Venous Thromboembolism after Abdominal Wall Reconstruction: A Prospective Analysis and Review of the Literature

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PATIENT SAFETY

Background: Ventral hernias are a common problem after exploratory laparotomy, and plastic surgeons often become involved for hernia repair in complex situations. Plastic surgeons can achieve fascial closure through primary repair, an external oblique aponeurosis release, or a transversus abdominis release. Currently, there is scant literature evaluating venous thromboembolism rates after these procedures. The authors sought to evaluate their own experience with complex abdominal wall reconstruction and venous thromboembolism events.

Methods: The authors retrospectively reviewed their prospectively collected database of all patients who have undergone complex abdominal wall reconstruction performed by a single surgeon at their institution from September of 2013 to February of 2018. Demographic data, anticoagulant use, Caprini score, operative time, and postoperative venous thromboembolism events were recorded. A literature search was also performed, identifying all published articles evaluating venous thromboembolism events after abdominal wall reconstruction.

Results: The authors identified 175 patients for analysis. Four patients were found to have postoperative venous thromboembolism events, for a total venous thromboembolism rate of 2.3 percent. The average Caprini score for these patients was 8.5, compared to 5.26 for those without a venous thromboembolism event, and no deaths were reported from these complications. On literature review, three articles were identified in the literature discussing venous thromboembolism after abdominal wall reconstruction, all based on the American College of Surgeons National Surgical Quality Improvement Program database.

Conclusions: Patients undergoing complex abdominal wall reconstruction are at high risk for venous thromboembolism events. There is scant literature published on this topic, but surgeons should be aware of the risk for venous thromboembolism after complex abdominal wall reconstruction and work to minimize this risk as much as possible. (*Plast. Reconstr. Surg.* 143: 1513, 2019.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Ventral hernias are a common problem, with estimates stating that 11 to 37 percent of all exploratory laparotomies go on to develop an incisional hernia.[1–4] Frequently, plastic surgeons become involved as part of a multidisciplinary team after multiple previous failed repairs and/or for complex patients with comorbidities requiring additional expertise. Components

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separation techniques are often used to achieve fundamental goals of restoration of abdominal domain, primary reinforced repair of the abdominal musculofascia, and improvement of dynamic function.[5–7] This involves separation of the abdominal wall musculofascial layers to allow for medialization of the linea alba while protecting the neurovascular bundles, and therefore innervation. Typically, this is performed through either an "anterior" external oblique aponeurosis release originally described by Young in 1961 but popularized by Ramirez et al. in 1990, or as a posterior transversus abdominis release, originally described by Novitsky et al., with the term "posterior" coined by Carbonell et al.[8–11]

Patients undergoing complex abdominal wall reconstruction are frequently at increased risk for postsurgical complications, even after presurgical optimization, because of a variety of risk factors such as obesity, diabetes, and a sedentary lifestyle.[6] Restoration of domain with musculofascial reapproximation can increase abdominal wall pressure and thus decrease venous return and contribute to venous stasis, elements of the triad of Virchow.[12,13] These risk factors can lead to venous thromboembolism events such as deep venous thrombosis and pulmonary embolism. Similarly, these risk factors have been identified in the cosmetic abdominoplasty literature, which involves similar surgical elements. Keyes et al. recently reviewed outpatient plastic surgery data from 2001 to 2011 using the Internet Based Quality Assurance Program database and found an incidence of venous thromboembolism of 0.07 percent for abdominoplasty.[14] Hatef et al. performed a systematic review of the literature describing venous thromboembolism after abdominoplasty and found a cumulative incidence of 0.35 percent. This incidence increased dramatically with concurrent procedures and circumferential abdominoplasty, up to 3.40 percent.[15] In particular, they noted a rate of 2.17 percent after abdominoplasty with a concurrent intraabdominal procedure.[15] Rates of venous thromboembolism after abdominoplasty can be decreased with aggressive protocols for thromboembolic prophylaxis; however, this increases the risk for other complications such as postoperative hematoma.[16,17]

