*Clinical Study*

# Complications, Reoperations, and Nutrient Deficiencies Two Years after Sleeve Gastrectomy

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*Background*. The aim of this study was to investigate patient outcomes and nutritional deficiencies following sleeve gastrectomy (SG) during a follow-up of two years. *Methods*. Over a period of 56 months, all consecutive patients who underwent SG were documented in this prospective, single-center, observational study. The study endpoints included operative time, complication rates, nutritional deficiencies and percentage of excess weight loss (%EWL). *Results*. From September 26, 2005 to May 28, 2009, 82 patients (female : male = 48 : 34) with a mean age of 43.3 years (range: 22–64) and a preoperative BMI of 52.5 kg/m$^2$ (range: 36.8–77.0) underwent SG. Major complications were observed in 9.8% of the patients, with 1 death. During follow up 51.2% of patients were supplemented with iron, 36.6% with zinc, 37.8% with calcium, 26.8% with vitamin D, 46.3% with vitamin B12 and 41.5% with folic acid. %EWL was 54.3, 65.3 and 62.6% after 6, 12 and 24 months. *Conclusion*. SG as a single step procedure is an effective bariatric intervention. Nutritional deficiencies after SG can be detected by routine nutritional screening. Our results show that Vitamin B12 supplementation should suggest routinely after SG.

## 1. Introduction

Obesity has developed an epidemic way. Approximately 1.7 billion people are overweight, and 312 million are obese [1, 2]. In Germany in 2009, 60.1% of male and 42.9% of female population was overweight [3]. There are currently no conservative treatments having long-term effect on weight loss and amelioration of comorbidities.

Obesity is associated with an increased mortality risk [4]. Obesity is also associated with increased health costs. A BMI ≥ 35 kg/m$^2$ is associated with a 200% increase in health care costs compared to the normal weight range [5]. An indication for bariatric surgery is a BMI ≥ 40 kg/m$^2$ or a BMI ≥ 35 kg/m$^2$ accompanied by obesity-associated diseases.

As a result of new technologies with lower risks and better long-term results, bariatric and metabolic surgeries have grown in popularity in recent years. The number of operations performed is rapidly increasing. After the Magenstrasse and Mill procedure, laparoscopic sleeve gastrectomy was performed as the single-step procedure for surgically induced weight loss in 2000 [6].

Two-stage procedures are especially necessary for multi morbid patients with BMI above 50 kg/m$^2$ due to the rising risks of RYGBP or duodenal switch (DS).

Considering the high mortality rate of 6% following biliopancreatic diversion (BPD) with DS, SG is to be preferred as a first-step operation for these patients [7, 8].

The aim of this systematic study was to investigate nutritional deficiencies and outcomes following sleeve gastrectomy during a followup of two years in the daily routine of a maximal clinical care hospital.

## 2. Patients and Methods

From September 26, 2005 to May 28, 2009, 82 patients underwent sleeve gastrectomies in the Department of Surgery of the SRH Wald-Klinikum Gera Hospital.

After we ensured compliance with international and German guidelines [9, 10] and excluded endocrine causes of obesity, the patient participated in an informational seminar and was evaluated by experienced bariatric surgeons, and SG was performed.

TABLE 1: Recorded parameters.

| Age | OP duration |
| --- | --- |
| Sex | Use of staple line reinforcement |
| Hospitalization | Bougie size |
| Type of operation | Resected gastric volume |
| *Laboratory* | |
| Iron | Albumin |
| Zinc | Vitamin B12 |
| Selenium | Folic acid |
| Alkaline phosphatase | Calcium |
| Hemoglobin | Parathyroid hormone |
| MCV | |

All medical data were collected prospectively and analyzed retrospectively. Patients were classified according to the WHO classifications of obesity ($35$–$39.9 \, kg/m^2$; $40$–$49.9 \, kg/m^2$) with expansions to "super obesity" ($50$–$59.9 \, kg/m^2$) and "super-super obesity" ($\geq 60 \, kg/m^2$).

The evaluated parameters were recorded and are listed in Table 1.

Acute and postoperative complications, as well as their treatments, were evaluated. Acute complications were defined as intervention-associated or intraoperative complications.

*2.1. Sleeve Gastrectomy: Operation Technique.* SG was performed in the French position in a $30°$ reverse Trendelenburg position. The surgeon stood between the patient's legs with assistants on both sides.

Pneumoperitoneum was established to 15 mmHg using a Veress needle (the alternative open technique). The first trocar for placing the camera was inserted 15 cm distal to the xiphoid process, and the abdominal cavity was reflected outwards. Another trocar was placed on the epigastric angle, and the liver was retracted superiorly using a fan retractor. Two trocars were then placed on the right and left upper quadrants.

The dissection of the greater curve and the division of the short gastric vessels began 5-6 cm proximal to the pylorus and extended to the angle of His.

