Thromboembolic Risk Assessment and the Efficacy of Enoxaparin Prophylaxis in Excisional Body Contouring Surgery

Daniel A. Hatef, M.D.
Jeffrey M. Kenkel, M.D.
Marilyn Q. Nguyen, M.D.
Jordan P. Farkas, M.D.
Fatemeh Abtahi, M.D.
Rod J. Rohrich, M.D.
Spencer A. Brown, Ph.D.

Dallas, Texas

Background: There is a paucity of evidence within the plastic surgery literature concerning risk stratification and management of patients with respect to thromboembolic disease. A retrospective chart review was conducted to examine whether the Davison-Caprini risk-assessment model could stratify patients undergoing excisional body contouring surgery, allowing prophylaxis to be managed in an evidence-based manner.
Methods: Three hundred sixty excisional body contouring patients at the University of Texas Southwestern Medical Center in Dallas, Texas, under the senior authors' (J.M.K. and R.J.R.) care were reviewed. Patients were stratified into groups according to the risk-assessment model and into groups based on procedure. Patient characteristics were investigated for their effects on thromboembolic risk. Complications of enoxaparin administration were analyzed. The data were analyzed using appropriate statistical procedures.
Results: The highest risk patients had a significantly increased rate of venous thromboembolism when compared with lower risk patients. Body mass index greater than 30 and hormone therapy use were associated with a significantly increased venous thromboembolism rate. Enoxaparin administration was associated with a statistically significant decrease in deep venous thrombosis in circumferential abdominoplasty patients. Enoxaparin administration was associated with higher bleeding rates.
Conclusions: Low-molecular-weight heparin may affect the incidence of postoperative thrombotic complications in some surgical populations. In this study, patients who scored greater than four risk factors were at significant risk for venous thromboembolism. Enoxaparin significantly decreased deep venous thrombosis risk in patients undergoing circumferential abdominoplasty. This demonstrates the need for a multicenter, prospective, randomized study to examine various thromboembolic therapies and associated possible complications in these patients. (*Plast. Reconstr. Surg.* 122: 269, 2008.)

The number of bariatric surgical procedures is on the rise, with an estimated 160,000 procedures performed in 2005.[1] As greater numbers of patients lose significant amounts of weight, plastic surgeons are seeing an exponential increase in massive weight loss patients seeking body contouring. The American Society of Plastic Surgeons estimates that over 350,000 excisional body contouring procedures were performed in 2006—up 95 percent since 2000.[2] Massive weight loss patients accounted for over 68,000 of these procedures, and it is anticipated that this trend will continue exponentially with the number of bariatric procedures.

Some results from a recent questionnaire suggest that many plastic surgeons have not consistently incorporated a venous thromboembolism prophylaxis regimen in their practice.[3] There have been no data that address either risk stratification or thromboprophylaxis in plastic surgery patients. Clearly,

From the Department of Plastic Surgery, University of Texas Southwestern Medical Center.
Received for publication May 24, 2007; accepted October 17, 2007.

DOI: 10.1097/PRS.0b013e3181773d4a

Disclosure: *There are no financial disclosures that might pose or create a conflict of interest with any of the information discussed in this article.*

this deficiency must be addressed. These procedures involve prolonged operative time under general anesthesia; extensive dissection; and, often, a prolonged postoperative period of decreased mobility.

Massive weight loss patients constitute a substantial proportion of these patients and are considered to be at a higher risk for thromboembolic disease because of their body mass index and history of previous surgery. The bariatric surgery literature has shown the postoperative gastric bypass venous thromboembolism risk to range from 0.2 to 20 percent.[4–7] In an effort to increase the understanding of thromboembolic risk and venous thromboembolism prophylaxis in patients undergoing excisional body contouring surgery, the authors conducted a retrospective review of all available charts for patients who underwent excisional body contouring procedures from July of 2003 to August of 2006 by the senior authors (J.M.K. and R.J.R.).

PATIENTS AND METHODS

An institutional review board–approved retrospective chart review was undertaken, and all charts for patients who underwent excisional body contouring procedures from January of 2003 to August of 2006 at the University of Texas Southwestern Medical Center by the senior authors were obtained. Pertinent data were recorded (Table 1).

Statistical Analyses

Patients receiving enoxaparin were compared with patients who did not receive enoxaparin for every variable of interest and p values were used to highlight statistical significance. Statistical analyses were performed using the SAS statistical software package (SAS Institute, Inc., Cary, N.C.). Summary statistics were used for all data. Means, standard deviations, and medians were used for the continuous variables. Fisher's exact test and chi-square statistics were used for categorical data. Patients were stratified into categories of risk based on the Davison-Caprini risk-assessment model[8,9] (Tables 2 through 4). Logistic regression was performed to compare the enoxaparin and no-enoxaparin groups for differences in rates of deep venous thrombosis, pulmonary embolism, clinically significant drop in hematocrit (defined as any postoperative drop in the patient's hematocrit for which blood transfusion was administered), and hematoma formation. Analysis of covariance was used to compare intraoperative blood loss and drain output (24 hours postoperatively) between the two groups, with drain output and intraoperative blood loss as the dependent variables and enoxaparin as the explanatory variable, with type of surgery, operative time, and body mass index as covariates added in to determine any other explanations. Patients who received enoxaparin were put into two groups based on timing of initial dose: preoperative enoxaparin, and intraoperative or postoperative initial administration. Patients who were administered their first dose of enoxaparin preoperatively received it no sooner than 2 hours before the operation and no later than 1 hour before the operation. Patients who were administered their first dose postoperatively received it no later than 2 hours after the operation. These two groups were examined using logistic regression analysis to compare differences in rates of deep venous thrombosis, pulmonary embolism, clinically significant drop in hematocrit, intraoperative blood loss, and hematoma. Confounding variables were added to the basic statistical model to determine any other explanations of differences. Frequencies and percentages are reported for categorical values.

