

Bariatric and general surgical procedures in obese patients with a history of venous thromboembolism and concurrent anticoagulation therapy

Cirugía general y bariátrica en pacientes obesos con antecedentes de tromboembolia venosa y tratamiento anticoagulante concomitante

Raelina S. Howell^{1,2}, Helen H. Liu^{1,2}, Barbara M. Brathwaite³, Patrizio Petrone^{1,2*}, Meredith Akerman⁴, and Collin E. M. Brathwaite^{1,2}

¹Department of Surgery, NYU Langone Hospital–Long Island; ²Department of Surgery, NYU–Long Island School of Medicine, Mineola; ³School of Nursing, Stony Brook University, Stony Brook; ⁴Division of Health Services Research, NYU Long Island School of Medicine, Mineola. New York, USA

Abstract

Objective: The objective of this study was to examine the use and outcomes of perioperative anticoagulation (AC) in obese patients with a known history of venous thromboembolism event (VTE). **Method:** A retrospective review of a prospective database for patients with a VTE history undergoing bariatric and general surgery at a single center (1/2008-12/2017) was performed. Factors assessed included demographics, surgical details, and outcomes. **Results:** Sixty-five patients underwent 76 procedures: 46 females (71%); mean age 51 years (range 26-73), mean weight 284 pounds (range 110-558), mean body mass index 45 (range 19-87). Comorbidities include hypertension (60%), gastroesophageal reflux disease (54%), osteoarthritis (49%), obstructive sleep apnea (45%), and diabetes (37%). Operations: 22 general surgeries (29%), 20 sleeve gastrectomies (26%), 12 revisions/conversions (16%), 12 Roux-en-Y gastric bypasses (16%), and 10 gastric bands (13%). Modalities: 67% laparoscopic, 28% robotic, and 5% open. Twenty-two patients (34%) had a pre-operative inferior vena cava filter placed with no complications. The mean length of stay was 4.4 days (range 1-31). Complications: seven 30-day readmissions (9%), one 30-day reoperation (1%), and two 90-day VTEs (3%). Thirty-day readmissions: four for inability to tolerate PO, two for small bowel obstruction, and one for symptomatic anastomotic ulcer. **Conclusions:** In our patients, post-operative AC could be started without an increased risk of bleeding in patients with a history of VTE undergoing bariatric surgery.

Keywords: Anticoagulation. Bariatric surgery. Deep vein thrombosis. Morbid obesity. Pulmonary embolism.

Resumen

Objetivo: Examinar el uso y los resultados de la anticoagulación perioperatoria en pacientes bariátricos con antecedentes de tromboembolia venosa (TEV). **Método:** Revisión retrospectiva (base de datos prospectiva) de pacientes sometidos a cirugía general y bariátrica (1/2008-12/2017). Se evaluaron datos demográficos, detalles quirúrgicos y resultados. **Resultados:** Sesenta y cinco pacientes se sometieron a 76 procedimientos: 46 mujeres (71%), edad media 51 años (rango: 26-73), peso medio 284 libras (rango: 110-558), índice de masa corporal medio 45 (rango: 19-87). Comorbilidad: hipertensión (60%), enfermedad por reflujo gastroesofágico (54%), osteoartritis (49%), apnea obstructiva del sueño (45%), diabetes (37%). Operaciones: 22 cirugía general (29%), 20 gastrectomías en manga (26%), 12 revisiones/conversiones (16%), 12 Y-de-Roux (16%),

*Correspondence:

Patrizio Petrone

E-mail: patrizio.petrone@nyulangone.org

Date of reception: 12-04-2023

Date of acceptance: 03-10-2023

DOI: 10.24875/CIRU.23000190

Cir Cir. 2024;92(4):475-480

Contents available at PubMed

www.cirugiaycirujanos.com

0009-7411/© 2023 Academia Mexicana de Cirugía. Published by Permanyer. This is an open access article under the terms of the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

10 bandas gástricas (13%). Modalidades: 67% laparoscópica, 28% robótica, 5% abierta. A 22 pacientes (34%) se les colocó un filtro de vena cava inferior preoperatorio sin complicaciones. La estancia media fue de 4.4 días (rango: 1-31). Complicaciones: 7 reingresos a los 30 días (9%), 1 reoperación a los 30 días (1%), 2 TEV a los 90 días (3%). Reingresos a los 30 días: 4 por incapacidad para tolerar la vía oral, 2 obstrucciones de intestino delgado y 1 úlcera anastomótica sintomática. **Conclusiones:** En nuestros casos, la anticoagulación posoperatoria pudo iniciarse sin aumento del riesgo de sangrado en pacientes con antecedentes de TVE sometidos a cirugía bariátrica.