Despite the extensive literature evaluating venous thromboembolism after abdominoplasty, there is scant literature evaluating the risk of venous thromboembolism after abdominal wall reconstruction. Many patients after abdominal wall reconstruction have similar increases in abdominal pressure, yet also have the detriment of having longer hospital lengths of stay, more medical comorbidities, and worse morbidity. Our goal with this study was to evaluate the incidence of venous thromboembolism events after complex abdominal wall reconstruction at a single institution using an evidence-based venous thromboembolism prophylaxis protocol and compare this incidence to the previously published literature.[6]

PATIENTS AND METHODS

Since 2013, we have had institutional review board approval for a prospectively maintained database of all patients undergoing abdominal wall reconstruction performed by a single surgeon at The Ohio State University. This study was performed by retrospectively reviewing these prospectively collected data, including age, body mass index, race, American Society of Anesthesiologists class, sex, medical comorbidities, anticoagulant/antiplatelet use, operative time, Caprini score, and deep venous thrombosis or pulmonary embolism occurrence. Statistical significance was calculated using the *t* test and a chi-square test for a comparison of proportions.

A literature search was then conducted to obtain all articles related to the incidence of venous thromboembolism after abdominal wall reconstruction. Search terms to identify articles included "abdominal wall reconstruction," "components separation," and "venous thromboembolism." Articles were excluded based on abstract review if they did not describe the incidence of venous thromboembolism after abdominal wall reconstruction, described venous thromboembolism incidence after abdominoplasty, or were not written in English. Additional CME articles on the topic were reviewed, and citations of the identified articles were also assessed.

RESULTS

After reviewing all patients undergoing complex abdominal wall reconstruction from September of 2013 to February of 2018, 175 patients were identified for analysis. Average body mass index was 33.1 kg/m^2, and 22 patients had a body mass index greater than 40 kg/m^2 and were classified as morbidly obese. Most patients (96.5 percent) were classified as American Society of Anesthesiologists class 2 or 3. The average age of all patients included was 54.95 years (range, 20 to 84 years). The majority were female (56.5 percent) and white (94.8 percent). Average hernia width was 11.1 ± 5.7 cm. With regard to medical comorbidities,

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37 patients had diabetes (21.1 percent), 15 had chronic obstructive pulmonary disease (8.6 percent), 18 were on antiplatelet therapy (10.2 percent), and 13 were on anticoagulant therapy (7.4 percent). Fourteen patients (8.2 percent) without postoperative venous thromboembolisms had a history of venous thromboembolism, compared to 75 percent for those with a postoperative venous thromboembolism ($p < 0.0001$). Four patients (2.2 percent) had a history of hereditary hypercoagulable disorders, none of whom had postoperative venous thromboembolism events. All patients had anticoagulant therapy held before surgery. Twelve patients had antiplatelet therapy held before surgery, four continued antiplatelet therapy, and two were unknown. Antiplatelet therapy was predominantly aspirin, which was restarted on discharge from the hospital. Ninety-five patients were given subcutaneous heparin postoperatively (54.3 percent), 78 were given enoxaparin postoperatively (44.6 percent), and two received no prophylaxis for outpatient surgery or overnight observation only (0.1 percent). Fifty-one patients were given preoperative chemoprophylaxis (29.1 percent), with 50 receiving heparin and one receiving enoxaparin preoperatively. Three patients were discharged with extended chemoprophylaxis for a range of 2 to 3 weeks. Four patients were current smokers at the time of surgery. All patients were operated on in a multidisciplinary fashion that included general surgeons and plastic surgeons. The overwhelming majority (97.7 percent) had an operative time greater than 240 minutes combined for both the general surgery and plastic surgery portion of the procedure (Table 1). The majority of patients (68.6 percent) underwent components separation for hernia repair. Four patients had a recorded postoperative pulmonary embolism, and none had a documented deep venous thrombosis, for a venous thromboembolism event rate of 2.3 percent (Table 2). All patients had pulmonary embolisms confirmed with a computed tomographic scan with pulmonary embolism protocol after clinical suspicion for pulmonary embolism. Average time of diagnosis was postoperative day 11.25, with two patients having been discharged before diagnosis. No patients had any bleeding complications requiring operative intervention. Peak inspiratory pressure measurements were available for 83.4 percent of patients, with an average increase in peak inspiratory pressure after surgery versus baseline of 2.7 cm H_2O. There was no significant difference in peak inspiratory pressure between patients with mesh-reinforced primary fascial closure ($n = 157$; average peak inspiratory pressure, 2.7 cm H_2O) versus bridged mesh repairs ($n = 12$; average peak inspiratory pressure, 3.3 cm H_2O) ($p = 0.63$). There was a trend toward significance between the two groups, with an average peak inspiratory pressure differential of 2.63 cm H_2O for those without venous thromboembolism versus 5.50 cm H_2O for

