ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LXV, N 1, 6 SECTIO D 2010

2nd Department of Diagnostic Radiology, Medical University of Lublin, Poland

EWA M. KURYS-DENIS, KONRAD KRZYŻANOWSKI,
MAŁGORZATA O. ZAMECKA, WITOLD KRUPSKI.

The value of spiral CT angiography and 3-dimensional reconstructions in the evaluation of renal arteries

Wartość spiralnej angiografii TK i trójwymiarowych rekonstrukcji przestrzennych w ocenie tętnic nerkowych.

Spiral CT angiography has been described to have a high accuracy rate of diagnosing vascular pathologies. It is claimed to be a very good screening method in patients with arterial hypertension to assess renal arteries and exclude renovascular disease [1]. Renal hypertension is relatively rare with renal artery stenosis accounting for about 5% of patients with hypertension. Renal artery aneurysms are even rarer accounting for about 0.3 - 1% of cases among patients who undergo a diagnostic renal angiography [2]. However, treatment of these renal causes is highly effective in treating vascular-induced hypertension and therefore preventing such patients from future haemodialysis. Spiral CT angiography is also a non-invasive method compared to classical digital subtraction angiography (DSA).

The advancement in CT technique involves continuous data acquisition of a large patient volume during a single-breath hold. It is now possible to visualize all vascular pathologies on the transverse images and further to obtain 2D and 3D reconstructed images, such as multiple planar reconstructions (MPR), shaded surface display (SSD), volume rendered technique images (VRT) and multiplanar reformatting of the vascular system.

The aim of our study was to justify and illustrate the advantages of spiral CT angiography and its reconstructions in assessment of renal arteries in patients with unexplained hypertension.

MATERIAL AND METHOD

We diagnosed 12 patients aged 16-63 years, with recent onset of hypertension and a suspicion of renal vascular disease. There were investigated 27 renal arteries altogether in the 2nd Department of Diagnostic Radiology, Medical University of Lublin, with the use of Siemens Somatom ART CT scanner. All CT renal angiography examinations were performed with a highly standardized protocol in continuous 1 or 2 slices/pitch 1.5, which assured an optimal spatial resolution. The scanning was performed before and after administering the nonionic contrast agent with a dynamic protocol and

with the use of an automatic syringe. A contrast bolus of Ultravist (Bayer Schering Pharma) 100 ml was injected. After axial images were analyzed, further spatial and MPR reconstructions, as well as 3D reformatting images were done with a high resolution algorithm. The position, size and course of each renal artery were noted. In order to further analyze spatial distribution of the renal vascular system, 2D and 3D reconstructed images were obtained including multiple planar reconstructions (MPR), shaded surface display (SSD), volume rendered technique images (VRT).

RESULTS

Among 27 renal arteries analyzed, there were 4 tortuous arteries with a normal blood flow. There was no local pathological kinking or stenosis which could reduce the renal blood supply and be responsible for vascular hypertension [Fig. 1]. In one patient one kidney had a double supply with one normal renal artery stemming from the aorta and the second smaller artery arriving to the lower pole of the kidney, stemming probably from vertebral arteries [Fig. 2]. One patient had a dystopic right kidney with an incomplete rotation, located in the right pelvis and supplied by three arteries. The main renal artery displayed a normal contrast enhancement but issued from the lower part of the aorta, just over the aortic bifurcation into the common iliac arteries. The other smaller vessels were issued from the lower part of the aorta and the upper part of the right common iliac artery [Fig. 3, 4]. In one patient the right renal artery divided into two branches just before the renal hilum, with two branches entering the renal hilum. [Fig 5]. The rest of 18 renal arteries appeared normal in their course and CT anatomy and had no filling defects [Fig. 6]. Furthermore, with colour options the exact contrast distribution and renal enhancement could be observed in order to compare any possible filling defects [Fig. 7].

