



Increased incidence of surgical site infection with a body mass index ≥ 35 kg/m² following abdominal wall reconstruction with open component separation

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Abstract

Background To quantify the impact of body mass index (BMI) on surgical site infection (SSI) following abdominal wall reconstruction (AWR) using component separation techniques and attempt to identify obesity-related targets, such as BMI, that can be potentially used to guide preoperative patient optimization. Though AWR has established perioperative outcomes for hernia repair, the applicability in the obese population is not well established.

Methods The 2005–2013 ACS-NSQIP participant use file was reviewed to compare SSI, severe, and overall morbidity in non-emergent AWR patients based on BMI. Multivariable logistic regression was used to control for patient demographics and comorbidities. Odds ratios (OR) with 95% confidence intervals were reported.

Results We identified 4488 patients. The average BMI was 32.76 ± 7.70 kg/m². The majority of cases (76.8%) had wound classified as clean. The SSI rate significantly increased at a BMI of ≥ 35 kg/m² compared to < 35 (18.5% vs. 10.5%, $p < 0.0001$). There was no significant difference in SSI rate between BMI 35–40 and > 40 . After controlling for differences in baseline characteristics and wound classification, BMI ≥ 35 kg/m² was independently associated with SSI (OR 1.47, 1.21–1.78), minor complications (OR 1.65, 1.41–1.94), major complications (OR 1.91, 1.60–2.27), re-operation (OR 1.59, 1.23–2.05), and hospital re-admission (OR 1.93, 1.23–3.02).

Conclusion There is a significant increase in SSI and other perioperative complications in patients with a BMI ≥ 35 kg/m² undergoing AWR. Higher BMI is also independently associated with higher resource utilization in this patient population. Severely obese patients in need of AWR may benefit from a structured preoperative weight loss intervention.

Keywords Abdominal wall reconstruction · Obesity · Surgical site infections · Component separation · Hernia repair

Repair of ventral hernias remains an ongoing challenge for surgeons, with more than 350,000 performed in the United States annually [1]. Complex hernia repair requiring abdominal wall reconstruction (AWR) with open component separation carries a significant risk of surgical site infection (SSI) [2–4]. The rate of SSI following open ventral hernia repair ranges between 0–34%, with variability in the reported data due to patient factors and operative technique [5–7].

More importantly, SSI has been associated with a markedly increased risk of hernia recurrence and higher hospital costs [8–10].

Prior studies have identified factors such as smoking, steroid use, prolonged operative time, emergent surgery, and the use of mesh as risk factors of SSI after open hernia repair [5, 11–13]. Recently, attempts have been made to create predictive scoring systems for SSI in this setting. One factor commonly noted in such predictive scoring systems is obesity via body mass index (BMI) [13, 14].

Obesity, which now afflicts 34.9% of the United States population, is a major risk factor for the formation of hernias [15] as well as intraoperative and post-operative complications. In addition, it has been shown to be associated with a higher risk of recurrence following incisional hernia repair [16, 17] and a known risk factor for SSI following surgical

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procedures [18]. More specifically, an elevated BMI has been associated with rates of wound complications and hernia recurrence as high as 41.7% and 48.7% following AWR, respectively [15, 19, 20].

Despite evidence demonstrating the relationship between BMI and SSI following AWR, the degree of impact has not been well described. The aim of our study was to quantify the impact of BMI on SSI following AWR. Specifically, we aimed to identify obesity-related targets that can be potentially used to frame the process of informed consent and guide preoperative patient optimization.

Methods

Data acquisition

Following Institutional Review Board approval, the study was performed using 2005–2013 data from the Public Use File of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP is an audited clinical database which catalogs data on preoperative patient demographics, characteristics, intraoperative findings, and post-operative outcomes. The database was retrospectively reviewed to evaluate patients (age ≥ 18 years) who underwent non-emergent open component separation procedures for ventral or incisional hernias. Patients were identified using primary 9th International Classification of Disease diagnosis of a ventral or incision hernia (553.2, 553.20, 553.21, or 553.29) and Current Procedural Terminology code used for component separation (15734). Current Procedural Terminology code 15734 designates a muscle, myocutaneous, or fasciocutaneous flap. Details regarding the type of mesh used during surgical repairs were not documented within the database. Other types of hernia repair (groin) were excluded from the analysis to allow for more homogeneity of our study cohort. Patients were grouped based on established body mass index (BMI) categories: < 25 kg/m², 25–30 kg/m², 30–35 kg/m² (Class I obesity), 35–40 kg/m² (Class II obesity), and > 40 kg/m² (Class III obesity). Variables for patient demographics, comorbidities, perioperative risk factors, and surgical outcomes were collected for each BMI sub-group. The American Society of Anesthesiology physical classification system (ASA) was used as a baseline characteristic (ASA 1, healthy patient; ASA 2, mild systemic disease; ASA 3, severe systemic disease; ASA 4, severe systemic disease that is a constant threat to life; ASA 5, moribund patient who is not expected to survive without an operation). Cases were also stratified using the CDC Surgical Wound Classification: Class I (clean), Class II (clean-contaminated), Class III (contaminated), and Class IV (dirty-infected).

