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ORIGINAL CONTRIBUTIONS

Risk Factors for Postoperative Morbidity After Totally Robotic Gastric Bypass in 302 Consecutive Patients

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Abstract
Background Totally robotic gastric bypass (robotic Roux-en-Y gastric bypass, R-RYGBP) has been adopted in some centers on the basis of large retrospective studies. In view of some data showing higher morbidity and higher costs, some authors have considered that robotic gastric bypass may no longer be justified with the existing system. Although low postoperative complication rates after R-RYGBP have been reported, risk factors for postoperative morbidity have never been evaluated. The goal of this study was to identify risk factors for postoperative morbidity after R-RYGBP.
Methods A retrospective analysis of a prospectively maintained database was performed and included 302 consecutive patients after R-RYGBP performed between 2007 and 2013. This subset of patients represented 34 % of all gastric bypass procedures performed during this study period. Univariate and multivariate analyses were performed in order to identify risk factors for postoperative overall morbidity (Clavien scores 1–4 versus 0) and major morbidity (Clavien score ≥3 versus 0–1–2).
Results Postoperative morbidity and mortality rates were 24.4 and 0.6 %, respectively. In multivariate analysis, independent risk factors for overall morbidity were American Society of Anesthesiologists (ASA) score ≥3 (odds ratio (OR) 2.0) and previous bariatric surgery (revisional gastric bypass) (OR 2.0). Independent risk factors for major morbidity (Clavien ≥3) were previous bariatric surgery (revisional gastric bypass) (OR 3.7), low preoperative hematocrit level (OR 0.9), and revisional gastric bypass procedure with concomitant gastric banding removal (OR 5.7).
Conclusions R-RYGBP is prone to increased complications in the setting of a high preoperative ASA score and revisional surgery. This should be taken into consideration by clinicians when evaluating R-RYGBP.

Keywords Obesity · Gastric bypass · Robotics · Morbidity · Risk factors

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Introduction

Bariatric surgical procedures using robotic platforms have become a common practice in many bariatric surgery programs with totally robotic Roux-en-Y gastric bypass (R-RYGBP) as the most frequently performed technique in those centers [1–5]. However, the conventional transperitoneal laparoscopic approach remains the standard of care worldwide when performing gastric bypass (RYGBP) and its results should be used when evaluating the role of R-RYGBP [6–11]. As a majority of new available technologies, R-RYGBP has been adopted in some centers on the basis of

large single- and multi-institutional retrospective experiences [3]. We believe this data may not be sufficient to justify the higher cost due to the routine use of a robotic system to perform a gastric bypass in a morbidly obese patient [2, 3, 8, 12]. Furthermore, it is now unjustifiable that new technologies are adopted without a robust system of post marketing surveillance and professional oversight to evaluate safety, efficacy, and cost [1]. In this regard, it has been recently proposed to use the robotic system in more complex bariatric cases only, i.e., in patients with previous abdominal and bariatric surgical procedures [13, 14]. Despite several groups having reported low postoperative morbidity and mortality rates after R-RYGBP, risk factors for postoperative morbidity have never been evaluated in large studies [2, 3, 8, 12]. As a bariatric group, we have begun a dedicated prospective effort to evaluate the safety, feasibility, and reliability of a computer-assisted robotic platform in bariatric surgery since 2007 [13, 14]. The goal of this study was to identify risk factors for postoperative morbidity after totally R-RYGB in patients with morbid obesity.

Methods

Patient Selection A retrospective review of a prospectively maintained database was performed. We included all consecutive totally R-RYGBP performed between May 2007 and August 2013. Patients who underwent R-RYGBP as initial and revisional surgical procedures were included. During the same period, 585 other patients underwent a conventional laparoscopic or open RYGBP. All patients met the National Institutes of Health consensus criteria for bariatric surgery and the French guidelines for morbid obesity surgery and fulfilled the institutional guidelines [15, 16]. Selection criteria for the robotic approach to perform R-RYGBP were patient's choice and robotic system availability. One board-certified surgeon considered to be experienced in bariatric surgery performed all R-RYGBP. Four other surgeons considered to be in their robotic learning process performed some R-RYGBP steps (i.e., gastrojejunostomy or jejunojejunostomy) under proctoring, in 23 procedures (7.6 %). Signed informed consent was obtained from all patients.

