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Review article

Venous thromboembolism after laparoscopic bariatric surgery for morbid obesity: clinical burden and prevention

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Abstract

Background: The clinical benefit of prophylaxis for venous thromboembolism (VTE) in laparoscopic bariatric surgery is unclear. Our objective was to assess the clinical burden of VTE after laparoscopic bariatric surgery.

Methods: We performed a systematic review and meta-analysis. Studies were considered for the review if they reported on the methods used for antithrombotic prophylaxis and on the incidence of objectively confirmed VTE in patients who had undergone laparoscopic bariatric surgery.

Results: Overall, 19 studies were included in the analysis. The weighted mean incidence (WMI) of pulmonary embolism was .5% (12 events in 3991 patients, 12 studies; 95% confidence interval [CI] .2–.9%; I^2 38%) with unfractionated heparin (5000 UI twice or 3 times daily) or low-molecular-weight heparin (30 mg twice daily or 40 mg once daily). The WMI of major bleeding as originally reported in 7 of these studies was 3.6% (2741 patients; 95% CI .9–7.95; I^2 94%). The WMI of screened VTE in 3 high-quality studies with different regimens of heparin prophylaxis was 2.0% (8 events in 458 patients; 95% CI .9–3.5%; I^2 0%). The WMI of symptomatic VTE was .6% (4 studies; 7 events in 1328 patients; 95% CI .3–1.1%; I^2 0%) and that of major bleeding was 2.0% (95% CI 1.0–3.4%; I^2 55%), with weight-adjusted doses of heparin prophylaxis.

Conclusion: The rate of VTE after laparoscopic bariatric surgery seems to be relatively low with standard regimens for antithrombotic prophylaxis. The incidence of major bleeding seems to increase using weight-adjusted doses of heparin with no advantage in terms of VTE reduction. (Surg Obes Relat Dis 2012;8:108–115.)

Keywords: Bariatric surgery; Venous thromboembolism; Antithrombotic prophylaxis

Obesity (body mass index >25 kg/m^2) and morbid obesity (body mass index ≥40 kg/m^2) are associated with an increased risk of premature death and disability, and their prevalence is increasing in the United States [1,2]. Efficient strategies for weight loss are essential for subjects with a body mass index >25 kg/m^2 [2]. Surgery is the most effective strategy to achieve meaningful and sustainable weight loss [3]. Despite the advances in bariatric surgery, it remains a technically difficult operation performed on high-risk patients. The reported incidence of pulmonary embolism in open bariatric surgery varies from 0% to 3.4% [4], with the incidence .9% in the era of inconsistent or no heparin prophylaxis and .6% after the introduction of routine heparin prophylaxis [5]. The introduction of the laparoscopic approach to bariatric surgery dramatically reduced the incidence of wound complications from 20% to 25% to approximately 1%, as well as that of pulmonary complications [6,7]. Whether the laparoscopic approach is associated with a reduced risk of venous thromboembolism (VTE) in patients undergoing bariatric surgery is unknown.

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Similarly, the optimal strategy for the prevention of VTE in this setting remains uncertain [8]. The European Association for Endoscopic Surgery recommends intraoperative intermittent pneumatic compression for all prolonged laparoscopic procedures [9]. The Society of American Gastrointestinal Endoscopic Surgeons recommends the same thromboprophylaxis options as for the equivalent open surgery procedure [10].

We performed a systematic review and meta-analysis aimed at assessing the incidence of VTE after laparoscopic bariatric surgery for morbid obesity with currently used regimens of antithrombotic prophylaxis.

Methods

The protocol for the present review was defined by detailing the specific study objectives, criteria for study selection and assessment of study quality, study outcomes, and statistical methods.

Study objectives

The objectives of the present analysis was to assess the incidence of VTE (deep vein thrombosis of the lower limbs and/or pulmonary embolism) and, whenever possible, the clinical benefit (efficacy and safety) of antithrombotic prophylaxis after laparoscopic bariatric surgery.

Study identification and selection

We performed a systematic unrestricted search using the MEDLINE and EMBASE electronic databases until March 24, 2011, with the purpose of identifying all published studies on the incidence of VTE and the benefit of antithrombotic prophylaxis after laparoscopic bariatric surgery for morbid obesity. The search criteria included the terms "bariatric surgery AND venous thromboembolism" OR "bariatric surgery AND venous thrombosis." The reference lists of the retrieved reports and review studies were reviewed manually to identify additional studies. Only full reports were considered for analysis.

