Background: The purpose of this study was to investigate the incidence of venous thromboembolism (VTE) after elective arthroscopic shoulder surgery.

Materials and methods: One hundred seventy-five consecutive patients who underwent arthroscopic shoulder surgery were enrolled (mean age, 61 years). Patients who had VTE preoperatively and underwent trauma surgery or arthroplasty were excluded. All the patients used foot pumps or elastic stockings after surgery for deep venous thrombosis (DVT) prophylaxis. DVT in the 4 limbs was assessed by ultrasound before and after surgery. Pulmonary embolism was diagnosed by computed tomography pulmonary angiography. Risk factors related to DVT were assessed.

Results: The overall incidence of DVT was 10 of 175 patients (5.7%). Most of the DVT cases were detected at 1 to 2 days after surgery. All patients were asymptomatic. There were no patients who had symptomatic pulmonary embolism. However, an asymptomatic pulmonary embolus developed in 1 patient during the 3-month follow-up period. There were no significant differences between the DVT and non-DVT groups regarding the risk factors.

Discussion and conclusion: Our data have shown that symptomatic VTE is rare after elective arthroscopic shoulder surgery. However, asymptomatic VTE may occur even with DVT preventive measures. Because most of the DVTs were found in the calf veins, we recommend that surgeons pay attention to the possibility of DVT in the lower extremities even after arthroscopic shoulder surgery. The incidence of asymptomatic VTE after elective arthroscopic shoulder surgery was 5.7%. All patients were asymptomatic, and most of the DVTs occurred 1 or 2 days after surgery.

Level of evidence: Level I, Prospective Cohort, Prognosis Study.

Keywords: Venous thromboembolism; deep venous thrombosis; pulmonary embolism; shoulder surgery; arthroscopy; asymptomatic; ultrasonography
proximal femoral fracture have been published. The
guidelines include DVT standard prophylaxis such as
intermittent pneumatic compression devices, elastic
stockings, and anticoagulation therapy for perioperative
management.1,15,17,18

According to the DVT guidelines published by the
Japanese Circulation Society in 2009, patients undergoing
surgery of the upper extremity are not at risk for post-
operative DVT if there are no risk factors related to
DVT.17 Preventive measures—with the exception of early
ambulation and active calf stretch exercises—are not
recommended.11,18 In 1990, Burkhart5 reported the first
case of symptomatic DVT after shoulder arthroscopic
surgery. Meanwhile, the number of reports about symp-
tomatic VTE after shoulder surgery has been gradually
increasing.1,3,4,7,8,10,12-14,16,19-24,27 In 2009, Willis et al27
reported that the prevalence of DVT after shoulder
arthroplasty was 13% in 100 patients. Although there has
been increased awareness of the existence of DVT after
open shoulder surgery, it still has not been a major concern
for shoulder surgeons after arthroscopic shoulder surgery.
Some retrospective studies have shown that the incidence
of symptomatic VTE events after shoulder surgery was
extremely low, ranging from 0.01% to 0.68%.8,10,16,20,23
However, there have been only 2 prospective studies
investigating the incidence of VTE after elective shoulder
surgery.26,27

The purposes of this study were (1) to prospectively
investigate the incidence of VTE after elective arthroscopic
shoulder surgery and (2) to clarify the risk factors related to
VTE events. Our hypothesis was that symptomatic VTE
events after elective arthroscopic shoulder surgery are rare
whereas asymptomatic VTE might occur even with DVT
prophylaxis.

Materials and methods

This is a prospective cohort study of VTE that occurred after
elective arthroscopic shoulder surgery.

