Recommendations from the ICM-VTE: Shoulder & Elbow

The ICM-VTE Shoulder & Elbow Delegates*

Question: 1 - Concerning VTE risk, which surgeries can be considered major, and which surgeries can be considered non-major in shoulder and elbow surgery?

Response/Recommendation: Shoulder arthroscopy, non-fracture related shoulder arthroplasty, and all elbow procedures can be considered non-major venous thromboembolism (VTE) risk. Fracture related shoulder procedures can be considered major VTE risk.

Strength of Recommendation: Limited.

Delegates vote: Agree 93.94% Disagree 6.06% Abstain 0.00% (Strong Consensus)

Rationale: VTE following shoulder and elbow surgery are rare events. One study reported for all upper extremity deep venous thromboses (DVT) to represent 1% to 4% of all DVT[1]. In the shoulder, surgeries can be divided into arthroscopic, non-fracture shoulder arthroplasty, and fracture related surgeries. In the elbow, surgeries can be divided into arthroscopy, fracture related, and arthroplasty. With respect to these surgeries, several studies have reported VTE rates, however, a majority of this information comes from a collection of level 3 and level 4 evidence along with registry studies.

In shoulder arthroscopy, VTE rates are low with reported rates ranging from 0.011% to 0.38%[2-6]. Kuremsky et al., in a retrospective study of 2,872 patients undergoing shoulder arthroscopy reported VTE rate of 0.24%[2]. Jameson et al., in a registry study out of the United Kingdom reported 0.011% VTE rate in a retrospective review of 65,302 shoulder arthroscopy cases[3]. Similarly, Brislin et al., reported VTE rate of 0.38% in a consecutive series of 263 arthroscopic rotator cuff repairs (RCR)[4]. These VTE rates following arthroscopic RCR were similar to rates reported by Hoxie et al., (0.26%)[5]. Additionally, open instability surgeries also comprise higher VTE risk than their arthroscopic counterparts. Goodloe et al., in a registry study compared arthroscopic Bankart repair, open Bankart repair, and Latarjet-Bristow procedure with reported VTE rates of 0.1%, 0.0%, and 0.8%, respectively[7]. Thus, shoulder arthroscopy procedures can be considered non-major concerning VTE risk.

In shoulder arthroplasty, a distinction must be made between non-fracture indications for primary shoulder arthroplasty (glenohumeral arthritis or rotator cuff arthropathy) and arthroplasty for fracture. For non-fracture arthroplasty, VTE rates have ranged from 0.16% to as high as 13%[3,8-11]. Sperling and Cofield in a 20-year respective review of 2,885 shoulder arthroplasties reported 0.17% VTE rate[12]. In a UK registry study, Jameson et al., reported VTE rate of 0.16% for 10,229 shoulder arthroplasties[3]. Other registry studies have reported similar rates with Lyman et al., reporting 0.68% VTE rate (69 DVT, 32 PE) in 13,759 shoulder arthroplasties[9], Lovy et al., also reported 0.35% VTE rate (20 VTE) in 5,801 total shoulder arthroplasty (TSA)[11], and Young et al., reported a pulmonary embolism (PE) rate of 0.25% in 422,372 TSA[8]. Furthermore, Kirsch et al., in a retrospective review of 2,141 primary arthroplasty patients receiving aspirin 81 mg as chemoprophylaxis report a VTE rate of 0.56%[10]. Willis et al., in an observational trial of 100 consecutive patients reported VTE rate of 13%, however, all patients were screened irrespective of symptoms[13]. These findings suggest that reported VTE rates may be underrepresented. Tashjian et al., present higher symptomatic VTE rates of 2.6% (14/533) (5 DVT and 12 PE) in single institution retrospective review[14]. Primary shoulder arthroplasty for non-fracture indications can be considered non-major concerning symptomatic VTE risk.

For proximal humerus fracture related surgery, VTE rates can be delineated between open reduction internal fixation (ORIF) and arthroplasty. In fracture related arthroplasty, reported VTE rates are higher than non-fracture related arthroplasty with reported rates ranging from 0.51% to as high as 5.1%[3,15,16]. Jameson et al., reported 0.51% VTE rate in 4,696 hemiarthroplasties performed for fracture[3]. Farng et al., in a retrospective California registry study of 10,244 primary shoulder arthroplasties reported 1.0% VTE rate in fracture arthroplasty in comparison to 0.4% for non-fracture arthroplasty[15]. Furthermore, Navarro et al., demonstrated trends towards higher VTE rates for traumatic indications in comparison to elective surgery regardless of procedure type (1.71% vs. 0.80%, p=0.055)[17]. Hoxie et al., reported PE rate of 5.1% (7/137) in consecutive series of

*A list of the ICM-VTE Shoulder & Elbow Delegates is included in a note at the end of the article.

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137 arthroplasty for fracture[16]. For proximal humerus ORIF, Nayar et al., in another registry study reported VTE rate of 3.0% and also reported a 0.36% VTE for fractures around distal humerus/ elbow[18]. Thus, proximal humerus fracture surgery can be considered major concerning VTE risk.

For elbow surgery, the limited literature with respect to VTE risk. Intravia et al., in a retrospective review of 560 consecutive elbow arthroscopies reports no incidence of VTE[19]. For elbow arthroplasty, Duncan et al., report a 0.28% PE rate in a retrospective review of 816 consecutive total elbow arthroplasties (TEA) and 260 revision elbow arthroplasty cases over 20-year period[20]. Similarly, Krenek et al., in a California registry study of 1,625 patients undergoing TEA report a 0.25% PE rate[21]. Thus, elbow procedures can be considered non-major concerning VTE risk.

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Question: 2 - Does immobilization of the upper extremity influence the VTE prophylaxis protocol?

Response/Recommendation: No studies have directly answered the question of whether immobilization of the upper extremity influences the venous thromboembolism (VTE) prophylaxis protocol. There is insufficient evidence to support any alteration in VTE prophylaxis protocol based on need for immobilization of the upper extremity.

Strength of Recommendation: Limited.

