ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN-POLONIA
VOL. LXI, N1, 36 SECTIO D 2006

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Scanning delay time in spiral CT examination of abdominal aortic aneurysm

Aortic aneurysm is a frequently encountered disorder in cardiovascular practice. Its incidence has increased multifold, likely due to increased life span and improved detection. Most common cause of aortic aneurysm formation is atherosclerosis. Male gender, smoking, advanced age and family history is 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, mycotic, tuberculosis), trauma or the result of dissection (1, 8). 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 (8).

Intravascular contrast enhancement is required, as there is not sufficient contrast between flowing blood, intraluminal clot and the vessel wall. The contrast agent is administered at 3 ml to 5 ml per second. Single slice scanners require injection of 125 ml to 150 ml of contrast media. The delay between the start of the contrast injection and the start of the scan data acquisition is known as the scan delay. This delay allows the injected contrast media to flow from the injection site to the target vessels, and ensures the start of acquisition in the moment, when the aortic lumen is already properly enhanced (5, 7). Precise choice of the delay time is the crucial element of the angio-CT examination.

The purpose of our study was to evaluate scanning delay time after starting the injection of the contrast material for aortoiliac enhancement at helical CT.

MATERIAL AND METHODS

Material consists of a group of 22 patients with abdominal aortic aneurysms, in which angio-CT examination of the abdominal aorta was performed in our department. CT examination was performed from the level of the diaphragm to the bifurcation of the femoral arteries. Unenhanced section were performed with 8 mm thick collimation, pitch 1.5. The acquisition after administering of contrast agent was performed with 3 mm thick collimation, pitch 1–1.5. Contrast material is injected rapidly into a peripheral vein via a power injector, and the upper abdominal aorta was monitored visually for contrast enhancement by using automated-triggering hardware and dedicated software. These technique provides correct scanning delay time, ensuring that there is enough contrast material upstream to achieve adequate enhancement of both the abdominal aorta and the iliac arteries. The scanning was started, when the automatically controlled enhancement in the lumen of the aorta reached the desired level of 100 HU.

RESULTS

The monitoring section obtained every 2.5 sec revealed increasing density in the lumen of the aorta (Fig. 1a-C), until the desired density in the aortic lumen was exceeded (Fig. 2). The measured aortic densities obtained every second were used to create the enhancement curve (Fig. 3), representing the increasing aortic enhancement in time. The delay time in the examined group of patients ranged from 20.5 to 26 sec. The mean delay time was 22.7 sec. In 16 patients the delay time was below the mean value, and in the rest of them the delay time was greater than mean 22.7 sec.