Table 1. Summary of Prospectively Collected Data from Our Institution for Patients Undergoing Complex Abdominal Wall Reconstruction

Category	No.
Total no. of patients	175
Age, yr	
Mean	54.95
Range	20–84
BMI	
<40 kg/m²	153
>40 kg/m²	22
Sex	
Male	76
Female	99
Race	
White	166
Black	5
Hispanic	2
Asian or Pacific Islander	2
Diabetes	
Yes	37
No	138
COPD	
Yes	15
No	160
Current smoker	
Yes	4
No	171
ASA class	
1	5
2	114
3	54
4	2
Total operative time	
120–179 min	1
180–239 min	3
>240 min	171
Antiplatelet therapy	
Yes	18
No	157
Antiplatelet therapy held	
Yes	12
No	4
Unknown	2
Anticoagulant therapy	
Yes	13
No	162
Anticoagulant therapy held	
Yes	13
No	0
30-day PE	
Yes	4
No	171
30-day DVT	
Yes	0
No	175

BMI, body mass index; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists; PE, pulmonary embolism; DVT, deep venous thrombosis.

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Table 2. Summary of Data for Patients with a Pulmonary Embolus within 30 Days after Surgery

Patient	Age (yr)	Sex	Race	ASA Class	Operative Time (min)	BMI >40 kg/m^2	Diabetes	COPD	Antiplatelet/ Anticoagulants
1	65	Female	White	2	>240	No	Yes	No	No
2	69	Female	White	2	>240	Yes	No	No	No
3	67	Female	White	2	>240	No	No	No	No
4	63	Female	White	3	>240	No	No	No	No

ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

those with venous thromboembolism ($p = 0.08$). The average 2005 Caprini score for this cohort was 5.26 for those without venous thromboembolism and 8.5 for those with venous thromboembolism ($p = 0.0005$). There were no deaths resulting from these venous thromboembolism events. All patients with venous thromboembolism underwent components separation for primary fascial closure, giving a venous thromboembolism rate of 3.3 percent for patients undergoing components separation, and 0 percent for those without components separation.

Forty-seven articles were identified from the literature review using our stated search terms. After abstract review and application of exclusion criteria, three articles fit criteria for inclusion. The remaining 44 articles were related predominantly to venous thromboembolism after abdominoplasty, or abdominal wall reconstruction without description of venous thromboembolism incidence.

