OPEN

ORIGINAL ARTICLE
Breast

Method of Breast Reconstruction Determines Venous Thromboembolism Risk Better Than Current Prediction Models

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Background: Venous thromboembolism (VTE) risk models including the Davison risk score and the 2005 Caprini risk assessment model have been validated in plastic surgery patients. However, their utility and predictive value in breast reconstruction has not been well described. We sought to determine the utility of current VTE risk models in this population and the VTE rate observed in various methods of breast reconstruction.
Methods: A retrospective review of breast reconstructions by a single surgeon was performed. One hundred consecutive transverse rectus abdominis myocutaneous (TRAM) patients, 100 consecutive implant patients, and 100 consecutive latissimus dorsi patients were identified over a 10-year period. Patient demographics and presence of symptomatic VTE were collected. 2005 Caprini risk scores and Davison risk scores were calculated for each patient.
Results: The TRAM reconstruction group was found to have a higher VTE rate (6%) than the implant (0%) and latissimus (0%) reconstruction groups ($P < 0.01$). Mean Davison risk scores and 2005 Caprini scores were similar across all reconstruction groups ($P > 0.1$). The vast majority of patients were stratified as high risk (87.3%) by the VTE risk models. However, only TRAM reconstruction patients demonstrated significant VTE risk.
Conclusions: TRAM reconstruction appears to have a significantly higher risk of VTE than both implant and latissimus reconstruction. Current risk models do not effectively stratify breast reconstruction patients at risk for VTE. The method of breast reconstruction appears to have a significant role in patients' VTE risk. *(Plast Reconstr Surg Glob Open 2015;3:e397; doi: 10.1097/GOX.0000000000000372; Published online 15 May 2015.)*

Venous thromboembolism (VTE) is a significant source of morbidity in plastic surgery patients.[1–6] Although many studies have focused on defining individual VTE risk factors,[7–11] to date there have been no studies comparing the VTE risk in various methods of breast reconstruction. Attempts to define procedural VTE risk have been limited and often do not differentiate surgical technique or patient pathology.[4,12–14] Accurately defining VTE risks should lead to improved patient selection, preoperative risk stratification, and possible reduction in the morbidity and mortality associated with VTE in breast reconstruction.

Several scoring systems have been developed to estimate an individual's postoperative VTE risk.[12,13,15,16] Two such models are the Davison risk score (2008 version) and the 2005 Caprini Risk Assessment Model (2005 Caprini RAM).[12,13] For both

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Received for publication June 13, 2014; accepted March 30, 2015.
Presented at the Plastic Surgery: The Meeting 2013, October 12, 2013, San Diego, Calif., under the title "The incidence of venous thromboembolism embolism in breast reconstruction patients and the predictive value of current models."

DOI: 10.1097/GOX.0000000000000372

scoring systems, a calculated risk score of greater than or equal to 5 stratifies a patient into "high risk" for VTE.[12,13] As originally reported, this estimates a VTE rate of greater than 20% in the absence of prophylactic measures.[13]

The 2005 Caprini RAM has become a preferred VTE model[17,18] and is a recommended tool by the American Society of Plastic Surgeons.[19] This model takes into account dozens of patient parameters and the length of the procedure. Although originally developed for a broader population, the 2005 Caprini RAM has recently been validated in plastic surgery patients[20] and has demonstrated superiority to other VTE risk models.[17] However, the 2005 Caprini RAM has not been validated in specific procedures, including various methods of breast reconstruction.

Breast reconstruction patients represent a unique group in plastic surgery. These individuals often have a history of breast cancer, require hormonal regimens, have multiple comorbidities, and undergo procedures that can reduce postoperative mobility. These factors have a known association with VTE risk.[8,9,13,21] One retrospective study demonstrated a 2% prevalence of VTE in breast reconstruction patients.[22] Additionally, a recent study looking at abdominal flaps reported a VTE rate of 4%.[23] Neither of these studies examined whether patient factors or procedural factors had a greater impact on VTE rate.

