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Spiral CT venography of the lower extremities by injection via an arm vein in patients with leg swelling

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Abstract. The purpose of this prospective study was to assess the role of spiral CT venography (CTV) via an arm vein injection in the detection of causes of leg swelling. 42 consecutive patients with leg swelling were studied with indirect spiral CTV and ultrasound (US). CT parameters were as follows: 5 mm beam collimation; 7–10 mm s^{-1} table speed; and 2–3 mm reconstruction. Two consecutive spiral scans with a 40 s exposure time were performed from the pelvis to the knee. One bolus of 150 ml non-ionic contrast medium was injected at a rate of 3 ml s^{-1} by a power injector via an arm vein. The delay times to the first and second scans were 120 s and 180 s, respectively. Spiral CTV demonstrated not only deep vein thrombosis (DVT) (n=12) but also other abnormalities (n=25). US showed DVT (n=10) and some other abnormalities (n=5). The sensitivity and specificity of spiral CTV for femoropopliteal DVT, as compared with US, were both 100%. Two cases of DVT in the left common-external iliac vein (iliac vein compression syndrome) detected by spiral CTV were not confirmed by US. We were able to evaluate DVT above the knee with this method. Indirect spiral CTV showed promise for the diagnosis of DVT and other soft tissue diseases in patients with leg swelling.

Accurate evaluation of the swollen leg is crucial to effective therapy. There are many causes of leg swelling. In particular, deep vein thrombosis (DVT) of the legs is a major cause of mortality and morbidity and may lead to pulmonary embolism. It is therefore very important to differentiate DVT from other diseases in cases with leg swelling.

Various techniques may be used to assess leg swelling and oedema [1–3]. Pillari et al [3] reported that conventional CT was effective in demonstrating occult mechanisms of leg swelling, such as joint effusion and intramuscular haemorrhage, in patients with leg swelling and negative venography. In early reports [4, 5], spiral CT venography (CTV) of the legs was performed in cases with leg swelling by injection of the affected leg. Spiral CT is, therefore, a promising method for the detection of DVT and soft tissue abnormalities in cases with leg swelling. However, direct spiral CTV has the disadvantage of difficulty of venous puncture in patients with leg swelling [5]. We attempted to perform spiral CTV of the whole leg with an arm vein injection for the evaluation of the causes of leg swelling, and compared the findings of spiral CTV with those of ultrasound (US).

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Materials and methods

42 consecutive patients (20 male, 22 female; age range 32–77 years, mean age 58 years) prospectively underwent spiral CTV with injection via an arm vein (indirect spiral CTV) as well as US of the lower extremities, for evaluation of leg swelling. 25 patients had bilateral leg swelling and 17 patients had unilateral leg swelling. No patient had acute chest pain, allergy to iodinated contrast medium, renal insufficiency or a history of leg trauma or recent surgery. Five patients had a history of DVT. Appropriate informed consent was obtained from all patients in accordance with the Declaration of Helsinki principles.

A Somatom Plus-S CT scanner (Siemens, Erlangen, Germany) was used in all cases. The maximum continuous scanning time of spiral CT was 40 s. Scanning parameters were as follows: 5 mm beam collimation; 7–10 mm s^{-1} table speed; and 2–3 mm reconstruction. Two consecutive spiral scans with a 40 s exposure time were performed, with an interscan delay of 20 s for cooling of the X-ray tube. The first spiral scan was in the pelvis and groin region. The second spiral scan was in the thigh and knee region.

Patients were positioned supine with a folded blanket under the heels to avoid compression of the calf veins. A single 150 ml bolus of non-ionic contrast material (370 mgI ml^{-1}) was injected by a power injector via an arm vein at a rate of 3 ml s^{-1}. The delay times to the first and second scans were 120 s and 180 s, respectively.

