Article

BMI and VTE Risk in Emergency General Surgery, Does Size Matter? An ACS-NSQIP Database Analysis

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Abstract

Background: Venous thromboembolism (VTE) is a preventable cause of morbidity and mortality. Emergency general surgery (EGS) patients comprise 7% of hospital admissions in America with a reported rate of VTE of 2.5%. Of these, >69% required hospital readmission, making VTE the second most common cause for readmission after infection in EGS patients. We hypothesize a correlation between body mass index (BMI) and VTE in EGS patients.

Methods: The American College of Surgeons National Surgery Quality Improvement Database (NSQIP) was queried from January 2015 to December 2016. 83 272 patients met inclusion criteria: age ≥18 and underwent an EGS procedure. Patients were stratified by BMI. Descriptive statistics were used for demographic and numerical data. Categorical comparisons between covariates were completed using the chi-square test. Continuous variables were compared using Student's *t*-test, Mann Whitney U-test, or Kruskal-Wallis H test.

Results: 83 272 patients met the inclusion criteria. 1358 patients developed VTE (903 deep vein thrombosis (DVT) only, 335 pulmonary embolism (PE) only, and 120 with DVT and PE). Morbidly obese patients were 1.7 times more likely to be diagnosed with a PE compared with normal BMI ($P = .004$). Increased BMI was associated with the co-diagnosis of PE and DVT ($P = .027$). Patients with BMI <18.5 were 1.4 times more likely to experience a VTE compared with normal BMI ($P = .018$). Patients with a VTE were 3.2 times more likely to die ($P < .001$) and less likely to be discharged home ($P < .001$).

Discussion: Our study found that obese and underweight EGS patients had an increased incidence of VTE. Risk recognition and chemoprophylaxis may improve outcomes in this population.

Keywords
venous thromboembolism, body mass index, emergency general surgery

Introduction

The obesity epidemic continues to increase complicating many aspects of the health care system and leading to worse patient outcomes. According to the National Center for Health Statistics, the prevalence of obesity in the United States was 39.8% from 2015 to 2016, affecting 93.3 million adults.[1] One estimate found that medical spending for the obese is nearly 42% higher, with the annual medical cost for the individual obese patient being $1429.[2] However, an analysis of studies measuring the cost of obesity in the past decade has shown a wide range of estimates by methodology and consideration of obesity-related diseases.[3]

Venous thromboembolism (VTE) is not generally recognized as an obesity-related disease, although it has been shown to be the leading cause of postoperative death

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Table 1. BMI Classifications.

Classifications	BMI range (kg/m^2)
Underweight	<18.5
Normal weight	18.5-24.9
Overweight	25-29.9
Obese	30-39.9
Morbidly obese	40-50
Super obese	>50

Abbreviation: BMI, body mass index.

after elective bariatric surgery.[4] The majority of VTE studies related to obese patients have focused on those undergoing bariatric surgery, and chemoprophylaxis in these patients has become a standard of care.[5] Comparatively, little research has been done on the prevention of VTE in emergency general surgery (EGS), although EGS patients comprise 7% of all hospital admissions in the United States with a reported VTE rate of approximately 2.5%.[6] One study of over 130 000 EGS patients found that greater than 30% of the VTEs identified occurred after discharge. Of those that developed a VTE, 69% required hospital readmission, making VTE the second most common cause for readmission for EGS patients after infection. The patients that developed VTE tended to be older with additional comorbidities, including obesity, chronic obstructive pulmonary disease, hypertension, ascites, and diabetes.[7]

The need to determine what patients are at the highest risk in EGS is clear. Guidelines to prevent VTE, including deep venous thrombosis (DVT) and pulmonary embolism (PE), may lessen the morbidity and mortality of this large segment of hospitalized patients. We examined the incidence of VTE in patients undergoing EGS as it relates to body mass index (BMI). We hypothesized that increasing BMI was correlated with an increased incidence of VTE.

Methods

The American College of Surgeons National Surgery Quality Improvement Database (ACS-NSQIP) was queried from January 2015 to December 2016. Patients (83 272) met our inclusion criteria: age ≥18 and underwent an EGS procedure. They were stratified by BMI as shown in Table 1. This study was exempt from review by an institutional review board committee.

Descriptive statistics, including mean, median, SD, frequency, and percentage were used for basic demographic and numerical data. Categorical comparisons between covariates were completed using the chi-square test. Continuous variables were compared using a Student's *t*-test, Mann Whitney U-test, or Kruskal-Wallis H test as appropriate. Post hoc tests were performed with a Bonferroni adjustment for multiple comparisons. Statistical analysis was performed using QI Macros for Windows (KnowWare International, Inc., Denver CO, USA, 2012) *P* values less than .05 were considered statistically significant.

