Diagnosis of Deep Venous Thrombosis after Total Knee Arthroplasty: A Comparison of Ultrasound and Venography Studies

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Background: A prospective clinical study was performed to compare the diagnostic accuracy between ultrasound and venography of deep venous thrombosis (DVT) after total knee arthroplasty (TKA).

Methods: This series consisted of 55 patients (43 women and 12 men) with an average age of 61 (range, 51-81) years who underwent TKA. No pharmaceutical prophylaxis for DVT was administered. Ultrasound and venographic studies were performed to detect DVT within 5 to 7 days postoperatively.

Results: The incidence of DVT was 36% (20 of 55) by clinical examination, 42% (23 of 55) by ultrasound study, and 58% (32 of 55) with venography. The difference in number of cases of DVT determined between ultrasound and venography study was marginally significant statistically ($p=0.082$). When the venographic results were used as the baseline reference, the sensitivity and specificity of the ultrasound study in the diagnosis of DVT after TKA were 87% and 63%, respectively.

Conclusion: Ultrasound is a reasonably good alternative to venography in the diagnosis of DVT after TKA. Ultrasound is non-invasive, safe, and convenient. Ultrasound can be used as the initial screening test for clinically suspected DVT to be followed by venography in cases of equivocal results of the ultrasound study and in patients with negative ultrasound results but clinically evident DVT.

(Chang Gung Med J 2004;27:16-21)

Key words: **deep venous thrombosis, ultrasound, venography, total knee arthroplasty.**

The incidence of deep venous thrombosis (DVT) after total knee arthroplasty (TKA) in Western countries has consistently been high, ranging from 50% to 80%, and routine prophylaxis is considered a standard of patient care.[1-7] The incidence of DVT in Asian populations, however, was believed to be rare, and routine prophylaxis is not used in most hospitals.[8-12] One of the reasons for the low incidence of DVT was attributed to the methodology used in the diagnosis of DVT in those studies.[13-21] When venography was used to detect DVT, several recent studies demonstrated that the incidence of DVT in the Asians was similar to that of Western countries.[22,23] However, the rate of proximal DVT

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Received: Jun. 12, 2003; Accepted: Aug. 22, 2003

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was much lower, while the incidence of pulmonary embolism was quite rare.[23] Therefore, the significance of DVT and routine prophylaxis against DVT in Asians remains debatable.

Many methods have been employed in the diagnosis of DVT including I^{131} fibrinogen, Tc^{99}-labelled fibrinogen scintigraphy (venoscan), plethysmography, ultrasound, and venography.[2,6,16,17,19] Among these, ascending venography is considered the gold standard for the diagnosis of DVT.[24] However, many surgeons are reluctant to prescribe venography because it is an invasive procedure and may incur certain risks and complications. With improvements in technology, ultrasound has been used more and more frequently in the detection of DVT because of its non-invasiveness, convenience, and cost-effectiveness. However, the accuracy of ultrasound in the diagnosis of DVT was reported to be less favorable, especially in distal DVT and non-occlusive proximal DVT.[13-15] The majority of data on DVT after TKA were based on studies performed in Caucasians, and information on Asians is lacking.[25] The purpose of this study was to compare the accuracy of DVT detection between ultrasound and venography after TKA in Taiwanese patients.

METHODS

Between September 2001 and February 2002, 55 patients undergoing TKA were randomly recruited for this study. The exclusion criteria included patients with recent thromboembolic disorders, and a history of hematological coagulopathy or of an allergy to iodine. There were 12 males and 43 females with an average age of 66 (range, 51-81) years and an average body weight of 66 (range, 51-100) kg. The right knee was affected in 28 cases and the left knee in 27. One surgeon (CJW) performed all operations, and only 1 type of prosthesis was implanted (Advantim, Wright Medical, Arlington, TN). No pharmaceutical prophylaxis against DVT was given. Postoperative management included bedside continuous passive motion (CPM) on the second postoperative day, ambulation with partial weight bearing as tolerated, and quadriceps and hamstring exercises. Patients were encouraged to do calf pump exercises immediately after surgery. The pain was controlled with either patient-controlled anesthesia (PCA) or intramuscular meperidine for the first 72 hours, and then was changed to codeine or acetaminophen in conjunction with non-steroidal anti-inflammatory drugs (NSAIDs).

Informed consent was obtained for both ultrasound and venographic studies. Both studies were performed within 5 to 7 days after surgery. The ultrasound study was usually performed prior to venography.

