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SURGERY FOR OBESITY AND RELATED DISEASES

American Society for Metabolic and Bariatric Surgery and American Hernia Society consensus guideline on bariatric surgery and hernia surgery

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Preamble

The American Society for Metabolic and Bariatric Surgery issues the following guidelines for the purpose of enhancing quality of care in hernia treatment through metabolic and bariatric surgery. In this statement, suggestions for management are presented that are derived from available knowledge, peer-reviewed scientific literature, and expert opinion. This was accomplished by performing a review of currently available literature regarding obesity, obesity treatments, and hernia surgery. The intent of issuing such a guideline is to provide objective information regarding the impact of obesity treatment on effective and durable hernia repair. The guideline may be revised in the future should additional evidence become available. (Surg Obes Relat Dis 2018;14:1221–1232.)

Keywords: Bariatric surgery; Hernia repair; Hernia surgery; Obesity; Weight loss; Body mass index; Practice guidelines

The link between obesity and hernia formation

Obesity, defined as a body mass index (BMI) ≥30 kg/m^2, has been associated with an elevated risk for the development of abdominal wall hernias (AWH). This risk is likely due to multiple factors, such as increased visceral fat and intra-abdominal pressure, increased abdominal wall circumference, and a heightened risk for surgical site infections (SSI). A number of authors have documented the increased rate of both primary and incisional hernias in patients with obesity [1–7].

Dessy et al. [1] evaluated patients undergoing abdominoplasty or ventral hernia repair (VHR) for the presence of associated inguinal and/or hiatal hernias and found that the group of patients with a BMI >33 kg/m^2 had a significantly higher rate of multiple hernias or laxities at the time of evaluation. Sugerman et al. [2] compared the following 2 groups of surgical patients to evaluate their rate of development of incisional hernias (IH): patients with clinically severe obesity undergoing open metabolic/bariatric surgery (MBS) and patients with ulcerative colitis (UC) undergoing total abdominal colectomy. Of note, 97% of the UC patients had a BMI <30 kg/m^2. These authors found a higher rate of IH formation in the MBS group than the

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colectomy group (20% versus 4%) despite a significantly higher rate of steroid use among the UC patients [2].

Goodenough et al. [3] analyzed data from 625 patients who underwent abdominal surgery with median follow-up of 41 months and found that BMI >25 kg/m^2 (overweight or obesity) was predictive of IH formation. They hypothesized that intra-abdominal pressure and changes in abdominal wall configuration (from a more vertical linear structure to a circular structure) may have something to do with the correlation between increased BMI and AWH formation. Hanish et al. [4] studied 145 consecutive pancreas transplant patients and found that patients with a BMI >30 kg/m^2 had a higher risk of overall complications and specifically a higher frequency of dehiscence, infection, and IH formation. In a more recent study of 787 patients who underwent single incision laparoscopic surgery, Buckley et al. [5] found a significantly higher incidence of IH formation in patients with severe obesity, in their study classed as a BMI ≥40 kg/m^2 (18.2%) compared with healthy weight patients (3.5%).

Obesity has been shown to increase the risk for hernia recurrence after VHR in multiple studies [8–10]. Anthony et al. [8] performed a retrospective review of 77 patients who underwent VHR to determine the influence of chronic illness, obesity, and type of repair on the likelihood of hernia recurrence. They found that patients with a BMI >28 kg/m^2 who underwent prosthetic mesh repair had a higher rate of recurrence compared with patients with a BMI <28 kg/m^2. Similarly, Sauerland et al. [9] prospectively followed 160 patients who underwent IH repair and found that BMI was the most significant predictor of recurrence, with a rate ratio of 1.1 per unit BMI increase above normal ($P = .01$).

Several obesity-related factors are likely to lead to the increased risk for AWH formation. First, multiple studies have shown that obesity leads to increased intra-abdominal pressure [11–14]. Sugerman et al. [11] evaluated 84 morbidly obese patients undergoing MBS and found that after induction of general anesthesia they had increased intra-abdominal pressures (taken from urinary bladder pressures) when compared with 5 lean subjects, 18 versus 7 cm H_2O, respectively. He also found that 16% of patients had an AWH at the time of their MBS [11]. Similarly, Varela et al. [13] evaluated intra-abdominal pressures, again through bladder pressures, of 62 MBS patients with a mean BMI of 49 kg/m^2 and found that it was elevated in 77% of patients.

While most authors attribute the increased risk for AWH formation in the setting of obesity to BMI alone, others have suggested that abdominal circumference and elevated visceral fat may play a more significant role. In a retrospective study of 41 patients undergoing abdominoperineal resection, De Raet et al. [15] found that when waist circumference was >100 cm there was a 75% probability of developing a parastomal hernia. Similarly, Aquina et al. [16] retrospectively evaluated 193 patients who underwent abdominal operations for cancer and found a 21% incidence of IH formation in patients with increased central obesity as defined by visceral fat volume.

Severe obesity has also been shown to lead to an increased risk for SSI, another cause for incisional and recurrent hernia formation in patients with obesity [2–6,16,17]. Aquina et al. [16] showed that there was an increased risk for SSI in patients with a high visceral fat volume (25.8%) compared with those without (7.9%) a high visceral fat volume. Similar findings were seen in the study by Hanish et al. [4], where patients with obesity not only had a higher risk of IH but also had a higher risk of infectious complications—45% compared with 18% in patients with a BMI <30 kg/m^2. Sugerman et al. [2] found that 39% of MBS patients who developed an IH had a concomitant SSI, compared with 18% in those who did not develop IH. Only 2.8% of the UC patients had postoperative wound infections.

Prevalence of hernias in patients with obesity

The development of an AWH, primary or incisional, has been associated with many factors. The literature contains conflicting data on factors, such as patient age, sex, American Society of Anesthesiologists class, and smoking as contributors to AWH formation; however, one consistent finding in the majority of the literature is that obesity contributes significantly to the incidence of AWH.

A recent analysis of the American College of Surgeons National Surgical Quality Improvement Program database covering the years 2009 to 2012 demonstrated that nearly 60% of patients undergoing VHR in the United States had a BMI >30 kg/m^2 [18]. With the dramatic association between obesity, wound complications, and risk for hernia recurrence, patients with obesity and AWH represent a significant and increasingly common challenge for surgeons. AWH repair is one of the most common operations performed by general surgeons, with 350,000 ventral and 800,000 inguinal hernias repaired each year [19,20]. Of the AWH, the majority is IH resulting from prior abdominal surgery. With increasing healthcare costs and more focus on prevention, there have been recent efforts to create predictive models for the development of an IH [6,7,21,22]. In a prospective clinical trial of factors predicting IH after laparotomy, Veljkovic et al. [7] found that BMI was the only preoperative variable significant enough to contribute to IH formation.