The sleeve was created via a trocar incision at the right upper quadrant. Sleeve resection of the stomach was performed using an Endo GIA stapler (green) made by Covidien, Germany.

A bougie size 31–36 Fr was inserted transorally and guided along the lesser curvature toward the antrum of the stomach. The sleeve resection was continued using staple line reinforcement along the length of the bougie to the angle of His. Over sewing of staple line was not performed due to the use of staple line reinforcement.

At that point, approximately 75–80% of the stomach was separated. The bougie was removed after the application of methylene blue to inspect for leaks along the staple line.

The resected stomach was placed in a retrieval bag and removed by enlarging the trocar incision at the upper right quadrant.

After checking for possible further intraabdominal bleeding, a silicone drain was placed.

The trocar was removed under direct visualization, and the abdomen was deflated. The fascial defect was closed, and a sterile surgical dressing was set.

At the end of the surgery, the resected stomach was filled with water to determine the volume of the resection. Histopathological analysis was then performed on the specimen.

*2.2. DVT Prophylaxis.* DVT prophylaxis was performed in all patients. Besides antithrombotic stockings we used low molecular weight heparin (NMH) at least 21 days postoperatively. Only in patients with a length of stay in hospital more than 21 days prophylaxis was performed further on. In patients with a weight over 120 kg NMH was given once a day and over 120 kg twice a day.

*2.3. Antibiotics.* In all patients a single-shot antibiosis was given using a third-generation cephalosporin. If an intraoperative complication occurred antibiosis was continued.

*2.4. Nutrition and Postoperative Diet.* In all patients a contrast swallow was performed at the first postoperative day. After contrast swallow patients were allowed to drink 250 cc water or tea at the first, 500 cc at the second, 1000 cc at the third postoperative day. After the fifth day we started for a week with liquids and after the second postoperative week patients could eat pulpy.

*2.5. Postoperative Followup.* All of the patients were examined throughout a 24-month follow-up period (at 3, 6, 12, 18, and 24 months postoperatively). The information for this study came from patient records from the hospital and the clinical outpatient department.

Furthermore, short- and long-term results with regard to BMI, weight, %EWL, and important laboratory parameters (iron, zinc, selenium, alkaline phosphatase, hemoglobin, MCV, albumin, vitamin B12, folic acid, calcium, and parathyroid hormone levels) were registered. Furthermore, necessity of medical substitutions or second operations (DS or RYGBP) had been evaluated.

## 3. Results

*3.1. Demographic Data.* From September 26, 2005 to May 28, 2009, 82 patients (sex ratio, females : males = 48 : 34 [1.4 : 1]) with a mean age of 43.3 years (range, 22–64) and a preoperative BMI of $52.5 \, kg/m^2$ (range, 36.8–77.0) underwent sleeve gastrectomies. Operation was performed by three different surgeons, operating as a team in all the 82 recorded operations. Patient's outcome and operation time were not affected by changing the surgeon in these teams.

Six patients had BMIs between 35 and $39.9 \, kg/m^2$, 23 had BMIs between 40 and $49.9 \, kg/m^2$, 35 had BMIs between 50 and $59.9 \, kg/m^2$, and 18 had BMIs over $60 \, kg/m^2$. A total of 76.5% of the male patients and 56.3% of the females had BMIs more than $50 \, kg/m^2$.

TABLE 2: Data from patients and operations.

| | BMI | | | | |
|---|---|---|---|---|---|
| | 35–39.9 kg/m² | 40–49.9 kg/m² | 50–59.9 kg/m² | ≥60 kg/m² | Total |
| *Sex* | | | | | |
| Male | 4; 66.7% | 4; 17.4% | 18; 51.4% | 8; 44.4% | 34; 41.5% |
| Female | 2; 33.3% | 19; 82.6% | 17; 48.6% | 10; 55.6% | 48; 58.5% |
| *Age (years)* | 47.0 (33–64) | 42.8 (22–59) | 43.7 (22–58) | 41.7 (25–59) | 43.3 (22–64) |
| *BMI (kg/m²)* | 36.8 (36.8–39.5) | 44.3 (40.0–48.0) | 53.6 (50.0–59.1) | 65.6 (60.0–77.0) | 52.5 (36.8–77.0) |
| *Operation* | | | | | |
| Laparoscopy | 6; 100.0% | 22; 95.7% | 33; 94.3% | 14; 77.8% | 75; 91.5% |
| Laparoscopy with conversion | | 1; 4.3% | 1; 2.9% | 4; 22.2% | 6; 7.3% |
| Laparotomy | | | 1; 2.9% | | 1; 1.2% |
| *Operative time (minutes)* | 75.3 (41–101) | 73.7 (44–120) | 95.1 (39–275) | 102.0 (45–225) | 89.3 (39–275) |
| *Resected gastric* volume (mL) | 760.0 (650–900) | 826.9 (600–1100) | 1096.4 (500–1700) | 1156.3 (750–1700) | 1009.3 (500–1700) |
| *Bougie size* | | | | | |
| 31 French | | 1; 4.3% | | | 1; 1.2% |
| 32 French | 1; 16.7% | 1; 4.3% | 2; 5.7% | 1; 5.6% | 5; 6.1% |
| 34 French | 4; 66.7% | 21; 91.3% | 31; 88.6% | 17; 94.4% | 73; 89.0% |
| 36 French | 1; 16.7% | | 2; 5.7% | | 3; 3.7% |
| *Staple line reinforcement* | 5; 83.3% | 22; 95.7% | 29; 82.9% | 14; 77,8% | 70; 85.4% |

