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Arthur M. Carlin
Henry Ford Health, ACARLIN1@hfhs.org

Oliver A. Varban
Henry Ford Health, ovarban1@hfhs.org

Anne P. Ehlers

Aaron J. Bonham

Amir A. Ghaferi

See next page for additional authors

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Authors
Arthur M. Carlin, Oliver A. Varban, Anne P. Ehlers, Aaron J. Bonham, Amir A. Ghaferi, and Jonathan F. Finks

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Original article

Independent predictors and timing of portomesenteric vein thrombosis after bariatric surgery

Arthur M. Carlin, M.D., F.A.C.S., F.A.S.M.B.S.[a,b,*], Oliver A. Varban, M.D.[a,b], Anne P. Ehlers, M.D., M.P.H.[c,d], Aaron J. Bonham, M.Sc.[b], Amir A. Ghaferi, M.D., F.A.C.S.[b,c,d], Jonathan F. Finks, M.D.[b,c]

[a]*Department of Surgery, Henry Ford Health, Detroit, Michigan*
[b]*Michigan Bariatric Surgery Collaborative, Ann Arbor, Michigan*
[c]*Department of Surgery, Michigan Medicine, Ann Arbor, Michigan*
[d]*Center for Healthcare Outcomes and Policy, Ann Arbor, Michigan*

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Abstract

Background: Portomesenteric vein thrombosis (PVT) is a rare complication following bariatric surgery but can result in severe morbidity as well as death.
Objective: Identification of risk factors for PVT to facilitate targeted management strategies to reduce incidence.
Setting: Prospective, statewide bariatric-specific clinical registry.
Methods: We identified all patients who underwent primary bariatric surgery between June 2006 and November 2021 (n = 102,869). Patient characteristics, procedure type, operative details, and 30-day postoperative complications were analyzed with multivariable logistic regression to evaluate for independent predictors of PVT.
Results: A total of 117 patients (.11%) developed a postoperative PVT, with 6 (5.1%) associated deaths. The majority of PVTs occurred in patients who underwent sleeve gastrectomy (109 patients; 93.2%), and the PVT occurred most commonly during the second (37%), third (31%), and fourth weeks (23%) after surgery. Independent risk factors for PVT included a prior history of venous thromboembolism (odds ratio [OR] = 3.1; 95% confidence interval [CI]: 1.64–5.98; $P = .0005$), liver disorder (OR = 2.3; 95% CI: 1.36–4.00; $P = .0021$), undergoing sleeve gastrectomy (OR = 12.4; 95% CI: 4.98–30.69; $P < .0001$), and postoperative complications including obstruction (OR = 12.5; 95% CI: 4.65–33.77; $P < .0001$), leak (OR = 7.9; 95% CI: 2.76–22.64; $P = .0001$), and hemorrhage (OR = 7.6; 95% CI: 3.57–16.06; $P < .0001$).
Conclusions: Independent predictors of PVT include a prior history of venous thromboembolism, liver disease, undergoing sleeve gastrectomy, and experiencing a serious postoperative complication. Given that the incidence of PVT is most common within the first month after surgery, extending post-discharge chemoprophylaxis during this time frame is advised for patients with increased risk. (Surg Obes Relat Dis 2022;18:1385–1391.)

Keywords: Portomesenteric vein thrombosis; Venous thromboembolism; Sleeve gastrectomy; Liver disease; Postoperative complications; Hypercoagulable; Bariatric surgery; Chemoprophylaxis

*Correspondence: Arthur M. Carlin, M.D., Henry Ford Health, 16151 19 Mile Road, Suite 215, Clinton Township, MI 48038.
E-mail address: acarlin1@hfhs.org (A.M. Carlin).

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Portomesenteric vein thrombosis (PVT) is an uncommon complication following bariatric surgery but may result in lethal sequelae such as intestinal infarction, portal hypertension, and death [1]. Prior reports evaluating the incidence of PVT noted that it may occur following any type of procedure, but it is identified most frequently after laparoscopic sleeve gastrectomy (SG) [2]. Currently, SG is the predominant procedure for patients undergoing surgery for severe obesity [3,4]. As such, it is important to understand which patients can benefit from targeted interventions to reduce the risk of PVT following surgery.

