EJA

Eur J Anaesthesiol 2024; **41**:598–603

INFOGRAPHIC

GUIDELINES

European guidelines on peri-operative venous thromboembolism prophylaxis: first update.

Chapter 8: Plastic surgery

Guido Paolini, Guido Firmani, Michail Sorotos, Milomir Ninkovic and Fabio Santanelli di Pompeo

European Journal of Anaesthesiology 2024, **41**:598–603

Rationale

While no Risk Assessment Model (RAM) can be considered ideal to date, the 2005 Caprini scale has been formally validated to stratify plastic surgery patients based on their individual risk factors.[1] The 2010 update to the Caprini RAM is likely less accurate in representing plastic surgery procedures as it allots additional points for longer surgery times which are common, which could result in an over scoring phenomenon artificially placing patients in a higher than necessary risk category.[2,3] Nevertheless, the score does not take into account type of surgery, combined procedures, other patient comorbidities including acute coronary syndrome with implantation of a drug-eluting stent (DES), heart failure, respiratory failure, nephrotic syndrome, Behçet syndrome, paraprotein disorders, low levels of protein C, protein S or Antithrombin III, as well as other identified genetic predictors of thrombophilia (including PAI-1 gene polymorphism concomitantly with factor II, V or beta-fibrinogen mutations).

Thrombo-embolism has been identified as the most common cause of mortality following outpatient plastic surgery, which occurred most frequently after abdominoplasties.[4] An analysis of the American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF) database featuring 6 388 744 outpatient plastic surgery procedures revealed that abdominoplasties carry an increased thrombo-embolic risk compared to other plastic surgery procedures.[5] Patients undergoing complex abdominal wall reconstruction with component separation have also been found to have a higher risk for venous thromboembolic events.[6] Abdominal contouring in class III obesity patients (BMI $> 40\,kg/m^{-2}$) has been correlated with increased risk of Deep Venous Thrombosis / Pulmonary Embolism (DVT/PE), though this has not been found to be statistically significant in a retrospective review of 4497 panniculectomies.[7] Additionally, the amount of skin tissue resected has been correlated with postoperative complications.[8] Autologous breast reconstruction has been associated with higher risk of VTE, which was due to long hospital stays (over 3 days) and long operative times.[9] In microsurgical breast reconstruction, which most commonly featured abdominally-based flaps, surgical duration beyond 11 h, longer inpatient stay and patient comorbidities have been correlated with heightened VTE risk.[10–12] Overall, longer operative times in general have been associated with increased VTE rates in all plastic surgery procedures.[13] Some combinations of elective outpatient procedures conferred a higher thromboembolic risk, particularly abdominoplasty with liposuction, and abdominoplasty with hernia repair.[14] Evidence from a controlled clinical trial showed that patients undergoing the combination of abdominoplasty/flank liposuction with resection of fat in amounts >1500 g and undergoing procedures with longer duration were at increased risk of thromboembolic events.[15] Facelifts and rhinoplasties have an overall low incidence of thromboembolic events.[16] In rhinoplasty patients, intraoperative rib graft harvest has been found to increase VTE risk.[17] Other surgical risk factors in addition to the specific

From the NESMOS Department - Faculty of Medicine and Psychology - Sapienza University of Rome, Italy - Active member EURAPS (GP); Sapienza University of Rome, Italy (GF); NESMOS Department - Faculty of Medicine and Psychology – Sapienza University of Rome, Italy - Associate member EURAPS (MS); Head of Department for Plastic, Aesthetic, Reconstructive and Hand Surgery, International Medical Centre Priora, Čepin, Croatia - Active Member EURAPS (MN); NESMOS Department - Chair of Plastic Surgery Unit - Faculty of Medicine and Psychology - Sapienza University of Rome, Italy - EURAPS President (FSdP)

Correspondence to Guido Paolini, MD, PhD, Sapienza University of Rome: Universita degli Studi di Roma La Sapienza Rome, Faculty of Medicine and Psychology, Via di Grottarossa 1035/1039, 00189, Rome, Italy.
E-mail: guido.paolini@uniroma1.it

DOI:10.1097/EJA.0000000000001998

above-mentioned surgical procedures include longer surgical duration and longer in-hospital stay.

