We investigated the incidence of and risk factors for venous thromboembolism (VTE) following surgery of the shoulder and elbow and assessed the role of thromboprophylaxis in upper limb surgery. All papers describing VTE after shoulder and elbow surgery published in the English language literature before 31 March 2012 were reviewed. A total of 14 papers were available for analysis, most of which were retrospective studies and case series. The incidence of VTE was 0.038% from 92,440 shoulder arthroscopic procedures, 0.52% from 42,261 shoulder replacements, and 0.64% from 4,833 procedures for fractures of the proximal humerus (open reduction and internal fixation or hemiarthroplasty). The incidence following replacement of the elbow was 0.26% from 2,701 procedures. Diabetes mellitus, rheumatoid arthritis and ischaemic heart disease were identified as the major risk factors.

The evidence that exists on thromboprophylaxis is based on level III and IV studies, and we therefore cannot make any recommendations on prophylaxis based on the current evidence. It seems reasonable to adopt a multimodal approach that involves all patients receiving mechanical prophylaxis, with chemical prophylaxis reserved for those who are at high risk for VTE.

National guidelines in both the United Kingdom and the United States recommend the use of thromboprophylaxis in patients undergoing lower-limb joint replacement.1-4 However, the guidelines on prophylaxis following upper limb surgery are not as clear.1 Over 4000 shoulder and elbow replacements are performed in the United Kingdom each year,2 and more than twice that number in the United States,3 figures that are projected to increase more than threefold by 2015.4,5 Although the literature on venous thromboembolism (VTE) following upper limb surgery is sparse, there is some evidence to suggest that following shoulder replacement it may be as high as that observed following lower limb joint replacement.6

The purposes of this study were to assess the incidence of and risk factors for thromboembolic complications following shoulder and elbow surgery, and to evaluate the role of thromboprophylaxis in upper limb surgery.

Materials and Methods
We attempted to identify all papers describing cases of deep-vein thrombosis (DVT) and/or pulmonary embolus (PE) after shoulder and elbow surgery published in English before 31 March 2012. We performed an electronic search of Medline using the PubMed search and the EMBASE bibliographical and CINAHL databases. The terms shoulder surgery, elbow surgery, upper limb trauma and thromboembolism were used. The material retrieved included any studies in which postoperative VTE occurred after upper limb surgery. From the retrieved articles we scrutinised the reference lists for any papers also considered relevant. Single case reports, patients with primary upper limb thrombosis and other non-surgical causes of VTE were excluded.

Results
We reviewed 14 papers describing DVT and/or PE as a complication of shoulder surgery.7-22 Of these studies, eight were concerning arthroscopy of the shoulder (Table I),7-12,14,16-18 six concerning shoulder replacement (Table II),7,10,13,19-22 and three the treatment of fractures of the proximal humerus (Table III).11,15,19 We also reviewed two papers describing VTE after elective elbow surgery.23,24 There were no randomised controlled trials or non-randomised comparative studies.

Incidence. The incidence of VTE following arthroscopic surgery of the shoulder was 0.038% from 92,440 procedures, the incidence following shoulder replacement 0.45% from 37,217 procedures, and the incidence...
following open reduction and internal fixation (ORIF) or hemiarthroplasty for fracture of the proximal humerus was 0.82% from 9877 procedures (Tables I to III). Only two papers reported thromboembolic complications of elbow surgery, and the incidence was 0.26% from 2701 elbow replacements.

**Risk factors.** Diabetes mellitus, rheumatoid arthritis and ischaemic heart disease were identified as major risk factors in ten papers reporting the incidence of VTE following shoulder surgery. Placing the patient in the lateral decubitus position during arthroscopy was thought to predispose to DVT, so this was also assessed as a possible risk factor. The position of the patient during arthroscopy was not documented in half of the studies reviewed. In the 18 cases of shoulder arthroscopy complicated by VTE where the position was documented there was a higher incidence of DVT in the lateral decubitus position (14 cases) compared with the beach chair position (four cases).

**Diagnosis of VTE.** The location of the DVT was poorly documented, with only 33 of 124 cases describing it as either the upper (58%) or the lower limb (42%) (Tables I to III). The technique used to diagnose DVT or PE was described in detail in the majority of studies. The most commonly used methods for diagnosis of DVT were Doppler ultrasound (US) and computed tomography (CT), with ultrasound being the preferred method in most studies. Ultrasound was used to diagnose PE in one study, and computed tomography was used in two studies. The most common diagnostic method was the combination of ultrasound and computed tomography (CT).
in ten of the 14 papers. Doppler ultrasound (USS) and pulmonary CT were the most popular methods for detecting DVT and PE, respectively (Tables I to III). Only one study described the routine screening of patients for DVT with a four-limb Doppler USS. In the remaining papers patients were only evaluated for VTE if they became symptomatic. The time for the detection of DVT or PE was between one and 90 days post-operatively.