Similarly, Itatsu et al. [21] followed 4305 consecutive patients undergoing abdominal surgery and found that BMI >25 kg/m^2 was the second greatest contributor to development of an IH, with SSI being the first. Similar studies from the United States confirm this finding. In one of the largest series to date examining hernia risk after abdominal surgery, Fischer et al. [22] reviewed 12,373 patients who had undergone gastrointestinal or gynecologic surgery. In this series, patients with a BMI >30 kg/m^2 had a nearly 2-fold increase in the risk of developing an IH following their index operation. To add to the complexity of this issue, patients with obesity are more likely to present with an incarcerated AWH, increasing the likelihood of their requiring an emergent operation [6].

Data regarding inguinal hernias in the setting of obesity are less straightforward. The true incidence of inguinal hernias is difficult to establish, as some patients do not seek attention for minimally symptomatic hernias. As a result, it is difficult to correlate patient characteristics, such as weight and the incidence of groin hernias. One long-term Swedish cohort study following 7483 men for 34 years demonstrated an inverse relationship between BMI and development of an inguinal hernia: there was a 4% reduction in relative risk of developing an inguinal hernia for every unit increase in BMI [23]. A follow-up study by Rosemar et al. [24] reviewed 49,094 patients from the Swedish Hernia Registry who underwent inguinal hernia repair between 2003 and 2007. Among these patients, only 5.2% had a BMI >30 kg/m^2 [24]. A similar study investigating 47,950 patients in the United States found similar results, with BMI >30 kg/m^2 being associated with a lower risk of groin hernia diagnosis; however, this study also demonstrated an increased risk of incarceration and strangulation in patients with obesity [25].

In effect, the true incidence of inguinal hernias in patients with obesity cannot be determined, but clinically identifiable or symptomatic inguinal hernias appear to be less prevalent. The results of these large cohort studies are counterintuitive and deserve some discussion. One of the most common presenting complaints of patients with an inguinal hernia is a groin bulge. A small hernia in a patient with a BMI of 20 kg/m^2 will produce a significantly different bulge than in a patient with a BMI of 40 kg/m^2. Thus, patients with higher BMIs may not be aware of and therefore may not seek medical attention for inguinal hernias, and when they do present, it is more often with incarceration or strangulation.

The 34-year cohort study by Rosemar et al. [23] identified inguinal hernias not by physical examination or radiograph, but rather by operative intervention. A possible explanation for this is that, through surgeon preference or bias, patients with obesity may more commonly be offered "watchful waiting" because inguinal hernia repair, open or laparoscopic, is more challenging and has higher complication rates in this population [23]. This approach would also explain the associated higher rate of incarceration or strangulation in patients with obesity. Other studies have also demonstrated an increase in emergent surgery and cost resulting from the implementation of watchful waiting [26].

Hernia repair risks and recurrence related to BMI

Obesity has been consistently found to be a risk factor linked to both postoperative complications and recurrences after open and laparoscopic VHR. Several factors have been described as potential mechanisms responsible for this increase, including delayed wound healing, impaired pulmonary function, and increased intraabdominal pressure. Furthermore, the common association between obesity and other metabolic derangements, such as diabetes, could explain many of the postoperative complications noted in this patient population. Obesity and diabetes are chronic inflammatory conditions, as demonstrated by the increased levels of inflammatory markers, such as C-reactive protein; abnormal levels of micronutrients, such as zinc; and markers of micronutrient imbalance, such as mean corpuscular volume and red cell distribution width [27]. All these factors have been associated with hernia defect size [27]. Finally, patients with obesity are considered to be at higher risk for general anesthetic due to their comorbid conditions as well as an increased fat mass, which causes delayed metabolism of anesthetic agents. Spinal anesthesia might be a safer option in select patients [28].

It may be acceptable to repair AWH discovered at the time of MBS. Eid et al. [29] found that avoiding repair was associated with a high rate of acute hernia incarceration in the postoperative period. Raziel et al. [4] demonstrated the safety of concomitant hernia repair and MBS. In this study, 54 patients underwent laparoscopic repair with only a 1.8% hernia recurrence rate at 12 months of follow-up.

Most studies of hernia repair in patients with obesity are small-to-moderate size retrospective series. In addition, the methodology of these studies is heterogeneous, including different approaches (open versus laparoscopic), different hernia repair techniques (primary tissue repairs, onlay, underlay, and component separation mesh techniques), use of permanent versus biologic mesh, different types of hernias (primary, recurrent, simple, or complex), and finally different hernia sizes and locations. It is not possible, therefore, to make definitive recommendations on the ideal repair technique for patients with obesity or to determine the ideal BMI at which to perform such an operation. A summary of the different studies reporting the influence of obesity on complications and recurrences is listed in Table 1 [1,2,8–10,27,28,30–69].

Because the morphometric distribution of fat differs between patients, BMI alone may not be the most accurate predictor of postoperative complications, as noted previously. Levi et al. [49] performed morphometric assessments of body composition using preoperative computed tomography. Patients subsequently underwent open ventral hernia repair of IH using the traditional Ramirez components separation technique [70] with preservation of perfo-

Table 1
Summary of the literature on the influence of obesity on complications and recurrences after hernia repair.

Yr	First author	Article type	N	Hernia type	Approach	Repair type	Recurrence rate	SSI rate	Complications	Level of evidence	Statistical significant	BMI cut-off	Comments
2000	Anthony [8]	Retrospective review	77	Ventral	Incisional	Primary and mesh	47.9 versus 37.5%			III	NS	>30	Primary repair higher recurrence
2006	Asolati [30]	Retrospective review	244	Umbilical	Open	Primary and mesh	0		Cellulitis, seroma, ileus	III	NS	>40	
2001	Birgisson [31]	Retrospective review	64	Ventral	Laparoscopic	Mesh				III			
2004	Bower [32]	Review	100	Ventral	Laparoscopic	Mesh	2%	2%		III	NS	32	
2014	Chan [33]	Retrospective review	17,117	Ventral				NA	NA	NA	NA	NA	
2014	Chan [34]	Retrospective review	45	Ventral	Laparoscopic	Mesh	NA	NA	NA	NA	NA	NA	Concomitant bariatric operation
2005	Chan [35]	Retrospective review	236	Incisional	Open	Mesh	ND	ND	ND	III	NS	30	
2007	Chang [36]	Retrospective review	30	Ventral	Open	Component separation	3%	7%	Seroma	III	NA	>35	
2013	Colon [37]	Retrospective review	123	Umbilical	Open and laparoscopic	Mesh	4%	26%		III	Y	>35	
2013	Dessy [1]	Retrospective review		Inguinal, crural	Open	component separation	NA	NA	NA	III	NA	36	
2014	Diana [38]	Prospective cohort	120	Incisional, umbilical	Laparoscopic	Mesh		Increased LOS, pain		III		>30	
2014	Dietz [39]	Retrospective review	330	Incisional, ventral	Open	Mesh				III	Y	>25	
2013	Eid [40]	Retrospective review	28	Ventral	Laparoscopic	Mesh	10%			III		>50	Concomitant bariatric operation
2014	Geletzke [27]	Retrospective review	127	Ventral	Open			ND	ND	III	Y	>30	obesity associated with bigger hernias and abnormalities
2005	Halm [41]	Retrospective review	131	Umbilical	Open	Mesh	5%–18%			III	NS	25	
2011	Harth [42]	Retrospective review	30	Ventral	Open					III			Concomitant panniculec-tomy
2003	Heniford [43]	Retrospective review	850	Ventral	Laparoscopic	Synthetic mesh	7.8 vs. 2%		18.6 vs. 11.5%	III	Y	>40	
2007	Iannelli [44]	Case series	5	Periumbilical	Open	Mesh							Concomitant panniculec-tomy
2014	Koolen [45]	Retrospective review	4925	Various	Open	Primary		NA	Y	III	Y	>40	Concomitant panniculec-tomy
2013	Krpata [46]	Retrospective review	88	Ventral	Open					III			