Hypercoagulability has been associated with increased risk of flap failure as a consequence of microvascular thrombosis.[18] Selective therapeutic anticoagulation has been found to improve microsurgical lower limb reconstruction outcomes in high-risk patients with thrombophilia. However, this data has been reported from retrospective cohort studies featuring relatively small samples (57 and 41 patients respectively).[19,20] More evidence on the matter is still currently needed to corroborate findings.

Regarding the type of anticoagulant, postoperative enoxaparin prophylaxis for the duration of their inpatient stay has been deemed protective against 60-day VTE. This was reported in a multicentre retrospective cohort study on 3334 patients who had received plastic surgery procedures.[21] A 7-day postoperative course of once-daily 5000 IU of heparin or 4000 IU of enoxaparin delivered subcutaneously, or 10 mg of oral rivaroxaban for VTE risk reduction in abdominal body contouring surgery has not significantly increased the risk of bleeding. However, this is based only on two retrospective studies: the first on 195 patients,[22] and the second on 600 patients.[23] Another retrospective study featuring 360 circumferential abdominoplasty patients demonstrated that enoxaparin administration was associated with a statistically significant decrease in deep venous thrombosis.[2] Chemoprophylaxis using 3500 IU of bemiparin for 10 days did not increase risk of neither DVT/PE nor bleeding events.[24] Of note, bemiparin has an inferior cost compared to enoxaparin. Additionally, a randomised double-blind study on 40 patients undergoing abdominoplasty showed that oral rivaroxaban at 10 mg once daily for 10 days increased bleeding risk substantially, causing the study to be halted after 27 operations due to systemic complications.[25] A randomised clinical trial is currently underway, comparing Apixaban vs. Enoxaparin following microsurgical breast reconstruction [NCT04504318]. Use of multiple antithrombotic agents has been associated with increased risk of haematoma/bleeding.[26]

Regarding dosage of anticoagulation, evidence from prospective clinical trials suggests that fixed-dose heparin was deemed insufficient for reaching the level of anticoagulation required for VTE prophylaxis after microsurgical procedures.[27] Weight-based heparin infusions at 10 units kg^{-1} h^{-1} provided a detectable level of anticoagulation for some patients following microsurgical procedures, but most required dose adjustment to ensure adequate VTE prophylaxis.[28] In a clinical trial, twice-daily 4000 IU enoxaparin has been found to be superior to once-daily 4000 IU enoxaparin for 90-day acute venous thromboembolism risk reduction.[29] The increased dosage is however associated with an increased risk of bleeding, causing overtreatment.[30] In a randomized clinical trial on 295 patients, weight-based administration of enoxaparin at 0.5 mg per kg twice daily (every 12 h) showed superior pharmacokinetics for avoidance of underanticoagulation and overanticoagulation in postoperative patients compared to fixed dosage of 40 mg.[31] High-dose thromboprophylaxis nearly halved the rate of VTE in morbidly obese inpatients

Regarding duration of anticoagulation, patients undergoing microsurgical breast reconstruction and who received a short course of anticoagulation (only while hospitalised) were not associated with a statistically significant increase in VTE incidence compared to patients who received a 2-week course. However, this was based on a retrospective study of 249 patients where all thromboembolic events occurred in the group which received short-course anticoagulation.[32] Administration of extended chemoprophylaxis (consisting of 7–30 days of low molecular weight heparin) in a cohort of 750 patients who received 881 breast cancer surgeries (ranging from lumpectomy to mastectomy with or without axillary surgery and/or reconstruction) was not associated with an increased risk of bleeding.[33] A retrospective chart review of 64 patients attempted to demonstrate that mechanical thromboprophylaxis alone (consisting of elastic compression stockings, intermittent pneumatic compression boots, and early reambulation) could be used as an alternative to chemoprophylaxis in body contouring surgery following massive weight loss.[34] However, sequential compression devices were not found to be effective in reducing DVT onset in 1000 patients who underwent outpatient plastic surgery procedures.[35]

The level of evidence specifically catering to plastic surgery patients is very weak, but there is a study that demonstrated the safety of mechanical prophylaxis for DVT risk reduction.[34] Indirect evidence from other surgical branches such as general surgery is more convincing.[49]