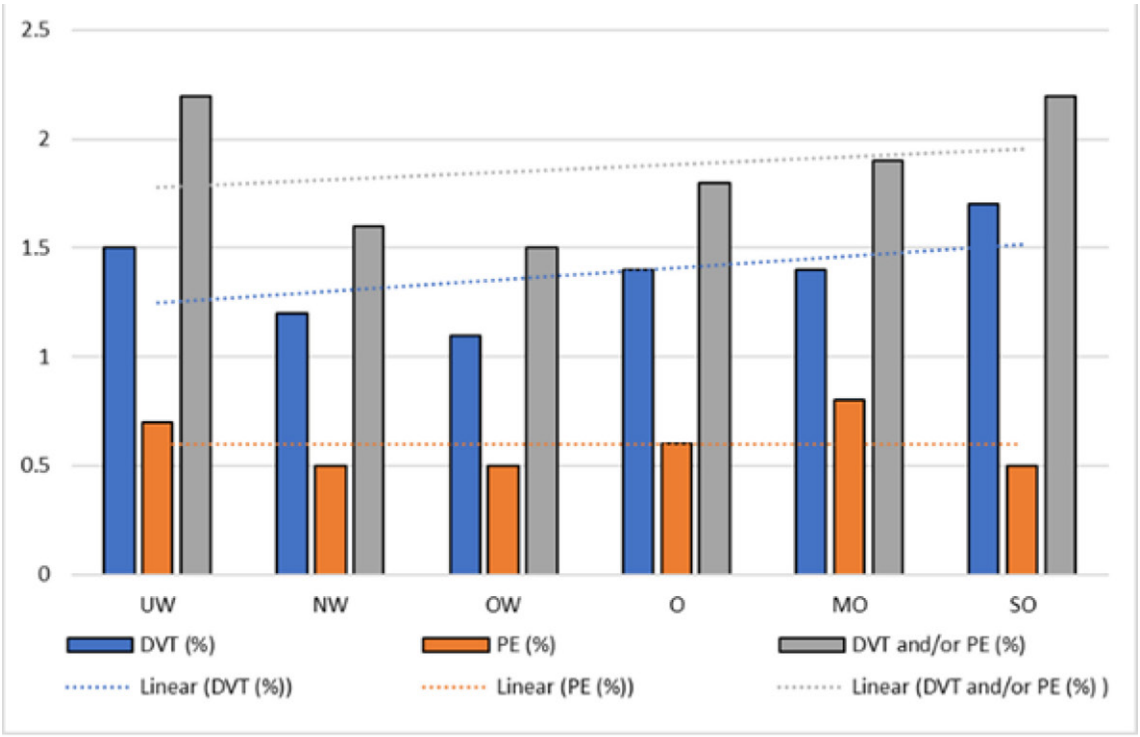
Results

Patients (83 272) met our inclusion criteria. BMI was not recorded for 4466 patients so these were excluded from our statistics. Of those, 1358 patients developed a VTE (903 with DVT only, 335 with PE only, and 120 with both DVT and PE). As shown in Figure 1, increasing BMI from normal is associated with an increased incidence of VTE. Morbidly obese patients were 1.7 times more likely to be diagnosed with a PE compared with patients with a normal BMI ($P = .004$). Increased BMI was associated with a co-diagnosis of PE and DVT ($P = .027$). Patients with BMI <18.5 were 1.4 times more likely to be diagnosed with a VTE compared with patients with a normal BMI ($P = .018$). VTE mortality rate was not related to BMI classification, but patients with a VTE were 3.2 times more likely to expire ($P < .001$), less likely to be discharged home ($P < .001$), and 3.7 times more likely to be discharged to an acute care facility than patients with a normal BMI; they were 4.7 times more likely to be discharged to a rehab facility and 5.3 times more likely to be discharged to a skilled nursing facility ($P < .001$) than patients with a normal BMI. As shown in Table 2, the risk of mortality was highest in patients with BMI <18.5 ($P < .001$).

