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REVIEW

Thromboprophylaxis in breast microvascular reconstruction: a review of the literature

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Abstract

Microsurgical breast reconstruction patients are at an increased risk for venous thromboembolism (VTE) due to numerous risk factors. A meta-analysis focusing on anti-thrombotics in breast microsurgery has yet to be completed. We aimed to perform a systematic review of the literature to examine the effects of thromboprophylaxis in breast microsurgical reconstruction with a focus on patient and flap complications. A PubMed, Cochrane, and Medline database search was conducted with the following keywords: "venous thrombosis, thromboprophylaxis, mechanical, pneumatic compression, aspirin, heparin, dextran, ketorolac, toradol, warfarin, and coumadin." Results were combined with the terms "breast microsurgery" and "breast free flap." All articles that resulted were analyzed. The reference list for each included article was analyzed for other applicable articles. Only articles that addressed pre-operative or post-operative anti-coagulation were included. For data analysis, if the article reported that there were no flap complications, it was assumed there were no operative hematomas, vessel thrombosis, or flap loss. Two hundred and fifty-seven studies were screened from the abovementioned search results and 17 fit inclusion criteria. The majority of included studies were retrospective chart reviews and the type of thromboprophylaxis and its effect on complications was rarely the primary end point. Due to lack of reporting on patient and flap characteristics that could impact outcomes, subgroup analysis was impossible. There has yet to be a consensus on the most effective way to prevent VTE in women undergoing microsurgical breast reconstruction without increasing the risk of hematoma and flap compromise. Studies published to date vary in their thromboprophylatic regimens and rarely include a control or comparison group to allow for intra- or inter-group analysis. There is a need for well-done, randomized, controlled trials in order to determine the best approach to thromboprophylaxis in these patients.

Keywords Breast · Free flap · Chemoprophylaxis · Thrombosis · Microsurgery

Introduction

Microsurgical breast reconstruction patients are at an increased risk for venous thromboembolism (VTE) due to numerous risk factors. Animal studies have demonstrated that anti-thrombotic agents can also prevent thrombosis in microvascular anastomosis [1–5]. However, the utilization of anti-thrombotics presents an increased risk of hematoma, which can be especially pertinent in microvascular reconstruction as it can constrict the pedicle and lead to congestion and flap loss. A meta-analysis analyzing 12 articles found that there was little evidence suggesting that the use of anti-thrombotics reduced thrombosis and flap failure, but all increased the risk of hematoma [6]. A recently published literature review examining head and neck microsurgery found variable evidence for post-operative thromboprophylaxis and a clear need for prospective studies to determine an appropriate consensus for patient management [7]. In this study, we aimed to perform a systematic review of the literature to examine the effects of thromboprophylaxis in breast microsurgical reconstruction with a focus on patient and flap complications.

Methods

We aimed to identify all full-text, peer-reviewed publications in English pertaining to thromboprophylaxis in microsurgical breast reconstruction. A PubMed, Cochrane, and Medline database search was conducted with the following keywords with no regional, time, or language restrictions: "venous thrombosis,

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thromboprophylaxis, mechanical, pneumatic compression, aspirin, heparin, dextran, ketorolac, toradol, warfarin, and coumadin." Results were combined with the terms "breast microsurgery" and "breast free flap" to retrieve articles. All articles that resulted were analyzed. The reference list for each included article was analyzed for other applicable articles.

Only articles that addressed pre-operative or post-operative anti-coagulation were included. Articles that only reported on intra-operative intra-flap anti-coagulation were not analyzed. Articles were excluded if they did not differentiate the type of anti-coagulation utilized. Studies were not included if the patient experienced an intra-operative thrombosis and were thus treated with a specific post-operative anti-coagulant that was not the standard of care for all free flaps at that institution. An article was considered unique if prior search terms failed to identify that article. For data analysis, if the article reported that there were no flap complications, it was assumed there were no operative hematomas, vessel thrombosis, or flap loss. Transfusion and deep vein thrombosis (DVT)/PE data were listed as "n/a" unless specifically reported upon. Percentages were calculated based on number of flaps in the study, as this was reliably reported.

