Validation of the Caprini Risk Assessment Model in Plastic and Reconstructive Surgery Patients

Christopher J Pannucci, MD, MS, Steven H Bailey, MD, George Dreszer, MD, MS, Christine Fisher Wachtman, MD, Justin W Zumsteg, MD, Reda M Jaber, BS, Jennifer B Hamill, MPH, Keith M Hume, MA, J Peter Rubin, MD, Peter C Neligan, MB, FRCS(I), FRCSC, FACS, Loree K Kalliainen, MD, FACS, Ronald E Hoxworth, MD, Andrea L Pusic, MD, MHS, FRCSC, Edwin G Wilkins, MD, MS

BACKGROUND: The Venous Thromboembolism Prevention Study (VTEPS) Network is a consortium of 5 tertiary referral centers established to examine venous thromboembolism (VTE) in plastic surgery patients. We report our midterm analyses of the study's control group to evaluate the incidence of VTE in patients who receive no chemoprophylaxis, and validate the Caprini Risk Assessment Model (RAM) in plastic surgery patients.

STUDY DESIGN: Medical record review was performed at VTEPS centers for all eligible plastic surgery patients between March 2006 and June 2009. Inclusion criteria were Caprini score ≥3, surgery under general anesthesia, and postoperative hospital admission. Patients who received chemoprophylaxis were excluded. Dependent variables included symptomatic deep vein thrombosis (DVT) or pulmonary embolism (PE) within the first 60 postoperative days and time to DVT or PE.

RESULTS: We identified 1,126 historic control patients. The overall VTE incidence was 1.69%. Approximately 1 in 9 (11.3%) patients with Caprini score >8 had a VTE event. Patients with Caprini score >8 were significantly more likely to develop VTE when compared with patients with Caprini score of 3 to 4 (odds ratio [OR] 20.9, $p < 0.001$), 5 to 6 (OR 9.9, $p < 0.001$), or 7 to 8 (OR 4.6, $p = 0.015$). Among patients with Caprini score 7 to 8 or Caprini score >8, VTE risk was not limited to the immediate postoperative period (postoperative days 1-14). In these high-risk patients, more than 50% of VTE events were diagnosed in the late (days 15-60) postoperative period.

CONCLUSIONS: The Caprini RAM effectively risk-stratifies plastic and reconstructive surgery patients for VTE risk. Among patients with Caprini score >8, 11.3% have a postoperative VTE when chemoprophylaxis is not provided. In higher risk patients, there was no evidence that VTE risk is limited to the immediate postoperative period. (J Am Coll Surg 2011;212:105–112. © 2011 by the American College of Surgeons)

Venous thromboembolism (VTE) is a disorder with short-term mortality and long-term morbidity. VTE has been deemed a major threat to patient safety by policymakers and payers, including the US Surgeon General,[1] the Centers for Medicare and Medicaid Services,[2] and the National Quality Forum.[3] To fully identify VTE risk in surgical patients, recent publications advocate individualized patient risk assessment.[4-7] The Caprini Risk Assessment Model (RAM) was derived more than a decade ago, based on a combination of clinical experience and published data.[8-10] Recently, the Caprini RAM has been validated for 30-day VTE events in a large series of general, urology, and vascular surgery patients.[5] Revised versions of the model have also been validated in postbariatric body contouring patients[7] and medical inpatients.[11,12]

Plastic and reconstructive surgery patients are known to be at high risk for venous thromboembolism after surgery.

Disclosure Information: Nothing to disclose.

This study was funded by the Plastic Surgery Educational Foundation. Dr Pannucci receives salary support through NIH grant T32 GM-08616.

Abstract presented at the 2010 American Venous Forum meeting, 2010 American Association of Plastic Surgeons meeting, and 2010 Plastic Surgery Research Council.

Received June 1, 2010; Revised August 19, 2010; Accepted August 23, 2010.

From the Section of Plastic Surgery, Department of Surgery, University of Michigan, Ann Arbor, MI (Pannucci, Zumsteg, Jaber, Wilkins); the Department of Plastic Surgery, University of Texas-Southwestern, Dallas, TX (Bailey, Hoxworth); the Department of Plastic and Hand Surgery, Regions Hospital, St Paul, MN (Dreszer, Kallianen); the Division of Plastic and Reconstructive Surgery, University of Pittsburgh, Pittsburgh, PA (Fisher, Rubin); JBH Consulting, Shohola, PA (Hamill); the American Society of Plastic Surgeons, Arlington Heights, IL (Hume); the Division of Plastic Surgery, University of Washington, Seattle, WA (Neligan); and the Plastic and Reconstructive Surgery Service, Memorial Sloan Kettering Cancer Center, New York, NY (Pusic).

Correspondence address: Dr Christopher J Pannucci, University of Michigan, Section of Plastic Surgery, 2130 Taubman Center, 1500 E Medical Center Dr, Ann Arbor, MI 48105.