Table 1. Pertinent Retrospective Data

Data Collected
Age
Sex
Race
Body mass index
Medical and surgical history
Medications
Operation
Operative time
Estimated blood loss
Inpatient stay
Drain output
No. of drains
Thromboprophylaxis (enoxaparin, sequential compression devices, early ambulation)
Enoxaparin administration (timing of first dose, days of treatment, total dosage)
Complications (hematoma, hematocrit drop requiring transfusion, seroma, wound-healing problems, DVT, PE)

DVT, deep venous thrombosis; PE, pulmonary embolism.

RESULTS

A total of 347 patients qualified for the main portion of the study. Eleven patients were excluded from some analyses because of incomplete data and the subsequent inability to retrospectively stratify them by risk according to the model. Two patients were excluded from the study because they had a previous history of deep venous thrombosis and were managed perioperatively with subcutaneous heparin injections at the recommendation of a consulting hematologist. Patients were assigned to all risk categories except the low-risk group ($n = 0$). Patients assigned to the

Table 2. Davison-Caprini Risk-Assessment Model: Exposing Risk Factors

1 Factor	2 Factors	3 Factors	5 Factors
Minor surgery	Major surgery	Previous MI/CHF	Hip, pelvis, leg fracture
	Immobilization	Severe sepsis	Stroke
	Central venous access	Free flap	Multiple trauma

MI, myocardial infarction; CHF, congestive heart failure.

Table 3. Davison-Caprini Risk-Assessment Model: Predisposing Risk Factors

	Factor
Age 40–60 years	1
Age >60 years	2
History of VTE	3
Current pregnancy	1
Current malignancy	2
Obesity	1
OCP/HRT	1
Hypercoagulable disorder	3

VTE, venous thromboembolism; OCP, over-the-counter progesterone; HRT, hormone replacement therapy.

Table 4. Davison-Caprini Risk-Assessment Model: Risk Assignment

1 Factor	2 Factors	3–4 Factors	>4 Factors
Low risk	Moderate risk	High risk	Highest risk

highest risk group had a significantly increased ($p < 0.001$) rate of venous thromboembolism (17 events) when compared with lower risk patients (two events; both events in patients assigned to the high-risk group) (overall, 19 events; average day of presentation, 9.95; venous thromboembolism rate, 5.28 percent; $n = 360$).

The majority of patients underwent abdominoplasty ($n = 159$). Eighty-six of these patients had only an abdominoplasty performed (not excluding liposuction); 73 underwent abdominoplasty with a concomitant procedure, typically breast/upper body procedures. There were 65 circumferential abdominoplasty patients. This is an entirely distinct group from the abdominoplasty group. Circumferential abdominoplasty (also known as belt lipectomy or lower body lift) constitutes an abdominal contouring procedure that involves a completely circumferential excision. Twenty-two of these had combined procedures and 43 had only circumferential abdominoplasty (not excluding liposuction).

Abdominoplasty was associated with a 5.03 percent overall rate of venous thromboembolism [eight events: three deep venous thromboses (1.89 percent); and five pulmonary embolisms (3.14 percent); 159 patients; $p = 1.00$]. Four venous thromboembolism events were in patients who underwent abdominoplasty alone (4.65 percent), and four events were in patients who underwent combined abdominoplasty with other excisional procedures (5.48 percent). Circumferential abdominoplasty was associated with a significantly higher rate of deep venous thrombosis ($p = 0.02$; $n = 65$; five events; 8.33 percent) when compared with all other procedures ($n = 293$; five events; 1.73 percent) (Tables 2 through 4). Circumferential abdominoplasty was not associated with an increased rate of pulmonary embolism ($n = 0$). Breast/upper body contouring procedures alone (not excluding liposuction) were associated with a 2.91 percent venous thromboembolism rate (103 patients: one deep venous thrombosis and two pulmonary embolisms; $p = 1.00$).

Body mass index over 30 ($n = 102$) was associated with an increased rate of deep venous thrombosis ($p = 0.007$; seven events; 6.86 percent) (Table 5). A trend toward increased pulmonary embolism rate was found, but there was no significant difference, between those subjects with a body mass index of 30 or more and those with body mass index of less than 30 ($p = 0.13$).

Hormone therapy was associated with an increased rate of both deep venous thrombosis ($n = 93$; eight deep venous thrombosis events; 8.6 percent; $p < 0.001$) and pulmonary embolism ($n = 93$; seven pulmonary embolism events; 7.5 percent; $p = 0.003$) (Table 6). Patients who were using oral contraceptive pills or hormone replacement therapy were placed in this group; these patients were asked to discontinue their hormone use 1 week before the operation.

Table 5. Deep Venous Thrombosis Rate of Circumferential Abdominoplasty Compared with All Other Procedures

	DVT Event (%)	No DVT (%)	Total (%)
Circumferential*	5 (7.7)	60 (92.3)	65 (51.5)
Others	5 (1.7)	288 (98.3)	293 (48.5)
Total	10 (2.8)	348 (97.2)	358

DVT, deep venous thrombosis.
*Fisher's exact test demonstrates a significantly higher ($p = 0.02$) deep venous thrombosis occurrence for those subjects undergoing circumferential abdominoplasty.

Table 6. Deep Venous Thrombosis Rate in Patients with BMI ≥30 Compared with Patients with BMI <30

	DVT Event (%)	No DVT (%)	Total (%)
BMI ≥30*	7 (6.9)	95 (93.1)	102 (28.6)
BMI <30	3 (1.2)	252 (98.8)	255 (71.4)
Total	10 (2.8)	347 (97.2)	357

DVT, deep venous thrombosis; BMI, body mass index.
*Fisher's exact test indicates ($p = 0.007$) significantly higher DVT occurrence with BMI ≥30.

Table 7. Venous Thromboembolism Rate in Patients on Hormone Replacement Therapy/Over-the-Counter Progesterone Compared with Patients Not on Estrogen/Over-the-Counter Progesterone

	DVT Event (%)	No DVT (%)	Total (%)
Estrogen*	15 (16.1)	78 (83.9)	93 (35.8)
No estrogen	4 (0.1)	263 (99.9)	267 (74.2)
Total	19 (5.3)	339 (94.7)	358

DVT, deep venous thrombosis.
*Fisher's exact test indicates a significantly higher ($p < 0.001$) venous thromboembolism occurrence for those subjects receiving estrogen therapy.

