Venous Thromboembolism Prophylaxis

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ABSTRACT

The term venous thromboembolism (VTE) has been coined to refer to the collective diseases of deep vein thrombosis (DVT) and pulmonary embolism (PE). Each year, an estimated 150,000 to 200,000 deaths are attributed to PE. Although the incidence appears to be lower in plastic surgery, with little published in the literature, it is a subject of great concern to specialty surgeons who operate on a purely elective aesthetic basis. Recently, increasing attention has been paid to the prevention of VTE in plastic surgery. This is evident in the numerous articles being published to educate physicians on this very preventable disease. This article is a part of that mission, embarking on identifying risk factors and establishing prophylaxis guidelines. At the end of this article, readers should have an understanding of the pathophysiology, incidence, and risk factors associated with VTE as well as the current prophylactic recommendations that should be considered in the aesthetic patient.

KEYWORDS: Venous thromboembolism, deep vein thrombosis, pulmonary embolism, plastic surgery, chemoprophylaxis, cosmetic patient, aesthetic patient

PATHOPHYSIOLOGY AND CLINICAL PRESENTATION

As described by Virchow's triad, thrombosis occurs as a result of hypercoagulability, endothelial damage, or stasis, or a combination of these. In the surgical setting, venous stasis appears to be the major factor in clot formation. Prolonged operative time and general anesthesia–induced vasodilation lead to potential venous stasis. Immobilization, flexed positioning (abdominoplasty, breast augmentation), and the absence of mechanical contraction by thigh and calf muscles contribute to venous pooling. In the absence of prophylaxis, clot formation commonly occurs behind valves in the deep veins of the calf and propagates proximally to the popliteal, femoral, and iliac veins.

Endothelial damage can occur more frequently than we previously thought in surgery. Positioning of a flaccid patient can result in stretching, compression, and dilatation of the muscles and veins, creating tiny intimal tears. Even though damage can be microscopically small, the coagulation cascade can be initiated and propagate considerably in the already compromised venous stasis state.[1] Additional consideration should be paid to combined gynecologic procedures, such as hysterectomies, which can directly cause intimal damage where retracting devices are placed deep in the pelvis.

Prothrombotic states should be identified prior to surgery with a thorough history. Family history of bleeding disorders should be ascertained, with most hypercoagulable states being inherited. The most common hypercoagulable states include factor V Leiden, antiphospholipid antibodies, protein C or S deficiency, antithrombin deficiency, hyperhomocysteinemia, heparin-induced thrombocytopenia, dysfibrinogenemia, and polycythemia vera.

Most deep vein thromboses (DVT) associated with surgery begin in the deep veins of the calf with one, two, or all three of Virchow's triad present. It is

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estimated that half of all DVTs associated with surgery begin intraoperatively and half of all surgery-associated DVTs resolve spontaneously within 3 days.[2] DVTs are most commonly found in the lower extremities and are often asymptomatic. Although 75% of all calf thrombi remain isolated in the calf, screening tests have confirmed that as many as 35% of distal DVTs propagate proximally if left untreated.[2,3] It is often the proximally propagating thrombosis occurring at or above the deep popliteal vein that commonly results in embolization; however, one third of fatal pulmonary embolisms (PEs) have also been shown to originate from the calf.[4]

Symptomatic DVT patients may demonstrate a Homans sign with edema and dorsiflexion calf pain. Less than 10% develop severe thrombophlebitic symptoms including pain, edema, leg ulcers, or skin induration. Suspicion of a DVT should warrant rapid noninvasive ultrasonography, which has 96% specificity and 95% sensitivity for diagnosis at or above the popliteal vein.[5,6]

The period of highest risk for a fatal PE is within 3 to 7 postoperative days.[7] Signs and symptoms of PE can range from mild shortness of breath to overt distress. Commonly, patients present with dyspnea, tachypnea, tachycardia, diaphoresis, and pleuritic chest pain; however, hemoptysis, leg edema, palpitations, wheezing, and angina like pain can also be present. Roughly 10 to 20% die within 30 minutes before any medical therapy can be instituted.[8] Half of all patients diagnosed with a PE die within 1 year, and of those who survive, 1% develop chronic pulmonary hypertension and 5% die of a recurrent PE.[9]

INCIDENCE

Various studies estimate DVT incidence to be around 250,000 per year in the United States[10–12] with PE incidence as high as 400,000 per year.[13–16] It is hard to report precisely what the incidence of VTE is each year because different authors report different rates. With approximately 1 million patients tested each year, this estimate is conservative when one takes into consideration that only symptomatic and clinically suspicious patients are being evaluated. It is believed that only one third of patients with DVT present with any clinical symptoms, leaving the other two thirds completely asymptomatic.[6] Thus, we cannot even begin to estimate the number of occult VTE cases.

