648/724), 77% (n = 557/724), 46,7% (n = 338/724), 32% (n = 232/724), 14% (n = 101/724) and

4,8% (n = 35/724) in cohort 1 and 88,5% (n = 566/640), 79,7% (n = 510/640), 52,5% (n = 336/640), 59,3% (n = 380/640), 36,3% (n = 232/640) and 27,8% (n = 178/640) in cohort 2. In the subgroup of patients who had an episode of SBO, the follow-up rates were 96,4% (n = 54/56), 83,9% (n = 47/56), 50% (n = 28/56), 32,1% (n = 18/56), 12,5% (n = 5/56) and 1,8% (1/56) in cohort 1, 86% (n = 43/50), 82% (n = 41/50), 52% (n = 26/50), 68% (n = 34/50), 50% (n = 25/50) and 48% (n = 24/50) in cohort 2a and 100% (n = 7/7), 100% (n = 7/7), 86% (n = 6/7), 71,4% (n = 5/7), 14,3% (n = 1/7) and 14,3 (n = 1/7) in cohort 2b.

3.4. Small bowel obstruction

There was no significant difference in incidence of SBO between cohort 1 (7.7%) and cohort 2a (9.9%, p = 0.18) or between cohort 1 and cohort 2b (5%, p = 0.38). Nor was there a statistically significant difference between cohort 2a and cohort 2b (p = 0.09) (Table 2). Further subgroup analysis of patients who developed SBO is shown in Fig. 3. The proportion of small bowel obstruction due to IH was significantly lower in cohort 2a (48%) versus cohort 1 (71.4%, p = 0.02), with an overall incidence of IH of 5.5% in cohort 1 and 4.7% in cohort 2. There was no significant difference in relative incidence of IH between cohort 1 and 2b (42.9%, p = 0.19) or cohort 2a and 2b (p = 1). The proportion of SBO due to adhesions however was significantly lower in cohort 1 (21.4%) versus cohort 2a (48%, p = 0.004) with an overall incidence of 1.6% in cohort 1 and 4.7% in cohort 2a. No statistical difference was noted between cohort 1 and 2b (57.1%, p = 0.06) or cohort 2a and 2b (p = 0.71). Incarcerated incisional hernia was found to be the cause of SBO in 7.1% (n = 4/56), 2% (n = 1/50) and 0% of the cases respectively in cohort 1, 2a and 2b without any statistical significance (p = 0.45). In three cases a perforation at the gastro-enterostomy or jejunum-jejunostomy site was withheld as the cause of (paralytic) SBO with numbers being too small

Table 1
Baseline characteristics.

	Cohort 1	Cohort 2a	Cohort 2b	Total
n (%)	724 (53,1%)	501 (36,73%)	139 (10,2%)	1364 (100%)
M/F ratio (%)	201/523 (27,8/72,2%)	135/366 (27/73%)	41/98 (29,5/70,5%)	377/987 (27,6/72,4%)
Age ± SD	39,7 ± 11,2	39,7 ± 12,3	41 ± 10,9	39,8 ± 11,6
Pre-operative BMI ± SD	42,3 ± 5,6	42 ± 5,3	40,3 ± 4,6	41,9 ± 4,6
Co-morbidity				
Arterial hypertension	278 (38,4%)	209 (41,7%)	37 (26,6%)	524 (38,4%)
Cardiac co-morbidity	31 (4,3%)	33 (6,6%)	8 (5,8%)	72 (5,3%)
Dyslipidemia	183 (25,3%)	224 (44,7%)	56 (40,3%)	463 (34%)
Diabetes	104 (14,4%)	83 (16,6%)	16 (11,5%)	203 (14,9%)
Sleep apnea	121 (16,7%)	141 (28,1%)	48 (34,5%)	310 (22,7%)
Osteoarthritis	384 (53%)	350 (69,9%)	121 (87,1%)	855 (62,88%)
Thyroid co-morbidity	19 (2,6%)	41 (8,2)	17 (12,2%)	77 (5,6%)
Dyspnea	280 (38,7%)	364 (72,6%)	117 (87,2%)	761 (55,8%)
Psychiatric disorder	54 (7,5%)	136 (27,2%)	45 (32,3%)	235 (17,2%)
Pulmonary co-morbidity	9 (1,24%)	43 (8,6%)	10 (7,2%)	62 (4,6%)

Table 2
Effect of closure of mesenteric defects on incidence of small bowel obstruction in different cohorts.