To date, the overall reported incidence of PVT after bariatric surgery is .42% [2]. Although associated risk factors such as procedure type and a history of hypercoagulability have been described, specific independent predictors for PVT are not well defined [5,6]. In addition, prior studies have demonstrated that the majority of PVTs occur within the first postoperative month, which supports the use of extended prophylaxis [7,8]. However, appropriate patient selection, effectiveness, and exact duration of any chemoprophylaxis to prevent PVT remain unclear.

In this context, we sought to identify independent predictors and timing of PVT following bariatric surgery to inform targeted strategies to mitigate the risk of postoperative PVT. Identification of patients at elevated risk of PVT would allow treatment with extended chemoprophylaxis for the subset of patients who could benefit the most. In addition, by evaluating the postoperative timing of PVT, we can better understand the duration of extended chemoprophylaxis required to best reduce the risk of PVT.

Methods

Study population

This study analyzes data from a statewide bariatric-specific data registry used by the Michigan Bariatric Surgery Collaborative (MBSC), which is a consortium of 80 surgeons and 41 bariatric surgery programs that perform >95% of the bariatric procedures in the state of Michigan [9,10]. The study population included all adult patients (age >18 years) undergoing primary (nonrevisional) bariatric surgery procedures between June 2006 and November 2021. Data were collected by centrally trained abstractors who perform chart reviews and collect preoperative demographic data, medical co-morbidities, perioperative details, and 30-day postoperative outcomes. Nurses from the coordinating center of the MBSC audited each hospital annually to ensure data accuracy. The collection of data for the purposes of participation in the MBSC has been approved by the institutional review boards of all member sites.

Data collected

Data collected included patient demographic characteristics (i.e., age, sex, race, and type of insurance), clinical characteristics (i.e., height, weight, history of cigarette smoking, and mobility limitations), preoperative co-morbid conditions (e.g., prior history of venous thromboembolism [VTE], lung disease, cardiovascular disease, cerebrovascular disease, peripheral vascular disease, hyperlipidemia, diabetes, liver disorder, sleep apnea, gastroesophageal reflux disease, peptic ulcer disease, cholelithiasis, urinary incontinence, renal disease, and psychological disorders) and operative details (i.e., procedure type, approach, and operative time). Liver disorder is defined as a history of liver transplant or cirrhosis identified by biopsy or clinically by bleeding varices, ascites, or encephalopathy or nonalcoholic fatty liver disease identified by radiologic imaging.

We also assessed complications according to severity as follows: grade 1, non–life-threatening complications (e.g., surgical-site infection including wound and port-site infections treated with antibiotics and/or wound opening, anastomotic stricture requiring dilatation, bleeding requiring blood transfusion of <4 units, and pneumonia requiring treatment with antibiotics only); grade 2, potentially life-threatening complications (e.g., abdominal abscess requiring percutaneous drainage or reoperation, bowel obstruction requiring reoperation, leak requiring percutaneous drainage or reoperation, bleeding requiring transfusion >4 units, reoperation, or splenectomy, band-related problems requiring reoperation, respiratory failure requiring 2–7 days of intubation, renal failure requiring in-hospital dialysis, wound infection/dehiscence requiring reoperation, and VTE); and grade 3, life-threatening complications associated with residual and lasting disability or death (e.g., myocardial infarction or cardiac arrest, renal failure requiring long-term dialysis, respiratory failure requiring >7 days of intubation or tracheostomy, and death). Hemorrhage is defined as any intraoperative or postoperative blood transfusion within 30 days postoperatively, endoscopy or reoperation for bleeding, or splenectomy to control intraoperative bleeding. Other complications that are not included in these categories were assessed by an endpoints committee to determine their severity (i.e., non–life threatening, potentially life threatening, or life threatening associated with residual and lasting disability or death).

The primary outcome for this study was the incidence of a postoperative PVT event presenting within 30 days of the surgical procedure. Secondary outcomes included any venous thromboembolic events including DVT or pulmonary embolism (PE) requiring treatment. We also assessed timing of PVT events and grouped them according to postoperative week of occurrence.

