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Feasibility of multi-slice computed tomography in the diagnosis of arteriogenic erectile dysfunction

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Objective To compare computed tomography (CT) angiography (CTA) obtained by multi-slice CT (a new minimally invasive method) with the current standard of arterial imaging, digital subtraction angiography (DSA), in diagnosing arteriogenic erectile dysfunction (ED).

Patients and methods Twenty-one patients with suspected arteriogenic ED underwent DSA and CTA after providing informed consent. Prostaglandin E1 was injected into the penile cavernosal body and then non-ionic contrast medium was rapidly infused into the antecubital vein. The DSA and CTA images were diagnosed as showing a normal or abnormal status by three reviewers independently. CTA was undertaken on an outpatient basis but DSA required hospitalization.

Results In the 42 internal pudendal arteries, DSA showed 28 normal and 14 impaired arteries; CTA showed 21 normal arteries and 21 occlusions. The CTA image correlated closely with the diagnosis of stenosis or occlusion in internal pudendal arteries, with a sensitivity of 93%, a specificity of 71% and an accuracy of 79%. In the cavernosal arteries, DSA depicted 14 normal and 28 impaired arteries; CTA showed seven normal arteries and 35 occlusions. The CTA image agreed closely with the diagnosis of stenosis or occlusion in cavernosal arteries, with a sensitivity of 96%, a specificity of 43% and an accuracy of 79%. Of the 42 inferior epigastric arteries, DSA could not depict 11 arteries but CTA showed all 42 inferior epigastric arteries.

Conclusions CTA images correlated with DSA images; at present DSA is better than CTA in visualizing stenosis in fine arteries. However, CTA is less invasive and relatively inexpensive, and in future will probably provide even greater improvements in graphic quality. CTA would be an adequate replacement for DSA in evaluating internal pudendal arterial stenosis.

Keywords arteriogenic erectile dysfunction, multi-slice CT, CT angiography, digital subtraction angiography, internal pudendal artery

Introduction

Penile angiography is usually undertaken before penile revascularization surgery, but angiography is a relatively invasive and expensive examination. The rate of change from invasive luminal contrast imaging to noninvasive cross-sectional imaging using ultrasonography, CT angiography (CTA) and MRI is increasing [1]. Recently multi-slice CT has been developed and the quality of CTA has improved remarkably. High-quality angiography, equivalent to that which was obtained previously only by digital subtraction angiography (DSA), can now be obtained by CTA more quickly and less invasively [2–4]. Therefore, this new diagnostic tool has been assessed in many fields of vascular disease [5]. We examined the feasibility of CTA in diagnosing arteriogenic erectile dysfunction (ED).

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Patients and methods

The study included 21 patients (median age 31 years, range 22–57) with suspected arteriogenic ED; after obtaining informed consent, they underwent a standard examination by DSA and then CTA. The results obtained from each examination were compared.

CTA was undertaken as an outpatient examination, using a multi-slice CT scan system (Asteion™, TSX 021, Toshiba Medical, Japan). The scanning conditions were as follows: X-ray beam width 2 mm; scan time 0.75 s/revolution; pitch for reconstruction 1 mm; volume rendering; contrast medium, iomeprol (350 mgI/mL); volume of contrast medium 100 mL; infusion through 22 G intravenous catheter into the antecubital vein, at 3 mL/s; scanning initiated after ≈30 s delay (actual preparation at the femoral artery, 140 HU). Before starting the scan, 10 μg of PGE1 was injected into the cavernosal body of the penis. Contrast medium (iomeprol) was infused into the antecubital vein using an auto-infuser (Autoenhance™ A250, Nemoto-kyorinndou, Japan). Scanning was started automatically when 140 HU was detected by a cursor in the origin of the femoral artery.