### 3.2. Operation Data.

Of the 82 patients, 81 underwent primarily laparoscopic surgery. In 7.4% of these patients (6 of 81), a conversion from laparoscopy to laparotomy was necessary. In one case, a primary laparotomy was performed because of an abdominal wall hernia, resection of an anus praeter, subtotal colectomy with an ileorectostomy and known adhesions of the small intestine. Postoperative course of the patient was uneventful.

The mean duration of the OP was 89.3 min, and the mean resected gastric volume was 1009.3 mL. A 34Fr calibration tube was used in 89% of the patients (73). Staple line reinforcements were not available during our first cases. So they were used in 85.4% of the patients (Table 2). Comparing leakage rate and bleeding in patients using staple line reinforcement or over sewing was of no difference.

There were significant differences among the durations of the OP. When staple line reinforcements were used, the mean OP duration was 80.7 minutes, compared to 141.4 minutes without staple line reinforcements ($P = 0.012$).

A laparoscopy with conversion to laparotomy was performed significantly more often for patients with BMIs over 60 kg/m² compared to patients with lower BMIs ($P = 0.02$).

The duration of the OP averaged 75.3 minutes for patients with BMIs between 35 and 39.9 kg/m², 73.7 minutes for patients with BMIs between 40 and 49.9 kg/m², 95.1 minutes for patients with BMIs between 50 and 59.9 kg/m², and 102.0 minutes for patients with BMIs over 60 kg/m² ($P < 0.001$). Patients with BMIs over 50 kg/m² had significantly longer OP durations compared to patients with BMIs under 50 kg/m² (97.4 versus 74.0; $P = 0.01$).

The resected gastric volume was significantly higher in patients with BMIs over 50 kg/m² compared to patients with BMIs under 50 kg/m² (1109.7 versus 808.3 mL; $P < 0.0005$).

### 3.3. Intraoperative and Early Postoperative Complications.

Twenty patients (24.4%) had intraoperative or/and postoperative complications (Table 3). Out of the 82 patients, 81 were operated laparoscopically, and in 6 cases (7.4%), a conversion to laparotomy was necessary. In 4 cases, this conversion was performed because of an insufficient laparoscopic overview with high intraabdominal pressure. In 2 cases, the conversion was because of laparoscopically uncontrollable bleeding, which was related to an insufficient abdominal overview in 1 case.

Postoperative complications occurred in 17 patients (20.7%). One patient died (1.2%). This patient had a BMI of 55.5 kg/m², and on the tenth postoperative day, he complained of left upper abdominal pain. The CT scan showed an insufficient suture with a subcardial abscess. A CT-guided puncture ensued. Subsequently, to create an internal drainage, a gastroscopy was performed, and during this investigation, the patient aspirated. The patient's cardiac situation worsened, an ARDS developed, and the patient died.

Acute complications have occurred significantly more frequently in patients with BMIs over 60 kg/m² ($P < 0.001$). Major complication rate was 9.8% (Table 4).

### 3.4. Follow-Up Data.

Follow-up rate was 97.6% (80/82). All of these patients were clinically examined with a laboratory test 24 months after SG, so mean follow-up time is 24 months. The other 2 patients died during followup—1 of them related due to a complication.

The mean preoperative BMI of all of the patients examined was 52.5 kg/m². At the end of the followup, there was a significant reduction in BMI to 35.4 kg/m² ($P < 0.0005$). The greatest weight loss occurred within the first

Table 3: Acute and postoperative complications.