Statistical analysis

Potential risk factors for PVT included patient characteristics (i.e., age, sex, race, height, weight, and co-morbidities) and surgery characteristics (i.e., procedure performed and operative time). These characteristics were analyzed using χ^2 tests (for categorical risk factors) and independent-samples t tests (for normally distributed continuous risk factors such as age and body mass index) or Wilcoxon rank-sum tests (for nonnormally distributed operative time risk factor) to determine which were associated with the occurrence of PVT. Risk factors that had a significant association with PVT ($P < .10$) were entered into a hierarchical logistic regression model, which provided a multivariate test for significant predictors of PVT while also controlling for patient clustering within surgical facility. Significant risk factors ($P < .05$) were kept in the final model that we report in the results below in the multivariate analysis. All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) with data downloaded from the MBSC registry on December 2, 2021.

Results

A total of 102,869 patients underwent primary bariatric surgery during the study period. This included 32,009 (31.1%) gastric bypass procedures, 59,462 (57.8%) SGs, 10,654 (10.4%) adjustable gastric banding procedures, and 744 (.7%) biliopancreatic diversions with duodenal switch (BPD/DS). The patient mean age was 45.5 years, mean body mass index was 47.7 kg/m^2, and mean operative time was 89.3 minutes, and 79.0% were female and 74.6% had private insurance. Patient racial distribution included 73.8% White, 16.5% Black, and 9.7% other. Current and past smoking was reported in 39.5%.

Overall postoperative VTE was identified in .45% of patients (512 VTE events in 458 patients) including 211 DVTs, 184 PEs, and 117 PVTs (Fig. 1). Among the 117 cases of PVT, most occurred following SG (109; 93.2%) with the remaining following gastric bypass (7; 6.0%) and biliopancreatic diversion with duodenal switch (1; .9%).

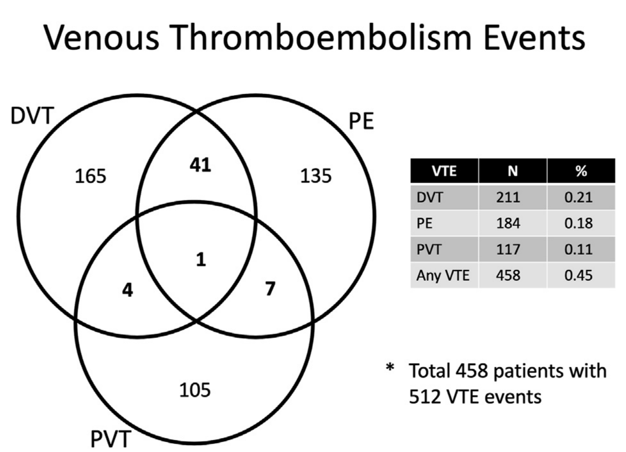

Fig. 1. Venn diagram and percentages of the different types of venous thromboembolic events. DVT = deep vein thrombosis; PE = pulmonary embolus; PVT = portomesenteric vein thrombosis; VTE = venous thromboembolism.

Most patients with PVT presented between the second and fourth weeks following bariatric surgery (106; 91%). PVTs were identified in the first (8%), second (37%), third (31%), fourth (23%), fifth (1%), and sixth (1%) weeks after surgery. Associated mortality rates were highest with PE (8.7%), followed by PVT (5.1%) and DVT (2.8%). While rates of DVT and PE remained relatively stable during the study period, the rate of PVT increased gradually such that it became the most common type of VTE in the past 2 years in our study population (Fig. 2).

On univariate analysis, factors with a significantly higher association with PVT included age <60 years, body mass index of 40–49 kg/m^2, SG, robotic approach, shorter operative times, history of VTE, liver disorder, and surgical complications, including leak, hemorrhage, obstruction, and infection (Table 1). On multivariate logistic regression, independent risk factors for PVT included a prior history of VTE (OR = 3.1; 95% confidence interval [CI]: 1.64–5.98; $P = .0005$), liver disorder (OR = 2.3; 95% CI: 1.36–4.00; $P = .0021$), undergoing SG (OR = 12.4; 95% CI: 4.98–30.69; $P < .0001$), and postoperative complications, including obstruction (OR = 12.5; 95% CI: 4.65–33.77; $P < .0001$), leak (OR = 7.9; 95% CI: 2.76–22.64; $P = .0001$), and hemorrhage (OR = 7.6; 95% CI: 3.57–16.06; $P < .0001$). Hyperlipidemia was identified as protective of PVT (OR = .6; 95% CI: .38–.95; $P = .0293$; Table 2).