Results

Two hundred and fifty-seven studies were screened from the abovementioned search results and 17 fit inclusion criteria (Fig. 1). The majority of included studies were retrospective chart reviews (Table 1), and the type of thromboprophylaxis and its effect on complications was rarely the primary end point (Table 2). Below we summarize the findings and recommendations of each study.

Low-molecular weight heparin

A retrospective chart review published in 2015 examined 29 patients who underwent double transverse myocutaneous gracilis flaps for unilateral breast reconstruction. All patients received low-molecular weight heparin (LMWH) post-operatively. In this study, there were six hematomas, all of which led to venous thrombosis and required re-operation [8].

A case series in 2011 reported on two patients with factor V Leiden mutation who underwent SGAP or deep inferior epigastric perforator (DIEP) breast reconstruction and received 5000 IU heparin prior to induction, per institution protocol. Both of these patients experienced flap loss secondary to venous congestion. This led the authors to propose that patients with factor V Leiden mutation must be treated as high risk and likely require increased anti-coagulation [9].

A retrospective study published in 2004 from Sweden reported on 16 patients who underwent free Transverse Rectus Abdominis Muscle (fTRAM) breast reconstruction and received LWMH post-operatively. There were two DVTs and one PE in this cohort. There was one minor hematoma, one venous thrombosis, one artery thrombosis, and 16 patients required transfusion [10].

A retrospective study published in 2017 reported on 192 patients who underwent DIEP reconstruction and received LMWH starting 6 h post-operatively until discharge. There were six VTEs (2 DVT/PE and 4 only DVT), 12 hematomas, and nine flap losses. The authors based their anti-coagulation regimen on the patients' Caprini scores and concluded that most DIEP patients belonged with the highest-risk group and warranted combined anti-coagulation prophylaxis [11].

A cohort study in 2010 examined two groups of patients who underwent DIEP or TRAM reconstruction. There were 225 patients, all of whom received enoxaparin, compression devices, and were encouraged to ambulate early. One hundred and eighteen patients underwent duplex screening prior to discharge, and 107 historical controls were not screened. There were four DVTs in the screened group and no PEs. There were no DVTs or PEs in the historical control group. The average Caprini scores were 7.6 ± 0.9 for the screened group and 7.7 ± 1.2 for the historical control group, making all patients considered highest risk [12].

A retrospective study published in 2009 examined patients who underwent fTRAM breast reconstruction and received either no thromboprophylaxis (450 patients) or LMWH for 7 days (200 patients). In group 1, there were eight symptomatic DVTs and nine asymptomatic DVTs. There were no DVTs in group 2. There were eight hematomas in group 1 and three in group 2. Twelve and six patients required transfusion in group 1 and 2, respectively. The authors concluded that LMWH could prevent VTE without leading to an increase in bleeding complications [13].

A retrospective review published in 2017 examined 2328 microsurgical breast reconstructions with a focus on the association between vasopressor utilization and complications. Per institutional protocol, all patients received 40 mg LMWH daily until discharge. There were 31 arterial thrombosis, 55 venous thrombosis, and 41 flap losses [14].

A study published in 2017 sought to analyze if ketorolac was associated with increased risk of hematoma in all breast reconstruction. All patients, regardless of reconstruction, were given LMWH or heparin post-operatively. The only complication that was broken down by type of reconstruction was hematoma rate. There were two hematomas in patients who underwent microsurgical breast reconstruction and did not received ketorolac and one in a patient who did receive ketorolac [15] .

A retrospective study in 2013 examined breast reconstructions performed where protocol initially was to provide no thromboprophylaxis and then involved to deliver 40 mg enoxaparin daily or 30 mg BID to all patients. Analyzing both tissue expander and autologous reconstruction, the authors demonstrated statistically similar rates of hematomas and transfusions in the tissue expander and autologous cohorts. In the autologous cohort, there were no DVTs, but one patient who

