review

Computed tomographic angiography of body vasculature

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Background. *The introduction of helical CT scanners in combination with simultaneous opacification of vessels with contrast medium allows the demonstration of vessels within the chosen volume of interest. This examination is called CT angiography. Being a minimally invasive method, it has been quickly acctepted in the spectrum of vessel-imaging modalities, as for example: Doppler ultrasound, magnetic resonance angiography, transesophageal ultrasound etc. In the field of cardiovascular radiology, it has been used to demonstrate pathology of ascending and descending aorta, like the aneurysms, dissection, traumatic rupture or congenital anomalies. It is also very useful in pre-and postoperative follow - up in the aortic stent-graft insertion, a method which has recently become popular. Also the CT angiography has greatly influenced the preoperative calculations and has clearly demonstrated the postoperative anatomical changes as well as complications (i.e. peristental leakage).*

Conclusions. *In this context, it is comparable to intraarterial angiography and even offers some advantages over the latter. The only draw-back being somewhat lower spatial resolution and longer processing time, but with the advent of a new, so called multi-slice scanners and powerful workstations, these draw-backs will be minimized.*

Key words: tomography scanners, X-ray computed; aortic disease - ultrasonography - radiography

Introduction

The advent of spiral (helical) CT has made a great revolution at the performance of body CT and has enabled the development of CT angiography (CTA). It is minimally invasive investigation method of vascular system and can in many cases replace a conventional angiography. In CTA, there is a volume of data obtained rapidly with virtually no respiratory misregistration at peak vascular opacification following peripheral injection of contrast. The appropriate timing ensures that either venous or arterial tree is perceived and multiple overlapping slices can be obtained in order to generate two- and three-dimensional reconstructions with no increase in radiation dose to the patient. When performed as a dedicated study, CTA is faster, less invasive and (should be) cheaper than conventional angiography, with a reduced radiation dose.

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However, there is no significant contrast saving and spatial resolution is somewhat limited to the vessel diameter of 1-2 mm.

The technique must be meticulous if good-quality angiograms are to be obtained. The variables that can be altered are collimation ("beam width"), table speed, contrast volume and flow rate and reconstruction index, which are all set according to the volume of interest and suspected diagnosis. From this data, two - and three dimensional images can be generated, like multi-planar reconstructions (MPR), maximum-intensity projections (MIP), shaded surface display (SSD) and volume rendering tecnique (VRT).

Main indications for CTA of aorta and its branches are aneurysms and dissections of thoracic aorta, suspected blunt trauma or thoracic rupture; pulmonary embolism; in abdominal aorta, the diagnosis of aneurysms, dissections, rupture, and suspected pathology in renal or visceral arteries as well as pelvical arteries. It is very useful to perform CTA at first and afterwards surgical or interventional procedures on aorta and its branches.

Thoracic aorta

Conventional CT has an established role in detection of aortic aneurysms and dissections. CTA has the advantage of thinner collimation and of more axial slices obtained during the peak vessel opacification.[1] Entire aorta can be imaged on a single spiral and excellent multiplanar reformats can also be obtained. It can actually demonstrate the size, the extent and the quality of the wall of aneurysm as well as the thickness of intimal flap in the case of dissection (Figure1). True and false lumen can be identified and followed, so the origin of the vessels from true or false lumen or the extension of the dissection into the branches can be determined accurately. Some authors prefer the use of CTA over conventional CT and catheter aortography in cases of blunt chest trauma or

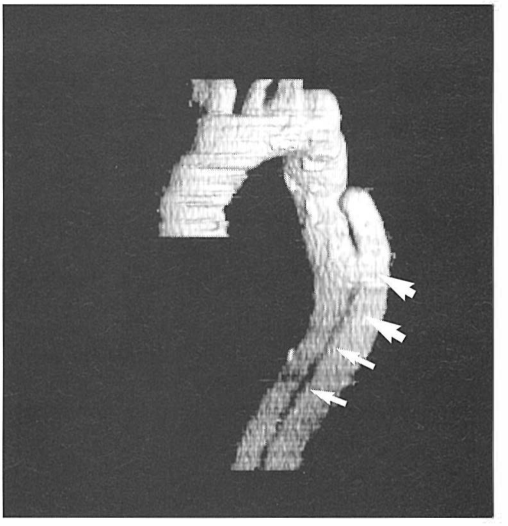

Figure 1a. A dissection of descendent aorta with intimal flap (arrows) are seen in "left anterior oblique" projection.