No other chapter from these current ESAIC guidelines has suggested the administration of more than a single daily dose of Low Molecular Weight Heparin (LMWH). However, the supporting evidence we found could not be ignored and deserves some special consideration. We found three clinical trials in plastic surgery in favour of a higher number of daily administrations of LMWH, all of which were conducted by the same first author. The rationale behind more than one daily administration is related to enoxaparin pharmacokinetics. Namely, the half-life of enoxaparin is about 4 h after a single dose administered subcutaneously, and about 7 h after several doses, posing the risk of possible under-anticoagulation. In a study by Pannucci *et al.*[29] they compared two trials: (Trial 1: NCT02411292) to (Trial 2: NCT 02687204). Trial 1 was conducted in 2015 (https://clinicaltrials.gov/study/NCT02411292#study-record-dates), and compared 94 patients with single dose LMWH.[36,37] Trial 2 compared 118 patients and twice daily doses. They found

that twice-daily 4000 IU enoxaparin was superior to once-daily 4000 IU enoxaparin for 90-day thromboembolic risk reduction. Out of the same 118 patients from Trial 2 who received twice-daily LMWH, the same author found in another study published the same year that while being associated with a lower under-anticoagulation rate, this practice was associated with a high rate of clinically relevant bleeding.[30] In a randomised clinical trial (RCT) by Pannucci *et al.*[31] from 2021 on 295 patients, weight-based administration of enoxaparin at 0.5 mg kg^{-1} twice daily (every 12 h) showed superior pharmacokinetics for avoidance of underanticoagulation and overanticoagulation in postoperative patients compared to fixed dosage of 40 mg. In this study, bleeding rate was slightly higher (8.3% vs. 6.0%) but was not statistically significant. However, because of the concerns over the risk of bleeding, there is reason to suggest that additional administrations per day, although potentially more effective, may cause overtreatment, thus it is best to err on the side of caution and advise against such practice for the time being. Additionally, this RCT does not have a NCT number, thus is considered to be at high risk of bias. In 2022, Pannucci *et al.*[38] conducted a pooled analysis from 8 prospective clinical trials conducted in a single institution over a 4-year period with 985 patients in total: 3 pertaining to plastic surgery (all mentioned above), 2 thoracic surgery, 1 colorectal surgery, 1 orthopaedic surgery, 1 trauma surgery. This pooled analysis demonstrated an association between inadequate initial enoxaparin dosing and 90-day symptomatic VTE, but could not be used to suggest non-inferiority of twice daily administration given the dissimilarities among studies. Given the low certainty and paucity of evidence, and the existence of a single RCT in literature for plastic surgery patients, no strong recommendation can be made. However, we acknowledge indirect evidence in the executive summary for non-bariatric surgery from the ESA VTE 2018 Guidelines.[39] While the indirectness of evidence on which this statement is based should be acknowledged, we still believe that the tradeoff between risks and benefits is deserving of the implementation.

Dextran 40 has been found to have a valuable effect on haemodilution, but does not demonstrate superior outcomes in terms of venous flap thrombosis.[40] However, it has been abandoned because of potential systemic complications.

Weight-based LMWH administration has been validated for therapeutic indications,[41,42] though its proposal for thromboembolic prophylaxis poses more questions regarding possible risks of potential errors with calculations, either due to over or undercoagulation. The plastic surgery population may include post-bariatric patients and obese patients, which is why specific recommendations are required for this category of patients. Obesity, including morbid obesity, is associated with a high risk of thromboembolic events and anticoagulant regimens with fixed doses may not provide optimal VTE prophylaxis in these patients.[43] Assessment of different dosing regimens have been performed in past studies.[44] Retrospective evidence from Wang *et al.*[45] found in 3928 morbidly obese inpatients (BMI $\geq$ 40 kg m^{-2}) that a weight-based higher dose thromboprophylaxis nearly halved the rate of VTE without increasing bleeding risk, though 5313 patients with BMI $<$ 40 kg m^{-2} had no benefit of higher dose thromboprophylaxis. Nevertheless, a double-blind randomised controlled Fixed or Variable Enoxaparin (FIVE) trial was conducted by Pannucci *et al.* in a plastic surgery population of 295 patients.[31] All patients were aged 18 years or over, and underwent a plastic surgery procedure with in-hospital stay of at least 2 nights. Surgery was therefore not specific for body contouring procedures. Furthermore, the population had a mean BMI of 28.8 kg m^{-2}. The FIVE trial found that weight-based administration of LMWH was more effective in avoiding overcoagulation or undercoagulation, although no statistically significant differences could be found in terms of symptomatic DVT rate at 90 days. Because of the paucity of literature on the subject and because the existence of some conflicting evidence, we suggest the use of a weight-based strategy only for the morbidly obese patient population.