Axial CT images were used to evaluate the deep venous system and the other soft tissues. Maximum intensity projection (MIP), shaded surface display (SSD) and multiplanar reformation (MPR) were only created at the request of a referring physician. Spiral CTV and US were scored independently. Discrepancies were resolved by an additional consensus reading. The grade of venous opacification was scored on a three point scale, 0 being poor opacification, 1 being moderate opacification and 2 being excellent opacification. This scale was applied to three segments of 84 limbs; the pelvic veins (common and external iliac veins), the femoral vein including any duplication and the popliteal vein. In cases with positive findings of DVT, normal venous segments just distal or proximal to a DVT were interpreted using the grading. The presence or absence of DVT was judged using the same three segments. The diagnostic criteria of DVT on CT [4–10] were the presence of an intraluminal filling defect in an opacified vein, or a localized non-opacified venous segment on at least two consecutive axial CT images if the vein distal and proximal to the non-opacified segment was opacified. The criteria for determining the absence of DVT on CT was uniform enhancement in a vein. In addition, soft tissue abnormalities on CT were noted. US of the femoropopliteal areas (from the inguinal ligament to the popliteal trifurcation) was performed in all patients within 1 day of spiral CTV, using standard compression and Doppler techniques [11–13]. No attempt was made for the evaluation of direct or indirect findings indicating pelvic DVT by US. The findings of spiral CTV were compared with those of US. In the detection of DVT, when the findings of spiral CTV did not agree with those of US, radionuclide venography (RNV) using $^{99}Tc^{m}$-labelled macroaggregated albumin [14–16] was subsequently used to diagnose the presence of DVT. The final clinical diagnosis of DVT was made by considering the results of all examinations.

Results

No technical failures occurred in the spiral CTV studies. There were no complications related to spiral CTV in any of the cases. The grades of venous opacification are shown in Table 1. There was no grade 0 (poor opacification) in any vein.

Table 1. Grade of venous opacification in 84 limbs

Segment	Grade		
	0	1	2
Pelvic veins	0	24	60
Femoral vein	0	26	58
Popliteal vein	0	32	52

Grade 0, poor opacification; Grade 1, moderate opacification; Grade 2, excellent opacification.

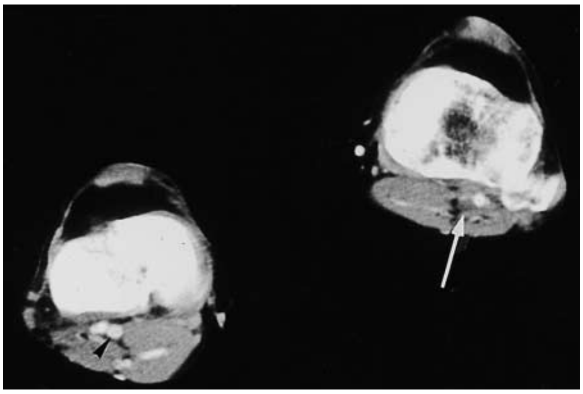
In summary, indirect spiral CTV showed good visualization of the deep vein system in all cases.

From the results of all corroborative studies, DVT was present in 12 patients. Spiral CTV findings were positive for DVT in 12 patients. Spiral CTV showed no evidence of DVT in 30 patients. 10 cases of DVT in the femoropopliteal veins detected by spiral CTV were confirmed by US (Figure 1). Two cases of DVT in the left common-external iliac vein detected by spiral CTV were not examined by US. However, RNV and follow-up spiral CTV confirmed the presence of pelvic DVT. Spiral CTV of these two cases indicated that pelvic DVT was secondary to iliac vein compression syndrome (May–Thurner syndrome). The sensitivity and specificity of indirect spiral CTV for femoropopliteal DVT, as compared with US, were both 100%.

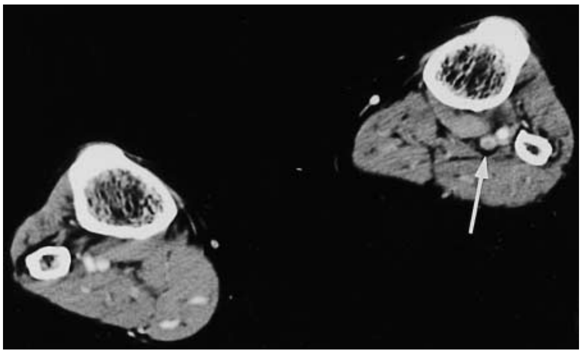
CT axial images showed lymphadenopathy (n=7), generalized soft tissue oedema including lymphoedema (n=6), obesity (n=3), joint effusion (n=3), retroperitoneal fibrosis (n=1), popliteal cyst (n=1), bone metastasis (n=1), iliopsoas bursitis (n=1), haematoma (n=1) and haemangioma (n=1). US demonstrated joint effusion (n=2), popliteal cyst (n=1), iliopsoas bursitis (n=1) and haematoma (n=1). Five patients had no obvious reason for leg swelling on spiral CTV and US.