Certain specialties such as orthopedics, neurosurgery, and trauma are associated with even higher incidence rates. Absolute DVT risk in these specialties can be as high as 80% in the absence of prophylaxis.[3] PE following gastric bypass surgery occurs in 2.4% of patients, with 0.21% being fatal.[17,18] Autopsies have shown that 30% of those who die from gastric bypass surgery die from a PE and 80% have evidence of microemboli.[19] The prevalence of VTE in abdominal surgery has also been well documented and includes studies showing the effectiveness of chemoprophylaxis in preventing 50% of PE cases and 65% of DVT cases in that population of patients.[20]

Numerous articles have highlighted the prevalence of DVT and PE in plastic surgery. A large national study by Grazer and de Jong isolated PE as the single largest cause of mortality in patients receiving liposuction.[21] The frequency of DVT and PE in patients undergoing large-volume liposuction ranges between 0 and 1.1%.[22–24] Mortality rates with liposuction have been reported to be about 1 in 47,415. However, when it is combined with another procedure, the rate increases to 1 in 7314 with PE causing the largest percentage (23%) of deaths.[21,25]

Abdominoplasty consistently has the highest published rates of DVT and PE in plastic surgery. Reasons include long duration of surgery and postoperative inactivity. Patients are also more likely to have impaired drainage of the deep veins of the legs and pelvic area because of flexion at the hip during and after surgery. Increased intra-abdominal pressure from plication and abdominal binders can also slow venous return. Van Uchelen et al reported a 1.4% incidence of DVT and PE in 86 patients undergoing elective abdominoplasty.[26] Grazer and Goldwyn echoed these results by publishing a 1.2% incidence of DVT and 0.8% incidence of PE in their abdominoplasty patients.[27] When abdominoplasty was combined with intra-abdominal procedures such as hysterectomy, the incidence of PE was cited to be as high as 6.6%.[28,29] More extensive and invasive surgeries have even higher incidence rates. An article in 2003 by Aly et al at the University of Iowa cited a significant PE rate of 9.3% with belt lipectomy even in light of sequential compression devices (SCDs), early ambulation, and occasional use of subcutaneous (SC) heparin for prophylaxis.[30]

Even rhytidectomy has been associated with small but significant DVT and PE rates of 0.35 and 0.14%, respectively.[31] With a combined incidence of 0.49, a plastic surgeon can expect a VTE complication in 1 out of 200 face lift procedures. This survey also reported that one in nine surgeons had some sort of VTE complication. Of the patients who had VTE, 83.7% were patients who received general anesthesia. Of 273 plastic surgeons surveyed, only 39% routinely used any prophylactic measures when performing face lift procedures.

RISK FACTORS

When prophylaxis is considered, each patient should be assessed individually for risk for VTE. Differences between individuals such as age, medical history, and social history have made it hard to set universal prophylactic guidelines. Even racial differences have been shown to be associated with varying risks; whites and

Table 1 Venous Thromboembolism Risk Factors to Be Considered in Plastic Surgery

Major
Prior history of DVT/PE
Hypercoagulable states
Factor V Leiden
Hyperhomocysteinemia
Antiphospholipid antibodies
Prothrombin 20210A mutation
Antithrombin deficiency
Protein C or S deficiency
Low levels of tissue factor
Dysfibrinogenemia
Polycythemia vera and primary thrombocytosis
Heparin-induced thrombocytopenia
Decreased levels of plasminogen and plasminogen activators
Malignancy
Hormone therapy (birth control, tamoxifen, hormone replacement therapy)
Obesity
Minor
Age > 40
General anesthesia
Pregnancy
Smoking
Prolonged travel
Varicose veins
Inflammatory bowel disease
Nephritic syndrome
Trauma (pelvis or leg fractures)