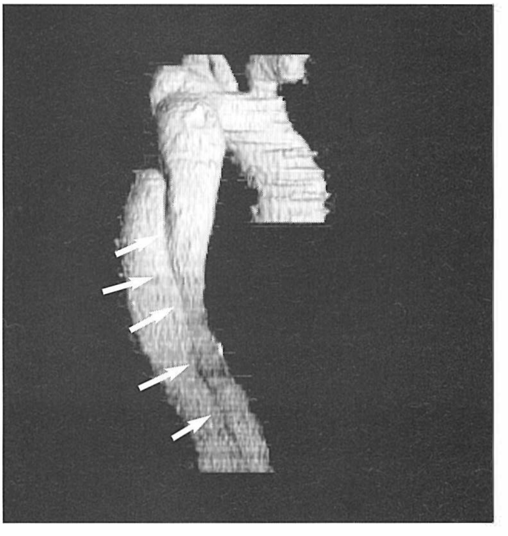

Figure 1b. The same patient with "right posterior oblique" view.

suspected aortic rupture, although the rate of technically suboptimal results may limit its usefulness.[2] Also, the determination and differential diagnosis of congenital anomalies is made (Figure 2). In our institution, we found CTA of a great benefit in preoperative treatment planning and postoperative follow-up at

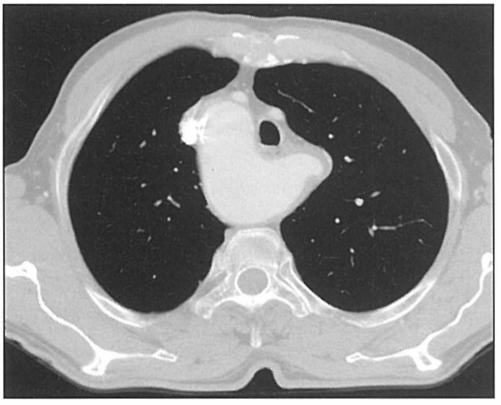

Figure 2a. A CT scan showing a right-sided aortic arch and retrotracheal left subclavian artery with a diverticulum at the orrifice.

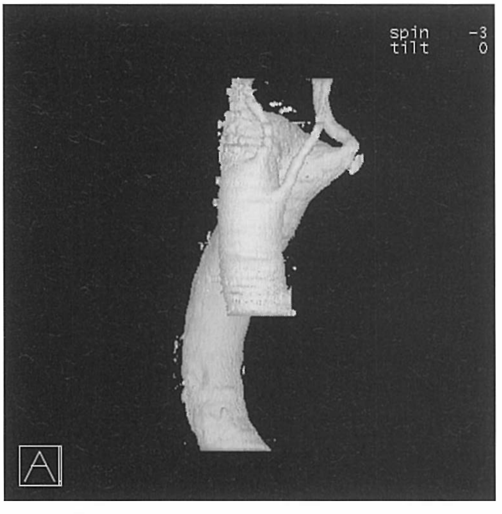

Figure 2b. Three-dimensional reconstruction showing a right aortic arch with mirror imaging of aortic branches.

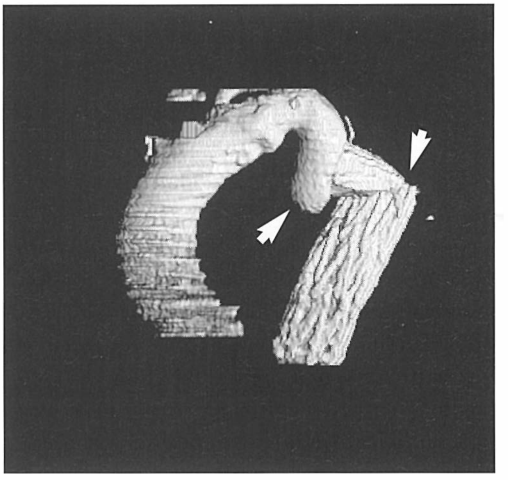

Figure 3a. An aneurysm of descending aorta (arrow) due to a kink of aortic endoprosthesis (arrowhead).

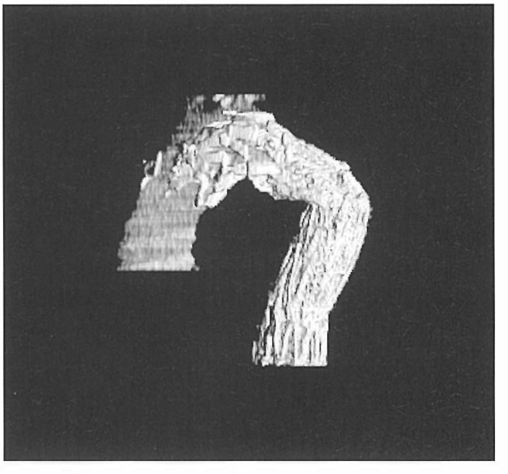

Figure 3b. Reduction of the aneurysm after the insertion of additional endoprosthesis.

the percutaneously or sugically inserted aortic endoprostheses (Figure 3).