One hundred thirty-seven patients were treated with perioperative enoxaparin, sequential compression devices, and early ambulation (38.3 percent); 221 patients were treated with sequential compression devices and early ambulation alone (61.7 percent). All patients in this group received 30-mg subcutaneous enoxaparin injections every 12 hours. Forty-nine of these patients received their first dose of enoxaparin in the preoperative period, at least 2 hours before the commencement of the case. Eighty-eight patients received their first dose of enoxaparin intraoperatively or immediately postoperatively in the recovery room. The rate of venous thromboembolism in all patients was unchanged by the administration of enoxaparin: six events in enoxaparin patients (4.38 percent) and 13 events in the no-enoxaparin patients (5.88 percent; $p = 0.55$). In patients who were stratified into the highest risk group in the Davison-Caprini model, the rate of pulmonary embolism was unchanged by the administration of enoxaparin ($p = 0.78$). In the highest risk patients, chi-square analysis demonstrated nonsignificant trends toward decreased rates of deep venous thrombosis (6.3 percent rate in enoxaparin patients versus 15.9 percent in no-enoxaparin patients; $p = 0.20$) and venous thromboembolism (15.6 percent rate in enoxaparin patients versus 27.3 percent in no-enoxaparin patients; $p = 0.23$) were found in those who were administered enoxaparin. Enoxaparin administration was associated with a statistically significant decrease in ($p = 0.0064$) deep venous thrombosis in circumferential abdominoplasty patients (Table 7). Enoxaparin use was associated with a nonsignificant trend toward decreased rate in overall venous thromboembolism [three events in enoxaparin patients (5.8 percent); nine events in no-enoxaparin patients (18.4 percent); $p = 0.051$) in patients with body mass index greater than 30.

In all patients, enoxaparin administration was associated with a statistically significant higher rate of hematoma [10 events in enoxaparin patients (7.3 percent); one events in no-enoxaparin patients (0.5 percent); $p < 0.001$] (Table 8), Clinically significant bleeding requiring transfusion [nine events in enoxaparin patients (6.6 percent); two events in no-enoxaparin patients (0.9 percent); $p = 0.004$] (Table 9), operative time (304.9 minutes in enoxaparin patients; 227.8 minutes in no-enoxaparin patients; $p < 0.001$), estimated operative blood loss (233.5 cc in enoxaparin patients; 135.5 cc in no-enoxaparin patients; $p < 0.001$), and 24-hour postoperative drain output [432.7 cc in enoxaparin patients; 205.1 cc in no-enoxaparin patients (10.2 percent); $p < 0.001$].

There were 237 patients who had concomitant liposuction along with their excisional surgery. Sixteen of these patients experienced a venous thromboembolism event (6.8 percent), and three of the 123 patients who did not have liposuction experienced a venous thromboembolism event (2.4 per-

Table 8. Deep Venous Thrombosis Rate with Respect to Enoxaparin Administration in Circumferential Abdominoplasty Patients

	DVT Event (%)	No DVT (%)	Total (%)
Enoxaparin	0 (0.0)	40 (100.0)	40 (61.5)
No enoxaparin*	5 (20.0)	20 (80.0)	25 (38.5)
Total	5 (7.7)	60 (92.3)	65

DVT, deep venous thrombosis.
*Fisher's exact test indicates a significantly higher ($p = 0.0064$) deep venous thrombosis occurrence for no-enoxaparin patients undergoing circumferential abdominoplasty.

Table 9. Hematoma Rate Associated with Enoxaparin Administration

	Hematoma		
	Yes (%)	No (%)	Total (%)
Enoxaparin*	10 (7.3)	127 (92.7)	137 (38.3)
No enoxaparin	1 (0.5)	220 (99.5)	221 (61.7)
Total	11 (3.1)	347 (96.9)	358

*Fisher's exact test indicates a significantly higher ($p < 0.001$) occurrence of hematoma among those subjects receiving enoxaparin as compared with those not receiving enoxaparin.

cent). The difference between these groups approached statistical significance ($p = 0.083$).

Operative time did not appear to be a risk factor for venous thromboembolism. The mean operative time for patients who experienced venous thromboembolism was 295.3 ± 88.8 minutes; for patients who did not have a venous thromboembolism event, it was 255.1 ± 106.0 minutes. This difference approached but did not reach statistical significance ($p = 0.11$).

The timing of administration of the first dose of enoxaparin (2 hours preoperatively versus intraoperatively/immediately postoperatively in the recovery room) did not demonstrate an effect on clinically significant bleeding requiring transfusion, venous thromboembolism, or intraoperative blood loss. There was a statistically significant increase in the mean drain output for the first 24 hours postoperatively seen in the group of patients who received their first dose of enoxaparin intraoperatively or postoperatively (Table 10). Patients in the group who received enoxaparin for 3 days or longer had statistically significant increases in clinically significant bleeding requiring transfusion ($p < 0.02$) (Table 11) but did not have statistically increased rate of hematoma ($p = 0.72$).

Based on these results, it was felt that if the Davison-Caprini risk-assessment model was to be more effective at predicting thromboembolism, it would need to be revised to reflect the increased thromboembolic risk seen with circumferential abdominoplasty, use of hormones, and body mass index over 30. This was done, and retrospective application of the revised risk-assessment model placed all patients who experienced a venous thromboembolism event into the highest risk category (Table 12).

Table 10. Clinically Significant Bleeding (Patients Requiring Transfusion) Associated with Enoxaparin

	HCT Drop, Transfused		
	Yes (%)	No (%)	Total (%)
Enoxaparin*	9 (6.6)	128 (93.4)	137 (38.3)
No enoxaparin	2 (0.9)	219 (99.1)	221 (61.7)
Total	11 (3.1)	347 (96.9)	358

HCT, hematocrit.
*Fisher's exact test indicates a significantly higher ($p = 0.004$) occurrence of HCT drop among those subjects receiving enoxaparin as compared with those not receiving enoxaparin.