African Americans have 2.5 to 4 times higher VTE incidence rates than others.[32] Risk factors include those that are chronic, transient, inherited, or acquired (Table 1). Aside from predicting the exact duration of surgery, most risk factors can be ascertained prior to surgery. A review of symptomatic DVT patients found that 24% of people with one risk factor had a DVT, 50% had three risk factors, and 100% of patients with DVT had five or more risk factors.[33,34] In general, VTE risk can rise cumulatively or exponentially with each additional risk factor.[33]

Intuitively, bedridden patients are at highest risk for VTE. The spectrum of patients includes those involved with trauma, lower extremity reconstruction, and spinal cord paralysis, to name a few. Patients who are obese and elderly are also less likely to ambulate immediately postoperatively. Studies have shown that older age is associated with increased VTE risk, particularly after age 40.[32,33] When compared with patients half the age, the risk was reported to be as high as 10-fold. It is thought that some of this risk is due to postoperative inactivity. Obese individuals are inherently less active and more likely to have more venous stasis. Postoperative pain may deter them from ambulating, and studies comparing obese with nonobese patients reported that the obese patients had relative risk factors of 2.5 and 2.1 for DVT and PE, respectively.

Perhaps the highest and most important risk factor includes the subset of patients with a prior history of DVT or PE. The estimated VTE recurrence rate at 1 year after the diagnosis of DVT has been reported to be as high as 11% (95% confidence interval: 2–28%) for patients with symptomatic DVT and silent PE.[35] Other studies have reported an eightfold increase for developing a new VTE during a high-risk period such as surgery, pregnancy, or injury in patients who have had a prior history of VTE.[36]

Advanced cancers such as breast, prostate, lung, and brain are associated with a six times higher risk for VTE and further increases with the presence of a chemotherapy regimen.[33] Even after surgical resection of the malignancy, VTE remains a common complication of cancer surgery, with a remarkable proportion of events occurring late after surgery.[37] These studies highlight the importance of assessing a patient's past medical history and how remission may still render a hypercoagulable state.

Hormone therapy, including oral contraceptives and hormone replacement therapy, has long been known to increase the risk of DVT.[38–43] Twofold to threefold increases have been reported in patients who take only oral contraceptives.[44] Increased estrogen levels lower systemic protein S, thereby promoting thrombosis. This phenomenon is further enhanced in the smoking female. Some physicians do not operate on patients taking hormone therapy and recommend stopping oral contraceptives 3 to 4 weeks prior to surgery and not restarting them until 2 weeks after surgery.[45]

MECHANICAL AND CHEMOPROPHYLAXIS

Mechanical prophylaxis includes graduated compression stockings (GCSs), SCDs, and venous foot pumps (VFPs). They help prevent DVTs by reducing venous pooling in the legs and by facilitating venous return.

GCSs have been shown to reduce the incidence of DVT.[46] GCSs work "passively" by applying constant pressure, thereby decreasing vein distention, and by reducing the volume of blood that can be stored in the leg. They have been shown to be most effective when combined with SCDs.[31] SCDs and VFPs work "actively" by a combination of pumping blood out of the calf and back to the heart along with stimulating the fibrinolytic system. The mechanical action of SCDs on the calves reduces plasminogen activator 1 levels and increases release of tissue plasminogen activator.[47–49] Fibrinolytic activity can even be initiated if they are placed on the arms should there be any contraindications to placing them on the legs (peripheral vascular disease).

When compared with no prophylaxis, SCDs have been shown to reduce the risk of DVT by as much as 60%.[50] Because patients are most susceptible to venodilation and venous stasis at induction, it is recommended that GCSs and SCDs be placed prior to administration of anesthesia.[51]

Chemoprophylaxis in VTE routinely and most commonly involve heparins. Low-dose unfractionated heparin (LDUH) inhibits factors Xa and IIa and has been widely used over the years. However, with the advent of low-molecular-weight heparin (LMWH), their use has been slowly declining. LMWHs have the advantage of selectively inhibiting factors Xa and IIa without binding other plasma proteins, which make LDUH harder to titrate. Therapeutic levels can be achieved more readily and accurately without the need to check coagulation profiles. LMWH also has the advantage of less frequent dosing (once a day) because of its longer half-life along with less chance of developing heparin-induced thrombocytopenia: 0 versus 2.7%.[52] Certain studies even indicate that LMWH may cause less major bleeding episodes than LDUH.[3] Although it is controversial, the critical factor appears to be the dosing of LMWH. As long as the dosing is below 3400 anti-Xa units, LMWH is as effective as LDUH in preventing VTE and is associated with lower rates of bleeding complications.[3,53]