Delegates vote: Agree 100.00% Disagree 0.00% Abstain 0.00% (Strong Consensus)

Rationale: The Guidelines in Emergency Medicine Network (GEMNet) posed a similar question in 2013, asking "*in patients with isolated upper extremity injury, does the use of temporary immobilization via plaster cast/sling increase the risk of subsequent venous thromboembolic events during short-term follow-up?*"[22]. Only four papers met their inclusion criteria[23-26], of which three were retrospective cohort studies and one was a case-control study. All four studies were small and none were designed to directly test the association between temporary upper extremity immobilization and VTE or associated prophylaxis protocols. They determined from this limited evidence that there was no evidence to suggest a significant risk of VTE in ambulatory patients with temporary upper extremity immobilization.

In the United Kingdom, the 2018 the National Institute for Health and Care Excellence (NICE) guidelines for reducing the risk of hospital-acquired VTE makes two recommendations. First, that VTE prophylaxis is generally not required if upper limb surgery is taking place under local or regional anaesthesia; and second, that VTE prophylaxis should be considered if the duration of upper limb surgery under general anaesthesia will exceed 90 minutes or if the operation will make it more difficult for the patient to mobilize afterwards[27,28]. Again, the recommendation does not include immobilization of the upper limb as a factor in the decision-making process.

A 2013 consensus statement from Italy provided limited recommendations for VTE prophylaxis in patients undergoing upper limb surgery. They recognized that VTE is a rare complication of upper extremity surgery and non-joint replacement surgery of the shoulder but recommended pharmacological prophylaxis with low-molecular-weight heparin (LMWH) in patients undergoing shoulder joint replacement surgery. They also suggested pharmacological prophylaxis with LMWH should be considered in non-prosthetic surgery patients who have risk factors for VTE for a minimum of seven days and prolonged if a patient will be confined to bed for an extended period. Similar

recommendations were made for shoulder arthroscopy. In circumstances of upper limb fracture, VTE prophylaxis was recommended only in circumstances of bed confinement, poorly mobile patients with VTE risk factors, and crush injuries – with prophylaxis for 30 days or until mobility out of bed is restored. For elbow and wrist arthroscopy, VTE prophylaxis was not advised, but they recognized that this is an area that has not been studied[29].

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Question: 3 - Is there a risk stratification method for VTE of the upper extremity?

Response/Recommendation: No universal risk stratification for venous thromboembolism (VTE) exists with respect to the upper extremity except during hand, wrist, and elbow orthopaedic surgery. It is deemed appropriate that personal and procedural-based risk factors should be considered for all patients. Those upper limb operations under local or regional anesthetic without heavy sedation are at very low-risk for VTE and therefore detailed risk assessment is not indicated.

Strength of Recommendation: Limited.

Delegates vote: Agree 100.00% Disagree 0.00% Abstain 0.00% (Strong Consensus)

Rationale: There are no risk assessment tools for stratifying the requirement for thromboprophylaxis prior to upper limb surgery even for shoulder procedures[30]. Guidelines have been formulated for higher risk procedures in the lower limb, e.g., hip, and knee arthroplasty, but given the lower risk in the upper limb (even considering shoulder arthroplasty) these guidelines are not directly transferrable. Generalized rather than specific risk stratification tools have been created to help guide whether a patient is at higher risk of deep venous thrombosis (DVT), but there is a paucity of evidence to support these risks when considering upper limb surgery, in particular the risk of developing upper extremity VTE[31-34].

Evidence with respect to upper limb surgery postulates that obesity is correlated with an increased risk of VTE following total elbow arthroplasty[35]. American Society of Anesthesiologist (ASA) score 3-4, hypoalbuminemia and dehydration are associated with a risk of VTE after humeral fracture fixation in elderly patients. Furthermore, hypoalbuminemia is also associated with an increased risk of VTE following shoulder arthroplasty, as is inflammatory arthritis, diabetes and ischemic heart disease[36,37]. Risk stratification tools should therefore incorporate those factors which have shown to increase the risk of developing VTE.

Risk stratification is therefore dependent on both patient and procedural-based factors. National guidelines in certain countries have been formulated to identify patients at higher risk of developing VTE. The British Society for the Surgery of the Hand (BSSH) have created a detailed set of guidelines based on risk stratification tools from across the globe and from the evidence of VTE following hand, wrist and elbow surgery in the literature[38]. As there have been no reported cases of VTE following wide-awake local or regional anaesthetic, thromboprophylaxis is deemed not to be indicated[31]. Therefore, assessment tools to stratify risk can be tailored accordingly.

There are no such guidelines following proximal humeral or shoulder procedures, despite numerous studies documenting the VTE risk and identifying the need for guidance for VTE prophylaxis[39,40]. Several studies have proposed that all patients should receive mechanical prophylaxis after shoulder surgery, with chemical prophylaxis reserved for those at high-risk for VTE[36,39]. To determine the level of risk, however, requires a risk stratification tool tailored for the use in the shoulder surgery, which has not been currently formulated.

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Question: 4 - Should routine VTE prophylaxis be administered to patients undergoing upper extremity immobilization, such as casting?

Response/Recommendation: While there are no official guidelines recommending routine venous thromboembolism (VTE) prophylaxis for patients undergoing upper extremity immobilization, the risk of upper extremity VTE is still present. Given that VTE prophylaxis for high-risk patients undergoing various lower limb or spinal orthopaedic procedures is recommended, VTE prophylaxis in high-risk patients undergoing upper extremity immobilization may be beneficial. However, evidence is inconclusive and further research must be done.

Strength of Recommendation: Limited.

