Risk factors associated with the development of trocar site hernia after laparoscopic bariatric-metabolic surgery

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Abstract

The aim of this study is to investigate the effects of three laparoscopic bariatric-metabolic surgery (BMS) techniques [sleeve gastrectomy (SG), SG with transit bipartition (SG-TB), one anastomosis gastric by-pass (OAGB)] and patients’ sociodemographic and clinical features on trocar site hernia (TSH) development after laparoscopic BMS. This was a retrospective study conducted between January 2015 and February 2022. A total of 54 obese patients, 18 who developed TSH and 36 who did not develop TSH during follow-up after laparoscopic BMS, were included in the study. The mean age was 55.28 ± 7.98 years in the TSH group and 40.58 ± 11.47 years in the non-TSH group (p < 0.001). Seventeen (94.4%) of the TSH group and 23 (63.9%) of the non-TSH group were females (p = 0.021). TSH developed in 1 patient who underwent SG (5.6%), 1 patient who underwent OAGB (5.6%), and 16 patients who underwent SG-TB (88.9%). Multiple logistic regression analysis revealed that high age (p=0.018) and undergoing SG-TB (p=0.018) were independently associated with TSH development. In order to reduce TSH risk and to increase the chance of early diagnosis in patients with advanced age or SG-TB recipients, we believe that taking additional intraoperative precautions and performing closer follow-up will be necessary.

Keywords: trocar site hernia, sleeve gastrectomy, sleeve gastrectomy with transit bipartition, one anastomosis gastric by-pass, bariatric-metabolic surgery, risk factors

1. Introduction

Bariatric-metabolic surgery (BMS) is being performed with increasing frequency in the treatment of obesity and metabolic disorders (1-3). Although BMS seems to be the most effective and permanent treatment option for obesity, it is associated with a number of perioperative complications. These include anastomotic bleeding, leakage, myocardial infarction, pulmonary embolism, and even mortality, while delayed complications, such as dumping syndrome, malnutrition due to malabsorption, inadequate weight loss, and marginal ulceration, may also be encountered relatively frequently (2, 4, 5).

Besides the common complications of laparoscopic BMS, trocar site hernia (TSH) is a problem whose true incidence is difficult to detect and its likelihood is often ignored by many surgeons, especially because TSH usually occurs long after the primary surgery, is asymptomatic at onset, and remains difficult to diagnose when weight loss after surgery is limited (6, 7). Current estimates of TSH incidence after BMS report a range of 0–39.3%, although it is notable that these values are dependent upon the method of TSH diagnosis and follow-up time (6, 8). It has been shown that higher TSH risk is observed in patients with diabetes mellitus, postoperative malnutrition, higher intraabdominal pressure, difficulty in full-thickness closure of the trocar site, thicker peritoneum, and larger preperitoneal space (5, 9, 10). Moreover, it is difficult to diagnose TSH by inspection and palpation in obese patients because of excess subcutaneous fat tissue (3, 11). There are various studies which have used imaging methods for the detection of postoperative abdominal wall defects in obese patients, and it is evident that the presented incidence of TSH is much higher in these studies (6, 8, 12, 13). Considering the difficulty of diagnosis and the delayed nature of this complication, we believe that the risk of TSH after laparoscopic BMS should be taken into account and risk factors that facilitate the development of TSH must be identified. In a study investigating the effects of many factors, including BMS procedures, only excessive weight loss was identified as a risk factor for TSH (14). Furthermore, although there are many studies assessing TSH frequency and risk factors in non-BMS laparoscopic procedures (7, 15-17), there are very few which have investigated risk factors specific to BMS (9, 14, 18). In fact, a recent systematic review described TSH development following BMS as "an underestimated issue" (6).

In this study, we aimed to investigate the effects of three laparoscopic BMS techniques and some other sociodemographic and clinical features of patients with regard to their influence on TSH development after laparoscopic BMS.