Complex anatomy and the extent and the course of intimal flap can be determined by multiplanar reformats (MPR) or SSD and VRT, respectively.[3,4] In order to cover the entire thoracic aorta, it is used a collimation of 3mm, table speed of 4,5 mm/s (pitch 1,5), the volume of contrast is set to 140 ml with the infusion rate of 3 ml/s. In cases when the entire aorta is to be imaged it is used a 5mm collimator with a pitch of 1,5-2. If renal arteries are to be assessed precisely, two spirals are made, one for thoracic and the other for abdominal aorta.

Pulmonary circulation

With CTA it is possible to identify reliably the emboli in central and segmental arteries, but not in the vessels below the fourth division (subsegmental arteries) (Figure 4).[5] Therefore,

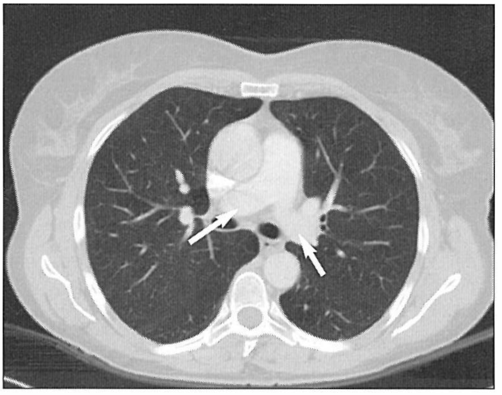

Figure 4a. Pulmonary arteries without filling defects (arrows).

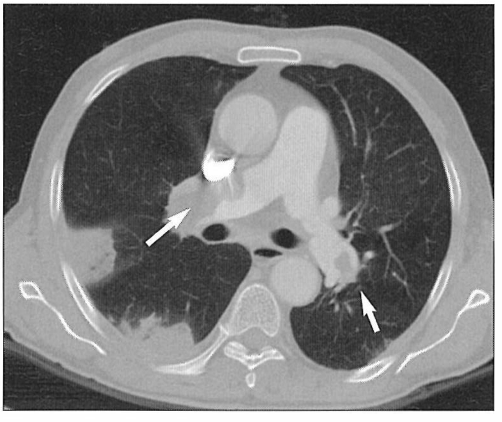

Figure 4b. Emboli in main pulmonarty arteries (arrows). Lung consolidation in the right lobe (arrowheads), indicating possible infarction.

Figure 4c. Multiplanar reconstruction of left pulmonary artery, demonstrating a massive thrombus (arrows).

we scan the patient from the top of aortic arch down to the domes of diaphragm. Ideally, it is used a 3 mm slice with a pitch of 1,5, allowing the scanning time of 20 - 25 sec., but patients usually cannot hold the respiration so long, so we have to use the 5 mm slice and the pitch of 1-1,5, so that the scan duration of about 10 seconds is achieved.

Reported sensitivity and specificity for the detection of pulmonary emboli are 87 and 95%, in comparison with V/Q scans where the result is 65 and 94%. Therefore, many authors advise new protocols for highly suspicious PE: Doppler US of the lower limbs and CTA of pulmonary arteries, which not only reliably determines emboli, but enables a very accurate differential diagnosis.[6,7] Scintigraphy and pulmonary angiography should be reserved for negative CTA with possible subsegmental emboli.[8] CTA can also be used for follow-up, i.e. to determine the effectiveness of the treatment.[9]

Abdominal aortoiliac disease

Conventional CT with contrast was frequently used for the assessment of abdominal aortic aneurysms and provided accurate information about the size of the aneurysm, thrombus formation and diameter of true lumen.[10,11] CTA can provide all this information, as well as can accurately assess the concomitant renal or mesenteric artery stenoses (Figure 5). It also provides useful information for abdomino-iliacal stent-graft insertion, like the necessary device length and diameter, distance of the neck of aneurysm to renal arteries, and the involvement of pelvic arteries.[12,13] After the insertion, it is used to confirm the success of the procedure, and for detection of the complications, like kicking of the stent and peri-stent leaks.[14]

Although there exist many different protocols for performing abdominal and pelvic CTA, we are using the following method: after having made native scans, the collimation is set to 5 mm and table speed at 7,5 mm/s, enabling the scan from above the coeliac trunk or superior mesenteric artery down to external iliac artery in a single scan. Axial reconstruction is made at 3 mm interval, and

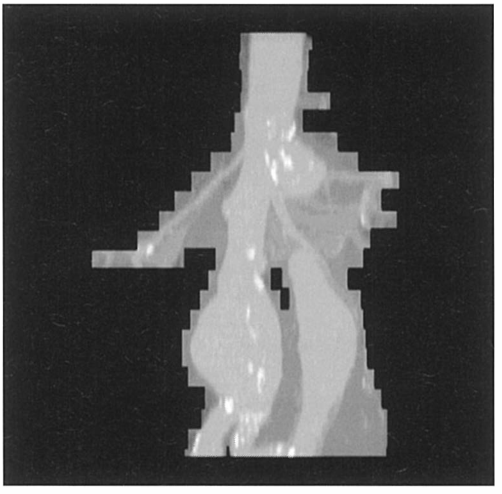

Figure 5a. MIP reconstruction demonstrates aneurysms of abdominal aorta with extensive calcination and concomitant aneurysm of superior mesenteric artery.