Our objective was to determine the utility of current VTE risk assessment models in this population. We also sought to evaluate the prevalence of symptomatic VTE in transverse rectus abdominis myocutaneous (TRAM) flap reconstruction, latissimus dorsi flap reconstruction, and implant-based reconstruction.

PATIENTS AND METHODS

A retrospective review was performed on all patients undergoing breast reconstruction by the senior author (D.S.W.) from January 2002 to January 2012. Breast reconstruction methods included TRAM, latissimus, and implant-based reconstruction. Approval for this research protocol was obtained from the institutional review board at our institution. Patients were identified by reviewing consecutive cases of each reconstruction type for a total of 100 patients for each reconstruction method. All patients had intraoperative and postoperative sequential pneumatic compression stockings and ambulated the evening of surgery. Patients did not receive VTE chemoprophylaxis except for 7 patients with a personal history of VTE. No patients were excluded from data collection or analysis.

Patient records were reviewed to collect demographic information and risk factors associated with VTE. Preoperative factors included body mass index (BMI), BRCA status, medications, medical history, recent hospitalizations, smoking history, use of hormonal contraceptives, history of spontaneous abortions, familial hypercoagulable state, and mastectomy indication. Perioperative factors collected included presence of malignancy, estimated length of procedure, postoperative complications, imaging studies, and the diagnosis of VTE. We also collected the average length of stay for the 3 methods of breast reconstruction.

All TRAM and latissimus reconstructions were performed as pedicled flaps. Reconstructions were performed in an immediate or delayed fashion, as well as unilaterally or bilaterally. Patients were questioned and examined for signs and symptoms of VTE in the postoperative period. This was continued subsequently at each postoperative office visit. Duplex ultrasound of the lower extremities and chest computed tomography were selectively performed. These diagnostic evaluations were ordered based on examination findings, such as edema, and patient complaints, such as extremity pain and shortness of breath. 2005 Caprini RAM and Davison risk scores were retrospectively calculated for each patient.

Categorical variables are presented as actual prevalence. Continuous variables are presented as means with SDs when appropriate. Categorical variables were examined using 2-way and 3-way Fisher's exact tests. All continuous variables were examined using analysis of variance testing. Microsoft Excel (Version 14.0, Microsoft Corporation, Redmond, Wash.) was used for data collection. GraphPad Prism (Version 6.0, GraphPad Software, Inc., La Jolla, Calif.) was used for analysis.

An a priori power analysis was performed. This was done using a dichotomous Fisher's exact test simulation for 200 patients in 2 groups. Assuming a VTE rate of 8%, there was a 91% chance of detecting a 7% difference in VTE rate and a 72% chance of detecting a 5% difference in VTE rate. Assuming a VTE rate of 6%, there was an 81% chance of detecting a 5% difference in VTE rate. The power of the analysis was further increased by utilizing a 3-way Fisher's exact test.

RESULTS

Three hundred breast reconstruction patients were identified. This cohort included 100 consecutive TRAM flap reconstructions, 100 consecutive implant reconstructions, and 100 consecutive latissimus

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*

reconstructions. Twelve patients had a VTE imaging study performed of which 6 studies were positive for VTE. Six patients in the TRAM flap reconstruction group (6%) developed a symptomatic VTE. No patients in the implant reconstruction group (0%) or the latissimus reconstruction group (0%) developed a symptomatic VTE. This represented a significantly increased rate of VTE in the TRAM group when compared with both the latissimus and implant reconstruction groups ($P = 0.004$). Characteristics of patient operations and postoperative period are shown in Table 1. All patients had greater than 30 days of follow-up, and 96% of patients (288/300) had greater than 60 days of follow-up. Two of the 6 VTEs were found greater than 30 days postoperatively, and 1 VTE was found more than 60 days postoperatively.