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2. Material and Methods

This retrospective case-control study was carried out by including patients who underwent BMS from January 2015 to February 2022 in our bariatric surgery Center of Excellence, Department of General Surgery, Büyük Anadolu Hospital, Samsun, Turkey. The study was approved by the Ethics Committee of Büyük Anadolu Hospital (date: 28.07.2021, no: 04). The study was conducted according to the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Due to the study’s retrospective nature, written informed consent was deemed unnecessary by the ethics committee. All data were recorded anonymously.

2.1. Study population

A total of 54 obese patients, 18 who developed TSH and 36 who did not develop TSH in their follow-up after laparoscopic BMS, were included in the study. Participants in the control group were randomly assigned in a 2:1 ratio for patients undergoing BMS who met inclusion criteria, using an internet-based random number generator (https://www.random.org). The exclusion criteria were determined as follows for both groups: being younger than 18 or older than 65 years old, having undergone revision BMS, being diagnosed with a postoperative complication related to the trocar incision site (e.g., wound infection), presence of complications necessitating revision surgery after primary surgery, history of inguinal, femoral, umbilical or epigastric hernia, history of a previous abdominal surgery (e.g., cesarean section etc.), severe mineral or vitamin malnutrition after surgery, known wound healing disorder, steroid therapy, renal insufficiency or cancer. Patients who did not attend follow-up or had missing relevant data were also excluded from the study.

2.2. Data collection

Demographic information (age, sex, etc.), anthropometric data [height, weight, and body-mass index (BMI)], occupation, smoking status, number of transvaginal births among female participants, comorbidities and drug use, type of BMS procedure applied, use of protein supplementation, and necessary follow-up information were obtained from hospital records.

2.3. Operative technique and post-operative follow up

Patients with a BMI of ≥40 or a comorbidity with a BMI of ≥35–40 was considered eligible for BMS (19). The most appropriate BMS procedure was determined according to the preferences of the patients after necessary information was provided. All three surgical techniques [sleeve gastrectomy (SG), SG with transit bipartition (SG-TB), one anastomosis gastric by-pass (OAGB)] were performed under general anesthesia and with standard laparoscopic surgical procedures.

Five trocars for SG (20) and OAGB (21) were placed as recommended in the literature. In patients who underwent SG+TB, an 11-mm optic trocar was inserted one and a half hands from the xiphoid process, in addition to a 5-mm trocar from the right lateral, a 15-mm trocar from the left lateral, a 5-mm trocar from the left lower quadrant, and a 5-mm trocar from the xiphoid for the liver retractor. For the first stapler application in both SG and SG-TB, an 11 mm optical trocar was routinely removed and replaced with a 15 mm trocar. Sleeve material was taken out of the abdomen through a 15-mm umbilical trocar site in SG, and from the left lateral 15-mm trocar site in SG-TB.

Stapling devices and stapler materials (Endo GIA™; Covidien, USA) in different sizes were used in all operations for basic anastomosis and stomach resection. In all operational procedures, trocar sites (except for the 5-mm fascial defect) were closed using 1/0 absorbable polyglactin (Vicryl™; Ethicon) sutures with the help of a trocar site closure device (Endo Close™ Auto Suture™; Covidien™; USA).

While no protein supplement was given to any patient in the SG-TB group postoperatively, it was given to the majority of patients in the SG and OAGB groups. The patients requiring protein supplementation were identified by an expert dietitian. Standard postoperative follow-up included clinical visits at 1 week, 1 month, 3 months, 6 months, 1 year, and once a year thereafter. TSH in symptomatic patients was confirmed by ultrasonography. Hernias developing in the 5-mm trocar sites were repaired by open surgery using polypropylene mesh. The remaining hernias were repaired with laparoscopic dual mesh and all the patients were discharged without any complications.