Table 11. Timing of First Dose of Enoxaparin Effect on Drain Output at 24 Hours

	No.	Mean	SD	*t*	*p*
Intraoperative/ postoperative enoxaparin*	88	504.7	359.5	2.86	<0.006
Preoperative enoxaparin	49	320.1	243.6		

*Independent groups *t* test comparison of means indicates significantly higher drain output for those subjects receiving intraoperative and postoperative enoxaparin as compared with those receiving preoperative enoxaparin.

DISCUSSION

Venous Thromboembolism in Plastic Surgery

Body contouring procedures involve a number of factors that increase the risk for developing a deep venous thrombosis or a pulmonary embolism: (1) vessel injury, with intense dissection and disruption of superficial veins; (2) general anesthesia, with a decrease in peripheral vascular resistance; (3) intraoperative positioning possibly decreasing venous return from the lower extremity; and (4) decreased ability for postoperative mobilization. In addition, there are few data addressing incidence, risk, and prophylaxis in body contouring patients, making it unclear as to what is the best course of perioperative treatment Tables 13 and 14.

Deep venous thrombosis is a well-documented surgical complication, associated with a high level of morbidity. The incidence of postoperative deep venous thrombosis in general surgery patients ranges from 16 to 40 percent.[10,11] It is even higher for orthopedic surgery patients undergoing hip or knee surgery. Without adequate thromboembolic prophylaxis, 45 to 70 percent of hip surgery patients[12] and 53 to 84 percent of knee surgery patients will develop a deep venous thrombosis.[13]

In 1998, the board of directors of the American Society of Plastic Surgeons began a task force on deep vein thrombosis.[14] The task force based its recommendations on guidelines published by the American College of Chest Physicians at their Fifth

Table 12. Number of Days of Treatment Effect on Clinically Significant Bleeding (Patients Requiring Transfusion)

	HCT Drop, Transfused		
	Yes (%)	No (%)	Total (%)
<3 days enoxaparin	5 (4.2)	114 (95.8)	119 (100.0)
3 days or more of enoxaparin*	4 (22.2)	14 (77.8)	18 (100.0)
Total	9 (6.6)	132 (93.4)	137

HCT, hematocrit.
*Fisher's exact test indicates a significantly higher ($p < 0.02$) occurrence of hematocrit drop among those subjects receiving enoxaparin for 3 days or greater as compared to those receiving enoxaparin for less than 3 days.

Table 13. Suggested Revisions to the Davison-Caprini Risk-Assessment Model: Exposing Risk Factors

1 Factor	2 Factors	3 Factors	5 Factors
Minor surgery	Major surgery	Previous MI/CHF	Hip, pelvis, leg fracture
	Immobilization	Severe sepsis	Stroke
	Central venous access	Free flap	Multiple trauma
		Circumferential abdominoplasty	

MI, myocardial infarction; CHF, congestive heart failure.

Table 14. Suggested Revisions to the Davison-Caprini Risk-Assessment Model: Predisposing Risk Factors

	No. of Factors
Age 40–60 years	1
Age >60 years	2
History of venous thromboembolism	3
Current pregnancy	1
Current malignancy	2
Obesity	2
OCP/HRT	2
Hypercoagulable disorder	3

OCP, over-the-counter progesterone; HRT, hormone replacement therapy.

Consensus Conference.[15] The data reviewed did not include plastic surgery patients.

In 2004, the Seventh American College of Chest Physicians Consensus Conference on Antithrombotic Therapy published their discussion of venous thromboembolism, stratifying patients by venous thromboembolism risk into four categories: low, moderate, high, and highest. The levels of risk were defined by the patient's age, type of surgery, and additional risk factors.[11] This consensus statement has become very widely used in the creation of prophylaxis regimens. Patient age and risk factors are and applicable to all disciplines. However, whether a procedure within plastic surgery qualifies as "minor," "nonmajor," or "major" surgery is unclear. Time of surgery, body region operated on, and extent of dissection all may play some role. The earliest work addressing thromboembolic complications in body contouring was published by Grazer and Goldwyn in 1977. In their survey of over 10,000 abdominoplasties, there was a 1 percent incidence of pulmonary embolism.[16] Survey results and reported clinical frequencies of venous thromboembolism in liposuction patients have ranged from 0 to 2 percent.[17–20]

Within the scope of plastic surgery, abdominoplasty, and circumferential abdominoplasties have the highest reported rates of venous thromboembolism. Hester et al. reported an overall rate of 1.1 percent of pulmonary embolism in abdominoplasty patients, with the majority being in patients who had abdominoplasty combined with an intraabdominal procedure.[21] Some authors have shown that combining abdominoplasty with intraabdominal procedures increased venous thromboembolism frequency from 0 percent to 6.8 percent.[22] The data presented here show that abdominoplasty alone was associated with a 4.7 percent rate of venous thromboembolism. The combination of abdominoplasty with another procedure did not produce a statistically significant increased rate of venous thromboembolism (5.5 percent; $p = 1.00$); however, for all but five patients in this group, the additional procedure was a plastic surgical operation that did not involve intraabdominal surgery.

The increased risk for venous thromboembolism when liposuction is added to an excisional case has been described previously.[23] These data were from a survey of board-certified plastic surgeons who were members of the American Society for Aesthetic Plastic Surgery. Our experience demonstrates that the addition of liposuction to excisional body contouring procedures led to a higher rate of venous thromboembolism complications, but this did not quite reach statistical significance (6.8 percent versus 2.4 percent; $p < 0.09$).

Circumferential abdominoplasty was associated with a 7.7 percent rate of deep venous thrombosis, similar to the rate of venous thromboembolism noted by Aly et al. Their review of 32 belt lipectomies yielded a 9.4 percent incidence of pulmonary embolism.[24] The deep venous thrombosis rate in the group of patients studied here was noted to be statistically significant. That circumferential abdominoplasty would place patients at an increased venous thromboembolism risk is not surprising, as there is the added dissection, operative time, circumferential disruption of superficial veins, and a tougher postoperative mobilization course. The increased intraabdominal pressure noted previously by other authors with abdominoplasty[25,26] is surely the same, if not more significant, in circumferential body contouring procedures. Interestingly, none of the circumferential abdominoplasty patients went on to experience a pulmonary embolism. This may be a result of vigilance for venous thromboembolism complications associated with these procedures, preventing these

early deep venous thromboses from progressing to pulmonary embolism.