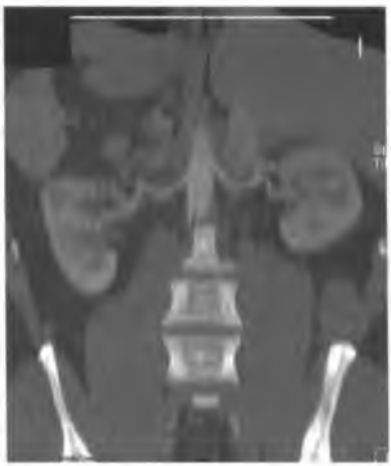

Fig.1 – Tortuous renal arteries with no stenosis or filling defects seen on a 2D multiplanar reconstruction image.

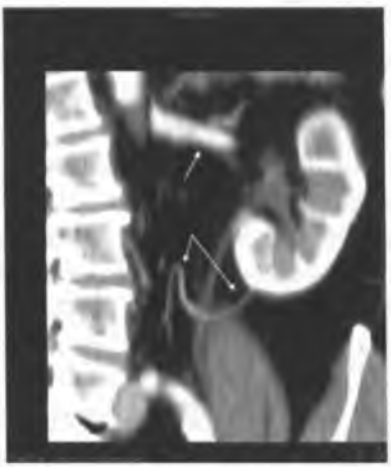

Fig. 2 – Multiplanar reconstruction showing both arteries supplying the left kidney. The smaller second one stems probably form vertebral vessels.

Fig. 3 – VRT image showing distopic pelvic kidney supplied by 3 arteries, stemming form the aorta.

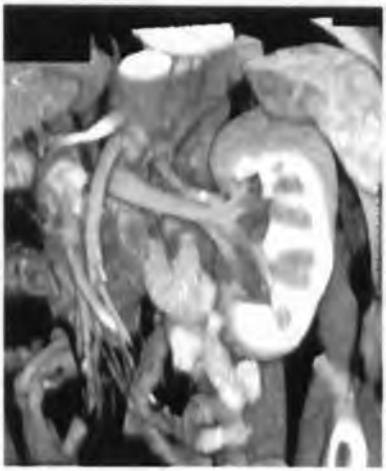

Fig. 4 – Normal renal vessels of the left kidney in the same patient (3D image).

Fig. 5 - Volume rendered technique image showing the left renal artery divided into two arteries entering the renal hilum.

Fig. 6 – Normal renal vasculature well visualized on a 3D CT image reconstruction.

Fig. 7 – Normal local renal supply seen on a coloured 3D reconstruction image.

DISCUSSION

CT examinations have long been used for assessment and evaluation of vascular abnormalities, especially concerning abdominal aorta aneurysms. Recently with more advanced techniques, MDCT has been largely used to diagnose and evaluate for surgical planning smaller arteries, such as renal ones. Many cases of renal arteries pathologies have been described, mainly concerning renal stenosis, renal artery aneurysms or aortic dissection [3, 4]. Detailed information of the morphology of the aorta and its branches is necessary for any successful aortic aneurysm repair. Angiography has traditionally been a procedure of choice in evaluating abdominal aorta aneurysm. However, it has been noted that by producing 2-D images, it might produce misleading information concerning the true 3-D vessel anatomy [5]. Many studies compared the value of ultrasound, computed tomography and magnetic resonance in imaging true vessel morphology, concluding that CT angiography is the preferred method for visualizing complex anatomy of large and small vessels especially for evaluating accessory renal arteries and proximal aortic branches [6]. In rare cases, standard CT contrast examination may give misleading information about the true nature of tortuous small vessels. In such cases, image post-processing into 3D reconstruction series can help establish the true spatial morphology. Some authors report that 3D spiral CT reliably depicts second to forth order aortic branches. Multiplanar reconstructions, surface shades displays and other special 3D views provide enough vessel information for preoperative planning and endovascular intervention [5, 6].

