ORIGINAL MANUSCRIPT

Ventral hernia surgery in morbidly obese patients, immediate or after bariatric surgery preparation: results of a case-matched study

Short title: ventral hernia in obese patients

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ABSTRACT

Background: Obesity is a risk factor for the development of ventral hernia, and also increases the risk of recurrence and surgical site infection after hernia repair (HR).

Objectives: We tested the hypothesis that bariatric surgery (BS) prior to HR would decrease these risks in patients with morbid obesity.

Setting: University Hospital, France.

Methods: We **retrospectively** compared two groups of patients with morbid obesity in a case-matched study: one underwent immediate HR surgery (control); and the other initially underwent BS then HR following weight loss (case). Patients were individually matched at a 2:1 ratio according to defect size (<7 or ≥ 7 cm), obesity grade (<40 or ≥ 40 kg/m²), American Society of Anesthesiologists score, gender, smoker status, and presence of chronic obstructive pulmonary disease.

Results: From 2000 to 2017, 41 patients underwent BS, **in association with herniorraphy in 14 cases (34%)**. Initial BMI was higher in the BS group (46.7 ± 6.4 vs. 42.4 ± 7.2 , $p < 0.0001$), but had decreased by the time of HR (34.1 ± 6.5 vs. 42.3 ± 7.2 , $p < 0.0001$). **Prosthetic** hernia repair was performed after 21.5 months (range 7–87); however, seven patients did not receive HR at this time due to insufficient weight loss. Postoperative morbidity was similar in the two groups. Hospital stay was shorter in the BS group (6.2 ± 2.6 vs. 10.7 ± 9.3 days, $p = 0.002$). After a median follow-up of 4.6 ± 4.1 years, the recurrence rate was lower in the BS group (2/30, 6.7%) than in the control group (12/50, 24%; $p = 0.048$).

Conclusion: For morbidly obese patients with ventral hernia, BS prior to HR surgery can decrease recurrence without increasing morbidity.

KEYWORDS: Bariatric surgery; Incisional hernia; Ventral hernia; Obesity

ARTICLE SUMMARY

We hypothesized that bariatric surgery (BS) prior to ventral hernia repair (HR) would decrease the recurrence risk in patients with morbid obesity. We compared two groups of patients in a case-matched study: one underwent immediate HR; the other
30 underwent BS then HR following weight loss. After a median follow-up of 4.6 ± 4.1 years, the recurrence rate was significantly lower in the BS group (2/30, 6.7%) than in the control group (12/50, 24%; $p = 0.048$). Postoperative morbidity was similar in the two groups, but hospital stay was significantly shorter in the BS group (6.2 ± 2.6 vs. 10.7 ± 9.3 days, $p = 0.002$).

35 INTRODUCTION

Obesity **is a risk factor for postoperative complications after** abdominal surgery. Firstly, morbid obesity is linked to an increased risk of incisional hernia formation after abdominal surgery, as a body mass index (BMI) $>30 \text{ kg/m}^2$ is recognized as a risk factor for the development of incisional hernia ^(1, 2). Secondly, obesity increases **surgical morbidity** after open ventral hernia repair **due to an increased incidence of surgical site infection, seroma and wound dehiscence** ⁽³⁾. Thirdly, patients with obesity are one of the highest risk groups for recurrence after ventral hernia repair, where patients with grade I or II obesity (BMI = 33 and 38 kg/m^2 , respectively) run a 2.6- or 4.2-fold increased risk of recurrence, respectively, when compared to a normal-weight patient with a BMI of 23 ⁽⁴⁾. A thick abdominal wall can also hide an umbilical hernia. In addition, patients with morbid obesity are prone to other perioperative complications such as pneumonia, delayed wound healing and cardiovascular events ^(5, 6). Therefore, adequate weight loss is generally recommended before elective hernia surgery.

In daily surgical practice, obese patients consulting for ventral hernia surgery are usually asked to lose some weight before surgery, often without success. Bariatric surgery (BS) was shown to be the only effective treatment for early and significant weight loss, whereas conventional care alone was ineffective ⁽⁷⁾.