2.4. Statistical Analysis

All analyses were performed on IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA), with a significance threshold of p<0.05. For the normality check of the continuous variables, the Shapiro-Wilk test was used. Normally distributed continuous variables were analyzed with the independent samples t-test. Non-normally distributed continuous variables were analyzed with the Mann-Whitney U test. Categorical variables were analyzed with the chi-square tests or the Fisher’s exact or Fisher-Freeman-Halton tests. Multiple logistic regression analysis (forward conditional method) was performed to determine significant risk factors of the trocar site hernia. The model included all parameters with univariate significance.

3. Results

The mean age of all participants was 45.48 ± 12.50 years. The TSH group had a mean age of 55.28 ± 7.98, while the non-TSH group had a mean age of 40.58 ± 11.47 years. Seventeen (94.4%) of the TSH patients and 23 (63.9%) of the non-TSH patients were female. There was a significant difference between the groups in terms of age (p<0.001) and sex (p = 0.021). While there was a significant difference between the groups in terms of height (p = 0.037) and weight (p = 0.010) in favor of the non-TSH group, there was no significant difference in terms of BMI (p = 0.152). In the TSH group, the percentage of housewives (p = 0.021), median number of births (among women) (p<0.001), frequencies of hypertension (p = 0.021), and time of last menstrual cycle (p = 0.010) were significantly different compared to the non-TSH group. There was a significant difference in terms of the number of births (p = 0.010) and months of breastfeeding (p = 0.021) between the groups. In the TSH group, the percentage of women who used oral contraceptives (p = 0.010) was significantly higher than in the non-TSH group. While the percentage of women who used hemostatic agents (p = 0.001) was significantly higher in the non-TSH group, the percentage of women who used cigarette (p = 0.010) was significantly higher in the TSH group. The TSH group had a significantly higher percentage of women who used alcohol (p = 0.021) and use of protein supplement (p = 0.001) than the non-TSH group. The differences in terms of the number of friends (p = 0.010) and socioeconomic status (p = 0.010) were also significant between the groups.

The mean follow-up time was 28 ± 14.2 months. The mean follow-up time for the TSH group was 30 ± 13.5 months, and for the non-TSH group, it was 25 ± 14.8 months. The mean follow-up time for the non-TSH group was significantly shorter than that for the TSH group (p<0.001). While the mean follow-up time for the TSH group was significantly longer than that for the non-TSH group (p = 0.001), there was no significant difference in terms of the number of follow-up visits (p = 0.152) between the groups.

The mean follow-up time for the TSH group was significantly longer than that for the non-TSH group (p<0.001). While the mean follow-up time for the TSH group was significantly longer than that for the non-TSH group (p<0.001), there was no significant difference in terms of the number of follow-up visits (p = 0.152) between the groups. The differences in terms of the number of follow-up visits were also significant between the groups (p = 0.010). There was a significant difference in terms of the number of follow-up visits (p = 0.010) between the groups. The differences in terms of the number of follow-up visits were also significant between the groups (p = 0.001). There was a significant difference in terms of the number of follow-up visits (p = 0.010) between the groups. The differences in terms of the number of follow-up visits were also significant between the groups (p = 0.001). There was a significant difference in terms of the number of follow-up visits (p = 0.010) between the groups.
developed in 1 patient at the right lateral site. The most common symptoms in 18 patients with TSH were pain while moving and swelling when lifting something heavy. Of note, the patient who developed TSH from the left lateral incision on the right lateral side after SG-TB had been treated with hook cautery for bleeding from the trocar site. The median hospital stay after TSH repair was 2 days (IQR: 1-3).

