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Contrast medium usage reduction in abdominal computed tomography by using high-iodinated concentration contrast medium

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Contrast medium usage reduction in abdominal computed tomography by using high-iodinated concentration contrast medium

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Abstract: This study was to determine if administration of a low volume high-concentration iodinated contrast medium can preserve image quality in comparison with regular-concentration intravenous contrast medium in patient undergoing contrast-enhancement abdominal computed tomography (CT). Eighty-four patients were randomly divided into 3 groups of similar iodine delivery rate; A: 1.2 cc/kg of iomeprol-400, B: 1.0 cc/kg of iomeprol-400 and C: 1.5 cc/kg of ioversol-350. Contrast enhancement of the liver parenchyma, pancreas and aorta was quantitatively measured in Hounsfield units and qualitative assessed by a radiologist. T-test was used to evaluate contrast enhancement, and Chi-square test was used to evaluate qualitative image assessment, at significance level of 0.05 with 95% confidence intervals. There were no statistically significant differences in contrast enhancement of liver parenchyma and pancreas between group A and group C in both quantitative and qualitative analyses. Group C showed superior vascular enhancement to group A and B on quantitative analysis.

1. Introduction

Clinical use of multidetector computed tomography (MDCT) has increased in the past decades because of its accuracy in diagnosis of many diseases, fast acquisition and wide availability. In many CT studies, particularly abdominal CT, intravenous iodinated contrast medium administration is essential to improve image quality and to enhance image interpretation. However, contrast medium poses additional risk of contrast-induced nephropathy (CIN) because the development of CIN is dependent on the volume of administered iodinated contrast medium [4], reduction of the contrast medium volume could potentially help alleviating this phenomenon. Reduction of iodinated contrast volume needs to be balanced with the degree of parenchymal organ and vascular enhancement, given that they are proven to be directly dependent on each other [5]. Fenchel S *et. al.* [7] reported that the use of a high-concentration iodinated contrast medium, such as iomeprol-400, could help reduce the contrast volume while preserving the degree of contrast enhancement. Because contrast medium volume reduction is preferable to reduce the risk of CIN, the objective of this investigation was to compare image quality, in terms of parenchymal and vascular enhancement, between administration of low-volume iomeprol-400 and regular-volume ioversol-350 using weight-based injection protocols [2, 3].

2. Materials and Methods

2.1. Patients

This prospective investigation was approved by our hospital's Ethics Committee. All consecutive patients undergoing contrast-enhanced abdominal CT at the accident and emergency center, Ramathibodi Hospital, who gave informed consents, were prospectively enrolled in the investigation. Patients with a history of diabetes, pregnancy or nursing women, asthma, hypersensitivity to iodinated contrast medium, hyperthyroidism, eGFR lower than 60 ml/min/1.73 m^2, were excluded. A total of eighty-four patients (40 men; mean age 57 years) was randomly assigned to three groups, consisting of 28 in each group of different volume and concentration of intravenous contrast administration.

- Group A: 1.2 ml/kg of iomeprol-400 (equal to 480mgI/kg).
- Group B: 1.0 ml/kg of iomeprol-400 (equal to 400 mgI/kg).
- Group C: 1.5 ml/kg of ioversol-350 (equal to 525 mgI/kg).

At our institution, the standard technique for administering intravenous contrast medium in abdominal CT is to use weight-based dosage [1]. Because the total amount of iodine that is administered to a patient divided by patient's weight (mgI/kg) for optimal parenchymal enhancement is between 500 and 700 mgI/kg [6], our standard dose delivers a weight-base dose of 1.5 ml/kg of a low-osmolar contrast medium with concentration between 350 and 370 mgI/ml (equal to at least 525 mgI/kg). Ten-percent reduction of iodine administration below the standard dose was equal to 1.2 cc/kg iomeprol-400 at 480 mgI/kg (Group A). Group B represented a 23% reduction of iodine administration of the standard dose.

2.2. Imaging protocol

All scans were performed on a 64-row multidetector CT scanner (Toshiba Aquilion CX). Routine abdominal CT protocol included venous and delayed acquisitions. Scanning parameters for the venous phase were 120 kVp automatic tube current modulation (SD 15, Sure Exposure 3D) with minimum and maximum mA of 40 mA and 440 mA, rotation time 0.6s, pitch factor 0.906, collimation 0.5×64. Automatic contrast medium-injector was used to deliver intravenous contrast medium IV at a flow-rate of 2.6 ml/s, followed by 20 ml of normal saline solution at a flow rate 2.0 ml/s. The venous-phase images were acquired at 70s after contrast administration.

2.3. Image evaluation

Quantitative assessment of enhancement was performed by measuring CT attenuation in Hounsfield Unit with a 1-cm-diameters circular regions of interest (ROI) on the images viewed on Picture Archiving and Communication System (PACS). The ROIs were placed at the right and left liver lobes excluding hepatic vessels, abdominal aorta and pancreas on venous phase images. Qualitative assessment was performed by an experienced radiologist as a blind reader for overall image enhancement and evaluation of vessels. Image quality grading was performed using a 5-point scale (5=excellent, 4=good, 3=sufficient, 2=insufficient, 1=poor) Statistical analysis was performed using Predictive Analytic SoftWare (PASW) Statistics 18 at a significance level of 0.05 with 95% confidence intervals, by comparing group by group (group A vs group C, group B vs group C, group A vs group B). Independent T-test was to compare contrast enhancement and Chi-squared test for qualitative analysis.