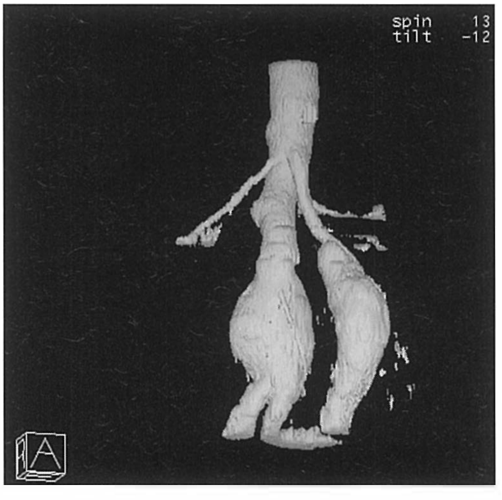

Figure 5b. SSD reconstruction demonstrates both aneurysms in their full extent.

if necessary (like in suspected renal artery stenosis), the segment of "raw data" from superior mesenteric artery to renal arteries is reconstructed at 1,5 mm interval in order to demonstrate selectively the pathology in this region.

Renal arteries

Hypertension is a common condition, and up to 10 % of patients have a renovascular cause. Although not all the renal artery stenoses cause hypertension it is important to diagnose significant stenoses, that is more than 50 %.[15] Presently, the gold standard for diagnosis is arteriography, after the Doppler US and potentially scintigraphy having been performed. The advantage of CTA over conventional arteriography is the identification of the vessel wall, leading to the improved differentiation between ostial and truncal stenoses.[16] With CTA, the presence and the extent of calcination at the site of stenosis is accurately demonstrated, so that therapeutic decision for dilatation and/or primary stent insertion should be made much easier (Figure 6).[17,18] The additional advantage of CTA is the ability to detect possible non-renal causes of hypertension, i.e. suprarenal tumors etc.[18]

This technique is of great importance. Usually, it is used a 2 mm slice with a table speed of 3 mm and the axial images reconstructed at 1-1,5 mm interval. Besides axial images, maximum intensity projection (MIP) is very useful to differentiate between calcifi-

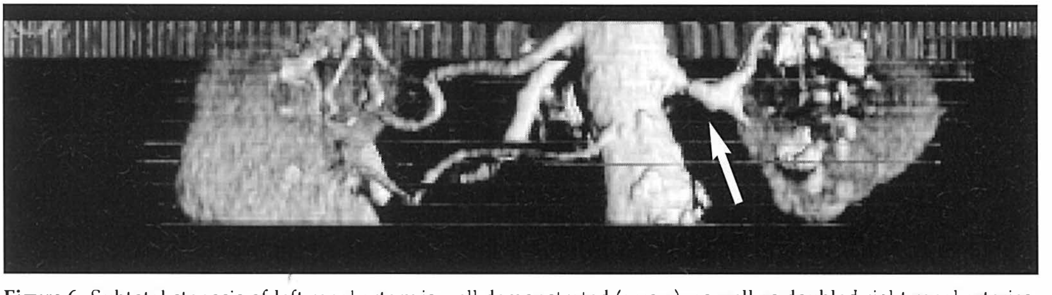

Figure 6. Subtotal stenosis of left renal artery is well demonstrated (arrow), as well as doubled right renal arteries.

cation and contrast-filled lumen, and SSD for the morphological assessment. MPRs are made for the measurements, and after the therapeutical procedures, the same imaging protocol is used for comparison.

Other indications

CTA has proven to be superior to conventional CT in the cases of preoperative assessment of live renal donors[19,20], evaluation of mesenteric ischaemia[21], portal vein and hepatic artery thrombosis, but these application fields have been still in the experimental phases.

Conclusion

The CTA technique offers several advantages over conventional arteriography. Although other noninvasive modalities are gaining popularity, CTA is in many cases the definite method of the vessel pathology diagnosis and differential diagnosis. Although MR angiography is being established in this field, and has many advantages over CTA, like the lack of radiation exposure and there is no iodinated contrast material needed, CTA will continue to be the forefront of noninvasive vascular imaging due to its availability, relatively low cost and effectiveness in diagnosis and treatment planning.

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