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Research about Contrast Media Volume Injection by Body Mass Index in Cardiac CT

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Abstract: Even a little smaller amount of contract medium is used for cardiac CT according to patient's BMI, excellent image with high HU and SNR can be obtained. CT equipment used in this study was light speed volume CT 64 channel (GE healthcare, USA). Patients with heart rate <65 were classified into 4 groups according to their BMI and SNR was measured by injecting different amount of contrast media. Collected materials were analyzed using SPSS 23.0 Ver. at the significance level of $p<0.05$. By BMI, measured value was the highest at underweight and the lowest at extreme obese. By contrast media dose, it was the highest at 90 mL and the lowest at 80 mL. Correlations analysis of variance showed statistically significant difference according to contrast media dose by BMI. It is considered that contrast medium does should be decided considering BMI to minimize side effects of contrast medium while acquiring excellent quality SNR.

Key words: MDCT, contrast side effect, BMI, SNR, contrast media

INTRODUCTION

The current era is an information era in which computer technology has developed rapidly (Woon *et al*., 2015). The clinical usage of Computed Tomography (CT) has increased greatly, since its development in 1972 (You *et al*., 2015). The basic principle of image composition of CT is to measure inner structure of human body from various directions through X-ray penetration and detector, reconstruct those cross-section images using a computer and record the reconstructed image in image recording device. It is the device making image of cross-sections of human body using differences of various structures of human body in HU by combining existing X-ray and computer technology. In other words, it receives rotating X-ray tube in detector, transforms it to light and electric signal, reconstructs a cross-section image using mathematical method in the computer and presents the image on the monitor through necessary image processing (Kim *et al*., 2013). Existing CT acquires a single image per rotation but with the development of Multi-Detector Computed Tomography (MDCT) with 320 detector columns, there was revolutionary improvement in examination speed. As examination duration is reduced, new clinical application range was expanded enormously (Kim and Kim, 2014). By minimizing artifact caused by patient's movement, it could secure clinical efficacy as it can examine whole stomach while the patient holds his breath. With development of CT equipment, it was possible to reduce examination time to enhance image evaluation capacity according to reduction of slice thickness and to reconstruct image of bone and veins with 3 dimensional works. Therefore, diagnosis value of CT image increases and examination cases are increasing accordingly. As CT examination time reduces and MDCT rapidly develops in cardiovascular examination, it is widely used in coronary artery disease diagnosis. When comparing MDCT with Conventional CT, it needs less time and has diversified areas to examine. As enhancement of diagnosis area is required, it uses more amount of contrast medium more frequently and injection speed and pressure increase. Accordingly, diverse side effects are shown (Yang and Shin, 2008). Currently, non-ionic water-soluble low-osmolality contrast medium is used to enhance the safety of patients rather than ionic contrast medium. Because of unexpected side effects of contrast medium after CT both of patients and radiological technologists feel burden. Additionally, because of characteristics of examination, medical institutions may not be able to respond to side effects of contrast medium. Use of optimal amount of contrast medium is a very important factor to acquire high quality image with diagnosis value at the same time to secure stability by reducing anxiety and mental stress of patients through reducing side effects to some extent. Accordingly, this study tries to present the most optimal amount of contrast medium by minimizing overuse applying BMI of patients when deciding contrast medium amount in Cardiac CT routine contrast media test.

MATERIALS AND METHODS

Research equipment: In this study, light speed volume CT 64 channel (GE healthcare, USA) was used. For scan

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Fig. 1: CT inspection equipment

Table 1: Research equipment

Equipment	Light speed volume CT 64 channel (GE healthcare, USA)
Scan type	Cardiac
Cardiac mode	Snap shot segment (Helical)
Rotation time	0.35 sec
Detector coverage	40.0 mm
Slice thickness	2.5 mm
Interval	2.5 mm
Scan FOV	Cardiac small
KVP	120 KVP
mA	Max. 500 in ECG modulated mA min. 140

type cardiac for cardiac mode snap shot segment (Helical) were used, respectively. Rotation Time was set as 0.35 sec, detector coverage as 40.0 mm, slice thickness as 2.5 mm, interval as 2.5 mm, scan FOV cardiac small as 120 kVp and ECG modulated mA as min. 140 max. 500 (Table 1).