Technical Considerations All procedures were performed using the da Vinci Standard or the da Vinci SI device (Intuitive Surgical®, Sunnyvale, CA, USA). Operative technique corresponded to a totally robotic gastric bypass (R-RYGBP) and was previously described in detail [17]. A manual hand-sewn gastrojejunal anastomosis and a side-to-side linear stapled anastomosis with closure of the remaining intestinal openings were performed. Two robotic arms and one robotic camera were used. According to the technique of Olbers et al., all patients had a 100-cm alimentary limb and a 60-cm biliopancreatic limb [18]. No drains were left and the nasogastric tube was removed at the end of the operation.

Table 1 Details of patients with revisional R-RYGBP

Details of revisional R-RYGBP	*n* (%)
AGB (previously removed)	18 (30 %)
AGB (removed during R-RYGB procedure)	21 (36 %)
VBG	15 (29 %)
AGB+VBG	2 (5 %)
Total	56 (100 %)

AGB adjustable gastric banding, *VBG* vertical banded gastroplasty

Data Collection Data were recorded prospectively on specific Excel sheet forms and computerized files. All patients were consecutive and ranked according to the date of operation (case rank).

Preoperative Data Hypertension was defined as preoperative elevated blood pressure (>140/90 mmHg) or patients taking medication to control blood pressure. Respiratory disease was defined as chronic obstructive pulmonary disease, asthma, respiratory insufficiency, or obstructive sleep apnea. Diabetes was defined as elevated glycemic values or the need to take antidiabetic drugs. Cardiovascular disease was defined as the presence of cardiac valvulopathy, myocardial ischemia or infarctus, cardiac failure, or arrhythmia. Renal disease was defined as renal insufficiency. Neurological disease included stroke, epilepsy, and Parkinson or Alzheimer disease. We also collected other comorbidities including upper gastrointestinal disorders (gastroesophageal reflux, gastritis, and/or gastric or duodenal ulcer) and arthrosis requiring medical or surgical treatment. Preoperative American Society of Anesthesiologists (ASA) score, BMI, previous abdominal surgery

Table 2 Preoperative patient characteristics

	n (%)
ASA score	
ASA score 1	10 (3.5 %)
ASA score 2	160 (57.5 %)
ASA score 3	127 (38.5 %)
ASA score 4	1 (0.4 %)
Comorbidities	
Hypertension	141 (46.6 %)
Respiratory disease	182 (60.6 %)
Diabetes mellitus	114 (38 %)
CV disease	48 (16 %)
Renal disease	13 (4.3 %)
Neurological disease	18 (6 %)
Arthrosis	28 (9.3 %)
UGI disorders	77 (25.6 %)

ASA American Society of Anesthesiologists, *UGI* upper gastrointestinal, *CV* cardiovascular disease

Table 3 Intraoperative complications and causes of conversions to laparotomy

	n (%)
Intraoperative complications	
Robot device malfunctioning	1 (0.3)
Gastric pouch difficult dissection	1 (0.3)
Hemorrhage (spleen injury)	1 (0.3)
Small-bowel perforation	5 (1.7)
Tracheal extubation due to patient slippage on table	1 (0.3)
Omega limb intestinal reconstruction	2 (0.6)
Total	11 (3.6)
Conversions to laparotomy	
Hypercapny	1 (0.3)
Intraabdominal adhesiolysis	8 (2.6)
Gastric pouch difficult dissection	1 (0.3)
Omega limb intestinal reconstruction	1 (0.3)
GI anastomosis not feasible due to short mesentery	1 (0.3)
Total	12 (3.9)

GI gastrointestinal anastomosis between gastric pouch and jejunum

(including all abdominal or bariatric procedures), and preoperative protein and hematocrit levels were also collected. Preoperative morbidity and mortality risk scores were evaluated using validated scoring systems [19, 20].