Risk Stratification

Risk-Assessment Models are widely used to stratify patients into categories of risk on the basis of patient and procedure characteristics. First discussed in the mid 1970s, these early models recognized the risk of increasing age, high body mass index, and the presence of venous varicosity.[27] In 2004, Davison et al. examined the use of risk-assessment models by previous authors, and modified the Caprini model to make it more relevant for plastic surgery patients.[9] This model divides patients into the risk groups of low, moderate, high, and highest, in a manner similar to the American College of Chest Physicians guidelines. This model did not delineate what constitutes "major" surgery, other than a procedure lasting longer than 1 hour.

The data from this review clearly demonstrate that the Davison-Caprini risk-assessment model is a useful tool for assigning thromboembolic risk in plastic surgery patients; 89.5 percent (17 of 19) of the venous thromboembolism events that were seen in this patient group were stratified retrospectively into the highest risk group. The two venous thromboembolism events that were not seen in this group were in patients assigned to the high-risk group.

The analysis of this data set elucidates three risk factors that may enable the plastic surgeon to more accurately risk-stratify potential body contouring patients: circumferential abdominoplasty, body mass index, and hormone therapy use. Body mass index greater than 30 was associated with a statistically significant increased rate of venous thromboembolism complications. This echoes what was found in the previously mentioned study by Hester et al., where it was reported that there was an increased frequency of pulmonary embolism in patients described as "obese."[28] This association has been described in other patient populations.[29,30] The association between hormone replacement/oral contraceptive use is also very well recognized. First identified in the 1960s, the basic physiology behind this effect is not completely understood. It is believed that there is an increase in both coagulation activation and fibrinolysis but that there is some fundamental change in the balance between the two systems.[31,32] Patients who were taking oral contraceptive pills or hormone replacement therapy were instructed to discontinue use 1 week before surgery. It is interesting to note that this did not decrease the rate of venous thromboembolism in this group to a nonsignificant level.

The authors are suggesting a further revision to this risk-assessment model that adds circumferential abdominoplasty, body mass index greater than 30, and over-the-counter progesterone/hormone replacement therapy as risk factors for venous thromboembolism. Adding this model to our patients retrospectively placed every patient who experienced a venous thromboembolism event into the highest risk group. It must be noted that the Davison-Caprini risk-assessment model, with or without these updates, is considered to be a grade 2C recommendation by the American College of Chest Physicians.[33]This is the highest grade of recommendation that can be made with data that do not come from randomized controlled trials. Randomized controlled trials designed for plastic surgery patients must be instituted so that the data from which recommendations can be made are of a higher quality.

Deep Venous Thrombosis Prophylaxis

Proper deep venous thrombosis prophylaxis has been shown to decrease the incidence of deep venous thrombosis. In the general surgery population, sequential compression device use alone has been shown to reduce the incidence of deep venous thrombosis by 60 percent.[34] In orthopedic surgery patients, it has been demonstrated that low-molecular-weight heparins may decrease the incidence of proximal vein thrombosis by 78 percent, without any increase in the rate of bleeding complications.[35] These data show that perioperative enoxaparin was useful in the prophylaxis of venous thromboembolism in patients undergoing circumferential abdominoplasty. This effect may be seen in this group because there was a relatively higher deep venous thrombosis rate associated with this group. This increased frequency led to higher numbers and therefore the impact of enoxaparin may have been assessed more accurately. The relatively lower numbers in other groups have given us trends toward enoxaparin efficacy, although statistical significance was not reached.

In patients with a body mass index greater than 30, there was an increased rate of venous thromboembolism complications. Enoxaparin was demonstrated to have a strong trend toward decreasing the risk for venous thromboembolism in this patient group ($p = 0.051$), regardless of procedure. There was a slight trend toward a decrease in deep venous thrombosis seen in patients on oral contraceptive pills and hormone replacement therapy.

With respect to enoxaparin efficacy throughout the risk-assessment groups, there was a trend toward a decreased rate of deep venous thrombosis and pulmonary embolism in the highest risk group, although this did not achieve statistical significance. The venous thromboembolism frequency in the other risk-assessment groups was too low to assess the efficacy of enoxaparin prophylaxis.

The timing of administration of the first dose of enoxaparin (2 hours preoperatively versus intraoperatively/immediately postoperatively in the recovery room) did not demonstrate an effect on clinically significant bleeding requiring transfusion, venous thromboembolism, or intraoperative blood loss. There was a statistically significant increase in the mean drain output for the first 24 hours postoperatively seen in the group of patients who received their first dose of enoxaparin intraoperatively or postoperatively (Table 10). Patients in the group who received enoxaparin for 3 days or longer had statistically significant increases in clinically significant bleeding requiring transfusion ($p < 0.02$) (Table 11) but did not have a statistically increased rate of hematoma ($p = 0.72$). Some orthopedic surgery data demonstrate that the timing of initial chemoprophylaxis dose is important in preventing complications. It has been shown that administration of the first dose within the first 6 hours postoperatively significantly increases the risk of clinically significant bleeding.[36] In these patients, the timing of the first dose of enoxaparin did not affect any of the outcomes to a great degree, other than the increased 24-hour postoperative drain output seen in the group of patients who received their first dose intraoperatively or postoperatively.