Patients

A prospective cohort study was designed to document the in-
cidence of VTE after shoulder surgery in consecutive patients.
Between June 2011 and May 2013, a total of 353 consecutive
shoulder surgeries were performed at our hospital, as well as a
related hospital (one of our affiliated hospitals). Of the patients,
175 who met the following inclusion criteria were enrolled: (1)
patients underwent elective arthroscopic shoulder surgery and (2)
patients provided informed consent. The exclusion criteria were
(1) patients who had a history of symptomatic VTE preopera-
tively, (2) trauma patients including elective fracture surgery
cases, (3) patients who underwent arthroplasty, and (4) patients
who were unable to undergo ultrasound examination before and
after surgery. Arthroscopic surgery was performed in 175 shoul-
ders in 175 patients. There were 145 arthroscopic rotator cuff
surgeries, 17 arthroscopic Bankart repairs, and 13 other
procedures (Table I). There were 125 men and 50 women, and the
mean age at the time of surgery was 61 ± 13 years (range, 18-
80 years). All procedures were performed with patients under
general anesthesia, in the beach-chair position. The procedure was
not conducted in the lateral decubitus position in any patient.

DVT preventive measures

During and after surgery, DVT prophylaxis such as elastic
stockings, pneumatic compression pumps, and early ambulation
was used in all patients. Intermittent pneumatic compression de-
vices were used as DVT prophylaxis for the lower extremities
during surgery in 173 cases (99%). An elastic stocking for the
lower extremities was used in 2 of 175 cases (1%) during surgery.
None of the patients in this study used low–molecular weight
heparin or aspirin. The pneumatic compression pumps were used
from the beginning of surgery for 24 hours. Patients who were not
able to begin early ambulation used pneumatic compression
pumps until they started ambulation. On the day after surgery, 171
patients (98%) were able to get out of bed. After surgery, inter-
mittent pneumatic compression devices were used in 162 patients
(93%), elastic stockings in 2 (1%), and the combination thereof in
11 (6%).

Questionnaire and ultrasound examination

A questionnaire was completed before surgery. The potential risk
factors associated with VTE, which have been previously re-
ported, were assessed.2,17,27 As preoperative factors, the patient’s
background (age, sex, race, body mass index [BMI], and smoking
habit), the presence of malignant disease, and comorbidities
diagnosed previously were documented (Table II). As perioper-
avive and postoperative factors, operative time, complications,
length of hospitalization, and any associated VTE complications,
such as symptomatic or fatal pulmonary embolism (PE), were
recorded.

A 4-limb surveillance duplex ultrasound examination was
performed to investigate the incidence of DVT. All examinations
were performed and interpreted by a single orthopaedic surgeon
specializing in musculoskeletal ultrasonography. In addition, he
had 3 months of training in venous ultrasonography to detect DVT
in the 4 limbs. To show the accuracy of detecting DVT by ultra-
sound in this study, the incidence of lower-extremity DVT in
patients who underwent total knee arthroplasty during the same
period was also investigated by conducting the same ultrasound
procedure. Thirty-nine patients who had total knee arthroplasty at
our hospital were enrolled, comprising 7 male and 32 female
patients with a mean age of 72 years. Their diagnoses were
osteoarthritis in 31 cases, rheumatoid arthritis in 7 cases, and
psoriatic arthritis in 1 case. The ultrasound examination was
performed between 3 days and 1 month after total knee
arthroplasty.

The ultrasound devices used in this study were the Hi-Vision
Preirus system (Hitachi-Aloka Medical, Tokyo, Japan) and M-
Turbo system (SonoSite, Bothell, WA, USA) with linear probes
ranging from 6 to 13 MHz and convex probes ranging from 2 to
5 MHz. The posture was the supine position with the arm in slight
abduction. The examination sites were from the elbow joint level
to the subclavian vein in the upper extremity and from the pos-
terior calf to the inguinal area in the lower extremity. Duplex
ultrasound has been reported to be an accurate and effective screening modality. DVT was diagnosed by ultrasound when both of the following findings were present: (1) intravenous hyperechoic lesion or venous incompressibility on B-mode imaging and (2) venous flow defect or abnormality proven in color-flow Doppler mode. When DVT was diagnosed by ultrasound, the serum D-dimer level was also tested to establish the differential diagnosis. Both DVT findings by ultrasound and positive D-dimer levels indicated a definitive diagnosis of VTE. In cases with DVT in which the clinical symptoms of PE were suspected, computed tomography pulmonary angiography (CTPA) was conducted to confirm PE. The presence and location of DVT, as well as clinical symptoms related to VTE, were recorded. The mean follow-up period was 10 months after surgery, and DVT after hospital discharge was assessed by the operating surgeon.