ISSN 1072-7515/11/$36.00
doi:10.1016/j.jamcollsurg.2010.08.018

Abbreviations and Acronyms

DVT = deep venous thrombosis
HR = hazard ratio
LMWH = low molecular weight heparin
OR = odds ratio
PE = pulmonary embolism
RAM = risk assessment model
VTE = venous thromboembolism
VTEPS = Venous Thromboembolism Prevention Study

Symptomatic VTE occurs with high frequency after postbariatric body contouring surgery, including circumferential abdominoplasty (7.7%), abdominoplasty (5.0%), and breast or upper body contouring (2.9%) procedures.[7] Using the modified Davison-Caprini RAM,[13] Seruya and colleagues[14] showed a 7.5% VTE incidence in patients stratified to the "highest risk" group. Symptomatic, postoperative VTE occurs in 2.2% of women having flap-based breast reconstruction after mastectomy.[15] However, asymptomatic VTE rates in the flap-based breast reconstruction population may be much higher. A recent study screened asymptomatic women before discharge using duplex ultrasonography and demonstrated that 4% had occult deep venous thrombosis (DVT).[16] In addition, a small case series demonstrated that 16.7% of women may have occult pulmonary embolism (PE) within 3 days of surgery.[17]

The Venous Thromboembolism Prevention Study (VTEPS) was funded by the Plastic Surgery Educational Foundation in 2008. The study's primary objective is to examine the effectiveness of postoperative, prophylactic dose enoxaparin (Lovenox [Sanofi Aventis]) for prevention of symptomatic VTE events in a diverse population of adult plastic and reconstructive surgery patients. The study's control group is comprised of historic control patients who had plastic and reconstructive surgery but did not receive postoperative heparin, low molecular weight heparin (LMWH), anti-factor Xa medications, or warfarin (collectively referred to as "chemoprophylaxis").

In this initial analysis of the VTEPS data, we sought to examine VTE incidence and when VTE events occur after plastic surgery. In addition, we examined the ability of the Caprini RAM to risk-stratify plastic and reconstructive surgery patients. Analyses were limited to VTEPS control patients, none of whom received chemoprophylaxis.

METHODS

Study design

VTEPS is being conducted at 5 tertiary care facilities in the United States. VTEPS sites include Regions Hospital (St. Paul, MN), University of Michigan (Ann Arbor, MI), University of Pittsburgh (Pittsburgh, PA), University of Texas-Southwestern (Dallas, TX), and University of Washington (Seattle, WA). The analyses described here were limited to data from the VTEPS historic control group. Historic control patients were identified using medical record review for all plastic and reconstructive surgery procedures performed at each of the 5 VTEPS sites between March 2006 and June 2009. During this time period, the standard of care for VTE prophylaxis at all VTEPS sites did not include routine chemoprophylaxis. Postoperative chemoprophylaxis was provided to less than 10% of patients based on attending surgeon discretion. Historic control eligibility criteria included moderate to high risk for VTE (Caprini score $\geq$3), operation under general anesthesia, and overnight hospital stay. Control patients did not receive heparin, LMWH, factor Xa inhibitors, warfarin, or other means of prophylactic or therapeutic anticoagulation for 60 days after surgery. This included the patient's inpatient stay and postdischarge course. Perioperative sequential compression devices were used.

Independent variables

At each study site, medical record review was performed by physician-led teams. Before chart review, each team participated in a standardized training session administered by the VTEPS study coordinators. Retrospective chart review was carried out to identify VTE risk factors per the Caprini RAM (Fig. 1). The factors were used to calculate a risk score based on risk factors present before (eg, medical comorbidities or known thrombophilia) and during (eg, surgery length or central venous line insertion) hospitalization. Additional independent variables included the year the procedure was performed, VTEPS site, patient sex, total number of operations, description of surgical procedure, receipt of chemoprophylaxis, administration of aspirin or clopidogrel, and length of hospitalization.

Dependent variables

Dependent variables of interest were identified using medical record review, including documentation from the operating room, inpatient stay, and outpatient visits. Records were reviewed for 60 days after surgery. Patients who lacked 60-day followup were excluded. Chart review identified symptomatic DVT (including upper and lower extremity DVT), symptomatic PE, or hematoma requiring a second operation. All VTE events required confirmation using objective imaging (lower extremity venous duplex ultrasound, ventilation-perfusion scan, or PE protocol CT scan). Autopsy-proved DVT or PE were considered positive outcomes when they were believed to be the proximate cause of death. Among patients with an outcome of interest, time to VTE and time to