Discussion

This is the first study to identify independent predictors of PVT following bariatric surgery: undergoing SG, a prior history of VTE, liver disorder, and experiencing a serious postoperative complication, such as obstruction, leak, and hemorrhage. In addition, we found that PVTs occurred most commonly during the second through fourth weeks after surgery. Using a statewide prospective bariatric registry, we also noted an increase in PVT over time. As such, we believe that this study provides valuable clinical information that can identify patients at higher risk for PVT and allow us to recommend a paradigm shift to extending VTE chemoprophylaxis to prevent an otherwise highly morbid outcome after bariatric surgery.

The rapid rise in SG has altered the landscape of postoperative VTE. Prior to 2009, SG accounted for <10% of bariatric procedures performed annually in Michigan, but since 2015, SG has accounted for 75%–80% of annual bariatric procedures. We noted an increased incidence of PVT over time, and for the past 2 years, PVT has been the most common VTE following bariatric surgery. Although PVT has been identified following all bariatric procedures, it has been reported most frequently following SG [5,11]. The most recent meta-analyses report a PVT incidence rate of .4%–.42%, with up to 79% of the patients having undergone SG [2,6]. In comparison, we found an overall PVT incidence rate of .11%, with the highest rate of .18% in patients

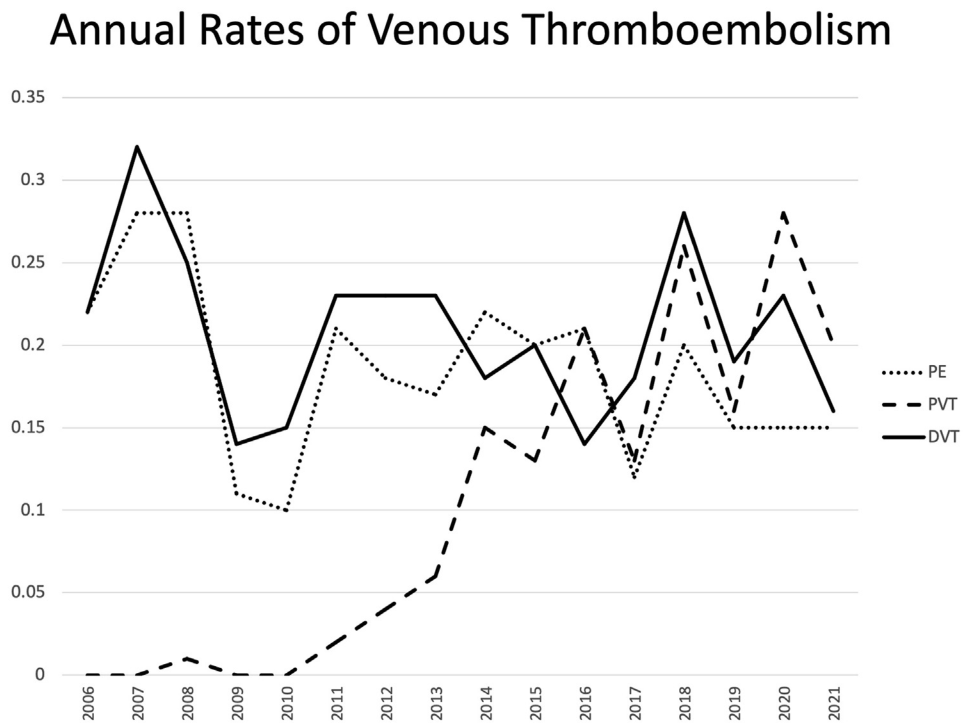

Fig. 2. Annual rates of the different types of postoperative venous thromboembolic events in Michigan between 2006 and 2021. DVT = deep vein thrombosis; PE = pulmonary embolus; PVT = portomesenteric vein thrombosis.

undergoing SG. Our lower rate may be explained by the use of standardized VTE chemoprophylaxis regimens by at least 90% of surgeons in the MBSC and other studies including patients with PVTs beyond 30 days [12].

