As a large private group practice with a designated and well organized clinical research center, it has been our primary goal to increase the safety of aesthetic surgery. Plastic surgeons must be conscious of the potential risk of deep vein thrombosis (DVT) and pulmonary embolism (PE), and should be aware of the preemptive measures that can significantly reduce this risk. To address this problem, we first needed to establish accurate rates of occurrence. Because data were sparse regarding DVT/PE in the context of aesthetic surgery, it was first necessary to review relevant data gathered from general surgery literature to provide a baseline. These data show an incidence of postoperative DVT ranging from 16% to 30%, and of PE ranging from 0.1% to 0.8%. Data regarding DVT/PE in aesthetic surgery reflect incidence rates of 1.2% according to Grazer and Goldwyn and 0.8% for PE among patients who underwent abdominoplasty.

To provide more data on this subject and promote patient safety, several studies have recently been published regarding thromboembolism in high-risk aesthetic surgery. According to Schmitz, PE is the most frequently reported cause of death resulting from procedures performed in the office-based surgery facility; those procedures with the highest level of DVT incidence are abdominoplasty and circumferential liposuction. In 2004, the American Society of Plastic Surgeons provided additional information on DVT and PE and collaborated on development of a DVT module in association with the Tracking Operations and Outcomes for Plastic Surgeons (TOPS) program. The TOPS Committee chair, Dr. Gutowksi, reported, "... we are very pleased that the DVT module also gathered information on patient selection criteria and plastic surgeons' practice patterns related to perioperative thromboprophylaxis across facility types."
After a year of collecting data, the committee reported that “DVT/PE was 5 times more likely to occur in the acute care setting than the office-based surgery setting.” Dr. Gutowski further stated that “Patient selection criteria was also an important factor since patients who experienced DVT/PE included an 8% higher incidence in use of hormonal contraceptives at the time of surgery, 7% higher incidence with use of hormone replacement therapy (HRT) at time of surgery, and a 21% higher incidence if patients were obese with a body mass index (BMI) of 30 or greater.”

A survey by Broughton et al published in January 2007 showed that only 48.7% of surgeons performing face lifts, 43.7% of surgeons performing lipoplasty, and 60.8% of surgeons performing a combined procedure actively use DVT prophylaxis on a continual basis.

These publications clearly support a growing need for educational guidelines concerning aesthetic surgery procedures and DVT, and additional study should take place on this important issue.

OBJECTIVES
It is the purpose of this study to review 3871 consecutive high-risk cases, and to identify common factors that could have contributed to the onset of DVT/PE in 17 of these patients. A close evaluation of these 17 patients was conducted to identify the contributing factors that could have been prevented, or at least promptly managed, while finding practical and efficient ways to avoid them in the future.

Safety guidelines are presented, resulting from the review of these 17 patients, to be used for the implementation of thromboprophylaxis in high- and highest risk patients. We also provide recommendations for pre-, intra-, and postoperative phases of surgery based on our experience with these 3871 cases.

METHODS
This retrospective study involves 3871 consecutive procedures performed by experienced board-certified plastic surgeons in our American Association for Accreditation of Ambulatory Surgery Facilities–certified office-based surgical facility over the last 8 years (August 25, 1999 to July 30, 2007). The procedures included abdominoplasty, large volume lipoplasty, breast surgery, and various body lift/contouring procedures. In all cases, a board-certified anesthesiologist administered general anesthesia. All patients followed a standard DVT thromboprophylaxis protocol. An exhaustive analysis was conducted on the 17 patients who, despite established preventive measures, developed serious complications of DVT and PE. In terms of risk factors, the Georgetown Risk Management Classification was used in all patients (Table 1). In addition, patients were subjected to a preoperative evaluation based on the American Society of Anesthesiologist’s (ASA) classification standards (Table 2). The most recent data regarding patient condition were obtained directly from the patient via telephone interviews conducted by an outside independent professional.

Among those patients presenting with complications, the following parameters were carefully evaluated: age, weight, BMI, medical history (including medications), and surgical, family, and social history. During the course of surgery, we evaluated the duration of the procedure, amount of tumescent infiltration, the patient’s total aspiration volume, and the amount of tissue removed. The patient’s temperature was monitored throughout the pre-, intra-, and postoperative periods. A postoperative evaluation was also performed, taking into account any complications, such as the date and time when signs and symptoms were first noticed and an analysis of the different methods used to verify such complications, including venous Doppler scan, spiral computed tomography scan, and V/Q scan.

