APPLICATION OF MULTIDETECTOR COMPUTER TOMOGRAPHY IN ACQUISITION OF CORONARY ARTERIES

Received: 22 June 2016 / Accepted: 14 September 2016

Abstract: MSCT coronary angiography is a noninvasive diagnostic procedure that allows an accurate and precise assessment of the degree of narrowing of the coronary vessels as well as the type of plaque. Further development of methods of recording the training apparatus, introducing the use of a scanner with the dual source technology as well as the proper selection of patients take to be more precise estimate of the degree of stenosis in coronary arteries.

Key words: Cardiology, multislice computed tomography, coronary angiography

1. INTRODUCTION

Modern developments in the field of radiology enabled the improvement of diagnostic procedures in all areas of medicine. The emergence of multi-slice computerized tomography (MSCT) with 16-slice and the subsequent 64, 128 and 256-slice devices with a multidetector scanners, and a possible layer thickness (resolution) of 0.3 to 0.6 mm, has led to significant changes in the diagnostic methods of coronary heart disease.

2. DEVELOPMENT OF MSCT

The first multi-slice CT scanner ELSCINT Twin was developed in 1991 [1]. It was a two-slice scanner, which is made during each rotation of the two sections. This technology has developed rapidly, and soon 4- slice was put into operation, then a 16-slice, 64, 128 and 256-slice [1]. The emergence of dual source technology, with two X-ray sources and the use of multislice detectors that are positioned opposite of each other and at a 90 degrees from each other, continually rotating around the patient during scanning, enabled shorter scanning time (and also the time in which is necessary that the patient holds his breath) and provided a better image of tested blood vessels (Figure 1) [2].

3. TECHNICAL BASICS OF MSCT TECHNOLOGY

CT scanners have an X-ray source and a detector placed opposite one another which are continuously rotating around the patient. Recordings (scans) are made when patient is moving through the opening apparatus (gentry), as shown in Fig. 2. A computer processes data obtained from images and, based on them, creates a three-dimensional (3D) volumetric model. Formed 3D object can then be seen from different angles, perspectives and different sections [3].

3D object that can be seen on a workstation is made up of a series of three-dimensional pixels (called voxels), the size of which depends on the resolution of the scanner. Voxel is shown in different shades of gray (from black to white) which represent the level of attenuation of X-rays, depending on the type of tissue through which the X-ray beam had passed. Bone and calcium (which is especially important in the diagnosis of coronary heart disease) imply a higher level of attenuation, which appears in white color on the image. The air is characterized by a very low level of attenuation, which represents voxels in black. A smaller voxel size corresponds to a higher resolution scanner as it depends on the X-ray sensor resolution, and not the number of sections. By increasing the number and size of the detector (multidetector MSCT), as well as speeding up the rotation apparatus (gentry) around the patient, images with better quality are obtained.

Fig. 1. The difference between single and multislice scanner
4. APPLICATION OF MSCT SCANNERS IN CARDIOLOGY

The specificity of the coronary arteries imaging in relation to the recording of other organs lies in the fact that the heart and the organs keeps moving. For this reason, it is much harder to get an adequate image. To use this technology for shrinkage evaluation of the blood vessels, the scanning is performed only in a certain phase of the cardiac cycle - in late diastole. This is the phase where the heart muscle is least moving. For this reason ECG-triggering is introduced. Scanning in a certain part of diastole (late diastole) and cardiac triggering or ECG gating (Eng. Prim. Aut.) is a very important factor for obtaining high-quality images of coronary arteries (Fig. 3 and 4) [4].

5. RADIATION DOSES DURING MSCT CORONARY ANGIOGRAPHY

In the beginning of the application of MSCT technology, the level of radiation that the patient received was significantly higher, compared to conventional angiography (invasive coronary angiography), where the radiation dose was up to 21 mSv [5]. The "CORE" study in 2006 (comparing CT coronary angiography with invasive coronary angiography) showed a mean effective radiation dose of 16 mSv for men and for women 15 mSv [5]. In "PROTECTION I" study an average radiation of 12 mSv was obtained [5].

During the diagnostic invasive coronary angiography, moderate doses are ranging from 2.5 up to 10 mSv [5]. The introduction of EKG triggers technology during the MSCT coronary angiography, the scanning is performed only in a certain part of the cardiac cycle (diastole portion) and by reducing the voltage tube, it can achieve reduced radiation dose of up to 90% [5]. Typical effective doses of radiation at different diagnostic procedures are shown in Table 1.