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Table 1 (*continued*)

Yr	First author	Article type	N	Hernia type	Approach	Repair type	Recurrence rate	SSI rate	Complications	Level of evidence	Statistical significant	BMI cut-off	Comments
1988	Lamont [47]	Retrospective review	1022	Ventral	Open	Primary	37.5% versus .5%			III			
2013	Lee [48]	Retrospective review	47,661	Ventral	Open and laparoscopic	Mesh				III			
2014	Levi [49]	Retrospective review	93	Ventral + component separation	Open					III			
1997	Luijendijk [50]	Retrospective review	68	Ventral	Open	Primary	46.1% versus 37%			III			
1991	Manninen [51]	Retrospective review	172	Ventral	Open	Primary	24.6% versus 13.3%			III			
2013	Martindale [10]	Review	N/A	Various						IV			
2014	Marx [52]	Retrospective review	79	Umbilical, ventral	Laparoscopic	Mesh	3.80%			III			
1996	Mendoza [53]	Retrospective review	125	GU procedures	Laparoscopic	N/A			21%	III		>30	
2002	Mittermair [54]	Retrospective review	208	Incisional	Open	Primary	50% versus 22.5 %			III			
2008	Moore [55]	Retrospective review	90	Ventral incisional	Open	Mesh	5.5%	10%	8%	III			
2006	Novitsky [56]	Retrospective review	163	Ventral	Laparoscopic	Mesh	5.5%	1.2%	12.3%	III		>30	
2013	Novitsky [57]	Retrospective review	78,348	Ventral						III			
2014	Okusanya [58]	Retrospective review	10	Incisional	Open	Mesh	10			III		>40	
1998	Paul [59]	Retrospective review	114	Incisional	Open	Primary	59.4% versus 44.4%			III			
2002	Raftopoulos [60]	Retrospective review	50	Ventral	Laparoscopic	Mesh	ND			III			
2007	Raftopoulos [61]	Retrospective review	27	Ventral	Laparoscopic	Synthetic and biologic	18.5%		25.9%	III	N	>35	
2014	Raziel [62]	Retrospective review	54	Ventral	Laparoscopic	Mesh	1.80%			III			Concomitant bariatric operation
2003	Rosen [63]	Retrospective review	96	Incisional	Laparoscopic	Mesh	20.4% versus 15.3 %			III			
2005	Sanjay [64]	Retrospective review	100	Umbilical	Open	Primary and mesh	11.5%			III	Y	34.1	

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Table 1 (*continued*)

Yr	First author	Article type	N	Hernia type	Approach	Repair type	Recurrence rate	SSI rate	Complications	Level of evidence	Statistical significant	BMI cut-off	Comments
2004	Sauerland [9]	Randomized	160	Incisional	Open	Primary, onlay mesh, autodermal	11%	ND	ND	Ib	Y	>30	Recurrence risk increased by factor 2.6 and 4.2 for BMI 33 and 38. Rate ratio 1.1 per unit BMI
2008	Saxe [65]	Retrospective review	100	Ventral	Open	Primary and mesh			55%	III			Concomitant panniculec-tomy
2003	Schumacher [66]	Retrospective review	140	Umbilical	Open	Primary and mesh	31.8%			III		>30	
2006	Schuster [67]	Retrospective review	12	Incisional, umbilical	Open and laparoscopic	Primary and mesh	17%			III	NA	>38	Concomitant repairs during LRYGB and ORYGB
1996	Sugerman [2]	Retrospective review	1145	N/A	Open		5%			III	Y	>35	
2013	Symeonidis [28]	Retrospective review	23	Ventral	Laparoscopic					III			
2008	Tsereteli [68]	Retrospective review	1071	Ventral	Laparoscopic	Mesh	8.3% versus 2.9%	LOS, OR time		III	Y	>40	
2015	Warren [69]	Retrospective review	86	Ventral Incisional	Open	Mesh		ND		III			

SSI = surgical site infection; BMI = body mass index; LOS = length of stay; ND = not documented; OR = operating room; Y = yes; N = no; NA = not applicable; NS = not significant; LRYGB = laparoscopic Roux-en-Y gastric bypass; ORYGB = open Roux-en-Y gastric bypass.

rating vessels when feasible. This study found that subcutaneous fat cross-sectional area, total body cross-sectional area, and total body circumference demonstrated increased odds ratio (OR) for SSI, whereas BMI did not. These findings demonstrate the deleterious effect of elevating large skin and subcutaneous tissue flaps, as required for the Ramirez technique during open IH repair.

Laparoscopic repair

Laparoscopic surgical procedures have long offered the benefits of decreased pain, quicker recovery, and lower wound complication rates compared with open surgical procedures. Several investigators have demonstrated the feasibility of laparoscopic ventral hernia repair (LVHR) in patients with obesity. In one of the largest series, LVHR in 163 patients with a mean BMI of 38 kg/m^2 was associated with a very low, 1.2% rate of wound complications and a recurrence rate of only 5.5% at a mean 25-month follow-up [56]. A similar study with 79 patients demonstrated a 3.8% recurrence rate at a mean 18-month follow-up [52]. Raftopoulos et al. [61] reviewed the results of 27 LVHR in patients with a mean BMI of 46.9 kg/m^2. This was a heterogeneous group including primary, incisional, and recurrent hernias, and even concomitant hernia repair during laparoscopic Roux-en-Y gastric bypass (LRYGB). All cases involved intraperitoneal placement of either biologic or permanent mesh with at least a 4-cm defect overlap, and affixed with 4-corner transfascial sutures as well circumferential spiral tacks. The authors reported an 18.5% recurrence rate during mean follow-up of 15 months and a 25.9% incidence of 30-day major and minor complications, including small bowel obstruction, bladder injury, wound infection, pneumonia, and need for reoperation [61].