Timing of ultrasonographic diagnosis

Most thromboembolic events after lower-extremity surgery have been reported to occur in the first postoperative week. Because it has been reported that DVT and related thromboembolic complications occur until 12 weeks after knee or hip arthroplasty, it was necessary for us to carefully observe whether VTE events occurred until 3 months after surgery. Thus, duplex ultrasound was performed (1) before surgery, (2) 1 or 2 days after surgery (acute phase), and (3) 3 weeks to 3 months after surgery (subacute phase). All 175 patients underwent preoperative and postoperative acute-phase examinations, but only 85 patients underwent subacute-phase examinations because some patients or the examiner had time restrictions regarding the ultrasonographic examinations in the outpatient clinic.

Statistical analysis

We used \( \chi^2 \) analysis or the Fisher exact test to investigate the difference in the incidence of DVT with regard to sex, surgical procedures, smoking habit, and comorbidity. We performed the Mann-Whitney \( U \) test to assess the difference in the incidence of DVT with regard to age, BMI, operative time, and other factors. No corrections were made for multiple comparisons. All statistical analyses were performed with JMP Pro 9 software (SAS Institute, Cary, NC, USA).

When this study was planned, there was only 1 report available in the literature on the same topic. Therefore, it was difficult for us to calculate the estimated sample size. The sample size was determined based on the number of shoulder surgeries that were performed at our hospitals (about 200 cases per year). The power analysis was calculated after this study to check whether the hypothesis was correct. We used G*power 3 software to calculate the statistical power.

---

Table I  Demographic data of all patients

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>Overall</th>
<th>Arthroscopic rotator cuff surgery</th>
<th>ARCR</th>
<th>A-Patch</th>
<th>ABR</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>175</td>
<td>134</td>
<td>11</td>
<td>17</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Age (range) (y)</td>
<td>61 ± 13 (18-80)</td>
<td>61 ± 14 (18-87)</td>
<td>69 ± 7 (55-78)</td>
<td>38 ± 16 (18-66)</td>
<td>60 ± 14 (34-76)</td>
<td></td>
</tr>
<tr>
<td>Male-female ratio</td>
<td>2.5:1</td>
<td>2.5:1</td>
<td>2.7:1</td>
<td>3.3:1</td>
<td>1.6:1</td>
<td></td>
</tr>
<tr>
<td>Diagnosis (n)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCT</td>
<td>149 (85%)</td>
<td>130 (97%)</td>
<td>11 (100%)</td>
<td>0 (0%)</td>
<td>8 (62%)</td>
<td></td>
</tr>
<tr>
<td>RAD</td>
<td>17 (10%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>17 (100%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>9 (5%)</td>
<td>4 (3%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>5 (38%)</td>
<td></td>
</tr>
</tbody>
</table>

A-Patch, Arthroscopic patch graft procedure; ABR, arthroscopic Bankart repair; ARCR, arthroscopic rotator cuff repair; RAD, recurrent anterior dislocation; RCT, rotator cuff tear.