Intraoperative and Postoperative Data Operative time frames were defined as skin incision to skin closure [13]. Conversion to open or conventional laparoscopy, intraoperative blood loss (more than 500 ml), need for transfusions, and intraoperative complications were evaluated. Intraoperative methylene blue test at the end of the procedure and upper gastrointestinal series at postoperative day 1 were performed in all patients to detect gastrojejunostomy anastomotic leak. Mortality rate was evaluated within a postoperative period of 60 days after the initial surgical procedure. Sixty-day postoperative morbidity rate was evaluated using Clavien-Dindo classification [21]. We intended to obtain a valid postoperative morbidity rate

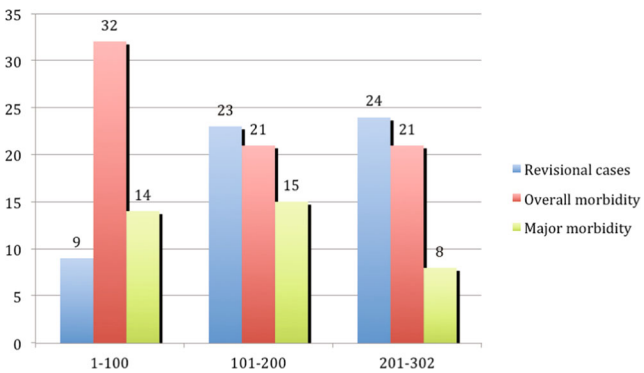

Fig. 1 Revisional cases and overall and major morbidities in the first hundred (*N* 1 to 100), second hundred (*N* 101 to 200), and third hundred (*N* 201 to 302) patients

Table 4 Distribution of postoperative complications using Clavien-Dindo classification [21]

Postoperative morbidity	*n* (%)
1	23 (7.6)
2	14 (4.6)
3a	7 (2.3)
3b	25 (8.3)
4a	5 (1.7)
4b	0 (0)
Total	74 (24.4)

using the postoperative clinic visit at 60 days as a landmark in time. Total hospital and ICU length of stay and rehospitalization data (with or without reoperation) within 60 days were collected.

Outcomes The first outcome variable was 60-day postoperative overall morbidity (0) patients with Clavien classification=0 versus (1) patients with Clavien classification >0. The second outcome variable was 60-day postoperative major morbidity (0) patients with Clavien classification= 0, 1, and 2 versus (1) patients with Clavien classification >2.

Statistical Analysis Descriptive statistics for quantitative variables were expressed as a mean±SD or median (range) and, for qualitative variables, as a percentage.

In univariate analyses, preoperative, intraoperative, and postoperative characteristics between groups were compared using the Pearson or Fisher's exact test for categorical variables and Student's *t* test or Wilcoxon-Mann-Whitney test for continuous variables. Variables significant at the 0.05 level were subsequently used in multivariate analysis. In multivariate analysis, factors associated with 60-day postoperative overall morbidity and 60-day postoperative major morbidity were each treated as dependent variables in separate logistic regressions. The level of significance for variables retained in

Table 5 Causes of reoperations

Causes of reoperations	*n* (%)
Gastrojejunal leak	11 (3.6)
Postoperative bleeding	5 (1.6)
Gastrogastric fistula	3 (0.9)
Jejunojejunal leak	3 (0.9)
Jejunojejunal stenosis	3 (0.9)
Perisplenic abscess	2 (0.6)
Trocar site small-bowel evisceration	1 (0.3)
Omega small-bowel reconstruction	1 (0.3)
Small-bowel ischemic necrosis	1 (0.3)
Nasogastric tube incarceration	1 (0.3)
Total	31 (10.2)

the multivariate models was set at 0.05. Data were recorded on Excel files. Statistical analysis was performed using SAS 9.3 statistical software.

Results

Preoperative and Intraoperative Data A total of 302 consecutive patients that underwent a totally robotic RYGBP were included. This subset of patients represented 34 % of all RYGBP performed during this study period. Two hundred forty-six patients (81.5 %) had a R-RYGBP as an initial bariatric procedure, and 56 patients (18.5 %) had at least one previous bariatric surgical procedure (Table 1). Among 41 patients with previous gastric banding, 21 of them (51 %) had their gastric banding removed during R-RYGBP procedure.

Mean age was 43 years (min–max 18–67) and 246 patients were female (81 %). Mean BMI was 45.4±6.4 kg/m^2 (min–max 30–64.5). Preoperative ASA scores ≥2 and ≥3 were observed in 96 and 39 % of patients, respectively. One

Table 6 Non-significant criteria for 60-day overall postoperative morbidity (univariate analysis)