Postoperative surgical complications of obstruction, leak, and hemorrhage were all identified as independent predictors of PVT. This finding is not surprising because postoperative complications, including blood transfusions following bariatric surgery, have been associated previously with significantly increased overall risk of VTE [13–15]. History of VTE also was identified as an independent risk factor for PVT in this study. This is consistent with the literature and is likely an indicator of hypercoagulability. In addition, both bariatric surgery–specific VTE risk calculators include history of VTE as a predictor for overall VTE [16,17]. In 2 reports where all post–bariatric surgery patients with PVT were evaluated for hypercoagulability, testing identified hypercoagulability in 17.6% and 35.3% [11,18]. Although liver disorder is a known risk factor for PVT following other surgical procedures such as splenectomy, it had not been previously identified as a risk factor in the bariatric surgery population [19]. Chronic liver disease, and specifically cirrhosis, is a common cause of portal vein thrombosis, with the prevalence of PVT in compensated liver disease reported to be .6%–16% [20]. In a study of patients undergoing liver transplantation, the strongest risk factor independently associated with a diagnosis of PVT was nonalcoholic steatohepatitis cirrhosis, which is consistent with our finding of liver disorder predicting PVT following bariatric surgery [21]. An unexpected finding in our analysis was that hyperlipidemia was protective of PVT, which also has not been described previously. This may be related to the use of statins in the treatment of hyperlipidemia. Previous studies have shown that statins have favorable effects on liver disease, with reductions in steatosis, inflammation, and fibrosis as well as a decrease in portal venous pressure, development of malignancy, and death [22]. These beneficial effects may reduce the risk of PVT as well.

The timing of most PVT occurrences was an additional important finding we identified. Although PVT occurred most commonly during the second postoperative week, more than half the PVTs occurred after that, during the third and fourth postoperative weeks. In a recent meta-analysis, it was reported that 88.9% of PVTs occur within the first postoperative month [6]. This has therapeutic implications for the duration of extended chemoprophylaxis required to reduce the risk of PVT following bariatric surgery. Extended chemoprophylaxis to prevent PVT has been advocated by some, but patient selection, effectiveness, and duration of therapy have been unclear [7,8].

Based on our findings and the relevant literature, we have several recommendations. First, use low-molecular-weight heparin chemoprophylaxis preoperatively and postoperatively during hospitalization for all bariatric surgery patients because it is more effective than unfractionated heparin and

Table 1
Risk factors and associated incidence of PVT among patients undergoing bariatric surgery in Michigan between June 2006 and November 2021

Risk factor	PVT incidence (%)		Relative risk	95% CI	*P* value
	With risk factor	Without risk factor			
Procedure type					
Gastric bypass	.02	.16	.14	.07–.30	<.0001
Sleeve gastrectomy	.18	.02	9.96	4.86–20.43	<.0001
Adjustable gastric band	0	.13	.04	0–.59	.0198
BPD/DS	.13	.11	1.18	.17–8.48	.5725
Surgical approach					
Open	0	.12	.26	.02–4.28	.3503
Laparoscopic	.11	.16	.71	.37–1.36	.3042
Robotic	.21	.11	1.91	1.00–3.64	.0473
Operative time					
>Median time (79 min)	.09	.14	.66	.45–.95	.0263
>75th percentile (110 min)	.07	.13	.51	.31–.86	.0098
Patient characteristics					
Age category, yr					
<30	.09	.12	.78	.39–1.53	.4657
≥30 and <40	.14	.11	1.28	.86–1.90	.2201
≥40 and <50	.13	.11	1.2	.82–1.77	.3435
≥50 and <60	.11	.11	1.01	.66–1.54	.9724
≥60	.05	.12	.39	.17–.89	.0198
BMI category, kg/m^2					
<40	.07	.12	.61	.33–1.10	.0985
≥40 and <50	.13	.09	1.47	1.01–2.12	.0419
≥50 and <60	.10	.12	.79	.51–1.23	.2992
≥60	.12	.11	1.05	.55–2.00	.8876
Male sex	.14	.11	1.36	.90–2.05	.1441
Private insurance	.12	.10	1.14	.74–1.75	.5592
Current or past smoker	.10	.12	.83	.57–1.21	.3295
Race					
White	.10	.10	1.03	.63–1.69	.9029
Black	.13	.10	1.33	.78–2.27	.2956
Other	.05	.11	.47	.17–1.30	.1367
Co-morbidities					
History of prior VTE	.38	.10	3.76	2.25–6.30	<.0001
Hypertension	.10	.13	.72	.50–1.04	.0793
Hyperlipidemia	.08	.14	.55	.37–.81	.0022
Diabetes	.09	.13	.67	.44–1.02	.0596
Gastroesophageal reflux	.13	.10	1.29	.90–1.87	.1663
Sleep apnea	.11	.12	.91	.63–1.31	.6166
Coronary artery disease	.05	.12	.44	.14–1.40	.1533
Cerebrovascular disease	.10	.13	.79	.55–1.13	.1973
Peripheral vascular disease	.22	.11	2.01	.82–4.93	.1190
Urinary incontinence	.07	.12	.52	.29–.95	.0315
Kidney disease	0	.11	.75	.05–11.97	.8357
Liver disorder	.22	.10	2.09	1.31–3.37	.0017
Peptic ulcer disease	.10	.11	.85	.27–2.69	.7883
Cholelithiasis	.10	.12	.85	.55–1.30	.4432
Psychological disorder	.12	.11	1.11	.77–1.60	.5817
Musculoskeletal disorder	.10	.14	.7	.48–1.03	.0669
Mobility limitations	.19	.11	1.69	.89–3.24	.1705
Complications					
Leak or perforation	1.22	.11	11.28	4.58–27.78	.0001
Hemorrhage	.81	.10	7.93	4.45–14.15	<.0001
Obstruction	.54	.11	4.89	1.99–12.01	.0044
Infection	.29	.11	2.63	1.07–6.45	.0472