Table II  Potential VTE risk factors and perioperative data

<table>
<thead>
<tr>
<th>VTE risk factors (n)</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;60 y</td>
<td>111 (63%)</td>
</tr>
<tr>
<td>BMI &gt;30 kg/m²</td>
<td>7 (4%)</td>
</tr>
<tr>
<td>Comorbidity</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>34 (19%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>62 (35%)</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>14 (8%)</td>
</tr>
<tr>
<td>COPD</td>
<td>10 (6%)</td>
</tr>
<tr>
<td>CKD</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Chronic liver failure</td>
<td>3 (2%)</td>
</tr>
<tr>
<td>Active cancer</td>
<td>2 (1%) (prostate)</td>
</tr>
<tr>
<td>Inflammatory disease</td>
<td>3 (2%) (RA in 2 and Behçet disease in 1)</td>
</tr>
<tr>
<td>Smoking habit</td>
<td>81 (46%)</td>
</tr>
<tr>
<td>History/other factors</td>
<td></td>
</tr>
<tr>
<td>Family history of VTE</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Cancer</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Cerebral stroke</td>
<td>8 (5%)</td>
</tr>
<tr>
<td>VTE</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Major surgery</td>
<td>28 (16%)</td>
</tr>
<tr>
<td>Orthopaedic surgery</td>
<td>33 (19%)</td>
</tr>
<tr>
<td>Trauma (within 6 mo)</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Additional surgery</td>
<td>8 (5%)</td>
</tr>
</tbody>
</table>

CI; Confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; RA, rheumatoid arthritis.
Results

Incidence of DVT

The overall incidence of DVT was 10 of 175 patients (5.7%). However, all patients had no symptoms related to VTE. DVT was found in the upper (subclavian vein) and lower (calf vein) extremities in 1 patient and in the lower extremities in 9 patients. DVT was detected in 10 cases at 1 to 2 days after surgery and in 1 case at 3 weeks to 3 months after surgery. The DVT observed in the subclavian vein was a free-floating thrombus (Fig. 1, A and B). All DVTs that occurred in the lower extremities were the distal type of DVT. Nine cases had DVTs in the soleus veins, and 1 case had DVT in the gastrocnemius vein. In this study, proximal DVT including popliteal and femoral vein thrombosis was not found. Bilateral calf vein thromboses were detected in 4 cases (Table III). Two patients underwent CTPA. DVTs were found in the bilateral soleus veins on the day after surgery in 1 case. This patient showed a reduction in percutaneous oxygen saturation; this prompted the cardiologist to perform the CTPA examination, without any positive findings.

Incidence of PE

There were no patients who had symptomatic PE in this study. However, an asymptomatic pulmonary embolus developed, as evidenced on CTPA, in 1 patient at 3 months’ follow-up. This patient had a DVT in the upper and lower extremities. This asymptomatic and fresh DVT occurred in the subclavian vein of the operative upper extremity at around 4 weeks after an arthroscopic patch graft procedure for a massive rotator cuff tear. Then, an asymptomatic PE was detected by CTPA (Fig. 1, C). This patient needed to receive anticoagulant therapy with warfarin for 6 months.

Incidence of VTE after total knee arthroplasty

The incidence of lower-extremity DVT in patients who underwent total knee arthroplasty during the same period was 13 of 39 cases (33%). All DVTs were found in the calf veins and were asymptomatic. No symptomatic PE was found.

DVT risk factors

The patients whose DVT had been proved by ultrasound (DVT group) and the patients who had no DVT (non-DVT group) were compared. There were no significant differences between the DVT and non-DVT groups regarding the risk factors, such as age, sex, BMI, operative time, smoking habit, and comorbidity (Table IV).

Ex post analysis of statistical power

Because this study could not predict the risk factors from the incidence of VTE after shoulder surgery, the power analyses after the fact were calculated on the risk factors.
retrospectively. Calculating statistical power for VTE risk factors, we found that the power was in the range between 0.098 and 0.355, which was not sufficient to make any conclusion on the risk factors.