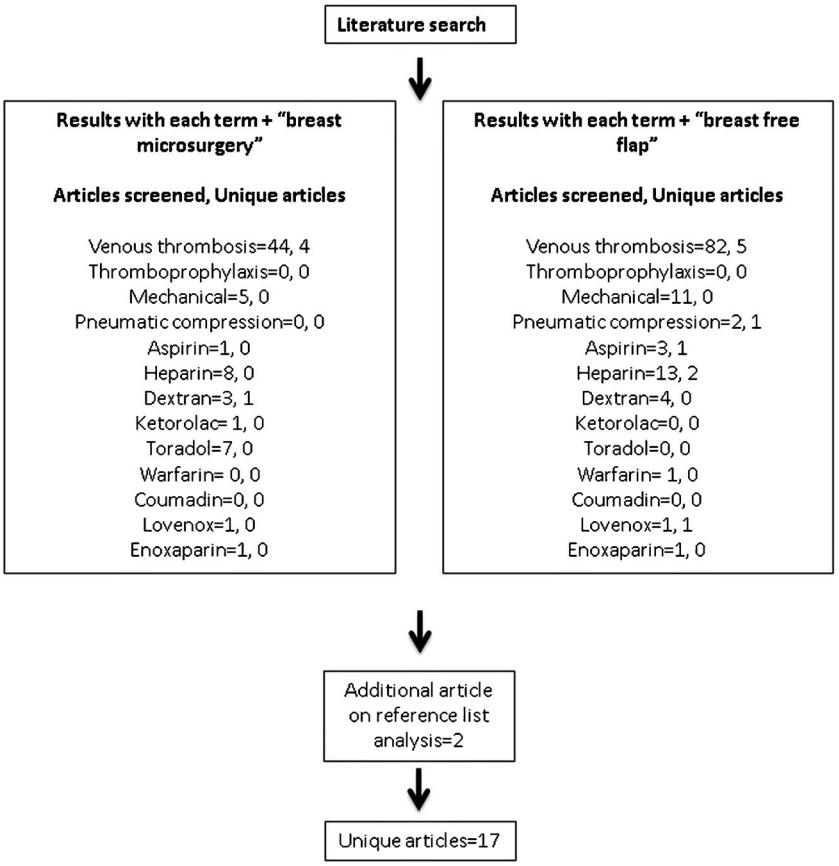

Fig. 1 Literature search results

received post-operative enoxaparin was found to have an asymptomatic pulmonary embolism. Thus, the authors concluded that enoxaparin resulted in acceptable post-operative bleeding complications [16].

Aspirin

A retrospective study in 2011 reported on 20 patients who underwent microsurgical breast reconstruction with the inner thigh tissue as the donor site. All patients receive post-operative ASA. There was one venous thrombosis and no flap losses in this cohort [17].

Combination therapy

A retrospective study published in 2016 sought to determine if the utilization of multiple anti-thrombotics led to more complications or more flap successes. The authors analyzed consecutive microsurgical breast patients from 2006 to 2012, which resulted in 139 patients and 150 flaps. All patients received 2500 IU heparin peri-operatively and LWMH 40 mg the night before the surgery and for the first post-operative week. Based on institutional protocol, each patient initially received dextran 70 60 mg/mL for 10 h post-operatively and then at 50 mL/h during the 1st and 3rd days; however, only the first 78 patients received this regimen. All patients also received 75 mg ASA for weeks 2–5. There was a statistically increased rate of hematomas and flap losses in the dextran cohort. There was no difference in necessity of transfusion. Based on these results, the authors stopped routinely using dextran [18].

A study published in 2014 compared the thromboprophylaxis protocol at two institutions. At one institution, patient received only LMWH until discharge, and at the other, patients also received ASA for 6 weeks post-operatively. Analysis revealed no difference between the cohorts in relation to flap failure, thrombosis, or overall complications, but there was a higher rate of hematomas in the ASA group. Based on this, the authors stopped routinely administering ASA [19].

A retrospective chart review published in 2016 reported on 433 patients who underwent DIEP or SIEA breast reconstruction. Institutional thromboprophylaxis protocol included LMWH 2500 IU the night before surgery and 5000 IU daily for 10 days, along with 75 mg ASA for 30 days. With this approach, there were 15 hematomas, four venous thrombosis, and ten arterial compromises leading to six partial flap losses and ten complete losses [20].