Acuson (Mountain View, CA) Aspen ultrasound was used in the study. The examination begins from the calf veins where anterior tibial, posterior tibial, peroneal, and muscular branches are sequentially scanned. The patient sits on the bedside with the legs over the side of the table to produce distension of the veins. Once the calf veins have been examined, the patient then lies in a lateral decubitus position with elevation of the cranial side of the table. Partial flexion of the knee is also necessary to facilitate scanning of the popliteal veins. Finally, the patient turns into a supine position to study the femoral vein up to the groin area. The parameters of the sonographic color Doppler system are set up for detecting the venous system of the lower extremities, and Duplex ultrasound is also performed if necessary. Compression of the veins and augmentation of venous flow are routinely applied.

Venography was performed under sterile conditions and local anesthesia. Approximately 60 to 70 ml of ionized contrast media (hypaque-76) was injected into the vein on the dorsum of the foot. The venous flow of the lower extremity was viewed using a full-length X-ray film. During the course of the study, vital signs were carefully monitored. At completion of the procedure, patients were checked for complications such as fever, chills, skin rash, and local redness at the injection site.

Clinical findings of suspected deep venous thrombosis included pain and swelling of the affected leg, leg edema, calf and thigh girth enlargement, skin discoloration, venous engorgement, and Homans' sign. The criteria of ultrasonic DVT included echogenic substance in the vein such as static echoes, incomplete color fill-in and expansion of the vein, absent flow, loss of spontaneous flow and respiratory variation, absent or reduced compressibility, and impaired or absent augmentation of flow. The criteria of venographic DVT included an intraluminal filling defect, abrupt termination of the opaque contrast column, and non-filling of deep veins above

the knee. The results of both ultrasound and venography studies were independently interpreted by 2 blinded orthopedic radiologists. Any difference of opinion was discussed to reach a consensus before the final report was issued.

RESULTS

The incidence of DVT was 36% (20 of 55) by clinical examination, 42% (23 of 55) with ultrasound, and 58% (32 of 55) by venography. No pulmonary embolism was noted in this series. Results between ultrasound and venography were summarized and compared in Table 1. The difference in the incidence of DVT between ultrasound and venography was marginally statistically significant ($p=0.082$). The rates of proximal and distal DVT were 9% and 91% with ultrasound, and 12.5% and 87.5% with venography. The locations of the DVTs are summarized in Table 2. The majority of DVTs occurred in the calf, and approximately 30% of the DVTs only involved the muscular branches. The average size of clots was 4.7 (range, 4-8) cm for proximal DVTs, and 5.4 (range, 0.5-23) cm for distal DVTs.

Table 1. Incidence of Deep Venous Thrombosis by Ultrasound and Venography

Study method	Ultrasound	Venography	*p*
Case number	55	55	
(+) DVT	23 (42%)	32 (58%)	0.082
Proximal DVT	2 (9%)	4 (12.5%)	
Distal DVT	21 (91%)	28 (87.5%)	
(-) DVT	32 (58%)	23 (42%)	
Pulmonary embolism	0	0	

(by Chi-square test)

Table 2. Geographic Distribution of Deep Venous Thromboses

Location	Ultrasound	Venography
Proximal DVT		
Iliac	0	0
Femoral	0	0
Popliteal	2	4
Distal DVT		
Ant. tib.	0	1
Ant. tib.+post. tib.	0	2
Ant. tib.+peroneal	0	1
Ant. tib.+post. tib.+peroneal	1	2
Post. tib.	2	1
Post. tib.+peroneal	6	6
Peroneal	5	5
Muscular branches	7	10
Total	23	32

Ant. tib.: anterior tibia; Post. tib.: posterior tibia.

When venography was used as the baseline diagnostic reference, 20 of 23 cases positive for DVT by ultrasound study were also positive for DVT by venography; and 20 of 32 cases negative for DVT by ultrasound study were also negative for DVT by venography. This resulted in a 87% sensitivity and 63% specificity for ultrasound study in the diagnosis of DVT after TKA. By clinical examination, 16 of 20 cases clinically positive for DVT were also positive for DVT by venography, and 19 of 35 cases clinically negative for DVT were also negative for DVT by venography. This resulted in 80% sensitivity and 54% specificity when a DVT diagnosis was made by clinical examination.

Five patients developed transient local redness and pain at the injection site of the foot which spontaneously resolved within a few days. There was no systemic complication related to the venographic study.