Palabras clave: Anticoagulación. Cirugía bariátrica. Trombosis venosa profunda. Obesidad mórbida. Embolia pulmonar.

Introduction

Bariatric patients are at an increased risk of venous thromboembolism events (VTE) due to a combination of factors, such as high body mass index (BMI), immobility, weight-related ventilation disorders (i.e., obstructive sleep apnea [OSA] and obesity hypoventilation syndrome), and venous stasis disease^{1,2}. The dilemma is with respect to the concurrent prevention of VTE while avoiding bleeding events for bariatric patients undergoing major operations. Current literature reports the incidence of 30-day post-operative, symptomatic VTE in the bariatric population as 0.4% and 0.42% in the 90-day post-operative period^{3,4}. Furthermore, VTE incidence following bariatric procedures ranges from 1% to 5.4% and < 1% for laparoscopic procedures¹. Despite a low incidence of VTE following bariatric procedures, autopsies performed on 10 post-bariatric patients revealed pulmonary embolism (PE) as the cause of death in 30% of the patients⁵. While no exact epidemiological data are available, the incidence of PE is estimated at 60-70/100,000, and that venous thrombosis is approximately 124/100,000 of the general population⁶, emphasizing the high prevalence of both fatal and non-fatal VTEs. A 2018 study reviewing the impact of bariatric surgery complications on clinical outcomes suggests that initiatives focused on reducing post-operative VTE have the greatest potential to lower mortality and readmission after bariatric surgery⁷.

Chemoprophylaxis of VTE must be balanced with the inhibition of hemorrhagic events. A recent article reviewing patients with chronic anticoagulation (AC) undergoing bariatric procedures found patients to be at higher than average risk for post-operative complications and readmissions⁸. The authors state that attention to AC protocols and operative technique is necessary to decrease perioperative risk in this population. A meta-analysis of 19 studies found a weighted mean incidence of major bleeding in 2% with weight-adjusted, prophylactic heparin⁹. Optimal perioperative AC and the resulting occurrence of post-operative bleeding events or acute

thrombotic events in patients with a known history of VTE have not been well-established. We hypothesize that there is a very low risk of bleeding complications in bariatric patients with a history of VTE. Therefore, the goal of this study was to examine the use and outcomes of perioperative AC in obese patients with a known history of VTE, undergoing bariatric and general surgical procedures at a Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program Center of Excellence.

Material and methods

After approval of our Institutional Review Board approval was obtained, our prospective database was retrospectively reviewed for patients with a VTE history who underwent primary and secondary bariatric and non-bariatric procedures from January 2008 through December 2017. Independent demographic variables included age, gender, weight, and BMI. Examined comorbidities included diabetes, hypertension (HTN), gastroesophageal reflux disease (GERD), osteoarthritis (OA), and OSA. The surgical details include procedure type, modality, presence of inferior vena cava filter (IVCF), and perioperative AC. Outcomes were reported as the length of stay (LOS), 30-day readmission, 30-day reoperation, 30-day and 90-day VTE, bleeding events, and mortality.

The prophylactic protocol used at this institution included the use of 5000 units of low molecular weight heparin (LMWH) given subcutaneously preoperatively in combination with bilateral lower-extremity intermittent pneumatic compression unless the patient had a contraindication such as lymphedema. Patients were encouraged to ambulate 3-4 h following extubation and every 3-4 h while admitted. Patients with a BMI > 50 kg/m² were also discharged with 40 mg subcutaneous post-operative enoxaparin sodium twice daily for 14 days. If a patient was taking therapeutic doses of AC, for example, warfarin or apixaban, discussions with the prescribing physician and recommendations for

perioperative AC were made. The patients were instructed to discontinue the use of home AC preoperatively for a pre-determined number of days (e.g., clopidogrel held 10 days before surgery) and use subcutaneous enoxaparin sodium until the morning of surgery. Postoperatively, full AC with subcutaneous enoxaparin sodium based on weight was resumed after 48 h to a maximum of 100 mg/kg. This was continued until the recommencement of the patient's home medication. For patients with a BMI > 60 kg/m², vascular surgery consultation was obtained for the evaluation of potential placement of a prophylactic IVCF. Patients who refused IVCF were treated with AC through enoxaparin sodium as noted above. Oral contraceptive pills were held 1 month before and 1 month following surgery. Smoking cessation was required for 6 weeks before primary bariatric procedures and confirmatory testing was performed using carboxyhemoglobin and nicotine levels. Patients with a known hypercoagulable state were referred to hematology for evaluation and recommendations before surgery. Non-compliant patients did not undergo elective operations.