Literature is currently scant for any type of study using direct oral anticoagulants (DOACs) in plastic surgery. There is an RCT with a small sample population currently underway testing Apixaban vs. Enoxaparin following microsurgical breast reconstruction [NCT04504318]. The project was started in 2020, and the latest update was posted in August 2023, with no preliminary results to analyse for the time being. Indirect evidence has also been considered but has been deemed insufficient. The main reason is that the studies which tested DOACs were conducted for surgical procedures that are widely different from standard plastic surgery procedures, which require wide dissections and undermining, thus creating larger areas of potential bleeding. Apixaban for DVT prevention after knee replacement surgery did not meet statistical criteria for noninferiority.[46] Rivaroxaban for DVT prevention after orthopaedic surgery (hip or knee arthroplasty) found a small increase in bleeding.[47] Neither of these studies made it through the inclusion criteria for the systematic review of Chapter 8. While we are aware of more current evidence suggesting that prophylaxis with DOACs is safe, associated with lower DVT rates, lower bleeding rates and even cost-effectiveness, the evidence still pertains to orthopaedic surgery, cardiothoracic surgery or general surgery.[48] Thus, we still believe that the risk of bleeding is sizably different, warranting its own investigation for our own surgical field before expressing any specific recommendation. For these reasons, we do not feel confident in providing recommendations either in favour or against the use of DOACs.

Recommendations

- We recommend the 2005 Caprini Risk Assessment Model (RAM) as a reference point for DVT/PE risk stratification in plastic surgery. (Grade 1C)
- We suggest that abdominal contouring procedures (especially abdominoplasty combined with liposuction or with hernia) be considered at higher VTE/PE risk. (Grade 2B)
- Patients with a hypercoagulable pattern are at an increased risk of flap failure caused by microvascular thrombosis. We suggest using prevention with selective therapeutic anticoagulation. (Grade 2C)
- We suggest the use of low molecular weight heparin (LMWH) in the postoperative period once daily. (Grade 2B)
- We suggest that in surgery with an indication for VTE prophylaxis, a higher prophylactic dose of LMWH (3000–4000 anti-Xa IU every 12 h subcutaneously) should be considered for morbidly obese patients with a BMI of more than 40 kg m^{-2} undergoing plastic surgery. (Grade 2C).
- We suggest using a duration of anticoagulation ranging from 7 to 30 days, according to DVT/PE risk stratification, as described in 2005 Caprini RAM. (Grade 2C)
- Clinical practice statement: There is insufficient evidence to support specific preoperative or postoperative blood parameters, including haemoglobin and haematocrit level for reducing flap thrombosis and failure in microsurgical procedures.
- Clinical practice statement: Weight-based LMWH (Enoxaparin 0.5 mg/ 50 IU per kg) for thromboembolic prophylaxis in the postoperative period for plastic surgery patients deserves further research which should incorporate both a multicentre and randomised design.
- Simple statement: There is no evidence to support the use of DOACs over LWMH because we do not know if DOACs are non-inferior to LMWH for thromboembolic prophylaxis in plastic surgery patients.
- Clinical practice statement: The use of Infection Prevention and Control (IPC) might play a role in VTE risk reduction in plastic surgery patients, either in combination with chemoprophylaxis, or alone, in patients where LMWH is contraindicated, but further evidence is needed.

VTE Section 08 - Appendix 1 - Summary Table, http://links.lww.com/EJA/A949

VTE Section 08 - Appendix 2 - Detailed Table, http://links.lww.com/EJA/A950

VTE Section 08 - Appendix 3 - PICOs and Tools, http://links.lww.com/EJA/A951

VTE Section 08 - Appendix 4 - Review Flow Diagram, http://links.lww.com/EJA/A952

Acknowledgements relating to this article

Assistance with Editorial: none.