| n | Cause of acute complications/conversions (6/82; 7.3%) | Postoperative complications (17/82; 20.7%) |
|---|---|---|
| | Complications (20/82; 24.4%) | |
| 1 | Insufficient intraabdominal view | Abscess |
| 2 | Insufficient intraabdominal view | |
| 3 | Insufficient intraabdominal view | Severe sepsis<br>Wound infection<br>Thrombosis |
| 4 | Insufficient intraabdominal view | |
| 5 | Bleeding | |
| 6 | Insufficient intraabdominal view Bleeding | Wound infection |
| 7 | | Perforation of duodenum<br>Insufficient wound healing |
| 8 | | Bleeding |
| 9 | | Abdominal pain |
| 10 | | Gastric ulcer bleeding |
| 11 | | Bleeding<br>Pleural effusion<br>Abscess<br>Leakage |
| 12 | | Leakage |
| 13 | | Insufficient wound healing |
| 14 | | Wound infection |
| 15 | | Leakage<br>Abscess<br>Severe sepsis with ARDS<br>Pneumonia<br>Pleural effusion<br>Death |
| 16 | | Abscess<br>Insufficient wound healing |
| 17 | | Wound infection |
| 18 | | Mild pulmonary edema |
| 19 | | Pneumonia |
| 20 | | Insufficient wound healing |

Table 4: Major complications ($n = 8$).

| N | Major complication |
|---|---|
| 1 | Bleeding |
| 2 | Iatrogenic perforation of duodenum |
| 3 | Bleeding + leakage + abscess |
| 4 | Leakage |
| 5 | Abscess |
| 6 | Leakage + abscess + ARDS with death |
| 7 | Severe wound infection with sepsis + thrombosis |
| 8 | Abscess |

12 postoperative months ($52.5 \, \text{kg/m}^2$ to $36.7 \, \text{kg/m}^2$), and the loss gradually stabilized, with further weight loss from $36.7 \, \text{kg/m}^2$ to $35.4 \, \text{kg/m}^2$ for all of the patients examined until now.

The %EWL in the BMI categories between 35 and $39.9 \, \text{kg/m}^2$ and 40 and $49.9 \, \text{kg/m}^2$ was 45.8% and 47.7%, respectively, after 3 months. The greatest %EWL in these categories was achieved after 18 (69.6% and 76.7%) months.

Both groups showed a slight tendency toward increased weight after this time. Patients with BMIs between 50 and $59.9 \, \text{kg/m}^2$ and over $60 \, \text{kg/m}^2$ showed continuous weight loss throughout the entire 24-month follow-up period (Figure 1).

Table 6 shows the BMI progression for the 57 patients (69.5%) who did not need a second operation for further weight loss. On average, there was a tendency toward increased weight after 18 months in these patients ($34.0 \, \text{kg/m}^2$ to $35.6 \, \text{kg/m}^2$). The most significant weight loss was achieved within the first postoperative year ($P < 0.0005$) (Table 5). Regarding the percentage overweight loss, the highest %EWL of 68.4% occurred after 18 months, and after 24 months, there was a further %EWL of 62.6%. The highest %EWL of 83.3% was observed in patients with BMIs between 35 and $39.9 \, \text{kg/m}^2$ after 18 months (Table 6).

3.5. Mortality Rate. Mortality rate after 24 months of total followup is 2.4%. One patient died during hospital stay at 73rd day postoperatively, due to SIRS and ARDS. Second patient died several months after SG due to his cardiac situation without any relation to operation.

TABLE 5: Weight progression (BMI in kg/m$^2$) of patients without a second operation during the follow-up period ($n = 57$).

| | | | Timeline (months) | | | |
|---|---|---|---|---|---|---|
| BMI | OP | 3 | 6 | 12 | 18 | 24 |
| 35–39.9 kg/m$^2$ | 38.3 | 31.3 | 30.2 | 27.8 | 27.5 | 28.4 |
| 40–49.9 kg/m$^2$ | 44.0 | 34.7 | 31.5 | 29.4 | 29.3 | 29.9 |
| 50–59.9 kg/m$^2$ | 53.2 | 44.2 | 39.6 | 37.5 | 36.8 | 38.2 |
| ≥60 kg/m$^2$ | 65.6 | 52.5 | 47.0 | 43.5 | 42.1 | 43.7 |
| Total | 50.9 | 40.9 | 37.6 | 34.5 | 34.0 | 35.6 |