Cohort	Small bowel obstruction		Total
	No	Yes	
Cohort 1	668 (92,2%)	56 (7,7%)	724 (100%)
Cohort 2a	451 (90%)	50 (9,9%)	501 (100%)
Cohort 2b	132 (95%)	7 (5%)	139 (100%)

Fischer's Exact Test: Cohort 1 vs Cohort 2a.: Two-sided Pr ≤ P: 0.1798, Cohort 1 vs Cohort 2b: Two-sided Pr ≤ P: 0.37, Cohort 2a vs Cohort 2b: Two-side Prs ≤ P: 0.09.

to account for any statistical significance. A peak of SBO incidence was found at 23.4 months postoperatively in cohort 1 and 18.9 months in cohort 2 without any statistical difference (p = 0.16).

3.5. Complication rate

An overview of the incidence of early (< 30 days) postoperative surgical and non-surgical complications illustrated in Table 3 shows no major statistical differences between the three cohorts. An overview of incidence of late (> 30 days) postoperative complications (except causes of SBO) per cohort is shown in Table 4. Patients in cohort 2a (5.6%) and 2b (4.3%) reported a significantly higher incidence of abdominal pain compared to patients in cohort 1 (2.1%, p = 0.007). Incisional hernia was found as a late complication in 16 patients (2,2%) in cohort 1 and in 8 patients (1,6%) in cohort 2a without any statistical significance (p = 0,09). Although the fascia is closed systematically, the majority of incisional hernias was found at the site were the 25 mm EEA was introduced through the ventral abdominal wall.

3.6. Risk factors for SBO

Table 5 shows a univariate analysis of potential risk factors for SBO in cohort 2. Smoking is identified as the only potential risk factor

Table 3
Incidence of early (< 30 days) postoperative complications per cohort. (Mantel-Haezel Chi-Square Test).

	Cohort 1 (n = 724)	Cohort 2a (n = 501)	Cohort 2b (n = 139)	Total (n = 1364)	p-value
Early surgical complications					
Bleeding	11 (1,5%)	5 (0,4%)	4 (2,9%)	20 (1,47%)	0,62
Anastomosis ulcer	5 (0,7%)	1 (0,2%)	0 (0%)	6 (0,4%)	0,22
Anastomosis leakage	5 (0,7%)	2 (0,4%)	0 (0%)	7 (0,5%)	0,4
Peritonitis	0 (0%)	2 (0,4%)	0 (0%)	2 (0,2%)	0,6
Internal herniation	1 (0,1%)	0 (0%)	0 (0%)	1 (0,1%)	0,63
Incarcerated hernia	2 (0,3%)	1 (0,2%)	0 (0%)	3 (0,2%)	0,7
Infected intra-abdominal hematoma	1 (0,1%)	1 (0,1%)	0 (0%)	2 (0,2%)	1
Early non-surgical complications^a	13 (1,8%)	18 (3,6%)	5 (3,6%)	36 (2,6%)	0,07

^a Cardiac complications, fever of unknown origin, pulmonary complications, hypoglycemia, deep venous thrombosis, pulmonary embolism.

(p = 0.02). A multivariate analysis (LOGISTIC procedure) confirms smoking as a risk factor for SBO in cohort 2 (p = 0.02). Further subgroup analysis with differentiation between SBO due to IH (61.9% smoking vs. 41.2% no smoking, p = 0.17) or adhesions (38.1% smoking vs. 58.8% no smoking, p = 0.17) fails to demonstrate smoking as a risk factor for these two subgroups separately.