Participation in Guidelines production: Dr Louise Elander, Dr Gennaro D'Orsi, Dr Vittoria Amorosi.

Financial support and sponsorship the work was funded by ESAIC, EACTAIC, EACTS, ISTH, EURAPS and EKS.

Conflict of interests: none.

Presentation: none.

This article was reviewed by ESAIC members and approved by ESAIC Board.

This manuscript was handled by Prof. Guido Paolini.

References

1 Pannucci CJ, Bailey SH, Dreszer G, *et al.* Validation of the Caprini risk assessment model in plastic and reconstructive surgery patients. *J Am Coll Surg* 2011; **212**:105–112.
2 Hatef DA, Kenkel JM, Nguyen MQ, *et al.* Thromboembolic risk assessment and the efficacy of enoxaparin prophylaxis in excisional body contouring surgery. *Plast Reconstr Surg* 2008; **122**:269–279.
3 Yago H, Yamaki T, Sasaki Y, *et al.* Application of the Caprini Risk Assessment Model for evaluating postoperative deep vein thrombosis in patients undergoing plastic and reconstructive surgery. *Ann Vasc Surg* 2020; **65**:82–89.
4 Bucknor A, Egeler SA, Chen AD, *et al.* National mortality rates after outpatient cosmetic surgery and low rates of perioperative deep vein thrombosis screening and prophylaxis. *Plast Reconstr Surg* 2018; **142**:90–98.
5 Keyes GR, Singer R, Iverson RE, *et al.* Incidence and predictors of venous thromboembolism in abdominoplasty. *Aesthet Surg J* 2018; **38**:162–173.
6 Kraft CT, Janis JE. Venous thromboembolism after abdominal wall reconstruction: a prospective analysis and review of the literature. *Plast Reconstr Surg* 2019; **143**:1513–1520.
7 AlQattan HT, Mundra LS, Rubio GA, *et al.* Abdominal contouring outcomes in class III obesity: analysis of the ACS-NSQIP Database. *Aesthetic Plast Surg* 2018; **42**:13–20.
8 De Paep K, Van Campenhout I, Van Cauwenberge S, *et al.* Postbariatric abdominoplasty: identification of risk factors for complications. *Obes Surg* 2021; **31**:3203–3209.
9 Castaldi M, George G, Stoller C, *et al.* Independent predictors of venous thromboembolism in patients undergoing reconstructive breast cancer surgery. *Plast Surg (Oakv)* 2021; **29**:160–168.
10 Qiu CS, Jordan SW, Dorfman RG, *et al.* Surgical duration impacts venous thromboembolism risk in microsurgical breast reconstruction. *J Reconstr Microsurg* 2018; **34**:47–58.
11 Rochlin DH, Sheckter CC, Pannucci C, *et al.* Venous thromboembolism following microsurgical breast reconstruction: a longitudinal analysis of 12 778 patients. *Plast Reconstr Surg* 2020; **146**:465–473.
12 Zarb RM, Ramamurthi A, Doren EL, *et al.* Clinical course of venous thromboembolism following abdominally based microsurgical breast reconstruction: a case series. *J Plast Reconstr Aesthet Surg* 2021; **74**:2550–2556.
13 Mlodinow AS, Khavanin N, Ver Halen JP, *et al.* Increased anaesthesia duration increases venous thromboembolism risk in plastic surgery: a 6-year analysis of over 19 000 cases using the NSQIP dataset. *J Plast Surg Hand Surg* 2015; **49**:191–197.
14 Saad AN, Parina R, Chang D, *et al.* Risk of adverse outcomes when plastic surgery procedures are combined. *Plast Reconstr Surg* 2014; **134**:1415–1422.
15 Gravante G, Araco A, Sorge R, *et al.* Pulmonary embolism after combined abdominoplasty and flank liposuction: a correlation with the amount of fat removed. *Ann Plast Surg* 2008; **60**:604–608.
16 Gupta R, John J, Gupta M, *et al.* Venous thromboembolism prophylaxis in plastic surgery patients undergoing facelift. *Aesthet Surg J Open Forum* 2022; **4**:ojac024.
17 Okland TS, Wadhwa H, Patel PN, *et al.* Risk of venous thromboembolism following rhinoplasty. *Aesthet Surg J* 2021; **41**:N728–N734.
18 Falkner F, Thomas B, Aman M, *et al.* The prognostic role of extended preoperative hypercoagulability work-up in high-risk microsurgical free flaps: a single-center retrospective case series of patients with heterozygotic factor V Leiden thrombophilia. *BMC Surg* 2022; **22**:190.