### Discussion

Although it has been reported that symptomatic VTE after shoulder surgery is a rare complication, there have been no reports describing asymptomatic VTE. Recently, some reports describing VTE after shoulder surgery have been published.\(^1\)\(^3\)\(^7\)\(^8\)\(^10\)\(^12\)\(^14\)\(^16\)\(^19\)\(^20\)\(^23\)\(^24\)\(^25\)\(^26\)\(^27\) In addition, it has been pointed out that there is a risk of asymptomatic DVT even after arthroscopic surgery, although the risk of DVT has been reported to be at low.\(^25\) However, the risk of VTE after shoulder surgery is very low because there are no high-evidence reports about VTE after shoulder surgery according to the guidelines.\(^17\) Willis et al\(^27\) reported that the prevalence of asymptomatic DVT after shoulder surgery was 13% and the rate of symptomatic PE was 3%. However, all surgeries were arthroplasty cases. In our study, the incidence of asymptomatic DVT after surgery was 5.7% and the proportion of symptomatic PE was 0%. However, asymptomatic PE was detected by CTPA in 1 case. All surgeries in our study were arthroscopic surgeries. The overall incidence of DVT in this study was 5.7% in 175 patients. This difference may come from the different inclusion criteria for the different surgical procedures. Willis et al included patients with a history of VTE events that have been reported as yielding the highest risk of DVT in the guidelines. All the procedures in their series consisted of shoulder arthroplasties. Our data showed that DVT occurred in all cases at 1 or 2 days after surgery. In contrast to the report of Willis et al, arthroscopic surgeries were performed in all of our cases and a history of VTE was an exclusion criterion in our study. Because of this, the incidence of VTE in this study appears lower than that in the previous report. Only 1 patient underwent anticoagulant treatment with heparin for a few days, because he showed a transient decrease in percutaneous oxygen saturation on monitoring, but this was discontinued after a CTPA showed no PE. Only 1 patient underwent anticoagulant treatment with heparin for a few days until CTPA showed no PE because he showed a transient decrease in percutaneous oxygen saturation on monitoring. In another case, no treatment was performed. Of the 10 cases with DVT, 7 (70%) were followed up by repeat ultrasonography. In 5 of these 7 cases (71%), the DVT findings changed during the follow-up period. Among the cases in which DVT was detected by ultrasound 1 to 2 days after surgery, DVT disappeared between 3 days and 3 months after surgery in 5 of 10 cases (50%) in this study. In the literature, there have been no reports investigating the incidence of DVT longitudinally except for the report of Willis et al. Regarding lower-extremity surgery, Cullison et al\(^6\) reported that DVT was detected in only 1 of 67 cases and that asymptomatic DVT was seen in the femoral vein 3 days after surgery but disappeared 10 days after surgery. Willis et al\(^27\) conducted ultrasonographic evaluation of 100 patients at 2 days after surgery. Half of these patients (50 patients) were examined at 12 weeks after surgery.

### Table III

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Operative procedure</th>
<th>DVT location</th>
<th>Findings and timing of US (initially postoperatively, at final follow-up)</th>
<th>PE</th>
<th>VTE risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Bilateral soleus</td>
<td>DVT positive at 1 d, DVT negative at 11 d</td>
<td>No</td>
<td>HT</td>
</tr>
<tr>
<td>75</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Bilateral soleus</td>
<td>DVT positive at 2 d, DVT positive at 1 wk</td>
<td>No</td>
<td>HT</td>
</tr>
<tr>
<td>63</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Contralateral gastrocnemius</td>
<td>DVT positive at 1 d, no follow-up</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>58</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Ipsilateral soleus</td>
<td>DVT positive at 2 d, no follow-up</td>
<td>No</td>
<td>HT</td>
</tr>
<tr>
<td>66</td>
<td>M</td>
<td>RAD</td>
<td>ABR</td>
<td>Contralateral soleus</td>
<td>DVT positive at 2 d, DVT negative at 9 d</td>
<td>No</td>
<td>HT</td>
</tr>
<tr>
<td>64</td>
<td>F</td>
<td>RCT</td>
<td>ARCR</td>
<td>Ipsilateral soleus</td>
<td>DVT positive at 2 d, no follow-up</td>
<td>No</td>
<td>HT, DM Prostate cancer</td>
</tr>
<tr>
<td>70</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Bilateral soleus</td>
<td>DVT positive at 1 d, DVT negative at 3 wk</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>60</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Ipsilateral soleus</td>
<td>DVT positive at 1 d, DVT negative at 3 d</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>60</td>
<td>M</td>
<td>RCT</td>
<td>ARCR</td>
<td>Contralateral soleus</td>
<td>DVT positive at 1 d, DVT negative at 3 mo</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>69</td>
<td>F</td>
<td>RCT</td>
<td>A-Patch</td>
<td>Bilateral soleus</td>
<td>DVT positive at 2 d</td>
<td>No</td>
<td>HT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Affected subclavian</td>
<td>DVT positive at 4 wk</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