Some studies have shown that 3D rendered surface images of the aorta generated by spiral CT could potentially replace DSA [7]. However other data suggest that CT angiography underestimates the tortuousity of vessels, especially iliac ones. Classical DSA is therefore necessary in endovascular assessment of aortic stents. Conventional CT scanning is best at determining vessel diameter, whereas digital subtraction angiography (DSA) gives the most accurate assessment of vessel length. With the advent of multi-slice CT and new workstation software, however, it is now possible to measure

intraluminal length though tortuous vessels. Such technology might replace DSA in determining intraluminal length of stents in tortuous vessels in the future [8].

In patients with recent onset of unexplained hypertension, assessment of renal arteries is necessary to rule out any vascular causes, such as stenosis, renal artery aneurysms, fibromuscular displasia or renal artery dissection [9]. Furthermore, in patients with an established, unexplained hypertension, it is also important to assess renal arteries, especially their tortuosity and the presence of accessory arteries. Some authors have suggested that anatomic variants of renal arteries including accessory arteries might be responsible for unexplained hypertension in such patients. MDCT seems to be the most effective, non-invasive method for imaging renal arteries. It is technically interpretable in most patients and can safely rule out arterial stenosis or fibromuscular dysplasia. Volume rendered images can further show the exact course and spatial view of renal arteries. In our study we observed 4 tortuous renal arteries, one distopic kidney and two cases of multiple accessory renal arteries. Coulier et al has recently showed that the prevalence of multiple renal arteries appears similar in both hypertensive and normotensive patients, therefore ruling out the hypothesis that multiple renal arteries could predispose to hypertension [10].

CONCLUSIONS

Evaluation of morphological features of vessels is important in determining further medical treatment. CT angiography precisely assesses vascular morphology, minimizes radiation and contrast exposition to the patient. It also is noninvasive, less expensive and easily tolerated by patients than DSA. 3D surface and volume rendered reformatted images generated by spiral CT enable further an exact visualization of vessel anatomy, its course and tortuousity. Even in small vessels such as renal ones it is an especially useful modality to evaluate any stenosis, tortuous course or dislocation and should be therefore performed to confirm or discharge any possible vascular cause of a renal disease, especially in patients with an equivocal ultrasound examination.

Spiral CT examination should also be preformed as an effective diagnostic examination, thus eliminating other more invasive imaging methods and shortening the diagnostic process.

LITERATURE:

1. Wittenberg G, Ken W, Tschammler A, Sandstede J, Hahn D. Spiral CT angiography of renal arteries: comparison with angiography. Eur Radiol 1999; 9:546-551.
2. Hayashi H, Kawamata H, Ishio M, Kumazaki T. Multiple renal artery aneurysms diagnosed by three-dimensional CT angiography. J Clin Imaging 2000; 24:221-223.
3. Paul JF, Blacher J, Blancher JF, Sapoval M, Safar M, Gaux JC. Spontaneous renal artery dissection revealed by helical CT angiography. Eur Radiol. 2000; 10:783-785.
4. Sabharwal R, Vladica P, Law WP, Lau H, Patel M. Multidetector spiral CT renal arteriography in the diagnosis of giant renal artery aneurysms. Abdom Imaging 2007; 37:17-20.
5. Khan A, Lad T, Jacobs AJ. Computed tomography aortic three-dimensional reconstruction: an invaluable tool for diagnosis of juxtarenal abdominal aortic aneurysm. J Vasc Nurs 2006; 24:133-136.

6. Halpern E, Nazarian L., Wechsler R et al. US, CT and MR evaluation of accessory renal arteries and proximal arterial branches. Acad Radiol 1999; 6:299-304.
7. Brown WA, Miller R, Birch S, Scitt A. Is aortic angiography necessary for accurate planning of endovascular aortic aneurysm stents? Cardiovasc Surgery 2003; 11:1-5.
8. Parker MV, O'Donnell S, Chang AS. et al. What imaging studies are necessary for abdominal aortic endograft sizing? A prospective blinded study using conventional computed tomography, aortography and three-dimensional computed tomography. J Vasc Surg 2005; 41:199-205.
9. Ilica AT, Bilici A, Ilhan A, Kara M, Gur S. Thoracoabdominal aorta coarctation with bilateral artery renal involvement: diagnosis with multidetector CT angiography (MDCTA). Int J Cardiovasc Imaging 2007; 23:645-648.
10. Coulier B. Multidetector –row CT of renal arteries: review of the performances in normo- and hypertensive patients. J Belge Radiol 2006; 88:311-321.