19 DeFazio MV, Economides JM, Anghel EL, *et al.* Lower extremity free tissue transfer in the setting of thrombophilia: analysis of perioperative anticoagulation protocols and predictors of flap failure. *J Reconstr Microsurg* 2019; **35**:270–286.
20 Wang TY, Serletti JM, Cuker A, *et al.* Free tissue transfer in the hypercoagulable patient: a review of 58 flaps. *Plast Reconstr Surg* 2012; **129**:443–453.
21 Pannucci CJ, Dreszer G, Wachtman CF, *et al.* Postoperative enoxaparin prevents symptomatic venous thromboembolism in high-risk plastic surgery patients. *Plast Reconstr Surg* 2011; **128**:1093–1103.
22 Vasilakis V, Klein GM, Trostler M, *et al.* Postoperative venous thromboembolism prophylaxis utilizing enoxaparin does not increase bleeding complications after abdominal body contouring surgery. *Aesthet Surg J* 2020; **40**:989–995.
23 Vasilakis V, Kortesis BG, Bharti G, *et al.* Safety of rivaroxaban for postoperative venous thromboembolism prophylaxis following abdominal body contouring surgery: 600 patients. *Aesthet Surg J* 2021; **41**:674–681.
24 Revilla-Peñaloza F, Olsoff-Pagovich PJ, Ochoa-Gomez JR, *et al.* Randomized trial of deep vein thrombosis chemoprophylaxis with bemiparin and enoxaparin in patients with moderate to high thrombogenic risk undergoing plastic and reconstructive surgery procedures. *Aesthetic Plast Surg* 2020; **44**:820–829.
25 Dini GM, Ferreira MCC, Albuquerque LG, *et al.* How safe is thromboprophylaxis in abdominoplasty? *Plast Reconstr Surg* 2012; **130**:851e–857e.
26 Jakobsson S, Kamali A, Edsander Nord A, *et al.* Free flap surgery outcome related to antithrombotic treatment regime: an analysis of 1000 cases. *Plast Reconstr Surg Glob Open* 2021; **9**:e3961.
27 Bertolaccini CM, Prazak AMB, Agarwal J, *et al.* Adequacy of fixed-dose heparin infusions for venous thromboembolism prevention after microsurgical procedures. *J Reconstr Microsurg* 2018; **34**:729–734.
28 Bertolaccini CM, Prazak AMB, Goodwin IA, *et al.* Prevention of venous thromboembolism in microvascular surgery patients using weight-based unfractionated heparin infusions. *J Reconstr Microsurg* 2022; **38**:395–401.
29 Pannucci CJ, Fleming KI, Agarwal J, *et al.* The impact of once- versus twice-daily enoxaparin prophylaxis on risk for venous thromboembolism and clinically relevant bleeding. *Plast Reconstr Surg* 2018; **142**:239–249.
30 Pannucci CJ, Fleming KI, Momeni A, *et al.* Twice-daily enoxaparin among plastic surgery inpatients: an examination of pharmacodynamics, 90-day venous thromboembolism, and 90-day bleeding. *Plast Reconstr Surg* 2018; **141**:1580–1590.
31 Pannucci CJ, Fleming KI, Bertolaccini C, *et al.* Optimal dosing of prophylactic enoxaparin after surgical procedures: results of the double-blind, randomized, controlled fixed or variable enoxaparin (FIVE) trial. *Plast Reconstr Surg* 2021; **147**:947–958.
32 Huang H, Bernstein JL, Otterburn DM. Prolonged venous thromboembolism prophylaxis may not be necessary for DIEP flap breast reconstruction: a tertiary center's 10-year experience. *J Reconstr Microsurg* 2022; **38**:647–653.
33 Kim NE, Conway-Pearson L, Kavanah M, *et al.* Standardized risk assessment and risk-stratified venous thromboembolism prophylaxis for patients undergoing breast operation. *J Am Coll Surg* 2020; **230**:947–955.