Discussion

Venous thrombosis and embolism are known complications in medicine since their pathogenesis was first described by Rudolf Virchow in 1856. Virchow's triad, consisting of venous stasis, vessel damage, and hypercoagulability, continues to be relevant today. All surgical patients are predisposed to have at least 2 of the 3 factors. Surgical patients have significant immobility leading to stasis preoperatively, perioperatively, and postoperatively despite surgeons' best attempts at encouraging early postoperative ambulation and mobility. Release of the procoagulant tissue thromboplastin during surgery, which converts prothrombin to thrombin leading to coagulation, has been suggested as a cause of intraoperative hypercoagulability and likely corresponds with the time the nidus for venous thrombosis is formed. Postoperatively, there is reduced fibrinolytic activity further exacerbating the risk of developing a clinically significant VTE.[8]

The 2 main modalities of prophylaxis against VTE include mechanical and chemical. Mechanical, including



BMI Classification	Total Population	PE and/or DVT Rate (n=1,358)	PE Rate (n=455)	DVT Rate (n=1,023)
Underweight (UW), *n* (%)	2,310	51 (2.2)	17 (0.7)	35 (1.5)
Normal weight (NW), *n* (%)	24,480	382 (1.6)	116 (0.5)	292 (1.2)
Overweight (OW), *n* (%)	24,354	368 (1.5)	129 (0.5)	278 (1.1)
Obese (O), *n* (%)	21,543	382 (1.8)	121 (0.6)	300 (1.4)
Morbidly Obese (MO), *n* (%)	4,686	91 (1.9)	38 (0.8)	65 (1.4)
Super Obese (SO), *n* (%)	1,433	31 (2.2)	7 (0.5)	25 (1.7)

Figure 1. Venous thromboembolism after acute care surgery, by BMI class. BMI, body mass index; DVT, deep vein thrombosis; PE, pulmonary embolism.

Table 2. Mortality Rate Based on BMI Classification.

BMI classification	Patient population (n = 78 806)	Population with known outcome	Expired (n = 3134)	Mortality rate (%)
Underweight, n	2310	2293	218	9.5
Normal weight, n	24 480	24 406	1065	4.4
Overweight, n	24 354	24 302	805	3.3
Obese, n	21 543	21 483	747	3.5
Morbidly obese, n	4686	4668	201	4.3
Super obese, n	1433	1424	98	6.9

Abbreviation: BMI, body mass index.

sequential compression devices and compression stockings, act to reduce venous stasis. Chemoprophylaxis, primarily unfractionated heparin (UH), and low molecular weight heparin (LMWH) act to inhibit activated factor X (Xa). We are unable to draw conclusions as to what if any prophylaxis was used in the NSQIP database; however, due to the relatively high rates of VTE, particularly in the morbidly obese, we have identified potentially problematic areas that may increase the incidence of VTE in EGS patients: a lack of clear guidelines for EGS patients, problems with compliance in ordering and administration of prophylaxis, and different dosing requirements in the morbidly obese.

The high prevalence of VTE in surgical patients has led to extensive research in those patients who are at the highest risk and into mechanisms of effective prophylaxis; however, we propose that EGS patients may be a unique subset of patients with higher risk. VTE is known to be over 2.5 times more common after nonelective procedures than elective procedures,[9] but this is not generally accounted for in consensus recommendations for prophylaxis.

Guidelines published by the American Society of Hematology (ASH) attempt to stratify general surgery patients based on VTE risk and recommend chemoprophylaxis for major abdominal surgery and against outpatient elective surgery, such as laparoscopic cholecystectomy.[10] The ASH also recommends chemoprophylaxis for acute inpatient medical conditions.[11] Their guidelines for hospitalized surgical patients do not specify acuity of care, while their guidelines for medical patients do not address surgical procedures. EGS patients may fall into both categories of surgical and medical management due to the acuity of their condition and yet be underrepresented in the literature for the same reason.

The American College of Chest Physicians (ACCP) attempts to stratify general surgery patients based on risk and employs a modification of the Caprini score, which adds points for various VTE risk factors, to determine the method of prophylaxis.[12] Although both the ASH and ACCP consensus statements suggest populations at increased risk for VTE, neither has focused on the 7% of hospital admissions that comprise EGS and neither specifically focuses on the challenges of the morbidly obese patient. And while the Caprini score used by the ACCP adds one point for BMI $\geq$25 kg/m^2, our study suggests that the VTE risk of the morbidly obese patient in EGS may considerably higher and modification of prophylaxis guidelines may be beneficial in reducing VTEs in this population.

Compliance with prophylaxis in EGS patients is a second area where significant improvements could be made. Compliance is 2-fold; first, recommended prophylaxis may not be ordered, and second, ordered doses of prophylactic medications may not be given. Many patients in EGS present to the emergency department and proceed to the operating room directly, perhaps only receiving fluid, pain medication, and antibiotics. We believe that the acuity and lack of a standardized approach to chemoprophylaxis contribute to low compliance.