4. Discussion

In this study systematic closure of the mesenteric defects during LRYGB did not result in an overall reduction of the incidence of SBO. Although we observed a significant reduction in SBO due to IH from 5.5% to 4.7%, this effect was largely counteracted by the observed increase of SBO due to adhesions from 1.6% to 4.7%. The peak in incidence of SBO in our study is observed between 1 and 2 years postoperative, which is similar to other reports [2,3,13]. Compared to the findings of the multicenter randomized controlled trial published by

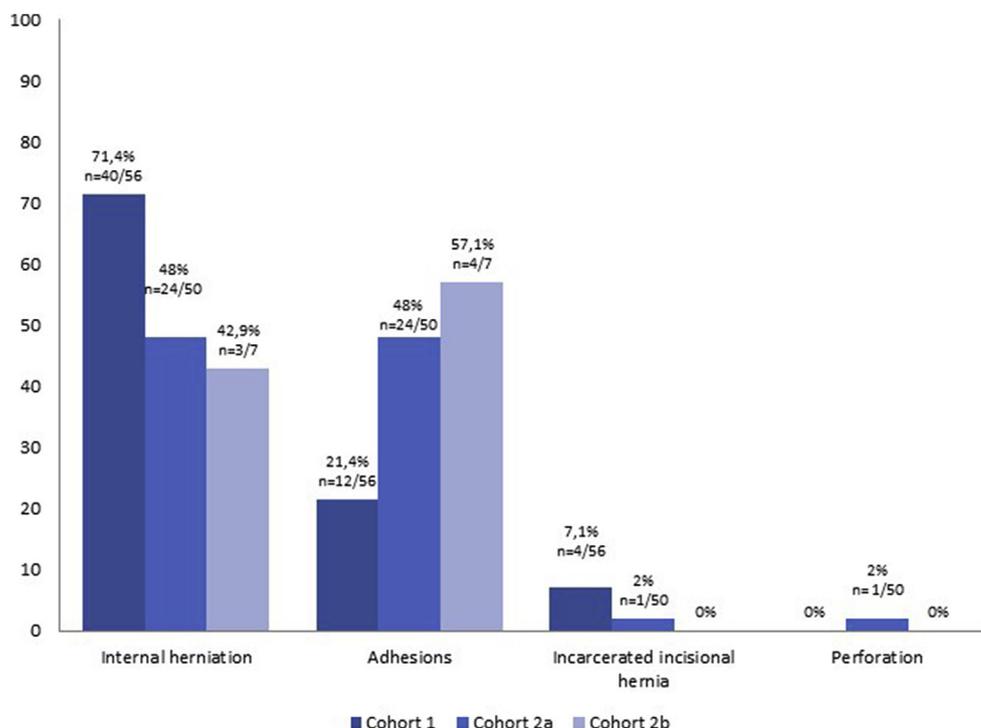


Fig. 3. Subgroup analysis according to cause of SBO with relative incidence (%) per cohort.

Table 4
Incidence of late (> 30 days) postoperative complications per cohort (except causes of SBO). (Mantel-Haezel Chi-Square Test).

	Cohort 1 (n = 724)	Cohort 2a (n = 501)	Cohort 2b (n = 139)	Total (n = 1364)	p-value
Late postoperative complications					
Anastomosis ulcer	67 (9,3%)	45 (9%)	9 (6,5%)	121 (8,9%)	0,39
Gastrogastric fistula	3 (0,4%)	0 (0%)	0 (0%)	3 (0,2%)	0,22
Stenosis	10 (1,4%)	4 (0,8%)	0 (0%)	14 (1%)	0,16
Pain with negative investigations	15 (2,1%)	28 (5,6%)	6 (4,3%)	49 (3,6%)	0,007
Malabsorption	2 (0,3%)	1 (0,2%)	0 (0%)	3 (0,2%)	0,7
Intestinal perforation	9 (1,2%)	3 (0,6%)	0 (0%)	12 (0,8%)	0,13
Incisional hernia	16 (2,2%)	8 (1,6%)	0 (0%)	24 (1,7%)	0,09

Table 5
Univariate analysis of potential risk factors for small bowel obstruction in cohort 2 (2a + 2b).