**Prophylaxis and treatment.** The use of mechanical and/or pharmacological prophylaxis was not mentioned in nearly 90% of cases. When it was documented, methods of treatment included thromboembolic deterrent stockings (TEDs), pneumatic compression foot pumps, low-molecular-weight heparin and aspirin. Definitive treatment of VTE (TEDs), pneumatic compression foot pumps, low-molecular included thromboembolic deterrent stockings (TEDs), pneumatic compression foot pumps, low-molecular-weight heparin and aspirin. Definitive treatment of VTE was only reported in 11% of cases.

**Discussion**

A DVT of the upper limb is defined as a thrombus in any of the deep veins of the upper limb. The aetiology of upper limb DVT (ULDVT) can be classified into primary and secondary. Primary or ‘effort’ thrombosis (Paget-Schroetter syndrome) is rare, and is associated with anatomical abnormalities that predispose to venous compression of the axillary and/or subclavian veins at the thoracic outlet. Secondary ULDVT arises as a result of predisposing factors such as central venous catheters, hypercoagulable states, trauma or surgery. The clinical features are swelling, pain, erythema, skin discoloration and a non-specific feeling of heaviness or discomfort in the upper limb. In up to one-third of patients ULDVT may be asymptomatic. Doppler USS is the preferred imaging technique for patients with suspected ULDVT.

The reported incidence of PE in patients with a documented ULDVT was twice that of patients with a lower limb DVT (LLDVT), with a mortality rate of up to 16%. Because of this the American College of Chest Physicians recommends that all patients with ULDVT should be treated with unfractionated heparin, low molecular weight heparin or warfarin. As with LLDVT, the incidence of post-thrombotic syndrome after ULDVT can be as high as 25% within the first two years.

Only between 1% and 4% of all DVTs involve the upper limbs. However, we found an incidence of ULDVT of 58% in the studies where the location of the thrombus was documented. The overall incidence of DVT following shoulder surgery could not be accurately calculated from the literature, as there was only one study that reported the radiological screening of all patients for the presence of a DVT. In all the other studies a Doppler USS of the operated upper limb was only performed when there were symptoms of VTE. In addition to the affected upper limb, Doppler USS of the lower limbs was only performed in patients with a PE (Tables I to III). It is therefore possible that the true incidence of DVT following shoulder replacement has been underestimated in this review, as most of the studies only reported patients with symptomatic DVT that required radiological evaluation, and silent DVTs would have been missed. However, a critical appraisal of the available information showed that VTE following arthroscopic shoulder surgery is rare, with an incidence similar to that in the general population. The incidence of VTE following shoulder replacement and fixation of proximal humeral fractures was found to be much higher, at 0.45% and 0.82%, respectively, and as this is a significant risk it should be discussed with the patient when obtaining consent for surgery.

There may be many reasons for the considerably higher incidence of VTE following shoulder replacement compared with that following arthroscopy of the shoulder. First, patients who undergo replacement are usually older and age is a risk factor for VTE. Secondly, the axillary vein may sustain intimal damage when the humerus is repeatedly rotated during shoulder replacement. A similar phenomenon causing scissoring of the femoral vein has been proposed as a cause of LLDVT during hip replacement. The axillary vein may also be damaged by traction or direct pressure from retractors, especially during exposure of the glenoid. Thirdly, intramedullary reaming during preparation of the proximal humerus has been shown to cause an embolic shower, which can result in a PE. Fourthly, shoulder replacement usually takes longer than arthroscopic procedures, and increased duration of surgery is associated with the systemic release of thrombogenic factors. Finally, shoulder replacement may require the patient to be in a beach chair position for a longer time, which can cause venous stasis as a result of the loss of muscular pumping in the lower limbs.

In line with previous reports, we found the risk factors for ULDVT to be the same as those for LLDVT. At least one risk factor was identified in eight of the ten studies where risk factors were documented. Following arthroscopic shoulder procedures, other mechanisms have also been proposed for development of ULDVT. These include the presence of venous aneurysms and injury to veins by the motor-driven arthroscopic shaver, excessive fluid extravasation, traction on the arm or post-operative immobilisation in a brace. One study, in a small cohort of patients, found a statistical difference in the development of ULDVT in the lateral decubitus position compared with the beach chair position. Similarly, we found that in the 18 cases of shoulder arthroscopy complicated by VTE where the patient positioning was documented, there was a higher incidence in the lateral position (14 cases) than in the beach chair position (four cases). An explanation for this may that suspension of the arm during the procedure includes traction, which reduces perfusion of the limb. However, our results have to be interpreted with caution because of the small numbers.