A recent review of interventions for implementing thromboprophylaxis in hospitalized patients found only around 2/3 of high-risk patients had appropriate prophylaxis ordered, and this could be improved to over 90% with automatic reminder systems.[13] It is highly likely that the EGS population may have appropriate prophylaxis ordered at an even lower rate.

Compliance with the administration is a second confounding factor. A study examining missed doses of VTE prophylaxis over 7 months found that of over 100 000 doses of UH or LMWH ordered, 12% of doses were not given. Patient refusal was documented as the reason in 59% of missed doses.[14] Recent literature has shown that patients who miss as little as 1 dose may have a 5-fold higher risk of developing a VTE.[6] This underscores the need for physicians to not only order proper prophylaxis but also educate patients and staff regarding its importance.

Even when patients are identified that may need chemoprophylaxis and it is administered, the dose of the morbidly obese patient may be considerably greater than the flat rate of 40 mg/day for the average general surgery patient. A

study measuring levels of antifactor Xa activity of enoxaparin for VTE prophylaxis in morbidly obese surgery patients found that 0.5 mg/kg daily provided adequate prophylaxis for 88% of patients to reach their goal antifactor Xa levels (0.2-0.6 IU/mL). In addition, there was no thrombocytopenia, symptomatic VTE, or bleeding events.[15] These results are consistent with studies performed on morbidly obese medically ill patients as well. At the University of Utah, patients with a BMI ≥35 kg/m^2 were also given once-daily doses of 0.5 mg/kg. The average peak anti-Xa level was 0.25, also within the recommended range of 0.2-0.6 U/mL. There were no bleeding events, symptomatic DVT or PE, or significant thrombocytopenia.[16]

Other methods of prevention of VTE, including preoperative assessment with bilateral lower extremity venous duplex ultrasonography and preoperative placement of inferior vena cava filters (IVCFs), have been studied in the bariatric population and not found to be useful. In fact, the placement of IVCFs was associated with higher rates of DVT and mortality.[17,18] We suggest that these modalities would not be useful for the EGS patient and would delay treatment and increase the cost.

The effect of discharging patients on chemical VTE prophylaxis has been studied as well. A review of studies on prolonged thromboprophylaxis of at least 30 days postdischarge with LMWH after major abdominal or pelvic surgeries showed a statistically significant reduction in the incidence of VTE from 1.7% to 0.2% and no significant increase in bleeding events.[19] This may be promising for EGS patients at particularly high risk, although identifying which patients may benefit most from this intervention has not been addressed.

Interestingly, while our hypothesis that BMI was correlated with increased rates of VTE was correct, we also found that EGS patients who were underweight also had higher incidences of VTE. To our knowledge, this is the first study to demonstrate a bimodal distribution of VTE based on BMI in the surgical literature. This may be multifactorial, and it is difficult to draw conclusions from this information. The mortality rate in the underweight EGS population was significantly higher than all other BMI classes. This may suggest that the acuity of the patients was higher, perhaps from underlying medical comorbidities, which could skew the incidence of VTE higher in this population. However, we are unable to draw clear conclusions from the NSQIP database.

There are several limitations to our study. We are restricted to outcomes captured in the ACS-NSQIP database. Based on the information available, we are unable to determine if these patients had received chemical VTE prophylaxis prior to their surgery or during their hospitalization. By using the International Classification of Diseases coding, patients can be miscoded or misdiagnosed in the dataset. We are also limited in our ability to determine if these VTE events were directly related to the EGS procedure or if the patients had an underlying coagulopathy or preexisting VTE.

Conclusion

It has been a challenge in medicine to identify those patients at high risk for venous thrombosis and provide prophylaxis for the disease. There is a multitude of studies available to guide VTE prophylaxis in the elective surgery population and nonsurgical populations but few relating to EGS, particularly in the obese population. Confounding factors that limit the translation of existing guidelines to the EGS patient are not only the heterogeneity of the patient population and the severity of illness but also the diversity of procedures being performed.

Our study demonstrates that the risk of VTE in EGS may be higher than the sum of its parts. Taken individually, obesity, abdominal surgery, and acute illness may carry their own risk; however, taken together, there seems to be a multiplying factor. We believe that EGS patients carry a higher risk of the development of VTE, and increased awareness is necessary for adequate prophylaxis. A multifaceted approach to recognition of risk, compliance with ordering and administration of prophylaxis, and appropriate medication dosing will help prevent morbidity and mortality in the EGS population.