A retrospective study in 2018 examined 133 patients who underwent microsurgical breast reconstruction and received 5000 IU heparin TID until discharge as well as 325 mg ASA. There were nine VTEs and one death from a PE. There were ten

Table 1 Studies analyzed with patient demographics and VTE PPX utilized

Author	Year	Type of study	Patients	Type of reconstruction	VTE PPX
Werdin	2015	Retrospective	29	Double TMG	• Subcutaneous LMWH
Halle	2016	Retrospective	139 (first 78 got dextran)	DIEP/SIEA/SGAP/TMG	• 2500 IU heparin peri-operative • LMWH 40 mg night prior to surgery and first post-operative week • 75 mg ASA for weeks 2–5 • ± Dextran 70 60 mg/mL for 10 h at 50 mL/h during 1st and 3rd days
Enajat	2014	Retrospective	261 got ASA 169 no ASA	DIEP/TRAM	• LMWH until d/c • 261 patients got 40 mg ASA from POD 1 for 6 weeks
Khansa	2011	Case series	2	DIEP/SGAP	• 5000 IU heparin prior to induction
Unukovych,	2016	Retrospective	433	DIEP/SIEA	• 2500 IU LMWH night before surgery and 5000 IU daily for 10 days • ASA 75 mg for 30 days
Sultan	2018	Retrospective	133	Microsurgical breast	• 5000 IU TID preoperatively until d/c • 325 mg ASA while inpatient
Duncumb	2016	Case series	3	DIEP	• 5000 IU LMWH daily for 6 days
Hein	1999	Case report	1	fTRAM	• IV dextran at flap ischemia for 5 days • 325 mg ASA post-op for 30 days
Olsson	2004	Retrospective	16	fTRAM	• LMWH
Buntic	2011	Retrospective	20	Inner thigh	• ASA
Modarressi	2017	Retrospective	192	DIEP	• 40 mg LMWH 6 h after surgery until d/c
Lemaine	2010	Cohort study	225 118 underwent duplex 107 did not	DIEP/TRAM	• LMWH
Kim	2009	Retrospective	650 Group 1: 450 Group 2: 200	fTRAM	• Group 1: nothing • Group 2: LMWH for 7 days begun 1 h before operation (40 or 60 mg based on weight)
Arnljots	1997	Retrospective	52	fTRAM	• LMWH evening before surgery • 1000 ml dextran during surgery • 500 mL dextran on POD 2 and 4 • LMWH (20–40 mg) starting POD 5 until ambulate
Fang	2017	Retrospective	2328	Microsurgical breast	• 40 mg LMWH daily
Nguyen	2017	Retrospective	38	Microsurgical breast	• LMWH or heparin
Keith	2013	Retrospective	146	Microsurgical breast	• Group 1: nothing • Group 2: Enoxaparin 40 mg or 30 mg BID until ambulatory

hematomas, 46 patients required transfusion, six venous thrombosis, three arterial issues, two partial flap losses, and one complete flap loss. The goal of this study was to examine risk factors for VTE and interestingly the authors found patients having VTE were more likely to be Hispanic, more likely to have an increased transfusion volume and more likely to be discharged without ASA [21].

A study in 2016 sought to assess the feasibility of performing abdominally based microsurgical breast reconstruction on women who had previously injected LMWH into their panniculus. Three patients underwent four DIEP reconstructions and received 5000 IU LMWH for 6 days (one patient) or 2 weeks (one patient) or enoxaparin (one patient). There were no patient or flap compromises [22].

A case report published in 1999 reported on a woman who underwent fTRAM breast reconstruction and was placed on IV dextran and 325 mg ASA post-operatively. While there were no flap compromises, the patient developed ARDS secondary to the dextran, highlighting an important risk factor to dextran utilization [23].