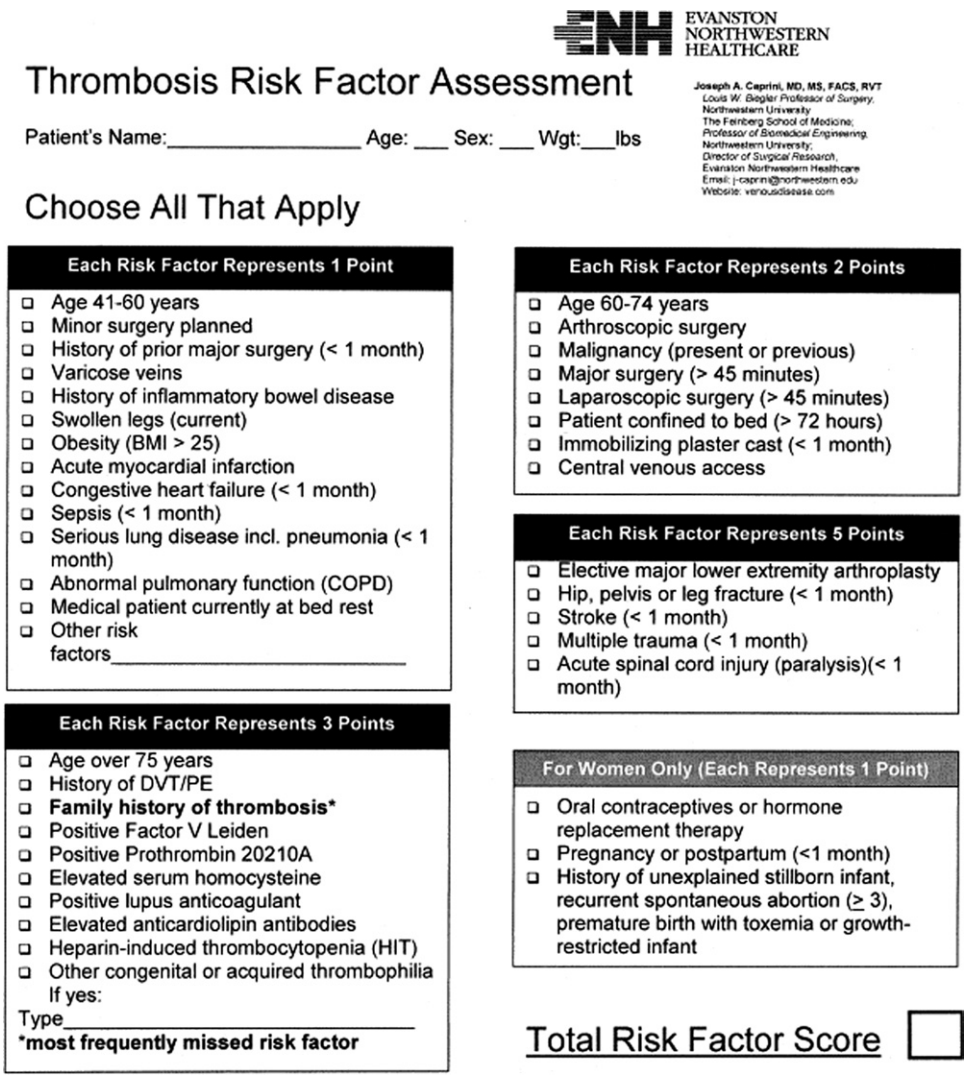

Figure 1. The Caprini Risk Assessment Model. (Adapted from: Caprini JA. Thrombosis risk assessment as a guide to quality patient care. Dis Mon 2005;51:70–78, with permission.)

reoperative hematoma in days were identified as additional dependent variables.

Data storage and analysis

A secure, password-protected Website was created through a modification of the American Society of Plastic Surgeons' Tracking Operations and Outcomes for Plastic Surgeons (TOPS) platform (http://tops.plasticsurgery.org). The Website was developed and maintained by Outcomes, Inc. Deidentified patient-level data for risk factors and outcomes were uploaded and stored on Outcomes, Inc's secure data server. For analysis purposes, deidentified data were extracted by the American Society of Plastic Surgeons and provided to study personnel in Microsoft Excel spreadsheets.

Data analysis was performed using Stata 11 (StataCorp LP). A VTE variable, including patients with either DVT or PE, was created. Descriptive statistics that examined DVT, PE, and VTE incidence were generated. For VTE risk analysis, patients were stratified by Caprini score at accepted and published levels (Caprini scores of 3 to 4, 5 to 6, 7 to 8, and >8).[5,18] Descriptive statistics on VTE rate by stratified Caprini score were generated. Group differences were examined using logistic regression. A value of $p < 0.05$ was considered significant. Kaplan-Meier analysis using stratified Caprini score was performed to examine the number of VTE events over time. Hazard ratios (HRs) were generated. The institutional review board at each VTEPS site approved this study.