The mean Caprini RAM scores for the TRAM (6.0), latissimus (6.3), and implant (6.0) reconstruction groups were similar ($P = 0.183$). Davison risk scores were also similar between TRAM (5.1), latissimus (5.4), and implant (5.3) reconstruction groups ($P = 0.212$) (Fig. 1). Risk factors for VTE formation were similar among the 3 groups (Table 2). None of the 7 patients who received VTE chemoprophylaxis (2 TRAM, 2 latissimus, and 3 implant patients) developed a VTE.

Two risk factors that were statistically different between reconstruction groups were BMI and smoking. The TRAM reconstruction group had a higher BMI than the latissimus and implant-based reconstruction groups ($P = 0.001$). In addition, the latissimus reconstruction group was noted to have a higher smoking rate ($P = 0.001$) than both the TRAM and implant-based reconstruction groups. TRAM patients also had a longer average hospital length of stay (2.2 days) compared with latissimus (1.2 days) and implant-based reconstruction patients (1.1 days).

Table 1. Characteristics of Operations and Postoperative Period

	TRAM	Latissimus	Implant
No. patients	100	100	100
Immediate	66	58	75
Unilateral	25	54	27
Bilateral	41	4	48
Delayed	34	42	25
Unilateral	24	38	10
Bilateral	10	4	15
Mean follow-up weeks (median)	133 (88)	123 (77)	105 (67)
Length of stay (d)	2.2	1.2	1.1
High-risk Davison score	66	72	68
High-risk 2005 Caprini score	91	94	82
VTE	6	0	0
Deep vein thrombosis	3	0	0
Pulmonary embolism	3	0	0

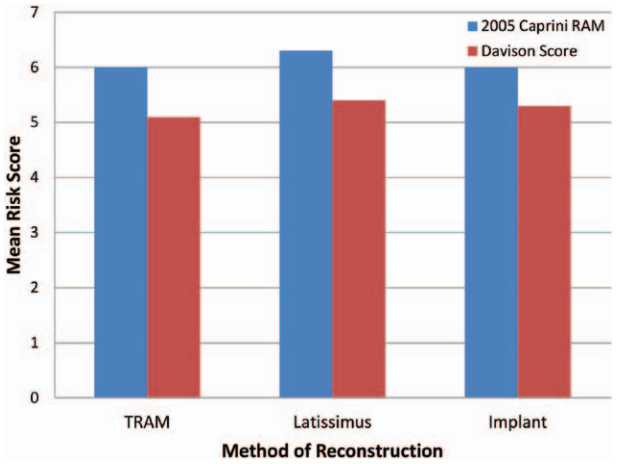

Fig. 1. VTE risk scores by breast reconstruction method.

Both the 2005 Caprini RAM and the Davison risk score stratified the vast majority of patients into the "high-risk" category. The 2005 Caprini RAM stratified 262 patients (87.3%) as high risk and the Davison risk score stratified 215 patients (71.7%) as high risk. For the 2005 Caprini RAM, this included 94 latissimus dorsi reconstructions and 80 implant-based reconstructions—none of which developed a symptomatic VTE. The distribution of risk scores is shown in Figure 2.

The TRAM patients who developed a VTE had similar demographics and risk scores when compared with other TRAM reconstruction patients (Table 3). None of these patients had a history of coagulopathy, previous VTE, or tobacco use. No other risk factors were identified in these patients.

DISCUSSION

The 2005 Caprini RAM and the Davison risk score were developed to stratify VTE risk for a wide variety of patients. Our data demonstrate that these models stratify breast reconstruction patients poorly. Although the vast majority of patients (87%) is stratified as high risk by at least 1 VTE risk model, only the TRAM reconstruction group demonstrated a significant VTE risk. The major factor leading to VTE appears to be the method of reconstruction rather than individual patient factors. This is shown by the increased VTE rate in the TRAM reconstruction group despite similar Caprini and Davison risk scores across all reconstruction groups.