Delegates vote: Agree 90.91% Disagree 9.09% Abstain 0.00% (Strong Consensus)

Rationale: At this point in time there are no official guidelines recommending routine VTE prophylaxis for patients undergoing upper extremity immobilization. This immobilization can include a cast, splint, or other orthopaedic intervention for stability. VTE involves the formation of a blood clot within the venous system, often in the deep veins of the leg or pelvis[41,42]. Other terminology associated with a VTE may include a deep venous thrombosis (DVT) or pulmonary embolism (PE), with both being potentially dangerous complications resulting in elevated mortality. Risk factors for VTE include major surgery, trauma, malignancy, and immobilization[43,44]. Although less common than in the lower extremity, an estimated 1% to 4% of VTE involve the upper extremity[45]. Multiple case reports from orthopaedic literature discuss this potential for upper extremity VTE following orthopaedic injury[46-48]. Further morbidity or mortality may arise from these upper extremity VTE with 9% to 14% of these VTE progressing to a PE[49]. Therefore, it is important to recognize high-risk patients for upper extremity VTE and provide appropriate prophylaxis. "High-risk" patients include an elevated age, or presence of comorbidities including hypertension treated with medication, and wound infection as these have been shown to increase the risk of DVT[50].

Despite the lack of evidence surrounding upper extremity VTE prophylaxis, there have been multiple studies focused on VTE prophylaxis in other orthopaedic procedures. These include hip and knee arthroplasty, as well as spinal surgery. The American Academy of Surgeons (AAOS) and the American College of Chest Physicians (ACCP) have created guidelines specifically covering prophylaxis following hip and knee arthroplasty[51-53]. Between these guidelines, there is no conclusive universal recommendation for which specific chemoprophylaxis to provide, the timeline of administration, and the scenarios for which chemoprophylaxis should be withheld. For example, patients undergoing knee arthroscopy with minimal risk factors are recommended to have no chemoprophylaxis. Alternative measures include early mobilization/ambulation, mechanical compression, transcutaneous nerve stimulation, and adequate hydration[54-56]. European guidelines demonstrating that hydration and early ambulation are especially promising for low-risk patients undergoing day surgeries[57].

For specific instances of upper extremity VTE in patients with immobilization in a cast or splint as a risk factor, a case-control study highlighted a patient cohort of 10 individuals with plaster immobilization. Three out of ten patients demonstrated upper extremity VTE within 3-months of immobilization [odds ratio [OR] 7.6 (2.0-29.9)][58]. Another case report demonstrated upper extremity VTE in a patient with distal humeral shaft fracture treated with a coaptation splint[59]. Four days post immobilization, the patient presented with increasing forearm pain and swelling. Ultrasound later confirmed the presence of a right brachial vein thrombus. This patient was not on any prophylaxis at the time, requiring a brief hospitalization and home-discharge on warfarin. It is important to note that inherent in these case reports is the individual variability seen when placing different types of immobilizations. This adds further uncertainty to guidelines when assessing the need for VTE prophylaxis. The 2018 published guidelines by the National Institute for Health and Care Excellence (NICE) stated that for upper limb orthopaedic surgery: 1) VTE prophylaxis is generally not needed if giving local or regional anesthetic for upper limb surgery. 2) VTE prophylaxis may be considered for people undergoing upper limb surgery if the person's total time under general anesthesia is over 90 minutes or the operation will likely make the patient more difficult to mobilize themselves[60].

Considering the known risk factor of immobilization with the development of VTE, the case reports found in orthopaedic literature, and the 2018 guidelines published by NICE, it is appropriate to recognize the possible need for VTE prophylaxis for upper extremity immobilization, especially in patients with predisposing comorbidities or other risk factors. Further research will need to be conducted to assess whether the type and duration of immobilization impacts the risk of VTE as well as which form of prophylaxis is best standard of care for each situation.

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Question: 5 - Is there a role for administration of aspirin as a VTE prophylaxis in patients undergoing upper limb surgery?

Response/Recommendation: There is insufficient evidence to support or recommend against using aspirin as venous thromboembolism (VTE) prophylaxis in upper extremity surgery. It may be most beneficial for high-risk patients undergoing more complex reconstructive surgery.

Strength of the Recommendation: Limited.

Delegates vote: Agree 93.94% Disagree 6.06% Abstain 0.00% (Strong Consensus)

Rationale: There is a paucity of literature regarding venous thromboembolic (VTE) prophylaxis in upper limb surgery[61,62]. In general, the risk of VTE following upper limb surgical procedures is considered low[62-65].

Most of the clinical guidelines do not recommended or mention VTE prophylaxis following upper limb procedures the American Academy of Orthopaedic Surgeons (AAOS), the American College of Chest Physicians (ACCP), the European Society of Anaesthesia (ESA)[61,62,66]. Nonetheless, The National Institute for Health and Care Excellence (NICE) and the British Society for Surgery of the Hand (BSSH) have described a set of risk factors and prophylaxis indications for VTE following upper extremity surgery[67,68]. There are recommendations that only longer duration surgeries (more than 90 minutes of general anesthesia) of the upper should be considered for chemical thromboprophylaxis when associated with another personal intrinsic risk factor[67,68].

There are few studies directly investigating aspirin (ASA) as a VTE chemoprophylactic agent after upper limb surgery. Most studies analyzing upper limb postoperative VTE prophylaxis are retrospective series with no uniform pattern of prophylaxis. Regarding rotator cuff repair, the only direct comparative study between aspirin 81 mg/daily vs. no chemoprophylaxis is a retrospective case-control study carried out on 914 patients[69]. Both groups received mechanical prophylaxis. Low rates of symptomatic VTE were found, with no differences between the ASA (0.93%) and non-ASA groups (0.66%). For shoulder arthroplasty, Kirsch et al., reported a rate of 0.63% for symptomatic VTE after 2,394 primary shoulder arthroplasties treated with 81 mg ASA daily for 6 weeks postoperatively[70]. One large series of upper limb procedures, with nearly 50% of patients without prophylaxis, found a similar rate of symptomatic VTE of 0.53%[71]. For proximal humeral fractures, one study on 163 patients treated for proximal humerus fracture without chemical prophylaxis (only mechanical prophylaxis) found a rate of symptomatic VTE of 3.3%[72].

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Question: 6 - Should routine VTE prophylaxis be administered to patients undergoing upper extremity osteosynthesis?

Response/Recommendation: Routine venous thromboembolism (VTE) prophylaxis in patients undergoing upper extremity osteosynthesis under local or regional anesthesia is not needed. VTE prophylaxis should be considered in patients at high risk of VTE and those undergoing surgery under general anesthesia that lasts over 90 minutes.