Table 1. Summary of patients’ characteristics with regard to trocar site hernia

<table>
<thead>
<tr>
<th>Trocar site hernia</th>
<th>Total (n=54)</th>
<th>Yes (n=18)</th>
<th>No (n=36)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>45.48 ± 12.50</td>
<td>55.28 ± 7.98</td>
<td>40.58 ± 11.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>40 (74.1%)</td>
<td>17 (94.4%)</td>
<td>23 (63.9%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14 (25.9%)</td>
<td>1 (5.6%)</td>
<td>13 (36.1%)</td>
<td></td>
</tr>
<tr>
<td>Height, cm</td>
<td>163.54 ± 9.80</td>
<td>160.11 ± 6.86</td>
<td>165.25 ± 10.65</td>
<td>0.037</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>108.4 (96.6 - 124.3)</td>
<td>97.45 (92.1 - 113.0)</td>
<td>113.05 (99.8 - 131.6)</td>
<td>0.010</td>
</tr>
<tr>
<td>Body mass index, kg/m2</td>
<td>40.41 (36.43 - 46.14)</td>
<td>38.60 (35.30 - 42.74)</td>
<td>40.86 (37.62 - 46.69)</td>
<td>0.152</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>4 (7.4%)</td>
<td>0 (0.0%)</td>
<td>4 (11.1%)</td>
<td>0.021</td>
</tr>
<tr>
<td>Housewife</td>
<td>23 (42.6%)</td>
<td>13 (72.2%)</td>
<td>10 (27.8%)</td>
<td></td>
</tr>
<tr>
<td>Desk job</td>
<td>12 (22.2%)</td>
<td>2 (11.1%)</td>
<td>10 (27.8%)</td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td>15 (27.8%)</td>
<td>3 (16.7%)</td>
<td>12 (33.3%)</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>24 (44.4%)</td>
<td>7 (38.9%)</td>
<td>17 (47.2%)</td>
<td>0.771</td>
</tr>
<tr>
<td>Number of birth</td>
<td>2 (0 - 3)</td>
<td>3 (2 - 4)</td>
<td>0 (0 - 2)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>22 (40.7%)</td>
<td>13 (72.2%)</td>
<td>9 (25.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>6 (11.1%)</td>
<td>1 (5.6%)</td>
<td>5 (13.9%)</td>
<td>0.651</td>
</tr>
<tr>
<td>Type II Diabetes mellitus</td>
<td>27 (50.0%)</td>
<td>16 (88.9%)</td>
<td>11 (30.6%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Duration of diabetes mellitus, years</td>
<td>1 (0 - 10)</td>
<td>9 (5 - 13)</td>
<td>0 (0 - 5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Drug use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>27 (50.0%)</td>
<td>2 (11.1%)</td>
<td>25 (69.4%)</td>
<td></td>
</tr>
<tr>
<td>Oral antidiabetics</td>
<td>3 (5.6%)</td>
<td>3 (16.7%)</td>
<td>0 (0.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Insulin</td>
<td>9 (16.7%)</td>
<td>5 (27.8%)</td>
<td>4 (11.1%)</td>
<td></td>
</tr>
<tr>
<td>Oral antidiabetics + Insulin</td>
<td>15 (27.8%)</td>
<td>8 (44.4%)</td>
<td>7 (19.4%)</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeve gastrectomy</td>
<td>14 (25.9%)</td>
<td>1 (5.6%)</td>
<td>13 (36.1%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sleeve gastrectomy + Transit bipartition</td>
<td>26 (48.1%)</td>
<td>16 (88.9%)</td>
<td>10 (27.8%)</td>
<td></td>
</tr>
<tr>
<td>One anastomosis gastric by-pass</td>
<td>14 (25.9%)</td>
<td>1 (5.6%)</td>
<td>13 (36.1%)</td>
<td></td>
</tr>
<tr>
<td>Protein supplement</td>
<td>14 (26.4%)</td>
<td>2 (11.1%)</td>
<td>12 (34.3%)</td>
<td>0.102</td>
</tr>
<tr>
<td>Time between operation and hernia, months</td>
<td>8.5 (7 - 10)</td>
<td>8.5 (7 - 10)</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Follow-up time, months</td>
<td>29 (20 - 65)</td>
<td>20 (12 - 65)</td>
<td>32.5 (23.5 - 65.5)</td>
<td>0.060</td>
</tr>
</tbody>
</table>