Hernia recurrence, therefore, can be significantly affected by the degree of obesity. In a review of 100 consecutive patients undergoing LVHR by Bower et al. [32], the majority of the complications (73%) occurred in the group of patients with a BMI >30 kg/m^2. In addition, all recurrences (2%) were seen in the same group. In another series of LVHR patients at a mean follow-up of 19 months there was a 2.9% recurrence rate in lean patients versus 8.3% in patients with a BMI >40 kg/m^2 (OR = 4.3) [68]. These authors also found the time to hernia recurrence to be shorter in the higher BMI group. Birgisson et al. [31] retrospectively reviewed 64 LVHR patients, among whom 16 had a BMI ≥40 kg/m^2. The patients with clinically severe obesity had longer operative times and length of stay (LOS), but no difference in postoperative complications or recurrences. A large retrospective multi-institutional review of LVHR performed with a standardized synthetic mesh technique showed statistically significant differences, including increased operative times in patients with a BMI >40 kg/m^2 (mean 156 versus 114 min; $P < .01$), larger defects (mean size 167 versus 105 cm^2 $P < .01$), and recurrence rate (7.8% versus 2% $P = .05$). Overall the patients with obesity had a nonstatistically significant trend toward increased postoperative complications (18.6% versus 11.5%) [43].

Open repair

A large study investigated the outcomes of LVHR versus open ventral hernia repair in over 47,000 patients with obesity using the Nationwide Inpatient Sample, the largest inpatient discharge database in the United States [48]. With LVHR, there was a significantly shorter LOS, lower hospital charges, and a lower percentage of patients discharged to a rehabilitation facility. Additionally LVHR was associated with a lower incidence of all complications, wound complications, pulmonary complications, and accidental puncture or laceration of viscera.

In a large series of open retromuscular incisional hernia repairs, in which 63% of the patients had a BMI ≥30 kg/m^2, the overall wound complication rate was 16% and the hernia recurrence rate was 5% at a mean follow-up time of 17.8 months [46]. Similarly, Moore et al. [55] described the results of 90 patients with a mean BMI of 39.9 kg/m^2 who underwent open retromuscular incisional hernia repairs. Wound complications occurred in 18.8% of patients, and the overall hernia recurrence rate was 5.5% at a mean follow-up of 50 months [55]. Halm et al. [41] reported the results of 131 umbilical hernia repairs (UHR) and found a recurrence rate at a median follow-up of 32 months of 18% in patients with a BMI >25 kg/m^2 compared with 5% in patients with a normal BMI. As noted earlier, Sauerland et al. [9] randomized 160 patients with IH to 3 different techniques of repair, including mesh repair, suture repair, or autologous dermal hernioplasty. Despite the different approaches, BMI was the only factor shown to play a role in hernia recurrence.

Some variability exists on the BMI cut-off at which increased recurrence rates have been reported. For instance, Schumacher et al. [66] found an increased recurrence, although at an unknown time point, of up to 31.8% in patients with a BMI >30 kg/m^2. Not surprisingly, however, the same patient population also presented with larger hernia defects of >3 cm. A similar BMI cutoff was also reported by Anthony et al. [8], where patients with BMI >30 kg/m^2 had a recurrence rate of 47.9%, compared with 37.5% in patients with a lower BMI at a median follow-up of 45 months.

Complications

Another Nationwide Inpatient Sample database study, of 78,000 patients undergoing elective VHR was performed to assess the effect of obesity on surgical outcomes [57]. Compared with lean patients, those with obesity had an increased OR of wound disruption, pulmonary complications, myocardial infarction, shock, LOS, discharge to another facility, and discharge to home healthcare. Diana et al. [38] analyzed the results of 120 consecutive patients undergoing laparoscopic incisional or UHR. In their analysis they found that patients with a BMI >30 kg/m^2 had increased LOS and postoperative pain. In an analysis of almost 5000 patients undergoing abdominoplasty with or without hernia repair, Koolen et al. [45] reported increased wound complications in patients with a BMI >40 kg/m^2.

Incisional hernia repair with concurrent panniculectomy

Panniculectomy may be combined with open ventral hernia repair to eliminate dystrophic skin and hernia sac, to decrease the pendulous effect of the pannus upon a healing incision, and to spare patients a second anesthetic. Several authors have studied concomitant hernia/panniculectomy surgery. Okusanya et al. [58] described the results of 10 patients with a BMI ≥40 kg/m^2 who underwent a partial underlay mesh placement hernia repair technique at the time of panniculectomy. The wound complication rate was 40%, with a hernia recurrence rate of 10% at a mean follow-up of 1 year [58]. Another study compared the risk of wound complications in patients undergoing open ventral incisional hernia repair with or without panniculectomy. The mean BMI in both groups was 34.3 kg/m^2. Patients undergoing concomitant panniculectomy had an increased risk of surgical site occurrences but not SSI. Hernia recurrence at a mean follow-up of 11.4 months was not statistically different between the groups (11.6% with versus 9.3% without panniculectomy) [69].

Saxe et al. [65] described a series of 71 patients who had previously undergone MBS. At a mean BMI of 29 kg/m^2 (range, 25–65), patients underwent concomitant panniculectomy and open ventral incisional hernia repair with and without mesh. The incidence of wound complications was 55%, with more than half of these patients requiring a procedural intervention. The complication rate was not found to be affected by BMI in this study.

Moreno-Egea et al. [71] performed a randomized prospective trial of 111 patients comparing isolated IHR versus IHR combined with abdominoplasty. While there was a significant difference in operative time between the 2 groups, there was no significant difference in early or late morbidity. In addition, there was significant improvement in perceived quality of life in the combined surgery group [71]. While the results vary between publications, there are arguments both for and against such combined procedures.

Weight loss options for hernia patients with obesity

A patient with severe obesity and an abdominal wall hernia can pose a dilemma for the treating surgeon: whether to treat the hernia first, the obesity first, or both at the same time. The situation may be even more difficult in patients who have already undergone MBS and have regained substantial weight. There is currently no consensus on the management of such patients. Most surgeons take an individualized approach based upon the patient's symptoms, goals, BMI, comorbidities, and hernia characteristics [40]. An additional consideration is the technique of hernia repair. If the hernia is amenable to a laparoscopic repair, simultaneous hernia repair and MBS may be feasible.

Simultaneous laparoscopic hernia repair and metabolic/bariatric surgery

A number of retrospective case reports, as well as one analysis of large-scale registry data, demonstrate the safety and good short-term results of simultaneous LVHR and MBS. In one of the first published case series, Eid et al. [29] reported on 85 patients with AWH (mostly umbilical) who were undergoing LRYGB. All patients had at least 6 months of follow-up [29]. Fifty-nine patients underwent concomitant primary sutured UHR, 12 underwent UHR with biological mesh, and UHR was deferred for 14. Early morbidity was minimal in all groups and LOS was not affected by concomitant UHR. At a mean follow-up of 26 months, the authors reported a 22% recurrence rate in patients who underwent sutured UHR and no recurrences in those who underwent mesh UHR, suggesting mesh repair is preferable. Furthermore, 38% of patients with deferred hernia repair later developed intestinal obstruction due to incarceration.