ABSTRACT

The aim of our study was to justify and illustrate the value of spiral CT angiography and its 2D and 3D reconstructions in assessment of renal arteries in patients with unexplained hypertension. Multiple planar reconstructions (MPR), shaded surface display (SSD) and volume rendered technique images (VRT) were analyzed in 12 patients aged 16-63 years, with recent onset of hypertension and a suspicion of renal vascular disease. Among 27 renal arteries analyzed, we found 4 tortuous arteries with a normal blood flow, one kidney of a double supply, a dystopic right kidney with an incomplete rotation, located in the right pelvis and supplied by three arteries and in one patient the right renal artery which divided into two branches just before the renal hilum, with two branches entering the renal hilum. The rest of 17 renal arteries appeared normal in their course and CT anatomy and had no filling defects.

Spiral CT angiography precisely assesses renal vascular morphology, minimizes radiation and contrast exposition to the patient. It is also noninvasive, relatively less expensive and easily tolerated by patients. 3D surface and volume rendered reformatted images generated by spiral CT enable further exact visualization of vessel anatomy, its course and tortuousity. Spiral CT examination should be preformed as an effective non-invasive diagnostic examination, especially in patients with an equivocal ultrasound examination.

STRESZCZENIE

Celem pracy była analiza wartości angiografii spiralnej TK oraz wtórnych rekonstrukcji płaszczyznowych i przestrzennych MPR, SSD oraz VTR w ocenie tętnic nerkowych u pacjentów z nadciśnieniem tętniczym o niejasnej etiologii. Ocenie poddano grupę 12 pacjentów w wieku 16 – 63 lat, u których wystąpił epizod nadciśnienia tętniczego niejasnego pochodzenia z podejrzeniem przyczyny pochodzenia naczyniowego. Przy ocenie badania wykorzystano rekonstrukcje wielopłaszczyznowe (MPR), rekonstrukcje cieniowania powierzchniowego (SSD) oraz rekonstrukcje objętościowe (VRT). Wśród 27 przeanalizowanych tętnic nerkowych stwierdzono: 4 tętnice o krętym

przebiegu z prawidłowym wypełnieniem kontrastowym, jedną nerkę z podwójnym zaopatrzeniem tętniczym, jedną nerkę ektopiczną z zaburzonym zwrotem, leżącą w obrębie miednicy małej, zaopatrywaną przez 3 tętnice nerkowe oraz jedną tętnicę nerkową ulegającą podziałowi na 2 gałęzie przed wejściem do zatoki nerkowej. U pozostałych pacjentów nie stwierdzono anomalii tętnic nerkowych.

Angiografia spiralnej TK pozwala na precyzyjną ocenę morfologii tętnic nerkowych przy ograniczeniu ilości podanego dożylnie kontrastu oraz ograniczeniu narażenia pacjenta na promieniowanie. Jest badaniem nieinwazyjnym, względnie tanim i dobrze tolerowanym przez pacjentów. Wtórne rekonstrukcje powierzchniowe i objętościowe obrazów TK naczyń pozwalają na dokładne uwidocznienie anatomii i przebiegu naczyń tętniczych. Będąc łatwym, skutecznym i nieinwazyjnym badaniem, pozwalającym często na skrócenie procesu diagnostycznego, angiografia spiralnej TK powinna zostać wykonana zwłaszcza w przypadku pacjentów z dwuznacznym wynikiem badania ultrasonograficznego naczyń.

Key words: CT angiography, renal arteries, 3D reconstructions