Statistical analysis

Descriptive statistics were calculated for the overall sample. Data are reported as mean ± SD (range) for continuous variables and frequency (%) for categorical variables.

Results

Patient demographics

Sixty-five patients underwent 76 surgical procedures over the 10-year period. Table 1 shows the baseline demographic data of patients who underwent primary and secondary bariatric procedures between 2008 and 2017. Of these, the majority were female (71%) and the mean age for all patients was 51 years (range 26-73 years). The average BMI was 44.8 kg/m² (range 20.0-87.0 kg/m²), and the average weight in pounds was 284 with a range of 110-558. Most patients were noted to have class III obesity, with a BMI > 40.0 kg/m². The following co-morbidities were identified: HTN (n = 39; 60%), GERD (n = 35; 53.8%), OA (n = 32; 49.2%), OSA (n = 29; 44.6%), and diabetes mellitus (n = 24; 36.9%). Of the 54 patients who underwent bariatric procedures, 22 (41%) had pre-operative IVCF in place. The range in time of placement

Table 1. Patient demographics

Variable	n = 65 (%)
Gender	
Female	46 (71)
Male	19 (29)
Age, years	51.0 ± 12.2* (26-73)
Caucasian	160 (76.9)
BMI	44.6 ± 11.6* (20-87)
< 30.0	6 (9.2)
30.0-39.9	13 (20)
40.0-49.9	28 (43.1)
50.0-59.9	12 (18.5)
≥ 60.0	6 (9.2)
Weight, pounds	284.0 ± 89.2* (110-558)
Therapeutic AC [†]	15.0 (23.1)
Co-morbidities	
OSA	29 (45)
HTN	39 (60)
GERD	35 (54)
OA	32 (49)
DM	24 (37)
IVCF [‡]	22 (33.8)

*Data are reported as mean ± SD (range) for continuous and frequency (%) for categorical measures. [†]AC: anticoagulation; includes warfarin, rivaroxaban, enoxaparin sodium, and apixaban. [‡]IVCF: inferior vena cava filter; pre-operative; BMI: body mass index; OSA: obstructive sleep apnea; HTN: hypertension; GERD: gastroesophageal reflux disease; OA: osteoarthritis; DM: diabetes mellitus.

before the surgery spanned from 16 years (for a remote history of VTE) up to 5 days preoperatively. Six were placed specifically for VTE prophylaxis before surgery (mean 17-day preoperatively). Fifteen patients (23%) were on therapeutic pre-operative AC; agents included warfarin, rivaroxaban, enoxaparin sodium, and apixaban.

Operative details

Overall patients underwent procedures that included herniorrhaphy (hiatal, internal, umbilical, ventral, and incisional), adhesiolysis, cholecystectomy, repair of intestinal perforation, and colon resection (total n = 76). Table 2 illustrates the operative details of the 76 cases performed.

A minimally invasive approach was used in 95% of the cases with no conversions to open. The mean LOS was 4.4 days (1-31 days). The data were further stratified into patients who underwent bariatric procedures (n = 65). Of the 42 primary bariatric procedures performed, 15 patients had a pre-operative IVCF in place,

Table 2. Operative details of the studied cohort

Variable	n = 76 (%)
General Surgery	22 (29)
Gastric Band	10 (13)
Sleeve Gastrectomy	20 (26)
Roux-en-Y Bypass	12 (16)
Revision/Conversion	12 (16)
Modality	
Laparoscopic	51 (67)
Robot-assisted	21 (28)
Open	4 (5)

Table 3. Post-operative outcomes of the studied cohort

Variable	n = 76 (%)
LOS (day)	4.4 ± 7.1* (1-31)
	n (%)
VTE	
30-day	0 (0)
90-day	2 (2.6)
30-day readmissions	7 (9)
30-day reoperations	1 (1)
Conversion to open	0 (0)
Bleeding event	0 (0)
Mortality	0 (0)