One of us (C. B.) performed the electronic search and listed the reports that were eligible for inclusion in our study. Study selection was initially performed by a review of the titles and abstracts. Candidate abstracts were then reviewed and selected for data retrieval.

Study selection

Two reviewers (F. R., G. M.) performed the study selection independently, with disagreements resolved through discussion with a third reviewer (G. A.), if necessary. Studies were considered for the present analysis provided that (1) they included patients who had undergone laparoscopic bariatric surgery for morbid obesity; (2) the incidence of postoperative VTE (deep vein thrombosis of the lower limbs or pulmonary embolism) was reported; and (3) the regimen for antithrombotic prophylaxis was specified.

To assess the agreement between reviewers for study selection, the kappa (κ) statistic, which measures agreement beyond chance, was used [11].

Study quality assessment

Three of us (C. B., F. R., G. M.) independently completed the assessment of study quality. The quality of the randomized controlled trials and observational studies was assessed separately. The quality of the observational studies was assessed using a specific checklist consistent with the consensus recommendations by the Meta-Analysis of Observational Studies in Epidemiology group [12]. Case-control studies and observational studies could be included if they had a high level of quality. The studies were assessed for the presence of 5 features: a description of patient characteristics, a description of the inclusion and exclusion criteria, potential selection bias, completeness of follow-up, an a priori definition of study outcomes, and a description of study events during the follow-up period.

Data extraction

The following data were extracted independently by 2 reviewers using standardized extraction forms:

- Study: year of publication, design, duration of follow-up, number of patients included
- Surgery: type of intervention, duration of surgery
- Antithrombotic prophylaxis: mechanical and/or pharmacologic; anticoagulant agent: unfractionated heparin (UFH) or low-molecular-weight heparin (LMWH), regimen (once daily, twice daily, three times daily)
- Postoperative VTE screening: objective test (venography or compression ultrasonography), timing of VTE screening
- Endpoints: number and type of VTE, number and type of major bleeding

Study outcomes

For the purposes of our analysis, confirmed VTE (symptomatic or asymptomatic deep vein thrombosis or pulmonary embolism) qualified as the study outcome. Bleeding was considered major using to the criteria reported in the individual studies. An additional analysis was performed after reassessing the major bleeding events according to the criteria suggested by the International Society of Thrombosis and Haemostasis (ISTH) [13].

Quantitative data synthesis

The weighted mean incidence (WMI) of VTE was calculated in different subgroups of the studies [14]. Pooled odds ratios and 95% confidence intervals (CIs) were calculated to test the efficacy of antithrombotic prophylaxis. The data were pooled using a fixed-effects model and a random-effects model. Statistical between-study heterogeneity was

evaluated by the I^2 statistic, which assesses the appropriateness of pooling individual study results, or Cochran's chi-square test, as appropriate [15]. I^2 >50% and/or $P < .05$ were considered to denote statistically significant heterogeneity. The presence of publication bias was investigated using funnel plots [16].

Results

The computerized search for "venous thrombosis AND laparoscopic bariatric surgery" OR "venous thromboembolism AND laparoscopic bariatric surgery" identified 129 potentially eligible reports overall. Of these studies, 93 were excluded after screening the titles and abstracts using the predefined inclusion and exclusion criteria. The remaining 36 studies were retrieved for full text examination. Of these, 20 were excluded because they were studies of open surgery (n = 11), did not provide adequate data on antithrombotic prophylaxis or VTE complications (n = 6), were duplicate publications or studies of laparoscopic versus open surgery or commentaries (n = 1 each). Three studies were found from manually searching the reference lists and were included in the present review [17–19]. The study identification and selection process is summarized in Fig. 1.

A total of 19 studies were included in the systematic review [17–35]. The interobserver agreement for study selection was excellent (κ = .92). Gastric bypass was the surgical procedure in all 19 studies. Three studies also included patients who had undergone laparoscopic gastric banding [26,34,35]. In 3 of the studies, patients who underwent open or laparoscopic bariatric surgery were included [29,32,34]. However, separate data were reported with regard to the incidence of VTE in patients undergoing laparoscopic or open surgery.

