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RESEARCH

The Impact of Perioperative Antibiotic Prophylaxis on Surgical Site Infections in Laparoscopic Gastric Bypass Surgery: A Single Center Analysis Among 494 Patients

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Abstract

Background Perioperative antibiotic prophylaxis (PAP) prior to laparoscopic gastric bypass surgery is still under debate due to a lack of high evidence. Thus, the study at hand aimed to find out whether this medication lowers the rate of postoperative complications or not.

Methods In 2020, a retrospective analysis took place at Helios Hospital Berlin Buch, Germany. The data of patients who underwent laparoscopic Roux-Y gastric bypass (LRYGB) surgery between December 2019 and December 2020 were consecutively enrolled. Individuals who received a PAP (PAP +) were compared with those who did not receive this medication (PAP −). Primary objective was the rate of postoperative complications.

Results A total of 494 patients' charts were analyzed. The mean age was 39.7 (± 12.1) years. The body mass index was on average 46.4 (± 6.5) kg/m^2. Among these individuals, 259 patients received a PAP and 235 did not. In terms of baseline characteristics and perioperative data, no significant differences were revealed between both groups. A total of 7 surgical site infections (SSI, all grade III) were diagnosed. Patients in the PAP + group had less SSI, (PAP + group, $n = 2$ (0.8%) vs. PAP- group, $n = 5$ (2.1%), $p = 0.27$). Individuals in the PAP + group stayed a shorter time in hospital (PAP + group, 3.83 (± 0.89) days vs. PAP − group, 4.34 (± 3.05) days; $p < 0.005$). In a multivariate analysis, no administration of PAP was not identified as an independent risk factor for the occurrence of a SSI Grade III (administration of PAP, odds ratio of 0.28 (*CI* 0.08–1.04), $p = 0.058$). The PAP administration did not affect the rate of the overall postoperative complication rate (odds ratio of 0.61 (*CI* 0.32–1.15), $p = 0.13$).

Conclusion In LRYGB, with linear anastomosis, PAP did not significantly reduce SSIs or complications, although a potential benefit in high-risk subgroups (e.g., smokers, patients with diabetes, or high *BMI*) cannot be excluded.

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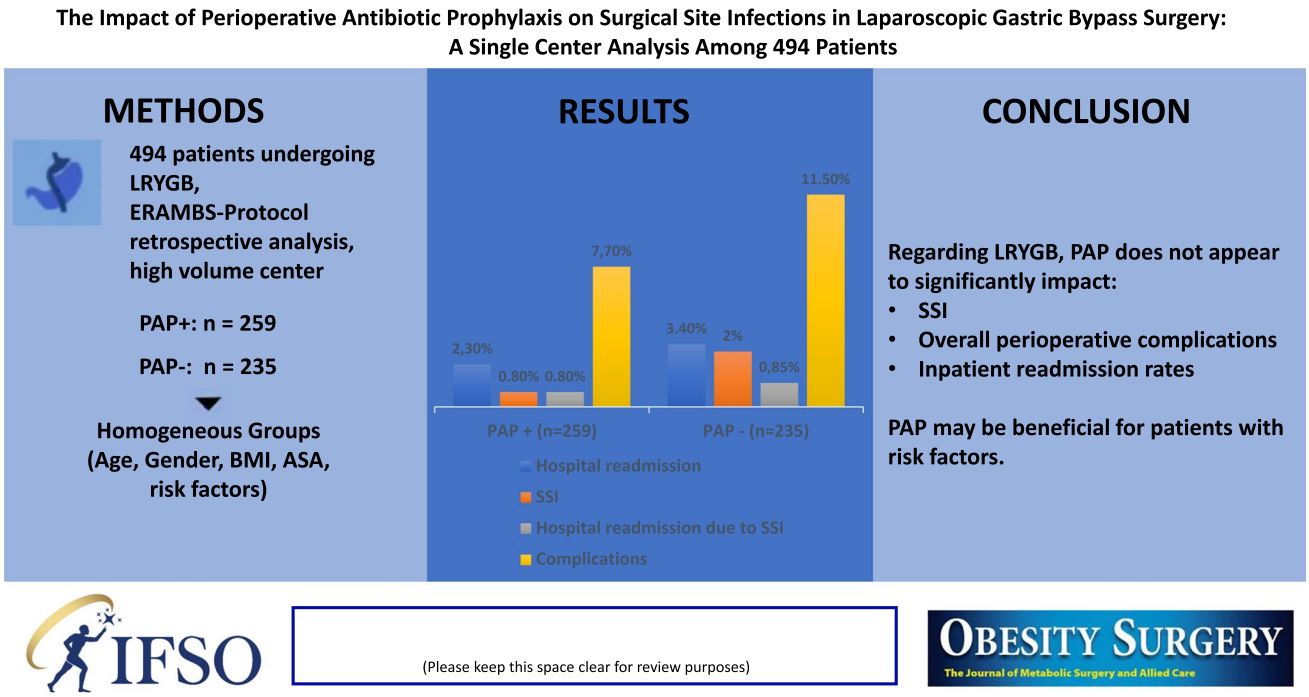
Graphical Abstract