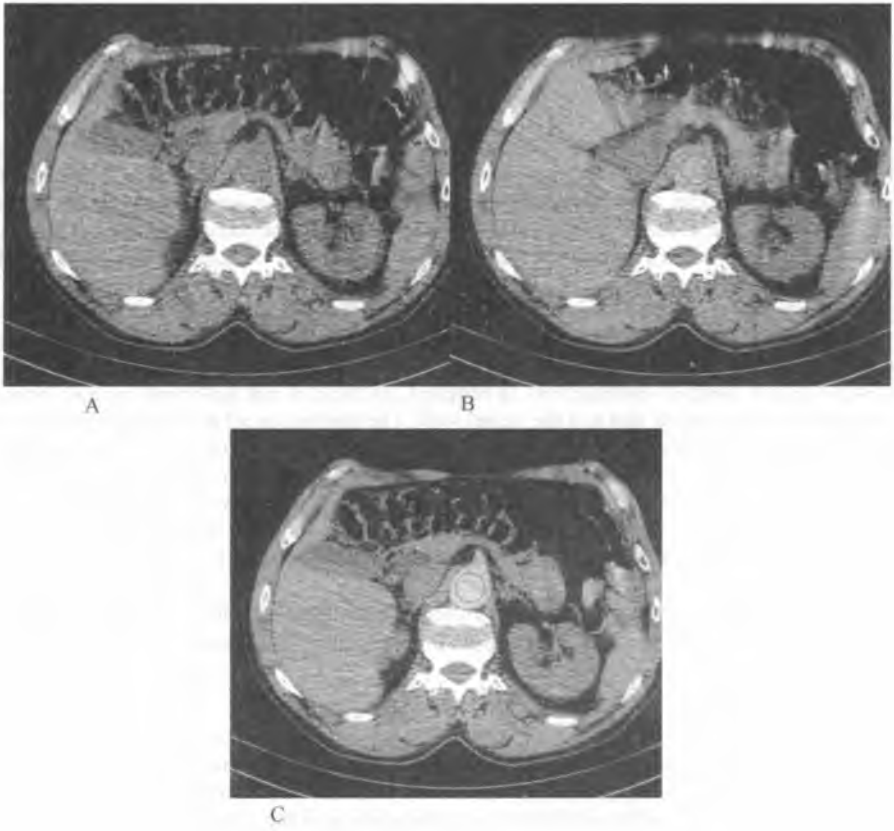

Fig. 1. The region of interest (ROI) marker positioned in the aortic lumen. A – the first section after starting contrast injection, the enhancement of the aortic lumen equals 1 HU. B – after 22 sec the aortic enhancement equals 27 HU; C – after 24.5 sec, the aortic enhancement equals 69 HU

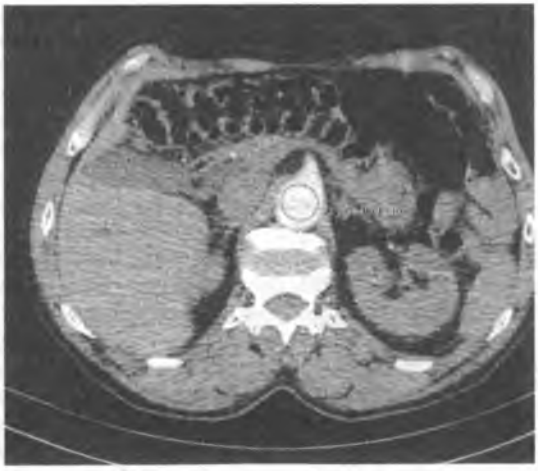

Fig. 2. Scan obtained 26 sec after the beginning of the contrast agent injection – the aortic enhancement exceeded the threshold level of 100 HU

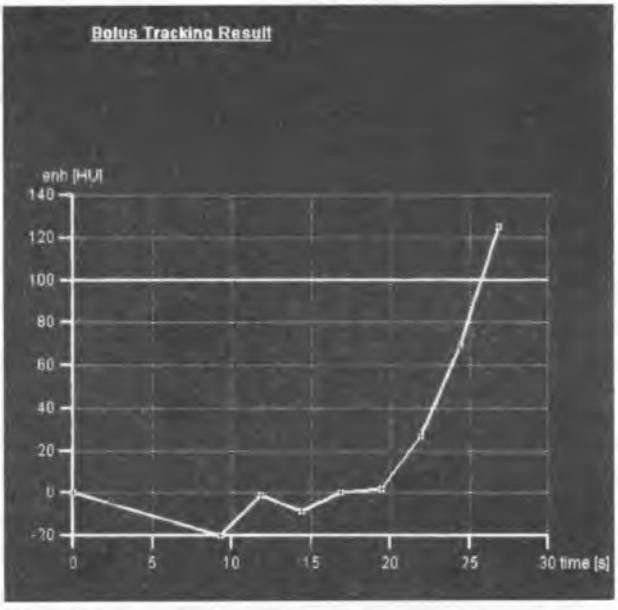

Fig. 3. Enhancement curve present the aortic enhancement in time

DISCUSSION

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).

Conventional CT is useful for aneurysm detection and overall measurement of the lesion, but cannot be used in detecting all accessory renal arteries or in grading stenoses of the aorta and of the renal, mesenteric, and celiac arteries. Spiral CT can detect a greater number of renal artery orifices and accessory renal arteries and in many patients can better define the relationships of these vessels to aortic aneurysms (6).

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 more minimally 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 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 (4).

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 (8). Typically, 80–150 mL of intravenous non-ionic contrast agent is administered at an injection rate of 2.5–5 ml/sec (2, 3). Various protocols have been described for performing angiography with single–detector row helical CT scanners. The simplest, easiest, and perhaps most widely used technique includes a fixed contrast medium dose and fixed scanning delay based on empiric data. Because of the narrow temporal window for achieving optimal attenuation of the target vessels, however, various methods have been investigated for improving the consistency of vascular contrast enhancement (3).