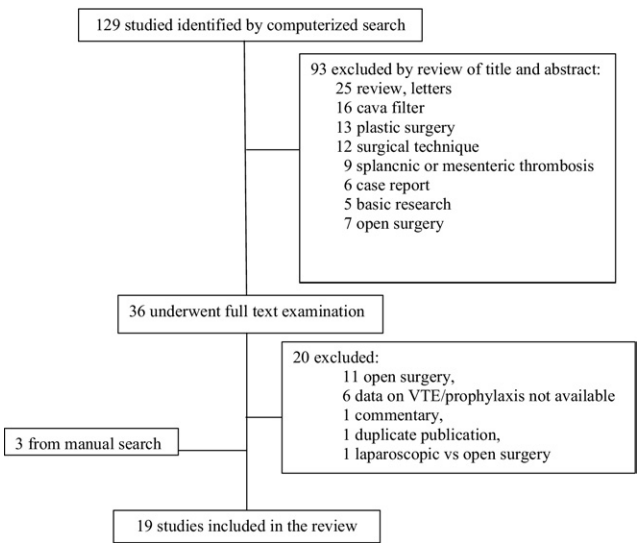

Fig. 1. Summary of data search and included studies.

Study characteristics and study quality

The regimens of antithrombotic prophylaxis and methods for postoperative VTE screening across the studies are summarized in Table 1.

No randomized controlled trial was found, with all the studies having an observational design. Of the 19 studies, 12 were prospective cohort studies [17–21,24,25,28,29,31–33] and 7 were retrospective cohort studies [22,23,26,27,30,34,35].

The number of included patients was 41–1500; 13 studies enrolled patients consecutively. Objective testing for VTE screening was scheduled in 4 studies (all high-quality studies) [24,29–31]. In the remaining studies, objective testing was scheduled only to confirm the clinical suspicion of VTE.

Overall, the selected studies were categorized into 4 groups according to the regimen for antithrombotic prophylaxis.

Laparoscopic bariatric surgery for morbid obesity and VTE

Standard UFH or LMWH regimens for antithrombotic prophylaxis. Of the 19 studies, 12 (3991 patients) reported on the incidence of pulmonary embolism after laparoscopic bariatric surgery in patients receiving standard regimens of UFH or LMWH for antithrombotic prophylaxis (UFH 5000 UI 2 or 3 times daily, LMWH 30 mg twice daily or 40 mg once daily) [17–19,23–25,27–29,31,34,35]. The WMI of pulmonary embolism was .5% (95% CI .2–.9%; I^2 38%), with no evidence of publication bias.

The incidence of major bleeding was reported in 7 of these studies (2741 patients) [17,18,23,27–29,31]. The WMI of major bleeding according to the criteria of the individual studies was 3.6% (95% CI .9–7.95; 84 events) with evidence of significant between-study heterogeneity (I^2 95%) and publication bias. The WMI of major bleeding defined according to the ISTH criteria was 1.0% (95% CI .6–1.4%; 25 events) with no evidence of between-study heterogeneity (I^2 0%) or publication bias.

High-quality studies. Four studies (1076 patients) evaluated the incidence of VTE, as screened by compression ultrasonography, in patients who had received different regimens of antithrombotic prophylaxis [24,29–31]. These were considered high-quality studies. The WMI of symptomatic or asymptomatic VTE was 1.2% (9 events; 95% CI .2–2.9), with evidence of significant heterogeneity (I^2 69%). The WMI of symptomatic or asymptomatic VTE calculated after excluding the only study evaluating a higher dose of heparin (40 mg twice daily) was 2.0% (8 events in 458 patients; 95% CI .9–3.5%), with no evidence of between-study heterogeneity (I^2 0%).

