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DIAGNOSIS OF PERIPHERAL VASCULAR DISEASES AND THE PATENCY OF FEMORO-DISTAL BYPASS BY COMPUTED TOMOGRAPHIC ANGIOGRAPHY

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Successful management of patients with peipheral vascular disease reqiures detailed vascular imaging, usually performed by contrast angiography. Arteriography, however, is not without limitations and risks, including failure to identify patent runoff vessels suitable for use in limb salvage procedures in up to 70% of patients. We used computed tomographic angiography (CTA) in preoperative imaging of the peripheral vascular tree of 15 pateints. Conventional angiography and magnetic resonance angiography were used in some patients in addition to CTA to compare their ability in the detection of peripheral vessel and femoro-distal bypass graft patency and the presence of hemodynamically significant stenoses. The findings of CTA were verified by direct operative exploration. CTA accurately detected patent and occluded arterial segments and hemodynamically signifacant stenoses as well as arteriograpy and MRA. Therapeutic plans based on either CTA or conventional arteriography were identical. Conclusions: 1- CTA is a noninvasive imaging technique, obviating arterial puncture and contrast. 2- the sensitivity of CTA for slow flow makes it a very good screening device for vessel and bypass graft patency. 3- Review of the individual axial images not only indicates the exact level at which vessels are patent but also provides a three-dimensional view of stenotic lesions.

INTRODUCTION

Lower extremity angiography is one of the most common angiographic procedures performed in radiology. Conventional angiography are considered the standard of reference for evaluation of the peripheral vasculature, and digital subtraction angiography has been shown to produce results that are virtually equivalent to those of conventional angiography [1,2] Spiral computed tomography (CT) allows rapid acquisition of data that can be properly timed to allow visualization of arterial blood flow in particular anatomic regions [3] The development of CT angiography has included the demonstration of many arterial systems [4] However, this technique has not been employed to evaluate the patency of femoro-distal bypass used in the treatment of peripheral vascular diseases, which may have in part been a result of the long anatomic length of the lower limbs. Imaging of the exremities is not limited by the need for breath holding, and it could be possible to link two to three spiral sets together. By injecting the contrast material at a slower rate, imaging of the lower limb from above the inguinal ligament to below the knee can be performed [4] This prospective study was undertaken to develop a CT angiographic technique that would cover an extended peripheral vascular territory and to investigate the accuracy of CT angiography in the evaluation of peripheral vascular disease and the patency of bypass grafts.

PATIENTS AND METHODS

Fifteen patients (12 men and three women; mean age, 46 years; age range, 42-73 years) were studied by means of spiral CT angiography. They were 15 consecutive patients who were referred from other institutions because of a clinical suspicion of peripheral vascular disease. All patients were symptomatic. The presenting symptoms were long-standing intermittent claudication (n=12), recent marked deterioration of long-standing intermittent claudication (n=2), recent onset of severe intermittent claudication (n=1). Nine patients were smokers, four had diabetes, and none had renal impairment. All patients had undergone color Doppler ultrasound, magnetic resonance angiography (MRA) was done in 5 patients and conventional angiography was performed in 5 patients using standard angiographic technique with a 4- or 5- F pigtail catheter inserted via the femoral artery. Two patients underwent screen-film angiography, and three patients underwent arterial digital subtraction angiography.