AMERICAN COLLEGE OF CHEST PHYSICIANS RECOMMENDATIONS

With the emerging concerns regarding VTE, a consensus report was issued by a selected group of medical experts who reviewed the literature to set guidelines and recommendations. The American College of Chest Physicians (ACCP) published recommendations in 2001 and 2004 for prevention of VTE in various surgical subspecialties.[3] The recommendations were made by stratifying patients on the basis of risk factors and are regarded as the national standard of care. The ACCP focused on the highest risk surgical subspecialties—general, gynecologic, orthopedic, urologic, burn, and neurosurgery. There were no specific guidelines for plastic surgery. Recommendations for general surgical procedures are as follows:

1. Low risk: age younger than 40 with no additional risk factors undergoing minor surgery (< 1 hour). No prophylaxis recommended except for early ambulation.
2. Moderate risk: minor surgery in patients 40 to 60 years old or with additional risk factors or major surgery in patients younger than 40 years with no additional risk factors. Recommend LDUH 5000 U twice a day or LMWH 3400 U once daily, first dose 2 hours prior to surgery.
3. High risk: nonmajor surgery in patients older than 60 years or with additional risk factors or patients undergoing major surgery who are older than 40 years or have additional risk factors. Recommend LDUH 5000 U three times a day or LMWH 3400 U once daily, first dose 2 hours prior to surgery
4. Very high risk: multiple risk factors. Recommend pharmacologic methods (i.e., LDUH 5000 three times a day or LMWH 3400 U daily) be combined with the use of GCSs and SCDs.
5. Selected high risk: major cancer surgery, multiple risk factors. Recommend post–hospital discharge prophylaxis with LMWH or perioperative warfarin (international normalized ratio 2–3).

SUGGESTED PROPHYLAXIS IN PLASTIC SURGERY

Dujon et al noted the variability in prophylaxis in 1992 and pointed out the need for fixed protocols for the prevention of thromboembolism.[54] Recent focus has been specifically on recognizing the precautions that should be taken to avoid DVT and PE in the plastic surgery patient.

McDevitt through the American Society of Plastic Surgery Task Force on Deep Venous Thrombosis Prophylaxis established and published guidelines in 1999.[55] These recommendations were extrapolated from the ACCP protocol mentioned previously, which did not specifically address plastic surgery patients. The guidelines recommended stratifying patients into three categories—low, moderate, and high risk for DVT/PE.

1. Low-risk patients
- age < 40 years
- surgery less than 30 minutes
- no associated risk factors

  Recommendations: Comfortable positioning with knee flexion at 5 degrees with a pillow to allow maximal blood flow through the popliteal vein. Avoid external pressure or constriction on the lower extremities.

2. Moderate-risk patients
- age > 40 years
- surgery greater than 30 minutes
- no associated risk factors
- patients taking oral contraceptives or hormone replacement therapy

  Recommendations: Same measures as low risk plus GCSs and SCDs. Consider chemoprophylaxis if dissection is limited.

3. High-risk patients
- age > 40 years
- surgery greater than 30 minutes
- additional risk factors such as malignancy, immobilization, obesity, and hypercoagulable states

Step I. **Total = _____**

Exposing Risk Factors			
Check the box corresponding to each condition			
1 Factor	**2 Factors**	**3 Factors**	**5 Factors**
Minor surgery ☐	*Major surgery ☐	Previous myocardial infarction ☐	Hip,pelvis, or leg fracture ☐
	Immobilizing plaster cast ☐	Congestive heart failure ☐	Stroke ☐
	Patient confined to bed for > 72 hrs ☐	Severe sepsis ☐	Multiple trauma ☐
	Central venous access ☐	Free flap ☐	Acute spinal cord injury ☐

*Major surgery is defined by the use of general anesthesia or any procedure lasting longer than 1 hour.