PVT = portomesenteric vein thrombosis; CI = confidence interval; BPD/DS = biliopancreatic diversion with duodenal switch; BMI = body mass index; VTE = venous thromboembolism.

Table 2
Independent predictors for PVT based on hierarchical logistic regression among patients undergoing bariatric surgery in Michigan between June 2006 and November 2021

Risk factor	% No PVT (n = 102,752)	% PVT (n = 117)	Odds ratio	95% CI	*P* value
Hyperlipidemia	46.6	32.5	.6	.38–.95	.0293
Liver disorder	9.4	18.0	2.3	1.36–4.00	.0021
History of prior VTE	4.3	14.5	3.1	1.64–5.98	.0005
Hemorrhage	1.6	11.1	7.6	3.57–16.06	<.0001
Leak or perforation	.4	4.3	7.9	2.76–22.64	.0001
Obstruction	.9	4.3	12.5	4.65–33.77	<.0001
Sleeve gastrectomy	57.8	93.2	12.4	4.98–30.69	<.0001

PVT = portomesenteric vein thrombosis; CI = confidence interval; VTE = venous thromboembolism.

confers no increased risk for bleeding [23]. Second, use a bariatric-specific overall VTE risk calculator to determine patient-specific intensity and duration of postoperative chemoprophylaxis [16,17]. The MBSC Weigh the Odds application contains a VTE risk calculator and is freely available on both iOS and Android platforms. Third, prescribe postdischarge chemoprophylaxis for patients at increased overall risk. We prefer to use the cutoff of 1% for high-risk patients, which incorporates 3.3% of bariatric surgery patients in Michigan. Fourth, if patients have <1% risk but have more than one independent predictor for PVT, consider prescribing postdischarge chemoprophylaxis. This includes any patient undergoing SG who has 1 or more of the following: prior VTE or hypercoagulability, severe liver fibrosis or nonalcoholic steatohepatitis cirrhosis, and a serious surgical complication. Finally, if it is decided to use postoperative chemoprophylaxis, extend the duration of therapy through the first postoperative month because >50% of PVTs occur during the third and fourth postoperative weeks. Further investigation regarding the potential role of statin therapy to reduce the risk of PVT is needed.

Our study has several limitations. First, the findings of this study may not be generalizable to patients or hospitals outside the state of Michigan. Quality improvement initiatives with standardized VTE MBSC chemoprophylaxis guidelines are used by 90% of bariatric surgeons in the state of Michigan and may lead to lower rates of PVT [12]. Second, only symptomatic patients with PVT were identified for the purposes of this study. Although some patients with PVT may have been missed, all clinically significant PVTs were captured. Third, only patients with PVT that presented initially within 30 days of their bariatric surgery were included. Although some patients were missed, most patients with PVT present within the first month following bariatric surgery.

Conclusion

PVT after bariatric surgery is uncommon but associated with high mortality. These events occur most commonly after SG, but other risk factors include a prior history of VTE, liver disease, and experiencing a serious postoperative complication. Extended VTE prophylaxis should be considered in patients undergoing SG who have at least 1 additional risk factor. Given that the incidence of PVT occurs most commonly within the first month after surgery, extending postdischarge chemoprophylaxis during this time frame should be considered for patients with increased risk.

Disclosures

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