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Original research paper

LOW RADIATION AND CONTRAST MEDIUM DOSE IN 64-SLICE MULTIDETECTOR CT ANGIOGRAPHY OF THORACIC AORTA*

Ippolita Valentina Di Molfetta[1], Stefano Del Monte[1], Antonino Guerrisi[1], Giuseppe Guglielmo Aloise[1], Anna Forbidussi[1], Domenico Vito Di Molfetta[2], Basilio Lippi[1]**

[1]Service of Radiology Imaging Ospedale Israelitico, Roma, Italia
[2]Department of Radiological Sciences, Institute of Radiology, Fondazione Policlinico Universitario A. Gemelli, School of Medicine, Catholic University, Rome, Italy

Abstract. *The evaluation of chronic aortic diseases, many protocols of low radiation dose and low medium iodine contrast dose are performed. The main aim of this study is to give a preliminary evaluation of dose reduction and iodine dose reduction. In our hospital, from February 2013 to November 2016 we selected 150 patients divided into two groups: 60 for our study and a control group of 90 cases. All CT examinations were performed with a 64-MDCT scan (Optima-CT GE Healtcare). Tube voltage was reduced in our study (80 kVp versus 120 in our standard) with automated current modulation system in both groups. Concerning the iodine dose reduction, in the study groups it was strongly reduced (40 cc of 370 mg/ml versus 90 cc of 370 mg/ml): a mechanical power injector was used to administer the contrast material via catheters (20-gauge) placed in the antecubital vein at a flow rate of 4.5 ml/sec. Two radiologists qualitatively graded the image quality of all cases, defining the walls and the enhancement of the lumen of the aorta. On the basis of the criteria reported in the literature, a five-point subjective scale was used to grade image quality, from excellent (1) to non-diagnostic quality (5). The reasons for the degraded image quality were due to high BMI and consisted especially in low signal/noise ratio, and in two cases it was due to the suboptimal contrast enhancement owing to poor bolus timing. In the cases of low signal/noise ratio, a smooth filter was applied to reduce the noise. The results of this study provide useful information about the reduction of the radiation dose and the medium iodine contrast. The diagnostic quality of the scan performed with a low dose of iodine and radiation overlays with the scans performed with the standard protocol. The study groups revealed a strong reduction dose in terms of DLP, and the quality of images was similar to the control group.*

Key words: *Angiographic CT, ASIR, CT, Low contrast dose, Multidetector CT (64), Radiation dose, Thoracic Aorta*

1. INTRODUCTION

The reduction of the dose of a contrast medium is a prominent topic in the literature.

In fact, the contrast medium is related to many problems, especially in old patients, in particular to kidney overload.

The radiation dose exposure is correlated to many neoplasms.

For these reasons in many centers, the study of a low dose protocol is a bet.

2. MATERIALS AND METHODS

For this retrospective study, from February 2013 to November 2016, we selected 150 patients referred for clinical or Doppler examination, suspected of an aortic chronic disease (age range from 40 to 87 years), divided into two groups: 90 patients were the control group while 60 patients were in the study group. These patients were retrospectively selected because, in their report, the volume of the contrast medium was clearly defined.

All CT examinations were performed using a 64-MDCT scan (Optima CT GEHealthcare).

The technical parameters are reported in Tables 1 and 2.

In the control group, every patient received a full radiation dose with 120 kV and the automated current modulation system, while in the study group, the radiation dose exposition was reduced to 80 kV and automated current modulation system. In fact, according to Marin et al. [9], ASIR algorithm has the potential to reduce the exposition dose in the vascular evaluation.

In each patient, the bolus tracking technique (SMARTPREP; GE) was used, monitored with a low-dose automatic timing device to optimize the delay

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** v.dimolfetta@ospedaleisraelitico.it

time from the start of injection to the start of scanning, at the level of the ascending aorta. For this reason, we placed a region of interest (ROI) of average range (1-1.4 cm^2) in the ascending aorta.