After collecting preliminary information from the 3871 patients, a group of statistics was designed to provide several analyses and projections. First, patients were placed into 2 groups, and a sample size was determined for each group. Group I included patients in whom DVT/PE had developed (sample size, 17). Group II included patients that did not present signs and symptoms of DVT/PE complications (sample size, 3854). The 2-sample t test was applied to compare both groups and a logistic regression model was created to predict the probability of DVT complications in patients (Table 3). The statistical evaluation was performed by the Department of Industrial Engineering Section of Statistics at the University of Houston.

RESULTS
After evaluating the data gathered from all 17 patients in group I, overall averages in each category were calculated and reported as follows: median age, 39 years; median height, 5’4”; median weight, 185 pounds; and median BMI, 29.9. It was apparent that the majority of patients examined were categorized, according to ASA standards, as low-risk patients (ASA I or ASA II). Of the 17 patients that developed serious complications, 31% were categorized as ASA I, 56% were categorized as ASA II, and 13% were categorized as ASA III. When these data were combined with the information derived from the Georgetown Risk Assessment Classification model, it was verified that all of the patients were at the high or highest risk level for venous thromboembolic complications. Using the Georgetown Classification model, 7 of 17 patients fell into the high-risk category, while the other 10 fell into the highest risk category. All of the patients in the highest risk category exhibited more than 4 factors, shown by our research, predisposing them to DVT and PE.

In terms of surgical data, the following was found: the average surgical duration was 5 hours 25 minutes (ranging from 1 hour 5 minutes to 9 hours), the average aspiration volume was 6437 mL, and the average body temperature was 35.1°C (range, 31.8°C to 38.0°C). After
closely monitoring the patients, it was discovered that of the 17 patients, DVT developed in 12, PE developed in 3, and both events developed in 2 patients. From this data, an incidence rate of 0.42% was derived, and no mortality was encountered in this study.

In terms of the DVT/PE complications, the symptoms that were found included exquisite pain and swelling of the affected extremity, shortness of breath, chest pain, syncope, and anxiety. These symptoms appeared within a range of 3 to 23 days postsurgery (average, 11 days). Upon close review, 70% of these patients were diagnosed as having a predisposition for thrombogenesis caused by either increased levels of clotting factors or inherited or acquired thrombophilias. Further, it was discovered that at least 58% of the patients suffering from DVT/PE were on regimens of oral contraceptives or HRT at the time of surgery. Laboratory results also indicated that acquired and inherited thrombophilias were present factors among the patients. In fact, one of our patients tested positive for lupus, which is a clearly identified acquired thrombophilia. In reference to inherited thrombophilias, one patient was positive for factor V Leiden.
mutation; this patient was also taking oral contraceptives at the time this study was conducted. Another patient, who was also taking HRT, tested positive for a prothrombin mutation and exhibited low levels of proteins C and S. Another patient possessed a genetic mutation related to elevated levels of homocysteine in the body. Other interesting findings of equal importance involved 2 patients who had a recent history of smoking, while one of these patients had a documented history of anemia.

As part of our findings, we present in Table 4 the incidence rates associated with DVT and PE that were found in this study as compared with other studies.

After performing a number of statistical analyses on the 2 groups (group 1, patients with DVT complication [n = 17]; group 2, patients without DVT complication [n = 100]), the following conclusions were reached (Tables 5 and 6):

1. The mean value of patient weight before surgery in group 1 was statistically significantly greater than in group 2 (P = .076).
2. The mean value of patient height in group 1 was statistically significantly smaller than in group 2 (P = .03).
3. The mean value of patient BMI before surgery in group 1 was statistically significantly greater than in group 2 (P = .017).

4. The mean value of duration of surgery in group 1 was statistically significantly greater than in group 2 (P = .023).
5. The mean value of patient temperature in group 1 was statistically lower than in group 2 (P = .105).
6. The mean value of total surgical fat removal in group 1 was statistically significantly greater than in group 2 (P = .08).
7. The proportion of abdominoplasty procedures in group 1 was statistically significantly greater than in group 2 (P = .008).
8. The proportion of body lift procedures in group 1 was statistically significantly greater than in group 2 (P = .024).

In this study, a number of student t tests were performed to compare the mean values of many key factors in the 2 groups. The first group consisted of 17 patients with a thrombogenic complication after surgery; the second group consisted of 100 patients without a thrombogenic complication after surgery, randomly selected from our study population of 3854 consecutive cases. The first group of patients is referred to as the “thrombogenic group” and the second group is referred to as the “non-thrombogenic group.”