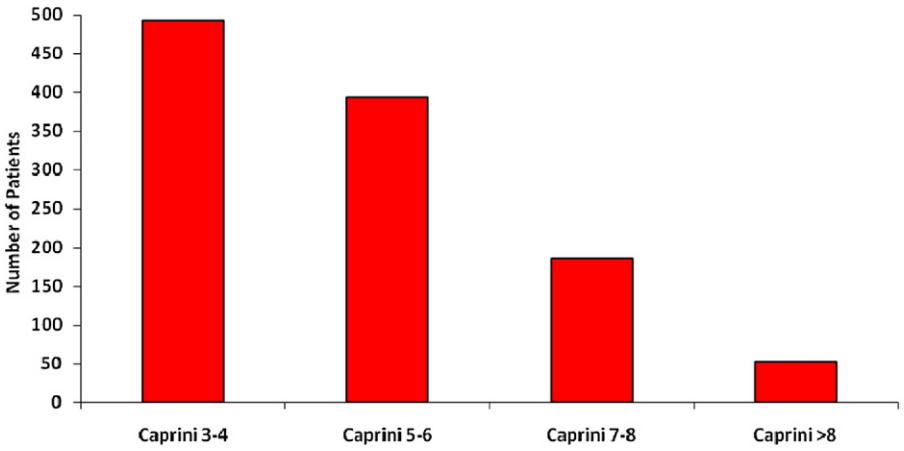

Figure 2. Histogram of Caprini score in plastic and reconstructive surgery patients (n = 1,126).

RESULTS

A total of 1,126 historic control patients were identified from 5 VTEPS network sites. No patient in this series received pre- or postoperative chemoprophylaxis. Most patients (79%) were in the Caprini 3 to 4 or Caprini 5 to 6 groups (Fig. 2).

At 60 days after surgery, the overall VTE incidence was 1.69%. Overall DVT incidence was 1.26% and overall PE incidence was 0.89%. Patients with both DVT and PE comprised 0.44% of the total number of patients. A stratified analysis of VTE by procedure type is shown in Table 1. A univariate analysis examining individual risk factors in patients with and without VTE is presented in Table 2.

VTE incidence increased dramatically with increased Caprini score (Fig. 3). In patients with Caprini score >8, 11.3% had a symptomatic VTE event between postoperative days 0 and 60. Patients with Caprini score >8 were significantly more likely to develop VTE when compared with patients with Caprini score of 3 to 4 (odds ratio [OR] 20.9, $p < 0.001$), 5 to 6 (OR 9.9, $p < 0.001$), or 7 to 8 (OR 4.6, $p = 0.015$). Additionally, patients with Caprini score 7 to 8 were significantly more likely to develop VTE when compared with patients with Caprini score 3 to 4 (OR 4.5, $p = 0.04$) (Table 3).

Two of 5 sites systematically omitted data on time to VTE. These 2 sites did not provide the postoperative day on which VTE occurred for any patient with VTE at their institution. As required by our Institutional Review Board, data were initially uploaded to our secure, web-based server in a de-identifed fashion. Thus, we were unable to re-query the primary data source to obtain time to VTE data for these two sites. All data from these 2 sites were dropped before time series analysis. Kaplan-Meier analysis was per-

Table 1. Venous Thromboembolism Stratified By Procedure Type

Procedure type	Patients, n	Patients with VTE, n (%)
Upper extremity reconstruction	153	0
Breast reconstruction	307	4 (1.3)
Breast reduction	99	1 (1.0)
Cosmetic breast surgery	12	0
Post-bariatric body contouring	26	0
Other body contouring	27	0
Lower extremity reconstruction	47	0
Head and neck reconstruction	198	4 (2.0)
Trunk reconstruction	82	6 (7.3)
Burn reconstruction	16	1 (6.3)
Surgery for decubitus ulcers	96	3 (3.1)
Genitourinary reconstruction	28	0
Facial cosmetic surgery	35	0

VTE, venous thromboembolism.

Table 2. Univariate Analysis Examining Individual Risk Factors in Patients With and Without Venous Thromboembolism

Risk factor	Without VTE	With VTE	p Value
Patients, n	1,107	19	
Age (y), mean	48.2	54.2	0.083
Female, %	64.8	63.2	0.864
BMI > 25, %	66.5	79.0	0.252
BMI > 40, %	8.3	10.5	0.727
Prior surgery within 1 mo, %	11.9	47.4	<0.001
OR time, mean	3.5	3.8	0.621
History of VTE	2.5	0	0.481
Family history of VTE, %	0.53	5.26	0.008
Cancer (present or previous), %	37.6	36.8	0.946
Central venous access, %	11.3	47.4	<0.001
Women, n	734	12	
Oral contraceptive use, %	9.1	16.7	0.371

VTE, venous thromboembolism; BMI, body mass index.