Strength of recommendation: Limited.

Delegates vote: Agree 100.00% Disagree 0.00% Abstain 0.00% (Strong Consensus)

Rationales: Upper-extremity deep vein thrombosis (UEDVT) has a very low overall incidence of 0.4 to 1 in 10,000 persons[73-76]. Upper extremity thrombosis is divided into primary (20%) and secondary (80%) causes. Among these, idiopathic thrombosis, effort-related thrombosis (Paget-Schroetter syndrome), or venous thoracic-outlet syndrome due to compression of the subclavian vein resulting from abnormalities of one or more structures at the costoclavicular junction represents the cause of primary thrombosis. The more common secondary thrombosis of the upper extremity results from catheter- or pacemaker-associated thrombosis, cancer-associated thrombosis, hormone-induced coagulation abnormalities, and surgery or trauma to the upper extremity[74,77]. Pulmonary embolism (PE), post-thrombotic syndrome, and thrombosis recurrence have been described as serious complications associated with UEDVT[74,77,78]. However, UEDVT has a significantly lower risk of PE compared to lower extremity venous thrombosis[78-81]. UEDVT occur more frequently in association with central catheters and in association with malignancies and are less associated with immobilization[75,76,81]. Very few studies report the incidence of deep venous thrombosis due to upper extremity osteosynthesis. In a report by Levy et al., among 300 patients with UEDVT, 31% of patients had developed thrombosis of upper extremity as a result of surgery or trauma[79]. In another study comprising of 3,357 patients undergoing upper extremity orthopedic procedures, only six patients (0.0018%) developed postoperative VTE, and five out of six patients had a strong history of prior VTE[82]. Calotta et al., analyzing registry 24,494 patients in a registry database reported an incidence of 0.3% of upper extremity DVT in patients undergoing open reduction and internal fixation of distal radius fractures[83]. The risk factors identified for upper extremity deep venous thrombosis (DVT) in the latter study were history of congestive heart failure and use of estrogen[83]. In another study by Mino et al., on 1,857 patients undergoing general surgery, the incidence of postoperative thrombosis of the upper extremity was 1.13%, with all, but one, patient developing the DVT in association with central catheter[84]. In contrast, Blom et al., reporting on an association between upper extremity surgery and UEDVT in two patients in a sub cohort of 179 patients out of the MEGA study selected due to UEDVT, resulting in the odds ratio of 11.8 compared to control cohort of 2398 patients, in which three patients underwent upper extremity surgery within three months before index date[85,86]. In addition, Hoxie et al., reported an occurrence of pulmonary embolism in 5.6% of surgically treated patients with a proximal humerus fracture (4 hemiarthroplasty, 3 open reduction internal fixation [ORIF])[87]. In contrast, Widmer et al., found no thromboembolic events in 50 patients, receiving VTE prophylaxis, after proximal humerus fracture[88]. In addition to the aforementioned studies, there are sporadic case reports of the occurrence of UEDVT and PE and upper extremity fracture or osteosynthesis[89-95]. Two reviews around the topic of the need for thromboprophylaxis of upper limb surgery were identified. The article by Roberts and Warwick summarizes the literature and guidelines regarding prophylaxis for thrombosis in hand, wrist, and elbow surgery[96,97]. They recommend risk assessment for DVT in patients with prolonged elbow or forearm surgery and found that history of active cancer or cancer treatment, age over 60 years, admission to intensive care unit, dehydration, history of VTE, obesity, history of one or more significant medical co-morbidities, family history of VTE, use of hormone replacement therapy or estrogen-containing contraceptives, varicose veins with phlebitis to be predisposing factors for upper extremity VTE. The authors recommended that VTE prophylaxis be considered for patients at high-risk population and patients undergoing upper extremity osteosynthesis under local or regional anesthesia were considered to be at low-risk[96,97]. The other review article by Anakwe et al., also discussed the topic thromboprophylaxis in patients undergoing elective upper extremity osteosynthesis[98]. They also recommended an approach that involved risk assessment and administration of chemoprophylaxis for high-risk patients and mechanical prophylaxis for others, unless contraindicated[98]. Evidence on which form of mechanical or chemical thromboprophylaxis should be chosen in case of upper limb osteosynthesis does not exist. However, some organizational guidelines have been proposed. The National Institute for Health and Care Excellence (NICE) Guidelines has produced guidelines that are stated below[99]:

- 1.11.15 Be aware that VTE prophylaxis is generally not needed if giving local or regional anaesthetic for upper limb surgery. [2018].
- 1.11.16 Consider VTE prophylaxis for people undergoing upper limb surgery if the person's total time under general anaesthetic is over 90 minutes or where their operation is likely to make it difficult for them to mobilize. [2018].

The British society for Surgery of the Hand (BSSH) has also proposed guidelines that are stated below (Table I)[100]:

The evidence for the use of thromboprophylaxis in upper extremity osteosynthesis is limited. There is scarce but consistent evidence that VTE prophylaxis in patients undergoing

TABLE I BSSH recommendations for prophylaxis in hand, wrist, and elbow surgery

Risk	Example	Recommendation
Low	LA, regional anaesthesia or <90 minutes GA	No prophylaxis
Moderate	>90 minutes GA (including elbow arthroplasty) and/or 1 risk factor	Mechanical prophylaxis until mobile
High	>90 minutes GA and >1 risk factor, prolonged post-operative immobility, or tumour surgery	Mechanical prophylaxis and consider pharmacological prophylaxis until mobile

upper extremity osteosynthesis under local or regional anesthesia is not necessary. Instead, chemoprophylaxis should be reserved for patients undergoing upper extremity osteosynthesis under long general anesthesia (> 90 minutes), those at high-risk VTE (as discussed above), and patients who are likely to have difficulty with mobilization. The potential benefits of chemoprophylaxis should always be weighed against the bleeding risk.

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Question: 7 - Should routine chemical VTE prophylaxis be administered to patients undergoing shoulder arthroplasty?