UFH 5000 2 or 3 times daily. Six studies (2247 patients) evaluated the incidence of symptomatic VTE in patients undergoing laparoscopic gastric bypass after prophylaxis

Table 1
Main features of included studies

Investigator	Study design	RCT	Intervention type	Follow-up duration	Consecutive patients	Lost to follow-up	Operative time (min)
Schauer et al. [17], 2000	Prospective	No	Gastric bypass	1–12 mo	Yes	8 patients	260 (105–734)
Higa et al. [18], 2001	Prospective	No	Gastric bypass	10 yr	Yes	NR	NR
DeMaria et al. [19], 2002	Prospective	No	Gastric bypass	In-hospital	Yes	NR	234 ± 77 and 162 ± 42*
Shepherd et al. [20], 2003	Prospective	No	Gastric bypass	NR	NR	No	NR
Gonzalez et al. [21], 2004	Prospective	No	Gastric bypass	Hospital stay	Yes	None	103 ± 24
Miller et al., 2004) [22]	Retrospective	No	Gastric bypass	3 wk	No	No	174
Shin et al., 2005) [23]	Retrospective	No	Gastric bypass	6 mo	Yes	None	93 (39–238)
Prystowsky et al.[24], 2005	Prospective	No	Gastric bypass	30 d	Yes	None	138 ± 47
McCollough et al. [25], 2006	Prospective	No	Gastric bypass	30 d	Yes	None	172 ± 56 to 253 ± 293†
Frezza et al. [26], 2006	Retrospective	No	Gastric bypass (n = 124); gastric banding (n = 26)	3 mo	NR	NR	NR
Parini et al. [27], 2007	Retrospective	No	Gastric bypass	30 d	Yes	No	80–420
Kothari et al. [28], 2007	Prospective	No	Gastric bypass	30 d	No	None	129 ± 25‡160 ±29§
Brasileiro et al. [29], 2007	Prospective	No	Gastric bypass	5 wk	NR	No	282 ± 59
Escalante-Tattersfield et al. [30], 2008	Retrospective	No	Gastric bypass	52 wk	Yes	No	93
Raftopoulos et al. [31], 2008	Prospective	No	Gastric bypass	30 d	Yes		220
Borkgren-Okonek et al. [32], 2008	Prospective	No	Gastric bypass	3 mo	Yes	1	96 ± 28
Clements et al. [33], 2009	Prospective	No	Gastric bypass	30 d	Yes	1	39–238
Vaziri et al. [34], 2010	Retrospective	No	Gastric bypass (n = 16); gastric banding (n = 9)	18 ± 23 d	No	No	106
Magee et al. [35], 2010	Retrospective	No	Gastric bypass Gastric banding	90 d	Yes	NR	NR

RCT = randomized controlled trial; NR = not reported.
* Duration of surgery reported separately for first and last quartile.
† Duration of surgery reported for tertiles of cardiorespiratory fitness.
‡ Low-molecular-weight heparin.
§ Unfractionated heparin.

with fixed-dose UFH (5000 IU 2 or 3 times daily postoperatively; Table 2) [17,18,24,25,28,34]. The WMI of pulmonary embolism was .3% (6 events; 95% CI .1–.6%), with no evidence of between-study heterogeneity (I^2 0%). The WMI of pulmonary embolism after excluding 1 larger study [18] was .6% (3 events in 747 patients; 95% CI .2–1.3%; I^2 0%). No evidence of publication bias was found in these analyses.

The WMI of major bleeding as reported in 4 of these studies was 1.6% (2113 patients, 25 events; 95% CI .7–3.0; I^2 62%) [17,18,24,28]. The WMI of major bleeding reclassified according to the ISTH criteria in these same studies was .9% (18 events; 95% CI .5–1.4%; I^2 0%).

LMWH 40 once or twice daily or 30 mg twice daily. Four studies (1264 patients) evaluated LMWH, 30 or 40 mg twice daily postoperatively (fixed-dose LMWH) [23,27,28,30]. Overall, 7 patients had symptomatic VTE, of whom 3 had confirmed pulmonary embolism. The 30-day WMI of symptomatic VTE was .7% (95% CI .1–1.7; I^2 65%; Table 3). These studies reported on major bleeding complications. The WMI of major bleeding as reported in the individual studies was 5.2% (74 events; 95% CI .7–13.0%; I^2 95%). The WMI of major bleeding according to the ISTH criteria was 1.2% (13 events; 95% CI .1–3.5%; I^2 86%).