Potential risk factor	SBO (n = 57)	no SBO (n = 583)	p-value [†]
Age (mean ± SD)	37,2 ± 12	40,3 ± 12	0,07
Pre-operative BMI	41,1 ± 7,4	41,6 ± 4,9	0,64
Sex (Male/female) (%)	12/45 (21/79%)	164/419 (28,1/71,9%)	0,28
Smoking (%)	23 (40,4%)	151 (25,9%)	0,02
Co-morbidity			
Arterial hypertension (%)	19 (33,3%)	227 (38,9%)	0,48
Cardiac co-morbidity (%)	2 (3,5%)	39 (6,7%)	0,57
Dyslipidemia (%)	27 (47,4%)	253 (43,4%)	0,58
Diabetes (%)	11 (19,3%)	88 (15,1%)	0,44
Sleep apnea (%)	18 (31,6%)	171 (29,3%)	0,76
Thyroid co-morbidity (%)	3 (5,3%)	55 (9,4%)	0,47
Dyspnea (%)	43 (75,4%)	438 (75,1%)	1
Psychiatric disorder (%)	16 (28,1%)	165 (28,1%)	1
Pulmonary co-morbidity (%)	5 (3,5%)	51 (8,8%)	0,21
Type of suture ^a			0,44
Ethibond 0	16 (28,1%)	113 (19,4%)	
V-lock non-resorbable	35 (61,4%)	371 (63,7%)	
Ethibond 2/0	1 (1,8%)	12 (2,1%)	
Ticron 2/0	0 (0%)	3 (0,5%)	
Ticron 3/0	0 (0%)	6 (0,7%)	
PDS 2/0	0 (0%)	4 (0,7%)	
Endohernia stapler	1 (1,75%)	1 (0,2%)	
Filbloc	0 (0%)	5 (0,9%)	
Ethibond 3/0	4 (7%)	64 (11,5%)	
Vicryl	0 (0%)	1 (0,2%)	
Perioperative cholecystectomy	3 (5,3%)	43 (7,4%)	0,79
Primary gastric bypass	53 (93%)	524 (90%)	0,64
Early postoperative complications ^b	6 (10,5%)	34 (5,8%)	0,16

Anastomosis leakage, peritonitis, internal herniation, incarcerated hernia, obstruction and non-surgical complications (cardiac complications, fever of unknown origin, pulmonary complications, hypoglycemia, deep venous thrombosis, pulmonary embolism).

[†] Fisher's Exact test was used except for age and pre-operative BMI (TTEST procedure) and type of suture (Chi-square test).

^a For closure of hernia space behind jejunum-jejunostomy.

^b < 30 days postoperatively: surgical complications (bleeding, wound infection, anastomosis ulcer).

Stenberg et al., our study confirms the beneficial effect of closure of the mesenteric defects on the incidence of IH but not on the overall incidence of SBO [2]. In the study of Stenberg et al. the fraction of patients diagnosed with SBO due to adhesions (> 30 days postoperative) was only 7/1248 (0.56%) in the group of patients in which the defects were not closed and 11/1259 (0.87%) in the group in which the defects were closed. In another study by Elms et al. in 28 out of a total of 2414 patients, severe adhesions were identified as the main cause of SBO (1.15%), which accounts for 33% of all patients operated for SBO [14]. Several hypotheses could explain why the incidence of SBO due to adhesions is that high in our study:

First of all, it is plausible that the trauma caused by closing the mesenteric defects or the presence of a non-absorbable suture in the mesentery results in a higher level of postoperative adhesion formation.