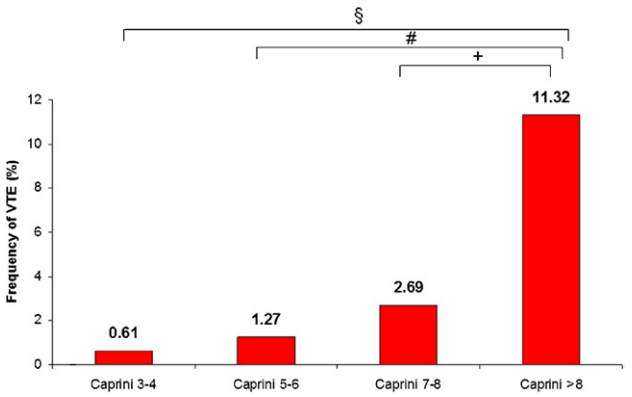

Figure 3. Rates of venous thromboembolism (VTE) in the first 60 postoperative days by stratified Caprini score (n = 1,126). OR, odds ratio; § Compares Caprini>8 to Caprini 3-4, OR 20.85, p<0.001; # compares Caprini>8 to Caprini 5-6, OR 9.93, p<0.001; + compares Caprini>8 to Caprini 7-8, OR 4.62, p=0.015.

formed on 1,087 patients from the remaining 3 sites. Patients with Caprini score >8 had significantly increased hazard for VTE when compared with patients with Caprini score 3 to 4 (HR 48.6, $p < 0.001$), 5 to 6 (HR 9.3, $p = 0.001$), or 7 to 8 (HR 3.6, $p = 0.041$) (Table 4). In patients with Caprini score 7 to 8 and >8, VTE events occurred across the 60-day follow-up period (Fig. 4).

DISCUSSION

Our data demonstrate that the Caprini RAM is a useful and effective tool to stratify plastic and reconstructive surgery patients for VTE risk. For patients with higher Caprini scores, a significantly greater likelihood of VTE events was observed. Approximately 1 in 9 patients (11.3%) with Caprini score >8 had a VTE event within 60 days after surgery. Particularly among patients with Caprini score 7 to 8 or >8, there was no evidence that VTE risk is limited to the immediate postoperative period.

Venous thromboembolism in plastic surgery patients

Venous thromboembolic events carry the risk of both morbidity and mortality. Patients presenting with symptomatic

Table 4. Sixty-Day Hazard for Venous Thromboembolism Stratified by Caprini Score

Score	Caprini 5–6	Caprini 7–8	Caprini >8
Caprini 3–4	5.2 (0.6–46.7) p = 0.139	13.3 (1.6–114.1) p = 0.018	48.6 (5.7–416.0) p < 0.001
Caprini 5–6	—	2.6 (0.7–9.5) p = 0.162	9.3 (2.5–34.7) p = 0.001
Caprini 7–8	—	—	3.6 (1.1–12.6) p = 0.041

Data are presented as hazard ratio (95% CI).

Table 3. Sixty-Day Odds for Venous Thromboembolism Stratified by Caprini Score

Score	Caprini 5–6	Caprini 7–8	Caprini >8
Caprini 3–4	2.1 (0.5–8.8) p = 0.312	4.5 (1.1–19.1) p = 0.040	20.9 (5.1–86.1) p < 0.001
Caprini 5–6	—	2.2 (0.6–7.5) p = 0.231	9.9 (2.9–33.8) p < 0.001
Caprini 7–8	—	—	4.6 (1.4–15.8) p = 0.015

Data are presented as odds ratio (95% CI).

PE have a 10% death rate within 1 hour. Of patients who survive, 50% demonstrate evidence of right ventricular dysfunction. An additional 5% will eventually develop chronic pulmonary hypertension.[19] Between 4% and 7% of plastic surgeons report a patient death from postoperative PE.[20,21] DVT can damage venous valves, which can result in venous reflux and the post-thrombotic syndrome. Severe PTS occurs in approximately 10% of patients with symptomatic DVT[19] and manifest as a chronically swollen, tender, and ulcerated extremity. Post-thrombotic syndrome is a major predictor of poor quality of life after DVT.[22]

Plastic surgeons underuse chemoprophylaxis in high-risk patients and may fail to recognize risk factors when present.[20-24] Others may recognize risk factors but fail to actively modify them before surgery.[25] Plastic surgeons commonly cite risk of re-operative hematoma and lack of evidence in the plastic surgery literature as reasons for not providing chemoprophylaxis.[21] Recently, plastic surgeons have been inundated with information on postoperative thromboembolic complications. Multiple recent publications have defined VTE incidence and risk factors in plastic surgery patients.[7,14,15,17,26-33] Barriers to surgeons providing chemoprophylaxis and methods to minimize VTE risk have been discussed in several letters to the editor.[34-36] A modified version of

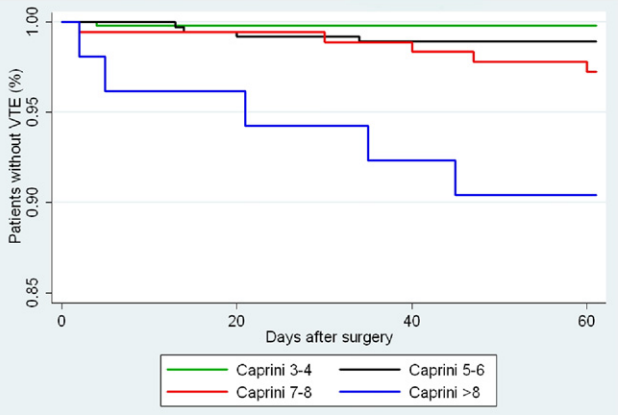

Figure 4. Survival analysis examining time to venous thromboembolism (VTE) by stratified Caprini score (n = 1,087).

the Caprini RAM has been validated in postbariatric body contouring patients.[7] However, no RAM had previously been validated in a broad range of adult plastic and reconstructive surgery patients.