Data are given as mean ± standard deviation or median (1st quartile - 3rd quartile) for continuous variables according to normality of distribution and as frequency (percentage) for categorical variables. Abbreviations: N/A: Not applicable

Multiple logistic regression analysis revealed that high age (p=0.018) and SG-TB (p=0.018) were the significant factors independently associated with TSH development. Patients who underwent SG-TB operation had 8,600-fold higher risk for TSH than other types of surgery (OR: 8.600, 95% CI: 1.446 - 51.152) (Table 2). Other variables included in the analysis, sex (p=0.168), height (p=0.923), weight (p=0.129), occupation (p=0.799), number of births (p=0.191), hypertension (p=0.854), T2DM (p=0.600), duration of T2DM (p=0.097) and drug use (p=0.624) were found to be non-significant (Table 2, Fig. 1., Fig. 2.).

Table 2. Significant risk factors of the trocar site hernia, multiple logistic regression analysis

<table>
<thead>
<tr>
<th></th>
<th>β coefficient</th>
<th>Standard error</th>
<th>p</th>
<th>Exp(β)</th>
<th>95.0% CI for Exp(β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.101</td>
<td>0.043</td>
<td>0.018</td>
<td>1.106</td>
<td>1.017 - 1.203</td>
</tr>
<tr>
<td>Sleeve gastrectomy + Transit bipartition</td>
<td>2.152</td>
<td>0.910</td>
<td>0.018</td>
<td>8.600</td>
<td>1.446 - 51.152</td>
</tr>
<tr>
<td>Constant</td>
<td>-6.954</td>
<td>2.201</td>
<td>0.002</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

CI: Confidence Interval, Nagelkerke R²=0.535

No postoperative early complications occurred in any of the patients included in the study. The patients were followed up for a median of 29 (IQR: 20 - 65) months. TSH developed in 4 patients at the umbilical 15-mm trocar site, in 11 patients at the 15-mm left lateral trocar site and in 1 patient at the right lateral 5-mm trocar site after SG-TB. After SG, TSH developed in 1 patient at the umbilical 15-mm trocar site. After OAGB, TSH developed in 1 patient at the right 15-mm trocar site. The median hospital stay after TSH repair was 2 days (IQR: 1-3).
follow analysis of a recent study, age, sex, BMI at baseline, BMI development after BMS (9, 14, 18, 26). In the multivariable which have addressed the specific risk factors for TSH smoking status (22 trocars, trocar site, long operating time, literature. The most common ones among these are size of the factors independently associated with TSH development in this group of patients. Various risk factors (in addition to obesity) for TSH after BMS were found to be SG-TB and higher age.

Obesity stands out as a prominent risk factor for TSH development in a number of studies involving various patient groups and laparoscopic operations/ Obesity has been identified as a significant risk factor for TSH development in a number of studies involving different patient groups and laparoscopic procedures (9, 10). In this study, we sought to determine factors that increased TSH likelihood among patients who had undergone BMS for obesity treatment, and found that advanced age and SG-TB procedure were the risk factors independently associated with TSH development in this group of patients. Various risk factors (in addition to obesity) for TSH after laparoscopic surgeries have been described in the literature. The most common ones among these are size of the trocars, trocar site, long operating time, sex, advanced age, and smoking status (22-25). There are also some limited studies which have addressed the specific risk factors for TSH development after BMS (9, 14, 18, 26). In the multivariable analysis of a recent study, age, sex, BMI at baseline, BMI at follow-up, excessive weight loss, type of surgery, T2DM, smoking history, ASA score, abdominoplasty reconstruction, length of surgery, and length of hospital stay were evaluated to detect potential risk factors related to the development of TSH after BMS. The only factor that was related to a higher risk for TSH was found to be excessive weight loss (14). In another study investigating the risk factors for TSH in patients who underwent SG, TSH development was not found to be associated with sex, age, preoperative BMI, T2DM, comorbidities (hypertension, dyslipidemia, obstructive sleep apnea, metabolic syndrome), operation time, or weight regain (9). In another study examining similar risk factors, TSH was only found to be associated with the 12-mm trocar site closure after SG (18). Despite a lack of conclusive evidence on this matter, it appears that advanced age is a reasonable risk factor for TSH development, especially due to its relationship with fascia weakening, decreased abdominal muscle volume, and delayed wound healing (13, 22).