The technique for the delivery of contrast medium remains one of the most difficult and controversial facets of computed tomographic (CT) angiography. Unlike the ideal enhancement profile for conventional angiography, in which a narrow and tall time-attenuation curve is optimal to maximize arterial opacification, the ideal enhancement profile postulated for CT angiography is a long, consistent plateau. However, we and others have observed that, despite an appropriately timed scanning delay, arterial enhancement is not uniform over time with the standard technique for the injection of contrast material (2). At CT angiography, the successful delivery of contrast material requires the integration of the complex morphologic and physiologic characteristics of a patient's vasculature with the technical performance of the available scanning equipment. Since CT angiography was introduced, various injection techniques, which primarily focus on timing the scanning delay, have been presented (2).

In the method we use, contrast material is injected rapidly into a peripheral vein via a power injector, and the upper abdominal aorta is monitored visually for contrast enhancement by using automated-triggering hardware and dedicated software. These technique provides correct scanning delay time, ensuring that there is enough contrast material upstream to achieve adequate enhancement of both the abdominal aorta and the iliac arteries (3).

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 (8). Enhancement of greater than 100 HU, ideally greater than 150 HU in the aorta is desirable for reliable depiction and evaluation of aorta and its branches (5, 7).

Significant variation in the quantization of aneurysm size occurs depending on the technique of CT assessment used. In most patients diameter assessment is adequate, particularly if diameters

are measured on centerline CT images. Volumetric analysis appears to be very helpful in certain patients who do not show aneurysm regression, or in whom the diameter increases or where endoleaks persist. Three-dimensional reconstruction and volumetric analysis are also useful to assess the mechanism by which the endovascular device accommodates to morphology changes and to determine criteria for reintervention (9).

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 (8, 9).

CONCLUSIONS

The difference between the longest and the shortest delay time was only 5.5 sec. The mean delay time, 22.5 sec ensure the proper aortic enhancement in most of the patients. The longest delay time (26 sec) ensure the proper aortic enhancement in all patients, with acceptable up to 5.5 sec time lost in some patients, which obtained the desired enhancement in shorter delay time (minimum 20.5 sec). Therefore, to ensure the proper aortic enhancement in departments that do not have possibility to monitor the enhancement in time, setting the scanning delay time on 26 sec is reasonable.

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SUMMARY

Aortic aneurysm is a frequently encountered disorder in cardiovascular practice. To assess the abdominal aortic aneurysm precisely in CT examination intravascular contrast enhancement is required, as there is not sufficient contrast between flowing blood, intraluminal clot and the vessel wall. The delay between the start of the contrast injection and the start of the scan data acquisition is known as the scan delay. This delay allows the injected contrast media to flow from the injection site to the target vessels, and ensures the start of acquisition in the moment, when the aortic lumen is already properly enhanced. Precise choice of the delay time is the crucial element of the angio-CT examination. The purpose of our study was to evaluate scanning delay time after starting the injection of the contrast material for aortoiliac enhancement at helical CT. Material consists of a group of 22 patients with abdominal aortic aneurysms, in which angio-CT examination of the abdominal aorta was performed in our department. CT examination was performed from the level of the diaphragm to the bifurcation of the femoral arteries. Unenhanced section were performed with 8 mm thick collimation, pitch 1.5. The acquisition after administering of contrast agent was performed with 3 mm thick collimation, pitch 1–1.5. Contrast material is injected rapidly into a peripheral vein via a power injector, and the upper abdominal aorta was monitored visually for contrast enhancement by using automated-triggering hardware and dedicated software. These technique provides correct scanning delay time, ensuring that there is enough contrast material upstream to achieve adequate enhancement of both the abdominal aorta and the iliac arteries. The scanning was started, when the automatically controlled enhancement in the lumen of the aorta reached the desired level of 100 HU. The monitoring section obtained every 2.5 sec revealed increasing density in the lumen of the aorta, until the desired density in the aortic lumen was exceeded. The measured aortic densities obtained every second were used to create the enhancement curve, representing the increasing aortic enhancement in time. The delay time in the examined group of patients ranged from 20.5 to 26 sec. The mean delay time was 22.7 sec. In 16 patients the delay time was below the mean value, and in the rest of them the delay time was greater than mean 22.7 sec. The difference between the longest and the shortest delay time was only 5.5 sec. The mean delay time, 22.5 sec ensure the proper aortic enhancement in most of the patients. The longest delay time (26 sec) ensure the proper aortic enhancement in all patients, with acceptable up to 5.5 sec. time lost in some patients, which obtained the desired enhancement in shorter delay time (minimum 20.5 sec). Therefore, to ensure the proper aortic enhancement setting the delay time on 26 sec. is reasonable.