The incidence of pulmonary embolism was reported in 4 studies (1555 patients) for patients receiving LMWH, 40 mg daily postoperatively [19,27,29,35]. Overall, 4 patients had symptomatic pulmonary embolism, corresponding to a rate of .2% (95% CI .05–.4%; I^2 4%).

Weight-adjusted heparin prophylaxis. Weight-adjusted doses for heparin prophylaxis after laparoscopic gastric bypass surgery were used in 4 studies (1328 patients) [20,22,26,32]. Symptomatic VTE occurred in 7 patients (all pulmonary embolism), corresponding to a WMI of symptomatic VTE of .6% (95% CI .3–1.1%; I^2 0%). The WMI of major bleeding as reported in these studies was 2.0% (22 events; 95% CI 1.0–3.4%; I^2 55%). The WMI of major bleeding according to the ISTH criteria in the same studies was 1.6% (17 events; 95% CI .6–2.9% I^2 60%).

Mechanical prophylaxis. Two studies reported on the incidence of symptomatic VTE after laparoscopic gastric bypass in patients who had received only mechanical

Table 2
Regimen for antithrombotic prophylaxis and strategies for VTE surveillance

Investigator	Patients (n)	Antithrombotic prophylaxis methods	VTE screening	Screening timing
Schauer et al. [17], 2000	275	GCS + UFH 5000 IU twice daily (low-dose SC)	No*	Symptom onset
Higa et al. [18], 2001	1500	GCS + UFH 5000 IU twice daily (mini-dose SC)	No*	Symptom onset
DeMaria et al. [19], 2002	281	GCS + LMWH 40 mg once daily	No*	Symptom onset
Shepherd et al. [20], 2003	700	UFH [(71.34 × weight) + (87.35 × height) −3467.59] twice daily	No*	Symptom onset
Gonzalez et al. [21], 2004	380	IPC	No*	Symptom onset
Miller et al. [22], 2004	255	UFH 5000 UI or 7500 UI 3 times daily if BMI >50/<50 kg/m^2	No*	Symptom onset
Shin et al. [23], 2005	100	LMWH 30 mg twice daily	No*	1 wk, 1, 3, and 6 mo postoperative
Prystowsky et al. [24], 2005	106	UFH 5000 IU twice daily	CUS	Days 2 and 8 and 15 d postoperative
McCollough et al. [25], 2006	109	IPC + UFH 5000 IU twice daily	No*	Symptom onset
Frezza et al. [26], 2006	150	IPC + enoxaparin 1.5 mg/kg twice daily or UFH 7000 U twice daily in low-risk patients† IPC + enoxaparin 1.5–2.0 mg/kg twice daily or warfarin in high-risk patients†	No*	Symptom onset
Parini et al. [27], 2007	250	LMWH	No*	Symptom onset
Kothari et al. [28], 2007	476	LMWH 40 mg twice daily (n = 238); UFH 5000 IU 3 times daily (n = 238)	No*	Symptom onset
Brasileiro et al. [29], 2007	126‡	LMWH 40 mg once daily for 15 d	CUS	Preoperative and 2 and 5 wk postoperative
Escalante-Tattersfield et al. [30], 2008	618	UFH preoperatively; LMWH 40 mg twice daily postoperatively	CUS	Day 1, and 2, 8, 12, 24, and 52 wk postoperative
Raftopoulos et al. [31], 2008	308	LMWH 30 mg twice daily in hospital; 40 mg after discharge	CUS	Discharge
Borkgren-Okonek et al. [32], 2008	223§	LMWH 40 mg twice daily if BMI ≤50 kg/m^2; LMWH 50 mg twice daily if BMI >50 kg/m^2	No*	Symptom onset
Clements et al. [33], 2009	957	IPC	No*	Symptom onset
Vaziri et al. [34], 2010	41	IPC + UFH 5000 IU 3 times daily	No*	Symptom onset
Magee et al. [35], 2010	735	Dalteparin 2500 preoperatively; 5000 UI once daily postoperatively	No*	Symptom onset

VTE = venous thromboembolism; GCS = graduated compression stockings; UFH = unfractionated heparin; SC = subcutaneously; LMWH = low-molecular-weight heparin; BMI = body mass index; IPC = intermittent pneumatic compression; CUS = compression ultrasonography.

* Objective tests were performed in the presence of symptoms of VTE.