Keywords Gastric bypass · Antimicrobial prophylaxis · Obesity

Introduction

To reduce surgical site infections (SSI), the perioperative antibiotic prophylaxis has been implemented into daily routine in general surgery.

In bariatric surgery, the administration of a PAP is recommended in guidelines. However, this recommendation mainly bases on historical data when this approach was not performed minimally invasively. Pories et al. conducted a randomized clinical trial ($n = 50$) on that topic. The intervention group received Cefazolin. A placebo was given patients among the control group. The authors stopped the trial, as the rate of SSI was significantly higher among individuals, who did not receive the PAP. This publication has frequently citied to justify the PAP prior to gastric bypass surgery [1]. But the study population consisted of patients, who underwent open gastric bypass surgery. Register data from Germany, published in German language 8 years ago, did not reveal significant differences in terms of the SSI rate between patients who received a PAP within 24 h after surgery (0.4%) and those who did not (1%) in bariatric surgery. The authors analyzed 12.296 operations (approximately $n = 4977$ LRYGB). The majority underwent laparoscopic surgery and received in 77.3% a PAP [2].

Against the background of contradictive results on that topic and in order to avoid potential antibiotic site effects, the usefulness of the PAP has to be further evaluated. Thus, the study at hand was conducted.

Methods

The study was designed as a monocentric retrospective analysis. A review of the patient file took place. People who received an LRYGB at Helios Hospital Berlin Buch, Germany between 1 December 2019 and 31 December 2020 were consecutively enrolled and divided into two groups.

One study group (PAP +) consists of patients, who received perioperative antibiotic prophylaxis (PAP) with 3 g of intravenous cefuroxime at the induction and before the skin incision. The control group (PAP-) consists of individuals, who did not receive a PAP.

The recommendation of current guidelines [3] to administer a PAP prior to gastric bypass surgery is mainly based on historical data when this approach was not performed minimally invasively [1]. Register data from Germany suggested that the routine use of PAP should not take place [2]. Since June 2020, the PAP was not administrated on a regular basis.

The authors decided to review the patient chart 6 months (PAP +, December 2019 to June 2020; PAP −, June 2020 to December 2020) before and after the new recommendation in our hospital.

The publication content is part of the dissertation of Gianluca De Santo. The dissertation has been submitted in August 2024.

The study was conducted in accordance with the Declaration of Helsinki (2013 version) and adhering to ICH-GCP guidelines. Patient names and all other confidential information were subject to confidentiality and the provisions of the Federal Data Protection Act (BDSG). Patient data was not shared. Patient contact for informed consent in this study was not required. The patient data, including long-term data, was collected exclusively from the electronic patient file in anonymized form.

The study was approved by the Ethics Committee of the Berlin Medical Association (Application No.: Eth-KB 13/20). Subsequently, the study was registered in the German Clinical Trials Register (DRKS00022421).

Objectives

The primary objective was the rate and grade of SSI (superficial vs. deep vs. organ/space), according to the Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection. The main secondary objective was the rate of readmission to the hospital due to SSI and perioperative complications.

Inclusion Criteria

All patients who underwent laparoscopic Roux-en-Y gastric bypass (LRYGB) at our institution between 1 December 2019 and 31 December 2020 due to morbid obesity were included in the study.