We hypothesized that BS preparation would decrease these risks for morbidly obese patients, especially the risk of hernia recurrence. To date, only small-sample, non-comparative series have been published, which have described a multi-step approach for the treatment of giant hernia with loss of domain in patients with obesity, with sleeve gastrectomy as the initial step toward weight loss ⁽⁸⁾. The aim of

60 this study was to assess the feasibility and potential benefits of a two-step approach of initial BS followed by definitive ventral hernia repair in patients with morbid obesity.

METHODS

Patients

65 Patients managed surgically for morbid obesity (BMI ≥ 35 kg/m²) from 2000 to 2017 were retrospectively evaluated. In total, 211 adjustable gastric banding procedures, 543 sleeve gastrectomies and 1686 Roux-en-Y gastric bypass (RGBP) surgeries, in addition to 116 various interventions for complications were performed, including 41 morbidly obese patients with ventral (**n = 26**) or incisional (**n = 15**) hernia. Thirty of
70 the 41 patients were identified to benefit from hernia surgery after significant weight loss (Figure 1). We compared patients who underwent the two-step treatment (BS followed by HR after weight loss) with a control group of patients with morbid obesity who had not undergone BS, instead being immediately treated for ventral HR. Patients with groin or lumbar hernia were excluded.

75 The patient matching process was blinded to the study outcomes and performed individually at a 2:1 ratio according to defect size (<7 or ≥ 7 cm), obesity grade (<40 or ≥ 40 kg/m²), American Society of Anesthesiologists (ASA) score, gender, smoker status, and presence of chronic obstructive pulmonary disease (COPD).

80 *Operative procedures*

Bariatric surgery was proposed for patients who met the criteria of the French health agency (Haute Autorité de Santé, HAS) for BS. These patients underwent the usual preparation before BS, including psychological and dietetic evaluation to exclude any medical contraindication, for a minimum of 6 months. The surgical technique was
85 laparoscopic sleeve gastrectomy, RGBP or gastric banding, depending on the patient's characteristic and wishes, and a multidisciplinary team evaluated all

candidates. In the particular case of large incisional hernia with possible incarcerated small bowel in the hernia sac, a sleeve gastrectomy was favored in order to avoid bowel injury.

90 During bariatric surgery, any defect larger than 5 cm was not treated. In the case of a smaller defect, incarcerated omentum was kept in place, but fascial closure was indicated in the case of an empty sac in order to prevent postoperative small bowel incarceration. A continuous suture of slowly absorbable monofilament **(USP 0 double loop PDS Plus II with a 48 mm needle or USP 1 Vicryl with a 36 mm**
95 **needle; Ethicon)** was favored.

Hernia repair was indicated after optimal weight loss, decided by the treating surgeon, according to the following criteria: BMI <35 kg/m², body weight <100 kg, or stable weight loss.

Incisional hernia repair was performed with **an open** standardized technique, as
100 described previously ⁽⁹⁾. Briefly, a polyester mesh was placed in the sublay position in the retromuscular space, extending at least 5 cm above and below the fascial defect, previously confirmed to be the best mesh localization ⁽¹⁰⁾.

Follow-up and study endpoints

105 All patients underwent routine follow-up after hernia repair, with evaluations performed every 6 months during the first 2 years, again at 3 years postoperative, and as required thereafter. At each follow-up appointment, patients underwent clinical examination. If there was no sign of clinical recurrence, an abdominopelvic computed tomography (CT) scan was conducted at 1 year postoperative.

110 The primary endpoint of the present study was hernia recurrence during the follow-up period, as confirmed by a CT scan. Clinical incisional hernia was defined as a

palpable fascial defect or visible protrusions at or near the surgical incision at rest or with the Valsalva maneuver. Radiologic hernia was defined as any protrusion of abdominal contents, including the anterior parietal peritoneum, visible as discontinuity of the fascial layers on the CT scan performed during follow-up without the Valsalva maneuver. Secondary endpoints were postoperative morbidity (defined as any in-hospital complication or complication arising within 30 days postoperative), including wound infection (defined as a suppurative discharge at the location of wound incision), reoperation or weight loss.