Based on results obtained from the student t tests, the following conclusions were reached: there was statistical evidence demonstrating that mean values of weight before surgery, BMI, length of surgery, and amount of surgical fat removal in the thrombogenic group were significantly higher than those in the nonthrombogenic group. In addition, the proportion of patients with tummy tuck and body lifting operations was statistically higher in the thrombogenic group than those in the nonthrombogenic group. Finally, there was also statistical evidence illustrating that the mean values of patient height and temperature in the thrombogenic group were significantly lower than those in the nonthrombogenic group.

Table 3. Explanation of statistical analysis model used in this study

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr(DVT) =</td>
<td>$\frac{1}{1 + e^{-(22.5057+0.10989(BMI)-0.295474(Temp)+0.811581(TT)+2.2755(BodyL))}}$</td>
</tr>
<tr>
<td>Where:</td>
<td></td>
</tr>
<tr>
<td>Pr(DVT) = probability of the patient having the DVT complication</td>
<td></td>
</tr>
<tr>
<td>BMI = the value of patient body mass index</td>
<td></td>
</tr>
<tr>
<td>Temp = the value of the room temperature in the patient in fahrenheit</td>
<td></td>
</tr>
<tr>
<td>TT = 1 if a “tummy tuck” procedure is performed on the patient, 0 if otherwise</td>
<td></td>
</tr>
<tr>
<td>BodyL = 1 if the body lifting procedure is performed on the patient, 0 if otherwise</td>
<td></td>
</tr>
</tbody>
</table>

We used this model to predict the probability of DVT complication in 117 patients. The model correctly predicts the result about 90% of the time.

Table 4. Deep venous thrombosis and pulmonary embolism incidence rates

<table>
<thead>
<tr>
<th>Incidence</th>
<th>DVT</th>
<th>PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the United States</td>
<td>1.2%</td>
<td>0.8%</td>
</tr>
<tr>
<td>ASPS (abdominoplasty)</td>
<td>1.2%</td>
<td>0.08%</td>
</tr>
<tr>
<td>ACPS</td>
<td>0.46%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

ASPS, American Society of Plastic Surgeons; ACPS, Aesthetic Center for Plastic Surgery; DVT, deep venous thrombosis; PE, pulmonary embolism.
Table 5. Comparative analysis between the thrombogenic and nonthrombogenic groups

<table>
<thead>
<tr>
<th>Category</th>
<th>Group 1: Thrombogenic (N = 17)</th>
<th>Group 2: Nonthrombogenic (N = 100)</th>
<th>P for comparing mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>Mean: 39.94, SD: 9.74</td>
<td>Mean: 39.2, SD: 11.1</td>
<td>.389</td>
</tr>
<tr>
<td>Presurgery weight (lbs)</td>
<td>Mean: 178.5, SD: 33.1</td>
<td>Mean: 165.4, SD: 34.6</td>
<td>.076</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>Mean: 162.1, SD: 6.49</td>
<td>Mean: 165.63, SD: 7.95</td>
<td>.03</td>
</tr>
<tr>
<td>Body mass index</td>
<td>Mean: 30.95, SD: 6.41</td>
<td>Mean: 27.23, SD: 4.59</td>
<td>.017</td>
</tr>
<tr>
<td>Length of surgery (min)</td>
<td>Mean: 282, SD: 135</td>
<td>Mean: 201, SD: 131</td>
<td>.023</td>
</tr>
<tr>
<td>Patient temperature (°F)</td>
<td>Mean: 95.23, SD: 1.97</td>
<td>Mean: 95.93, SD: 1.57</td>
<td>.105</td>
</tr>
<tr>
<td>Total fat removed (cc)</td>
<td>Mean: 6509, SD: 4883</td>
<td>Mean: 4715, SD: 2889</td>
<td>.08</td>
</tr>
<tr>
<td>Intravenous fluids (mL)</td>
<td>Mean: 2533, SD: 1767</td>
<td>Mean: 2174, SD: 998</td>
<td>.228</td>
</tr>
<tr>
<td>Proportion of patients undergoing tummy tuck</td>
<td>0.706, 0.47</td>
<td>0.379, 0.488</td>
<td>.008</td>
</tr>
<tr>
<td>Proportion of patients undergoing body lift/contouring</td>
<td>0.294, 0.47</td>
<td>0.046, 0.211</td>
<td>.024</td>
</tr>
</tbody>
</table>

SD, standard deviation.