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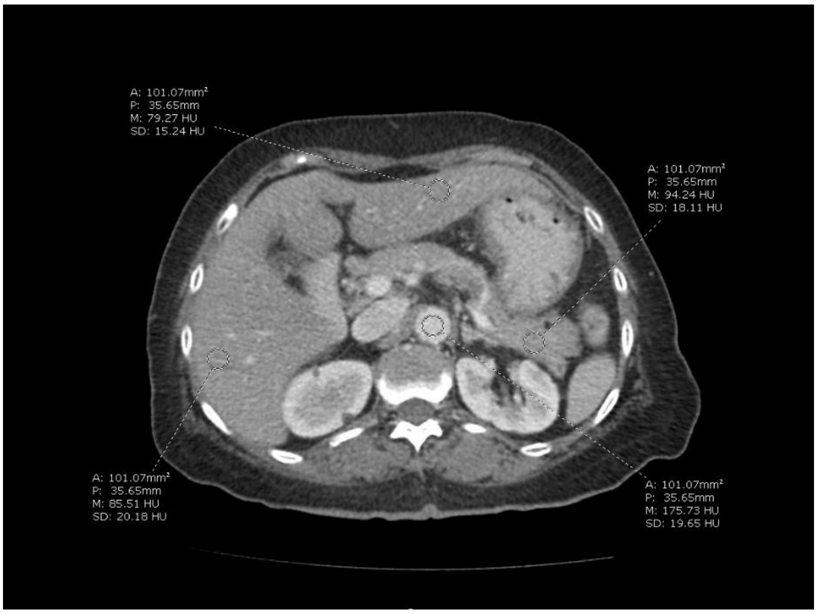

Figure 1. The ROIs were placed at the right and left liver lobes excluding hepatic vessels, abdominal aorta and pancreas on venous phase images.

3. Results

3.1. Quantitative analysis

The average HUs (±standard deviation) of the liver parenchyma, pancreas, and aorta were shown in table 1. Between group A and group C, there was no statistical difference of enhancement of the right-lobe liver parenchyma (97.9±13.4HU vs 101.5±13.2, p = 0.321), left-lobe liver parenchyma (101±15.5HU vs 107.7±12.8HU, p = 0.084) and pancreas (92.5±9.8HU vs 96.8±13.7HU, p = 0.193). However, there was a significantly difference in the attenuation of the aorta (144.9±21.6HU vs 164.5±28.7HU, p = 0.006). Between group B and group C, there was a significantly difference in all parts ($p < 0.05$). Between group A and group B, there was no statistical difference of the attenuation of the aorta (144.9±21.6HU vs 135.8±15.7HU, p = 0.078) and pancreas (92.5±9.8HU vs 86.4±14HU, p = 0.069). There was a significant difference between the right-lobe liver parenchyma (97.9±13.4HU vs 90.8±9.3HU, p = 0.001) and left-lobe liver parenchyma (101±15.5HU vs 93.3±9.3HU, p = 0.0001).

Table 1. Comparison of contrast enhancement in venous phase: group A (Iomeprol400 1.2ml/kg) v.s. group C (Ioversol350 1.5 ml/kg), group B (Iomeprol400 1.0 ml/kg) vs group C and group A vs group C, using independent t-test.

Quantitative Analysis	Average HU			*p*-value		
	Group A	Group B	Group C	A vs C	B vs C	A vs B
Right-Lobe Liver Parenchyma	97.9±13.4	90.8±9.3	101.5±13.2	0.321	0.001	0.026
Left-Lobe Liver Parenchyma	101±15.5	93.3±9.3	107.7±12.8	0.084	0.000	0.027
Aorta	144.9±21.6	135.8±15.7	164.5±28.7	0.006	0.000	0.078
Pancreas	92.5±9.8	86.4±14.4	96.8±13.7	0.193	0.008	0.069

3.2. Qualitative analysis

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None of all groups contained 5-point scales of 5 and 1(table 2). Statistical calculation of all group had *p*-value > 0.05(table 3) that denoted no statistical difference in overall image enhancement and vessels.

Table 2. Total 5-point scale of all groups.

Qualitative Analysis	Group A			Group B			Group C		
	4	3	2	4	3	2	4	3	2
Overall image enhancement	18	10	0	18	8	2	17	10	1
Evaluation of vessels	21	7	0	19	9	0	21	7	0

Table 3. Group by group of statistical comparison using Chi-squared test.

Qualitative Analysis	*p*-value		
	A vs C	B vs C	A vs B
Overall image enhancement	0.598	0.747	0.329
Evaluation of vessels	1.000	0.554	0.554

4. Conclusion

Low volume of iomeprol-400 could provide parenchymal image quality similar to regular-volume ioversol-350 on both qualitative and quantitative assessment. For vascular enhancement, regular-volume ioversol-350 still demonstrated superior enhancement on quantitative analysis but not on qualitative assessment.

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