Outcomes

The primary outcome was rate of SSI, defined as an infection within 30 days following an operation that involves only the skin or subcutaneous tissue and is associated with erythema, pain, tenderness, swelling, or warmth [21]. Secondary outcomes examined included minor complications, major complications, re-operation, and hospital re-admission, as defined previously [21]. Major complications being defined as having documentation of one of the following: organ space SSI, wound dehiscence, neurologic event (cerebrovascular accident or coma lasting > 24 h), cardiac arrest, myocardial infarction, bleeding requiring transfusion, pulmonary embolism, ventilator dependence for > 48 h, progressive or acute renal insufficiency, sepsis or septic shock, and death. Considering the ACS-NSQIP as the source of patient data, all outcomes are limited to 30 days post-operatively.

Data analysis

Data analysis was performed using SPSS for Windows v24 (IBM, Somers, NY). Categorical and continuous variable are reported as counts (percentages) and mean (standard deviation), respectively. These were compared using Chi square and two-tailed *t* testing. Odds ratios (OR) with 95% confidence intervals were reported when applicable. A *p* value < 0.05 was considered statistically significant. Multivariable logistic regression was used to control for patient demographics and comorbidities. Variables with *p* < 0.1 on univariable analysis were entered in the model.

Results

A total of 4488 patients who met inclusion criteria were identified with an average age of 56 ± 13 years, BMI 32.76 ± 7.69 kg/m², and just over half being female (51.9%). The majority of cases had wound classified as clean (76.8%) and belonged to ASA class of 2 or 3 (94.9%). Patients were grouped based on BMI: < 25 kg/m² (*n* = 560), 25–30 kg/m² (*n* = 1167), 30–35 kg/m² (*n* = 1212), 35–40 kg/m² (*n* = 765), and > 40 kg/m² (*n* = 680).

Overall, 576 (12.8%) patients developed a SSI within 30 days. Figure 1 demonstrates the incidence of SSI per BMI group. The risk of developing a SSI significantly increased at a BMI of ≥ 35 kg/m² (18.5% vs. 10.5%, *p* < 0.0001), with no significant difference between BMI 35–40 kg/m² and > 40 kg/m². Table 1 demonstrates comorbidities among patients with a BMI > 35 kg/m² and < 35 kg/m².

Comparing those patients with SSI to those without, ASA 3 or 4 (64.2% vs 52.3%, *p* < 0.0001), Type-2 diabetes