DISCUSSION

Patients undergoing abdominal wall reconstruction are at high risk for postoperative complications, particularly venous thromboembolism. Our current protocol follows the venous thromboembolism guidelines outlined by the American Society of Plastic Surgeons Venous Thromboembolism Task Force.[18] Specifically, modified 2005 Caprini scores are calculated preoperatively on all patients.[18] Intraoperatively, peak inspiratory pressure was recorded at baseline and after reconstruction. Both intraoperatively and postoperatively, all patients had sequential compression devices on before induction of general anesthesia and postoperatively at all times when not ambulating. Furthermore, all patients were required to ambulate with assistance at least once on the day of surgery, transitioning to a minimum of five times daily starting the day after surgery, and continued for 6 weeks after discharge. Weight-based chemoprophylaxis with enoxaparin or subcutaneous heparin was initiated 6 to 8 hours after surgery until discharge.[6] Average length of stay was 6.7 days. Epidural analgesics and transversus abdominis plane blocks with liposomal bupivacaine supplemented a postoperative multimodal pain control regimen consisting of acetaminophen, celecoxib, gabapentin, and as-needed low-dose oxycodone to help promote ambulation and minimize opioid-related adverse events such as dizziness, nausea, and falls. Foley catheters were removed on postoperative day 1. It is important to note that the American Society of Plastic Surgeons venous thromboembolism guidelines to not provide concrete recommendations for venous thromboembolism prevention such as timing, dosages, or length of treatment, but instead are evidence-based suggestions and considerations for management. In our practice, the decision regarding preoperative chemoprophylaxis and postdischarge chemoprophylaxis is made at the discretion of the attending physicians based on Caprini score and is not currently based on a standardized protocol. Based on this study, we are considering the development of more standardized indications for preoperative and postdischarge prophylaxis, as this has the potential to contribute to some of our venous thromboembolism events.

When reviewing the literature, three articles were identified specifically addressing the rates of venous thromboembolism events after abdominal wall resection (Table 3). Kim et al. recently reviewed data for ventral hernia repair with and without components separation and evaluated rates of venous thromboembolism using the American College of Surgeons National Surgical Quality Improvement Program database from 2005 to 2011.[19] They looked at 34,541 patients and found a 30-day postoperative rate of venous thromboembolism complications of 0.3 percent for patients undergoing ventral hernia repair without components separation (30,040 patients), and 0.2 percent for those with components separation (501 patients) (deep venous thrombosis, $p = 0.998$; pulmonary embolism, $p = 0.591$). They found through multivariate analysis that preoperative functional status ($p = 0.018$) and venous

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Table 3. Summary of Current Literature Evaluating Venous Thromboembolism Incidence after Abdominal Wall Reconstruction

Reference	Population Studied	Years Evaluated	Database Used	Total No. of Patients	DVT (%)	PE (%)
Nelson et al.	Obese (BMI >30 kg/m^2)	2005–2010	ACS-NSQIP	Nonobese, 614	4 (0.7)	1 (0.2)
				Obese, 1078	15 (1.4)	23 (2.1)
Nelson et al.	Morbidly obese (BMI >40 kg/m^2)	2005–2010	ACS-NSQIP	Nonobese, 614	4 (0.7)	1 (0.2)
				Morbidly obese, 314	7 (2.2)	8 (2.5)
Kim et al.	All patients	2005–2011	ACS-NSQIP	Ventral hernia repair, 34,040	90 (0.3)	56 (0.2)
				With components separation, 501	1 (0.2)	2 (0.4)

DVT, deep venous thrombosis; PE, pulmonary embolism; BMI, body mass index; ACS-NSQIP, American College of Surgeons National Surgical Quality Improvement Program.

thromboembolism risk score (p = 0.023) were significantly associated with risk of venous thromboembolism events. These findings differ from our own cohort, with a 3.3 percent rate of venous thromboembolism for patient undergoing components separation. This is likely because plastic surgeons are primarily consulted for more complex hernias, which are more likely to require components separation. This is evidenced by the fact that 68.6 percent of our cohort required components separation for hernia repair, compared to 1.4 percent for this cohort. Of note, Pannucci et al. have also published an article using the general ventral hernia data from the American College of Surgeons National Surgical Quality Improvement Program database to propose a risk-assessment tool for patients undergoing ventral hernia repair, although this does not differentiate patients undergoing components separation from those undergoing primary repair.[20] They identified a total venous thromboembolism 30-day venous thromboembolism rate of 0.92 percent for all patients, with a 25-fold variation in venous thromboembolism risk based on their assessment tool. Although this is a valuable risk-assessment tool, specific recommendations for venous thromboembolism prophylaxis based on this tool must still be elucidated.