Table 6. Recommendations (based on this study) and traditional guidelines for DVT and PE prevention

<table>
<thead>
<tr>
<th>Preoperative</th>
<th>Intraoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete a thorough medical history and stratify patients according to ASA classification17</td>
<td>Continue to avoid hypothermia 1. Use humidified oxygen 2. Use upper and lower Bair Huggers when possible 3. Minimize surface area exposure with sterile warmed blankets 4. Use warm fluids for irrigation 5. Use warm tumescent solution 6. Use intermittent pneumatic compression devices 7. Place regional infusion pain pumps</td>
<td>Avoid hypothermia 1. Administer low-molecular-weight enoxaparin, 40 mg administered SQ 1 hour after surgery and then q 12 hours × 72 hours, but only for those cases not involving combination breast surgery 2. Use warmed blankets in recovery room 3. Use new Bair Hugger gown 4. Perform active plantar flexion and dorsiﬂexion of feet 5. Start infusion of pain pump (marcaine) 6. Use intermittent pneumatic compression devices until patient is discharged the next day 7. Use graded elastic compression stockings 8. Initiate early ambulation 9. Use compression garments for 4–6 weeks</td>
</tr>
<tr>
<td>Complete a thorough risk assessment evaluation using Georgetown Classification16</td>
<td>Discontinue all hormone therapies at least 4 weeks before the procedure</td>
<td>Avoid hypothermia</td>
</tr>
<tr>
<td>Discontinue all hormone therapies at least 4 weeks before the procedure</td>
<td>Consider multivitamins with folic acid, B complex, and iron supplementation at least 2 weeks before surgery</td>
<td></td>
</tr>
</tbody>
</table>

ASA, American Society of Anesthesiologists; SQ, subcutaneously.
DISCUSSION

DVT results from the synergistic effects of combined factors. We recommend that a variety of techniques be used to maintain a proper balance between thrombogenesis and thrombolysis. The signs and symptoms of DVT/PE are unpredictable. Symptoms may range from florid manifestations, involving shortness of breath and chest pain, to asymptomatic manifestations that are difficult to diagnose. Therefore, a high level of suspicion is necessary to perform an effective diagnosis. Patients must be informed preoperatively of these symptoms and directed to seek emergency medical assistance at the first sign of complications. Among the patients studied, symptoms of DVT/PE arose from the third postoperative day to up to 23 days following surgery.

A reliable diagnosis of DVT/PE requires the surgeon to closely evaluate all clinical findings, including positive tests, and, using the process of elimination, to rule out other possibilities. Examinations that support final diagnoses have a low sensibility. For instance, an abnormal chest radiograph is seen in only 80% of cases for pulmonary embolism, and nonspecific electrocardiographic abnormalities occur in only 70% to 75% of cases. Although plethysmography and Doppler ultrasound are more advanced methods of detection, their sensibility is only moderate, and they can be cost prohibitive. A D-dimer test is highly sensitive with a moderate false (+) rate and a very low false (−) rate.

Because the patients who present the highest risk for complications of DVT/PE were those considered either high or highest risk according to the Georgetown Classification model this particularity prompted us to analyze the following: (1) patient selection criteria; (2) surgical procedures; (3) known complications; (4) predisposition factors; and (5) postoperative management. Although there was not one specific precipitating factor common among all patients in whom a thromboembolic event developed, we noticed a trend of certain predisposing factors. It was found that 12 of 17 (70%) of patients were suspected to have had a previous hypercoagulable state. Of these 12 patients, 10 (58%) were using oral contraceptives or HRT. This is the second most common cause of inherited thrombophilia, producing an incident rate of 1% to 2% among Caucasian patients. To clarify, a prothrombin mutation also results in slower inactivation and persists longer in the circulation, which creates a threefold increase for thromboembolism. Another patient involved in our study produced positive results for a genetic mutation that causes elevated levels of homocysteine. Homocystinemia has been implicated in the development of venous thromboembolism. Statistics show that levels may be elevated in 5% to 7% of the population and can result from factors such as genetic mutation, B complex and folic acid deficiencies, and cigarette smoking. In addition, it has been documented that the presence of lupus anticoagulant and antiphospholipid antibody can predispose one to thromboembolism. One of our patients was positive for systemic lupus erythematosus. This is a chronic systemic inflammatory disease that is predominant in African American women in their twenties and thirties.

RECOMMENDATIONS

Our recommendations emphasize the effective use of sequential compression devices and anticoagulants to serve as a preventive measure among surgical candidates who present elevated risk factors. It is not cost effective to conduct extensive tests on all patients for each type of coagulopathy disorder. In lieu of this, for those patients who exhibit the aforementioned factors (placing them into a high risk category), we highly suggest that the plastic surgeon implement a standard antithrombotic regimen to decrease the incidence rates of DVT/PE. (Please refer to the recommendations summarized in Table 6.)

