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ORIGINAL ARTICLE

A model to determine factors influencing intraoperative complications in sleeve gastrectomy

Un modelo de determinantes de complicaciones intraoperatorias en gastrectomía en manga

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Abstract

Objective. *The study presents a logistic regression model describing the factors leading to intraoperative complications in laparoscopic sleeve gastrectomy (LSG) and a detailed description of the intraoperative complications that occurred in our operations.* **Material and methods.** *The study was designed as a retrospective and cohort study. It includes patients who underwent laparoscopic sleeve gastrectomy between January 2008 and December 2020.* **Results.** *The study included 257 patients. The mean (SD) age of all patients included in the study was 40.28 (9.58) years. The body mass index of our patients ranged from 31.2 to 86.6 kg/m^2. The Stepwise Backward model was used (Cox and Snell R^2 = 0.051, Nagelkerke R^2 = 0.072, Hosmer-Lemesxow χ^2 = 1.968, df = 4, p = 0.742, overall model accuracy of 70.4%). The model shows that pre-operative diabetes mellitus or hypertension Stage 3 significantly increases the probability or risk of intraoperative complications.* **Conclusions.** *The study shows which intraoperative complications occur in LSG, how they can be remedied and which factors can lead to them and influence the outcome of the operation itself. The recognition and successful treatment of intraoperative complications are very important as they reduce the number of reoperations and treatment costs.*

Keywords: *Bariatric. Laparoscopic. Sleeve gastrectomy. Complications.*

Resumen

Objetivo. *El estudio presenta un modelo de regresión logística que describe los factores que conducen a las complicaciones intraoperatorias en la gastrectomía en manga laparoscópica (LSG) y una descripción detallada de las complicaciones intraoperatorias que ocurrieron en nuestras operaciones.* **Material y métodos.** *Estudio de cohorte retrospectivo. Incluye pacientes que se sometieron a LSG entre enero de 2008 y diciembre de 2020.* **Resultados.** *El estudio incluyó a 257 pacientes. La edad media (DE) de los pacientes del estudio fue de 40.28 (9.58) años. El índice de masa corporal de nuestros pacientes osciló entre 31.2 y 86.6 kg/m^2. Se utilizó el modelo Stepwise Backward (Cox y Snell R^2 = 0.051, Nagelkerke R^2 = 0.072, Hosmer-Lemesxow χ^2 = 1.968, gl = 4, p = 0.742, precisión global del modelo del 70.4%). El modelo muestra que la diabetes mellitus o hipertensión preoperatoria en estadio 3 aumenta significativamente la probabilidad de complicaciones intraoperatorias.* **Conclusiones.** *El estudio muestra qué complicaciones intraoperatorias ocurren en la LSG, cómo se pueden remediar y qué factores pueden conducir a ellas e influir en el resultado de la operación en sí. El reconocimiento y el tratamiento exitoso de las complicaciones intraoperatorias son muy importantes ya que reducen el número de reintervenciones y los costos del tratamiento.*

Palabras clave: *Bariátrica. Laparoscópica. Gastrectomía en manga. Complicaciones.*

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Introduction

With the increase in obesity in the world, bariatric surgery is becoming increasingly important. At present, the most popular and frequently performed bariatric procedure worldwide is laparoscopic sleeve gastrectomy (LSG), accounting for 55.4% of all bariatric procedures[1].

Due to the low number of complications and the good results in the treatment of obesity and metabolic syndrome, it stands out as a procedure in its own right. LSG used to be used as the first measure in patients who had a body mass index (BMI) of more than 50 kg/m^2 and a high intraoperative risk of complications, which was followed by a new and additional procedure with a malabsorptive component[2-4].

Indications for laparoscopic bariatric surgery: in patients with a BMI $\geq$ 40 kg/m^2 and patients with a BMI $\geq$ 35-40 kg/m^2 and associated comorbidities where improvement through weight loss is expected, but also in patients with a BMI $\geq$ 30-35 kg/m^2 and Type 2 diabetes and/or arterial hypertension with poor control despite optimal medical therapy[5,6].

Barrett's esophagus is the only absolute contraindication to LSG. Some authors consider gastroesophageal reflux disease (GERD), liver cirrhosis, hiatal hernia, and uncontrolled diabetes to be contraindications, while others believe that there are no contraindications[7,8]. Although LSG is considered a safe procedure, there are still complications.

Bariatric surgery solves the problem of weight and comorbidities in the long-term, but the comorbidities also affect the complications. Complications in bariatric surgery are divided into intraoperative, early complications up to 30 days after surgery and late complications beyond 30 days after surgery[9]. The most common intraoperative complication of LSG is bleeding. Bleeding can occur from the staple suture or from injury to the short gastric arteries toward the upper pole of the spleen. To avoid subsequent revision surgery, it is necessary to treat these complications appropriately[10,11].