The type of contrast medium was the same in both groups, but the dose was really different, because in the control group it was 90 ml of 370 mg/ml with a flow rate of 3.0 ml/sec, followed by 50 ml of saline flush at the same rate, while in the study group, the volume was strongly reduced, and it consisted of 40 ml of the same contrast, followed by 30 ml of saline flush at higher flow (4.5 ml/sec): due to their different densities, the two liquids do not mix.

In each group of patients, a mechanical power injector was used to administer the contrast material via catheters (18-gauge) placed in the antecubital vein.

Subsequent reconstructed axial images of 2 mm slice thickness were obtained using a medium-sharp convolution kernel (B20 f) with an image matrix of 512×512 pixels. We used a MDCT-A window setting (width, 400 HU; level, 100 HU).

Two highly experienced radiologists, one with 10 years of experience and the other with 5 years of experience, graded the image quality of all cases, defining the walls and the enhancement of the lumen of aorta.

On the basis of the criteria reported in the literature, a five-point subjective scale was used to grade image quality, from excellent (1) to non-diagnostic quality (5).

The reasons for the degraded image quality were due to high BMI and consisted especially in low signal/noise ratio, and in two cases it was due to the suboptimal contrast enhancement owing to poor bolus timing.

In the cases of low signal/noise ratio, a smooth filter was applied to reduce the noise.

3. Results

Concerning the quantitative analysis, a ROI (region of interest) was placed at the origin of the ascending thoracic aorta (Point 1) and immediately above the emergency of the celiac trunk (Point 2).

We proved that there were no significant differences in the density (measured in HU) between the medium concentrations in both aortic districts examined. In particular, the main value was different for each patient, in both places, with a range described in Table 3. So, we could assume that there was an optimal opacification of thoracic aorta after a small contrast volume administration, the same as with the control group.

Concerning the noise/ratio signal, we fixed the noise index at 21.4 so the quality of all images, qualitatively evaluated from two experienced radiologists (with 10 years and 5 years of experience) was unanimously considered good.

4. Discussion

The expression “low dose CT” is not well defined.

Many authors refer to radiation dose reduction and contrast medium reduction. According to Kyongtae, contrast enhancement is affected by numerous interesting factors, depending on the patients, the contrast medium and the CT-scans with their parameters [7].

The parameters that affect the CT radiation dose include tube current and voltage, scanning modes and scanning length. Concerning radiation exposure, new automatic techniques have a common purpose consisting in adjusting the X-ray tube current to compensate for the different level of attenuation of the scanner’s X-Ray beam. These different techniques may be combined with kVp modulation. Good quality of images may be obtained if the noise index is previously fixed and, in our study, it is usually 21.4.

Nakayama et al, using a 16-CT row, demonstrated that by changing the tube voltage from 120 to 90 kVp, the radiation dose was reduced for more than 20% [8]; the experience of Yanguangshen et al. confirms that the major advantage of lowering the tube voltage is to reduce the radiation dose. With the dual source CT, they confirmed the dose reduction using a low voltage, but with significant improvements of the image quality.

In our experience, the radiation dose was reduced by use of ASIR; as defined by Marin D. Et al. [1], the ASIR algorithm yields significantly improve image quality at low-tube-voltage (80 kVp), high-tube-current CT and may be an effective strategy for reducing the radiation exposure.

Ippolito D. et al. [2], using a 256-row CT, significantly decreased the radiation exposure by ECG-gated Aortic CT.

Concerning contrast reduction, a significant contribution came from Ippolito D. et al. [2] who, using 256-row CT, administered only 30 ml of contrast medium.

Seehofnerova A. et al. [3] was able to reduce the radiation dose using a dual source scanner, while the medium contrast reduction was not more significant than ours; in fact, they used the technique of bolus test (10 cc) followed by the main bolus (50 cc), so in total 60 cc of contrast were administered.

E. Cakmackci et al. [4] used a 128-section multidetector CT, administering 40 ml of 320 mgI/ml iodine contrast.

In our experience, we used a 64-row CT and we gave 45 ml of contrast medium to the patients.

Our analysis was both quantitative and qualitative.