Validation of the Caprini Risk Assessment Model

Earlier versions of the Caprini RAM[9] placed all patients with a score ≥5 into the same "highest risk" group. This designation was challenged by a recent publication by Bahl and colleagues[5] from the University of Michigan. In a series of more than 8,000 general, urology, and vascular surgery patients, widely variable VTE rates were seen among patients previously lumped into the same "highest risk" category. Observed differences in VTE incidence among patients with Caprini score of 5 to 6 (1.3%), 7 to 8 (2.6%), and >8 (6.5%) were statistically significant. As a result, recent modifications of the Caprini RAM recognize patients with Caprini score >8 as a separate, "super high risk" group. Extended-duration chemoprophylaxis for 30 days after surgery is recommended for this "super high risk" patient subgroup.[18,37]

Superficially, the study design for VTEPS and Bahl and colleagues'[5] analyses appear similar. Both used the Caprini RAM to retrospectively risk-stratify surgical patients, and they then examined VTE incidence by stratified Caprini score. However, the observed VTE incidence by stratified Caprini score was notably different between the VTEPS and Bahl patient populations. VTE incidence among "super high risk" patients included in VTEPS approached twice the incidence seen in Bahl's patient population (11.3% vs 6.5%).

Plastic surgery patients are not necessarily at increased risk for VTE events when compared with general, urology, and vascular surgery patients. The differences in observed VTE incidence between the 2 studies may be explained by differences in study methodology. First, the VTEPS dataset contains 60-day patient follow-up, compared with 30-day outcomes in the Bahl study. Second, VTEPS methodology used manual chart review to identify VTE events; this method may be more robust than using hospital billing data. Finally, 32% of Bahl's Caprini >8 group received LMWH prophylaxis. In contrast, this analysis of the VTEPS database specifically excluded patients who received chemoprophylaxis.

Late venous thromboembolism risk

For patients with Caprini score 7 to 8 and >8, VTE risk was not limited to the immediate postoperative period. Our results echo recently published data from the UK's Million Women Study.[38] The Million Women Study demonstrated that in middle-aged women, VTE risk may remain substantially elevated for at least 90 days after surgery. Published guidelines for total hip or knee replacement and hip fracture surgery support postdischarge chemoprophylaxis for up to 5 weeks after surgery.[39] Similar recommendations for extended duration chemoprophylaxis have been made in selected groups of medical patients[40] and general surgery patients.[18,41-43] The Enoxaparin and Cancer (ENOXACAN II) study was a randomized control trial examining 7 versus 28 days of LMWH for VTE prevention after surgery for intra-abdominal or pelvic malignancy. Extended-duration prophylaxis significantly reduced VTE events at 30 and 90 days after surgery.[43] Interestingly, plastic surgery patients have demonstrated excellent compliance with outpatient LMWH injections for VTE prophylaxis. A small case series of postdischarge subcutaneous LMWH prophylaxis has shown >90% medication compliance.[14]

Limitations

Our analysis is limited by several factors. The VTEPS data were identified and uploaded in a retrospective manner. Risk factors were identified using physician review of the medical record. So, inadvertent omissions from the dictated medical record may have resulted in underestimation of a patient's Caprini risk score.

Multiple physicians and physician-led teams at 5 separate VTEPS sites identified and uploaded data to the study's central Website. Sites contributed variable numbers of patients to the 2 study cohorts (historic control and clinical protocol). Intersite variability in data collection may have been present. Before undertaking VTEPS, we attempted to control for this confounder. Each individual involved in data collection was provided with explicit, written study protocols. All individuals who collected VTEPS data participated in a standardized training session, administered by study personnel. Data were retrospectively checked by VTEPS core investigators for completeness. Ongoing feedback was provided to each VTEPS site. Incomplete data were dropped from the analysis.

Medical record review was conducted at each VTEPS site. Patients who had a VTE event diagnosed and/or treated at another hospital may not be represented in the VTEPS database. Literature published after our study protocol was designed and implemented supports elevated VTE risk for at least 90 days after surgery.[38] However, patients whose VTE event occurred after postoperative day 60 are not included in our database. Clinical diagnoses of DVT and PE are known to be unreliable. Clinical examination alone is known to underestimate true incidence of VTE.[44-48] We did not screen patients for asymptomatic VTE, as has been done in other high risk surgical groups.[16,17,49,50] As a result of these factors, the VTEPS database likely under-represents the true incidence of VTE after plastic surgery.

In conclusion, the Caprini RAM effectively risk-stratifies plastic and reconstructive surgery patients for perioperative VTE risk. Among patients with Caprini score >8, 11.3% have a postoperative VTE when chemoprophylaxis is not provided. In patients with Caprini score 7 to 8 or Caprini score >8, there was no evidence that VTE risk is limited to the immediate postoperative period. Future goals of the VTEPS study will include examination of both VTE and re-operative hematoma rates between patients who receive and do not receive post-operative, prophylactic dose enoxaparin.