Step II. **Total = _____**

Predisposing Risk Factors		
Check the box corresponding to each condition		
Clinical Setting	**Inherited**	**Acquired**
Age 40 to 60 (1 Factor) ☐	Any genetic hypercoaguable disorder (3 Factors) ☐	Lupus anticoagulant (3 Factors) ☐
Age > 60 (2 Factors) ☐		Antiphospholipid antibodies (3 Factors) ☐
History of DVT/PE (3 Factors) ☐		Myeloproliferative disorders (3 Factors) ☐
Pregnancy or < 1 month postpartum (1 Factor) ☐		Heparin-induced thrombocytopenia (3 Factors) ☐
Malignancy (2 Factors) ☐		Hyperviscosity (3 Factors) ☐
Obesity > 20% IBW (1 Factor) ☐		Homocystinemia (3 Factors) ☐
Oral contraceptive / hormone replacement therapy (1 Factor) ☐		

Step III. **Total Step I and Step II = _____** **Factors**

Step IV. Orders

1 Factor	Low risk	Ambulate patien: TID ☐
2 Factors	Moderate risk	Intermittent pneumatic compression stockings with elastic compression stockings on at all times when not ambulating ☐
3-4 Factors	High risk	Intermittent pneumatic compression stockings with elastic compression stockings on at all times when not ambulating ☐
> 4 Factors	Highest risk	Intermittent pneumatic compression stockings with elastic compression stockings on at all times when not ambulating ☐ + 1. Enoxaparin (Lovenox) 40mg SQ once daily post op ☐ ***For 1 : Give first dose 12 hours Post Op***

Signature _____ Date/Time_____

Print Name Pager #

Figure 1 Plastic surgery risk assessment and recommendations for venous thromboembolism prophylaxis. From Davison et al,[58] with permission.

Recommendations: Same as for low- and moderate-risk patients plus considerations for preoperative hematology consultation and LMWH injections 2 hours prior to surgery and daily until the patient is fully ambulatory.

These recommendations were reiterated by Iverson in 2002 as part of an article by the American Society of Plastic Surgery (ASPS) Task Force on Patient Safety in Office-based Surgery Facilities.[56] Because most aesthetic patients would fall into the high- and moderate-risk categories, the emphasis was again on prevention and early ambulation.

The algorithm was simplified by Davison et al.[57] The authors approached the patient by creating an algorithm that combined the McDevitt recommendations with Caprini's risk assessment model utilizing the point system to stratify plastic surgery patients.[58] Perioperative risk factors are added to predisposing risk factors such as age and hypercoagulability, and an overall score assigns a patient to a specific prophylactic risk group with suggested recommendations (Fig. 1). According to the authors, this allows easy assessment with clear management options. Reiterating, the recommendations mentioned by McDevitt included flexion of the knee at 5 degrees with a pillow and early ambulation as logical and effective measures that should be applied to every patient. The controversial decision concerning preoperative versus postoperative LDUH/LMWH was left up to the discretion of the physician on the basis of risks and consequences of bleeding. If the agent was administered postoperatively, such as in the highest risk group, recommendations were for a 12-hour delay along with continuation until the patient is fully ambulatory. The authors also favored LMWH over LDUH because of the once-daily dosing, lower incidence of heparin-induced thrombocytopenia, and greater bioavailability.

In 2006, a thorough and comprehensive article by Young and Watson once again urged the need for VTE prophylaxis in plastic surgery.[7] In expanded detail, the article summarized the incidence, etiology, and risk factors and suggested prophylaxis for VTE. The authors broke down the risk factors in more detail and stratified patients into low-, moderate-, high-, and very high risk categories, mirroring the ACCP protocol. Chemoprophylaxis is aggressively recommended as in the ACCP guidelines with initiation at the moderate-risk category. Initial dose can either be LMWH (enoxaparin 40 mg SC per day) 2 hours prior to surgery or 12 hours after surgery or fondaparinux (2.5 mg SC per day) 6 hours after surgery. Regardless of the drug of choice, prophylaxis was to be continued every day for up to 12 days depending on category. The authors understand the reluctance of plastic surgeons to use chemoprophylaxis because of bleeding but note little to no increase in the frequency of bleeding if these drugs are used appropriately[3,59] The authors' guidelines go a step further than the ACCP to recommend SCDs and GCSs in all categories except for low risk.