LOS: length of stay; VTE: venous thromboembolism event.

with six placed specifically for VTE prophylaxis before surgery (mean 17-day preoperatively). No IVCF-related complications occurred. Thirty-day complications included seven readmissions (9%). Four readmissions were for inability to tolerate oral (PO) intake, two were for small bowel obstruction, and one was for a symptomatic anastomotic ulcer evidenced by syncope secondary to anemia. The patient with a symptomatic ulcer had a suspected bleeding event but was never confirmed during the workup. There were no other bleeding events that occurred. All readmitted cases were managed nonoperatively with esophagogastroduodenoscopy or placement of a nasogastric tube as indicated. No mortalities or reoperations occurred. All bariatric patients who had a pre-operative IVCF received pre-operative heparin and those who were started on post-operative enoxaparin sodium within 24 h, were discharged on it with no bleeding complications or readmissions. Of the 15 patients that were on home AC, 11 (73%) received post-operative enoxaparin or heparin and were discharged on the former, while the remainder were discharged on their prior home regimen. No readmissions or bleeding events were noted in this group.

Of the 76 patients in the cohort, the occurrence of 30- and 90-day clinically significant VTEs was zero and two (2.6%), respectively. Of the two patients readmitted for 90-day VTE, both were bariatric cases. One was a laparoscopic Roux-en-Y and the second was a laparoscopic gastric banding procedure (Table 3). Both patients were Caucasian; the former was a 63-year-old female, with a BMI of 54 kg/m² and the second patient was a 61-year-old male, with a BMI of 37 kg/m². One patient had an IVCF placed preoperatively secondary to her habitus, and the second patient had an IVCF placed after thrombectomy for the

DVT in the lower extremity on readmission. The female patient had a history of a DVT and received pre-operative heparin per institution protocol but to our knowledge was not on any home AC. Both patients received post-operative enoxaparin sodium.

Discussion

While the incidence is low, PE is the most common cause of post-discharge mortality after bariatric surgery and is a feared complication¹⁰. Bariatric surgery patients are at least at moderate risk of thromboembolism and ideally should be started on combined mechanical and pharmacological prophylaxis¹¹. This study aimed to evaluate the incidence of VTE in a single institution population cohort to better assess the optimal timing of AC treatment in patients with a history of VTE and the risk of occurrence of post-operative hemorrhagic events. Several risk factors must be taken into account when planning the ideal perioperative VTE prophylaxis, including a history of prior VTE². The American Society for Metabolic and Bariatric Surgery (ASMBS) released an updated statement on VTE prophylaxis in the bariatric surgery population, which states the lack of class I evidence to provide guidance². However, nine recommendations were given which include mechanical prophylaxis and early ambulation for all bariatric surgery patients; a combination of mechanical and chemoprophylaxis based on clinical judgment and bleeding risk; LMWH may offer better VTE prophylaxis than unfractionated heparin without increasing bleeding risk – though the evidence is conflicting; the use of IVCFs should be used in conjunction with chemical and mechanical prophylaxis in select high-risk patients. The authors

also stated that most VTE events occur in the first 30 days after discharge. However, there was not enough evidence to recommend a specific duration of prophylaxis extension. The ASMBs also states that individual practices developed and adhered to prophylactic protocols show a reduction in the incidence of VTE complications.

In 2012, the American College of Chest Physicians released evidence-based clinical practice guidelines with respect to the prevention of VTE in non-orthopedic surgical patients¹². Recommendations for mechanical or chemical prophylaxis for patients undergoing bariatric surgery were stratified by the patients' risk of thrombotic events. Virtually all bariatric patients are categorized as moderate risk and some even high depending on other co-morbidities. Moderate-risk patients are placed on either LMWH or mechanical prophylaxis. High-risk patients without a high risk of bleeding are placed on either AC in addition to mechanical prophylaxis. If there is a significant risk of major bleeding complications, mechanical prophylaxis is preferred until the risk of bleeding diminishes and pharmacologic prophylaxis may be initiated. The use of IVCF as a primary VTE prophylaxis was not recommended. No level 1 evidence was provided for optimal perioperative AC bridging for patients on prior therapeutic AC. In essence, the choice of prophylaxis should be determined based on the provider's individual risk assessment of the patient.