Author Contributions

Study conception and design: Pannucci, Hamill, Hume, Hoxworth, Fisher, Rubin, Pusic, Wilkins

Acquisition of data: Pannucci, Bailey, Fisher, Dreszer, Zumsteg, Jaber

Analysis and interpretation of data: Pannucci, Pusic, Wilkins

Drafting of manuscript: Pannucci, Wilkins

Critical revision: Pannucci, Bailey, Dreszer, Zumsteg, Jaber, Hume, Hamill, Rubin, Neligan, Kallianen, Hoxworth, Pusic, Wilkins

REFERENCES

1. Wakefield TW, McLafferty RB, Lohr JM, et al. Call to action to prevent venous thromboembolism. J Vasc Surg 2009;49:1620–1623.
2. Centers for Medicare and Medicaid Services press release, April 14 2008. Available at: http://www.cms.hhs.gov. Last accessed November 23, 2010.
3. National Quality Forum press release, May 15 2008. Available at: http://www.qualityforum.org. Last accessed November 23, 2010.
4. Green D. VTE prophylaxis in aesthetic surgery patients. Aesth Surg J 2006;26:317–324.
5. Bahl V, Hu HM, Henke PK, et al. A validation study of a retrospective venous thromboembolism risk scoring method. Ann Surg 2009;241:344–50.
6. 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.
7. Hatef DA, Kenkel JM, Nguyen MQ, et al. Thromboembolic risk assessment and the efficacy of enoxaparin prophylaxis in excisional body contouring surgery. Plast Reconstr Surg 2008;122:269–279.
8. Motykie GD, Zebala LP, Caprini JA, et al. A guide to venous thromboembolism risk factor assessment. J Thromb Thrombolysis 2000;9:253–262.
9. Caprini JA. Thrombosis risk assessment as a guide to quality patient care. Dis Mon 2005;51:70–78.
10. Caprini JA, Arcelus JI, Reyna JJ. Effective risk stratification of surgical and nonsurgical patients for venous thromboembolic disease. Semin Hematol 2001;38:12–19.
11. Arcelus JI, Candocia S, Traverso CI, et al. Venous thromboembolism prophylaxis and risk assessment in medical patients. Semin Thromb Hemost 1991;17:313–318.
12. Zakai NA, Wright J, Cushman M. Risk factors for venous thrombosis in medical inpatients: Validation of a thrombosis risk score. J Thromb Haemost 2004;2:2156–2161.
13. Davison SP, Venturi ML, Attinger CE, et al. Prevention of venous thromboembolism in the plastic surgery patient. Plast Reconstr Surg 2004;114:43E–51E.
14. Seruya M, Venturi ML, Iorio ML, Davison SP. Efficacy and safety of venous thromboembolism prophylaxis in highest risk plastic surgery patients. Plast Reconstr Surg 2008;122:1701–1708.
15. Pannucci CJ, Chang EY, Wilkins EG. Venous thromboembolic disease in autogenous breast reconstruction. Ann Plast Surg 2009;63:34–38.
16. Lemaine V, Mehara BJ, Pusic AL, et al. Venous thromboembolism after microsurgical breast reconstruction: an objective analysis in 100 consecutive patients using low molecular weight heparin prophylaxis. Podium presentation, American Society of Plastic Surgeons (ASPS) Annual Meeting, Seattle, Washington, October 23 - 27, 2009.
17. Kim EK, Eom JS, Ahn SH, et al. The efficacy of prophylactic low-molecular-weight heparin to prevent pulmonary thromboembolism in immediate breast reconstruction using the TRAM flap. Plast Reconstr Surg 2009;123:9–12.
18. Caprini JA. Risk assessment as a guide for the prevention of the many faces of venous thromboembolism. Am J Surg 2010;199:S3–10.
19. Kearon C. Natural history of venous thromboembolism. Circulation 2003;107:122-130.
20. Pannucci CJ, Oppenheimer AO, Wilkins EG. Practice patterns in venous thromboembolism prophylaxis: a survey of 606 reconstructive breast surgeons. Ann Plast Surg 2010;64:732–737.
21. Clavijo-Alvarez JA, Pannucci CJ, Oppenheimer AO, et al. Prevention of venous thromboembolism (VTE) in body contouring surgery. A national survey of ASPS surgeons. Ann Plast Surg, In Press.
22. Kahn SR, Shbaklo H, Lamping DL, et al. Determinants of health-related quality of life during the 2 years following deep vein thrombosis. J Thromb Haemost 2008;6:1105–1112.
23. Broughton G 2nd, Rios JL, Rohrich RJ, Brown SA. Deep venous thrombosis prophylaxis practice and treatment strategies among plastic surgeons: Survey results. Plast Reconstr Surg 2007;119:157–174.
24. Spring MA, Gutowski KA. Venous thromboembolism in plastic surgery patients: survey results of plastic surgeons. Aesth Surg J 2006;26:522–529.
25. Johnson RL, Hemington-Gorse SJ, Dhital SK. Do cosmetic surgeons consider estrogen-containing drugs to be of significant risk in the development of thromboembolism? Aesthetic Plast Surg 2008;32:743–747.
26. Chen CM, Disa JJ, Cordeiro PG, et al. The incidence of venous thromboembolism after oncologic head and neck reconstruction. Ann Plast Surg 2008;60:476–479.
27. Davison SP, Kessler CM, Al-Attar A. Microvascular free flap failure caused by unrecognized hypercoagulability. Plast Reconstr Surg 2009;124:490–495.
28. Keyes GR, Singer R, Iverson RE, et al. Mortality in outpatient surgery. Plast Reconstr Surg 2008;122:245–250; discussion 251–253.
29. Liao EC, Taghinia AH, Nguyen LP, et al. Incidence of hematoma complication with heparin venous thrombosis prophylaxis after TRAM flap breast reconstruction. Plast Reconstr Surg 2008;121:1101–1107.