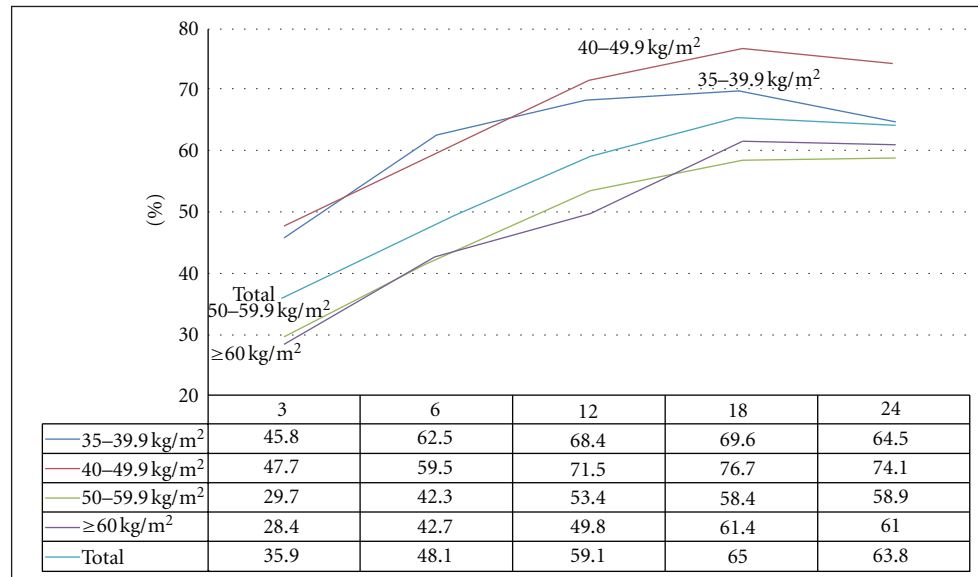| | 3 | 6 | 12 | 18 | 24 |
|---|---|---|---|---|---|
| 35–39.9 kg/m$^2$ | 45.8 | 62.5 | 68.4 | 69.6 | 64.5 |
| 40–49.9 kg/m$^2$ | 47.7 | 59.5 | 71.5 | 76.7 | 74.1 |
| 50–59.9 kg/m$^2$ | 29.7 | 42.3 | 53.4 | 58.4 | 58.9 |
| ≥60 kg/m$^2$ | 28.4 | 42.7 | 49.8 | 61.4 | 61 |
| Total | 35.9 | 48.1 | 59.1 | 65 | 63.8 |

FIGURE 1: %EWL of all of the patients during the follow-up period.

### 3.6. Revisional Procedures after SG.

Over the total observation period of 24 months, a second operation to induce weight loss was required in 30.5% (25) of the patients to develop further weight loss or amelioration on comorbidities. Three patients with BMIs between 50 and 59.9 kg/m$^2$ underwent RYGBP as a second operation. The other 22 patients (26.8%) underwent DS.

### 3.7. Laboratory Parameters

#### 3.7.1. Iron.

Iron supplementation was performed in 42 patients (51.2%). Six of these patients experienced microcytic anemia following SG, which required the initiation of iron supplementation. All patients did not suffer from iron deficiency before operation and were with normal hemoglobin and iron levels preoperatively. In all patients oral supplementation was performed with twice a day 120 mg iron. A parenteral supplementation due to the fact of severe iron deficiency was not necessary in these patients. In 23 of 42 patients, iron supplementation was performed as prophylaxis after a second operation (RYGBP or DS), and the other 19 patients (23.2%) were supplemented after SG. Of these 19 patients, 16 were female, and 3 were male. To examine if iron supplementation is only necessary in fertile women, we examined especially the data of the women. Women had a mean age of 41.6 years (25–59). Ten of these 16 women recorded a reduced iron value, and the other 6 women were supplemented with a combination of folic acid and iron.

#### 3.7.2. Zinc.

The highest average value for zinc 14.80 $\mu$mol/L was determined preoperatively (reference range 10–23 $\mu$mol/L). There were no significant differences among the average values in the follow-up period. In total, 30 patients underwent zinc supplementation, and 4 of these complained of hair loss. Nineteen patients were supplemented preventively because of a second operation (RYGBP or DS) for weight loss. Eleven patients (13.4%) were supplemented following SG due to zinc deficiency. Supplementation was performed as 15 mg zink daily.

#### 3.7.3. Selenium.

The highest average value for selenium of 81.7 $\mu$g/L (reference range 50–120 $\mu$g/L) was determined preoperatively. After 3 months, a significant decrease of 60.87 $\mu$g/L ($P < 0.0005$) occurred. No other significant differences were observed over the course of the followup. Due to selenium deficiency in laboratory eight patients after SG were treated with selenium supplementation using

Table 6: %EWL of patients without a second operation during the follow-up period ($n = 57$).

| BMI | Timeline (months) | | | | |
|---|---|---|---|---|---|
| | 3 | 6 | 12 | 18 | 24 |
| 35–39.9 kg/m$^2$ | 53.3 | 62.5 | 80.7 | 83.3 | 76.3 |
| 40–49.9 kg/m$^2$ | 49.3 | 65.4 | 76.6 | 78.0 | 74.5 |
| 50–59.9 kg/m$^2$ | 33.3 | 48.0 | 54.7 | 57.4 | 52.8 |
| ≥60 kg/m$^2$ | 30.9 | 45.1 | 53.4 | 59.8 | 53.8 |
| Total | 40.7 | 54.3 | 65.3 | 68.4 | 62.6 |

100 $\mu$g twice a day. Among the 57 patients who did not undergo a second operation, there was a gradual increase in the concentration of selenium (OP: 81.6 $\mu$g/L; 3rd month: 62.0 $\mu$g/L; 6th month: 62.7 $\mu$g/L; 12th month: 65.2 $\mu$g/L; 18th month: 66.8 $\mu$g/L; 24th month: 69.7 $\mu$g/L).