A 2013 study evaluated the prevalence of in-hospital VTE among post-bariatric surgery patients¹³. PE was diagnosed in 0.9% and DVT without PE was found in 1.3% of patients. IVCF was placed in 0.3% of all patients who underwent bariatric procedures and in 10.5% of patients with a VTE. The authors were unable to determine if the filters were placed before or after the development of the VTE. Of note, the in-hospital mortality of patients with a PE and an IVCF was 3.9% compared to 2.7% of those with a PE and no filter (not a statistically significant difference). Conversely, of patients with a DVT, in-hospital mortality was 0% with a filter and 1.3% without ($p = 0.009$), suggesting a potential propensity for patients with DVT. In comparison, a 2010 study found that IVCF did not reduce the incidence of post-operative VTE or mortality and that 57% of patients with an IVCF place experienced a fatal PE or complication related to the filter itself¹⁴. However, due to the relatively rare incidence of post-operative VTE, the lack of statistical power to demonstrate significant harm related to IVCF is a confounding variable.

Prophylactic planning in obese patients remains unstandardized. A single academic institution demonstrated effective risk reduction with the implementation of VTE prophylactic protocols for patients who underwent bariatric surgery¹⁵. Before the protocol, VTE and bleeding occurred in 1.6%, respectively. After protocol initiation, the incidence of VTE decreased to zero. Post-operative bleeding events increased to 2.7%; however, the incidence of severe bleeding, defined as requiring blood transfusion or re-operation, only occurred in 1.6% of the post-protocol group, which was no different than the pre-protocol incidence.

At our institution, VTE incidence was 2.6% ($n = 2$), which is higher than the stated literature. Given the small sample size, an overestimate of the magnitude is not unexpected. We also assume the degree of adherence to VTE prophylaxis is consistent but can contribute to increased incidence. Aminian et al.¹⁶ aimed to generate a risk calculator for post-discharge VTE events in patients undergoing primary and revisional bariatric surgery. The study found that patients who developed post-discharge VTE as compared to those with no VTE were black, male, had higher BMI, increased age, and had a high prevalence of the following medical conditions at baseline: congestive heart failure, peripheral vascular diseases, paraplegia, and chronic obstructive pulmonary disease. Both of our patients had factors that placed them at higher risk including age > 60 years, male sex, and super-obesity ($BMI \geq 50\text{kg/m}^2$). Bariatric centers can decide whether to be conservative or aggressive when considering extended pharmaco-prophylaxis in the setting of patients with a history of VTE, keeping in mind the potential benefits and complications of the available medication options. The question of choosing a stop point on estimated post-discharge VTE to guide extended pharmaco-prophylaxis should be considered. Particularly, patients with a prior history of VTE are at higher risk of reoccurrence and may warrant extended therapy.

The next question begs how to adequately carry out which AC for the bariatric patient. A large literature review by Huo and Muntz showed that LMWH was efficacious and associated with lower rates of clinically relevant bleeding complications¹⁷. LMWH has a longer half-life, carries less risk for heparin-induced thrombocytopenia, and has similar rates of post-operative hemorrhage when compared to unfractionated heparin (1.6%)¹⁸. Our study results support this; most patients were started on post-operative AC within 12 h

or bridged to their home reagent. There were no clinically significant bleeding events.

Post-discharge VTE in bariatric patients need prophylaxis. It is reasonable to consider a pre-operative risk assessment and stratify patients based on a calculated VTE risk. The likelihood of post-operative bleeding should be taken into consideration; from our study results, we support the resumption of full AC. Those with a prior VTE and other subset higher risk populations may benefit from extension pharmaco-prophylaxis.

Conclusions

Obese patients with a history of VTE can undergo bariatric and general surgical procedures with a low incidence of post-operative VTE or bleeding events. While the overall incidence rate is low, clinically fatal VTE is a single cause of mortality easily amenable to reduction by a systematic change in practice. Therefore, each institution should implement a VTE prophylaxis protocol to decrease the occurrence of clinically significant DVT and PE. The choice of prophylaxis should be based on the specific assessment of each patient's risk for VTE or bleeding; however, LMWH has generally been shown to be superior. Post-operative AC can be started within 12 h of surgery and patients at high risk should be considered for extension pharmaco-prophylaxis. Further prospective studies are needed to consider the optimal dose, time, and frequency of VTE post-discharge prophylaxis.

Funding

This research did not receive any external or internal funding.

