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Effect of tourniquet application on deep vein thrombosis after total knee arthroplasty

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Abstract
Introduction There is a great deal of controversy about the effect of tourniquets on development of deep vein thrombosis (DVT) after total knee arthroplasty (TKA).
Patients and methods We investigated the incidence of postoperative DVT after TKA with or without the use of a tourniquet. The patients were 48 consecutive patients undergoing primary ipsilateral cemented TKA for osteoarthritis. Group A (21 patients) underwent the operation without a tourniquet, and Group B (27 patients) underwent the operation with a tourniquet. Ultrasonography to assess DVT was performed before and after the operation.
Results Group B had less intraoperative and total blood loss than Group A. Postoperative DVT was detected in 81.3% of all cases, and symptomatic pulmonary embolism occurred in 1.7%. Most of DVT was found in the calf vein. There was no significant difference in the incidence of postoperative DVT between the two groups.
Conclusion We conclude that the use of a tourniquet is beneficial, because it decreases perioperative blood loss and does not increase the risk of DVT. The incidence of DVT after TKA is considerably high with or without use of a tourniquet. Therefore, prevention and early detection of DVT are important for prevention of fatal pulmonary thromboembolism.

Keywords TKA · DVT · Tourniquet · Ultrasonography · Complication

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Introduction

Deep vein thrombosis (DVT) is a serious complication after total joint arthroplasty. The reported incidence of DVT after total knee arthroplasty (TKA) is relatively high, ranging from 40 to 84% [16, 18, 26, 27], and pulmonary embolism is the major cause of mortality after TKA, with reported incidence ranging 0.5–1.8% [15, 26, 27]. Thus, prevention and early detection of postoperative DVT are important for prevention of such complications.

Pneumatic tourniquets are widely used in TKA, and provide a bloodless field and better cement-bone interface during operation. However, pneumatic tourniquets are associated with several complications, including nerve palsy [8, 23], vascular injury [11], muscle damage [21, 24], postoperative swelling and stiffness [13]. A tourniquet can cause venous stasis or endothelial damage via direct trauma. In several studies, thrombus has been detected by transesophageal echocardiography immediately after tourniquet release during TKA [20]. Moreover, previous study suggests that tourniquet deflation after knee surgery is associated with intraoperative cardiac arrest [17]. However, there is a great deal of controversy about the effect of tourniquets on development of DVT. The aim of the present study was to investigate the incidence of DVT after TKA with or without the use of a tourniquet.

Patients and methods

This study is a prospective comparison of a consecutive series of patients who were treated with primary TKA by the senior author. The subjects were 48 consecutive patients undergoing primary ipsilateral cemented TKA for osteoarthritis. Group A (21 patients) underwent TKA without a tourniquet between April 2003 and April 2004. Group B (27 patients) underwent TKA with a tourniquet between May 2004 and April 2005. We excluded patients with rheumatoid arthritis or previous thromboembolism. All patients received epidural anesthesia in conjunction with general anesthesia. A pneumatic thigh tourniquet was applied and inflated to a pressure of 350 mmHg and was released before wound closure.

All operations consisted of condylar-type, patella-resurfacing, cemented arthroplasty via a midvastus approach. None of the patients required lateral retinacular release. A hemovac drain was placed in the wound immediately after surgery, and was removed 48 h after surgery. All patients were managed with a foot pump (A-V Impulse System; Novamedix, Andover, UK) on both legs to prevent DVT, but none of the patients received anticoagulation prophylaxis.

Anticoagulant therapy was administered only if DVT was detected. Ultrasonography to assess DVT was performed by one experienced examiner 1 day before the operation and 5 days postoperatively, using a 7.5 MHz ultrasonography probe (EUB-165A; Hitachi Medical Corporation, Tokyo, Japan). The examiner was blinded to the intraoperative procedure. The following veins were examined for DVT: femoral, popliteal, posterior tibial, peroneal, gastrocunemius, and soleus vein. The criteria for a positive ultrasound test for DVT were non-compressibility of the vein and dense intraluminal echoes. Popliteal and femoral thrombi were classified as proximal DVT, and thrombi in the calf were classified as distal DVT. The sensitivity, specificity and accuracy of ultrasonographic screening for the diagnosis of DVT compared with venography in our institution was 96, 97 and 97% in the proximal DVT, 92, 75 and 86% in the distal DVT (unpublished data).