† Low risk and high risk determined by BMI <50 or ≥50 kg/m^2, previous VTE, previous surgery, and heart failure.

‡ Only 70 patients underwent laparoscopic surgery.

§ 93% of patients underwent laparoscopic procedure; separate data not available.

prophylaxis by intermittent pneumatic compression [21,33]. The WMI of symptomatic VTE in these studies was .4% (5 events in 1337 patients (4 with deep vein thrombosis and 1 with pulmonary embolism; 95% CI .2–.8%; P = .83; Table 3).

VTE and duration of surgery. Five studies reported a mean surgery duration <120 minutes [21,23,30,33,34] and 8 studies, a mean surgery duration >120 minutes (Table 1) [17,19,22,24,25,28,29,31]. Overall, 3 studies reporting a mean surgery duration <120 minutes [23,30,33] and all but 1 study reporting a mean surgery duration >120 minutes used similar regimens for heparin prophylaxis [22]. Symptomatic VTE occurred in .6% (3 studies, 759 patients, 2 events; 95% CI .01–3.9%; I^2 70%) and .7% (7 studies, 1619 patients, 9 events; 95% CI .3–1.1%; I^2 0%) of the patients included in studies with a surgery duration <120 and >120 minutes, respectively.

Discussion

The present systematic review shows that the incidence of pulmonary embolism after laparoscopic bariatric surgery for morbid obesity is <1%, regardless of the regimen used for antithrombotic prophylaxis. When an objective test was used to screen for asymptomatic deep vein thrombosis, the reported incidence of postoperative VTE in this setting was about 2%. The rate of postoperative VTE observed in our analysis after laparoscopic bariatric surgery is consistent with the results of recently published surveys of bariatric surgery performed in the United States [36,37]. In the Lon-

Table 3
Weighted mean incidence of VTE and major bleeding in patients undergoing laparoscopic surgery for morbid obesity receiving different regimens of pharmacologic antithrombotic prophylaxis

Antithrombotic prophylaxis	Events	Studies/patients	Events (n)	WMI (%)	95% CI	I^2 (%)
Standard prophylactic regimens*	Symptomatic PE	12/3991	15	.5	.2–.9	38
	Major bleeding†	7/2741	84	3.6	.9–7.9	95
	Major bleeding, ISTH	7/2741	25	1.0	.6–1.4	0
UFH 5000 IU 2 or 3 times daily	Symptomatic PE	6/2247	6	.3	.1–.6	0
	Major bleeding†	4/2113	25	1.6	.7–3.0	62
	Major bleeding, ISTH	4/2113	18	.9	.5–1.4	0
LMWH 30 or 40 mg twice daily	Symptomatic VTE	4/1264	7	.7	.1–1.7	65
	PE	4/1264	3	.3	.01–1.2	62
	Major bleeding†	4/1206	74	5.2	.7–13	95
	Major bleeding, ISTH	4/1206	13	1.2	.1–3.5	86
LMWH 40 mg die	Symptomatic PE	4/1555	4	.2	.05–.4	4
Weight-adjusted LMWH	Symptomatic PE	4/1328	7	.6	.3–1.1	0
	Major bleeding†	4/1328	22	2.0	1.0–3.4	55
	Major bleeding, ISTH	4/1328	17	1.6	.6–2.9	60

VTE = venous thromboembolism; WMI = weighted mean incidence (of symptomatic VTE); CI = confidence interval; PE = pulmonary embolism; ISTH = International Society of Thrombosis and Haemostasis; UFH = unfractionated heparin; LMWH = low-molecular-weight heparin.

* UFH (5000 UI 2 or 3 times daily) or LMWH (4000 UI once daily).

† According to criteria of individual study.

gitudinal Assessment of Bariatric Surgery study, the incidence of VTE complications at 30 days was about .3–.4%, with the risk increasing with increasing body weight [36]. However, the regimens used for antithrombotic prophylaxis were not reported in that study. Data from 73,921 patients who had undergone bariatric surgery included in the Bariatric Outcomes Longitudinal Database study were analyzed to assess the incidence of VTE events within 90 days after surgery [37]. Overall, 93% of patients received some form of antithrombotic prophylaxis that was pharmacologic in >70% of patients. The overall risk of VTE observed within 90 days after surgery was .42%, and 73% of these events occurred after discharge, most within 30 days. However, data regarding the incidence of VTE stratified by the different regimens for antithrombotic prophylaxis were not reported in that study.