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<th>PROCEDURE</th>
<th>Effective dose (mSv)</th>
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<td>MSCT coronary angiography</td>
<td>6 – 25</td>
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<tr>
<td>Invasive coronary angiography</td>
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<td>MSCT of the chest</td>
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Table 1. Effective radiation dose during various diagnostic procedures

6. THE IMPORTANCE OF MSCT CORONARY ANGIOGRAPHY IN CLINICAL PRACTICE

The tendency of modern medicine is that during the diagnostic procedure it resorts in less invasive procedures with the use of diagnostic and therapeutic methods that do not require hospitalization. MSCT coronary angiography, as a noninvasive diagnostic technique, enables evaluation of coronary vessels narrowing and different types of plaque, without hospitalization of patients and without any serious complications (death, acute myocardial infarction, cerebrovascular accident) and with a significant reduction in cost, in relation to invasive coronary angiography (ICA). Scientific research in the field of application of MSCT coronary angiography in which MSCT coronary angiography and ICA were compared, aimed at testing the degree of correlation of the findings of the two diagnostic procedures. MSCT coronary angiography, as a noninvasive procedure, has become the method of choice for the assessment of coronary circulation for certain patient groups (Fig. 5
and 6). Since the introduction of dual source MSCT coronary angiography technology, this method of visualization of the coronary arteries and the size and type of plaque in blood vessels, has an even more significant role in the diagnosis of patients with angina pectoris [6]. Sensitivity is thereby registered to 95% and specificity of 95% to 75% PPV, NPV 99% [7]. In the world every year a large number of ICA is performed in which there are no observed hemodynamically significant stenosis in the coronary arteries (according to some studies, up to 40%) [7].

In this way, on the one hand, patients are undergoing unnecessary hospitalization, risks and invasive diagnostic procedures with unnecessary costs for the health insurance system. MSCT coronary angiography in such cases could have a dual role. With high accuracy, sensitivity and specificity in younger patients and in patients who have a low Ca score, MSCT coronary angiography could replace the ICA in the diagnosis of coronary heart disease, or detection of stenosis in the coronary blood vessels that are not hemodynamically significant, and also reduce the number of unnecessary ICA procedures. By eliminating patients who have rhythm disturbances, primarily atrial fibrillation, followed by obese patients and those who can’t hold their breath long enough, with adequate training of doctors who can read the findings of MSCT coronary angiography, this recording method allows obtaining high accuracy of the findings in assessing the degree of coronary stenosis artery.

![Fig. 5. Correlation between findings of constriction in the right coronary artery MSCT (left) and the ICA (right) (7)](image)

The negative findings of MSCT coronary angiography with a high degree of probability excludes the existence of hemodynamically significant coronary artery disease, and patients with such findings should not run ICA. A certain degree of doubt exists with positive findings of MSCT coronary angiography because of the possibility of false positives, which ranges in different studies between 12-15% [8,9]. Further development of scanning methods and perfecting of the apparatus (128 and 256 slice units), with proper selection of patients in the future should lead to a reduction in false positives MSCT coronary angiography and therefore reduce the number of performing unnecessary invasive coronary angiography.

Extensive coronary artery calcification limits the possibility for successful visualization of the coronary blood vessels. Calcified plaques in the walls of blood vessels and high regard Ca score lead to the appearance of artifacts such as the effect of blooming and reflection, which significantly limit the quality assessment of the degree of narrowing of the blood vessel. The occurrence of artifacts is due to the fact that high-density objects (calcification) occupy a space that is greater than, or equal to the size of a voxel. As a consequence, it comes to overestimating the degree of stenosis [8]. So far, attempts were committed to reduce the interference in reading the findings, which are due to the presence of calcification. Advanced algorithms for image reconstruction were introduced, but without any significant effect. MSCT technology, image filters, increasing the tube voltage, to some extent reduce the interference. However, in clinical practice calcification in the walls of coronary arteries are still making it difficult to interpret the findings, suggesting that there is a need for further improvement of MSCT angiography for better applications, as well as different programs for better image processing. However, Ca score is closely linked with the emergence of significant hemodynamically narrowing of the blood vessels, so that the finding of calcification on MSCT shows the existence of a significant narrowing [10].

7. CONCLUSION

Multi-slice computed tomography of coronary arteries represents a reliable diagnostic method for the assessment of coronary blood vessels. It has a high sensitivity and specificity compared to conventional invasive coronary angiography. Further development of scanning methods, perfecting of the apparatus and by introducing the use of a scanner with the dual source technology as well as the proper selection of patients, are leading to a more precise estimation of the degree of stenosis of coronary arteries using MSCT technology.

8. REFERENCES


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