DISCUSSION

Results of this study showed that the overall incidence of DVT after TKA in Asian patients is similar to that reported in Western countries. Similar findings were also reported in our previous study.[23] Recently, another study reported that DVT after TKA in Asian patients tended to spontaneously dissolve regardless of the location or the size of the clot.[26] Therefore, the relevance of DVT after TKA and its clinical significance remain controversial, and the debate for routine prophylaxis against DVT continues. Most surgeons prefer a conservative attitude and are reluctant to prescribe venography because the risks may outweigh the benefits. In addition, most patients respond negatively to the suggestion of venography when the risks of venography are discussed. Most physicians have a tendency to utilize ultrasound study because it is a simple, quick, safe, and non-invasive procedure.

Physical examination is the least-accurate method for the diagnosis of DVT.[21] The accuracy of ultrasound in the diagnosis of DVT of the lower extremity remains controversial. Aitken et al.[13]

reported 94% sensitivity and 100% specificity with real-time ultrasound scanning in the diagnosis of DVT, and concluded that real-time ultrasound scanning is a rapid and non-invasive alternative to contrast venography. In addition, ultrasound can detect popliteal cysts, pelvic and inguinal lymphadenopathy, popliteal hematoma, and traumatic arterial aneurysms. However, many studies reported a lower reliability of ultrasound in the diagnosis of DVT as compared with venography despite its high accuracy, sensitivity, and specificity.[2,6,13-21,24] Bounameaux et al.[14] showed that the combination of 2 non-invasive methods (Doppler ultrasound flow examination and strain gauge plethysmography) could not reliably replace venography in the diagnosis of DVT despite all proximal DVT cases being diagnosed with a non-invasive method. Sandler et al.[19] compared the diagnosis of DVT by clinical evaluation, ultrasound, plethysmography, and venoscan with venography and concluded that venography is the only investigation suitable for a definite diagnosis of DVT. The venoscan may have a role as a screening procedure, to be followed by venography in patients with equivocal venoscan results. Jeffery et al.[17] showed that both impedance plethysmography and Doppler ultrasonography were highly sensitive in the diagnosis of proximal occlusive DVT, but considerably less sensitive for the potentially more-dangerous proximal non-occlusive thrombosis, and recommended that in the presence of clinically suspected DVT with negative non-invasive methods, ascending venography remains essential. The results of this study showed that ultrasound produced a comparable accuracy despite a lower sensitivity and specificity as compared with venography in the diagnosis of DVT after TKA, and these findings differed somewhat from the results of other previous studies.[13,17]

In conclusion, ultrasound produces comparable diagnostic accuracy, but a lower sensitivity and specificity as compared with venography, and is considered a reasonably good alternative to venography in the diagnosis of DVT after TKA. Ultrasound can be used as the initial screening test of choice in clinically suspected DVT to be followed with venography in cases with equivocal ultrasound results and in patients with negative ultrasound results but clinically evident DVT.

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全人工膝關節術後發生深部靜脈栓塞之診斷：超音波和靜脈攝影比較之研究

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背 景： 本論文是比較超音波和靜脈攝影，在診斷全人工膝關節置換後深部靜脈栓塞上的準確性的研究。

方 法： 對象包括55位接受全人工關節置換手術的病人，其中包含43位女性及12位男性，平均年齡61歲（從51至81歲）。所有病人皆無接受預防深部靜脈栓塞之藥物。病人在術後5至7天接受超音波及靜脈攝影檢查。

結 果： 經由臨床檢查，深部靜脈栓塞的發生率爲36% (20/55)；經由超音波檢查爲42%；經由靜脈攝影檢查爲58%。因超音波檢查或由靜脈攝影檢查之發生率的差別無統計學上之意義 ($p=0.082$)。若用靜脈攝影檢查的結果當參考基準，使用超音波檢查對術後深部靜脈栓塞之診斷的敏感度及特異度分別爲87%及63%。

結 論： 當臨床上有懷疑深部靜脈栓塞時，用超音波檢查是靜脈攝影檢查除外的一種好選擇。確認靜脈血栓遇到超音波檢查結果有異議，或臨床上有深部靜脈栓塞症狀但是超音波檢查正常者，一定要做靜脈攝影檢查。

(長庚醫誌 2004;27:16-21)

關鍵字： 靜脈栓塞，超音波，靜脈攝影，全人工膝關節置換術。

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