One concern in the MBS literature is the safety of implanting synthetic mesh at the time of stapled bariatric procedures, where the gastrointestinal tract is divided, potentially allowing for mesh contamination. A number of retrospective case series have shown implantation of synthetic mesh at the time of stapled MBS to be safe. Datta et al. [72] reported on 26 AWH identified during LRYGB. Mesh repair with monofilament polypropylene did not result in any infection, although LOS was increased [72]. Schuster et al. [67] reported on 12 patients who underwent combined LRYGB and VHR with polypropylene or polyester mesh; no mesh infections were seen. Chan et al. [34] reported on 45 patients who underwent combined laparoscopic MBS and VHR with either polytetrafluoroethylene or polypropylene mesh. Two patients (4%) with a polypropylene prosthesis developed mesh infection, but neither required mesh explant [34]. Raj et al. [73] reported on 36 patients who underwent LRYGB or laparoscopic sleeve gastrectomy (SG) with VHR using polypropylene mesh. No mesh infections or hernia recurrences were observed [73]. Raziel et al. [62] reported on 54 patients who underwent LGBP or SG combined with VHR repair with a dual polyvinylidene/polypropylene mesh. No mesh infections occurred, and there was only one recurrence [62]. Finally, Sharma et al. [74] reported on 159 patients who underwent combined MBS and VHR (115 VHR with sutures alone, and 44 with either biological or synthetic mesh). Although 9 patients developed wound infections, there were no mesh infections. Three patients developed a recurrent hernia [74]. This indicates that primary suture repair of some hernia defects may be perfectly acceptable at the time of MBS.

Only 1 report using large-scale registry data has been published regarding simultaneous VHR and weight loss surgery. Spaniolas et al. [75] studied over 17,000 LRYGB and SG patients reported in the National Surgical Quality Improvement Program, of whom 503 underwent synchronous VHR. Patients with concurrent VHR had slightly higher odds of SSI (OR 1.65, $P < .05$), but there was otherwise no increase in 30-day morbidity or mortality [75]. There have been no prospective or randomized trials published on this topic to date.

Other weight loss options before hernia repair

Many hernia patients with severe obesity are not good candidates for combined laparoscopic MBS and VHR. Examples are patients with large abdominal wall defects, loss of abdominal domain, extensive intestinal adhesive disease, poor quality skin (i.e., attenuated skin, prior skin graft, or ulcerated skin), incarcerated hernias containing bowel, hernias with previous synthetic mesh, hernias with chronic infection, or patients who have already undergone MBS with altered anatomy that is still intact. In such patients, weight loss prior to hernia repair is desirable as a means to optimize hernia outcomes. We review the published strategies here.

Preoperative very-low calorie diets

Very-low calorie diets (VLCDs) provide <800 kcal/d while preserving 60 to 80 g of protein per day. They have been shown to be effective at short-term weight loss, with dieters typically losing 10% to 20% of their initial body weight [76]. There has been 1 publication describing VLCDs as a means for weight loss prior to VHR [77]. In this report, 25 patients referred for VHR with BMI >35 kg/m^2 underwent preoperative VLCD under the supervision of a medical weight loss specialist. Mean initial BMI of the cohort was 49 kg/m^2, and mean initial body weight was 128 kg. Weight loss goals were initially set by the patient and later by both program and patient, striving for a BMI <40 kg/m^2. Mean BMI dropped 9 kg/m^2 over an average of 17 months, during which only 3 patients developed symptoms related to their hernia and underwent VHR prior to weight loss. Most of these patients were able to maintain their lost weight for 18 months after VHR. Other reports have shown mixed results with this strategy [78,79].

Pharmacotherapy

Several Food and Drug Administration–approved weight loss drugs are currently on the market and theoretically could be used preoperatively before abdominal hernia repair. There are no published reports investigating this strategy. Because available pharmacologic agents are unlikely to produce sufficient weight loss to meaningfully improve hernia outcomes, it is not anticipated that there will be trials investigating this strategy in the near future.

Intragastric balloon therapy

In 2015, the Food and Drug Administration approved an endoscopically placed intra-gastric balloon (IGB) for purposes of weight loss for patients with BMI 30 to 40 kg/m^2. In the initial trial, patients lost an average of 22 pounds (10% total body weight) over 6 months [80]. Since that time, several other such devices, whether swallowed or endoscopically placed, have gained approval or are under study. Several groups have investigated the strategy of IGB use for weight loss prior to VHR. Dabrowiecki et al. [81] reported on 25 patients who underwent placement of an endoscopically placed IGB system, some of them in preparation for hernia surgery. Two patients were intolerant of the balloon, 1 patient died of unrelated causes, and in the remainder the BMI reduction ranged between 2 and 6 kg/m^2, allowing them to undergo a planned surgical procedure [81]. Although other case series have reported similar results [82,83], 1 report questioned whether or not the IGB offered any additional benefit to a structured weight management program [84], and other reports, 1 of them a randomized study, showed no superiority of IGB prior to bariatric surgery in terms of risk reduction [85,86]. In the current healthcare environment in the United States, where the IGB is not covered by insurers and is not yet Food and Drug Administration approved in patients with a BMI >40 kg/m^2, its utility in preparing such patients for hernia surgery will be limited.

MBS as a first stage procedure before VHR

There are few reports on the use of MBS as a bridge to nonbariatric surgery. This may be the case because patients who are good candidates for laparoscopic MBS are often also good candidates for combined MBS and VHR. Second, early reports have cautioned bariatric surgeons not to leave hernias unaddressed at the time of MBS [29]. Additionally, insurance obstacles may have made staging (i.e. weight loss surgery, followed by planned VHR after weight loss) difficult to coordinate and study. Finally, many patients with obesity may be unaware of their candidacy for, are not interested in or willing to consider, or may not be insured to undergo MBS. The current literature is limited in the following 2 reports: Hidalgo et al. [87] reported on

18 patients who underwent SG prior to a nonbariatric procedure. Only 1 of these patients had an abdominal hernia [87]. The cohort's mean BMI fell from 45 kg/m^2 to 36 kg/m^2; there were no conversions to an open procedure, and morbidity was minimal. Newcomb et al. [88] reported on 27 patients who underwent gastric bypass (22 open and 5 laparoscopic) prior to VHR. Mean BMI fell from 51 to 33 kg/m^2 (range, 25–37 kg/m^2) at the time of VHR, which averaged 1.3 years later. One patient required emergency VHR during this time interval, and unfortunately, the number of new hernias created from the open gastric bypass incisions was not reported. To date, there are no published prospective trials incorporating this strategy.