Exclusion Criteria

The study excluded all other bariatric surgical procedures such as one-anastomosis gastric bypass, reoperations, sleeve gastrectomies, and combination procedures like LRYGB with cholecystectomy, partial gastrectomy, or placement of a non-adjustable gastric band during the same operative session. Additionally, revision surgeries due to therapy failure or late complications, conversion to open surgery, and individuals under 18 years of age were excluded.

Laparoscopic Gastric Bypass

Before the operation, the patient is positioned on an air cushion mattress in a ramp position. Anesthesia is induced with propofol, sufentanil, and atracurium, and dexamethasone and ondansetron are given to prevent nausea. Two IV cannulas are placed before intubation, but no arterial blood pressure measurement, epidural, or central venous catheter is used to maintain postoperative mobility. A gastric tube is inserted, and anesthesia is maintained with desflurane, remifentanil, and metamizole during the surgery. Five small incisions are made, and a laparoscopic procedure begins with a trocar and capnoperitoneum. A 15 to 20 ml gastric pouch is created, and a jejunal loop is measured and positioned for anastomosis. Side-to-side gastrojejunostomy is performed, using a 30-mm linear stapler cartridge, and the anastomosis is checked for leaks using a blue dye test. The alimentary (135 to 150 cm) and biliary (70 to 100 cm) limbs are connected using linear stapling techniques, and any mesenterial gaps are closed.

Post-surgery, the patient is moved to the recovery room, given antiemetics and pain management based on the VAS scale, and encouraged to mobilize early. Afterward, they are allowed to drink small amounts of water, and a drinking and pain protocol is provided.

Surgical Site Infection and Perioperative Complications

All patients were scheduled for follow-up examinations in our cooperating outpatient medical care center on postoperative days 10 to 14 and 28 to 32 and after then, they are systematically followed up, according to the German Guidelines for bariatric surgery. If complications occur, they are immediately readmitted to the clinic. To determine the rate of SSIs and perioperative complications, patients' charts were reviewed. The diagnosis of wound infection was confirmed based on clinical signs and laboratory tests (CRP, microbiological culture). In cases of suspected deep infection, a CT scan or laparoscopic revision was performed for confirmation.

Statistical Analysis

Data entry and collection were performed using Microsoft Excel software. Statistical analysis was conducted with version 4.2 of R statistical software (R Software Foundation).

The study population was compared regarding sociodemographic (age, gender, and *BMI*) and medical characteristics (ASA score, nicotine abuse, coronary artery disease, arterial hypertension, and surgeon experience). Continuous characteristics were presented as mean with standard deviation and, if not normally distributed, as median with interquartile range; categorical variables were presented as percentages. The two study groups were compared for baseline differences using the *t*-test (for normally distributed characteristics) or Mann–Whitney *U* test (for non-normally distributed characteristics) and Fisher's exact test. The

Shapiro–Wilk test was used to test for normal distribution. Data distribution was examined using the Shapiro–Wilk test and graphical inspection of quantile–quantile plots. Parametric methods were used for approximately normal distributions; otherwise, non-parametric versions of the corresponding statistical tests were used. For visualizing distributions, stratified box plot diagrams and histograms by groups were created. Univariate comparison of group differences in treatment outcomes (duration of surgery, hospital stay, intraoperative complications, Clavien-Dindo complications, postoperative peak body temperature), and study endpoints (SSI, overall readmission, and readmission due to SSI) was performed analogously to sociodemographic and medical characteristics.

To simultaneously consider multiple variables regarding predictive relevance for the prediction of adverse outcomes at study endpoints, multivariable regression analyses were employed. For binary outcomes (occurrence of SSI and reoperation), binary logistic regression was used. Due to the rarity of events and potential convergence issues in parameter estimation, the bias-reducing version by Firth (1993) was used instead of the classical maximum likelihood method. Regression coefficients were delogarithmized and reported along with 95% confidence intervals. For predicting the Clavien-Dindo complication grade, due to the 5-level ordinal response variable (none to IV), an ordinal regression model (cumulative logit model) was calculated. The assumption of proportional odds was tested using the likelihood-ratio test. To minimize type I errors and ensure the statistical robustness of the results, *p*-value adjustment was performed using the false discovery rate.