DSA was undertaken during hospitalization; using Seldinger's technique, a 5 F catheter was inserted into the femoral artery. First, an aortogram was taken, followed by selective internal pudendal arteriography. At the selected internal pudendal artery, the tip of the 5 F angiography catheter was brought just to the distal portion of the bifurcation of the superior gluteal artery. The X-ray projection axis was tilted 20–30°. An intracavernosal injection with 10 μg of PGE1 was administered 5–10 min before DSA. The contrast medium infusion speed was 2–4 mL/s for a total volume of 6–15 mL. DSA recording was begun just after starting the contrast medium injection and continued for 30 s. After completing the DSA recording on one side, the catheter was changed and DSA recorded on the selected internal pudendal artery on the other side, under the same conditions.

Three observers independently diagnosed the DSA and CTA images, focusing specifically on the internal pudendal, cavernosal and inferior epigastric arteries. In patients with no stenosis or obstruction, the images were diagnosed as normal, but those with stenosis or obstruction were diagnosed as abnormal. When the diagnosis of the images differed among the three reviewers the final diagnosis was determined by the majority.

The results were assessed statistically using Fisher's exact test. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated, with $P<0.05$ taken to indicate a significant difference.

Results

On CTA, the caudal view was especially helpful in evaluating internal pudendal arteries. In this inferior view, the right and left internal pudendal arteries were clear from their initiation at the internal iliac artery to the penis, in one image (Fig. 1). The images with no bone interposed facilitate a clear understanding of the whole profile of the internal pudendal arteries, common penile artery and cavernosal artery (Fig. 2). Furthermore, the internal inferior view of the sagittal sectional image showed the part of the internal artery running behind the pelvic bone in Alcock's canal (Fig. 3).

In the 42 DSA images, 28 of the internal pudendal arteries were diagnosed as normal and 14 as impaired. In the 42 CTA images, 21 arteries were diagnosed as normal and 21 arteries as impaired (Table 1). The PPV of CTA to DSA findings of internal pudendal arteries was only 62%, but the NPV was 95%. Therefore, CTA had a high false-positive rate and low false-negative rate.

For the main trunk of the cavernosal arteries, the CTA images were unclear; DSA images were obviously better than CTA images (Fig. 4). Furthermore, it was difficult to evaluate the details of the cavernosal arteries in the CTA