Discussion

The differentiation of DVT from other causes of leg swelling is very important for the initiation of anticoagulation therapy. Our experience shows that indirect spiral CTV can demonstrate not only DVT but also other abnormalities such as popliteal cyst, iliopectineal bursitis and bone metastasis. Iliac vein compression syndrome (May–Thurner syndrome) is caused by compression of the left iliac vein against the lumbar vertebrae by the right iliac artery. Baron et al [17] commented that iliac vein compression syndrome, often overlooked, is thought to be present in approximately 20% of the adult population. Radiologists and physicians need to be aware of this syndrome as one of the causes of pelvic DVT



(a)



(b)

Figure 1. Deep vein thrombosis of the left popliteal vein in a 54-year-old woman with unilateral leg swelling, later confirmed by ultrasound. (a) CT axial image at knee level shows non-opacification of the left popliteal vein (arrow). The right popliteal vein is normal (arrow head). (b) CT axial image 3.0 cm caudal to (a) shows an intraluminal filling defect of the left popliteal vein without expansion (arrow).

when radiological examinations show thrombus of the left common and external iliac veins. Sakakibara and Kujiraoka [18] stated that iliac vein compression syndrome may be confirmed more frequently by spiral CT. Recently, Spritzer et al [19] reported that the relative frequency of isolated pelvic DVT was higher than previously reported. They commented that the true frequency of isolated pelvic DVT has been underestimated owing to technical deficiencies of venography and US. It is therefore important to examine the pelvic veins on spiral CT with a smaller section thickness.

Conventional venography is the gold standard for the evaluation of DVT, but has some disadvantages. This method is associated with post-procedural phlebitis and sometimes yields technically inadequate examinations because the femoral or iliac veins in particular show poor opacification [20–22].

US of the legs has been used widely for the screening of DVT. The disadvantages of US are dependence on the skill of the operator, technical difficulties in patients with oedema, wounds or obesity, low sensitivity for assessing DVT in the iliac veins and duplicated superficial femoral veins, and difficulty in differentiating recanalized thrombus from fresh thrombus [11–13]. Therefore, whilst US is the accepted clinical standard, it is not 100% sensitive or specific in the detection of DVT. The advantages of CTV over US or conventional venography lie in the short examination time, the lack of operator dependence and the ability to study the iliac veins [5, 7]. Baldt et al [5] reported that use of MIP and SSD did not contribute to the final diagnosis of DVT. We believe that radiologists require only axial CT images, but many physicians prefer venography-like images. The disadvantages of direct CTV are the need for venous puncture in a swollen lower extremity and flow artefacts [4, 5]. Spiral CTV via an arm vein injection has no risk of post-procedural phlebitis in the swollen lower extremities. However, indirect spiral CTV requires a large volume of contrast medium and has limitations in patients with impaired renal function. The deep vein system above the knee can be evaluated with indirect spiral CTV. Advances in CT technology, such as multidetector-row helical CT (multislice CT) may allow coverage of the whole volume of the legs in a single continuous acquisition. CTV using multislice CT may become a popular examination for the detection of the causes of leg swelling in the near future. We are currently evaluating indirect CTV by multislice CT with long coverage of the legs.

There were several limitations of our study. The primary limitation was the lack of a gold standard for detection of soft tissue abnormalities. Secondarily, there were a small number of confirmed cases with DVT. There are therefore no data as to whether spiral CTV can actually distinguish a fresh thrombus from an old thrombus. However, Stehling et al [4] reported that a central filling defect within an expanded vein was characteristic of acute DVT, and a thrombus adherent to the wall was characteristic of chronic DVT on spiral CTV. Finally, there was a possibility of selection bias yielding a low incidence of DVT, because over 50% of the patients had bilateral leg swelling and no patients had chest pain.

In recent years, pulmonary embolism and DVT of the lower extremities have increasingly been considered as a single disease entity, namely venous thromboembolism. In recent reports [6, 8–10], CTV was performed via an arm vein injection after the completion of spiral CT pulmonary angiography in cases with suspected pulmonary embolism. Their approach was rational in patients with acute chest pain consistent with pulmonary embolism, but was not designed to thoroughly evaluate the pelvis and whole leg. Their limitation was the possibility that pelvic DVT was missed. Moreover, they did not evaluate soft tissue abnormalities as causes of leg swelling.

In conclusion, spiral CTV via an arm vein injection was easy to perform in patients in whom venous puncture would have been difficult in a swollen leg, and it demonstrated excellent visualization of the leg veins in all cases. There is no risk of post-procedural thrombosis in the swollen leg. Spiral CTV is more sensitive than US in the detection of the causes of leg swelling and is a promising method in the evaluation and management of patients with leg swelling.

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