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Statistical analysis

Quantitative data were expressed as mean $\pm$ 1 standard deviation and range, and qualitative data as frequency and percentage. Comparisons of means between groups were performed using Student's *t*-test. Comparisons of percentages were performed using the chi-square test and Fisher's exact test, as appropriate. A P-value of <0.05 was considered statistically significant. Statistical analyses were performed using R software, version 3.4.3 (<https://www.r-project.org>).

This database was approved and registered (reference no. 2013714V0) with the French National Data Protection Agency (Commission Nationale Informatique et Libertés). Informed consent was obtained from all patients. This study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

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RESULTS

135 *Patients and feasibility of surgical strategy*

The baseline characteristics of the patients are presented in Table 1. The two-step approach is summarized in Figure 1. The first-step, BS, was performed on 41 patients with morbid obesity. There was no hernia strangulation between the two steps. Eleven patients did not undergo hernia repair as two patients did not have recurrence, seven did not lose enough weight, one had an ongoing surgical site infection **related to previous suture hernia repair**, and one was lost to follow-up. In total, 30 patients were offered the second step, and these patients were matched with 60 patients who constituted the control group. The two groups did not differ in regard to the criteria used to match patients (defect size <7 or ≥7 cm, obesity grade 140 <40 or ≥40 kg/m², ASA score, gender, smoker status and COPD) except for age. In this population, 15 patients (17%) had umbilical hernia and 75 patients (83%) had incisional hernia.

Initial BMI was higher in the BS group (46.7 ± 6.4 vs. 42.4 ± 7.2, p < 0.0001), but had decreased by the time of incisional hernia repair (34.1 ± 6.5 vs. 42.3 ± 7.2, p < 150 0.0001). Hernia repair was performed 21.5 months (range 7–87) after BS. All hernia surgeries were performed as open surgeries except for one in the control group, which was performed laparoscopically for a **small incisional hernia at the patient's request**. We used mesh for almost all patients (29/30 in the BS group and 53/60 in the control group, p = 0.35). Mesh was primarily placed in the sublay (71/82, 87%) or underlay (11/82, 13%) position. **In the control group, concomitant procedures were performed in 11 patients (18%) in association with hernia repair, including cholecystectomy in three patients, abdominoplasty in four patients, right colectomy for cancer in two patients, and small bowel resection in two**

160 **patients.** Mesh was not used in eight patients (four associated with digestive
resections, one abdominoplasty, two skin ulcerations and one chronic infection). No
other associated technique (component separation technique, progressive
preoperative pneumoperitoneum) was needed to close the defect. One patient in
each group had a previous surgical site infection ($p = 1$).

165 *Morbidity after hernia repair*

Morbidity in the two groups is detailed in Table 2. After a median delay of 4.6 ± 4.1
years, the overall postoperative morbidity did not differ between the BS and control
groups (11/30, 37% vs. 23/54, 44%; $p = 0.45$). Minor morbidity (Dindo 1–2) was 10%
in the BS group and 11% in the control group ($p = 1$). Major morbidity (Dindo 3–5)
170 was 27% in the BS group and 31% in the control group ($p = 0.83$). Hospital stay **after
hernia repair** was significantly shorter in the BS group (6.2 ± 2.6 days) than in the
control group (10.7 ± 9.3 days, $p = 0.002$). At the end of the follow-up period, four
patients in the control group had died, but only one of these deaths was related to the
surgery (early pulmonary distress at postoperative day 2).

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Recurrence after hernia repair

After a median delay of 4.6 ± 4.1 years, the recurrence rate was significantly lower in
the BS group (2/30, 6.7%) than in the control group (12/50, 24%; $p = 0.048$). Only
five patients in the control group were reoperated on for recurrence. In the BS group,
180 total body weight loss at the end of the follow-up period was $28 \pm 11\%$, and 23% of
the patients were no longer obese.

DISCUSSION

185 This case-matched study presents the outcomes of BS preparation before ventral
hernia repair in patients with morbid obesity. We found that BS preparation
decreases the recurrence rate and length of hospital stay without increasing
morbidity after hernia repair. To the best of our knowledge, this is the first
190 comparative study on the subject.