Seven femoro-popliteal, 6 femoro-posterior tibial and 2 femoro–anterior tibial bypass grafts were carried out using in-situ saphenous veins. All patients underwent spiral CT angiography before and 6 weeks after femoro-distal bypass on a Hispeed Advantage spiral CT scanner (GE Medical systems, Milwaukee, Wis) Patients were positioned supine and underwent scanning from the inguinal ligament to the distal calf. Contrast agent was injected through an 18-gauge catheter placed in an antecubital vein. We administered 110 ml of iopamidol (Iopamiron [300 mg of iodine per milliliter] ; Schering, Bogota, Colombia) at a rate of 4.5 ml/sec by using a power injector. Scan delays after the start of administration of the bolus of contrast material ranged from 20 to 30 seconds and were individualized by means of a test injection. Ten ml of contrast material was layered under 40-50 ml of saline in a vertically held 60 ml syringe. The total volume was then injected as a bolus, while 15-20 consecutive scans were obtained at the level of the middle of the thigh every 2 seconds, after an initial 10-seconds delay. Visual inspection was performed and/or time-attenuation curves were obtained over the superficial femoral artery and the distal vessels to determine the arrival time of the bolus, from which time the scan delay was calculated. Although imaging during the first passage of bolus is generally necessary in CT angiography, slow runoff of contrast material in the calf allows imaging of these vessels after the bolus injection is completed [4]. Images were reconstructed at a spacing of 2.5 mm. Hard–copy images of the maximum intensity projection reconstructions were obtained at rotational increments of 15^{o} routinely and at other angles of rotation as necessary for optimal visualization of vessls.

RESULTS

In all 15 patients the arteries of the lower limb down to the feet were adequately visualized. CT angiography showed 7 occluded arteries, 4 isolated hemodynamically significant stenoses and 4 multilevel stenoses. Occlusion of variable lengths of the superficial femoral artery (Fig 1 a,b) was the commonest site, whereas the popliteal artery was the least site of affection (Fig 1.c) isolated stenosis in the popliteal trifurcation and multilevel stenosis of the termination of superficial femoral artery together with the anterior and posterior tibial arteries is shown in (Fig 2a,b). CT angiography did not suggest a nonatheromatous cause in any of the cases of stenosis or occlusion. CT angiography correctly demonstrated the cases of stenoses and occlusions detected with arteriography and MRA. However, spiral CT angiography provided supplementary clinically relevant data. CT angiography showed aneurysmal dilatation in oblique view of the popliteal artery (Fig 3a) and angiomatous malformation of the calf in another case (Fig 3b). Seven femoro-popliteal, 6 femoro-posterior tibial and 2 femoro-anterior tibial bypass garfts were carried out using in-situ saphenous vein (Fig 4 a,b,c) Imaging of the bypass grafts was done 3 to 6 weeks after surgery. The proximal anastomosis, the whole length of the graft and the distal anastomosis were identfied in (Fig 5a,b,c). Kinking of the graft in the thigh (Fig 6a) and 5-cm occluded segment at the distal anastomosis (Fig 6b) were also visualized. In contrary to MRA (Fig 7a, b), CT angiography did not overestimate the degree of stenosis at the sites of valves in the long saphenous vein. False-negative diagnoses were substantially less common with C T angiography. The stenosis missed with C T angiography tended to be very small and very likely overlooked.