As contrast medium, non-ionic contrast media Optiray 350 (Ioversol 741 mg/mL, Iyeon Pharmaceuticals) and ChoongwaeNS 1000 mL/bag (JW) N/S were injected by 5.0 mL/sec, respectively. MEDRAD Stellant dural injector was used as auto injector to acquire the image. With acquired axial image, image was reconstructed using GEAW olume share 4.5 advance workstation program (Fig. 1).

Test method: Subjects were patients who were referred to Cardiac CT routine contrast media examination out of outpatients in Heart Disease Center in M Hospital in Koyang City, Kyunggi-do because of chest pain and angina. When they sign the form of contrast medium use we got their agreement on this study. Patients with heart rate <65/min were classified into 4 groups according to BMI; <23 kg/m^2 as Grade 1 from 23-25 kg/m^2 as Grade 2 from 25-30 kg/m^2 as Grade 3 and over 30 kg/m^2 as Grade 4. Based on mean contrast medium amount used in hospitals in Korea (80 mL for optiray 350 contrast medium and 50 mL for N/S) we examined using contrast medium at 90, 80, 70 and 60 mL, respectively.

For objective evaluation of image, Region-of-Interest (ROI; cm^2) was set as large as possible not to include blood vessel wall or neighboring tissues and CT density Hounsfield Unit (HU) and Standard Deviation (SD) were

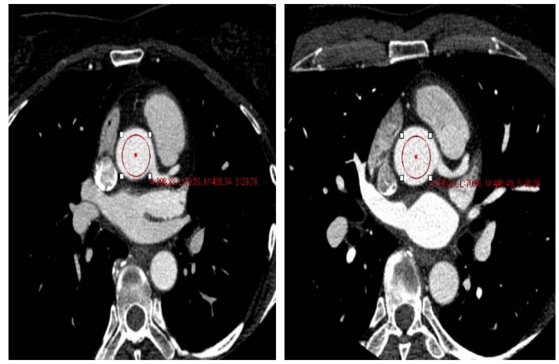

Fig. 2: Measurement of ROI of the image

measured to calculate Signal to Noise Ratio (SNR). SNR was calculated by setting ROI at Left Main Coronary Artery (LMA), ascending aorta in the origin and proximal, respectively (Fig. 2) (Kim *et al*., 2013).

For the subjective evaluation of image quality, 2 cardiologists analyzed by 4 steps with mutual agreement. Very good (4 point), nearly no artifacts and easy to diagnose because of good contrast, good (3 point) Although, there are several artifacts, they do not influence diagnosis with good contrast, fair (2 point) Although, there are severe artifacts, diagnosis can be made with some con, poor (1 point) when coronary artery is not visible or diagnosis cannot be made because of too many artifacts. SNR was measured at proximal ascending aorta and then mean SNR was calculated (Eq. 1):

$$SNR = \frac{\text{HU mean of proximal ascending aorta}}{\text{SD of proximal ascending aorta}}$$

Data analysis was made using statistics package program SPSS 23.0 Version (Statistical Package for the Social Science) was used and to identify general characteristics of subjects, frequency analysis and descriptive statistics analysis were used.

Analysis on BMI and contrast medium does was made through one way ANOVA test and correlation analysis. Statistical significance was set as significance level 95% ($p<0.05$). To determine minimum sample number, G power, a statistical power analysis program was used.

RESULTS

General characteristics of subjects: Among 246 subjects 145 (58.9%) were males and 101 (41.1%) were females. By contrast medium does to 78 patients (31.7%) 90-74 mL (30.1%) 80-50 mL (20.3%) 70-44 mL (17.9%) and 60 mL.