*3.7.4. Calcium and Parathyroid Hormone.* In 46 of the 82 patients, PTH levels were preoperatively determined, and 19.6% of the patients (9) had hyperparathyroidism. The average PTH levels (reference range 10.0–69.0 ng/L) for patients with BMIs over 60 kg/m$^2$ were 81.6 ng/L preoperatively, 67.3 ng/L after 6 months and 61.9 ng/L after 18 months. Thirty-one patients (37.8%) were supplemented with calcium carbonate and cholecalciferol, including 15 patients supplemented after a second operation (RYGBP or DS). For calcium supplementation patients got four times daily 500 mg calcium with 10 $\mu$g cholecalciferol. Twenty-two patients (26.8%) were treated with separate or additional vitamin D supplementation due to high levels of PTH, including 9 patients treated preventively after a second operation for weight loss.

Under supplementation, a rising concentration of PTH appeared 3 months after the operation. After 6 months, a decrease in the concentration of PTH was identified. After the 6 months, there were no significant differences among the PTH levels (Tables 7 and 8).

Vitamin D levels were not investigated routinely, due to the fact that follow-up examination in metabolic surgery is not covered by health insurance system in Germany.

*3.7.5. Albumin.* SG did not significantly affect the patients' albumin levels (reference range 34.0–48.0 g/L) during the follow-up period. Only 3 patients demonstrated hypoalbuminemia 3 months after SG, and all 3 of these patients had experienced intra- or postoperative complications.

*3.7.6. Vitamin B12.* Thirty-eight patients (46.3%) received vitamin B12 supplementation, including 18 patients after RYGBP or DS. For vitamin B12 supplementation 1000 $\mu$g vitamin B12 monthly was ordinated. The other 20 (24.4%) supplemented patients were treated with supplementation within the first postoperative year (Table 9). Under supplementation, the vitamin B12 levels achieved stable average values (reference range 175–810 pmol/L) during the entire follow-up period.

In addition, the other 57 patients, who did not undergo a second operation for further weight loss, demonstrated stable and not significantly different vitamin B12 concentrations (OP: 282.7 pmol/L; 3rd month: 289.6 pmol/L; 6th month: 265.8 pmol/L; 12th month: 260.0 pmol/L; 18th month: 256.1 pmol/L; 24th month: 277.5 pmol/L).

*3.7.7. Folic Acid.* Regarding folic acid (reference range 10.40–42.40 nmol/L), there was a significant decrease 3 months after the operation from 19.82 nmol/L to 15.51 nmol/L ($P < 0.0005$). 13 patients were supplemented following SG due to folic acid and/or iron deficiency with a combination of folic acid and iron. After RYGBP or DS were regularly supplemented 21 patients. After the third month following the operation, an increasing concentration of folic acid was observed as a result of supplementation, with a maximum average level of 20.96 nmol/L occurring after 24 months. Supplementation was performed with a combination of folic acid 0.5 mg and iron 40 mg daily.

## 4. Discussion

SG is an effective operative method for inducing weight loss. SG may be used as a single operation, or in the case of insufficient weight loss, it can be suggested as a second operation, such as RYGBP or DS. Additionally, SG can be performed as the first step of a two-stage procedure for high-risk patients to reduce the perioperative risks of DS or RYGBP.

An analysis of the literature shows the benefits of LSG compared to laparoscopic gastric banding (LAGB) and laparoscopic RYGBP. There are several technical advantages of SG: nonresection of the pylorus, which prevents dumping syndrome; no intestinal anastomoses and, consequently, no insufficiencies of anastomoses; nearly regular intestinal absorption and a lower risk of developing an internal hernia [11]. Due to high complication rate of SG procedure is still in discussion. particulary short-term complications as leakage and staple line insufficiency influence the complication rate. In the literature an increasing long-term complication rate is reported to be due to stenosis, gastroesophageal reflux, and reoperation rate due to insufficient weight loss, regain of weight or insufficient amelioration of comorbidities [12]. Evidence-based data on nutrient deficiencies, especially vitamin B12 and iron, after SG is not available.

TABLE 7: Postoperative course of calcium (mmol/L).

| | Timeline (months) | | | | | |
|---|---|---|---|---|---|---|
| *BMI* | OP | 3 | 6 | 12 | 18 | 24 |
| 35–39.9 kg/m$^2$ | 2.36 | 2.33 | 2.37 | 2.40 | 2.40 | 2.44 |
| 40–49.9 kg/m$^2$ | 2.36 | 2.38 | 2.40 | 2.35 | 2.38 | 2.36 |
| 50–59.9 kg/m$^2$ | 2.37 | 2.35 | 2.38 | 2.34 | 2.35 | 2.30 |
| ≥60 kg/m$^2$ | 2.34 | 2.45 | 2.39 | 2.34 | 2.34 | 2.33 |
| Total | 2.36 | 2.37 | 2.39 | 2.35 | 2.36 | 2.34 |