Response/Recommendation: Given the minimally increased risk of clinically significant thromboembolic events following shoulder arthroplasty, it is unlikely that the benefits of chemical deep venous thrombosis (DVT) prophylaxis outweigh the risks. There is insufficient evidence to support or recommend against using aspirin (ASA) as venous thromboembolism (VTE) prophylaxis in upper extremity surgery. The bleeding risks associated with low-molecular-weight heparin (LMWH) and direct oral anticoagulants (DOAC) outweigh the benefits in patients without substantial risk factors for VTE.

Strength of Recommendation: Limited.

Delegates vote: Agree 96.97% Disagree 3.03% Abstain 0.00% (Strong Consensus)

Rationale: While extensive studies have allowed for the recommendation that chemical DVT prophylaxis be used following lower extremity arthroplasty, lack of data has precluded such recommendations from being made for shoulder arthroplasty[101-106].

Available literature reports wide variability in the incidence of VTE events following shoulder arthroplasty, with estimates ranging from 0.2%-16%[101-116]. However, these studies

varied significantly in how VTE events were identified. Patients in some studies underwent routine surveillance with DVT ultrasound or computer tomography (CT) scans throughout their postoperative course and all positive findings were included as VTE events. Other studies were retrospective reviews which only included clinically significant VTE events[101-116]. Unsurprisingly, the incidence estimates in studies that only considered clinically significant VTE events were much closer to the lower end of that range, with most reporting an incidence of <1% and one study reporting a weighted average of 0.68%[101]. A recent meta-analysis of 19 studies reported a pooled 3-month incidence of 0.85%[107]. It should also be considered that the underlying rate of VTE events in the general population (i.e., those not necessarily undergoing procedures) has been reported at 0.5%[102].

Our recommendation is limited due to the lack of randomized control trials (RCT) addressing this question[103]. Studies have shown very low rates of clinically significant VTE events following shoulder arthroplasty in patients who take ASA or other VTE prophylaxis postoperatively[101-115]. The rate also appears to be low even in patients who underwent shoulder arthroplasty and had no chemical DVT prophylaxis postoperatively[108]. Given that no RCT have been completed on the topic, one might best follow the recommendation that an overall VTE risk of over 3% is required to outweigh the bleeding risk from pharmacological prophylaxis using LMWH[5]. Major bleeding has been postulated to occur in 2.5 per 1,000 patients prescribed LMWH, with an even higher risk of minor bleeding. Other complications reported to be associated with DVT prophylaxis include heparin-induced thrombocytopenia, skin reactions, thrombocytosis, electrolyte imbalances such as hyperkalemia and osteoporosis[105].

When deciding to prescribe anticoagulation following shoulder arthroplasty, several patient specific factors must be considered which have been shown to alter the incidence of VTE and include older age and principal diagnosis of fracture, history of VTE, cardiac arrhythmia, presence of a metastatic tumor, coagulopathy, congestive heart failure, anemia, urinary tract infection, sleep apnea, fluid & electrolyte balance, alcohol abuse, and obesity[102,104-113]. Furthermore, outpatient shoulder arthroplasty has been shown to be associated with reduced risk of VTE[107]. Importantly, statistically similar rates of VTE events have been shown between hemiarthroplasty, reverse total shoulder arthroplasty (RTSA), and anatomic total shoulder arthroplasty (TSA) in some studies while others have shown a trend toward lower rates for anatomic TSA indicating another area where further research is warranted[107,108].

As the clinical decision to initiate VTE prophylaxis is a complex process, until RCT have been undertaken better delineate the risk/benefit profile of VTE prophylaxis in the setting of shoulder arthroplasty, decision making should be individualized and tailored to each patient's preference and risk factors.

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Question: 8 - Should routine VTE prophylaxis be administered to patients undergoing rotator cuff repair?

Response/Recommendation: The incidence of venous thromboembolism (VTE) after arthroscopic rotator cuff repair (RCR) is very low. Although the current literature has identified several risk factors for VTE after arthroscopic RCR, there is limited evidence supporting the efficacy of routine VTE prophylaxis postoperatively. In the absence of any literature to guide a recommendation, it is our consensus opinion that patients undergoing RCR should have intraoperative mechanical compression and early mobilization. Patients should also be risk-stratified and if considered high-risk due to other medical conditions, consideration should be given to add VTE chemoprophylaxis.

Strength of Recommendation: Limited.

Delegates vote: Agree 96.97% Disagree 0.00% Abstain 3.03% (Strong Consensus)

Rationale: The incidence of VTE following arthroscopic shoulder surgery and RCR has been reported in several studies to be exceeding low, well below 1% in all but one study, but likely

elevated compared to the general non-surgical population[117-122]. Although individual studies report differing findings likely due to the low incidence of VTE[122], several risk factors for VTE after RCR have been established, including diabetes mellitus, heart disease, rheumatoid arthritis and high altitude[120,123].

One retrospective study evaluated 39,825 RCR, including 31,615 performed arthroscopically, and reported an overall VTE rate of 0.3% that occurred at a mean of 11.5 days postoperatively[124]. The authors identified the following risk factors for postoperative VTE: male sex, body mass index > 30 kg/m^2, American Society of Anesthesiologists score III or IV, duration of surgery > 80 minutes, bleeding disorder and dyspnea. While the authors did not specifically evaluate prophylaxis strategies, the risk factors identified could be used to identify higher risk patients that could be considered for more aggressive prophylaxis. Alyea, et al., published a retrospective case-control study of 914 patients who underwent arthroscopic RCR, of which 484 had intraoperative compression boots and early mobilization and 430 had the same measures with the addition of 81 mg/day aspirin[125]. The overall VTE rates were very low, and there were no differences in VTE rates between groups, leading the authors to conclude that the use of intraoperative mechanical prophylaxis and early mobilization is a sufficient method of VTE prophylaxis after arthroscopic RCR for most patients.

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Question: 9 - Should routine VTE prophylaxis be administered to patients undergoing arthroscopic stabilization procedures of the shoulder?