34 Petersen ML, Vázquez FJ, Mayer HF. Mechanical thromboprophylaxis alone in body contouring surgery for post massive weight loss patients: is this good enough? *Aesthetic Plast Surg* 2022; **46**:248–254.
35 Swanson E. Prospective study of Doppler ultrasound surveillance for deep venous thromboses in 1000 plastic surgery outpatients. *Plast Reconstr Surg* 2020; **145**:85–96.
36 Pannucci CJ, Hunt MM, Fleming KI, *et al.* Weight-based dosing for once-daily enoxaparin cannot provide adequate anticoagulation for venous thromboembolism prophylaxis. *Plast Reconstr Surg* 2017; **140**:815–822.
37 Pannucci CJ, Rockwell WB, Ghanem M, *et al.* Inadequate enoxaparin dosing predicts 90-day venous thromboembolism risk among plastic surgery inpatients: an examination of enoxaparin pharmacodynamics. *Plast Reconstr Surg* 2017; **139**:1009–1020.
38 Pannucci CJ, Fleming KI, Varghese TK Jr, *et al.* Low anti-factor Xa level predicts 90-day symptomatic venous thromboembolism in surgical patients receiving enoxaparin prophylaxis: a pooled analysis of eight clinical trials. *Ann Surg* 2022; **276**:e682–e690.
39 Samama CM, Afshari A, ESA VTE Guidelines Task Force. European guidelines on perioperative venous thromboembolism prophylaxis. *Eur J Anaesthesiol* 2018; **35**:73–76.
40 Filipan D, Dediol E, Blivajs I, *et al.* The effects of dextran on postoperative thrombosis and hemodilution in microvascular head and neck reconstruction. *Ann Plast Surg* 2020; **85**:38–42.
41 Raschke RA, Reilly BM, Guidry JR, *et al.* The weight-based heparin dosing nomogram compared with a 'standard care' nomogram. A randomized controlled trial. *Ann Intern Med* 1993; **119**:874–881.
42 Raschke RA, Gollihare B, Peirce JC. The effectiveness of implementing the weight-based heparin nomogram as a practice guideline. *Arch Intern Med* 1996; **156**:1645–1649.
43 Freeman AL, Pendleton RC, Rondina MT. Prevention of venous thromboembolism in obesity. *Expert Rev Cardiovasc Ther* 2010; **8**:1711–1721.
44 Hamad GG, Choban PS. Enoxaparin for thromboprophylaxis in morbidly obese patients undergoing bariatric surgery: findings of the prophylaxis against VTE outcomes in bariatric surgery patients receiving enoxaparin (PROBE) study. *Obes Surg* 2005; **15**:1368–1374.
45 Wang TF, Milligan PE, Wong CA, *et al.* Efficacy and safety of high-dose thromboprophylaxis in morbidly obese inpatients. *Thromb Haemost* 2014; **111**:88–93.
46 Lassen MR, Raskob GE, Gallus A, *et al.* Apixaban or enoxaparin for thromboprophylaxis after knee replacement. *N Engl J Med* 2009; **361**:594–604.
47 Turpie AG, Lassen MR, Eriksson BI, *et al.* Rivaroxaban for the prevention of venous thromboembolism after hip or knee arthroplasty. Pooled analysis of four studies. *Thromb Haemost* 2011; **105**:444–453.
48 Kröll D, Nett PC, Rommers N, *et al.* Efficacy and safety of rivaroxaban for postoperative thromboprophylaxis in patients after bariatric surgery: a randomized clinical trial. *JAMA Netw Open* 2023; **6**:e2315241.
49 Turpie AG, Bauer KA, Caprini JA, *et al.* Fondaparinux combined with intermittent pneumatic compression vs. intermittent pneumatic compression alone for prevention of venous thromboembolism after abdominal surgery: a randomized, double-blind comparison. *J Thromb Haemost* 2007; **5**:1854–1861.

GRAPHICAL ABSTRACT