DVT and PE cannot be reliably diagnosed on the basis of history and examination alone, even in high-risk patients. Serious concerns have also been raised about the misinterpretation of early symptoms of VTE following arthroscopic shoulder surgery.
shoulder surgery. Doppler USS and pulmonary CT, respectively, are the investigations of choice in patients with suspected VTE.\textsuperscript{50} In only one study\textsuperscript{9} were all patients routinely screened for DVT with Doppler USS. In this study, Willis et al\textsuperscript{9} prospectively followed 100 consecutive patients undergoing shoulder replacement over a 12-week period. A four-limb surveillance colour-flow Doppler USS was performed on the second post-operative day in all patients and in 50 randomly selected patients 12 weeks post-operatively. Mechanical or chemical prophylaxis was not used until after surgery, when all patients were prescribed enteric coated aspirin (325 mg twice a day) and used pneumatic compression foot pumps. The overall incidence of DVT was 13.0\%, and of PE was 2\%.\textsuperscript{9} The incidence of DVT after shoulder replacement was comparable with that after hip replacement at their institution using a similar thromboprophylaxis regimen. This study was the only one that reported the routine use of pharmacological DVT prophylaxis after shoulder replacement.\textsuperscript{9} A survey of the members of the British Elbow and Shoulder Society has shown that 58% of surgeons do not use any form of prophylaxis during shoulder surgery. In the United Kingdom the National Institute of Clinical Excellence (NICE) does not recommend routine thromboprophylaxis for patients undergoing upper limb surgery, but advises that patients considered to be at high risk of VTE should be given mechanical prophylaxis on admission and started on chemical prophylaxis six to 12 hours post-operatively.\textsuperscript{1} The British Orthopaedic Association has recently published a draft on the prevention of VTE in orthopaedic practice and recommends that patients undergoing shoulder and elbow surgery who are at low to medium risk of VTE should receive mechanical prophylaxis.\textsuperscript{4} Only patients thought to be at a high risk should receive pharmacological prophylaxis.\textsuperscript{4} If these criteria are applied in the English NHS, > 50% of patients undergoing arthroscopy of the shoulder and most patients undergoing shoulder replacement could receive chemical prophylaxis.\textsuperscript{13}

Pharmacological thromboprophylaxis in orthopaedic patients remains a controversial topic,\textsuperscript{48} because of the perceived risk of post-operative bleeding.\textsuperscript{48,52} Consequently, although national guidelines recommend the use of chemoprophylaxis after major orthopaedic surgery, it is not always instituted.\textsuperscript{48,53} For this reason, NICE acknowledges the need for surgeons to exercise clinical judgement, to take into consideration patient-specific factors, to regularly assess the risks and benefits of chemoprophylaxis, and ultimately recommend that patients be offered VTE prophylaxis where it is deemed appropriate.\textsuperscript{1}

Before drawing any conclusions from our study it must be recognised that there is no strong evidence upon which to provide recommendations regarding chemical prophylaxis following upper limb surgery. We examined retrospective series and questionnaires, which, by their nature, contain bias. The results were not presented in a manner that allowed statistical calculations to strengthen the evidence by the use of meta-analysis. We found a shortage of robust studies examining VTE after upper limb surgery. The evidence that exists is based on level III and IV studies, rather than randomised controlled trials. Thus we cannot make recommendations on chemoprophylaxis based on the current evidence. A well-designed, randomised controlled study to examine the epidemiology of VTE and the efficacy of thromboprophylaxis in upper limb surgery would be needed before recommendations for pharmacological prophylaxis can be made.

However, risk stratification to assess for risk factors for VTE should be performed on all patients undergoing shoulder surgery. These include stopping any thrombogenic drugs pre-operatively, minimising the time taken to work on the humerus, using leg or foot compression pumps per- and post-operatively with foot and ankle exercises, and prompt rehabilitation.\textsuperscript{54} In the absence of evidence regarding the superiority of any method of prophylaxis over another, it seems reasonable to adopt a multimodal approach that involves all patients receiving mechanical prophylaxis, with chemical prophylaxis reserved for those at high risk for VTE. The best option for thromboprophylaxis following shoulder replacement remains unknown, and the use of anticoagulants must be weighed against the risks of bleeding.

Supplementary material

Three tables detailing the relative incidence of thromboembolic events with respect to i) comorbidities and other risk factors, ii) patient positioning during shoulder arthroscopy and iii) prophylaxis and definitive treatment for venous thromboembolism, are available with the electronic version of this article on our website www.bjj.boneandjoint.org.uk

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References