Results

Between December 2019 and December 2020, a total of 494 patients were enrolled (PAP−, $n=235$; PAP+, $n=259$). The study flow chart is depicted in Fig. 1. The mean age was 39.7 years. The majority of 77.3% ($n=382$) of the

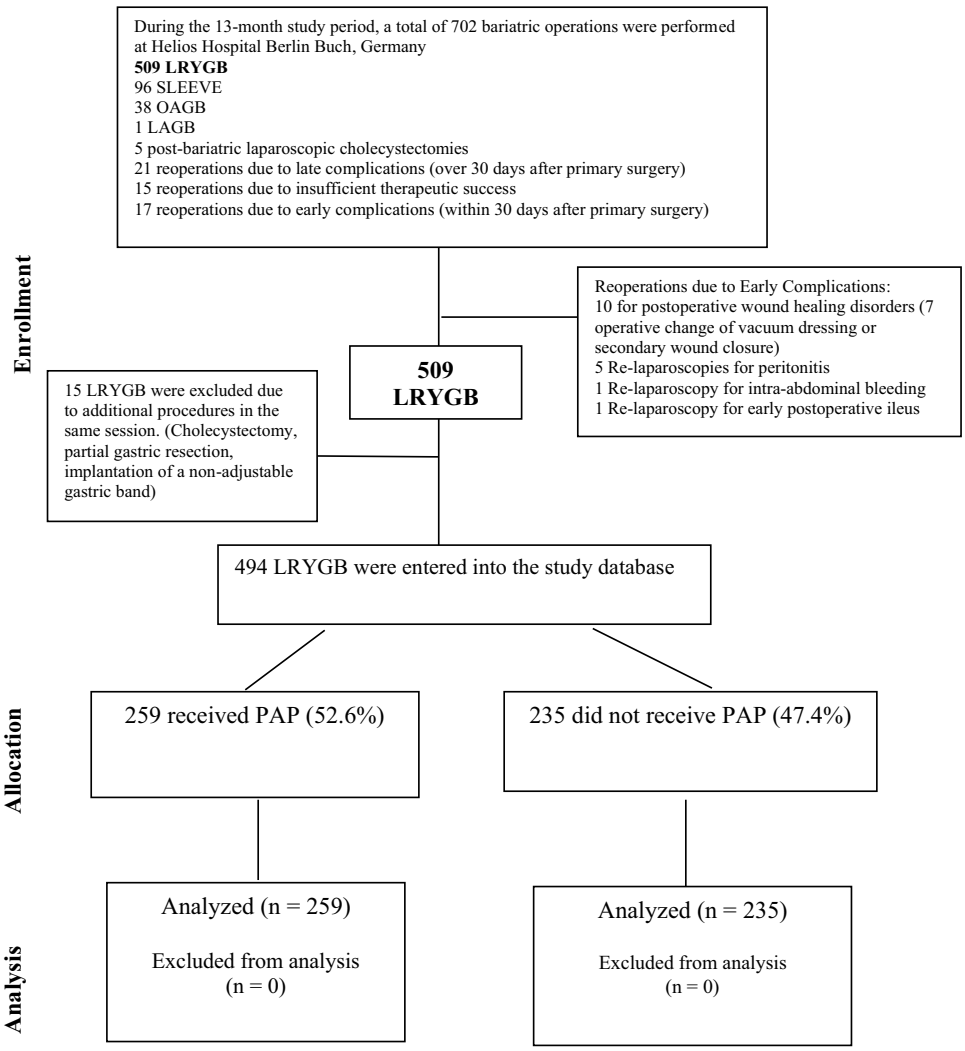


Fig. 1 Study flow chart

individuals were female. The body mass index was on average 46.4 kg/m^2 (Table 1).

The mean duration of hospital stay was 4.1 (2.2) days. A total of 7 (1.4%) SSI and 47 (9.5%) perioperative complications occurred.

A univariate analysis on baseline characteristics was conducted and depicted in Table 1. No significant differences were revealed between both study groups.

A univariate analysis on perioperative data took place. The length of hospital stay was with significance longer in the PAP − group (PAP −: 4.34 (3.05) days vs. PAP +: 3.83 (0.89) days; $p < 0.001$). In terms of the rate of SSI and perioperative complications no significant differences between both study groups were reported. Detailed findings on that analysis are summarized in Table 2. Specimens for microbiological examination were sent for all patients with SSI (see Table 3).