Discussion

In microsurgical reconstruction, the surgeon must weigh the risk/benefit ratio of preventing thrombosis in high-risk patients while avoiding hematomas, which have the potential to compromise reconstruction. Women, who undergo microsurgical breast reconstruction, have numerous risk factors for VTE, including prolonged surgery, decreased ambulation, possible cancer diagnosis, and, often, an abdominal donor site with a tight closure. A study examining the Nationwide Inpatient Sample (NIS)

Table 2 Complications for each analyzed study

Author	DVT/PE	Hematoma	Arterial thrombosis	Venous thrombosis/congestion	Transfusion	Partial flap loss	Total flap loss
Werdin	n/a	6 (20.7%)	1 (3.4%)	6 (20.7%)	n/a	2 (6.9%)	1 (3.4%)
Halle	n/a	21 (15.2%) (18 in breast); 15 on dextran, 3 non	4 (2.9%) 3 dextran, 1 non	Assessed venous congestion	21 (15.1%) patients	5 (7.2%) in each	2 (2.9%) in each
Enajat	n/a	19 (7.3%) on ASA 8 (4.7%) not on ASA	3 (1.1%) on ASA 3 (1.8%) not on ASA	2 (0.8%) on ASA 4 (2.3%) not on ASA	n/a	12 (4.6%) on ASA 14 (8.3%) not on ASA	5 (1.9%) on ASA 5 (1.1%) not on ASA
Khansa	n/a	0	1 (50%)	1(50%)	n/a	0	2 (100%)
Unukovych	n/a	15 (3.5%) flaps	10 (2.3%) flaps	4 (0.9%) flaps	n/a	6 (1.4%) flaps	10 (2.3%) flaps
Sultan	9 (6.7%) VTE, 1 (0.8%) death	10 (7.5%)	3 (2.2%)	6 (4.5%)	46 (34.6%)	2 (1.5%)	1 (7.5%)
Duncumb	n/a	0	0	0	2 (66.7%)	0	0
Hein	n/a	n/a	n/a	n/a	1 (100%)	n/a	n/a
Olsson	2 (12.5%) DVT, 1 (6.3%) PE	0	1 (6.3%)	1 (same patient with artery thrombosis) (6.3%)	9 (56.3%) intra-op 7 (43.8%) post-op	0	0
Buntic	n/a	0	0	1 (5%)	n/a	0	0
Modarressi	6 (3.1%) VTE 2 (1%) with PE/DVT 4 (2%) only DVT	n/a	n/a	n/a	n/a	n/a	9 (4.7%) flaps
Lemaine	4 (1.8%) DVT	12 (5.3%)	n/a	n/a	n/a	5 (2.2%) flaps	4 (1.8%) flaps
Kim	Group 1: 8 (1.8%) symptomatic, 9 (2%) asymptomatic Group 2: 0	Group 1: 8 (1.8%) Group 2: 3 (1.5%)	n/a	n/a	Group 1: 12 (2.7%) Group 2: 6 (3%)	n/a	n/a
Arnljots	n/a	n/a	n/a	n/a	n/a	4 (7.7%)	2 (3.8%)
Fang	n/a	n/a	31 (1.3%)	55 (2.3%)	n/a	n/a	41 (18%)
Nguyen	n/a	3 (7.9%) (1 with ketorolac, 2 without)	n/a	n/a	n/a	n/a	n/a
Nguyen	Group 1: 0 Group 2: 1 (0.7%)	Group 1: 1 (0.7%) Group 2: 3 (2%)	0	0	Group 1: 1 (0.7%) Group 2: 2(2%)	0	0

n/a not available

database for patients who underwent autologous breast reconstruction from 2009 to 2010 found the rate of VTE to be 0.13%. Risk factors for VTE in that study included longer hospital stay, immediate reconstruction, age over 65 years, obesity, and history of chemotherapy and chronic lung disease [24]. However, this is a heterogeneous group of women, making broad statements about overall risk of VTE difficult to make. With numerous different options with which to provide anti-coagulation, and the heterogeneity of these patients and procedures, it is somewhat not surprising that there lacks a consensus on how best to prevent thrombosis in these patients while not increasing the risk of bleeding complications.