Various procedures have been described for BMS, and they may have multiple advantages and disadvantages compared to each other. Almost all of them can be performed as open procedures as well as laparoscopic procedures. The laparoscopic approach may reduce the risk of incisional hernia, but it does not completely eliminate the risk (11, 21, 25). In an OAGB series of 407 patients, it was reported that none of the patients developed TSH during follow-up. However, in this study, the follow-up period was limited to an average of 160 days (21). Raziel et al. detected TSH in only 1 (0.3%) of 337 OAGB cases (27). In a study from Turkey, the incidence of TSH after SG was reported as 0.36% (28). In another study, 3.1% TSH was reported after laparoscopic SG-TB (29). We rarely come across studies that include SG-TB and compare TSH rates between procedures (14, 26, 30). In the present study, TSH results of three laparoscopic surgical procedures were compared, and the incidence of TSH after SG-TB was found to be significantly higher, and that after SG and OAGB was found to be significantly lower. According to the multiple regression analysis, SG-TB was identified as a risk factor for TSH. Coblijn et al. found no significant difference in TSH rates after laparoscopic Roux-en-Y gastric bypass (RYGB), laparoscopic adjustable gastric band and laparoscopic SG (26). In other similar studies, no significant differences were found in terms of TSH frequency after laparoscopic RYGB and laparoscopic SG (14, 30). A higher incidence of TSH can be expected after laparoscopic SG and SG-plus procedure because the sleeve material is usually taken out of the abdomen through the umbilical trocar site, and therefore, the incision of this site is further widened due to excessive manipulation (25). This hypothesis is supported by the results of studies stating that most TSH cases are seen in the umbilical region and that excessive manipulation of the trocar site to remove samples may be an important risk factor for TSH (31, 32).

Santoro et al. introduced the transit bipartition approach as a metabolic complement to standard SG and stated that they obtained successful results (29). The resulting SG-TB method may provide extra metabolic benefits, but it would not be

4. Discussion
Trocar site hernia is a neglected problem which is rarely diagnosed when only symptoms and physical examination are considered after BMS; however, various studies have shown that TSH frequency can reach 40% when imaging methods are utilized (6, 8, 14). As a result of the multiple logistic regression analysis of the present study, the most important risk factors for the development of TSH after BMS were found to be SG-TB and higher age.

![Fig. 1. Age with regard to trocar site hernia](image1)

![Fig. 2. Type of operation with regard to trocar site hernia](image2)
erroneous to expect a heightened risk for complications as it involves intestinal intervention and anastomosis and increases surgical duration. Although TSH was observed in only 1 patient each after SG and OAGB in this study, lower TSH probability may be expected from the other two procedures, since no specimens were removed from the trocar incisions in OAGB. In the current study, although the sleeve material was removed from the umbilical trocar site in all SG patients, TSH occurred in only 1 patient (umbilical trocar site, SG group). In the SG+TB group, trocar hernia was observed in the umbilical region in 4 patients, although all sleeve materials were removed from the 15-mm left trocar site. Moreover, the incidence of TSH after only SG was found to be quite low compared to the incidence of TSH after SG-TB. All of these contradict the hypothesis that enlargement of the trocar site while removing the sleeve material facilitates TSH development. According to the results of this study, it can be thought that the removal of the sleeve material and related manipulations do not have a significant effect on TSH development. This requires the consideration that other factors contribute to TSH after SG-TB. Age, as another independent variable, may be an effective factor in this situation. In addition, increased duration of surgery, another possible factor not investigated in this study, and more excessive manipulation as a requirement of SG-TB surgery can be considered as other possible causes. Moreover, the fact that all patients who underwent SG-TB had T2DM (and were not administered postoperative protein replacement), and that the number of females and the median number of births were higher in the group with TSH, may suggest that these factors may have influenced TSH likelihood, despite non-significant results in multiple regression analysis. Notably, diabetes mellitus and protein deficiency are factors that negatively affect wound healing (33). Also, the increase in the number of births may facilitate the development of TSH due to the weakness of the abdominal fascia (7). However, more comprehensive studies are needed to clarify factors that have a definite effect on TSH development.