Criteria		Clavien 0 (n=228)		Clavien 1–4 (n=72)		P value
		n	%	n	%	
Preoperative criteria						
Sex	Male	42	18.4	13	18.1	1
	Female	186	81.6	59	81.9	
BMI (kg/m^2)		228	45.6	72	44.6	0.399
Protein value (g/l)		226	74.8	72	73.8	0.102
Hematocrit value (%)		226	40.1	72	39.3	0.158
Functional status	Independent	224	98.2	72	100	0.575
	Dependent	4	1.8	0	0	
History of MI	No	223	97.8	71	98.6	1
	Yes	5	2.2	1	1.4	
History of CVA	No	226	99.1	71	98.6	0.562
	Yes	2	0.9	1	1.4	
Respiratory disease	No	89	39	30	41.7	0.782
	Yes	139	61	42	58.3	
CV disease	No	196	86	57	79.2	0.192
	Yes	32	14	15	20.8	
Renal disease	No	217	95.2	71	98.6	0.305
	Yes	11	4.8	1	1.4	
Neurologic disease	No	215	94.3	67	93.1	0.776
	Yes	13	5.7	5	6.9	
Age	<45	133	58.3	33	45.8	0.077
	≥45	95	41.7	39	54.2	
Hypertension	No	128	56.1	31	43.1	0.058
	Yes	100	43.9	41	56.9	
History of BD	No	213	93.4	62	86.1	0.083
	Yes	15	6.6	10	13.9	
Diabetes mellitus	No	149	65.4	38	52.8	0.069
	Yes	79	34.6	34	47.2	
Previous BS	No	192	84.2	52	73.6	0.054
	Yes	36	15.8	20	26.4	
Intraoperative criteria						
Proctoring (ST)	No	207	90.8	70	97.2	0.079
	Yes	21	9.2	2	2.8	
GBR+RYGB	No	215	94.3	64	88.9	0.120
	Yes	13	5.7	8	11.1	

MI myocardial infarctus, *CVA* cerebrovascular accident, *CV* cardiovascular, *GBR+RYGB* revisional R-RYGBP procedure with concomitant gastric banding removal, *BD* bleeding disorders, *BS* bariatric surgery, *ST* surgical teaching

hundred fifty-eight patients (52 %) had at least one prior abdominal surgical procedure before R-RYGBP. Preoperative mean serum total protein level and hematocrit level were 74.3 g/dl (±4.6) and 39.8 % (±3.9), respectively. Preoperative comorbidities and patient characteristics were reported in Table 2. Mean preoperative morbidity and mortality scores were 5.3±4.6 (min–max 3.3–56.2) and 0.4±1.4 (min–max 0–13.1), respectively. Mean operative time was 142.8±41.8 min (min–max 75–305). Intraoperative complications and conversions to laparotomy were observed in 11 (3.6 %) and 12 (3.9 %) patients, respectively (Table 3).

Postoperative Data Postoperative 60-day mortality rate was 0.6 % (2 patients). Causes of postoperative mortality were (1) 56-year-old female patient with a BMI of 60 kg/m^2 who had an alimentary loop necrosis incarcerated in an incisional hernia at postoperative day 5 after converted R-RYGBP (case no. 125) and (2) cardiovascular arrest at postoperative day 7 during hemodialysis in an ASA 4 patient with preoperative stage 5 renal insufficiency (case no. 285).

Postoperative 60-day morbidity rate was 24.4 % (74 patients) (Fig. 1). Distribution of postoperative complications using Clavien-Dindo classification was reported in Table 4. Major postoperative complications (Clavien grades 3 and 4) and minor postoperative complications (Clavien grades 1 and 2) were observed in 37 patients (12.2 %) and 37 patients (12.2 %), respectively. Blood transfusions were required in 10 patients (3.3 %) with a mean total of 2.5 units per patient transfused perioperatively.

A reoperation within 60 postoperative days was performed in 31 patients (10.2 %). Causes of reoperation are detailed in Table 5. The most frequent causes were gastrojejunal anastomotic leak and postoperative bleeding. Causes of postoperative bleeding were trocar site bleeding in four patients. The fifth patient was suspected to have a spleen injury, and reoperation showed a spleen hematoma without active bleeding. Two patients were reoperated on for perisplenic abscess without anastomotic leakage actual visualization. Reoperation was performed laparoscopically (n=9) or using an open approach (n=22). Overall, 97 (32 %) patients required hospitalization in an intensive care unit with a median stay of 2.4 days (±3.1). Mean overall length of hospital stay was 8.3 days (±5.4).