Nelson et al. also performed an analysis of the American College of Surgeons National Surgical Quality Improvement Program database from 2005 to 2010, looking specifically at the obese (body mass index >30 kg/m^2) population.[21] For this study, they looked specifically at patients undergoing components separation for complex abdominal wall resection. They identified 1695 patients who underwent components separation, 1078 of whom were obese. They noted that the rates of deep venous thrombosis and pulmonary embolism were substantially higher in the obese population. For nonobese patients, deep venous thrombosis occurred in 0.7 percent of patients, compared with 1.4 percent in the obese population (p = 0.006). The same increase was found in pulmonary embolisms, with a rate of 0.2 percent in the nonobese population versus 2.1 percent in the obese population (p = 0.001). They also noted that complication rates, including venous thromboembolism events, increased with increasing body mass index across the population studied (p = 0.02).

Finally, Nelson et al. refined their analysis of the American College of Surgeons National Surgical Quality Improvement Program database from 2005 to 2010 in a subsequent publication, looking specifically at the morbidly obese population (body mass index >40 kg/m^2) compared to the nonobese population (body mass index <30 kg/m^2).[22] They identified 314 patients with a body mass index greater than 40 kg/m^2. In addition to an increase in several other postoperative complication rates, they noted an increase in the rate of pulmonary embolisms from 0.2 to 2.5 percent for morbidly obese patients compared with nonobese patients (p = 0.001). Similarly, the rate of deep venous thrombosis increased from 0.7 percent to 2.2 percent for the morbidly obese (p = 0.04). Recommendations were made for both mechanical prophylaxis and chemoprophylaxis after abdominal wall resection in the morbidly obese population. They also highlight the need for prospective studies regarding prevention of venous thromboembolism events in this population, which this study attempts to address.

In our prospective analysis, we found four patients with a documented pulmonary embolism,

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Table 4. Summary of Risk Factors for Each Patient with a Documented Venous Thromboembolism Event Using the 2005 Caprini Risk Score Calculator

	Patient 1	Patient 2	Patient 3	Patient 4
Risk factors				
BMI, kg/m²	>25	>25	>25	>25
Age, yr	60–74	60–74	60–74	60–74
Surgery	Major surgery (>45 min)	Major surgery (>45 min)	Major surgery (>45 min)	Major surgery (>45 min)
History	DVT/PE	DVT/PE	DVT/PE	Inflammatory bowel disease
Malignancy	Previous malignancy		Previous malignancy	
Total	10	8	10	6

BMI, body mass index; DVT, deep venous thrombosis, PE, pulmonary embolism.

for an overall incidence of 2.3 percent. This is consistent with the previously published retrospective reviews of large databases for obese and morbidly obese patients, particularly because our report is the first published using a single-surgeon database rather than a national database, which may be subject to errors in reporting. These events occurred despite aggressive prophylaxis and ambulation protocols that were meticulously maintained while the patients were admitted. It is also interesting to note that, in general, the patients with pulmonary embolisms were not more medically complex. Only one patient had diabetes, one patient had a body mass index greater than 40 kg/m², and one was classified as American Society of Anesthesiologists class 3. However, three of the four patients had a previous history of deep venous thrombosis/pulmonary embolism, with 2005 Caprini scores of 6, 8, 10, and 10 preoperatively, compared with an average score of 5.34 (Table 4 and Fig. 1). This would indicate that despite maximum evidence-based venous thromboembolism prophylaxis while admitted, some venous thromboembolism events cannot be prevented. This may be attributable to a variety of reasons, including inadequate dosage of chemoprophylaxis, noncompliance with ambulation protocols after discharge from the hospital, the need for extended chemoprophylaxis, or the need for preoperative chemoprophylaxis. It is also interesting to note that all patients with venous thromboembolism events underwent components separation, two with unilateral transversus abdominis release, one with bilateral transversus abdominis release, and one with bilateral external oblique release. Although our numbers are too low to make any comment on anterior versus posterior components separation, the extended operative time and likely extended recovery associated with components separation versus primary fascial closure may have contributed to the venous thromboembolism events.