Use of enoxaparin has been increasing not only because of its anticoagulant effect, but also because it has been shown in some studies to have fewer bleeding complications than unfractionated heparin.[37,38] The reverse finding has also been demonstrated. In a 1997 meta-analysis of 39 articles including over 16,000 patients, Koch et al. found that there was an increased incidence of bleeding complications with the use of low-molecular-weight heparins.[39] It was later argued that the reason for the higher incidence of bleeding complications was that the dosages of the low-molecular-weight heparins were too high.[40] At more appropriate doses of less than 3400 anti-Xa units, the low-molecular-weight heparins maintain their equivocacy with heparin for deep venous thrombosis prophylaxis, and the risk for bleeding complications is considerably lower.[40] An increased risk of bleeding with the use of enoxaparin in face-lift patients has been shown in the plastic surgery literature.[41] In that study, the surgeons were using once-daily dosing of 40 mg, with the initial dose given before the operation. In the series of patients presented here, 30-mg twice-daily dosing was used. The authors have switched to once-daily 40-mg dosing, begun the morning after surgery. This was done for the convenience of ancillary support staff and patients, and also because once-daily dosing has been shown to be equivalent to twice-daily dosing, with a possible decrease in bleeding risk.[42] These data demonstrate an increase in bleeding complications with the use of enoxaparin. The effect of enoxaparin on bleeding cannot be discounted. The activating effect that enoxaparin has on antithrombin may leave the patient with such extensive surgery at an increased risk for blood loss. This urges discretion on the part of the treating surgeon and advocates even more loudly for the use of risk-assessment models in guiding venous thromboembolism prophylaxis, especially in this subset of patients in whom there may be a 50 percent rate of anemia.[36] Surgeons must be vigilant to avoid intraoperative hypotension and postoperative hypertension, as these have been shown to increase the risk for bleeding with enoxaparin use.[43]

It has been shown that the risk for development of a thromboembolic complication exists for an extended time past the immediate postoperative period after major surgery.[44,45] In this series, patients with venous thromboembolism complications presented at an average of postoperative day 10. Patients undergoing excisional body contouring surgery are having a major procedure performed and are clearly at risk for deep venous thrombosis and pulmonary embolism past the time of discharge. It is possible that extended chemoprophylaxis dosing would increase the efficacy of enoxaparin in high-risk patients. This has been demonstrated in the surgical oncology and orthopedic surgery literature.[44,45] When administered, we limited enoxaparin prophylaxis to inpatient stay. Although we were unable to demonstrate that longer dosage periods decreased the rate of venous thromboembolism, this is likely because the number of patients presented in this data set is comparatively small, and because the groups compared are 1 to 2 days versus 3 or more days postoperatively. The length of enoxaparin prophylaxis demonstrated a slight trend toward decreased venous thromboembolism with longer treatments of 3 days or more. However, these patients also had increased rates of bleeding events requiring trans-

fusion. The risk of bleeding and transfusion must be weighed against the potentially devastating impact of a venous thromboembolic event. This demonstrates both the need for the appropriate application of risk-assessment paradigms to these patients and the need for further exploration of the various prophylaxis regimens. Two of the patients in this series were not included in the final analysis of data because they had a prior history of venous thromboembolism. They were managed with perioperative subcutaneous heparin injections, at the recommendation of a consulting hematologist. A detailed discussion of the different methods of chemoprophylaxis, mechanical prophylaxis, and caval filter prophylaxis is beyond the scope of this review.

CONCLUSIONS

The data from this retrospective review demonstrate that a risk-assessment model such as the Davison-Caprini model should be applied preoperatively to categorize the venous thromboembolism risk of all excisional body contouring patients. Patients who are stratified into the highest risk category will be at a significantly increased risk for venous thromboembolism. Patients who are obese (body mass index >30) and patients who are on oral contraceptives or hormone replacement therapy will also be at an increased risk for venous thromboembolism. Circumferential abdominoplasty is demonstrated to place patients at an increased risk for venous thrombosis, with a 7.7 percent frequency of deep venous thrombosis.

The use of enoxaparin demonstrated a trend toward decreased rates of venous thromboembolism when used in patients in the highest risk category. Circumferential abdominoplasty patients who received enoxaparin had a statistically significant decrease in venous thromboembolism events. Perioperative enoxaparin administration was associated with an increased rate of hematoma and postoperative bleeding requiring transfusion. Some of these patients had clinically evident venous thromboembolism over 20 days postoperatively, and perhaps a longer course of enoxaparin, or another low-molecular-weight heparin, may be warranted.

It is suggested that patients in the highest risk group, and any patient undergoing circumferential abdominoplasty, be given perioperative chemoprophylaxis with a low-molecular-weight heparin. Plastic surgeons should also use discretion in considering other patients for low-molecular-weight heparin chemoprophylaxis, such as patients in the high-risk group, those who are obese (body mass index >30), those on over-the-counter progesterone/hormone replacement therapy, and perhaps patients undergoing abdominoplasty combined with other procedures. The risk of venous thromboembolism should be balanced against the increased risk for bleeding with the use of low-molecular-weight heparin, keeping in mind that bleeding is an expected, manageable complication, whereas pulmonary embolism can be a fatal and unacceptable sequela in the setting of elective surgery. Based on the findings from this and other studies,[42,45] these authors' use of prophylactic enoxaparin has evolved to once-daily 40-mg dosing, given within 6 hours postoperatively, to patients who are considered to be at the highest risk under this revised Davison-Caprini risk-assessment model. The reader must make note that these are recommendations that need further confirmation because they are based on a retrospective review of a relatively small number of patients and that recommendations are not standards of care.

This study validates the assignment of thrombotic risk for plastic surgery/body contouring patients' decision-making regarding venous thromboembolism prophylaxis. Retrospective, nonrandomized data from one clinical series do not substitute for the type of data that are used to construct these risk-assessment models, and to date, not one of these trials has involved plastic surgery patients. It is imperative that prospective, multi-institutional studies address the efficacy of enoxaparin, other low-molecular-weight heparins, and new antithrombotics; timing of first dosage; and what is the most efficacious length of time for postoperative chemoprophylaxis to be performed in plastic surgery. It remains unclear whether chemoprophylaxis should be administered only to patients within the highest risk group or whether patients in the high-risk group should receive prophylaxis also. In addition, more data concerning the venous thromboembolism rate of different types of procedures are required, as the appropriate assignment of procedural risk in plastic surgery remains to be elucidated.