_A-Patch_, Arthroscopic patch graft procedure; _ABR_, arthroscopic Bankart repair; _ARCR_, arthroscopic rotator cuff repair; _DM_, diabetes mellitus, _F_, female; _HT_, hypertension; _M_, male; _RAD_, recurrent anterior dislocation; _RCT_, rotator cuff tear; _US_, ultrasonography.
However, Willis et al did not check for DVTs preoperatively. In their study, because preoperative ultrasound examination was not performed, they cannot completely deny the possibility of pre-existing DVTs. Accordingly, they used the term “prevalence” in their report. In our study, on the other hand, ultrasound examination was performed 3 times: before surgery, 1 to 2 days after surgery (acute phase), and 3 weeks to 3 months after surgery (subacute phase). Thus, we were able to determine the incidence of DVT. These differences may also be related to the difference in the inclusions between our study and that of Willis et al.

Widmer et al reported that the prevalence rates of both DVT and PE after shoulder surgery for proximal humeral fracture were 0%. Their DVT preventive measures were aspirin administration and use of pneumatic compression pumps. The timing of their ultrasonography was, on average, 14 days after surgery, which was earlier than that in our study and in the study by Willis et al.27 The possibility of not being able to detect early DVT after surgery could be a major concern in the study by Widmer et al. They excluded patients who had active cancer and a hypercoagulable state, which have been known to yield a high risk of postoperative VTE. Their finding of a 0% prevalence rate might be caused by the late timing of ultrasonography, the inclusion criteria, and the small sample size of 50 patients. It remains unclear when DVT after surgery occurs in the subacute phase. Therefore, our detection of DVT may have been benefited by defining the subacute phase with a wide range, from 3 weeks to 3 months after surgery in this study.

Jameson et al reported a large-scale analysis comprising 80,227 patients from a national database. They showed that the overall prevalence of symptomatic VTE events after open shoulder surgery was less than 0.7% and the overall prevalence after arthroscopic procedure was 0.01%. Kuremsky et al investigated 1,908 cases of shoulder arthroscopic surgery retrospectively. They found that 6 patients (0.31%) were diagnosed with symptomatic VTE by ultrasound and computed tomography. There have been several reports describing the rarity of symptomatic VTE events after shoulder arthroscopic procedure, and the incidences ranged from 0.01% to 0.38%.2,3,4,10,14,16,20,23 The incidence of VTE after arthroscopic surgery in our study was 10 of 175 cases (5.7%). This value is higher than the values in the previous reports, although all VTEs were asymptomatic in our study.

To validate the accuracy of ultrasonographic diagnosis for DVT in this study, the incidence of lower-extremity DVT in patients who underwent total knee arthroplasty during the same period was investigated. DVTs were found in 13 of 39 patients (33%), and all were asymptomatic. It has been reported that the incidence of DVT after total knee arthroplasty was 36% on average (range, 25%-59%).28 Because the incidence of DVT in this study was close to our incidence, we assumed that the accuracy of diagnosis of DVT in this study was validated to be at an acceptable level.