TABLE 8: Postoperative course of parathormone (ng/L).

| | Timeline (months) | | | | | |
|---|---|---|---|---|---|---|
| *BMI* | OP | 3 | 6 | 12 | 18 | 24 |
| 35–39.9 kg/m$^2$ | 34.70 | 50.67 | 41.98 | 42.68 | 44.70 | 39.90 |
| 40–49.9 kg/m$^2$ | 50.42 | 58.84 | 51.20 | 51.68 | 50.71 | 54.94 |
| 50–59.9 kg/m$^2$ | 46.51 | 45.95 | 50.57 | 54.20 | 54.70 | 56.28 |
| ≥60 kg/m$^2$ | 81.58 | 87.62 | 67.25 | 60.75 | 61.86 | 64.81 |
| Total | 55.57 | 59.62 | 53.84 | 53.77 | 54.34 | 56.52 |

RYGBP and BPD are the most effective, but also the riskiest, bariatric methods. Both procedures tend to increase the risk of perioperative complications based on the difficult technical circumstances surrounding the patients' weight and the associated comorbidities, such as hypertension, diabetes, and sleep apnea. The complication rates for super-super obese patients are 23% for RYGBP and 38% for DS. The mortality after RYGBP is 0.5% and 1.0% after DS [13]. SG, however, reduces perioperative risks of morbidly obese patients with BMI above 60 as a first step procedure.

The reported initial weight loss after SG spans a wide range, between 33 and 83% [14, 15]. In a prospective study of 100 patients, Johnston et al. presented a %EWL of 60% after 5 years [16].

That study group achieved a %EWL of 59.1% after 12 months and 63.8% after 24 months.

Over a 24-month period, the entire patient population experienced continuous weight loss up to the 18th month. After 24 months a weight loss to a BMI of 35.4 kg/m$^2$ was achieved. SG as a single operation is suitable for patients with BMIs <50 kg/m$^2$. Only 10.3% of these patients (3/29) required a second intervention to induce further weight loss within the follow-up period (versus 41.5% with BMIs ≥50 kg/m$^2$).

After 24 months, patients who only underwent SG with BMIs between 35 and 39.9 kg/m$^2$ achieved the highest %EWL. Therefore, there was no correlation between the resected volume of the stomach and the %EWL. Only one patient (16.7%) needed to undergo a second operation for further weight loss.

After 18 months, patients who only underwent SG demonstrated increased mean weights, which may have been due to sleeve dilatation. This possibility was considered by Gluck et al., who presented %EWLs of 67.9% after 1 year,

62.4% after 2 years, and 62.2% after 3 years for patients after SG with preoperative BMIs between 35 and 43 kg/m$^2$ [17].

There is not always sufficient weight loss after SG; insufficient changes in food patterns or potential recidivism to old food patterns may cause a sleeve dilatation. One option for treatment may be a resleeve operation. There are inadequate data to properly appraise this option, and further studies must clarify the utility of this procedure in comparison to RYGBP or DS as a second operation.

In addition because of the moderate rate of major complications of 9.8% (8/82), SG can be recommended as a first-step operation before malabsorptive interventions. Regarding postoperative complications, there were no significant differences among the BMI categories. However, patients with BMIs ≥60 kg/m$^2$ required a change to laparotomy significantly more often because of an insufficient intraabdominal view. Preoperative implantation of a gastric balloon to reduce morbidity for patients with BMIs over 60 kg/m$^2$ still needs to be addressed.

In this study, there was a 30-day mortality of 0.0%, a hospitalization mortality of 1.2%, and a one-year mortality of 2.4%.

There were 2 patients who did not benefit from SG. One patient with a preoperative BMI of 50.5 kg/m$^2$ first lost weight after SG, but his weight eventually increased to a higher level than before SG (59.7 kg/m$^2$ by the end of the followup). An insufficient change in food patterns and intake of high-calorie foods appeared to be the cause. The other patient, with a preoperative BMI of 55.5 kg/m$^2$, died after a prolonged course with various complications on day 73 after SG.