Jeffrey M. Kenkel, M.D.
Department of Plastic Surgery
University of Texas Southwestern Medical Center
5373 Harry Hines Boulevard
Dallas, Texas 75390
dan.hatef@gmail.com

ACKNOWLEDGMENTS

The authors thank April Gorman for assistance with the statistics involved with this project and Kevin P. Hanz, M.D., for assistance with the preparation of the article.

REFERENCES

1. American Society for Bariatric Surgery. Available at: http://www.asbs.org/html/pdf/sanfran.pdf. Accessed May 12, 2007.
2. American Society of Plastic Surgeons. 2006 Statistics. Available at: http://www.plasticsurgery.org/media/statistics/2006Statistics.cfm. Accessed May 12, 2007.
3. Broughton, G., II, Rios, J. L., Rohrich, R. J., and Brown, S. A. DVT prophylaxis and treatment strategies among plastic surgeons: Survey results. *Plast. Reconstr. Surg.* 119: 157, 2007.
4. Eriksson, S., Backman, L., and Ljungstrom, K. G. The incidence of clinical postoperative thrombosis after gastric surgery for obesity during 16 years. *Obes. Surg.* 7: 332, 1997.
5. Kalfarentzos, F., Stavropoulou, F., Yarmenitis, S., et al. Prophylaxis of venous thromboembolism using two different doses of low-molecular-weight heparin (nadroparin) in bariatric surgery: A prospective randomized trial. *Obes. Surg.* 11: 670, 2001.
6. Sapala, J. A., Wood, M. H., Schuhknecht, M. P., and Sapala, M. A. Fatal pulmonary embolism after bariatric operations for morbid obesity: A 24-year retrospective analysis. *Obes. Surg.* 13: 819, 2003.
7. Westling, A., Bergqvist, D., Bostrom, A., Karacagil, S., and Gustavsson, S. Incidence of deep venous thrombosis in patients undergoing obesity surgery. *World J. Surg.* 26: 470, 2002.
8. Davison, S. P., Venturi, M. L., Attinger, C. E., Baker, S. B., and Spear, S. L. Prevention of venous thromboembolism in the plastic surgery patient. *Plast. Reconstr. Surg.* 114: 43E, 2004.
9. Caprini, J. A., Arcelus, J. I., and Reyna, J. J. Effective risk stratification of surgical and nonsurgical patients for venous thromboembolic disease. *Semin. Hematol.* 38: 12, 2001.
10. Silver, D. An overview of venous thromboembolism prophylaxis. *Am. J. Surg.* 161: 537, 1991.
11. Geerts, W. H., Pineo, G. F., Heit, J. A., et al. Prevention of venous thromboembolism: The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest* 126: 338S, 2004.
12. Dahl, O. E. Thromboprophylaxis in hip arthroplasty. *Acta Orthop. Scand.* 69: 339, 1998.
13. Stern, S. H., Wixson, R. L., and O'Connor, D. Evaluation of the safety and efficacy of enoxaparin and warfarin for prevention of deep vein thrombosis after total knee arthroplasty. *J. Arthroplast.* 15: 153, 2000.
14. McDevitt, N. B. Deep vein thrombosis prophylaxis: American Society of Plastic and Reconstructive Surgeons. *Plast. Reconstr. Surg.* 104: 1923, 1999.
15. Clagett, G. P., Anderson, F. A., Jr., Geerts, W., et al. Prevention of venous thromboembolism. *Chest* 114: 531S, 1998.
16. Grazer, F. M., and Goldwyn, R. M. Abdominoplasty assessed by survey with emphasis on complications. *Plast. Reconstr. Surg.* 59: 513, 1977.
17. Gilliland, M. D., Commons, G. W., and Halperin, B. Safety issues in ultrasound assisted large-volume lipoplasty. *Clin. Plast. Surg.* 26: 317, 1999.
18. Grazer, F. M., and de Jong, R. H. Fatal outcomes from liposuction: Census survey of cosmetic surgeons. *Plast. Reconstr. Surg.* 105: 436, 2000.
19. Commons, G. W., Halperin, B., and Chang, C. C. Large-volume liposuction: A review of 631 consecutive cases over 12 years. *Plast. Reconstr. Surg.* 108: 1753, 2001.
20. Teimourian, B., and Rogers, W. B., III. A national survey of complications associated with suction lipectomy: A comparative study. *Plast. Reconstr. Surg.* 84: 628, 1989.
21. Hester, T. R., Jr., Baird, W., Bostwick, J., III, Nahai, F., and Cukic, J. Abdominoplasty combined with other procedures: Safe or sorry? *Plast. Reconstr. Surg.* 83: 997, 1989.
22. Voss, S. C., Sharp, H. C., and Scott, J. R. Abdominoplasty combined with gynecologic surgical procedures. *Obstet. Gynecol.* 67: 181, 1986.
23. Hughes, C. E. Reduction of lipoplasty risks and mortality. *Aesthetic Surg. J.* 21: 120, 2001.
24. Aly, A. S., Cram, A. E., Chao, M., Pang, J., and McKeon, M. Belt lipectomy for circumferential truncal excess: The University of Iowa experience. *Plast. Reconstr. Surg.* 111: 398, 2003.
25. Marin Valladolid, J. A., Saucedo Ortiz, J. A., Orozco, C. F., et al. Variation of intraabdominal pressure caused by abdominoplasty in healthy women. *Rev. Gastroenterol. Mex.* 69: 156, 2004.
26. Al-Basti, H. B., El-Khatib, H. A., Taha, A., Sattar, H. A., and Bener, A. Intraabdominal pressure after full abdominoplasty in obese multiparous patients. *Plast. Reconstr. Surg.* 113: 2145, 2004.
27. Clayton, J. K., Anderson, J. A., and McNicol, G. P. Preoperative prediction of postoperative deep vein thrombosis. *Br. Med. J.* 2: 910, 1976.
28. Reinisch, J. F., Bresnick, S. D., Walker, J. W., and Rosso, R. F. Deep venous thrombosis and pulmonary embolus after facelift: A study of incidence and prophylaxis. *Plast. Reconstr. Surg.* 46: 485, 2001.
29. Rocha, A. T., de Vasconcellos, A. G., da Luz Neto, E. R., Araujo, D. M., Alves, E. S., and Lopes, A. A. Risk of venous thromboembolism and efficacy of thromboprophylaxis in hospitalized obese medical patients and in obese patients undergoing bariatric surgery. *Obes. Surg.* 16: 1645, 2006.
30. Beksac, B., Della Valle, A. G., and Salvati, E. A. Thromboembolic disease after total hip arthroplasty: Who is at risk? *Clin. Orthop. Relat. Res.* 453: 211, 2006.
31. Nguyen, N. T., Owings, J. T., Gosselin, R., et al. Systemic coagulation and fibrinolysis after laparoscopic and open gastric bypass. *Arch. Surg.* 136: 909, 2001.
32. Piper, S. N., Boldt, J., Schmidt, C. C., Maleck, W. H., Brosch, C., and Kumble, B. Hemodynamics, intramucosal pH, and regulators of circulation during perioperative epidural analgesia. *Can. J. Anaesth.* 47: 631, 2000.
33. Guyatt, G., Schunemann, H. J., Cook, D., Jaeschke, R., and Pauker, S. The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy: Applying the grades of recommendation for antithrombotic and thrombolytic therapy. *Chest* 126: 179S, 2004.
34. Jeffery, P. C., and Nicolaides, A. N. Graduated compression stocking in the prevention of postoperative deep vein thrombosis. *Br. J. Surg.* 77: 380, 1990.
35. Leyvraz, P. F., Bachman, F., Hoek, J., et al. Prevention of deep vein thrombosis after hip replacement: Randomized comparison between unfractionated heparin and low molecular weight heparin. *Br. Med. J.* 303: 543, 1991.
36. Rohrich, R. J. Body contouring after massive weight loss. *Plast. Reconstr. Surg.* 117S: 14S, 2006.
37. Nurmohamed, M. T., Rosendaal, F. R., Buller, H. R., et al. Low-molecular-weight heparin versus standard heparin in general and orthopaedic surgery: A meta-analysis. *Lancet* 340: 152, 1992.
38. Kakkar, V. V., Cohen, A. T., Edmonson, R. A., et al. Low molecular weight versus standard heparin for prevention of venous thromboembolism after major abdominal surgery: The Thromboprophylaxis Collaborative Group. *Lancet* 341: 259, 1993.
39. Koch, A., Bouges, S., Ziegler, S., Dinkel, H., Daures, J. P., and Victor, N. Low molecular weight heparin and unfractionated heparin in thrombosis prophylaxis after major surgical in-