We feel that sequential compression devices should be used both intra- and postoperatively as the standard of care in all patients under general anesthesia for 2 hours or more. Further considerations include the temporary discontinuation of all hormonal therapy at least 4 weeks before surgery to ensure the return of fibrinogen to normal levels. It is also advisable for patients to begin multivitamins that contain folic acid and B complex to avoid elevated homocysteine levels at least 2 weeks before surgery. Reducing the patient’s risk of hypothermia may theoretically reduce the risk of DVT by avoiding vasoconstriction and venous stasis. Studies have demonstrated that hypothermia precipitates clot formation more than degradation.
We feel that perioperative normothermia can be accomplished by employing the following: core pre-warming with (1) preoperative use of Bair Hugger gowns (Arizant, Eden Prairie, MN); (2) warmed intravenous fluids and tumescent solutions; (3) warm humidified oxygen applied as a circuit warmer (Humidi-Heat) to the anesthesia breathing circuit; and (4) minimizing the surface area of exposure during surgery by using warmed sterile blankets. These measures are an addition to the well known and established guidelines published in the literature.22-26

The use of regional infusion pain pumps is advised to help induce early ambulation along with the administration of low-molecular weight heparin such as enoxaparin, 40 mg/day beginning on postoperative day 1 and continuing for 2 more days. The senior author’s (CP) experience is that if this medication is given in high risk patients who are having additional breast procedures, a higher incidence of hematomas can be expected. Therefore, its use with breast surgery should be cautioned. The senior author feels comfortable recommending this medication for high-volume lipoplasty and body contouring procedures that do not involve large breast dissections and undermining. It is his experience that to avoid the risk of postoperative bleeding and hematoma formation, enoxaparin should not be administered in patients who undergo mastopexy/breast reduction or augmentation as an added procedure.

In a study by one of our partners, Newall et al,8 that reviews his personal experience of 291 consecutive cases with high-risk aesthetic surgery combination procedures using 40 mg of enoxaparin subcutaneously beginning 1 hour after surgery and continuing for 3 days, there was a 0% incidence of DVT and PE. In the coming months, Dr. Newall will be completing a retrospective review of more than 2000 high-risk patients that underwent abdominoplasty, high volume lipoplasty, and breast reduction/augmentation/mastopexy procedures concurrently, without a significantly higher hematoma rate than that reported in the literature.

Lastly, it is imperative to maintain close observation of the patient for the first 4 weeks after surgery and to advise the patient to avoid long periods of immobilization, such as prolonged car rides or air travel.

Table 6 summarizes our own prevention guidelines for DVT and PE and the established traditional guidelines that plastic surgeons have followed over the past 10 years.

CONCLUSIONS

The central purpose of this article is to create more awareness among plastic surgeons regarding the risk of DVT and PE by closely reviewing the negative factors that can contribute to such complications. In all 17 patients in this study that encountered a venous thromboembolic event, an early diagnosis with immediate and aggressive treatment was instituted, preventing a potential catastrophic death. The prevailing conclusion of this article is that patients need to be educated preoperative-}

ly by the surgeon and staff for signs and symptoms of PE and DVT. In addition, the surgeon is strongly encouraged to maintain close communication with the patient, and to stress with the patient the importance of keeping all follow-up appointments. It is also imperative that effective lines of communication be maintained between the patient and the patient’s family, and between the surgeon and his staff, to promote prevention and ensure early detection of DVT and PE. Phone calls by the patient for any symptoms related to potential DVT/PE should be encouraged.

It is not our recommendation that every patient undergo arduous and costly preoperative examinations to detect all potential disorders that may become manifest during aesthetic surgery, since this is not a realistic approach in terms of cost effectiveness.

We cannot emphasize enough the need to have a thorough understanding and a comprehensive and proactive approach to DVT and PE, by the surgeon, anesthesiologist, and the entire surgical and nursing staff. Being vigilant and reacting promptly and effectively to the early signs of thromboembolism has saved us from many problems and prevented potential fatalities.

We appreciate the cooperation of our patients in allowing us to collect the much needed data that enabled us to report our experience with the intent of promoting patient safety and the advancement of thromboembolism prophylaxis in aesthetic plastic surgery. }

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DISCLOSURES

The authors have no disclosures with respect to this article.

REFERENCES


**SUGGESTED READING**


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