CONCLUSIONS

VTE continues to be a topic of hot debate in medicine. Algorithms for the diagnosis of VTE continue to evolve with various specialties continuing to publish recommendations and guidelines for this very preventable disease.[60]

The American Society for Aesthetic Plastic Surgery (ASAPS) reported that ~364,610 breast augmentations, 150,401 face lifts, 455,489 liposuction procedures, and 169,314 abdominoplasties were performed in the United States in 2005. Liposuction was the most common procedure performed, and they estimated that each ASAPS member would perform roughly 78.9 cases per year. With a liposuction VTE rate of 1.1%, a plastic surgeon can expect a VTE complication once every 1.15 years. This would be the minimum risk for only one common procedure; additional procedures would only increase the incidence.

Given these astounding numbers, there still remain many plastic surgeons who overlook the use of VTE prophylaxis. Although VTE remains a small risk for plastic surgery patients, it remains a critically important topic for the elective aesthetic patient. With significant DVT morbidity and PE mortality rates, the result of such incidences in the elective setting is catastrophic for the patient as well as the plastic surgeon.

As a specialty, we need to lower the threshold for VTE prophylaxis. Although the guidelines are still unclear, increasing awareness should at least lead to the minimum use of SCDs and GCSs in most patients. Chemoprophylaxis should be considered as a prophylactic regimen prior to surgery and administered in nearly all patients who are not ambulatory after surgery. Abundant data exist from meta-analyses and placebo-controlled, double-blind, randomized trials that demonstrate either no increase or small increases in the absolute rates of major bleeding with the use of LDUH or LMWH.[3] Neglect of this topic will result in preventable complications and lawsuits in this litigious society. It is difficult for a jury to understand why a surgeon would not adhere to guidelines published by his or her own specialty society.[61]

REFERENCES

1. Stein PD. Observations in venous thromboembolism. Am J Med 2001;110:69–70
2. Kearon C. Natural history of venous thromboembolism. Circulation 2003;107(23 Suppl 1):I22–I30
3. Geerts WH, Heit JA, Clagett GP, et al. Prevention of venous thromboembolism. Chest 2001;119(Suppl):132S–175S