With the numerous options with which to provide anti-coagulation, it is important to consider the mechanism of thrombosis and how best to prevent their development. The main anti-thrombotics utilized include anti-platelet drugs, anti-coagulant drugs, and volume expanding drugs. Their efficacy in preventing thrombosis in microsurgery has largely been demonstrated in animal studies [1–5]. Aspirin (ASA) activates the platelet cyclooxygenase enzyme to decrease thromboxane A2 production, a platelet aggregator and vasoconstrictor. ASA also decreases the production of prostacyclin, another platelet aggregator [25]. However, the effect of ASA on anastomotic compromise in animal models has been conflicting [26–30]. Heparin binds to anti-thrombin III and inactivates thrombin to inhibit the activation of factors V and VIII. Animal models have demonstrated an increase in anastomotic patency when using intravenous infusion of heparin at the time of surgery or post-operatively [31–33]. Dextran reduces platelet adhesiveness by increasing the electronegativity of erythrocytes, platelets, and vascular endothelium as well as acts as a volume expander. Some studies suggest that platelets play a major role in arterial thrombosis, while others suggest fibrin is more important [26, 27]. Thus, it may be necessary to utilize two anti-thrombotic agents, one to inhibit fibrin strand formation, and the other to prevent platelet adherence [34].

Other options for providing anti-coagulation include encouraging early ambulation and the utilization of pneumatic compression devices. These were unreliably reported in the articles analyzed, and, as many institutions considered these routine, the lack of the mentioning could not be assumed to indicate their absence. However, these metrics of encouraging anti-coagulation have demonstrated efficacy and are without risk of side effects and should be routinely employed.

Large meta-analyses and retrospective chart reviews have been conducted examining thromboprophylaxis in microsurgical reconstruction for all recipient sites. One study analyzed 12 articles and found little evidence to support that thromboprophylaxis reduced thrombosis or flap failure, but it did increase the risk of hematoma, with ASA being the most significant [6]. Another study examined 470 patients undergoing 505 microvascular reconstructions for oncologic defects where patients received either ASA or LMWH. The authors found that post-operative anti-coagulation did not have a significant effect on flap complications [35]. A study reporting on 517 free flap procedures for all recipient sites analyzed outcomes based on type of thromboprophylaxis (none, various doses of heparin and dextran) and found a lower flap loss rate and thrombosis rate in the bolus and low-dose heparin groups compared to no intervention, but it was not statistically significant. There was no increased risk of hematoma or intraoperative bleeding with anti-coagulation [36]. However, these studies rarely break patient and flap complications down by recipient site, making translation to the microsurgical breast patient difficult.

Few studies focusing on microsurgical breast reconstruction comment on the type of thromboprophylaxis utilized. Thus, without an understanding of the type(s) of thromboprophylaxis, it is impossible to determine their effect on patient and flap outcomes. Also, studies that do report on thromboprophylaxis and flap outcomes often analyze all types of breast reconstructions and do not separate results by free or pedicled flaps, even though free flaps have a different complication profile. A study in 2008 reported on the rate of hematomas with and without heparin in free and pedicled TRAM breast reconstruction and demonstrated no increased risk of hematoma but failed to separate results by type of flap except to mention that no hematomas occurred in the fTRAM group [37]. For studies that are amenable to analysis on type of thromboprophylaxis and flap outcomes, the results are variable.

Means of thromboprophylaxis as it relates to complications are rarely the primary end point, and typically, all patients received the same thromboprophylaxis. Thus, while studies in breast microsurgery often reported on the rate of hematoma, there was rarely a comparison or control group, making any subgroup analysis or conclusion impossible [8, 12, 20, 38]. One study found an increased rate of hematoma when dextran was used, leading the authors to stop its utilization [18] and another found an increased rate of hematoma when ASA was used, also leading the authors to stop its utilization [19]. For studies comparing anti-coagulants and the necessity of transfusions, no anti-coagulant was linked with an increased need for transfusion [13, 18]. However, the pre-operative preparation of the patient in ensuring adequate hemoglobin status, the length of surgery, and intra-operative blood less were not addressed in these studies. Thus, it could not be determined if these patients would have had better pre-operative optimizations if they could have bypassed transfusion requirement nor could the role that expected blood loss had on transfusion necessity be assessed. For most studies reporting rate of flap loss, all patients received the same thromboprophylaxis [8, 9, 11, 12, 14, 20, 38]. However, one study was able to demonstrate no difference in rate of flap loss with dextran as part of the thromboprophylaxis regimen [18] and another demonstrated no difference with ASA as part of the thromboprophylaxis regimen [19].