Wielkość opóźnienia skanowania w spiralnej tomografii komputerowej tętniaków aorty brzusznej

W ocenie tętniaka aorty brzusznej w TK konieczne jest wzmocnienie kontrastowe. Czas między początkiem podawania kontrastu a jego pojawieniem się w świetle aorty i rozpoczęciem skanowania jest określany jako „opóźnienie skanowania". Umożliwia on dotarcie środka kontrastowego do światła badanej aorty brzusznej i jej adekwatne wzmocnienie kontrastowe, zanim rozpocznie się akwizycja. Jest to bardzo istotne, gdyż rozpoczęcie skanowania, zanim wzmocnienie kontrastowe w aorcie osiągnie odpowiedni poziom, uniemożliwia dokładną i pełną ocenę tętniaka, jak też wykonanie dobrej jakości rekonstrukcji MPR, MIP i 3D. Celem pracy jest określenie czasu opóźnienia skanowania, po rozpoczęciu iniekcji środka kontrastowego w badaniu TK tętniaków aorty brzusznej. Materiał stanowi grupa 22 pacjentów z tętniakiem aorty brzusznej, u których wykonano badanie TK. Skanowanie obejmowało odcinek aorty od poziomu przepony do rozwidlenia tętnic biodrowych. Badanie przed podaniem kontrastu wykonywane było przy kolimacji skanu 8 mm i skoku spirali 1,5. Badanie z kontrastem wykonywano przy kolimacji 3 mm i skoku spirali 1–1.5. Środek kontrastowy podawany był automatyczną strzykawką z prędkością 4,5 ml/sek, a po osiągnięciu właściwego wzmocnienia kontrastowego aorty i rozpoczęciu skanowania z prędkością 3,5 ml/sek. Rozpoczęcie skanowania odbywało się automatycznie, za pomocą

dedykowanego oprogramowania, mierzącego w czasie rzeczywistym wzmocnienie kontrastowe w świetle aorty po rozpoczęciu podawania środka kontrastowego. Poziom progowy wzmocnienia w świetle aorty wynosił 100 JH. Po rozpoczęciu iniekcji środka cieniującego mierzono wzmocnienie kontrastowe w świetle aorty co 2,5 sek aż do chwili, gdy przekroczyło ono zaprogramowany poziom progowy 100 JH. Wyniki pomiarów wzmocnienia aorty posłużyły do wykreślenia krzywej wzmocnienia kontrastowego w czasie. Czas opóźnienia skanowania w badanej grupie pacjentów wynosił od 20,5 do 26 sekund, średni czas opóźnienia wynosił 22,7 sekundy. U 16 pacjentów czas opóźnienia był niższy niż wartość średnia, u pozostałych wyższy. Różnica między najkrótszym a najdłuższym czasem opóźnienia skanowania wynosiła 5.5 sek. Średni czas opóźnienia, wynoszący 22,7 sek, zapewniał właściwe wzmocnienie kontrastowe u większości badanych pacjentów. Czas najdłuższy opóźnienia skanowania, wynoszący 26 sekund, zapewniał właściwe wzmocnienie kontrastowe u wszystkich badanych pacjentów. Wydaje się że w zakładach niedysponujących oprogramowaniem monitorującym wzmocnienie kontrastowe w czasie słuszne jest ustawianie czasu opóźnienia skanowania na najdłuższą wartość 26 sekund, zapewniającą u wszystkich badanych właściwe wzmocnienie kontrastowe.