As a second finding, we showed that limited evidence exists on the actual efficacy and safety of antithrombotic prophylaxis in the setting of laparoscopic bariatric surgery. Although several studies reported on the incidence of VTE after laparoscopic bariatric surgery for morbid obesity, an objective method for the assessment of VTE was scheduled in only a minority of these studies. Given these limits, the risk of VTE associated with bariatric surgery should be reconsidered in ad hoc high-quality studies.

The issue of the actual incidence of postoperative VTE in patients undergoing laparoscopic bariatric surgery for morbid obesity is crucial if we consider that it is common practice to use weight-adjusted doses of heparin after bariatric surgery. Current guidelines suggest considering the use of heparin at higher doses than standard (LMWH 40 mg daily or UFH 5000 UI 2 or 3 times daily) for VTE prophylaxis in patients undergoing bariatric surgery [8]. However, the evidence in favor of modified regimens is modest, which was made explicit by the 2C grade of recommendation. Our analysis showed a non-negligible risk of major bleeding complications associated with such increased heparin doses, without a clear benefit in terms of a reduction in postoperative VTE. The results of currently ongoing randomized studies evaluating the efficacy and safety of different regimens of heparin for VTE prophylaxis in bariatric surgery are essential to definitively assess the issue of the optimal heparin regimen for these patients.

The incidence of symptomatic VTE in the 2 large studies with mechanical prophylaxis appeared to be similar to that observed with heparin prophylaxis. Thus, balancing the risk of VTE and that of major bleeding, the use of fixed regimens of either LMWH or UFH (40 mg daily, 30 mg twice daily, or 5000 IU 3 times daily) should be preferred over weight-adjusted doses of these agents to reduce the incidence of bleeding complications until data from randomized studies are available.

Our analysis on the role of surgery duration on the incidence of postoperative VTE seems to indicate a similar incidence of postoperative VTE for surgery lasting <120 or >120 minutes. However, given the large range of surgery durations within the individual studies and the presence of between-study heterogeneity in 1 of the analyses, these data should not be retained as conclusive and should be viewed with caution.

The incidence of VTE complications, either symptomatic or asymptomatic, after laparoscopic bariatric surgery seems to be <1%. The reported incidence of pulmonary embolism after open bariatric surgery has varied from 0% to 3.4% [4]. Although 2 studies reported a comparison between open and laparoscopic bariatric surgery, a formal meta-analysis could not be performed. However, in the analysis of data from the Bariatric Outcomes Longitudinal Database study, the lapa-

roscopic approach seemed to be associated with a reduced incidence of VTE (.34% versus 1.54%) [37].

The analyses of the incidence of major bleeding complications were characterized by significant heterogeneity. The incidence of bleeding complications varied largely across the studies, and the differences were probably influenced by the definition of major bleeding used in the different studies. The heterogeneity tended to decrease when major bleeding was identified according to the ISTH criteria. These findings highlight the need for standardization of the definition of clinical endpoints in studies on antithrombotic therapy.

Meta-analyses have the intrinsic limit of combining heterogeneous data sets. The studies included in our systematic review and meta-analysis differed in the number of included patients, strategies used for antithrombotic prophylaxis, and methods used to diagnose VTE. However, most of the analyses did not show significant heterogeneity. As an additional limit, no randomized controlled study was available in the setting of laparoscopic bariatric surgery. Moreover, adjustments or subanalyses for known risk factors for postoperative VTE such as the duration of surgery were not possible.

Conclusion

The present systematic review has shown that limited evidence is currently available on the use of antithrombotic prophylaxis after laparoscopic bariatric surgery for morbid obesity. The incidence of postoperative VTE seems to be relatively low in this setting, and the benefit of weight-adjusted heparin prophylaxis remains controversial. Overall, our review highlights the need for randomized studies with time-scheduled screening for VTE and standardized criteria for defining bleeding complications to definitively assess the clinical benefit and optimal regimen of antithrombotic prophylaxis in patients undergoing laparoscopic bariatric surgery.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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