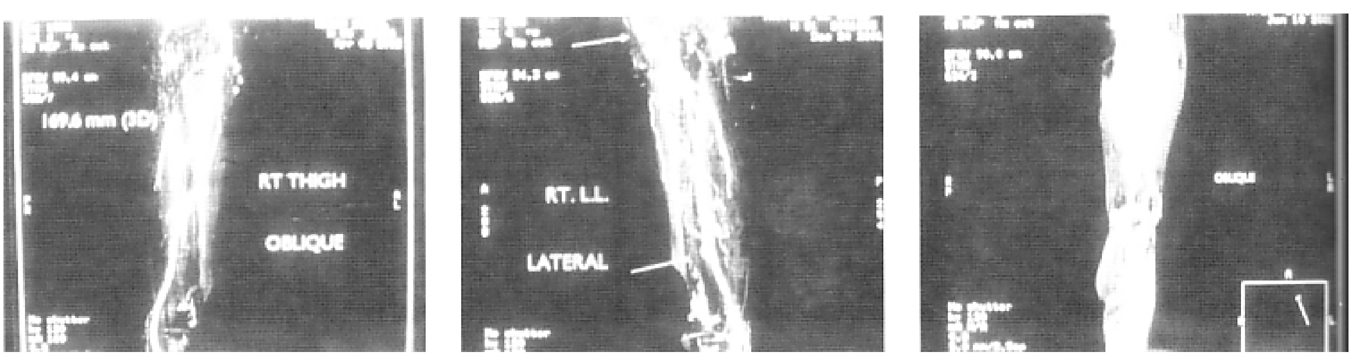

Fig (1) A: CT angiogram of the lower extremity showing an occluded segment, 16.9 cm, of the superficial femoral artery.
B: A longer segment of the occluded superficial femoral artery.
C: Occlusion of the popliteal artery in CT angiogram.

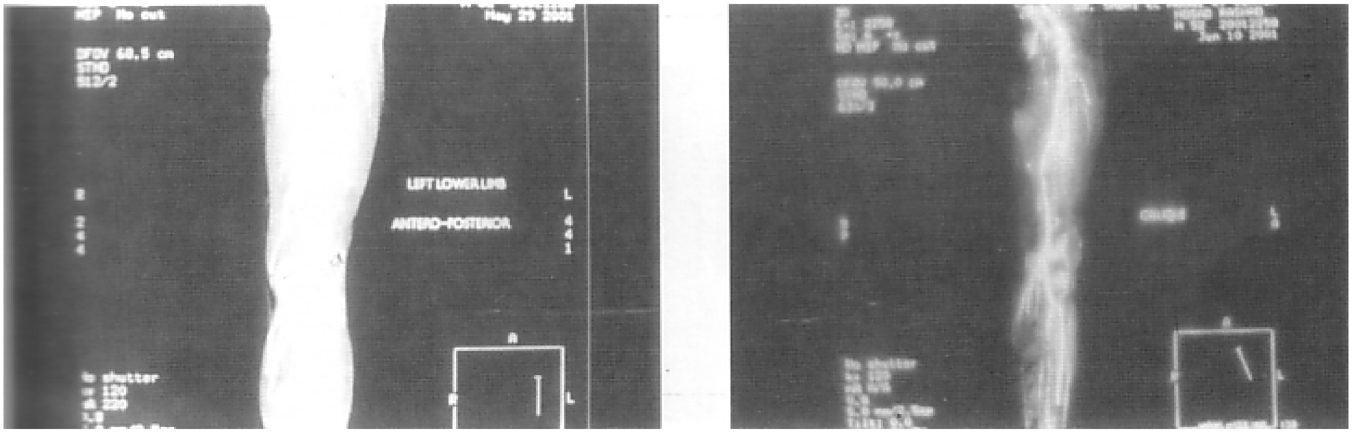

Fig. (2): A-CT angiogram of the lower extremity showing single stenosis
B- multiple stenoses of the popliteal, anterior and posterior tibial arteries.