Postoperatively, the operated limb was elevated on a pillow. Quadriceps-setting exercises were initiated 1 day after surgery. Standing and walking was allowed 2 days after surgery. We collected the following data for each patient: age, sex, height, weight, body mass index (BMI), operating time, and blood loss. Operating time was defined as the period from surgical incision to skin closure.

Intraoperative blood loss was measured by adding the amount of the volume in suction bottles after reduction of wound irrigation fluid and the net blood weight of the swabs during the operation.

Postoperative blood loss was estimated as the blood in the suction drainage at 24 h postoperative. Total blood loss was defined as the sum of intraoperative and postoperative blood loss.

Statistical analysis of differences between the two groups was performed using Student *t* test for normally distributed data and Mann–Whitney *U* test for not normally distributed data (nonparametric data). The incidence of postoperative DVT with or without tourniquet was analyzed by Fisher exact test. Statistical significance was defined as $P < 0.05$.

Results

The characteristics of the 48 patients are summarized in Table 1. There was no significant difference in gender, age, height, weight or body mass index between the two groups. The data regarding operating time and blood loss are summarized in Table 2. There was no significant difference in operating time or postoperative blood loss between the two groups. However, intraoperative and total blood loss was significantly higher in-group A than in-group B.

Postoperative DVT was detected in 81.3% of all cases, 86% of group A, and 77.8% of group B. The incidence of DVT was slightly higher in-group A than in-group B, but the difference was not significant (Table 3). Except for two cases, 46 cases were detected in the operated leg. The locations of DVT are summarized in Table 4. Proximal DVT was found in three cases: one patient in-group A, and two patients in-group B. The most frequent location of distal DVT was

Table 1 Patient characteristics

	Group A ($n = 21$)	Group B ($n = 27$)	*P*-value
Female/male	18/3	23/4	NS
Mean age (years) (range)	73.1 ± 5.6 (57–81)	71.2 ± 8.2 (52–83)	NS
Mean height (kg) (range)	149.6 ± 6.9(137–167)	149.7 ± 7 (137–163)	NS
Mean weight (kg) (range)	59.2 ± 7.2 (48–76)	58.9 ± 9.9 (42–82)	NS
Mean body mass index (range)	26.5 ± 2.8 (21.6–33.3)	26.1 ± 3 (21.1–32.8)	NS

Table 2 Operating time and blood loss

	Group A	Group B	*P*-value
Mean operating time (min) (range)	114.0 ± 13.6 (92–153)	117.4 ± 23.2 (82–176)	NS
Mean intraoperative blood loss (ml) (range)	631.1 ± 342.8 (104–1,290)	228 ± 165.1 (20–749)	$P < 0.0001$
Mean postoperative blood loss (ml) (range)	457.6 ± 163.4 (230–850)	467.3 ± 197.8 (115–1,115)	NS
Mean total blood loss (ml) (range)	1,088.8 ± 338.0 (587–1,790)	690.7 ± 273.9 (346–1,455)	$P < 0.0001$

Table 3 Incidence of postoperative DVT

	DVT (−)	DVT (+)	Total
Group A	3	18	21
Group B	6	21	27
Total	9	39	48

$P = 0.376534$

Table 4 Locations of postoperative DVT

	Group A	Group B
Proximal DVT	1	2
Distal DVT		
Soleus vein	15	18
Peroneal vein	7	11
Posterior tibial vein	2	2
Gastrocnemius vein	1	0
Total DVT	26	33

the soleus vein, followed by the peroneal vein, posterior tibial vein and gastrocunemius vein. Symptomatic pulmonary embolism, which was diagnosed on lung scans, occurred in two patients (1.7%): one patient in-group A, and one patient in-group B. Both of these patients received anticoagulation therapy with heparin, and neither patient suffered a fatal pulmonary embolism.