There are several possible explanations for the higher rates of VTE in TRAM patients. Although both TRAM patients and latissimus patients undergo autologous reconstruction, there are significant differences. Most notably, TRAM patients have an abdominal donor site. The abdominal donor site is a source of significant pain in the postoperative

Table 2. Characteristics of Breast Reconstruction Patients

	TRAM	Latissimus	Implant	TRAM vs Latissimus (*P*)	TRAM vs Implant (*P*)	Latissimus vs Implant (*P*)	3-Way Comparison (*P*)
No. patients	100	100	100	1	1	1	1
Age (y)	50.29 (8.6)	51.78 (11.8)	50.16 (11.1)	0.309	0.927	0.319	0.469
BMI (kg/m^2)	29 (5.6)	27 (7.4)	26 (5.1)	0.032*	0.001*	0.267	0.001*
BRCA gene positivity	8	8	11	1	0.631	0.631	0.792
Hormone usage	26	38	35	0.095	0.219	0.769	0.163
Active tobacco use	1	18	10	0.001*	0.010*	0.153	0.001*
History of previous VTE	2	2	3	1	1	1	1
Active malignancy	49	63	61	0.064	0.118	0.884	0.098
Family history of hypercoagulopathy	1	1	2	1	1	1	1
Extended immobilization	0	0	0	1	1	1	1
Hypothyroidism	21	14	17	0.260	0.590	0.697	0.448
Venous insufficiency	12	6	12	0.216	1	0.216	0.242
2005 Caprini RAM	6.0 (1.4)	6.3 (1.4)	6.0 (1.8)	0.131	1	0.190	0.183
Davison score	5.1 (1.5)	5.4 (1.7)	5.3 (1.9)	0.187	0.410	0.695	0.212
VTE	6	0	0	0.029*	0.029*	1	0.004*

*Statistically significant ($P < 0.05$).

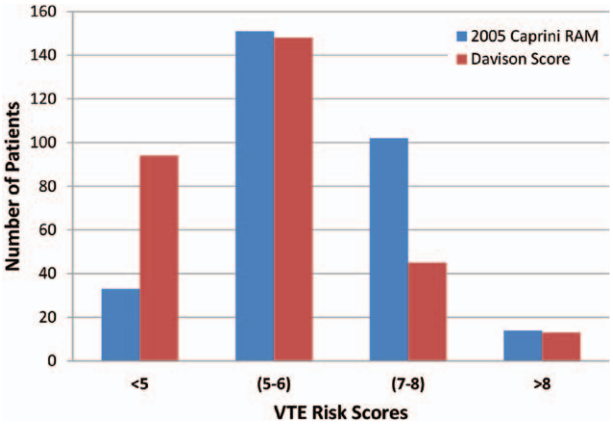

Fig. 2. Distribution of VTE risk scores.

period[24] and can lead to decreased mobility. The inability to stand fully upright in the early recovery phase may further impair mobility. This is reflected in the hospital length of stay for TRAM patients, which is 24 hours greater than both the implant and latissimus reconstruction groups. A potential intraoperative difference may be patient positioning. Patients are placed in a modified beach chair position to aid with donor site closure, which may reduce venous outflow.[25–27] Closure of the abdominal wall can also impair venous outflow by increasing intra-abdominal pressure.[28–30]

BMI may also account for the higher VTE rate in TRAM reconstruction. Increased BMI carries many risk factors associated with VTE, including decreased venous outflow and increased intra-abdominal pressure. However, it is also important to consider that some difference in BMI may be intrinsic to an abdominal flap procedure. For a patient to undergo a TRAM, he or she must have adequate abdominal tissue to allow for tissue transfer. Additionally, BMI is a significant portion of current VTE risk score calculation. If BMI is responsible for the increased VTE rate, then current models fail to adequately weigh this risk factor in breast reconstruction patients.

Interestingly, we found little evidence that length of procedure alone had a significant effect on VTE. Importantly, all patients underwent significant operations by both risk models as all surgeries were done under general anesthesia with duration longer than 45 minutes. Length of surgery in breast reconstruction is highly variable, as reconstruction method can be unilateral or bilateral and immediate or delayed. Immediate, bilateral reconstructions are usually the longest surgeries in duration, as they require a significant oncologic surgery followed by the reconstruction. Yet, half of patients who developed a VTE had a unilateral procedure and a third of patients who developed a VTE had reconstruction in a delayed fashion. When examining specific lengths of surgery, the patients who developed VTE did not have aberrant length of surgeries compared with patients who did not develop a VTE.

