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Abdominal aortic aneurysm in spiral computed tomography

Aortic aneurysm is a frequently encountered disorder in cardiovascular practice. The increase in its incidence ist multifold, likely due to increased life span and improved detection. The most common cause of aortic aneurysm formation is atherosclerosis. Male gender, smoking, advanced age and family history are risk factors for atherosclerotic aneurysms. Other causes include cystic medial necrosis (primary, Marfan's syndrome, Ehler-Danlos syndrome), vasculitis (Takayasu's arteritis, giant cell arteritis, rheumatoid arteritis), infection (syphilis, mycosis, tuberculosis), trauma or the result of dissection (3,7).

Computed tomography (CT) angiography has become the preferred screening tool for vascular disease since it was first described in 1992. This study tool is faster and much less invasive than previous tools, making it the imaging modality of choice when planning endovascular procedures as well as when performing routine follow-ups of these patients (4).

The aim of the study is to present the imaging possibility of helical computed tomography in evaluation of abdominal aortic aneurysm.

MATERIAL AND METHODS

The material comprises a group of 34 patients, 32 men and two women aged between 44 and 76 years, with abdominal aortic aneurysm. In each patient CT examination of the abdominal aorta and iliac arteries was performed in vascular protocol with Siemens Somatom Emotion CT scanner. The scanning was performed before administering contrast agents, and then enhanced examination was performed, using an automatic syringe. 100–150 ml of contrast agent was injected in two phases: in the first phase which lasted 8 seconds 4 ml per sec, and in the second phase – 2.5 ml per sec. The scanning was automatically started, when pick enhancement inside the lumen of the examined aorta was reached. After scanning the multiplanar reconstructions (MPR) were performed, and the arteries were assessed in maximum intensity projection (MIP). 3D images were created using Volume Rendering Technique (VRT), and evaluated before and after editing unnecessary bone structures.

RESULTS

In all the patients dilatation of the abdominal aorta was found and in five of them the descending thoracic aorta was also involved. The thrombus inside the aorta was found in all the patients. In one of them the thrombus was annular on axial images (Fig. 1A), and on MPR reconstructions angulations of the aorta was seen (Fig. 1B). VRT images revealed precisely the aneurysm and its relation to bony structures (Fig. 1C, D). In 14 patients the iliac artery was involved, that was precisely seen on VRT images (Fig. 2A). Edition of the bony structure revealed the precise morphology of the iliac arteries (Fig. 2B). In 10 patients the dilatation of the aorta involved the renal orifices, which was clearly seen on VRT images (Fig. 3A), especially after editing and removing bony structures (Fig. 3B).