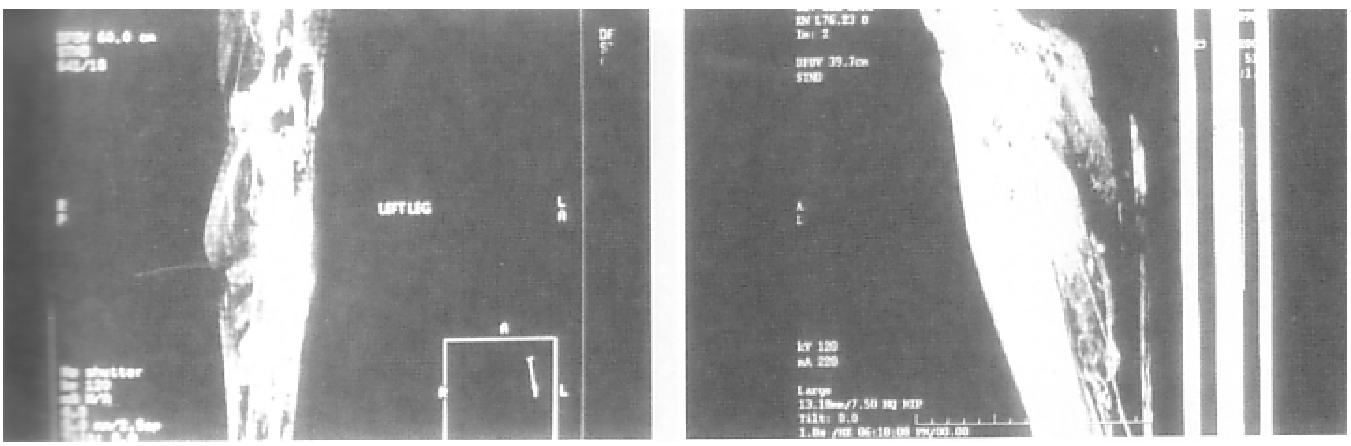

Fig. (3): A: An oblique view of CT angiogram showing popliteal artery aneurysm that was overlooked in conventional angiogram.
B: CT angiogram of the leg vessels depicting angiomatous malformation connected to the posterior tibial artery.

Fig (4): A: The proximal anastomosis of the femoro-distal bypass showing the implanted saphenous vein in the common femoral artery.
B: multiple interrupted incisions to control the tributaries of the saphenous vein.
C: The distal anastomosis of the saphenous vein to the posterior tibial artery.

Fig. (5): :A: Postoperative CT angiogram depicting the proximal anastomosis.
B: The whole length of the grafted saphenous vein from the groin to the lower leg.
C: The distal anastomosis to the popliteal artery showing the smooth curve of the graft, the patent anastomosis and the popliteal trifurcation.

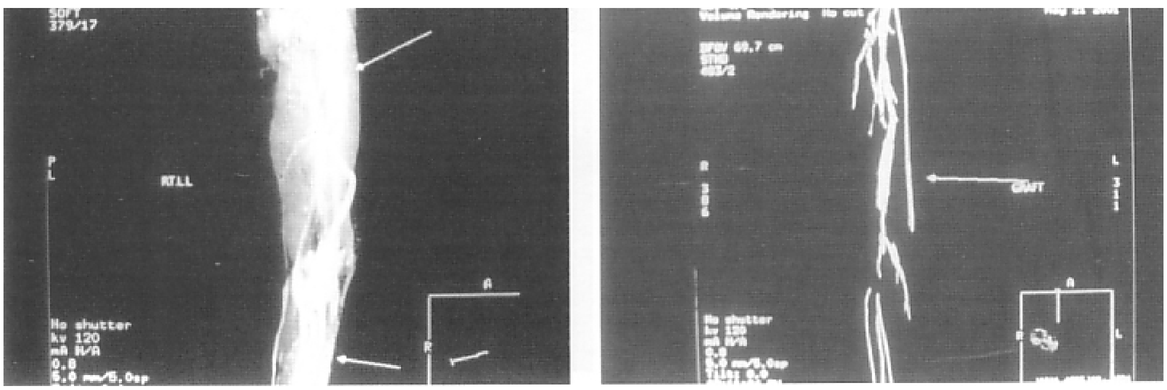

Fig. (6): A: The kinked saphenous vein along its course in the thigh and popliteal region.
B: The occluded segment of saphenous graft at the distal anastomosis to the popliteal artery.