In order to identify independent risk factors for the occurrence of SSI and perioperative complication, a multivariate analysis took place. No risk factor was identified for SSI. The variables PAP + and PAP − did not impact the rate of SSI (Table 4). Nicotine abuse was an independent risk factor for a perioperative complication. The variables PAP + and PAP − did not impact the rate of perioperative complications (Table 5). In the study population of the present investigation, the incidence rate of SSIs in the group with PAP was 0.77% (2/259), and in the group without PAP, it was 2.13% (5/235). There is a numerical increase in SSIs in the group without PAP, which may indicate a trend. Therefore, the possibility of SSI risk reduction through PAP was acknowledged and quantified by calculating the absolute risk reduction. The absolute risk reduction is calculated as the incidence rate without PAP minus the incidence rate with PAP. Accordingly, PAP could reduce the risk of SSIs by 1.36%. The number needed to treat to prevent one SSI, calculated as approximately 1/0.0136 = 74, is 74.

Discussion

For procedures in the lower gastrointestinal tract (e.g., appendectomy or colorectal procedures), there is strong evidence for PAP as well as for the prophylaxis of superficial and deep SSIs. This evidence has been incorporated into various international guidelines, such as some recommendations from the Scottish Intercollegiate Guidelines Network

Table 1 Univariate analysis on baseline characteristics

PAP				
Variable	**Study population**	**PAP-** $n = 235$	**PAP +** $n = 259$	***p*-value**[1]
Age				0.19
Standard deviation	39.7 (12.1)	38.9 (11.5)	40.4 (12.5)	
Median (IQR)	39.0 (30.0–48.0)	39.0 (30.0–46.0)	38.0 (30.5–50.5)	
Sex				0.67
Female	382 (77.3%)	184 (78.3%)	198 (76.4%)	
Male	112 (22.7%)	51 (21.7%)	61 (23.6%)	
Body mass index				0.21
Standard deviation	46.4 (6.5)	46.1 (6.4)	46.8 (6.7)	
Median (IQR)	45.0 (41.0–50.3)	45.0 (41.0–50.0)	47.0 (41.0–50.9)	
ASA classification				0.49
I		74 (31.5%)	67 (25.9%)	
II		118 (50.2%)	146 (56.4%)	
III		42 (17.9%)	45 (17.4%)	
IV		1 (0.4%)	1 (0.4%)	
Diabetes				0.091
Type 1		7 (3.0%)	4 (1.5%)	
Type 2		45 (19.1%)	72 (27.8%)	
Insulin resistance		25 (10.6%)	30 (11.6%)	
No diabetes		158 (67.2%)	153 (59.1%)	
Coronary heart disease		4 (1.7%)	10 (3.9%)	0.18
Hypertension		91 (38.7%)	115 (44.4%)	0.23
Nicotine abuses		79 (33.6%)	82 (31.7%)	0.70

ASA American Society of Anaesthesiologists physical status, *PAP* perioperative antibiotic prophylaxis
− no PAP; + PAP
[1] *T*-test; Fisher test