Conclusions and summary recommendations

- There is a significant link between obesity and hernia formation both after abdominal surgery and de novo. There is also evidence that AWH can more commonly present with obstruction or strangulation in patients with obesity.
- There is a higher risk for complications and recurrence after hernia repair in patients with obesity.
- In patients with severe obesity and VH, and both being amenable to laparoscopic repair, combined hernia repair and MBS may be safe and associated with good short-term outcomes and low risk of infection. There is a relative lack of evidence, however, about the use of synthetic mesh in this setting.
- In patients with severe obesity and AWH that is not amenable to laparoscopic repair, a staged approach is recommended. Weight loss, whether through surgery or through multidisciplinary medical management, prior to hernia repair is likely to improve hernia repair outcomes. MBS appears to provide far more significant and rapid weight loss than other modalities and would be a good option for selected patients with severe obesity and large, symptomatic AWH.

This Guideline is not intended to provide inflexible rules or requirements of practice and is not intended, nor should it be used, to state or establish a local, regional, or national legal standard of care. Ultimately, there are various appropriate treatment modalities for each patient, and surgeons must use their judgment in selecting from among the different feasible options. The American Society for Metabolic and Bariatric Surgery and the American Hernia Society caution against the use of this Guideline in litigation in which the clinical decisions of a physician are called into question. The physician, in light of all the circumstances presented, must make the ultimate judgment regarding appropriateness of any specific procedure or course of action. Thus, an approach that differs from this Guideline, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious physician may responsibly adopt a course of action different from that set forth in the Guideline when, in the reasonable judgment of the physician, such course of action is indicated by the condition of the patient, limitations on available resources, or advances in knowledge or technology. All that should be expected is that the physician will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient, in order to deliver effective and safe medical care. The sole purpose of this Guideline is to assist practitioners in achieving this objective.

Disclosures

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References

[1] Dessy LA, Mazzocchi M, Fallico N, Anniboletti T, Scuderi N. Association between abdominal separation and inguinal or crural hernia: our experience and surgical indication. J Plast Surg Hand Surg 2013;47(3):209–12.
[2] Sugerman HJ, Kellum JM Jr, Reines HD, DeMaria EJ, Newsome HH, Lowry JW. Greater risk of incisional hernia with morbidly obese than steroid-dependent patients and low recurrence with prefascial polypropylene mesh. Am J Surg 1996;171(1):80–4.
[3] Goodenough CJ, Ko TC, Kao LS, et al. Development and validation of a risk stratification score for ventral incisional hernia after abdominal surgery: hernia expectation rates in intra-abdominal surgery (The HERNIA Project). J Am Coll Surg 2015;220(4):405–13.
[4] Hanish SI, Petersen RP, Collins BH, et al. Obesity predicts increased overall complications following pancreas transplantation. Transplant Proc 2005;37(8):3564–6.
[5] Buckley FP III, Vassaur HE, Jupiter DC, Crosby JH, Wheeless CJ, Vassaur JL. Influencing factors for port-site hernias after single-incision laparoscopy. Hernia 2016;20(5):729–33.
[6] Lau B, Kim H, Haigh PI, Tejirian T. Obesity increased the odds of acquiring and incarcerating noninguinal abdominal wall hernias. Am Surg 2012;78(10):1118–21.
[7] Veljkovic R, Protic M, Gluhovic A, Potic Z, Milosevic Z, Stojadinovic A. Prospective clinical trial of factors predicting the early development of incisional hernia after midline laparotomy. J Am Coll Surg 2010;210(2):210–19.
[8] Anthony T, Bergen PC, Kim LT, et al. Factors affecting recurrence following incisional herniorrhaphy. World J Surg 2000;24(1):95–100.
[9] Sauerland S, Korenkov M, Kleinen T, Arndt M, Paul A. Obesity is a risk factor for recurrence after incisional hernia repair. Hernia 2004;8(1):42–6.
[10] Martindale RG, Deveney CW. Preoperative risk reduction: strategies to optimize outcomes. Surg Clin North Am 2013;93(5):1041–55.
[11] Sugerman H, Windsor A, Bessos M, Wolfe L. Intra-abdominal pressure, sagittal abdominal diameter and obesity comorbidity. J Intern Med 1997;241(1):71–9.
[12] Lambert DM, Marceau S, Forse RA. Intra-abdominal pressure in the morbidly obese. Obes Surg 2005;15(9):1225–32.
[13] Varela JE, Hinojosa M, Nguyen N. Correlations between intra-abdominal pressure and obesity related co-morbidities. Surg Obes Relat Dis 2009;5(5):524–8.
[14] Noblett KL, Jensen JK, Ostergard DR. The relationship of body mass index to intraabdominal pressure as measured by a mul-