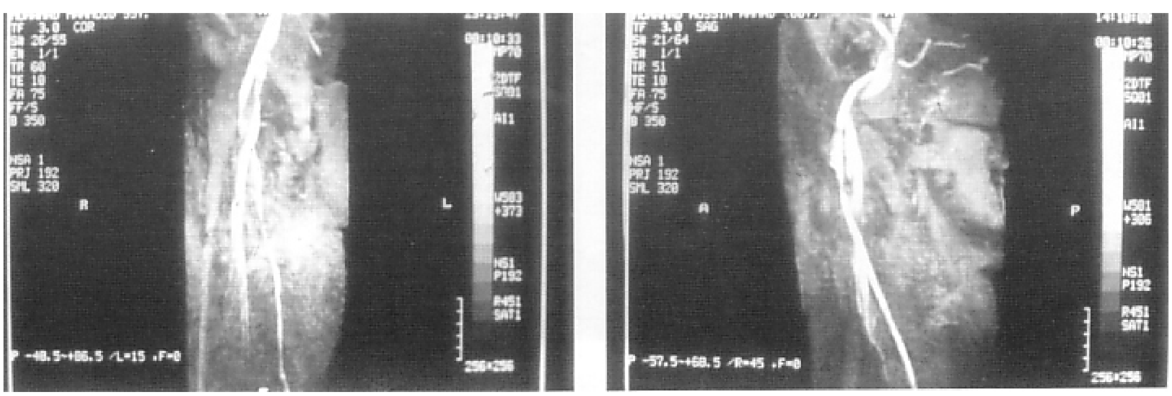

Fig. (7): A,B: MRA of the lower limb showing the overestimated degree of stenosis at the sites of valves in the saphenous vein close to the proximal anastomosis.

DISCUSSION

Computed tomographic (CT) angiography is a method for obtaining angiogram-like images by using the volume acquisition capabilities inherent in spiral CT. The evaluation of patients with lower extremity vascular disease is among the most common indications for angiographic referral. Although findings at conventional angiography are considered the standard of reference for evaluation of the peripheral vasculature, the value of these findings can be reduced by a decrease in quality of the examination as a result of improper timing, the high cost of catheters and film, the invasive nature of the technique, and the long examination time (5). There are relatively few studies that have carefully compared CT angiography with conventional angiography, one such area of interest was the common carotid artery and its bifurcation. The carotid artery is well suited to CT angiography because of its size and orientation. CT angiography demonstrated atherosclerotic stenosis of the carotid artery bifurcation with a correlation of 90% between conventional angiography and CT angiography (6,7), whereas Rubin et al (8) demonstrated 92% sensitivity in the detection of hemodynamically significant renal artery stenosis by using CT angiography. One advantage of CT angiography is the capacity to view the three-dimentional model from any angle after data acquisition to best visualize a stenosis or graft anastomosis. This capability of CT angiography accurately visualized the anastomotic sites & defined the length of occluded graft, moreover, an aneurysm of the posterior wall of the artery was recognized on projection of the artery at different angle. The limitations of Doppler ultrasonography in the assessment of aorta and femoro-popliteal disease (9,10) through its dependence on patient body habitus and operator experience were ruled out in CT angiography.

The limitation that, MRA can not detect retrograde flow because it is purposely designed to image only cephaled to caudal flow, did not seem to be a limitation with CT angiography. Signal loss in MRA because of surgical clips renders interpretation of the imaged segment ambiguous. However, surgical clips do not hamper the image of CT angiography.

Conventional Doppler and color duplex sonography are the most cost-effective procedures to detect or rule out peripheral arterial occlusive disease but can not provide specific recommendations for therapy. MRA with additional axial two-dimensional time-of-flight studies to search for non-anatomic runoff will replace diagnostic intra-arterial digital subtraction angiography for planning of reconstructive surgery (11). Although CT angiography equally identified arterial stenosis, obstruction, and the anastomotic morphology of bypass grafts as well as conventional angiography, the diagnostic accuracy was not helpful in the small arteries and grafts (12).

In conclusion, the results of this study indicate that CT angiography has the potential to be a useful method for identifying the arteries of the lower extremities, grading of stenoses, a low-invasive imaging method that is sufficient for forming strategies for bypass operations. It is a reliable method for visualization of graft patency and the ability to observe the acquired images at any angle was very useful for assessing the implanted graft in infrainguinal bypasses.

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