There are limited data in the existing literature as to whether definitive hernia
repair must be performed at the same time as BS or after significant weight loss.
According to Eid et al., hernia repair should not be deferred in patients undergoing
laparoscopic RGBP ⁽¹¹⁾. They included 59 patients undergoing RGBP with
195 concomitant hernia repair and 14 patients undergoing RGBP with deferred hernia
repair. In the deferred group, the authors observed 37% small bowel incarceration
before hernia repair. In the concomitant group, a 22% recurrence rate was noted. In
the current series, we did not observe any bowel incarceration. Other small studies
with short follow-up periods have also recommended this approach ^(12–14).

200 Bariatric surgery is performed under clean-contaminated conditions. When
concomitant hernia repair is performed, mesh is used in the contaminated field.
Cozacov et al. studied the occurrence of intraperitoneal contamination after BS. They
reported no intraperitoneal bacterial contamination after sleeve gastrectomy (0/51),
but 15% intraperitoneal bacterial contamination after RGBP (4/26) ⁽¹⁵⁾. Due to the
205 theoretically increased risk of mesh infection, we do not favor concomitant BS and
hernia repair using a non-absorbable mesh.

Other authors have recommended deferred hernia repair after BS. This multi-step
technique, using sleeve gastrectomy as the first step followed by incisional hernia
surgery after weight loss, was reported to be safe and effective in a study involving

210 15 patients [8]. After 2 years of follow-up, three patients were reoperated on, with one
patient requiring reoperation for recurrence, one for seroma and one for infection.
Similarly, in a study by Newcomb et al., RGBP was performed prior to incisional
hernia repair in 27 patients with morbid obesity who presented with recurrent
incisional hernia after a 1.3-year delay ⁽¹⁶⁾. The authors observed no recurrence after
215 a 20-month follow-up period.

We did not study the role of biologic mesh placed at the time of BS, performed
to repair a synchronous umbilical hernia or small incisional hernia without increasing
the risk of mesh infection. However, the rate of recurrence with underlay biologic
mesh placement seems to be high as a result of early and complete mesh resorption
220 and, in our experience, the recurrence rate after large incisional hernia repair can
reach 50%. Thus, the level of evidence for the safety and efficacy of biologic mesh
remains low.

**We found that overall postoperative morbidity did not differ between the
BS and control groups, but hospital stay was significantly shorter in the BS
225 group. However, these data should be interpreted with caution because 11
patients in the control group also underwent associated procedures such as
bowel resection or cholecystectomy. Although non-significantly different ($9.9 \pm$
 8.9 days with no additional operations vs. 15 ± 11.2 days with additional
operations; $p=0.18$), the length of stay might have been influenced by these
230 supplementary procedures.**

In this series, 11 patients **with a median starting BMI of 54.9 ± 8.5 kg/m²** did
not undergo hernia repair surgery. In seven of these patients, weight loss was not
sufficient, **so they were considered for a second-stage BS (only two of them
refused). In our opinion,** BS failure is mainly linked to insufficient physical activity,

235 often **related to mobility issues such as degenerative joint disease, respiratory**
disease (sleep apnea or COPD) and bulky hernias that limit the patient's **physical**
activity. In these patients, the measures employed to reinforce nutritional care are
often unsatisfactory.

Weight loss theoretically permits hernia repair, but there is no specific
240 threshold to allow secondary hernia surgery. In fact, a study by Kaminski et al.
showed that the recurrence rate after incisional hernia surgery increases with body
weight ⁽¹⁷⁾. The authors estimated a 5% recurrence rate when the patient's body
weight was lower than 90 kg, a 19% recurrence rate when their weight was between
90 and 113 kg, and a 33% recurrence rate when their weight was higher than 113 kg.
245 They argued that the bariatric procedure can only decrease the recurrence rate if the
patient's weight has decreased to below 90 kg at the time of incisional hernia
surgery. In our experience, we are more permissive and usually consider hernia
repair when the patient's body weight has reached less than 100 kg.