4. Havig O. Deep vein thrombosis and pulmonary embolism. An autopsy study with multiple regression analysis of possible risk factors. Acta Chir Scand Suppl 1977;478:1–120
5. Wells PS, Owen C, Doucette S, Fergusson D, Tran H. Does this patient have deep vein thrombosis? JAMA 2006;295: 199–207
6. Poponick J, Bosker G. The current challenge of venous thromboembolism (VTE) in the hospitalized patient. Part III: national guidelines for DVT prevention and their implications for hospital practice. Clin Cardiol Consensus Rep; Aug 1, 2002
7. Young VL, Watson ME. The need for venous thromboembolism (VTE) prophylaxis in plastic surgery. Aesthetic Surgery Journal 2006;26:157–175
8. Lee AY, Levine MN, Baker RI, et al. Low molecular-weight heparin versus a coumarin for the prevention of recurrent venous thromboembolism in patients with cancer. N Engl J Med 2003;349:146–153
9. Voss SC, Sharp HC, Scott JR. Abdominoplasty combined with gynecologic surgical procedures. Obstet Gynecol 1986;67: 181–185
10. Hirsh J, Lee AY. How we diagnose and treat deep vein thrombosis. Blood 2002;99:3102–3110
11. Davidson BL. Controversies in pulmonary embolism and deep venous thrombosis. Am Fam Physician 1999;60:1969–1980
12. Feied CF. Pulmonary chest pain, cor pulmonale, and pulmonary embolism. In: Gibler WB, Aufderheide TP, eds. Emergency Cardiac Care. St. Louis, MO: Mosby; 1994:243–303
13. Anderson FA, Wheeler HB, Goldberg RJ, et al. A population-based perspective of the hospital incidence and case fatality rates of deep vein thrombosis and pulmonary embolism: the Worcester DVT Study. Arch Intern Med 1991;151:933–938
14. Dalen JE, Alpert JS. Natural history of pulmonary embolism. Prog Cardiovasc Dis 1975;17:259–270
15. Silverstein MD, Heit JA, Mohr DN, et al. Trends in the incidence of deep vein thrombosis and pulmonary embolism: a 25-year population-based study. Arch Intern Med 1998; 158:585–593
16. Anderson FA Jr, Wheeler HB. Venous thromboembolism: risk factors and prophylaxis. Clin Chest Med 1995;16:235–251
17. Atluri P, Raper SE. Factor V Leiden and postoperative deep vein thrombosis in patients undergoing open Roux-en-Y gastric bypass surgery. Obes Surg 2005;15:561–564
18. 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
19. Melinek J, Livingston E, Cortina G, Fishbein MC. Autopsy findings following gastric bypass surgery for morbid obesity. Arch Pathol Lab Med 2002;126:1091–1095
20. Bergqvist D. Low molecular weight heparin for the prevention of postoperative venous thromboembolism after abdominal surgery: a review. Curr Opin Pulm Med 2005;11:392–397
21. Grazer FM, de Jong RH. Fatal outcomes from liposuction: census survey of cosmetic surgeons. Plast Reconstr Surg 2000; 105:436–446
22. Albin R, de Campo T. Large-volume liposuction in 181 patients. Aesthetic Plast Surg 1999;23:5–15
23. Commons GW, Halperin B, Chang CC. Large volume liposuction: a review of 631 consecutive cases over 12 years. Plast Reconstr Surg 2001;108:1753–1763
24. Gilliland MD, Commons GW, Halperin B. Safety issues in ultrasound assisted large volume lipoplasty. Clin Plast Surg 1999;26:317–335
25. Hughes CE III. Reduction of lipoplasty risks and mortality: an ASAPS survey. Aesthetic Surg J 2001;21:120
26. van Uchelen JH, Werker PMN, Kon M. Complications of abdominoplasty in 86 patients. Plast Reconstr Surg 2001;107: 1869–1873
27. Grazer FM, Goldwyn RM. Abdominoplasty assessed by survey, with emphasis on complications. Plast Reconstr Surg 1977;59:513–517
28. Hester TR Jr, Baird W, Bostwick J3rd, Nahai F, Cukic J. Abdominoplasty combined with other surgical procedures: safe or sorry? Plast Reconstr Surg 1989;83:997–1004
29. Voss SC, Sharp HC, Scott JR. Abdominoplasty combined with gynecologic surgical procedures. Obstet Gynecol 1986; 67:181–185
30. Aly AS, Cram AE, Chao M, Pang J, McKeon M. Belt lipectomy for circumferential truncal excess. Plast Reconstr Surg 2003;111:398–413
31. Reinisch JF, Bresnick SD, Walker JWT, Rosso RF. Deep venous thrombosis and pulmonary embolus after face lift: a study of incidence and prophylaxis. Plast Reconstr Surg 2001; 107:1570–1575
32. White RH. The epidemiology of venous thromboembolism. Circulation 2003;107(23 Suppl 1):I4–I8
33. Anderson FA Jr, Spencer FA. Risk factors for venous thromboembolism. Circulation 2003;107:I9–I16
34. Wheeler HB. Diagnosis of deep vein thrombosis. Review of clinical evaluation and impedance plethysmography. Am J Surg 1985;150:7–13
35. Jimenez D, Diaz G, Marin E, Vidal R, Sueiro A, Yusen RD. The risk of recurrent venous thromboembolism in patients with unprovoked symptomatic deep vein thrombosis and asymptomatic pulmonary embolus. Thromb Haemost 2006; 95:562–566
36. Samama MM. An epidemiologic study of risk factors for deep vein thrombosis in medical outpatients. The Sirius study. Arch Intern Med 2000;160:3415–3420
37. Agnelli G, Bolis G, Capussotti L, et al. A clinical outcome-based prospective study on venous thromboembolism after cancer surgery: the RISTOS project. Ann Surg 2006;243:89–95
38. Vessey M, Mant D, Smith A, Yeates D. Oral contraceptives and venous thromboembolism: findings in a large prospective study. BMJ 1986;292:526
39. Daly E, Vessey MP, Hawkins MM, Carson JL, Gough P, Marsh S. Risk of venous thromboembolism in users of hormone replacement therapy. Lancet 1996;348:977–980
40. Jick H, Derby LE, Myers MW, Vasilakis C, Newton KM. Risk of hospital admission for idiopathic venous thromboembolism among users of postmenopausal oestrogen. Lancet 1996;348:981–983
41. Grodstein F, Stampfer MJ, Goldhaber SZ, et al. Prospective study of exogenous hormones and risk of pulmonary embolism in women. Lancet 1996;348:983–987
42. Perez-Gutthann S, Garcia-Rodriguez L, Castellsague J, Duque-Oliart A. Hormone replacement therapy and the risk of venous thromboembolism: population-based case-control study. BMJ 1997;314:796–800