Conflicts of interest

The authors declare to have no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data and informed consent was not required for this retrospective observational study.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

References

- Gomes RM. Perioperative Venous Thromboembolism Prophylaxis After Bariatric Surgery. *Bariatric Surgical Practice Guide*. Singapore: Springer Singapore; 2017. p. 157-65.
- American Society for Metabolic and Bariatric Surgery Clinical Issues Committee. ASBMS updated position statement on prophylactic measures to reduce the risk of venous thromboembolism in bariatric surgery patients. *Surg Obes Relat Dis*. 2013;9:493-7.
- Longitudinal Assessment of Bariatric Surgery (LABS) Consortium, Flum DR, Belle SH, King WC, Wahed AS, Berk P, et al. Perioperative safety in the longitudinal assessment of bariatric surgery. *N Engl J Med*. 2009;361:445-54.
- Winegar DA, Sherif B, Pate V, DeMaria EJ. Venous thromboembolism after bariatric surgery performed by Bariatric Surgery Center of Excellence Participants: analysis of the Bariatric Outcomes Longitudinal Database. *Surg Obes Relat Dis*. 2011;7:181-8.
- Melinek J, Livingston E, Cortina G, Fishbein MC. Autopsy findings following gastric bypass surgery for morbid obesity. *Arch Pathol Lab Med*. 2002;126:1091-5.
- Oger E. Incidence of venous thromboembolism in a community-based study in western France. *Thromb Haemost*. 2000;83:657-60.
- Daigle CR, Brethauer SA, Tu C, Petrick AT, Morton JM, Schauer PR, et al. Which postoperative complications matter most after bariatric surgery? Prioritizing quality improvement efforts to improve national outcomes. *Surg Obes Relat Dis*. 2018;14:652-7.
- Sharma G, Hanipah ZN, Aminian A, Panchai S, Bucak E, Schauer PR, et al. Bariatric surgery in patients on chronic anticoagulation therapy. *Obes Surg*. 2018;28:2225-32.
- Becattini C, Agnelli G, Manina G, Noya G, Rondelli F. Venous thromboembolism after laparoscopic bariatric surgery for morbid obesity: clinical burden and prevention. *Surg Obes Relat Dis*. 2012;8:108-15.
- Froehling DA, Daniels PR, Mauck KF, Collazo-Clavell ML, Ashrani AA, Sarr MG, et al. Incidence of venous thromboembolism after bariatric surgery: a population-based cohort study. *Obes Surg*. 2013;23:1874-9.
- Jamal MH, Corcelles R, Shimizu H, Kroh M, Safdie FM, Rosenthal R, et al. Thromboembolic events in bariatric surgery: a large multi-institutional referral center experience. *Surg Endosc*. 2014;29:376-80.
- Gould MK, Garcia DA, Wren SM, Karanicolas PJ, Arcelus JI, Heit JA, et al. Prevention of VTE in non-orthopedic surgical patients. *Chest*. 2012;141:e227S.
- Stein PD, Matta F. Pulmonary embolism and deep venous thrombosis following bariatric surgery. *Obes Surg*. 2013;23:663-8.
- Birkmeyer N, Share D, Baser O, Carlin AM, Finks JF, Pesta CM, et al. Preoperative placement of inferior vena cava filters and outcomes after gastric bypass surgery. *Ann Surg*. 2010;252:313-8.
- Hill AA, Theprungsirikul PP, Quigley MT, Menduni ME, Trus TL, Adriaes GL, et al. Thromboprophylaxis in patients undergoing bariatric surgery. *Blood*. 2015;126:2080.
- Aminian A, Andalib A, Khorgami Z, Cetin D, Burguera B, Bartholomew J, et al. Who should get extended thromboprophylaxis after bariatric surgery? A risk assessment tool to guide indications for post-discharge pharmacoprophylaxis. *Ann Surg*. 2017;265:143-50.
- Huo MH, Muntz J. Extended thromboprophylaxis with low-molecular-weight heparins after hospital discharge in high-risk surgical and medical patients: a review. *Clin Ther*. 2009;31:1129-41.
- Birkmeyer NJ, Finks JF, Carlin AM, Chengelis DL, Krause KR, Hawasli AA, et al. Comparative effectiveness of unfractionated and low-molecular-weight heparin for prevention of venous thromboembolism following bariatric surgery. *Arch Surg*. 2012;147:994-8.