tichannel cystometery. Int Urogynecol J Pelvic Floor Dysfunct 1997;8(6):323–6.
[15] De Raet J, Delvaux G, Haentjens P, Van Nieuwenhove Y. Waist circumference is an independent risk factor for the development of parastomal hernia after permanent colostomy. Dis Colon Rectum 2008;51(12):1806–9.
[16] Aquina CT, Rickles AS, Probst CP, et al. Visceral obesity, not elevated BMI, is strongly associated with incisional hernia after colorectal surgery. Dis Colon Rectum 2015;58(2):220–7.
[17] Murray BW, Cipher DJ, Pham T, Anthony T. The impact of surgical site infection on the development of incisional hernia and small bowel obstruction in colorectal surgery. Am J Surg 2011;202(5):558–60.
[18] Regner JL, Mrdutt MM, Munoz-Maldonado Y. Tailoring surgical approach for elective ventral hernia repair based on obesity and National Surgical Quality Improvement Program outcomes. Am J Surg 2015;210(6):1024–9.
[19] Poulose BK, Shelton J, Phillips S, et al. Epidemiology and cost of ventral hernia repair: making the case for hernia research. Hernia 2012;16(2):179–83.
[20] Rutkow IM. Demographic and socioeconomic aspects of hernia repair in the United States in 2003. Surg Clin North Am 2003;83(5):1045–51.
[21] Itatsu K, Yokoyama Y, Sugawara G, et al. Incidence of and risk factors for incisional hernia after abdominal surgery. Br J Surg 2014;101(11):1439–47.
[22] Fischer JP, Basta MN, Mirzabeigi MN, et al. A risk model and cost analysis of incisional hernia after elective, abdominal surgery based upon 12,373 cases: the case for targeted prophylactic intervention. Ann Surg 2016;263(5):1010–17.
[23] Rosemar A, Angeras U, Rosengren A. Body mass index and groin hernia: A 34-year follow-up study in Swedish men. Ann Surg 2008;247(6):1064–8.
[24] Rosemar A, Angerås U, Rosengren A, Nordin P. Effect of body mass index on groin hernia surgery. Ann Surg 2010;252(2):397–401.
[25] Ravanbakhsh S, Batech M, Tejirian T. Increasing body mass index is inversely related to groin hernias. Am Surg 2015;81(10):1043–1046.
[26] Hwang MJ, Bhangu A, Webster CE, Bowley DM, Gannon MX, Karandikar SS. Unintended consequences of policy change to watchful waiting for asymptomatic inguinal hernias. Ann R Coll Surg Engl 2014;96(5):343–7.
[27] Geletzke AK, Rinaldi JM, Phillips BE, et al. Prevalence of systemic inflammation and micronutrient imbalance in patients with complex abdominal hernias. J Gastrointest Surg 2014;18(4):646–55.
[28] Symeonidis D, Baloyiannis I, Georgopoulou S, Koukoulis G, Athanasiou E, Tzovaras G. Laparoscopic ventral hernia repair in obese patients under spinal anesthesia. Int J Surg 2013;11(9):926–929.
[29] Eid GM, Mattar SG, Hamad G, et al. Repair of ventral hernias in morbidly obese patients undergoing laparoscopic gastric bypass should not be deferred. Surg Endosc 2004;18(2):207–10.
[30] Asolati M, Huerta S, Sarosi G, Harmon R, Bell C, Anthony T. Predictors of recurrence in veteran patients with umbilical hernia: single center experience. Am J Surg 2006;192(5):627–30.
[31] Birgisson G, Park AE, Mastrangelo MJ Jr, Witzke DB, Chu UB. Obesity and laparoscopic repair of ventral hernias. Surg Endosc 2001;15(12):1419–22.
[32] Bower CE, Reade CC, Kirby LW, Roth JS. Complications of laparoscopic incisional-ventral hernia repair: the experience of a single institution. Surg Endosc 2004;18(4):672–5.
[33] Chan DL, Talbot ML, Chen Z, Kwon SC. Simultaneous ventral hernia repair in bariatric surgery. ANZ J Surg 2014;84(7-8):581–3.
[34] Chan DL, Talbot ML. Synchronous ventral hernia repair in bariatric patients. Obes Surg 2014;24(6):944.
[35] Chan G, Chan CK. A review of incisional hernia repairs: preoperative weight loss and selective use of the mesh repair. Hernia 2005;9(1):37–41.
[36] Chang EI, Foster RD, Hansen SL, Jazayeri L, Patti MG. Autologous tissue reconstruction of ventral hernias in morbidly obese patients. Arch Surg 2007;142(8):746–9.
[37] Colon MJ, Kitamura R, Telem DA, Nguyen S, Divino CM. Laparoscopic umbilical hernia repair is the preferred approach in obese patients. Am J Surg 2013;205(2):231–6.
[38] Diana M, Callari C, D'Agostino J, Wu HS, Mutter D, Marescaux J. Laparoscopic tension-free abdominal wall repair: impact of mesh size and of different fixation devices in a consecutive series of 120 patients. Surg Laparosc Endosc Percutan Tech 2014;24(5):461–4.
[39] Dietz UA, Winkler MS, Härtel RW, et al. Importance of recurrence rating, morphology, hernial gap size, and risk factors in ventral and incisional hernia classification. Hernia 2014;18(1):19–30.
[40] Eid GM, Wikiel KJ, Entabi F, Saleem M. Ventral hernias in morbidly obese patients: a suggested algorithm for operative repair. Obes Surg 2013;23(5):703–9.
[41] Halm JA, Heisterkamp J, Veen HF, Weidema WF. Long-term follow-up after umbilical hernia repair: are there risk factors for recurrence after simple and mesh repair. Hernia 2005;9(4):334–7.
[42] Harth KC, Blatnik JA, Rosen MJ. Optimum repair for massive ventral hernias in the morbidly obese patient–is panniculectomy helpful? Am J Surg 2011;201(3):396–400.
[43] Heniford BT, Park A, Ramshaw BJ, Voeller G. Laparoscopic repair of ventral hernias: nine years' experience with 850 consecutive hernias. Ann Surg 2003;238(3):391–9.
[44] Iannelli A, Bafghi A, Negri C, Gugenheim J. Abdominal lipectomy and mesh repair of midline periumbilical hernia after bariatric surgery: how to spare the umbilicus. Obes Surg 2007;17(9):1189–92.
[45] Koolen PG, Ibrahim AM, Kim K, et al. Patient selection optimization following combined abdominal procedures: analysis of 4925 patients undergoing panniculectomy/abdominoplasty with or without concurrent hernia repair. Plast Reconstr Surg 2014;134(4). 539e–550e.
[46] Krpata DM, Blatnik JA, Novitsky YW, Rosen MJ. Evaluation of high-risk, comorbid patients undergoing open ventral hernia repair with synthetic mesh. Surgery 2013;153(1):120–5.
[47] Lamont PM, Ellis H. Incisional hernia in re-opened abdominal incisions: an overlooked risk factor. Br J Surg 1988;75(4):374–6.
[48] Lee J, Mabardy A, Kermani R, Lopez M, Pecquex N, McCluney A. Laparoscopic vs open ventral hernia repair in the era of obesity. JAMA Surg 2013;148(8):723–6.
[49] Levi B, Zhang P, Lisiecki J, et al. Use of morphometric assessment of body composition to quantify risk of surgical-site infection in patients undergoing component separation ventral hernia repair. Plast Reconstr Surg 2014;133(4). 559e–566e.
[50] Luijendijk RW, Lemmen MH, Hop WC, Wereldsma JC. Incisional hernia recurrence following "vest-over-pants" or vertical Mayo repair of primary hernias of the midline. World J Surg 1997;21(1):62–5.
[51] Manninen MJ, Lavonius M, Perhoniemi VJ. Results of incisional hernia repair: a retrospective study of 172 unselected hernioplasties. Eur J Surg 1991;157(1):29–31.
[52] Marx L, Raharimanantsoa M, Mandala S, D'Urso A, Vix M, Mutter D. Laparoscopic treatment of incisional and primary ventral hernia in morbidly obese patients with a BMI over 35. Surg Endosc 2014;28(12):3310–14.
[53] Mendoza D, Newman RC, Albala D, et al. Laparoscopic complications in markedly obese urologic patients (a multi-institutional review). Urology 1996;48(4):562–7.
[54] Mittermair RP, Klingler A, Wykypiel H, Gadenstätter M. Vertical Mayo repair of midline incisional hernia: suggested guidelines for selection of patients. Eur J Surg 2002;168(6):334–8.