Logically the question arises whether or not the decrease in incidence of IH in cohort 2 is merely due to the closure of the mesenteric defects. In analogy with the era of open RYGB the lower incidence of IH could be partially explained by the higher degree of intra-abdominal adhesions and thus a less mobile small intestine. Although a higher incidence of early postoperative complications such as kinking of the anastomosis, ischemia and bleeding have been described, literature about the influence of closing of the mesenteric defects on the formation of adhesions is scarce. A higher degree of adhesions in the group in which the defects were closed, could also explain the fact why patients in this group were found to have significantly more complaints of late postoperative abdominal pain. Our study is the first to report on the effect of closure of the mesenteric defects on late postoperative pain. In the study of Stenberg et al. 2% of patients had a reoperation because of abdominal pain with no statistical difference between the group with closed defects and the group with open defects [2]. However, these findings cannot be compared as such since it is unclear if there are patients in the study of Stenberg et al. that had complaints of late postoperative abdominal pain without reoperation and if so, to what extent.

Secondly and most importantly the authors believe that the higher incidence of SBO due to adhesions is correlated with the criteria used to define an SBO event. In our study SBO was defined as an obstruction of the small bowel diagnosed by laparoscopy. In the study by Stenberg et al. SBO was defined as 'an acute presentation of abdominal pain with signs of bowel obstruction during an operation (reoperation) for this complication'. The question remains how we deal with patients who have longer lasting intermittent symptoms of abdominal pain and/or obstruction. A large fraction of these patients finally ends up undergoing an exploratory laparoscopy which often confirms a (sub) obstructive image. To identify whether or not these findings can be attributed to an intermittent internal herniation or adhesions can be challenging. Due to the fact that a presentation of SBO was not necessarily adopted as 'acute' in the inclusion criteria, we believe that this also partially accounts for the higher fraction of SBO, assigned to adhesions, reported in our study.

When we synthesize the aforementioned hypotheses it is plausible that closure of the mesenteric defects results in a shift of SBO from an acute event, with rapid onset symptoms of IH in patients in which the defects were not closed to a more (sub) chronic state of obstructive complaints due to intra-abdominal adhesions or intermittent overlooked IH in patients in which the defects were initially closed.

The authors therefore believe that future studies should more clearly delineate and define the time frame of the SBO and the possible previous history of (sub) obstruction and/or complaints of longer lasting abdominal pain. Poor definition of IH and/or SBO has already been identified as one of the principal reasons for the wide variation in the reported incidence of IH. The suggestion made by Aghajani et al., to consider patients that have become asymptomatic three months after closure of the mesenteric defects as having intermittent IH, could be a helpful tool [15].

Finally, we believe that closure of the mesenteric defects could result in a biased evaluation of an SBO event. As frequently observed in daily clinical care and in spite of general recommendations, it is likely

that in some cases the threshold to proceed with an exploratory laparoscopy seems to be higher if there is foreknowledge that the mesenteric defects have been closed. Although a possible bias has not been investigated in this study, this could be an interesting subject for future studies.

To our knowledge, this report is the first to identify smoking as a risk factor for SBO after LRYGB with closure of the mesenteric defects. Further subanalysis could not confirm smoking as a risk factor for IH or SBO due to adhesions, separately. Animal studies have identified nicotine as a cause for increased peritoneal adhesion formation based on an increased mesenteric endothelial permeability mediated by vascular endothelial growth factor (VEGF) [16]. Other reports showed that fibrinolysis is decreased in chronic smokers with plasminogen activator inhibitor 1 (PAI-1) levels being significantly higher [17]. The effect of smoking on the incidence of IH after LRYGB however is not well studied. Nicotine is known to release nitric oxide which leads to relaxation of smooth muscle cells, but a literature search could not reveal specific studies focusing on the effect of smoking on small bowel motility [18].