Response/Recommendation: Currently, there is no data to suggest that routine thromboprophylaxis should be performed in patients undergoing arthroscopic shoulder stabilization in normative risk patients. Given the low risk of complications, intermittent pneumatic compression (IPC) devices should be used. Venous thromboembolism (VTE) pharmacological prophylaxis may be considered in patients undergoing stabilization surgery with the Latarjet/Bristow procedure.

Strength of Recommendation: Consensus.

Delegates vote: Agree 87.88% Disagree 9.09% Abstain 3.03% (Strong Consensus)

Rationale: Symptomatic VTE rates are higher after shoulder arthroplasty (0.24%-2.60%) than after shoulder arthroscopy (0.01%-0.38%)[126-128]. The range of VTE incidence is heavily affected by differences in surgical procedures, as operation severity and length have been associated with VTE development in shoulder arthroscopy[129-132]. Some shoulder stabilization procedures are longer and involve significantly more tissue repair, potentially leading to higher risk of developing a post-operative VTE[133]. The Latarjet-Bristow procedure (132 minutes) specifically lasts longer than other shoulder stabilization procedures such as open and arthroscopic Bankart repair (91 and 82 minutes, respectively)[129].

Two large cohort studies agree that Latarjet-Bristow patients are much more likely to develop VTE than Bankart patients (Table II). Bokshan et al.[129], compared 30-day complication rates in 2,864 patients who underwent arthroscopic Bankart, open Bankart, or Latarjet-Bristow procedures between 2005-2014 from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). Within 30 days post-operatively 3 (1.8%) Latarjet-Bristow patients had a deep venous thrombosis (DVT), while 2 (0.1%) arthroscopic Bankart repair patients had a DVT, 1 (0.04%) arthroscopic Bankart repair patient had a pulmonary embolism (PE), and no open Bankart repair patients had a VTE. Goodloe et al.[130], also utilized the ACS NSQIP database to evaluate 30-day complications rates among these three surgical procedures, with a larger cohort of 7,233 patients (471 Latarjet-Bristow, 798 open Bankart repair, 5,964 arthroscopic Bankart repair). Latarjet-Bristow patients had a low rate of developing DVT (0.8%) in this study, though still significantly higher than arthroscopic Bankart (0.1%) and open Bankart repair (0%). A multivariate analysis found that patients who undergo Latarjet surgery are 7.8 (95% confidence interval [CI]: 2.2-27.7) times more likely to develop a VTE than patients undergoing Bankart surgery.

Despite the increased incidence of VTE after Latarjet surgery, no studies were identified that evaluate VTE prophylaxis after shoulder stabilization procedures. Therefore, the closest recommendations for shoulder stabilization are those for shoulder arthroscopy as a whole. Takahashi et al.[134], reported the DVT preventive measures utilized in their prospective study cohort. Where 99% of the shoulder arthroscopy cases featured IPC devices for the lower extremities, with the remaining 1% using elastic stocking for the lower extremity and no patients receiving low-molecular-weight heparin

TABLE II Details about the nine included studies with results specific to VTE and the JBI critical appraisal tools scores

Study	Study design (LOE)	Purpose	Surgical Procedure	Sample size	VTE-specific results	JBI Quality Score
Bokshan et al.[129], 2017.	cohort study (3)	Compare incidence of complications between arthroscopic Bankart, open Bankart, and Latarjet-Bristow.	410 open Bankart, 163 Latarjet-Bristow, 2291 arthroscopic Bankart	2,864	3 DVT for Latarjet (1.8%), no DVT for open Bankart, and 2 DVT (0.1%) and 1 PE (0.04%) for arthroscopic Bankart.	8.5
Goodloe et al.[130], 2021.	Cohort study (3)	Compare incidence of complications between arthroscopic Bankart, open Bankart, and Latarjet-Bristow, and identify risk factors for VTE.	5964 arthroscopic Bankart, 798 open Bankart, 471 Latarjet	7,233	DVT: 0.1% rate for arthroscopic Bankart, none for open Bankart, 0.8% for Latarjet ($p<0.001$). PE: 0.1% for arthroscopic Bankart, none of open Bankart, 0.2% for Latarjet ($p=0.280$). Multivariate analysis shows Latarjet surgery increases odds of DVT by 7.84 relative to arthroscopic Bankart ($p=0.001$).	8.5
Shields et al.[131], 2014.	Cohort study (3)	To stratify risk of post-op morbidity and determine risk factors.	Stabilization	114	No DVT for 114 stabilization patients.	8.5
Takahashi et al.[134], 2014.	Prospective cohort study (1)	Determine incidence of VTE after elective shoulder arthroscopy.	Bankart repair	17 anterior instability patients	1 out of 17 Bankart repair patients had a DVT. Table 3 - a 66-years old male with hypertension had an asymptomatic DVT 2 days post-op in contralateral soleus.	9
Randelli et al.[135], 2010.	Surgeon survey with case series (3)	Determine rate of infection and DVT in shoulder arthroscopy, and association with prophylaxis.	Stabilization	9,385 shoulder arthroscopy patients. Unclear how many are stabilization.	Of 6 total DVT, only one was in a stabilization patient.	7
Kuremsky et al.[137], 2011.	case series (4)	Review a series of patients who experienced thromboembolic events after shoulder arthroscopy.	Case 3 – Rotator cuff repair, biceps tenodesis, and pancapsular plication with multidirectional instability. Case 5 - Arthroscopic surgery with capsular repair for anterior instability.	1,908 shoulder arthroscopy patients. Unclear how many stabilizations.	Case 3 - She was diagnosed with a DVT in the subclavian and axillary veins and prescribed warfarin. While still taking this drug, she had a second clot diagnosed on ultrasound in her jugular vein, 4 months after surgery. Workup showed a protein C deficiency. Her shoulder underwent a slow and incomplete recovery due to pain and an inconsistent rehabilitation, in part complicated by these concurrent medical issues. Case 5 - Four weeks after surgery, an ipsilateral subclavian vein DVT and PE developed. He was treated with warfarin and eventually had an uneventful recovery with respect to his shoulder. Workup for a hypercoagulable state was negative.	9

continued

TABLE II (*continued*)