The study presents a logistic regression model describing the factors leading to intraoperative complications in laparoscopic sleeve gastrectomy and a detailed description of the intraoperative complications that occurred in our operations.

Materials and methods

The study was designed as a clinical and observational study in the form of a retrospective cohort study. It includes patients who underwent laparoscopic sleeve gastrectomy at the Institute of Pulmonary Diseases of Vojvodina in Sremska Kamenica between January 2008 and December 2020.

Patients of both sexes aged over 18 years were enrolled in the study. The patients were examined and treated by a multidisciplinary team (bariatric surgeon, anesthetist, psychologist, cardiologist, and endocrinologist). According to the classification recommended by the World Health Organization, patients with increased body mass are divided into the following categories: pre-obesity (BMI = 25.0-29.9 kg/m^2), Obesity I: degree (30.0-34.9 kg/m^2), Obesity II: grades (35.0-39.9 kg/m^2), Obesity III: Grades (40.0-49.9 kg/m^2), Obesity IV: degrees (50.0-59.9 kg/m^2), and Obesity V: degrees (> 60.0 kg/m^2). Patients with IV and V degrees of obesity are referred to as "superobese" and "super-superobese" in the surgical literature. According to the European Association of Preventive Cardiology, patients with preoperative hypertension are classified into three stages. The first stage is 140-159 and/or 90-99 mmHg, the second stage is 160-179 and/or 100-109 mmHg, and the third stage is $\geq$ 180 and/or $\geq$ 110 mmHg.

Antibiotic prophylaxis (2nd-generation cephalosporins) and thromboembolic prophylaxis (low molecular weight heparin) were given to all patients according to the same protocol. Patient data were taken from the medical history and surgical lists. Approval was obtained from the Expert Council (number: 76-XV/1) and the Ethics Committee of the Institute of Pulmonary Diseases of Vojvodina in Sremska Kamenica (number: 72/XIII/24) for the preparation of the study.

Surgical technique of laparoscopic sleeve gastrectomy

All operations were performed by one bariatric surgeon under the same conditions. The patient is placed on the operating table in a supine position with his legs extended and spread, and the surgeon takes a place between his legs while the assistant is on the left side of the patient. A typical sleeve gastrectomy is performed as standard with three or more laparoscopic openings, initially immobilizing the large curve of the stomach. All LGS resections were performed using the Ethicon® Echelon Flex™ 60 mm stapler. We place the first stapler 3 cm from the pylorus and always use a stapler with one "green" cartridge, in the corpus a stapler with three "gold" cartridges and in

the fundus one or two "blue" cartridges. A 38-42 Fr probe is used during the operation. The staple line is not sutured. The sleeve gastrectomy is controlled intraoperatively with 50 mL methylene blue.

The commercial program Statistical Package for the Social Sciences (v. 18.0; SPSS Inc. Chicago, IL, USA) was used for statistical processing of the data obtained.

A multivariable logistic regression model was used for intraoperative complications and the factors leading to them.

Results

The study included 257 patients, of whom 134 (52.1%) were female and 123 (47.9%) were male. The mean age (SD) of all those included in the study was 40.28 (9.58) years. The BMI of our patients ranged from 31.2 to 86.6 kg/m^2. The most common comorbidities among the patients were: hypertension (43.9%), diabetes mellitus (24.2%), dyslipidemia (17.9%), cardiovascular disease (7.8%), respiratory disease (7.4%), and depression (7.4%). Intraoperative complications as well as the occurrence of complications according to BMI groups are shown in the tables (Tables 1 and 2).

Binary logistic regression was performed for the dichotomous outcome of intraoperative complication. In the univariable analysis, statistically significant results were obtained for the variables diabetes mellitus preoperatively (Crude OR = 2.094, 95% CI = 1.152-3.809) and hypertension preoperatively Stage 3 (Crude OR = 12.457, 95% CI = 1.347-115.173). The model shows that pre-operative diabetes mellitus or elevated blood pressure at sSage 3 significantly increases the likelihood or risk of intraoperative complications (Table 3). With diabetes about two and with elevated blood pressure 3 stages almost 12 times.

A multivariable logistic regression model for intraoperative complications was used. The Step-wise Backward model was used (Cox and Snell R^2 = 0.051, Nagelkerke R^2 = 0.072, Hosmer-Lemesxow χ^2 = 1.968, df = 4, p = 0.742, overall model accuracy of 70.4%). The following variables were used in the construction of the model: age, BMI categories, preoperative hypertension levels, comorbidities, gender, pre-operative diabetes mellitus, preoperative cholesterol, pre-operative triglycerides, and smoking. Other variables used in the construction of the model are either confounding or independent, indicating that their influence on the occurrence of the observed outcome was also considered in the model.