60-Day Postoperative Morbidity Risk Factors (Univariate Analysis) Significant risk factors associated with postoperative overall morbidity were preoperative ASA score ≥3 (56 versus 39 %) and history of previous abdominal surgery (63 versus 48 %). Significant intraoperative criteria were longer operative time (150 versus 140 min), blood loss >500 ml, need for transfusion, and conversion to open surgery. All other variables had no significant impact on overall postoperative morbidity in univariate analysis (Tables 6 and 7).

Significant risk factors associated with postoperative major morbidity (Clavien ≥3) were preoperative lower mean hematocrit value (38.5 versus 40) and history of previous bariatric surgery (42 versus 15 %). Intraoperative significant criteria were gastric banding removal during the same procedure (11 versus 6 %), longer operative time (156 versus 140 min), blood loss >500 ml, and need for transfusion. All other variables had no significant impact on postoperative major morbidity (Tables 8 and 9).

Multivariate Analysis for 60-Day Morbidity Risk Factors Regression logistic analysis showed that ASA scores ≥3 and 4 (odds ratio (OR) 2.0; confidential interval

Table 7 Significant criteria for 60-day overall postoperative morbidity (univariate analysis)

Criteria		Clavien 0 (n=228)		Clavien 1–4 (n=72)		P value
		n	%	n	%	
Preoperative criteria						
ASA score	1 and 2	138	61.1	32	44.4	0.014
	3 and 4	88	38.9	40	55.6	
Previous AS	No	118	51.8	27	37.5	0.042
	Yes	110	48.2	45	62.5	
Intraoperative criteria						
Operative time (min)		228	140.2	71	150	0.022
Blood loss >500 ml	No	228	100	69	95.8	0.013
	Yes	0	0	3	4.2	
Transfusion	No	228	100	62	86.1	0.001
	Yes	0	0	10	13.9	
Conversion rate	No	223	97.8	65	90.3	0.009
	Yes	5	2.2	7	9.7	

ASA preoperative American Society of Anesthesiology score, *AS* abdominal surgery

Table 8 Non-significant criteria for 60-day major postoperative morbidity (Clavien ≥3) (univariate analysis)

Criteria		Clavien 0–2, *n*=263		Clavien 3–4, *n*=36		*P* value
		n	%	*n*	%	
Preoperative criteria						
Sex	Male	49	18.6	6	16.7	1
	Female	214	81.4	30	83.3	
Age	<45	151	57.4	15	41.7	0.106
	≥45	112	42.6	21	58.3	
ASA score	1 and 2	151	57.9	19	52.8	0.593
	3 and 4	110	42.1	17	47.2	
BMI (kg/m^2)		263	45.5	36	43.9	0.144
Protein value (g/l)		261	74.6	36	74.2	0.832
Functional status	Independent	259	98.5	36	100	1
	Dependent	4	1.5	0	0	
History of MI	No	257	97.7	36	100	1
	Yes	6	2.3	0	0	
Hypertension	No	142	54	17	47.2	0.479
	Yes	121	46	19	52.8	
History of CVA	No	261	99.2	35	97.2	0.320
	Yes	2	0.8	1	2.8	
History of BD	No	242	92	32	88.9	0.520
	Yes	21	8	4	11.1	
Respiratory disease	No	105	39.9	14	38.9	1
	Yes	158	60.1	22	61.1	
Diabetes mellitus	No	162	61.6	24	66.7	0.588
	Yes	101	38.4	12	33.3	
CV disease	No	223	84.8	29	80.6	0.472
	Yes	40	15.2	7	19.4	
Renal disease	No	253	96.2	35	97.2	1
	Yes	10	3.8	1	2.8	
Neurologic disease	No	248	94.3	33	91.7	0.463
	Yes	15	5.7	3	8.3	
Previous AS	No	133	50.6	12	33.3	0.074
	Yes	130	49.4	24	66.7	
Intraoperative criteria						
Proctoring (ST)	No	242	92	34	94.4	1
	Yes	21	8	2	5.6	
Conversion rate	No	254	96.6	33	91.7	0.164
	Yes	9	3.4	3	8.3	

MI myocardial infarctus, *CVA* cerebrovascular accident, *BD* bleeding disorders, *CV* cardiovascular, *ST* surgical teaching, *AS* abdominal surgery

(CI) 95 % [1.2–3.4]) and history of previous bariatric surgery (OR 2.0; CI 95 % [1.1–3.6]) remained independent risk factors for overall postoperative morbidity (Table 10). It also showed that hematocrit value (OR 0.9; CI 95 % [0.8–0.9]), history of previous bariatric surgery (OR 3.7; CI 95 % [1.8–8]), and gastric banding removal during the same procedure (OR 5.7; CI 95 % [2.2–1.5]) remained independent risk factors for major (Clavien ≥3) postoperative morbidity (Table 10).