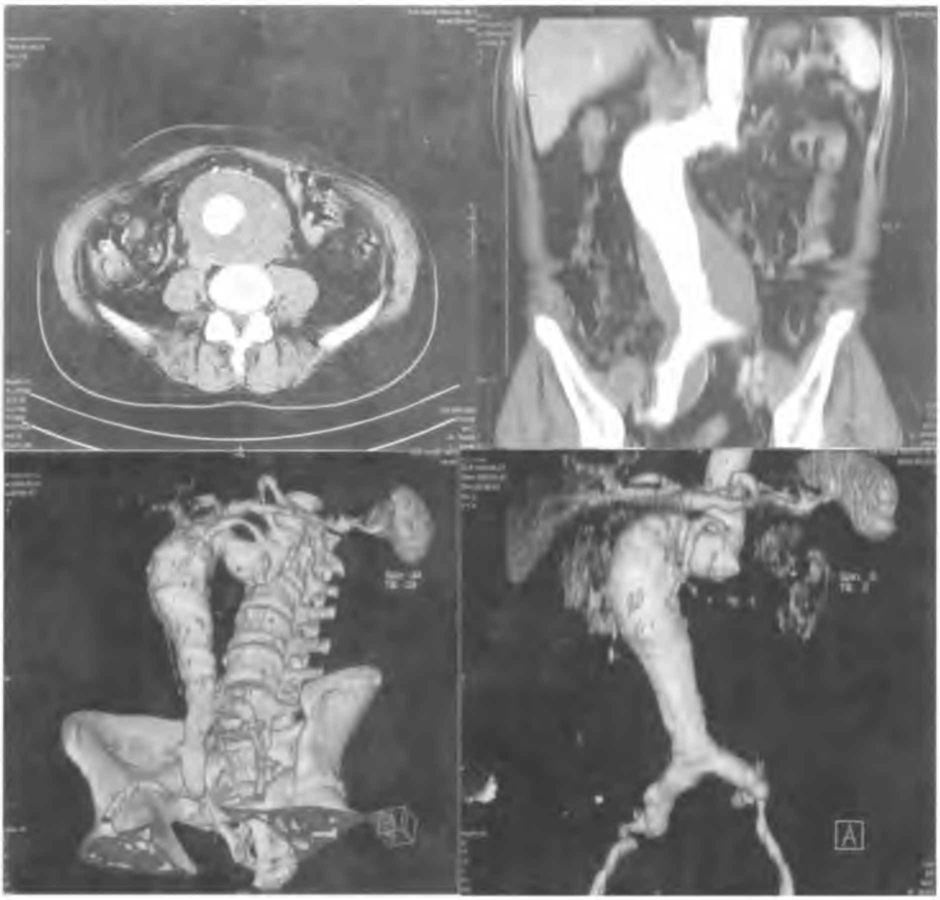

Fig. 1. A – abdominal aortic aneurysm. Axial section with annular thrombus; B – MPR reconstruction with angulations of the aorta; C – VRT image clearly revealing the morphology of the aneurysm; D – VRT image after editing of the bone structures

Fig. 2. A – abdominal aortic aneurysm on VRT image; B – VRT image after editing of the bone structures clearly reveal involvement of the right iliac artery

Fig. 3. A – abdominal aortic aneurysm on VRT image; B – VRT image after editing of the bone structure reveal involvement of the renal orifices

DISCUSSION

The strict definition of an aneurysm is a localized, irreversible dilatation of the aorta. In the elderly, the radiographic definition is typically reserved for focal dilatation greater than 3 cm (7). Conventional angiography has long been the preferred technique for evaluating aortic aneurysms. While it is invasive, it is rarely associated with complications such as puncture site hematomas and arterial dissection. However, it is only able to indirectly detect mural thrombi within an aneurysm. On the other hand, CT angiography is less invasive and more accurate in determining the true size of the aneurysm sac. It is also far superior in its ability to detect mural thrombus. CTA can directly visualize the wall of the aorta and the surrounding structures. This is of great importance when characterizing inflammatory aneurysms as well as aneurysm rupture. Moreover, CTA has been shown to accurately characterize juxtarenal or suprarenal extension of an abdominal aneurysm and to be highly accurate in the evaluation of branch vessel stenosis (4). The most important step in CT angiography is determining the area of the patient to be imaged. With current commercially available systems, a reasonable area to be covered is the chest and abdomen down to the patient's knees, or the abdomen and pelvis down to the patients' feet. It is important to realize that most endovascular procedures are performed from the common femoral artery approach. Typically, 80–150 ml of intravenous non-ionic contrast agent is administered at an injection rate of 2.5–5 ml/sec (4,7).

Helical CT is performed during a single breath hold at 3–5 mm (mostly 5 mm) collimation and 7.5 mm/s table speed with a pitch of 1.5–2, depending upon the volume of scan and breath holding capacity of the patient. Scanning is done in craniocaudal direction. Scan reconstruction is done at 1.5 mm (overlapping thin section) for making 3D images. The data set is then utilized for generating curved planar reformations and 3D rendering where MIP, SSD are reconstructed (7). A noncontrast CT would also identify any acute thrombosis in aneurysm lumen or in the false lumen of a dissection and would appear hyperdense. This is followed by the CTA, taking care to include normal aorta above and below the lesion. If thoracic aorta is involved, ascending aorta and arch should always be included. If the patient has dissection, entire aorta should be scanned (7).