Table 1. Intraoperative complications

Intraoperative complications	Frequency	Percentage (%)
Bleeding-stapler line	68	26.5
Spleen lesion	1	0.4
Deserosation of the stomach	1	0.4
Open-impossibility of laparoscopy	3	1.2
Splenectomy due to bleeding	1	0.4
Total	74	28.9

Discussion

Laparoscopic sleeve gastrectomy is a restrictive bariatric procedure consisting of a vertical subtotal gastrectomy in which the fundus, body and antrum of the stomach are resected while retaining the pylorus. In this way, a tubular channel is formed along the small curve of the stomach. About 80% of the stomach is removed by resection and the rest of the stomach has a capacity of about > 100 mL[1,12,13].

Among a variety of different procedures, LSG gradually gained acceptance and became the most popular and commonly performed method, both because of its technical simplicity and safety and because of the low number of complications and low mortality rate. This most common execution has led to a variety of variations, from surgical techniques to the use of different stapling devices and instruments. According to some authors, all of this was reflected and had an impact on the incidence of complications[14]. In addition to the division into intraoperative, early and late complications, complications in bariatric surgery are divided into other, less commonly used subdivisions, namely, surgical and non-surgical post-operative complications, and major and minor complications[10,11,15]. There are very few data on intraoperative complications in LSG. They are either not reported in the studies or the authors state that they did not exist.

Some studies show that they occur in about 14% of cases[16]. In our study, they occur in a much higher percentage, but there were no cases of gastric leakage.

The most common intraoperative complication in our study was bleeding from the staple suture at 26.5%.

Table 2. Intraoperative complications by BMI groups (kg/m²)

Intraoperative complications	30.0-34.9	35.0-39.9	40.0-49.9	50.0-59.9	> 60	Total
Bleeding-stapler line	4	10	33	15	6	68
Spleen lesion	1	0	0	0	0	1
Deserosation of the stomach	0	0	1	0	0	1
Open-impossibility of laparoscopy	0	1	0	1	1	3
Splenectomy due to bleeding	0	0	0	1	0	1
Total (%)	5 (2)	11 (4.4)	34 (13.2)	17 (6.6)	7 (2.7)	68 (28.9)

BMI: body mass index.

Table 3. Statistical significance for the variables diabetes mellitus preoperatively and hypertension stage 3 preoperatively

Independent variables	p	Exp (B)	95% confidence interval	
			Lower	Upper
Hypertension stage 3 preoperatively	0.030	11.816	1.264	110.459
Diabetes mellitus preoperatively	0.045	1.906	1.013	3.586

There is an opinion that bleeding depends on the surgical technique itself[14]. In our study, in all patients used a surgical technique in which the staple line was not sutured, and the bleeding itself was treated intraoperatively, mostly by placing a clip and in a few cases by suturing. This technique gives good results and reduces the length of hospital stay and thus the cost of surgical treatment[17].

Another intraoperative complication that occurred in three patients (1.2%) was conversion or open gastric sleeve resection due to inadequatue pneumoperitoneum. This complication occurred more frequently in "super-obese" and "super-super-obese" patients, which may be attributed to the difficulty of performing the surgery and the associated comorbidities. Considering that the pre-operative preparation took about 6 weeks and involved the whole team, the surgery was performed in these patients as it was expected that these patients were unlikely to be in a better state of preoperative preparation. Of the other intraoperative complications, there was one case of splenic lesion, one gastric deserosion, and one case of splenectomy.

The popularity of this procedure has also led to the development of various scores that can predict complications. One of these is the "SLEEVE BLEED" calculator, which is used to assess the risk of bleeding[18]. Logistic regression has been used to develop a risk calculator that is used to assess adverse events after LSG and can help the surgeon decide on surgical treatment, but also predicts the surgical risk for the patient[19].

Logistic regression was used to create our model with an accuracy of 70.4%. The model shows that the probability or risk of intraoperative complications increases significantly if the patient has preoperative diabetes or Grade 3 elevated blood pressure. For diabetes about 2 times (adjusted OR = 1.9) and for elevated blood pressure stage 3 almost 12 times (adjusted OR = 11.8).

Pre-operative treatment or improvement of comorbidities may reduce the risk of intraoperative complications.

This study also has some limitations. It is a retrospective study. Series with a larger number of patients are needed to gain an accurate insight into the incidence of intraoperative complications.

Conclusion

In summary, the study shows which intraoperative complications occur in LSG, how they can be resolved and which factors can lead to them and influence the outcome of the operation itself. The recognition and successful treatment of intraoperative complications are very important because they reduce the number of reoperations and the costs of treatment.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data and informed consent was not required for this retrospective and observational study.

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