One other severe obese patient with a preoperative BMI of 68.0 kg/m$^2$ died 10 months postoperatively. A causal

TABLE 9: Necessity of vitamin B12 supplementation during the follow-up period.

| Vitamin B12 | BMI | | | | | | | | | |
| | 35–39.9 kg/m$^2$ | | 40–49.9 kg/m$^2$ | | 50–59.9 kg/m$^2$ | | $\geq 60$ kg/m$^2$ | | Total | |
| | n | % | n | % | n | % | n | % | n | % |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| After OP | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 5.6 | 1 | 1.2 |
| After 3 months | 1 | 16.7 | 4 | 17.4 | 5 | 14.3 | 1 | 5.6 | 11 | 13.4 |
| After 6 months | 0 | 0.0 | 1 | 4.3 | 4 | 11.4 | 1 | 5.6 | 6 | 7.3 |
| After 12 months | 0 | 0.0 | 1 | 4.3 | 0 | 0.0 | 1 | 5.6 | 2 | 2.4 |
| After 18 months | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| After 24 months | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| After 2nd OP | 1 | 16.7 | 2 | 8.7 | 10 | 28.6 | 5 | 27.8 | 18 | 22.0 |
| Total | 2 | 33.3 | 8 | 34.8 | 19 | 54.3 | 9 | 50.0 | 38 | 46.3 |

relationship with SG was excluded after consultation with the family doctor.

The definitive success rate for SG in this study was 97.6%, with a mortality of 1.2% and a nonresponder rate of 1.2%.

Twenty-five patients (30.5%) in this study required a second operation via a two-stage procedure for further weight loss.

Nutritional deficits after LSG are rarely evaluated. In postoperative course there is no suggestion for vitamin supplementation. Evidence-based data on necessity of supplementation after SG does not exist in the literature. After evaluating nutritional deficiencies, there is no need for supplementation after SG, although preoperative existing deficits should be supplemented. Laboratory parameters should be monitored regularly to detect early nutritional deficiencies and to initiate appropriate therapies.

Vitamin B12 levels were in the lower third of the reference range without supplementation. Therefore, it is likely that, without supplementation, vitamin B12 deficiencies can occur, especially more than two years after operation due to empting of vitamin B12 storage. Therefore, a general vitamin B12 supplementation is advisable to avoid pernicious anemia and to prevent neuropathic pain.

Patients with deficiencies in albumin, vitamin D, or calcium have a higher risk of developing osteoporosis; therefore, it is recommended that appropriate supplementations be initiated, even if the concentrations of these parameters are only slightly decreased. PTH levels should be determined to diagnose secondary hyperparathyroidism.

Based on to parameters, iron supplementation should be initiated similar to the supplementation of folic acid. Moreover, supplementation of zinc should be based on symptoms (hair loss, immune deficiency, dry skin). High zinc intake reduces absorption of copper and iron and vice versa. Medication of zinc and calcium should be suggested to intake at different times, because zinc reduces calcium absorption. Supplementation of selenium is not generally necessary because postoperative deficiencies normalize on their own without supplementation, and an adequate, varied food intake seems to be sufficient.

Regular determination of laboratory parameters should be performed 3 and 6 months after the operation and

semiannually thereafter; if the patient's weight stabilizes, laboratory parameters should be determined once a year.

## 5. Conclusion

Our results following SG and those reported in the literature are promising. Nevertheless, adequate long-term results are still unavailable because long-term studies (>6 years) are rarely performed.

The effectiveness and safety of SG are encouraging.

The operative treatment is not comparable among studies because of a lack of standardization [9]. Also, the 3rd ICSSG could not recommend which part of the antrum should be left and to what degree the antrum should be minimized to achieve a long-term volume reduction in the sleeve [18]. Additionally, evidence-based data are unavailable concerning the size of the bougie or whether the use of staple line reinforcement could reduce the rates of leakage [19].

Good results are not only based on the operation being performed in a center for bariatric surgery; the patients' instructions from dietitians are at least as important.

The conditions for excellent results are patient compliance, an adequate change in lifestyle and food patterns, and regular aftercare in obesity consultation to optimize results, and detect nutritional deficiencies promptly. SG represents a good possibility as a single-step operation for surgically induced weight loss with a high patient acceptance rate. A second step for further weight loss can follow.

## 6. Summary

(1) SG is an effective intervention for weight loss. For patients with BMIs of 35–49.9 kg/m$^2$, a single-step procedure is suitable. For patients with BMIs $\geq$ 50 kg/m$^2$, SG is suitable as a first-step procedure for reducing perioperative risks for DS [20].

(2) There is still no consensus on the use of staple line reinforcements or the size of the calibration tubes.

(3) For patients with BMI above 60 kg/m$^2$, preoperative implantation of a gastric balloon should be discussed. Studies on this issue are necessary for reducing morbidity and mortality.

(4) There was no correlation between the %EWL and the resected gastric volume.

(5) Supplementation of vitamin B12 is indicated and should generally be initiated after SG.

(6) Supplementation of iron and folic acid should depend on laboratory parameters for both genders.

(7) A deficiency in albumin was not reproducible in our patients.

(8) Supplementation of zinc should be based on symptoms.

(9) Substitution of selenium is not necessary.

## Disclosure

N. Pech, F. Meyer, H. Lippert, T. Manger, and C. Stroh attest that they have no commercial associations (e.g., equity ownership or interest, consultancy, patent and licensing agreements, or institutional and corporate associations) that might present a conflict of interests in relation to the submitted paper.

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