Curved planar reformations and 3D reformations using maximum intensity projection (MIP), and shaded surface display (SSD) following segmentation and editing of bony and other unwanted structures, give excellent visualization of the aorto-iliac circulation and the major branch vessels. It is important that the patient receives no oral contrast before CTA because it would hamper 3D editing. Hyperventilation just before the scan acquisition should be performed routinely to enable a good uninterrupted breath hold without discomfort to the patient. Preliminary scans without intravenous contrast are obtained to localize the dilated segment as well as to demonstrate the aortic wall calcification (7, 10).

Compared to this, DSA has the disadvantage of limited view angle, single lumen opacification and can be quite confusing to interpret, especially in the situation of complex dissections. CTA is an excellent imaging modality for comprehensive evaluation of aortic aneurysm and dissection, combining the advantage of conventional contrast enhanced CT axial images and those of angiography in the form of 3D reformatted images. The marked reduction in examination time, increased contrast resolution, its minimally invasive technique, fewer potential complications and reduction in cost makes CTA the single best investigation for evaluation of aortic aneurysm and dissection (7).

With the recent introduction of multiple detector-row CT scanners, CT angiography can be performed more efficiently (more quickly and with higher longitudinal spatial resolution) than was possible with single detector-row CT scanners. Currently, multiple detector-row four-channel CT scanners acquire up to four channels of data simultaneously from interweaving helices. A single x-ray fan beam is used, and the length of the individual detector elements determines the section thickness. Table speeds of up to six times the nominal section thickness per gantry rotation (pitch, 6.0) are substantially faster than those of single-channel CT with a pitch of 2.0 (6).

Usually, CT aortography is performed with iodinated contrast agents. However, in the patient population predisposed to AAA, there are often comorbid conditions including renal insufficiency (serum creatinine level, >1.5 mg/dL). In this selective subpopulation of patients, an alternative contrast agent with the ability to provide adequate images and with a low risk of nephrotoxicity is desirable. In the literature, gadolinium has been used as an alternative contrast agent for digital subtraction angiography (DSA) and CT. In the various case reports and studies in which gadolinium has been used, it has provided adequate enhancement to enable interpretation of the images (4,9).

The imaging requirements for endovascular procedures are much more complex than those previously required for open vascular procedures. Many details must be evaluated before the physicians can select those procedure(s) and devices that will optimize the outcome. Poor planning usually results in a technical failure, with the need for repeat procedures or (ultimately) conversion to an open surgery. As a result, post-procedure imaging is essential for monitoring the success of the procedure and planning any further interventions. The endovascular specialist must be well versed in the latest imaging technology, in order to achieve technical success and adequately follow up patients who have undergone these minimally invasive procedures (4).

The ability of axial CT to enable proper patient selection and endograft sizing has recently been questioned. Several authors, including ourselves, have shown that on axial CT scans the true diameter of the aorta may be overestimated. In addition, there is concern that observer variability of axial CT may exceed the limits of clinical acceptability. Certainly axial CT is adequate in many cases, but the cited limitations may lead to inconsistent patient selection and preoperative endograft sizing (5,8,10).

CT aortic measurements have been previously used to measure the diameter of the aorta. These measurements can greatly overestimate the true diameter because of obliquity. Similarly, craniocaudal measurements can substantially underestimate the true aortic length by not accounting for tortuosity (1,2,4,9).

CONCLUSIONS

Spiral CT is a very valuable tool in evaluation of abdominal aortic aneurysm. The diameters, presence and morphology of thrombus and presence of calcifications are easily evaluated on axial section. MPR reconstructions enable visualization of the longitudinal aortic sections. Due to spiral acquisition maximum intensity projection (MIP) and three-dimensional images using volume rendered technique (VRT) enable precise evaluation of the aneurysm morphology, involvement of the renal and iliac arteries.