Declaration of Conflicting Interests

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References

1. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015-2016. *NCHS Data Brief*. 2017;288:1-8.
2. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Aff*. 2009;28(5):w822-w831. doi: 10.1377/hlthaff.28.5.w822
3. Kim DD, Basu A. Estimating the medical care costs of obesity in the United States: systematic review, meta-analysis, and empirical analysis. *Value Health*. 2016;19(5):602-613. doi:10.1016/j.jval.2016.02.008
4. Morino M, Toppino M, Forestieri P, et al. Mortality after bariatric surgery. *Ann Surg*. 2007;246(6):1002-1009. doi: 10.1097/SLA.0b013e31815c404e

5. Mechanick JI, Apovian C, Brethauer S, et al. Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures – 2019 update: Cosponsored by American association of Clinical Endocrinologists/american College of Endocrinology, the Obesity Society, American Society for Metabolic &Amp; Bariatric Surgery, Obesity Medicine Association, and American Society of Anesthesiologists. *Endocrine Practice*. 2019;25(suppl 2):1-75. doi:10.4158/GL-2019-0406
6. Murphy PB, Vogt KN, Lau BD, et al. Venous thromboembolism prevention in emergency general surgery: a review. *JAMA Surg*. 2018;153(5):479-486. doi:10.1001/jamasurg.2018.0015
7. DeWane MP, Davis KA, Schuster KM, Maung AA, Becher RD. Venous thromboembolism-related readmission in emergency general surgery patients: a role for prophylaxis on discharge? *J Am Coll Surg*. 2018;226(6):1072-1077. doi:10.1016/j.jamcollsurg.2018.03.021
8. Mammen EF. Pathogenesis of venous thrombosis. *Chest*. 1992;102(Suppl 6):640S-644S. doi:10.1378/chest.102.6_Supplement.640S
9. Mukherjee D, Lidor AO, Chu KM, et al. Postoperative venous thromboembolism rates vary significantly after different types of major abdominal operations. *J Gastrointest Surg*. 2008;12(11):2015-2022. doi:10.1007/s11605-008-0600-1
10. Anderson DR, Morgano GP, Bennett C, et al. American Society of Hematology 2019 guidelines for management of venous thromboembolism: prevention of venous thromboembolism in surgical hospitalized patients. *Blood Adv*. 2019;3(23):3898-3944. doi:10.1182/bloodadvances.2019000975
11. Schünemann HJ, Cushman M, Burnett AE, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: prophylaxis for hospitalized and nonhospitalized medical patients. *Blood Adv*. 2018;2(22):3198-3225. doi:10.1182/bloodadvances.2018022954
12. Gould MK, Garcia DA, Wren SM, et al. Prevention of VTe in nonorthopedic surgical patients. *Chest*. 2012;141(2):e227S-e277S.10.1378/chest.11-2297 doi:10.1378/chest.11-2297
13. Kahn SR, Morrison DR, Diendéré G, et al. Interventions for implementation of thromboprophylaxis in hospitalized patients at risk for venous thromboembolism. *Cochrane Database Syst Rev*. 2018;4(4):CD008201. doi:10.1002/14651858.CD008201.pub3
14. Shermock KM, Lau BD, Haut ER, et al. Patterns of non-administration of ordered doses of venous thromboembolism prophylaxis: implications for novel intervention strategies. *PLoS One*. 2013;8(6):e66311. doi:10.1371/journal.pone.0066311
15. Al Otaib N, Bootah Z, Al Ammari MA, et al. Assessment of anti-factor Xa activity of enoxaparin for venous thromboembolism prophylaxis in morbidly obese surgical patients. *Ann Thorac Med*. 2017;12(3):199-203. doi:10.4103/atm.ATM_31_17
16. Rondina MT, Wheeler M, Rodgers GM, Draper L, Pendleton RC. Weight-based dosing of enoxaparin for VTE prophylaxis in morbidly obese, medically-ill patients. *Thromb Res*. 2010;125(3):220-223. doi:10.1016/j.thromres.2009.02.003
17. Raj PP, Gomes RM, Kumar S, et al. Role of routine preoperative screening venous duplex ultrasound in morbidly obese patients undergoing bariatric surgery. *J Minim Access Surg*. 2017;13(3):205-207. doi:10.4103/jmas.JMAS_199_15
18. Kaw R, Pasupuleti V, Wayne Overby D, et al. Inferior vena cava filters and postoperative outcomes in patients undergoing bariatric surgery: a meta-analysis. *Surg Obes Relat Dis*. 2014;10(4):725-733. doi:10.1016/j.soard.2014.04.008
19. Rasmussen MD, Jorgensen LN, Wille-Jorgensen P. Prolonged thromboprophylaxis with low molecular weight heparin for abdominal or pelvic surgery (review). *Cochrane Database Syst Rev*. 2009;21(1):CD004318.