The surgical position and the anatomic structure of the calf veins have been thought to be a possible cause of DVT formation after shoulder surgery. In our study, soleus vein thromboses were found in 9 of 10 cases. The anatomic and physiological features of the soleus veins are that they are venous sinuses that have a plenty of bypass to the surrounding veins such as gastrocnemius and posterior tibial veins, being predisposed to excessive venous congestion in the lower extremity. The calf vein has been reported as the most common site for DVT observed after lower-extremity surgery.26 With patients in the beach-chair position, the hip and knee joints were always flexed during surgery. This may induce DVT formation in the lower extremities during surgery. Because no surgeries were performed with patients in the lateral decubitus position in our series, the difference between these positions remains unclear. Further studies are necessary to show the difference between these positions.

All 10 cases of DVT in our study were detected at 1 to 2 days after surgery. This is similar to the report of Willis et al.27 From this result, we are able to conclude that we need to carefully observe whether VTE events occur soon after shoulder surgery. Considering the fact that most DVTs occur in the calf veins, surgeons should be focused on preventive care for calf DVTs after shoulder surgery regardless of whether VTE-related symptoms are present.

There are several limitations in this study. First, the lateral decubitus position was not included. Thus, the incidences of VTE could not be compared between the beach-chair and lateral decubitus positions. Second, DVT prophylaxis during and after surgery was not controlled: elastic stockings, pneumatic compression pumps, and early ambulation were used as

### Table IV Comparison between DVT group and non-DVT group

<table>
<thead>
<tr>
<th>VTE risk factors</th>
<th>DVT group</th>
<th>Non-DVT group</th>
<th>P value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (y)</td>
<td>66 ± 7</td>
<td>60 ± 14</td>
<td>.258</td>
<td>0.212</td>
</tr>
<tr>
<td>Male-female ratio</td>
<td>4:1</td>
<td>2.4:1</td>
<td>.726</td>
<td>0.101</td>
</tr>
<tr>
<td>Mean BMI (kg/m²)</td>
<td>24.3 ± 3.8</td>
<td>24.3 ± 3.3</td>
<td>&gt;.99</td>
<td>—</td>
</tr>
<tr>
<td>Mean operative time (min)</td>
<td>139 (95% CI, 107-171)</td>
<td>135 (95% CI, 125-145)</td>
<td>.507</td>
<td>0.098</td>
</tr>
<tr>
<td>% with smoking habit</td>
<td>70</td>
<td>45</td>
<td>.191</td>
<td>0.355</td>
</tr>
<tr>
<td>% with DVT risk–related comorbidity</td>
<td>80</td>
<td>63</td>
<td>.334</td>
<td>0.185</td>
</tr>
</tbody>
</table>

CI, Confidence interval.
DVT prophylaxis. However, intermittent pneumatic compression devices were used in 99% of cases during surgery and in 99% of cases after surgery. Thus, we believe that the effect of variable prophylaxis was small. Third, ultrasonography was performed in only 85 patients at 3 weeks to 3 months after surgery, which was approximately half of all the patients. When we divided the patients into 2 groups—that is, the single ultrasonography group, comprising the 90 patients who underwent ultrasound at only 1 to 2 days after surgery, and the follow-up ultrasonography group, comprising the 85 patients who were able to undergo both acute- and subacute-phase examinations postoperatively—there were significant differences between the 2 groups in age, diagnosis, operative time, and length of hospital stay. Therefore, it was a limitation of this study not to be able to perform ultrasonographic examination at the same time points. Fourth, ultrasound examination for patients who had total knee arthroplasty was performed at 3 days after surgery or later. Because closed drainage with a compressive bandage was routinely used until 2 days after surgery, ultrasound examination could not be performed during the early postoperative period. Lastly, the ex post analysis of the statistical power for DVT risk factors showed that all power values were lower than 0.4, which was considered insufficient to detect any risk factor in this study. Further prospective studies including greater numbers of patients are needed to determine the risk factors for DVT after elective shoulder surgery.

Conclusions

The incidence of VTE after elective arthroscopic shoulder surgery was 5.7%. All patients who had DVTs were asymptomatic, and most of the DVTs occurred 1 or 2 days after surgery.

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