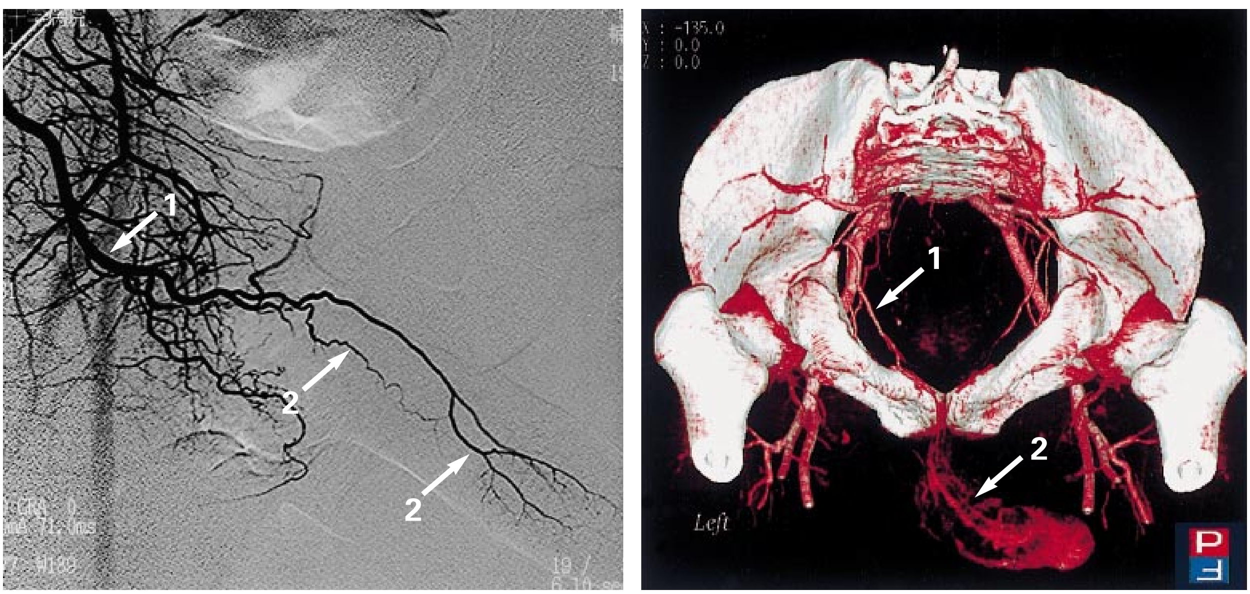

Fig. 1. Normal internal pudendal artery DSA and CTA images of the same patient. PGE1 (10 μg) was injected before imaging. In this normal case, the internal pudendal arteries (arrow 1) run from the internal iliac artery to the penis. The cavernosal artery (arrow 2) and dorsal artery are also visualized.

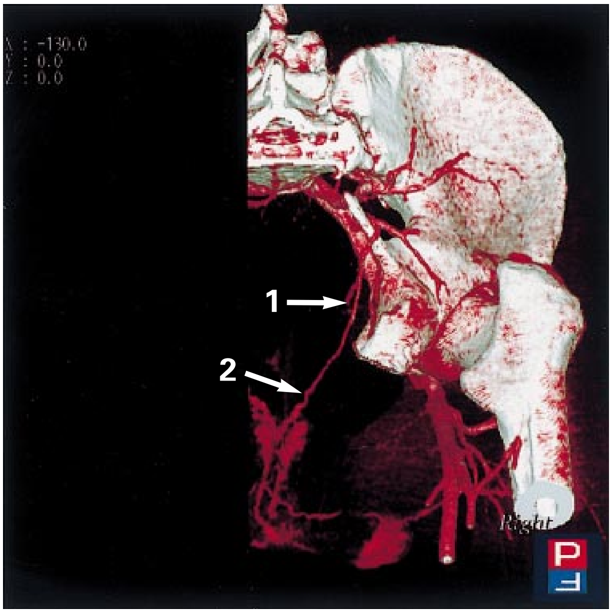

Fig. 2. CTA image with no bone interposed; this facilitates the understanding of the whole profile of the internal pudendal artery (arrow 1), common penile artery (arrow 2) and cavernosal artery.

Fig. 3. An internal inferior view of sagittal sectional images in CTA. Visualising the part of the internal pudendal artery that runs through Alcock's canal in the internal inferior view with no interposed bone is helpful. Note the part of the pubic bone where the internal pudendal artery (arrows) runs near the bone.

images because of the overlay of contrast medium in the cavernosal body. From the 42 DSA images of cavernous arteries, 11 were diagnosed as normal and 31 as having stenosis or occlusion. From the 42 CTA images, seven arteries were diagnosed as normal and 35 as impaired (Fig. 5). DSA and CTA findings are shown for comparison in Table 1. Compared with DSA, CTA had high sensitivity and low specificity.

Table 1 Comparison of CTA with DSA for arterial lesions

Variable (%)	*Internal pudendal artery*	*Cavernosal artery*
Sensitivity	93	96
Specificity	71	43
PPV	62	77
NPV	95	86
Accuracy	79	79
*P**	<0.001	<0.001

PPV, positive predictive value; NPV, negative predictive value; *Fisher's exact test.

Of the inferior epigastric arteries, often used to establish neo-arterial flow in penile revascularization surgery, 31 could be visualized by DSA, but 11 could not because of the overlaying pelvic bone or other arteries. CTA visualized all 42 inferior epigastric arteries clearly, especially in the lateral view (Fig. 6).