[55] Moore M, Bax T, MacFarlane M. Outcomes of the fascial component separation technique with synthetic mesh reinforcement for repair of complex ventral incisional hernias in the morbidly obese. Am J Surg 2008;195(5):575–9.
[56] Novitsky YW, Cobb WS, Kercher KW, Matthews BD, Sing RF, Heniford BT. Laparoscopic ventral hernia repair in obese patients: a new standard of care. Arch Surg 2006;141(1):57–61.
[57] Novitsky YW, Orenstein SB. Effect of patient and hospital characteristics on outcomes of elective ventral hernia repair in the United States. Hernia 2013;17(5):639–45.
[58] Okusanya OT, Scott MF, Low DW, Morris JB. The partial underlay preperitoneal with panniculectomy repair for incisional abdominal hernia in the morbidly obese. Surg Obes Relat Dis 2014;10(3):495–501.
[59] Paul A, Korenkov M, Peters S, Köhler L, Fischer S, Troidl H. Unacceptable results of the Mayo procedure for repair of abdominal incisional hernias. Eur J Surg 1998;164(5):361–7.
[60] Raftopoulos I, Vanuno D, Khorsand J, Ninos J, Kouraklis G, Lasky P. Outcome of laparoscopic ventral hernia repair in correlation with obesity, type of hernia, and hernia size. J Laparoendosc Adv Surg Tech A 2002;12(6):425–9.
[61] Raftopoulos I, Courcoulas AP. Outcome of laparoscopic ventral hernia repair in morbidly obese patients with a body mass index exceeding 35 kg/m^2. Surg Endosc 2007;21(12):2293–7.
[62] Raziel A, Sakran N, Szold A, Goitein D. Concomitant bariatric and ventral/incisional hernia surgery in morbidly obese patients. Surg Endosc 2014;28(4):1209–12.
[63] Rosen M, Brody F, Ponsky J, et al. Recurrence after laparoscopic ventral hernia repair. Surg Endosc 2003;17(1):123–8.
[64] Sanjay P, Reid TD, Davies EL, Arumugam PJ, Woodward A. Retrospective comparison of mesh and sutured repair for adult umbilical hernias. Hernia 2005;9(3):248–51.
[65] Saxe A, Schwartz S, Gallardo L, Yassa E, Alghanem A. Simultaneous panniculectomy and ventral hernia repair following weight reduction after gastric bypass surgery: is it safe? Obes Surg 2008;18(2):192–5.
[66] Schumacher OP, Peiper C, Lörken M, Schumpelick V. Long-term results after Spitzy's umbilical hernia repair. Chirurg 2003;74(1):50–4.
[67] Schuster R, Curet MJ, Alami RS, Morton JM, Wren SM, Safadi BY. Concurrent gastric bypass and repair of anterior abdominal wall hernia. Obes Surg 2006;16(9):1205–8.
[68] Tsereteli Z, Pryor BA, Heniford BT, Park A, Voeller G, Ramshaw BJ. Laparoscopic ventral hernia repair (LVHR) in morbidly obese patients. Hernia 2008;12(3):233–8.
[69] Warren JA, Epps M, Debrux C, et al. Surgical site occurrences of simultaneous panniculectomy and incisional hernia repair. Am Surg 2015;81(8):764–9.
[70] Ramirez OM, Ruas E, Dellon AL. "Components separation" method for closure of abdominal wall defects: an anatomic and clinical study. Plast Reconstr Surg 1990;86(3):519–26.
[71] Moreno-Egea A, Campillo-Soto A, Morales-Cuenca G. Does abdominoplasty add morbidity to incisional hernia repair? A randomized controlled trial. Surg Innov 2016;23(5):474–80.
[72] Datta T, Eid G, Nahmias N, Dallal RM. Management of ventral hernias during laparoscopic gastric bypass. Surg Obes Relat Dis 2008;4(6):754–8.
[73] Raj PP, Senthilnathan P, Kumaravel R, et al. Concomitant laparoscopic ventral hernia mesh repair and bariatric surgery: a retrospective study from a tertiary care center. Obes Surg 2012;22(5):685–9.
[74] Sharma G, Boules M, Punchai S, et al. Outcomes of concomitant ventral hernia repair performed during bariatric surgery. Surg Endosc 2017;31(4):1573–82.
[75] Spaniolas K, Kasten KR, Mozer AB, et al. Synchronous ventral hernia repair in patients undergoing bariatric surgery. Obes Surg 2015;25(10):1864–8.
[76] Tsai AG, Wadden TA. The evolution of very-low-calorie diets: an update and meta-analysis. Obesity 2006;14(8):1283–93.
[77] Rosen MJ, Aydogdu K, Grafmiller K, Petro CC, Faiman GH, Prabhu A. A multidisciplinary approach to medical weight loss prior to complex abdominal wall reconstruction: is it feasible? J Gastrointest Surg 2015;19(8):1399–406.
[78] Goldberg RF, Parker M, Stauffer JA, et al. Surgeons' requirement for obesity reduction: its influence on weight loss. Am Surg 2012;78(3):325–8.
[79] Pekkarinen T, Mustajoki P. Use of very low-calorie diet in preoperative weight loss: efficacy and safety. Obes Res 1997;5(6):595–602.
[80] U.S. Food and Drug Administration. PMA P140008: FDA summary of safety and effectiveness data. Intragastric balloon [monograph on the Internet]. Silver Spring: U.S. Food and Drug Administration [cited 2018 May 2]. Available from: https://www.accessdata.fda.gov/cdrh_docs/pdf14/P140008b.pdf.
[81] Dąbrowiecki S, Szczęsny W, Popławski C, Sosnowski D. Intragastric balloon (BIB System) in the treatment of obesity and preparation of patients for surgery – own experience and literature review. Polski Przeglad Chirurgiczny 2011;83(4):181–7.
[82] Spyropoulos C, Katsakoulis E, Mead N, Vagenas K, Kalfarentzos F. Intragastric balloon for high-risk, super-obese patients: a prospective analysis of efficacy. Surg Obes Relat Dis 2007;3(1):78–83.
[83] Alfalah H, Philippe B, Ghazal F, et al. Intragastric balloon for preoperative weight reduction in candidates for laparoscopic gastric bypass with massive obesity. Obes Surg 2006;16(2):147–50.
[84] Leeman MF, Ward C, Duxbury M, de Beaux AC, Tulloh B. The intra-gastric balloon for pre-operative weight loss in bariatric surgery: is it worthwhile? Obes Surg 2013;23(8):1262–5.
[85] Coffin B, Maunoury V, Pattou F, et al. Impact of intragastric balloon before laparoscopic gastric bypass on patients with super obesity: a randomized multicenter study. Obes Surg 2017;27(4):902–9.
[86] Milone L, Strong V, Gagner M. Laparoscopic sleeve gastrectomy is superior to endoscopic intragastric balloon as a first stage procedure for super-obese patients (BMI $\geq$ 50). Obes Surg 2005;15(5):612–17.
[87] Hidalgo JE, Roy M, Ramirez A, Szomstein S, Rosenthal RJ. Laparoscopic sleeve gastrectomy: a first step for rapid weight loss in morbidly obese patients requiring a second non-bariatric procedure. Obes Surg 2012;22(4):555–9.
[88] Newcomb WL, Polhill JL, Chen AY, et al. Staged hernia repair preceded by gastric bypass for the treatment of morbidly obese patients with complex ventral hernias. Hernia 2008;12(5):465–9.