Table 2 Univariate analysis on perioperative data and complications

Variable	Study population, $n=494$	PAP		
		PAP − $n=235$[1]	**PAP + $n=259$[1]**	***p*-value[2]**
Duration of surgery (minutes)				0.085
Standard deviation	92.6 (33.0)	93.2 (28.7)	92.1 (36.6)	
Median (IQR)	87.5 (69.0–108.8)	89.0 (72.0–107.5)	81.0 (66.0–109.5)	
Length of hospital stay (days)				**< 0.001**
Standard deviation	4.1 (2.2)	4.34 (3.05)	3.83 (0.89)	
Median (IQR)	4.0 (4.0–4.0)	4.0 (4.0–4.0)	4.0 (3.0–4.0)	
Surgical site infections	7 (1.4%)	5 (2.1%)	2 (0.8%)	0.27
Perioperative complications	47 (9.5%)	27 (11.5%)	20 (7.7%)	0.17
Pouch insufficiency + Peritonitis (SSI 3	1 (0.20%)	1 (0.4%)	0 (0%)	
Postoperative Ileus + peritonitis (SSI 3)	1 (0.20%)	1 (0.4%)	0 (0%)	
Peritonitis and intrabdominal abscess unknown origin (SSI 3)	4 (0.8%)	3 (1.45)	1 (0.4%)	
Pouchitis/anastomoisitis (SSI 3)	1 (0.2%)	0 (0%)	1 (0.4%)	
Cardial fibrillation	1 (0.2%)	0 (0%)	1 (0.4%)	
Volume deficiency/incompliance in terms of nutrition/obstipation	9 (0.20)	6 (2.6%)	3 (1.2%)	
Urinary retention/renal failure	2 (0.4%)	1 (0.4%)	1 (0.4%)	
Psychological disorder	1 (0.2%)	1 (0.4%)	0 (0%)	
Diabetic derangement/ketoacidosis	1 (0.2%)	1 (0.4%)	0 (0%)	
Gastrointestinal bleeding intramural	17 (2%)	10 (4.2%)	7 (2.7%)	
Intrabdominal bleeding	8 (1.6%)	3 (1.45%)	5 (1.9%)	
Ischial palsy	1 (0.2%)	0 (0%)	1 (0.4%)	
Clavien- Dindo classification				
I	14 (2.8%)	5 (2.1%)	9 (3.5%)	
II	16 (3.2%)	11 (4.7%)	5 (2.0%)	
III	13 (2.6%)	8 (3.4%)	5 (2.0%)	
IV	4 (0.8%)	3 (1.3%)	1 (0.4%)	

SSI surgical site infection, *PAP* perioperative antibiotic prophylaxis

− no PAP; + PAP

[1] *n* (%)

[2] Exact Fisher test; Wilcoxon-Mann Whitney-Test

(SIGN Guidelines) on antibiotic prophylaxis in surgery [1, 4]. The German guideline for bariatric surgery also recommends PAP [3].

The PAP administration, however, may also have negative implications. Excessive use of antibiotics can lead to antibiotic resistance, which means antibiotics may be less effective for future infections [5]. Additionally, the use of antibiotics increases perioperative care costs, especially when multiple classes of antibiotics are required [6–8]. Antibiotics can cause adverse side effects in some patients, such as allergic reactions, nausea, diarrhea, or other symptoms, as well as metabolic impacts due to dysbiosis or changes in the composition of the intestinal bacterial flora (microbiome).

Davies et al. have shown in bariatric patients that even a single dose of an intestinal-penetrating antibiotic significantly impacts the composition of the microbiota post-bariatric surgery: the spread of Lachnospiraceae was more common in individuals who achieved diabetes remission 1 year after bariatric surgery, suggesting a potentially negative impact of routine antibiotic administration [9]. This may indicate that the immediate postoperative change in the structure of the gut microbiota after bariatric surgery is significantly influenced by the single administration of an antibiotic and not by caloric restriction or the resulting anatomical changes. This study underscores the potentially adverse effects of antibiotic-induced dysbiosis on metabolic health.

In our patient cohort of 494 primary LRYGBs, the incidence of SSIs was 1.4% (7/494). The incidence rate of SSIs in the group with PAP was 0.77% (2/259), and in the group without PAP, it was 2.13% (5/235). No statistical significances were detected. It is important to note that this

Table 3 Microbiological results of SSI

Age (years)	Gender	*BMI* (kg/m^2)	ASA	Comorbidities	PAP	SNZ (m)	POTD	LOS	SSI	Type of SSI	CDC	Microorganisms
34	M	41	1	HTN	No	140	4	48	3	Suture insufficiency, gastric pouch	4	*Streptococcus sanguinis*, *Streptococcus mitis*, *Veillonella parvula*, and *Candida albicans*
37	F	44	3	DM2/HTN	No	113	9	20	1/2/3	Skin wound infection, abdominal wall abscess, and perigastric abscess	4	*Streptococcus constellatus*, *Streptococcus anginosus*, *Prevotella veroralis*, and *Prevotella nigrescens*
43	F	39	1	DM2/HTN	No	72	4	9	3	Peritonitis	2	*Proteus* sp.
30	F	50	2	Nicotine	No	80	2	17	3	Peritonitis with ileus/aspiration pneumonia	4	*E. coli*, *Staphylococcus hominis*, and *Streptococcus constellatus*
28	F	43	1	DM2, Nicotine	No	124	2	8	3	Peritonitis (CT-Scan)	2	No detection
58	M	52	3	CHD, DM2, HTN, and nicotine	Yes	73	18	10	3	Pouchitis/Anastomosis (CT-scan and endoscopy)	2	No detection
54	F	52	2	-	Yes	53	13	10	3	Microabscess at JJ (CT-scan)	2	No detection