Discussion

In the present study, the incidence of DVT following TKA was high as reported by others, and the use of a tourniquet did not increase the incidence of DVT. The present patients underwent cemented TKA under general anesthesia without anticoagulation prophylaxis. The high incidence of DVT in the present study is due to several factors, including patient characteristics, anticoagulation prophylaxis, type of anesthesia and surgical procedures. Patients who undergo joint arthroplasty often have a number of characteristics that increase risk of thromboembolism, including advanced age, obesity, prolonged immobilization, varicose veins, and cardiac dysfunction. Several studies indicate that patients who undergo joint arthroplasty under spinal or epidural anesthesia have a lower rate of DVT than patients who undergo joint arthroplasty under general anesthesia [5, 10, 19, 22, 28]. The use of cement may also increase the risk of postoperative DVT. It has been reported that cementing of a prosthesis is associated with increased incidence of DVT [7, 16]. However, recent randomized controlled studies indicate that the use of cement does not contribute to the onset of DVT [4, 12, 14, 30].

The triad of venous stasis, endothelial injury and hypercoagulability is associated with formation of thrombi, and is present in patients being managed with TKA. Positioning of the limb during TKA or the use of a tourniquet can cause venous stasis and endothelial damage. Moreover, the TKA procedure causes sustained activation of tissue factor and other clotting factors. It is reported that tourniquet ischaemia increases levels of plasma beta-thromboglobulin and plasma thromboxane-B2 (a marker of in vivo platelet release reaction), thus increasing the risk of DVT in patients undergoing TKA [31]. Therefore, the use of a tourniquet appears to increase the risk of DVT. However, there is still controversy about the effect of a tourniquet on development of DVT. In the present study, we found no statistical difference in the incidence of DVT between patients who underwent TKA with a tourniquet and patients who underwent TKA without a tourniquet.

Many surgeons prefer to use a tourniquet during TKA because it allows a shorter operative time, easier surgical technique and better cement fixation. Several reports indicate that use of a tourniquet does not increase the risk of DVT [3, 6, 9, 25, 27, 29]. However, in a study by Abdel-salam et al., use of a tourniquet in TKA was associated with increased incidence of postoperative pain, delayed recovery of muscle power, wound complications and DVT [1]. However, in those studies, the method used to assess DVT is unclear, and their reported incidence of DVT is much lower than the generally accepted rate. The present study is the first in which the incidence of both proximal and distal

DVT was precisely examined using ultrasonography, although we did not randomize the patients.

In the present study, the incidence of DVT was high with or without use of a tourniquet. Thus, it appears that parts of the TKA procedure itself, such as limb twisting and flexion of the knee, cause formation of DVT. In a previous study, a hypercoagulative state occurred in patients after TKA with or without use of a tourniquet. Also in that study, the total amount of thrombin generation was high after TKA without a tourniquet, and fibrinolysis was significantly greater after TKA with a tourniquet [2]. In the present study, incidence of DVT and blood loss was higher for patients who underwent TKA without a tourniquet than for patients who underwent TKA with a tourniquet, although the difference in incidence of DVT was not significant. These findings suggest that enhanced fibrinolysis in patients who undergo TKA with a tourniquet protects against formation of DVT and that hypercoagulable state secondary to an increased blood loss without using a tourniquet may contribute to the formation of DVT.

In conclusion, the present results suggest that it is beneficial to use a tourniquet during TKA because it decreases perioperative blood loss and does not increase the risk of DVT. The incidence of DVT after TKA is high with or without use of a tourniquet. Prevention and early detection of DVT are important for prevention of fatal pulmonary thromboembolism and cardiovascular complications, which are the major causes of mortality after TKA.

Acknowledgments I confirm that all authors have seen and agree with the contents of the manuscript and agree that the work has not been submitted or published elsewhere in whole or in part. Each author certifies that his institution has approved the human protocol for this investigation were and that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained. Each author certifies that he has no commercial associations that might pose a conflict of interest in connection with submitted article.

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