We previously published the results of retromuscular incisional hernia
250 **repair in 261 patients with an average BMI of 30 ± 6 kg/m² (range 17–58) ⁽⁹⁾. In**
this series, which also included patients who were not morbidly obese, the
average hospital stay was 7 days and early morbidity was 30%, including 16
reoperations for postoperative complications (6%). In our experience, patients
with morbid obesity in the control group had significantly higher LOS ($10.7 \pm$
255 **9.3 days) and morbidity (44%) than that reported in our previous series**
including non-obese patients, advocating for significant weight loss before
hernia repair. In order to reduce the LOS and healthcare costs, ambulatory care
was developed and is now the gold-standard for hernia surgery, given patients

are carefully selected. Recently, obesity was shown to be a preoperative factor
260 for the failure of day case surgery⁽¹⁸⁾.

The retrospective nature of the study and its small size are important limitations of this work, as it concerns a rare condition. Prospective comparative studies are mandatory.

CONCLUSION

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Bariatric surgery preparation for morbidly obese patients with ventral hernia offers a shorter hospitalization period with no increase in morbidity, and is also associated with a decreased recurrence rate. The risk of hernia incarceration in the period between BS and hernia repair is hypothetical. This approach should be considered in any patients with morbid obesity presenting with ventral hernia.

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FIGURE LEGENDS

Figure 1. Search flow chart.

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TABLES

Table 1. Patient characteristics.

Characteristic	BS [n = 30 (%)]	Control [n = 60 (%)]	P value
Male sex	7 (23)	16 (28)	0.83
Age at hernia repair (years)	50 ± 10	58 ± 11	<0.0001
Hernia size			
<7 cm	12 (46)	15 (32)	0.34
≥7 cm	14 (54)	32 (68)	
ASA score			
1, 2	23 (77)	35 (70)	0.70
3, 4	7 (23)	15 (30)	
Smoker	5/28 (18)	10/53 (18)	0.82
COPD	3 (10)	3 (5)	0.40
Initial obesity grade			
35–40	7 (24)	25 (42)	0.17
≥40	22 (76)	35 (58)	
Initial BMI (kg/m ²)	46.7 ± 6.4	42.4 ± 7.2	<0.0001
BMI at hernia repair (kg/m ²)	34.1 ± 6.5	42.4 ± 7.2	<0.0001
Previous hernia surgery	18 (60)	29 (48)	0.41

BS, bariatric surgery group; ASA score, American Society of Anesthesiologists score; COPD, chronic obstructive pulmonary disease; BMI, body mass index.

Table 2. Outcomes after hernia repair.

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Outcome	BS [n = 30 (%)]	Control [n = 60 (%)]	P value
Recurrence	2/30 (6.7)	12/50 (24)	0.048
Percentage weight loss	28 ± 11	13 ± 12	0.0008
Postoperative morbidity	11/30 (37)	23/54 (44)	0.45
Wound abscess	2 (7)	2 (3)	
Wound hematoma	3 (10)	1 (2)	
Seroma	2 (7)	3 (5)	
Chronic sepsis	2 (7)	1 (2)	
Small bowel occlusion	0	3 (5)	
Chronic pain	1 (3)	2 (3)	
Respiratory complication	1(3)	6 (10)	
Other medical complication	0	5 (8)	
Reoperation for recurrence or complication	4/30 (14)	10/54 (17)	0.76
Hospital stay (days)	6.2 ± 2.6	10.7 ± 9.3	0.002

BS, bariatric surgery group.

Bariatric surgery (BS) and ventral hernia

n=41

- Sleeve gastrectomy: n=19
- Roux-en-Y Gastric Bypass: n=18
- Gastric banding: n=4

Hernia management during BS

- Small defect closed: n= 14
- Small defect with incarcerated omentum left open: n=2
- Large defect left open: n=20
- Unknown : n=5

Strangulation between
the two steps
n=0

Hernia repair

n=30

patients included in the case-
matched analysis

- Mesh: n=29
 - Polypropylene: n=28
 - Biologic: n=1
 - Underlay: n=3
 - Sublay: n=26
- No mesh: n=1

No hernia repair

n=11

- No recurrence detected after first operation: n=2
- Insufficient weight loss: n=7
- Surgical site infection: n=1
- Lost to follow-up: n=1

Bariatric surgery (BS) and ventral hernia

n=41

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