SNZ suture time of the operation, *POTD* postoperative day of SSI diagnosis, *LOS* dumulative duration of hospital stay, ***HTN*** arterial hypertension, *DM2* diabetes mellitus type 2, *CHD* coronary heart disease, *GE* gastroenterostomy, *JJ* jejunojejunostomy

analysis was limited to patients undergoing RYGB with linear anastomosis, a technique generally associated with a lower risk of infection. As a result, the findings may not be fully applicable to other bariatric procedures. For example, in LRYGB with circular gastroenterostomy, which may carry a higher risk of infection, the results could differ.

SSIs can have devastating consequences after bariatric procedures, such as peritonitis, sepsis, septic shock, and organ space infections [10]. Therefore, preventing SSIs is of critical clinical importance. The incidence of SSIs in bariatric procedures ranges from 0.4 to 12%, depending on the type of procedure and patient risk factors [11].

Patients with morbid obesity have a higher risk for SSIs, compared to non-obese individuals, as described by Dindo et al. (2003) [12]. However, Topaloglu et al. found no difference in the frequency of wound infections between bariatric patients and obese visceral surgery patients not undergoing bariatric surgery. Coronary heart disease, diabetes mellitus, and chronic pulmonary diseases have been identified as risk factors for SSIs in bariatric patients [13].

The advantage of laparoscopic technique in reducing wound infection rates is well documented [14]. Chopra et al. found a total of 91 SSIs (12%) in a retrospective analysis of 751 RYGB procedures and identified five independent predictors or risk factors for SSIs after RYGB: bipolar disorder, sleep apnea, longer operation duration, absence of PAP with cefazolin, and urinary incontinence. They developed the BULCS score, which uses these five variables for risk stratification of SSIs after bariatric surgery. The study concluded that appropriate use of PAP can be beneficial in preventing SSIs in bariatric surgery but emphasized that antibiotics should not replace hygiene measures or surgical precision [15]. Another study also examined risk factors for the development of SSIs in bariatric procedures [11]. The study highlights antibiotic prophylaxis, female gender, high *BMI*, and perioperative hyperglycemia as risk factors for the development of SSIs in bariatric procedures.

Multivariate analysis of data from the present study population shows a higher risk for SSIs without PAP and with nicotine abuse, but the findings were not statistically significant. Other risk factors could not be identified.

As mentioned in the "Introduction," the recommendations for administering PAP prior to LRYGB are based on historical data from studies, where PAP was evaluated in open surgery. In the past decade, PAP has also been evaluated in laparoscopic gastric bypass surgery (Table S1). After reviewing the literature, we found two relevant publications [2, 16]. Neither of these was a randomized clinical trial. In 2016, Stroh et al. published register data on approximately 4677 LRYGB procedures. They did not reveal significant differences in terms of SSI rate between patients who received PAP within 24 h after surgery (0.4%) and those who did not (1%, $p = 0.95$). The authors did not state the

Table 4 Multivariate analysis on surgical site infections

Variable	Amount	Event	Odds ratio	95% Confidence interval	*p*-value
Sex					
Female	382	5	—	—	
Male	112	2	1.32	0.37–4374	0.67
Age	494	7	1.01	0.95–1.07	0.85
Body mass index	494	7	1.01	0.92–1.12	0.81
ASA Classification					
I	141	3	—	—	
II	264	2	0.22	0.04–1.10	0.066
III	87	2	0.29	0.04–1.98	0.21
IV	2	0	0.42	0.00–38.7	0.70
Diabetes					
Type 1	11	0	—	—	
Type 2	117	4	0.86	0.04–8.0	0.92
Insulin resistence	55	0	0.16	0.00–5.63	0.28
Coronary heart disease					
No coronary heart disease	480	6	—	—	
Coronary heart disease	14	1	5.10	0.65–40.3	0.12
Hypertension					
No hypertension	288	6	—	—	
Hypertension	206	1	0.95	0.22–4.12	0.94
Nicotine abuses					
No nicotine abuses	333	3	—	—	
Nicotine abuses	161	4	2.57	0.78–8.41	0.12
Duration of surgery					
< 90 min	264	4	—	—	
≥ 90 min	230	3	0.63	0.19–2.06	0.44
PAP					
PAP −	235	5	—	—	
PAP +	259	2	0.28	0.08–1.04	0.058