Compared with DSA, the CTA procedure was quicker, the amount of contrast medium required less and the cost involved low (Table 2). There were no serious complications during DSA but three patients had a haematoma in the inguinal area, which resolved within 1 week and needed no surgical intervention. There were no complications associated with CTA.

Discussion

Candidates for revascularization surgery have usually been screened with intracavernosal injection tests and colour Doppler examinations, and then finally diagnosed with angiography [6–8]. Angiography is relatively invasive and expensive; furthermore, it requires multiple catheter changes to take X-ray images, prolonging the examination time and resulting in increased use of contrast medium. Although angiography has improved with the application of computer enhancement to DSA, the necessity for angiography catheter changes and the long examination time remain.

DSA is still undertaken with the conventional technique but digital methods are increasingly used for diagnosing vascular lesions [1]. The development of three-dimensional imaging techniques, CTA and MR angiography, have provided clinically useful images non-invasively. Three-dimensional reconstructed images from single-slice CT have been reported in various fields, e.g. for large-vessel surgery [9–11], renal tumours [12,13], renal arteries [14] and renal calculi [15]. However, single-slice CT cannot visualize fine arteries, e.g. the internal pudendal and penile arteries, and thus its application was limited to relatively large vessels or large organs [16]. The new multi-slice helical CT scanner can

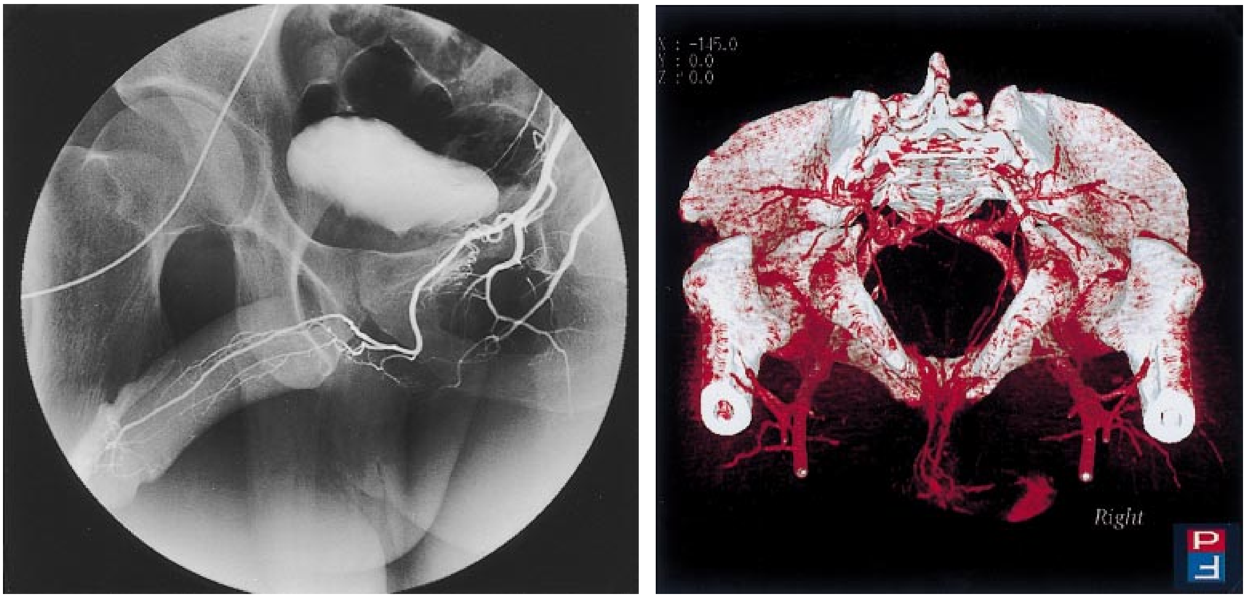

Fig. 4. Images of penile arteries from DSA and CTA; the DSA image shows more detail of the fine arteries than the CTA images.