Another issue to consider in a study assessing TSH after BMS is trocar site wound and/or fascia closure. In laparoscopic approaches other than BMS, suturing the fascia for trocar incisions larger than 10 mm is recommended, but TSH risk can be seen even in smaller-sized lesions (≤5 mm) (15, 16). In the present study, a significant majority of TSHs (94.4%) occurred at the 15-mm trocar site vs? whereas? TSH developed in only a single 5-mm trocar site. At this site, it was revealed that cauteration was performed due to bleeding during the operation. Karampinis et al. reported that in their department (where they did not perform fascia closure in trocar sites smaller than 10 mm) overall hernia prevalence was 2.5% in the 5-mm trocar site, 10.6% in the 12-mm site, and 22.4% in the 12-mm trocar site used for stomach extraction. Also in this study, suturing the fascia with interrupted, absorbable sutures did not appear to yield fewer TSHs than leaving the fascia open (3). However, in another study, it was reported that the frequency of TSH was significantly lower when the fascia was closed at the 12-mm epigastric trocar site using a protected port closure device (18). Aly and Lee (34), criticized the statement that the closure of trocar site wound can be omitted because the TSH incidence is 0.5% even when the trocar site wound is not closed as a conclusion of the study by Coblijn et al. (26), and stated that even this rate was rather high. They also stated that trocar site wounds of 10 mm and above should be closed and suggested that the two methods they introduced (Surgicel® and omental plug without fascial closure) could be vital in preventing TSH (30, 34). In general, it can be said that the risk of TSH increases as the size of the trocar and trocar incision increases. In addition, according to our results, we recommend routine fascial closure of trocar sites larger than 5 mm when they are involved in the removal of sleeve material. In addition, we think that fascia closure at the 5 mm trocar site is only necessary if cauteration (or other excessive manipulation) is performed during the operation.

Some limitations of the present study should be taken into account when interpreting the results. The generalizability of the results is limited, as it is a single-center study and the number of participants is small. The small number of participants may also have limited the specific comparisons between the types of surgeries compared. The retrospective nature also carries possible biases concerning patient inclusion/exclusion due to possible problems in data records. In addition, we could not assess additional possible factors such as anemia, ASA score, COPD, etc., which can cause wound healing disorders. The fact that routine imaging methods were not used for TSH screening may have resulted in an underestimation of TSH; however, the frequency reported in this study already demonstrates that TSH is not as rare as suggested by previous short-term studies.

In conclusion, SG-TB and advanced age were found to be the most important risk factors for TSH development after BMS. In order to reduce the risk of TSH development and to increase the chance of early diagnosis of TSH in patients with advanced age or SG-TB recipients, we think that it would be beneficial to take additional pre-and perioperative measures. Also, performing follow-up not only clinically but also with additional imaging methods may be necessary in these patients. We also recommend fascia closure if intraoperative cauteration or excessive manipulation has been performed in the trocar site, regardless of size. However, there is still a need for comprehensive prospective studies in which TSH screening is performed with imaging methods to precisely determine the real-world incidence of TSH after BMS and to identify risk factors specific to BMS procedures.

**Conflict of interest**
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
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Authors’ contributions

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