Study	Study design (LOE)	Purpose	Surgical Procedure	Sample size	VTE-specific results	JBI Quality Score
Hariri et al.[138], 2009.	case report (5)	Report a case of pulmonary embolism after posterior capsuloplasty.	Posterior capsuloplasty	1 posterior instability patient	On post-operative day 10, a chest X-ray demonstrated left pleural effusion and a left triangular opacity compatible with the diagnosis of PE. This diagnosis was confirmed with an angiography scan showing bilateral multifocal PE.	5
Burkhart[139], 1990.	case report (5)	Report a case of DVT after anterior shoulder stabilization.	Stabilization	1 anterior instability patient	On post-operative day 3, a complete thrombosis of the basilic vein and the innominate vein was identified. The DVT was treated initially with heparin, then with 3 months of warfarin. After discontinuing the warfarin, he had a recurrence of the thrombophlebitis, which necessitated reinstitution of anticoagulation. The swelling and tenderness have resolved, but the patient remains on a regimen of warfarin at 19 months postoperatively. Patient was discovered to have Hodgkin's disease (stage 1A).	7
Watanabe et al.[140], 2019.	case report (5)	Report a case of DVT and subsequent PE after labrum repair.	Labrum repair	1 anterior instability patient	On post-operative day 6, the patient developed tachycardia and oxygen desaturation with elevated serum D-Dimer. Enhanced CT demonstrated thrombi obstructing bilateral pulmonary arteries as well as the subclavian through basilar vein of the affected arm. A diagnosis of PE caused by upper extremity DVT was reached. Treatment started with oxygen therapy and intravenous heparin administration, which later was replaced by oral anticoagulant. The patient's symptoms improve seven days after the start of anticoagulation therapy. Anticoagulant was continued for an additional 3 months to obtain further improvement.	8

JBI Quality Scores range from 0-11 for cohort studies, 0-10 for case series, and 0-8 for case reports. VTE=Venous thromboembolism; JBI=Joanna-Briggs Institute; LOE=level of evidence, DVT=Deep venous thrombosis, PE=Pulmonary embolism; CT=Computer tomography.

(LMWH) or aspirin. Randelli et al.[135], showed that pharmacological thromboprophylaxis is not utilized for the majority of arthroscopic shoulder surgery patients, with only 2,410 out of 9,385 (25.7%) patients being provided thromboprophylaxis.

Despite these limitations, surgeons should be aware that Latarjet surgery patients are at an increased risk for developing a VTE compared to open or arthroscopic Bankart surgery patients. Clinicians should consider providing VTE prophylaxis for Latarjet surgery patients who meet other risk factors for VTE. Risk factors for VTE include advanced age, major surgery, history of thromboembolic events, and clotting disorders, as defined by Caprini et al.[136]. It should be noted that the majority of patients included in these analyses who underwent Latarjet/Bristow, did so with an open technique, and may not fit into a cohort of arthroscopically treated patients.

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Question: 10 - Should routine VTE prophylaxis be administered to patients undergoing elbow arthroplasty?

Response/Recommendation: There is no appropriate data to guide a strong evidence-based recommendation regarding the need for venous thromboembolism (VTE) prophylaxis for patients undergoing elbow arthroplasty (EA). At minimum, intermittent pneumatic compression (IPC) and early post-operative ambulation are low risk interventions that should be employed.

Strength of Recommendation: Consensus.

Delegates vote: Agree 90.91% Disagree 6.06% Abstain 3.03% (Strong Consensus)

Rationale: Four studies reported on cases of VTE following EA[141-144]. One systematic review, published in 2021 assessed whether VTE prophylaxis is beneficial in upper limb major joint replacement surgery[145]. The weighted mean VTE incidence in EA across the four included articles was 0.49% (range from 0.2% to 0.8%). The total number of VTE events was 34, comprising of 7 pulmonary embolism (PE), 25 deep venous thrombosis (DVT) and the remaining 2 episodes unspecified. Mortality secondary to VTE was reported in one article, which described one death occurring from three cases of VTE[141]. No other complications were reported. VTE risk factors were not identified in any of the four included studies. VTE prophylaxis techniques were reported by one study, which described IPC and early post-operative ambulation, without the use of pharmacological prophylaxis[141]. The effects of VTE prophylaxis on overall risk reduction or complication rates have not been reported and no direct comparisons have been made between patients undergoing joint replacement with or without prophylaxis.

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Question: 11 - Should routine VTE prophylaxis be administered to patients undergoing ligament reconstruction around the elbow?

Response/Recommendation: In the absence of any literature to guide a recommendation, it is our consensus opinion that patients undergoing ligament reconstruction for elbow instability should have intraoperative mechanical compression and early mobilization. Patients should also be risk-stratified and, if considered high-risk due to other medical conditions, consideration should be given to adding venous thromboembolism (VTE) chemoprophylaxis.

Strength of Recommendation: Consensus.

Delegates vote: Agree 93.94% Disagree 6.06% Abstain 0.00% (Strong Consensus)

Rationale: Controversies remain whether or not the patients undergoing ligament reconstruction surgery for elbow instability[146-148] should be routinely administered VTE prophylaxis.

A recent comprehensive literature review about all upper limb orthopaedic surgery suggests a VTE rate as low as 0.26% to 0.64%[149]. Nevertheless, the incidence of VTE risk has not been defined in ligament reconstruction around the elbow. There are available only retrospective studies or case reports[150,151]. A recent systematic review[146] on the outcome and complications of lateral ulnar collateral ligament reconstruction of the elbow for posterolateral rotatory instability has shown an incidence of deep venous thrombosis (DVT) of 0.60%. Sanchez-Sotelo et al.[151], reported only one case of DVT, with an incidence of 2%, in 44 patients undergoing ligament repair for posterolateral rotatory instability of the elbow. Furthermore, the VTE prophylaxis was not even cited in the postoperative management. Hannon et al.[150], reported a case report of DVT in an 18-year-old male baseball pitcher after ulnar collateral ligament reconstruction surgery. The VTE prophylaxis was not performed, and the patient developed an extensive clot throughout his calf and lower thigh and minor pulmonary emboli four months from the index surgery.