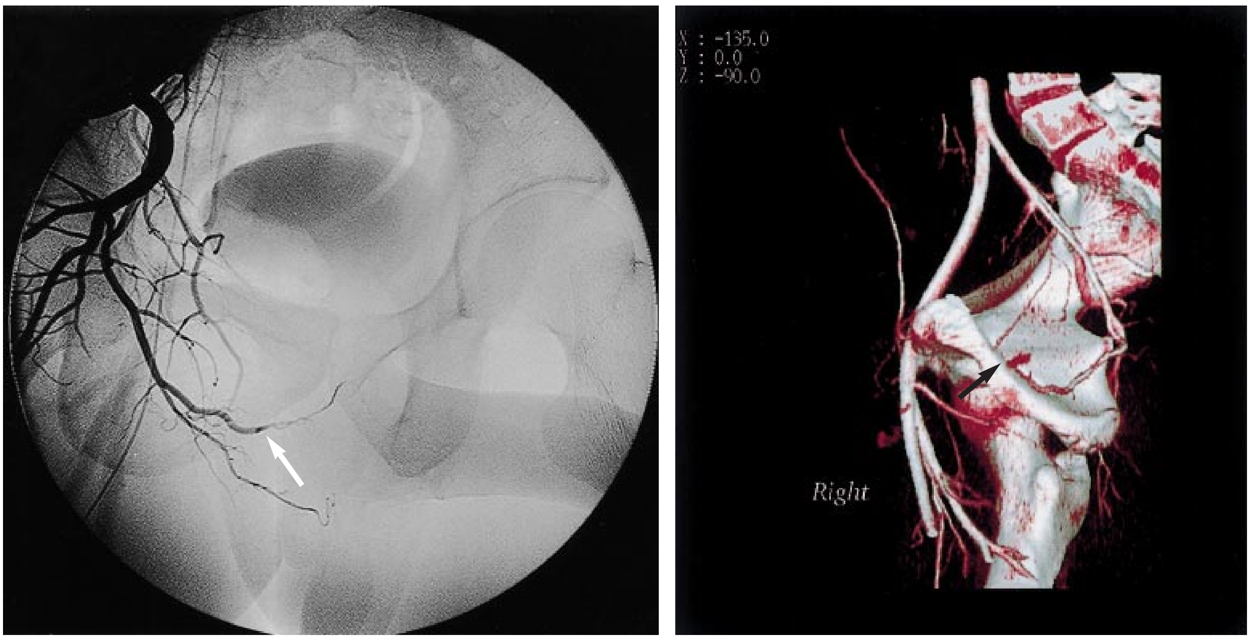

Fig. 5. An example of an arterial lesion; in the DSA image, the internal pudendal artery shows stenosis at the pubic bone, and the peripheral part shows narrowing and obstruction (arrow). In the CTA images, the internal pudendal artery is seen to be obstructed at the pubic bone (arrow).

quickly construct three-dimensional vascular images of even fine arteries. From the present results, for the internal pudendal and the cavernosal artery, the sensitivity, specificity, PPV, NPV and accuracy of CTA were almost the same as those obtained from single-slice CT in evaluating large vessels only [17]. CTA cannot yet match DSA in visualizing very fine arteries, but the sensitivity and NPV of CTA are high enough for most purposes. Therefore, when CTA shows normal arteries, the arterial system can be considered normal without using invasive and expensive DSA examinations.