5. Limitations

This study is a monocentric retrospective observational cohort study with an inherent incomplete and variable follow-up. Follow-up was measured as the percent of patients that attended the consultations scheduled at 1, 3, 6, 12, 18 and 24 months postoperative. The overall follow-up in the study is relatively low, especially in cohort 1. (4.8% follow-up at 24 months in cohort 1 vs. 27.8% in cohort 2). This can partially be explained by the fact that the importance of adequate follow-up after bariatric surgery was not yet that widely implemented in the era when patients from cohort 1 were treated. Increased follow-up rates in cohort 2 show how this has evolved over time. Another probable explanation is that a substantial fraction of late follow-up, including frequent blood tests, is provided by the general practitioner, most of the time in agreement with the treating bariatric surgeon. In the Belgian health care system, attendance to follow-up consultations at a bariatric center is not mandatory for reimbursement of the bariatric procedure.

Data on which fraction of patients presented at our center with an episode of SBO and which patients presented at other (nearby) hospitals is difficult to extract because of heterogeneity in the medical databases used by the different regional medical centers. Although we expect the fraction of incomplete follow-up to be equally represented over cohort 1 and cohort 2 as well as the fraction of patients with SBO who presented at another hospital, we consider this as the principal limitation of this study.

Patients in cohort 2 had a significant higher incidence of abdominal pain with negative investigations, defined as chronic abdominal discomfort or pain without any obvious cause after clinical examination, imaging (ultrasound, CT scan or MRI), biochemical evaluation or even negative exploratory laparoscopy. Presence of pain or abdominal discomfort was extracted by reviewing medical reports drafted at the consultation or emergency department. In which manner and to what extent the complaints were further evaluated depended on the clinical evaluation made by the treating physician (surgeon, emergency physician, gastro-enterologist). The authors acknowledge the lack of a uniformed protocol to evaluate these complaints as a limitation of this study. Also, the complaints of abdominal pain or discomfort were not systematically assessed using a standardized pain assessment tool ea. the visual analog scale (VAS).

6. Conclusion

Although closure of the mesenteric defects is associated with a lower incidence of SBO due to internal hernia, this effect is partially countered by a higher incidence of SBO due to postoperative adhesions. These findings could be attributed to a higher degree of postoperative

adhesion formation due to closure of the mesenteric defects or to the criteria used to define SBO. We therefore recommend that future studies more clearly delineate and define the time frame of the SBO and the possible previous history of (sub) obstruction and/or complaints of longer lasting abdominal pain. Closure of the mesenteric defects is associated with a significantly higher incidence of late postoperative pain which is potentially related to the findings of higher postoperative adhesion formation. Smoking is an independent risk factor for SBO.

Ethical approval

This study protocol was approved by the ethics committee at the investigational site (B396201837691). AZ Groeninge hospital, Kortrijk.

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None.

Conflicts of interest

None.

Trial registry number

researchregistry4863.
<https://www.researchregistry.com/browse-theregistry#home/registrationdetails/5cd81f07a27d280007dfa10f/>

Guarantor

Frederiek Nuytens.

Data statement

Due to the sensitive nature of the data, the ethics committee at the investigational site requested raw data to remain confidential en not to be shared.

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None.

CRediT authorship contribution statement

Frederiek Nuytens: Conceptualization, Data curation, Investigation, Methodology, Project administration, Visualization, Writing - original draft, Writing - review & editing. **Mathieu D'Hondt:** Conceptualization, Data curation, Investigation, Supervision. **Frank Van Rooy:** Conceptualization. **Franky Vansteenkiste:** Conceptualization, Supervision. **Hans Pottel:** Formal analysis, Software. **Mohammed Abasbassi:** Conceptualization, Data curation. **Ann Servaeghe:** Data curation. **Dirk Devriendt:** Conceptualization, Project administration, Supervision.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijssu.2019.09.017>.

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