Several studies[149,152-154] examined the prevalence of VTE in upper limb surgery and highlighted that patients should be stratified regarding the risk factor profile. Different national scientific associations have done indications for the prophylaxis dividing the patients in "low-risk" and "high-risk"[155-157]. Although it is recognized that upper limb surgery is associated with an increased risk of VTE, especially under certain circumstances, current literature lacks robust data evaluating the need for routine prophylaxis for patients undergoing ligament reconstruction around the elbow.

Surgeons should routinely assess the risk for each patient to identify the higher-risk subject that may benefit from VTE prophylaxis.

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Question: 12 - What are the classical signs, if any, of upper extremity DVT?

Response/Recommendation: Most of the signs and symptoms of an upper extremity deep venous thrombosis (DVT) are rather non-specific, such as pain and edema. However, more unusual signs such as visible venous collaterals and skin discoloration are more concerning for DVT.

Strength of Recommendation: Limited.

Delegates vote: Agree 100.00% Disagree 0.00% Abstain 0.00% (Strong Consensus)

Rationale: Upper extremity DVT is not as common as lower extremity DVT and represents approximately 10% of all DVT overall[158-162]. They are often divided into primary DVT, with no underlying pathology or foreign body, and secondary or provoked DVT, which are often associated with central venous catheters, pacemaker leads, or malignancy[158].

Paget-Schroetter Syndrome is a type of primary DVT commonly seen in athletes with thoracic outlet syndrome[163,164]. In this disorder, athletes who frequently perform repetitive external rotation and abduction of the shoulder develop a thrombosis in the axillosubclavian vein. They often present after a period of physical activity with acute pain, discoloration, swelling, and heaviness of the affected extremity[163].

Most of the signs and symptoms of upper extremity DVT are nonspecific and include pain, swelling, erythema, weakness, and paresthesia[159-162]. Less common signs that may be more indicative of an upper extremity DVT include skin discoloration and visible venous collaterals. According to the American College of Radiology (ACR), the location of the thrombosis typically correlates with the clinical presentation[165]. Unilateral swelling could be due to obstruction of the brachiocephalic, subclavian, or axillary veins. Superficial thrombophlebitis often presents with pain, induration, and a palpable cord. In severe cases with a more proximal thrombosis, such as superior vena cava or subclavian vein, patients may experience bilateral upper extremity or head and neck swelling.

There were four studies that specifically mentioned the signs and symptoms of patients presenting with an upper extremity DVT. Mustafa et al., identified 65 patients with an

upper extremity DVT in a community teaching hospital over a 2-year period[166]. Extremity swelling was present in all patients with 26 (40%) experiencing pain and 4 (6%) presenting with erythema in the extremity. In a retrospective review of 90 patients with ultrasound confirmed thrombosis of the internal jugular, subclavian, axillary, or brachial veins 31 patients (34%) experienced pain in the extremity and 76 (84%) presented with edema[167]. The largest series identified was a retrospective review of a prospective ultrasound DVT database with 5,451 patients of which 592 patients sustained an upper extremity DVT, 324 were associated with central venous catheters (CVC) and 268 were non-CVC associated[168]. They found that patients with an upper extremity DVT were more likely to have extremity edema and less likely to have extremity pain, dyspnea, or chest pain than patients with a lower extremity DVT. Most recently, Schastlivtsev et al., investigated the use of rivaroxaban for the treatment of 30 patients with an upper extremity DVT[169]. They found the presenting symptoms to be pain 6.6%), cramps (20.0%), heaviness (23.3%), pruritus (13.3%), and paresthesia (23.3%). The most common presenting signs were edema (16.6%), prominent subcutaneous arm veins (16.6%), prominent collateral veins (10.0%), tenderness (6.6%), redness (6.6%), and dependent cyanosis (16.6%).

Unfortunately, most of the signs and symptoms of upper extremity DVT are rather non-specific an include common postoperative findings such as pain, tenderness, swelling, and edema. However, more unusual signs such as distended or prominent collateral veins or extremity cyanosis should provoke further diagnostic testing to rule out upper extremity DVT.

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Question: 13 - What is the optimal management of DVT of the upper extremity?

Response/Recommendation: Patients with deep venous thrombosis (DVT) of the upper extremity should receive the same anticoagulant treatment regimens used for patients with DVT of the lower extremity. These include direct oral anticoagulants (DOAC) alone (apixaban and rivaroxaban), low-molecular-weight heparin (LMWH) and DOAC (edoxaban and dabigatran), LMWH alone, or LMWH and vitamin K antagonists. Anticoagulant treatment should be continued for at least 3 months and extended beyond 3 months if the event is unprovoked or secondary to permanent risk factors (e.g., cancer) and bleeding risk is low. The use of thrombolytic treatment or surgical approaches should be restricted to highly selected cases at low-risk for bleeding.

Strength of Recommendation: Limited.

Delegates vote: Agree 93.94% Disagree 6.06% Abstain 0.00% (Strong Consensus)

Rationale: Upper extremity DVT encompasses thrombosis of the brachial, axillary, subclavian, and jugular veins and accounts for up to one-tenth of the total of venous thromboembolic events[170]. There are no randomized controlled trials comparing different therapeutic strategies in patients with upper extremity DVT and therapeutic approaches are based on evidence derived from trials conducted in patients with lower limb venous thromboembolism (VTE).

The risk of pulmonary embolism (PE) was reported to be lower than in patients with lower limb DVT as well as the potential for recurrent VTE[171-174]. A number of studies including up to about 200 patients have reported on the safety and effectiveness of treatment with different anticoagulant regimens. No difference in outcome rates was detected between standard of treatment with LMWH and vitamin K antagonists and treatment with DOAC[175-186]. International guidelines on antithrombotic therapy suggest anticoagulant therapy alone over thrombolysis for patients with acute upper extremity DVT and suggest to consider thrombolysis in selected patients with severe symptoms, with thrombus involving most of the subclavian vein and the axillary vein, and with low-risk of bleeding[187].

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Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/G819).

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