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SUMMARY

The aim of the study is to present the imaging possibility of helical computed tomography in evaluation of abdominal aortic aneurysm. Material comprised a group of 34 patients, 32 men and two women aged between 44 and 76 years, with abdominal aortic aneurysm. In each patient CT examination of abdominal aorta and iliac arteries was performed in vascular protocol with Siemens Somatom Emotion CT scanner. The scanning was performed before administering the contrast agents, and then enhanced examination was performed, using automatic syringe. 100–150 ml of contrast agent was injected with speed 3.5 ml per sec. The scanning was automatically started, when pick enhancement inside the lumen of examined aorta was reached. After scanning the multiplanar reconstructions (MPR) were performed, and the arteries were assessed in maximum intensity projection (MIP). 3D images were created using Volume Rendering Technique (VRT), and evaluated before and after editing unnecessary bone structures. In all patients dilatation of the abdominal aorta was found and in five of them the descending thoracic aorta was also involved. The thrombus inside the aorta was found in all the patients. In one of them the thrombus was annular on axial images, and on MPR reconstructions angulations of the aorta were seen. VRT images revealed precisely the aneurysm and its relation to bony structures. In 14 patients the iliac artery was involved, that was precisely seen on VRT images. Edition of the bony structure revealed the precise morphology of the iliac arteries. In 10 patients the dilatation of the aorta involved the level of renal arteries, which was clearly seen on VRT images, especially after editing and removing bony structures. Conclusions: Spiral CT is a very valuable tool in evaluation of abdominal aortic aneurysm. The diameters, the presence and morphology of thrombus and presence of calcifications are easily evaluated on axial section. MPR reconstructions enable visualization of the longitudinal aortic sections. Due to spiral acquisition maximum intensity projection (MIP) and three-dimensional images using volume rendered technique (VRT) enable precise evaluation of the aneurysm morphology, involvement of the renal and iliac arteries.

Tętniaki aorty brzusznej w spiralnej tomografii komputerowej

Celem pracy jest przedstawienie możliwości obrazowych spiralnej tomografii komputerowej w ocenie tętniaków aorty brzusznej. Materiał stanowi grupa 34 pacjentów, 32 mężczyzn i 2 kobiety w wieku 44-76 lat, z tętniakiem aorty brzusznej. U każdego pacjenta wykonano badanie TK aorty brzusznej i tętnic biodrowych, aparatem TK Somatom Emotion firmy Siemens. Badanie wykonywano przed i po podaniu środka kontrastowego. 100-150 ml kontrastu podawano automatyczną strzykawką. Skanowanie rozpoczynało się automatycznie po osiągnięciu szczytowego wzmocnienia świetle badanej aorty. Wtórnie wykonywano rekonstrukcje MPR, MIP i 3D, wykorzystując *volume rendering technique* (VRT). U wszystkich pacjentów stwierdzono poszerzenie aorty piersiowej, a u 5 ponadto stwierdzono zajęcie zstępującego odcinka aorty piersiowej. Zakrzep w świetle aorty był widoczny u wszystkich pacjentów, u jednego z nich był to zakrzep pierścieniowaty; rekonstrukcje MPR wykazały zagięcie kątowe aorty brzusznej. Obrazy VRT precyzyjnie uwidoczniły morfologię tętniaka i przyległych struktur kostnych. U 14 pacjentów stwierdzono zajęcie tętnic biodrowych, wyraźnie widoczne na obrazach VRT. Edycja i usunięcie struktur kostnych ułatwiły dokładną ocenę morfologii tętnic biodrowych. U 10 pacjentów stwierdzono poszerzenie aorty brzusznej, obejmujące również miejsce odejścia tętnic biodrowych, wyraźnie widoczne na obrazach VRT, szczególnie po edycji struktur kostnych. Wnioski: Spiralna tomografia komputerowa jest wartościową metodą oceny tętniaków aorty brzusznej. Średnica tętniaka, obecność i morfologia zakrzepu i zwapnień są łatwo oceniane na przekrojach osiowych. Rekonstrukcje MPR umożliwiają ocenę przekrojów podłużnych aorty. Dzięki akwizycji spiralnej *Maximum intensity projection* (MIP) oraz rekonstrukcji trójwymiarowej z zastosowaniem *volume redered technique* (VRT) umożliwiają precyzyjną ocenę morfologii tętniaka i zajęcia tętnic nerkowych i biodrowych.