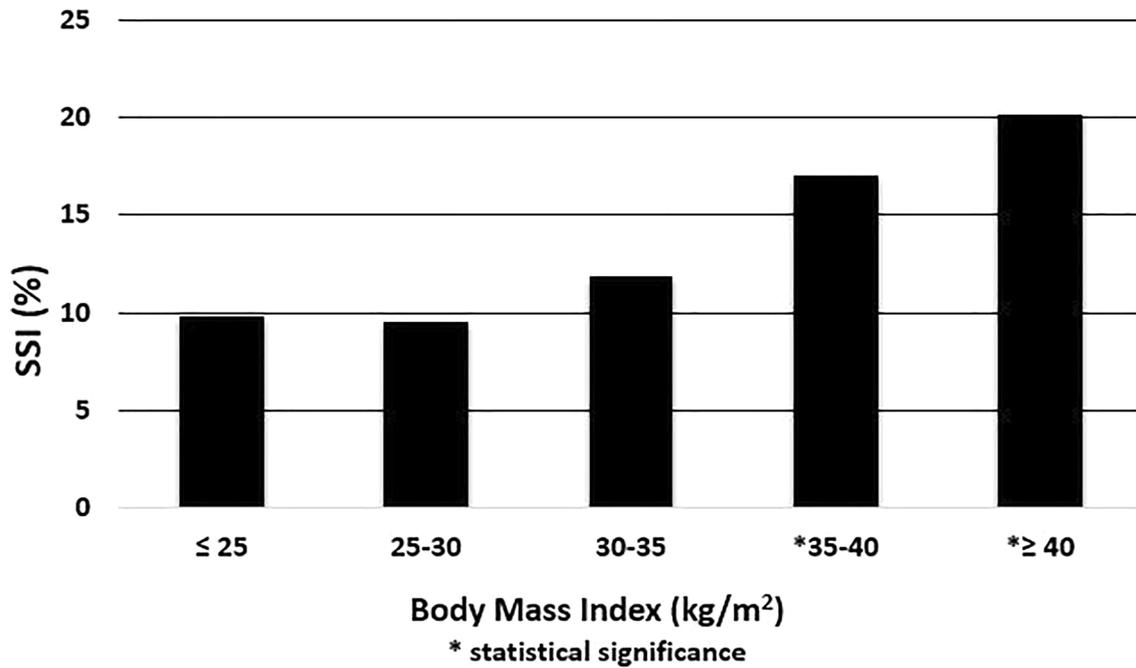


Fig. 1 30-day surgical site infection (SSI) incidence following abdominal wall reconstruction for patients in different BMI groups. Comparisons between groups revealed a significant increase for patients in the BMI 35–40 and a BMI > 40 groups compared to patients with lesser BMI

Table 1 Comorbidities among patients stratified between a BMI < 35 kg/m² and > 35 kg/m²

	< 35 (n = 3015)	> 35 (n = 1456)	p value
ASA class III or IV	1442 (47.8%)	962 (66.0%)	< 0.0001
DM	433 (14.4%)	410 (28.2%)	< 0.0001
COPD	162 (5.4%)	102 (7.05)	0.03
Smoker	699 (23.2%)	280 (19.2%)	0.003
Wound class			
Clean	2352 (78.0%)	1082 (74.3%)	0.001
Clean-contaminated	456 (15.1%)	220 (15.1%)	
Contaminated	103 (3.4%)	67 (4.6%)	
Infected	104 (3.4%)	87 (5.9%)	
Male	1626 (54.0%)	520 (35.7%)	< 0.0001

(26.1% vs 17.8%, $p < 0.0001$), history of severe COPD (9.7% vs. 5.3%, $p < 0.0001$), and history of smoking within 1 year (29.0% vs. 20.9%, $p < 0.0001$) were more common in patients with SSI. Chronic steroid use between those with SSI and without was not significantly different (2.7% vs. 3.7%, $p = 0.283$).

After controlling for differences in baseline characteristics and wound classification, BMI > 35 kg/m² was independently associated with SSI (OR 1.47, 95% CI 1.21–1.78), complications (OR 1.65, 95% CI 1.41–1.94), major complications (OR 1.91, 95% CI 1.60–2.27),

re-operation (OR 1.59, 95% CI 1.23–2.05), and re-admission (OR 1.93, 95% CI 1.23–3.02).

Discussion

Our study demonstrates a significant increase in SSI following AWR with open component separation repairs of ventral hernias in patients with a preoperative BMI ≥ 35 kg/m². Considering the dramatic impact of SSI on hernia recurrence, and cost [8–10], all efforts to limit their occurrence should be made. Previous studies have suggested that BMI plays a role in SSI following AWR; however, broad BMI ranges are often quoted [5, 13, 19, 20]. The Ventral Hernia Risk Score was used on 888 patients and BMI > 40 kg/m² was identified as a risk factor [5]. In contrast, the Hopkins Ventral Hernia Repair risk-scoring system was applied to 362 patients and BMI > 30 kg/m² was identified as a variable associated with SSI [13]. Giordano et al. [22] evaluated 511 consecutive patients who underwent open component separation with underlay mesh. Patients were stratified into three groups: BMI < 30 kg/m², BMI of 30–34.9 kg/m², and BMI > 35 kg/m². A significant increase in the rate of SSI was noted in BMI > 30 kg/m² compared to non-obese patients. Nelson et al. in an evaluation of 314 morbidly obese patients demonstrated a higher incidence of post-operative major surgical (18.5% vs 10.1%, $p < 0.001$) complications and a return to the operating room (12.1% vs 5.4%, $p < 0.001$) in morbidly

obese patients undergoing AWR by component separation [23]. The average BMI in the non-obese group ($n=614$) was 25.7 and the average BMI in the morbidly obese group ($n=314$) was 45.9 kg/m². The range of BMI in these studies is substantial, leaving clinical extrapolation difficult. The large sample size of the present nationwide study allowed for a distribution of patients across a wide BMI range, and afforded us the opportunity to more accurately define the BMI cutoff (> 35 kg/m²) associated with an increased risk of developing SSI. This is particularly important because patients with BMI > 35 kg/m² are commonly candidates for wider spectrum of obesity treatment modalities.