Our results are in agreement with Mourits M.M. et al. [10]; in fact, they highlight that low-tube-voltage CTA using 50 of ml of CM is not inferior to CTA qt 120 kV using 100 ml of CM. Concerning the quantitative analysis, if Yamamuro et al. [5], using a 64-slice multidetector CT, assumed that an optimal CT density in the coronary arteries had to be considered to be more than 250 to 350 HU, in our study we did not select an optimal density in the aorta, because we considered that it was not necessary due to the great dimension of the vessel: our parameter was concerned with the variation of density through the vessel.

In particular, we considered the quality of the exam correlated with a homogeneous density between the aortic root and the descending aorta, or non-significant inhomogenous density consisting in a difference of density between the two regions of maximum 50 HU.

Concerning the qualitative analysis, according to the literature [6], a five-point subjective scale was used to grade image quality, where 1 was excellent, 2 was good, 3 moderate, 4 poor and 5 non-diagnostic quality.

Several limits of this study should be mentioned: the first one concerns the patient's size: obese patients required higher kV because the signal/noise ratio was too low, as already defined by E. Cakmackci et al. [7]. Our experience was in line with Marin et al. [1] who, referring to abdominal aorta, demonstrated that ASIR algorithm yields significantly lower noise and improve image quality for low-tube-voltage and high-tube-current.

Figure 1. Control Group

Figure 2. Study Group

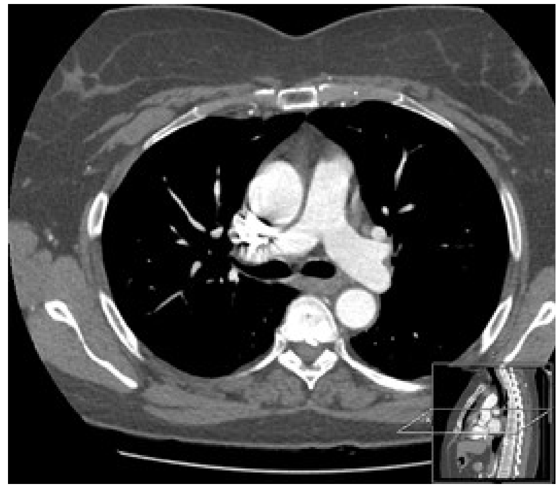

Figure 3. Control Group. Point 1

Figure 4. Study Group. Point 1

Figure 5. Control Group. Point 2

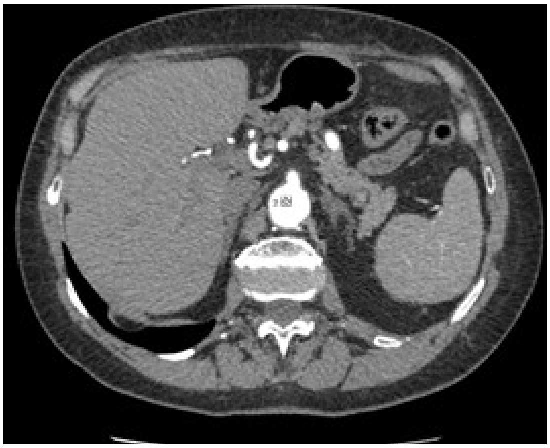

Figure 6. Study Group: Point 2

Table 1. Technical parameters of the study group

Technical parameters:	
Velocity	110 m/sec
Pitch	1.38 mm/ rot
Rotation time	0.5 msec
Acquisition time	4.22 sec
kV	80
Threshold	45 HU

Table 2. Technical parameters of the control group

Technical parameters:	
Velocity	91.66 m/sec
Pitch	1.38 mm/ rot
Rotation time	0.6 msec
Acquisition time	6.16 sec
kV	120
Threshold	100 HU

Table 3. Density value

		Control Group	Study Group
Minimum Density	Point 1	290 HU	196 HU
Maximum Density	Point 2	545	630 HU

5. Conclusion

The thoracic aorta may be evaluated with a low amount of iodine contrast, because it allows an adequate opacification: concerning the low radiation dose, using GE multidetector CT, with the protocol of ASIR, a good quality of images may be obtained if a high signal–noise ratio is previously fixed.

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