30. Miszkiewicz K, Perreault I, Landes G, et al. Venous thromboembolism in plastic surgery: Incidence, current practice and recommendations. J Plast Reconstr Aesthet Surg 2009;62:580–588.
31. Murray DJ, Neligan PC, Novak CB, et al. Free tissue transfer and deep vein thrombosis. J Plast Reconstr Aesthet Surg 2008;61:687–692.
32. Patronella CK, Ruiz-Razura A, Newall G, et al. Thromboembolism in high-risk aesthetic surgery: Experience with 17 patients in a review of 3871 consecutive cases. Aesthet Surg J 2008;28: 648–655.
33. Seruya M, Baker SB. MOC-PS(SM) CME article: Venous thromboembolism prophylaxis in plastic surgery patients. Plast Reconstr Surg 2008;122:1–9.
34. Davison SP, Massoumi W. Our complication, your problem. Plast Reconstr Surg 2007;120:1428–1429.
35. Ersek RA. General anesthesia gases are a common denominator in cases of thromboembolism. Aesthet Surg J 2009;29:340–341.
36. Pannucci CJ, Wilkins EG. Hematoma risk should not preclude the use of venous thromboembolism prophylaxis. Aesthet Surg J 2009;29:338; author reply 339.
37. Henke PH, Pannucci CJ. Venous thromboembolism risk factor assessment and prophylaxis. Phlebology 2010;25(5):219–223.
38. Sweetland S, Green J, Liu B, et al. Duration and magnitude of the postoperative risk of venous thromboembolism in middle aged women: Prospective cohort study. BMJ 2009;339:b4583.
39. Geerts WH, Bergqvist D, Pineo GF, et al. Prevention of venous thromboembolism: American College of Chest Physicians evidence-based clinical practice guidelines (8th edition). Chest 2008;133:381S–453S.
40. Yale SH, Medlin SC, Liang H, et al. Risk assessment model for venothromboembolism in post-hospitalized patients. Int Angiol 2005;24:250–254.
41. Rasmussen MS. Preventing thromboembolic complications in cancer patients after surgery: A role for prolonged thromboprophylaxis. Cancer Treat Rev 2002;28:141–144.
42. Rasmussen MS, Jorgensen LN, Wille-Jorgensen P, et al. Prolonged prophylaxis with dalteparin to prevent late thromboembolic complications in patients undergoing major abdominal surgery: A multicenter randomized open-label study. J Thromb Haemost 2006;4:2384–2390.
43. Bergqvist D, Agnelli G, Cohen AT, et al. Duration of prophylaxis against venous thromboembolism with enoxaparin after surgery for cancer. N Engl J Med 2002;346:975–980.
44. Mclachlin J, Richards T, Paterson JC. An evaluation of clinical signs in the diagnosis of venous thrombosis. Arch Surg 1962;85: 738–744.
45. Haeger K. Problems of acute deep venous thromosis. II. mobilization and discharge of the patient. Angiology 1969;20: 280–286.
46. Goldhaber SZ, Hennekens CH, Evans DA, et al. Factors associated with correct antemortem diagnosis of major pulmonary embolism. Am J Med 1982;73:822–826.
47. Douketis JD, Kearon C, Bates S, et al. Risk of fatal pulmonary embolism in patients with treated venous thromboembolism. JAMA 1998;279:458–462.
48. Anderson FA Jr, 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.
49. Wahl WL, Brandt MM, Ahrns KS, et al. Venous thrombosis incidence in burn patients: Preliminary results of a prospective study. J Burn Care Rehabil 2002;23:97–102.
50. Wibbenmeyer LA, Hoballah JJ, Amelon MJ, et al. The prevalence of venous thromboembolism of the lower extremity among thermally injured patients determined by duplex sonography. J Trauma 2003;55:1162–1167.