Despite having 300 patients, there are some study limitations. Although we report a symptomatic VTE rate, the true VTE rate is likely higher and unknown, as we did not use screening imaging. We also reviewed outcomes after patients had undergone a particular breast reconstruction rather than performing a prospective evaluation. We did not evaluate the complex decision making involved in method selection. Although the reconstructive groups appear quite similar, the retrospective review does uncover biases that may affect VTE rate. For instance, 2 differences observed in TRAM patients—higher BMI and decreased smoking rate—likely stem from variation in patient selection. As mentioned previously, patients require a certain amount of abdominal tissue

Table 3. Characteristics of Patients Who Developed VTE

	TRAM Patients with VTE	TRAM Patients without VTE	VTE vs No VTE (*P*)
No. of patients	6	94	NA
Mean age (range)	53 (45–60)	50 (36–74)	0.513
Mean height (range)	64 (61–66)	65 (60–72)	0.375
Mean weight (range)	177 (140–203)	173 (115–264)	0.842
Mean BMI (range)	31 (23–38)	29 (19–44)	0.551
Immediate reconstruction	4	62	1
Delayed reconstruction	2	32	1
Unilateral	3	49	1
Bilateral	3	51	1
Hormone usage	2	24	0.649
Active tobacco use	0	1	1
Active malignancy	4	45	0.432
Family history of hypercoagulopathy	0	1	1
History of previous VTE	0	2	1
Hypothyroidism	1	20	1
Venous insufficiency	2	10	0.151
Davison score	6 (3–7)	5 (2–9)	0.296
2005 Caprini score	6.5 (5–8)	6 (3–11)	0.161

NA, not applicable.

to undergo TRAM reconstruction, which requires higher BMI. The senior author will not offer TRAM reconstruction to patients who are active smokers. Both factors likely represent a bias in the selection process. Given this, it is difficult to compare the reconstruction groups to each other as equal groups. However, the most important comparison is that these groups had similar VTE risk scores, which did not translate into comparable VTE risk. Finally, the included reconstructions are from a single surgeon's practice. Although this allows for technical and institutional control, it also limits the analysis by including only one surgeon's experience.

Our methodology does allow for some analytical advantages. All symptomatic VTEs regardless of time of occurrence were included. VTE analyses, including recent publications, are often limited to a 30-day window.[23] As we show, many events occur outside of the 30-day window and some may even be detected outside of a 60-day window. Including patients from a single surgeon allows for comparison of distinct, well-defined procedures with minimal variation. An example of this control is that our patients did not routinely receive VTE chemoprophylaxis. As the safety of VTE prophylaxis in the perioperative period has been well substantiated,[31,32] VTE prophylaxis strategies continue to develop and vary widely by institution.

The senior author now uses VTE chemoprophylaxis on all patients undergoing TRAM reconstruction regardless of calculated VTE risk score. This chemoprophylaxis begins 2 hours preoperatively with 40 mg Lovenox or 5000 mg Fragmin subcutaneously and continues with appropriate dosing until discharge. The senior author also selectively uses chemoprophylaxis for implant and latissimus reconstruction for patients with a history of VTE or the presence of a significant hypercoagulable state. All of our patients receive mechanical prophylaxis and early postoperative ambulation.

CONCLUSIONS

TRAM reconstruction is associated with a higher risk of VTE compared with other methods of breast reconstruction. Both the Davison risk score and the 2005 Caprini RAM appear to be poor VTE risk stratification tools in breast reconstruction patients as nearly all patients are classified as high risk. Clinicians should consider VTE chemoprophylaxis in TRAM reconstruction patients. Current and future VTE risk assessment models should account for reconstruction method to more accurately determine VTE risk.

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