ASA American Society of Anaesthesiologists physical status, *PAP* perioperative antibiotic prophylaxis − no PAP; + PAP

exact number of laparoscopic approaches but estimated that more than 97% received minimally invasive surgery [2]. Additionally, Aktas et al. (2021) conducted a retrospective analysis of 176 patients who underwent LRYGB. The complication rate among individuals who received PAP was 2.6% ($n=3$), while it was 4.9% in those who did not receive PAP ($p=0.09$). No significant differences were detected in either publication. These findings align with our results and suggest that PAP may not be indicated before all LRYGB procedures. On the other hand, all authors, including us, observed a slight quantitative decrease in SSIs in the PAP groups. However, there appears to be a trend suggesting potential benefits, particularly in patients with additional risk factors such as nicotine abuse, diabetes, or high *BMI*. The retrospective study design is a study limitation. These observations imply that RCTs on this topic are needed. Given that the present analysis was limited to LRYGB with linear anastomosis—a technique generally associated with a lower risk of infection, compared to circular gastrojejunostomy or sleeve gastrectomy—the generalizability of these results to other bariatric procedures should be interpreted with caution.

Conclusion

In patients undergoing LRYGB with linear anastomosis, PAP did not show a statistically significant effect on SSIs, overall perioperative complications, or inpatient readmission rates. Nevertheless, PAP may confer advantages in patients with additional risk factors such as nicotine use, diabetes, or elevated *BMI*, as well as in those undergoing other bariatric procedures.

Table 5 Multivariate analysis on postoperative complications

Variable	Odds ratio	95% Confidence interval	*p*-value
Sex			
Female	—	—	
Male	0.92	0.42–1.98	0.82
Age	1.02	0.99–1.06	0.15
Body mass index	1.00	0.95–1.06	0.92
ASA Classification			
I	—	—	
II	*0.54*	*0.26–1.15*	*0.11*
III	*0.72*	*0.25–2.05*	*0.53*
IV	***0.00***	***0.00–0.00***	***< 0.001***[1]
Diabetes			
Type 1	—	—	
Type 2	0.84	0.09–7.75	0.88
Insulin resistance	0.22	0.02–2.88	0.25
Coronary heart disease			
No coronary heart disease	—	—	
Coronary heart disease	1.04	0.12–9.20	0.97
Hypertension			
No hypertension	—	—	
Hypertension	0.59	0.26–1.34	0.21
Nicotine abuse			
Non nicotine abuse	—	—	
Nicotine abuse	***3.07***	***1.63–5.81***	***< 0.001***[1]
Duration of surgery			
< 90 min	—	—	
≥ 90 min	0.57	0.29–1.09	0.090
PAP administration			
PAP −	—	—	
PAP +	0.61	0.32–1.15	0.13

ASA American Society of Anaesthesiologists physical status, *PAP* perioperative antibiotic prophylaxis

− no PAP; + PAP

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11695-025-08218-4.

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Author contributions Oliver Stumpf and Gianluca De Santo share the first authorship. Oliver Stumpf, Gianluca De Santo and Christoph Paasch contributed to the study conception and design. Peter Look, Oliver Stumpf, Gianluca De Santo and Marc Abdelmalek conducted the surgery. Material preparation and data collection were performed by Gianluca De Santo. Data analysis and statistics were performed by Gianluca De Santo and supervised by Richard Hunger. The first draft of the manuscript was written by Gianluca De Santo. The manuscript writing was supervised by Oliver Stumpf, Christoph Paasch and Michael Hünerbein. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data Availability Data is available for non-commercial researchers by application to the corresponding author.

Code availability Not applicable.

Declarations

Trial Registration The study was registered in the German Register of Clinical Studies (DRKS00022421).

Ethics Approval The study was approved by the Ethics Committee of the Berlin Medical Association (application no.: Eth-KB 13/20).

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Competing interests The authors declare no competing interests.

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