tervention: Update of previous meta-analyses. *Br. J. Surg.* 84: 750, 1997.
40. Bergqvist, D. Low molecular weight heparin and unfractionated heparin in thrombosis prophylaxis after major surgical intervention: Update of previous meta-analyses. *Br. J. Surg.* 85: 872, 1998.
41. Durnig, P., and Jungwirth, W. Low-molecular-weight heparin and postoperative bleeding in rhytidectomy. *Plast. Reconstr. Surg.* 118: 502, 2006.
42. Rubboli, A., Gatti, C., Spinolo, L., Parollo, R., Spitali, G., and Maresta, A. Subcutaneous enoxaparin following thrombolysis and intravenous unfractionated heparin in ST-elevation acute myocardial infarction: Safety and efficacy of low vs. full dose. *Minerva Cardioangiol.* 54: 131, 2006.
43. Farkas, J. P., Kenkel, J. M., Hatef, D. A., et al. *Aesthetic Surg. J.* (in press).
44. Kwong, L. M., and Muntz, J. E. Thromboprophylaxis dosing: The relationship between timing of first administration, efficacy, and safety. *Am. J. Orthop.* 31: 16, 2002.
45. Bergqvist, D., Agnelli, G., Cohen, A. T., et al. Duration of prophylaxis against venous thromboembolism with enoxaparin after surgery for cancer. *N. Engl. J. Med.* 346: 975, 2002.

Online CME Collections

This partial list of titles in the developing archive of CME article collections is available online at www.PRSJournal.com. *These articles are suitable to use as study guides for board certification, to help readers refamiliarize themselves on a particular topic, or to serve as useful reference articles. Articles less than 3 years old can be taken for CME credit.*

Cosmetic

The Silicone Gel-Filled Breast Implant Controversy: An Update—Arshad R. Muzaffar and Rod J. Rohrich
Understanding the Nasal Airway: Principles and Practice—Brian K. Howard and Rod J. Rohrich
Lateral Canthal Anchoring—Clinton McCord et al.
Male Rhinoplasty—Rod J. Rohrich et al.
The Cosmetic Use of Botulinum Toxin (October 2003 Supplement)—Rod J. Rohrich et al.
Thrombolytic Therapy following Rhytidectomy and Blepharoplasty—Stephanie L. Mick et al.
Current Concepts in Aesthetic Upper Blepharoplasty—Rod J. Rohrich et al.
Breast Augmentation: Cancer Concerns and Mammography—A Literature Review—Michael G. Jakubietz et al.
Prevention of Venous Thromboembolism in the Plastic Surgery Patient—Steven Paul Davison et al.
Breast Augmentation—Scott L. Spear et al.
Otoplasty: Sequencing the Operation for Improved Results—James Hoehn and Salman Ashruf
Thromboembolism in Plastic Surgery—Daniel Most et al.
Otoplasty—Jeffrey E. Janis et al.
Fire in the Operating Room: Principles and Prevention—Stephen P. Daane and Bryant A. Toth
Patient Safety in the Office-Based Setting—J. Bauer Horton et al.
Frequently Used Grafts in Rhinoplasty: Nomenclature and Analysis—Jack P. Gunter et al.
Injectable Soft-Tissue Fillers: Clinical Overview—Barry L. Eppley and Babak Dadvand
Body Dysmorphic Disorder and Cosmetic Surgery—Canice E. Crerand et al.
Use of Herbal Supplements and Vitamins in Plastic Surgery: A Practical Review—George Broughton, II, et al.
Psychological Considerations of the Bariatric Patient—David Sarwer