Discussion

Postoperative complications after bariatric surgical procedures are essential to be closely evaluated since they participate in the risks-benefits balance evaluation for optimal management in patients with morbid obesity. Several groups have reported postoperative outcomes after R-RYGBP, but none of them evaluated risk factors for postoperative complications specifically [3, 12, 13, 22, 23]. This study showed that history of

Table 9 Significant criteria for 60-day major postoperative morbidity (Clavien ≥3) (univariate analysis)

Criteria		Clavien 0–2, *n*=263		Clavien 3–4, *n*=36		*P* value
		n	%	*n*	%	
Preoperative criteria						
Hematocrit value (%)		261	40.1	36	38.5	0.034
Previous BS	No	223	84.8	20	58.3	0.001
	Yes	40	15.2	16	41.7	
Intraoperative criteria						
Operative time (min)		263	140.7	35	156.4	0.007
Blood loss >500 ml	No	263	100	33	91.7	0.001
	Yes	0	0	3	8.3	
Transfusion	No	262	99.6	27	75	0.001
	Yes	1	0.4	9	25	
GBR+RYGB	No	250	95.1	28	77.8	0.001
	Yes	13	4.9	8	22.2	

BS bariatric surgery, *GBR+ RYGB* revisional R-RYGBP procedure with concomitant gastric banding removal

previous bariatric surgery (revisional cases) was an independent risk factor for both overall and major (Clavien ≥3) postoperative morbidity. It also showed that gastric banding removal during the same procedure and low preoperative hematocrit value were independent risk factors for major postoperative morbidity. Lastly, ASA score ≥3 remained an independent risk factor for overall postoperative morbidity.

Higher incidence of postoperative morbidity after revisional laparoscopic or open RYGB is considered to be secondary to intraoperative difficulties to recognize actual anatomy during dissection, complex adhesiolysis during pouch construction, and gastrojejunostomy anastomosis performed on friable and inflamed tissues due to prior dissection [22, 24–31]. Consequently, postoperative morbidity rate has been reported from 11 to 38 % when RYGBP is performed after vertical banded gastroplasty (VBG) and from 6 to 46 % after adjustable gastric banding (AGB) [32–41]. In this setting, the robotic approach has been proposed to perform RYGBP after failed previous bariatric surgical procedures because it is considered to be associated with improved postoperative morbidity in comparison with conventional laparoscopic or open approaches [2, 22, 29, 31, 40, 42]. Hence, Buchs et al. reported that robotic group patients had no postoperative complications whereas postoperative morbidity rates were 14.3 and 10.7 % after conventional laparoscopic and open revisional RYGBP, respectively [42]. Similarly, morbidity rate was 17 % without major morbidity, anastomotic leak, or need for reoperation in another study including 80 robotic revisional RYGBP [22]. However, contrary to prior studies, we showed that a history of previous bariatric surgery was an independent predictor for both overall and major (Clavien ≥3) postoperative morbidity. Although the robotic system is well designed to help surgeons performing revisional RYGBP, this specific situation remains associated with a higher postoperative morbidity rate and the use of the robotic system may not lead to improved postoperative outcomes.

Revisional RYGBP after initial AGB can be performed either in a one-stage (gastric banding removal during revisional RYGBP) or a two-stage (gastric banding removal

Table 10 Multivariate analysis for 60-day overall and major morbidity (Clavien ≥3) risk factors

	OR	CI 95 %
Overall morbidity risk factors		
ASA score ≥3	2	1.2–3.4
History of previous bariatric surgery	2	1.1–3.6
Major morbidity risk factors		
Hematocrit value	0.9	0.8–0.9
History of previous bariatric surgery	3.7	1.8–8
Gastric banding removal during the same procedure	5.7	2.2–15