43. Varas-Lorenzo C, Garcia-Rodriguez L, Cattaruzzi C, Troncon MG, Agostinis L, Perez-Gutthann S. Hormone replacement therapy and the risk of hospitalization for venous thromboembolism: a population-based study in southern Europe. Am J Epidemiol 1998;147:387–390
44. Rosendaal FR, Vessey M, Rumley A, et al. Hormonal replacement therapy, prothrombotic mutations and the risk of venous thrombosis. Br J Haematol 2002;116:851–854
45. Shiffman MA. Estrogen and thromboembolic problems. Plast Reconstr Surg 2002;110:713–715
46. Wells PS, Lensing AW, Hirsh J. Graduated compression stockings in the prevention of postoperative venous thromboembolism: a meta-analysis. Arch Intern Med 1994;154: 67–72
47. Janssen H, Trevino C, Williams D. Hemodynamic alterations in venous blood flow produced by external pneumatic compression. J Cardiovasc Surg (Torino) 1993;34:441–447
48. Salzman EW, McManama GP, Shapiro AH, et al. Effect of optimization of hemodynamics on fibrinolytic activity and antithrombotic efficacy of external calf compression. Ann Surg 1987;206:636–641
49. Gertler JP, Abbott WM. Prothrombotic and fibrinolytic function of normal and perturbed endothelium. J Surg Res 1992;52:89–95
50. Urbankova J, Quiroz R, Kucher N, Goldhaber SZ. Intermittent pneumatic compression and deep vein thrombosis prevention. A meta-analysis in postoperative patients. Thromb Haemost 2005;94:1181–1185
51. Most D, Kozlow J, Heller J, Shermak M. Thromboembolism in plastic surgery. Plast Reconstr Surg 2005;115:20–30
52. Warkentin TE, Levine MN, Hirsh J, et al. Heparin-induced thrombocytopenia in patients treated with low-molecular-weight heparin or unfractionated heparin. N Engl J Med 1995;332:1330–1335
53. Koch A, Bouges S, Ziegler S, et al. Low molecular weight heparin and unfractionated heparin in thrombosis prophylaxis after major surgical intervention: update of previous meta-analyses. Br J Surg 1997;84:750–759
54. Dujon DG, Chatzis LA, Hart NB. Thromboembolic prophylaxis in plastic surgery: an appraisal. Br J Plast Surg 1992;45:418–420
55. McDevitt NB. Deep vein thrombosis prophylaxis. Plast Reconstr Surg 1999;104:1923–1928
56. Iverson RE. ASPS Task Force on Patient Safety in Office-based Surgery Facilities. Patient safety in office-based surgery facilities: I. Procedures in the office-based surgery setting. Plast Reconstr Surg 2002;110:1337–1342
57. Davison SP, Venturi ML, Attinger CE, Baker SB, Spear SL. Prevention of venous thromboembolism in the plastic surgery patient. Plast Reconstr Surg 2004;114:43E–51E
58. Caprini JA, Arcelus JI, Reyna JJ. Effective risk stratification of surgical and nonsurgical patients for venous thromboembolic disease. Semin Hematol 2001;38(2 Suppl 5):12–19
59. Levine MN, Raskob G, Beyth RJ, Kearon C, Schulman S. Hemorrhagic complications of anticoagulant treatment. The seventh ACCP conference on antithrombotic and thrombolytic therapy. Chest 2004;126(3 Suppl):287S–310S
60. Tapson V. Treatment of venous thromboembolism. Continuing Medical Education Series. Am J Med 2006
61. The Doctors Company. Deep venous thrombosis and pulmonary embolism in plastic surgery office procedures. Available at: www.thedoctors.com