Our study demonstrated a BMI ≥ 35 kg/m² was associated with minor complications, major complications, re-operation, and re-admission within 30 days post-operatively. These findings concur with previous studies. Novitsky et al. [24] recently published data on 428 consecutive TARs, with a mean BMI of 34.4 kg/m², which demonstrated a 39 (9.1%) of surgical site infections. The SSI rate published by Novitsky et al. is lower in comparison to the 12.8% overall SSI quoted in our study despite the lower mean BMI of our study group. The lower SSI rate quoted by Novitsky et al. has been attributed to the retromuscular sublay placement, an uncoated synthetic mesh. Within the current methodology of this study and ACS-NSQIP database, the ability to differentiate SSI between the various types of component separation repair is not feasible.

A recent study by Owei et al. [25] evaluated 102,191 open ventral hernia repairs stratified by BMI. Their findings suggest patients with a BMI > 40 kg/m² have greater than twice the risk for complications. However, their study population included emergent cases (strangulated and incarcerated hernias) and did not evaluate for a specific type of repair. Our current study evaluated non-emergency cases undergoing AWR.

Considering the evidence linking obesity with SSI following hernia repair, it would seem intuitive that preoperative weight loss maybe a reasonable strategy for patient optimization. Rosen and Petro describe collaborative approach between surgeons and medical weight loss specialists where the patient is encouraged to set 3-month weight loss goals. Most patients set a weight loss goal of 20–30 pounds with a final goal BMI < 40 kg/m². Patient evaluations are conducted every 3 months until they meet their ideal goal or plateau [26]. Rosen et al. [15] also prospectively evaluated 25 patients with a mean BMI of 49 kg/m² (range 36–85 kg/m²) being evaluated for AWR. Utilizing a supervised medical weight loss program, patients were placed on a protein sparing modified fast, with total caloric intake of < 800 kcal/day. Following completion of the weight loss program, the mean preoperative weight loss was 24 kg \pm 21 (range 2–80 kg) with an average decrease in BMI of 9 kg/m² \pm 8 (0.6–33). Of the 24 patients that initially lost weight in the

program preoperatively, 22 (88%) successfully maintained their weight loss for an average of 18 months [15].

Our study suggests that patients with BMI ≥ 35 kg/m² are at particular risk for SSI. Although our study did not assess for the effect of preoperative weight loss, it is plausible that obesity optimization may reverse the SSI risk in this patient population. Patients with BMI > 35 kg/m² are candidates for both medical and often surgical means for weight loss. Therefore, bariatric surgery may play an important role in the preoperative management of severely obese patients with ventral hernias. Staged ventral hernia repair following bariatric surgery has demonstrated promising results. Newcomb et al. [27] performed RYGB on 27 patients with an average BMI of 51 kg/m² prior to ventral hernia repair (19 open; eight laparoscopic). The average BMI decreased to 33 kg/m² and no recurrences were recorded following an average 20-month follow-up.

This study is limited by its retrospective design and the related inherit bias. The ACS-NSQIP database only collects data up to 30 days post-operatively; thus, any complications, morbidities, or mortalities beyond 30 days are not documented. This is also a detriment when attempting to evaluate hernia recurrence, which can be the down-stream effect of SSI. Some surgeons may find it reasonable to accept a higher risk of SSI in the morbidly obese patient if recurrence rates are similar across all surgical populations, although the overall impact of this complication is significant, even without accounting for the subsequent risk of recurrence. The details in regard to the component separation technique utilized and hernia details including size are unknown. The generalized category of component separation does not allow for specific comparison between various component separation techniques which have been previously suggested to impact SSI following AWR. The inability to identify the type of mesh utilized in the ACS-NSQIP database also further hinders our analysis.

Conclusion

Obesity significantly affects SSI rate after AWR. Using BMI > 35 kg/m² as a cutoff for risk assessment can allow us to identify a patient population of particularly high risk for post-operative infection. Although the current study did not directly assess the effect of weight loss, since BMI is a modifiable factor, it is possible that patients with a BMI > 35 kg/m² may benefit from a structured preoperative weight loss program before AWR.

Compliance with ethical standards

Disclosures Dr. Docimo is a consultant for Boston Scientific; Dr. Spaniolas reports non-financial support from Mallinckrodt, grants from

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