Using CTA, useful images can be obtained for diagnosis, including those of the bilateral internal pudendal and inferior epigastric arteries. Furthermore, CTA can provide views from any angle, which is impossible with DSA. Because lesions of the internal

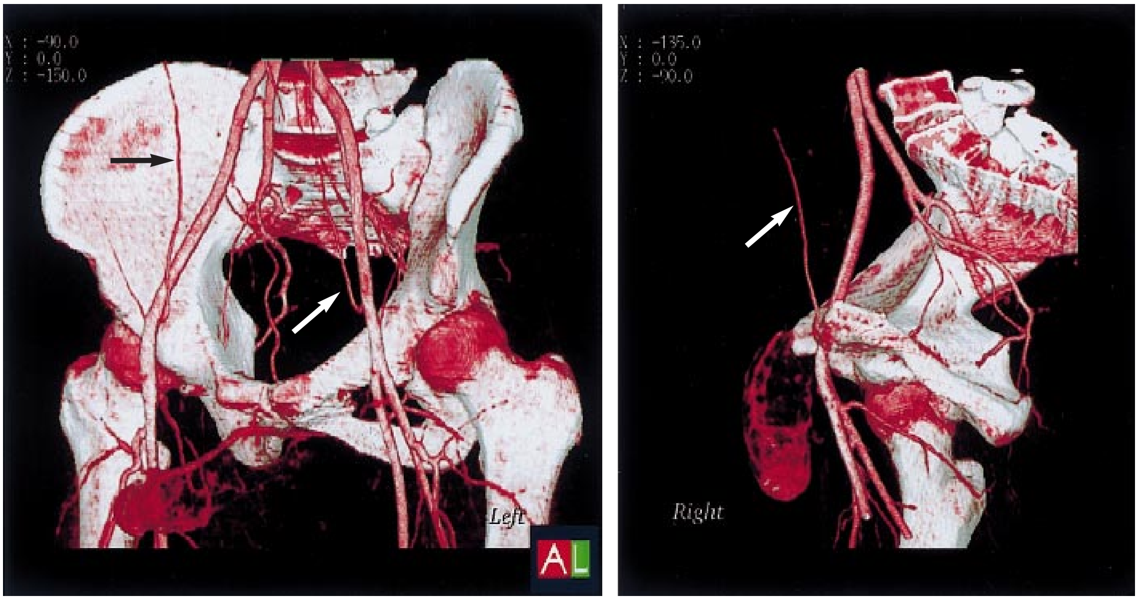

Fig. 6. The inferior epigastric arteries are sometimes difficult to evaluate in DSA images because of the overlay of bone and/or many other arteries. In the CTA images, the lateral or oblique view can provide very clear visualization of the inferior epigastric arteries (arrows) that may be used at revascularization surgery.

Table 2 Comparison of CTA and DSA

Variable	*DSA*	*CTA*
Cost (US $)*	1244	331
Mean (range)		
procedure time, min	57 (40–85)	17 (14–21)
contrast usage, mL	133 (10–175)	100
Personnel required (*n*):		
Radiologist	2	1
Nurse	2	0
Technologist	2	1

*US $1 = Yen 120.

pudendal artery are often behind the pelvic bone, the inferior view or internal view of the pelvis that can be obtained by CTA is very helpful for diagnosis.

In the CTA examination, the conditions under which the contrast medium is infused and timing of the scanning are important, because the scanning time is very short. In the present method scanning commenced when 140 HU was detected by a cursor in the origin of the femoral artery, and high-quality images were obtained. However, further improvement in the image quality may be possible by modifying the conditions for contrast medium infusion and the trigger for scanning. The infusion speed, amount of contrast medium and the timing of scanning were held constant in this study, but there is room for improvement. Had a higher threshold than 140 ± 128 HU been used to reconstruct the arterial images it may have been possible to eliminate the image of the cavernosal body. The origin of the femoral artery was chosen as the trigger because the distance from the aortic bifurcation to this point and to the internal pudendal artery is the same. Nevertheless, there may be scope for reconsidering the location of the scanning trigger, considering the cross-sectional differences between the vessels. At present, the quality of CTA images of fine arteries like the helicine arteries does not equal DSA in the present series, but CTA may become a possible standard examination for arteriogenic ED.

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Abbreviations: **CTA**, computed tomography angiography; **DSA**, digital subtraction angiography; **ED**, erectile dysfunction; **PPV**, positive predictive value; **NPV**, negative predictive value.