Pannucci et al. have recently published a series of articles evaluating the efficacy of daily enoxaparin administration for venous thromboembolism prophylaxis in plastic surgery patients. In their initial study using peak and trough anti–factor Xa levels with real-time dose adjustments,

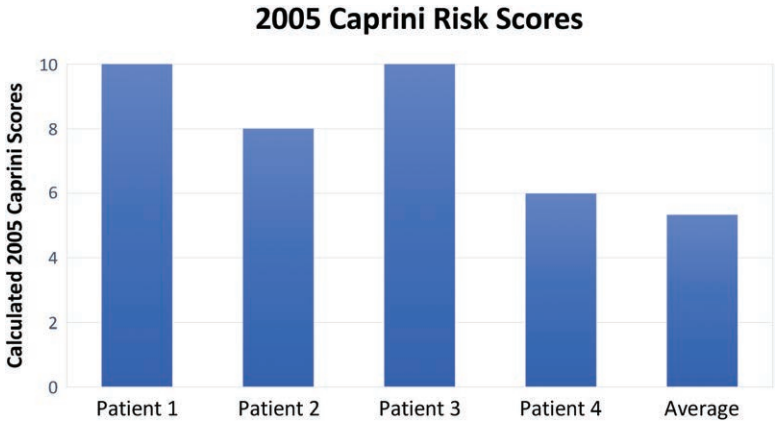

Fig. 1. Chart of 2005 Caprini venous thromboembolism risk calculator scores for patients with venous thromboembolism events compared with the average score for this cohort.

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they found that 55.7 percent of plastic surgery patients had low anti–factor Xa levels with once-daily administration of 40 mg of enoxaparin. Elevated body mass index ($p < 0.001$) and total body surface area of surgical injury ($p = 0.06$) were associated with low anti–factor Xa levels, both of which are generally elevated in complex abdominal wall reconstruction patients.[23] Based on these findings, Pannucci et al. subsequently evaluated the efficacy of twice-daily enoxaparin for venous thromboembolism prophylaxis and found that although up to 90.4 percent of patients can have adequate prophylaxis with adjustment, 27.8 percent were initially overtreated and the bleeding rate was increased to 6.8 percent.[24] Ultimately, this culminated in a head-to-head comparison of the two trials, with a recommendation of considering weight-based enoxaparin at 0.4 to 0.5 mg/kg twice daily based on the likelihood of achieving a therapeutic level in this range.[25] Additional consideration and study are warranted for this approach given the potential for increased bleeding risk, but it remains a promising avenue for increased venous thromboembolism prevention in this patient population.

There are several limitations to this study. Although this is a prospectively maintained database, the data were reviewed retrospectively, subjecting this study to potential inaccuracies in data review and interpretation. In addition, these data were collected from a single surgeon's experience, which may introduce some confounding variables not accounted for in the data set and limit generalizability. However, the prospective nature of our data adds clinical elements not available with national registry data as previously published. There was not a standardized protocol for preoperative prophylaxis, and there was variability in which medication was given for prophylaxis postoperatively, which could have potentially affected our results as well. Finally, our venous thromboembolism outcomes were limited to patients with clinically evident venous thromboembolism, whereas there may have been a greater incidence of subclinical venous thromboembolism that went undiagnosed. These cases could have been identified with routine duplex screening preoperatively and postoperatively, which may be a future consideration.[26]

CONCLUSIONS

Complex abdominal wall resection is frequently performed on patients at high risk for venous thromboembolism. Currently, there is scant literature on the incidence of venous thromboembolism events in patients undergoing complex abdominal wall resection, and these studies are limited by the inherent nature of large, national databases. In this study, we report our own experience with venous thromboembolism events after abdominal wall resection, using an evidence-based protocol for postoperative prophylaxis. Despite this, we have been unable to reduce the incidence of venous thromboembolism events to zero, and reconstructive surgeons should remain cognizant of the risk inherent in this population. Aggressive venous thromboembolism prophylaxis protocols may assist with minimizing the incidence of venous thromboembolism events postoperatively after abdominal wall reconstruction, but further research is needed to reduce this incidence further.

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