There have been very few studies assessing the rate of VTE in microsurgical breast reconstruction with a focus on the type of

thromboprophylaxis utilized. Some studies merely report that some thromboprophylaxis was given at the surgeon's discretion, typically because these studies are focusing on the rate of flap thrombosis, as opposed to risk of VTE [39]. One study published in 2009 found a high rate of VTE (2.2%) in autologous breast reconstruction, but outcomes were not separated into free or pedicled breast reconstructions [40]. For most microsurgical breast studies examining rate of VTE, all patients received the same thromboprophylaxis [10–12, 21]. Interestingly, a study in 2018 examined risk factors for VTE in microsurgical breast reconstruction and found that patients having VTE were more likely to be Hispanic, more likely to have an increased transfusion volume and more likely to be discharged without ASA [21]. A study published in 2010 sought to determine the rate of asymptomatic DVT in women who underwent microsurgical breast reconstruction with thromboprophylaxis with LMWH, early ambulation, and sequential compression devices. They demonstrated an incidence of asymptomatic lower extremity DVT of 3.4% as documented by duplex ultrasound [12]. Although these DVTs were asymptomatic, it does call into question the role of performing routine duplex scans on microsurgical patients, especially those with delayed ambulation or additional risk factors for DVT formation. One study with the primary end point of determining the role of LMWH in preventing PE found that while there was no difference in symptomatic PE with LMWH, it did reduce the rate of asymptomatic PE, without increasing bleeding complications [13].

When analyzing causation of hematomas and vessel thrombosis in microsurgical patients, the presence of freshly created anastomoses makes root cause analysis difficult. Anastamotic leak can result in a hematoma at the recipient site and inappropriate ligations of vessels at the donor site can similarly result in a hematoma. These hematomas can then lead to vessel compression and thrombosis. While a hematoma that is developing can certainly be propagated when anti-coagulation has been utilized, it is impossible to determine which had the greater effect on the hematoma, the surgical misadventure, or the anti-coagulation. Thus, this is another confounding factor in determining the effect that anti-coagulation has on the rate of hematoma and thrombosis development in this patient population.

In summary, given the significant heterogeneity in study designs, reporting, and patients, a definitive meta-analysis is unable to be performed and definitive recommendations regarding VTE prophylaxis cannot be made. Dextran in our review did demonstrate relatively increased risk of complications compared to other modalities, but this has been accepted and its use limited. The addition of ASA is a common adjunct, but its efficacy and complication profile are not clear based on the above studies and results are conflicting. In the orthopedic literature, there is similar controversy regarding the addition of aspirin and recommendations vary based on anatomic site. LMWH is the most frequently used VTE prophylaxis and has been shown to improve the rates VTE in both the plastic and orthopedic literature. Despite the number of articles published, there is a paucity of articles examining direct anti-thrombin and factor Xa inhibitors in microsurgical breast reconstruction. A Plastic Surgery Foundation (PSF)–funded study in 2012 demonstrated no difference in hematoma rates for breast surgery when LMWH was utilized but did find microsurgical procedures to be an independent risk factor for hematomas requiring reoperation. This study did not evaluate for any other complications including VTE [41]. Overall, there remains significant variability regarding the type, dosage, duration, and timing of administration across all VTE regimens making it impossible to draw consensus guidelines. This highlights the need for prospective, multi-institutional, trials comparing the efficacy and complication profiles of different VTE prophylaxes.

Conclusion

In conclusion, there has yet to be a consensus on the most effective way to prevent VTE in women undergoing microsurgical breast reconstruction without increasing the risk of hematoma and flap compromise. Studies published to date vary in their thromboprophylatic regimens and rarely include a control or comparison group to allow for intra- or intergroup analysis. There is a need for well-done, randomized, controlled trials in order to determine the best approach to thromboprophylaxis in these patients.

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Compliance with ethical standards

Conflict of interest Rebecca Knackstedt, Risal Djohan, and James Gatherwright declare that they have no conflict of interest.

Ethical approval n/a

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