OR odds ratio, *CI* confidential interval

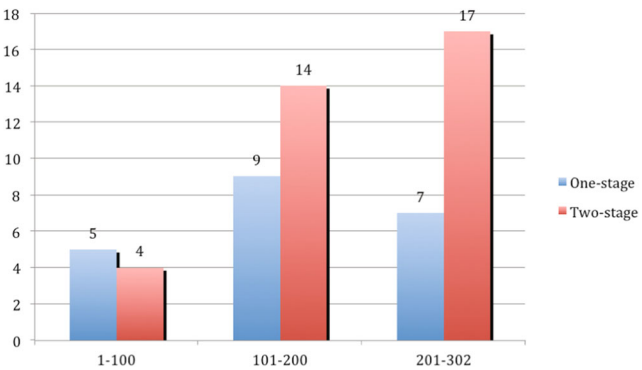

Fig. 2 Revisional cases of gastric banding to robotic RYGB: one-stage and two-stage approaches

1 or 2 months prior to revisional RYGBP) approach (Fig. 2). Because the timing of gastric banding removal (one- or two-stage approach) in patients who undergo a revisional RYGBP may also impact postoperative morbidity, this criterion needs to be addressed [29–31, 43–45]. In a large comparative series including 63,171 primary RYGBP versus 301 revisional RYGBP after AGB (with gastric banding removal during revisional RYGBP), intraoperative and postoperative complications were higher in revisional RYGBP group patients (5.6 versus 2.4 and 30.2 versus 4.9 %, respectively) [24]. However, the only available study specifically comparing one-stage versus two-stage revisional RYGBP concluded that early and late postoperative complications were higher and lower in two-stage group patients, respectively [30]. Overall, the data remain controversial whether gastric banding removal performed 1 or 2 months before revisional RYGBP (two-stage approach) could improve postoperative morbidity rate. Our study data supports a two-stage approach in patients with revisional RYGBP since gastric banding removal during the same procedure was an independent risk factor for major postoperative morbidity. Overall, the assumption that robotic surgery is superior in complex cases is not supported by this study data as in the available present literature evidence [46].

In general surgery, preoperative ASA score and postoperative complication rate are considered to be positively correlated [47]. More specifically, Hutter et al. reported in a large prospective multicentric study that preoperative ASA score ≥3 was also an independent risk factor for postoperative complications in 1356 patients after gastric bypass [7]. A risk stratification model related to laparoscopic and open RYGBP including 36,254 patients confirmed that ASA scores 4 and 5 were validated risk factors for postoperative adverse events [48]. Similarly, we showed that in patients who undergo totally robotic gastric bypass, a preoperative ASA score ≥3 was also an independent risk factor for overall postoperative morbidity.

Low preoperative hematocrit is associated with higher postoperative morbidity in patients after general surgery procedures [47]. In 28,241 patients after bariatric surgery, a low preoperative hematocrit value was reported to be an independent risk factor for reoperation (needed in 644 patients) (OR 1.058 [1.028–1]) [49]. However, this remains controversial since in the subset of patients with gastric bypass without other previous bariatric procedures, the logistic regression model showed in the same study that preoperative hematocrit level was not a significant risk factor for postoperative morbidity [49]. We showed that in this subset of patients, preoperative hematocrit value was an independent risk factor for postoperative major morbidity.

There are several limitations in this study. First, patient's choice and robotic system availability were the two main criteria leading to the performance of R-RYGBP. However, the mean preoperative score from the bariatric surgery morbidity risk calculator in this study was similar to previous prospective data reported in the NSQIP dataset [19]. Second, these data correspond to the experience of a unique surgeon with potential unaccounted bias. This bias could explain in part the higher postoperative leak rate observed in this study in comparison with recent conventional laparoscopic RYGBP series. Third, in this study including unselected and consecutive patients, two deaths occurred. Because the incidence of postoperative mortality was low, this study could not provide any significant data on risk factors for postoperative death. Lastly, costs evaluation was not discussed since this study was primarily designed to identify independent risk factors for postoperative complications after totally robotic RYGBP and not to be comparative with conventional laparoscopic gastric bypass. However, a recent systematic review of the literature concluded that complication rates did not differ significantly between robotic and laparoscopic RYGB, but the expected costs were greater for robotic RYGB [50]. Similarly, recent costs analysis in robotic hysterectomy showed that robotic surgery was not, from a hospital cost perspective, advantageous for benign hysterectomies [51, 52].

In conclusion, prior bariatric surgery, high ASA score, and preoperative hematocrit are predictors of postoperative morbidity in patients after R-RYGBP. Although multicenter studies are warranted, clinicians should be cognizant of these findings when considering this approach in this patient population.

Conflict of interest The authors declare no conflict of interest.

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