Table 2: General characteristics of subjects

Classification	No. (%)
Sex	
Male	145 (58.9)
Female	101 (41.1)
Injection volume (mL)	
90	78 (31.7)
80	74 (30.1)
70	50 (20.3)
60	44 (17.9)
BMI	
Underweight	62 (25.2)
Normal	45 (18.3)
Overweight	103 (41.9)
Severe obesity	36 (14.6)

Table 3: Changes in HU and SNR according to BMI

Variables	Underweight (23 under)	Normal (23~24.9)	Overweight (25~29.9)	Severe obesity (30 more)
N	62	45	103	36
LMA HU	540.9±55.0	475.8±74.8	452.8±80.4	363.6±58.2
SNR	20.4±3.3	14.9±2.7	12.8±2.7	9.1±3.1

Table 4: Changes in hu and snr according to amount of contrast medium dose

Variables	90 mL	80 mL	70 mL	60 mL
N	78	74	50	44
LMA HU	484.3±85.2	446.2±86.1	476.5±99.8	455.7±84.0
SNR	15.2±4.6	13.7±4.2	14.4±4.8	14.8±5.7

By BMI, under-weight were 62 (25.2%), normal 45 (18.3%), over-weight 103 (41.9%), severe obesity 36 (14.6%) and mean BMI was 25.4 (Table 2).

HU and SNR measurement according to BMI: Mean LMA HU of 4 groups according to, BMI was the highest at the group of under 23 as 540.9±55.0 and the lowest at the group of 30 and more as 363.6±58.2. As F = 49.799 and p = 0.000 there was statistically significant difference among groups (p<0.001**). SNR of 4 groups according to BMI was also the highest at under 23 as 20.4±3.3 and the lowest at 30 and more as 9.1±3.1. As F = 132.694 and p = 0.000 there was statistically significant difference among groups (p<0.001**). HU and SNR measurement according to BMI was the highest among underweighted people and the lowest among extreme obese people (Table 3).

HU and SNR measurement according to contrast medium dose: LMA HU mean value according to contrast media dose was the highest at 90 mL as 484.3±85.2 and the lowest at 80 mL as 446.2±86.1. As F = 2.778 and p = 0.042, there was statistically significant difference among groups (p<0.05*). However, SNR according to contrast media dose was the highest at 90 mL as 15.2±4.6 and the lowest at 80 mL as 13.7±4.2. As F = 1.343 and p = 0.261, there was no statistically significant difference among groups (p>0.05). It is thought that we can get high quality image with enough high SNR value even when we use less amount of contrast media than specified in manual (Table 4).

Table 5: Analysis of correlation between bmi and contrast medium dose

BMI	Contrast medium dose	LAD HU	SNR
BMI			
Contrast medium dose	0.061		
LAD HU	0.000**	0.233	
SNR	0.000**	0.681	0.000**

p<0.001**

Correlations analysis of HU and SNR according to BMI and contrast medium dose: BMI showed lineal correlation with LAD HU (R = -0.621, p<0.001**) and SNR (R = -0.784, p<0.001**) but it does not have correlational relationship with contrast media dose (p>0.05).

LAD HU showed correlational relationship with BMI (R = -0.621, p<0.001**) and SNR(R = 0.754, p<0.001**) but it does not have correlational relationship with contrast media dose (p>0.05).

SNR showed lineal correlation with BMI (R = -0.784, p<0.001**) and LAD HU (R = 0.754, p<0.001**) but it does not have correlational relationship with contrast media dose (p>0.05). Considering the above results, contrast media dose did not have correlation with all the groups (p>0.05) (Table 5).

DISCUSSION

As state-of-the-art medical technology development is accelerated, CT examination which is an important part of radiography for diagnosis comes to have higher usability with technical development of the equipment and examination methods and skills are diversely changed. Enhancement of usefulness and improvement of reliability of CT exam brought increase of examination incidents and rapid increase of CT contrast media use. By using optimal amount of contrast media we may minimize side effects of contrast media caused by overuse of contrast media while keeping the level of diagnosis power of CT (Kim *et al*., 2008).

Accordingly, this study tried to provide data for optimal amount of contrast media to reduce side effects while acquiring optimal quality image by applying different amount of contrast media according to BMI.

"Kim" and Kim (2014), Kim (2015) reported that HU of patients showed significant difference inversely proportional to body weight, contrast media amount did not make effects on HU and much bigger contrast effect could be acquired with the use of optimal amount of contrast media. In this study, HU and SNR values according to BMI were the highest at underweight and the lowest at extreme obesity.

HU and SNR values according to contrast media dose were the highest at 90 mL followed by 60 and 70 mL and the lowest at 80 mL. In the test reducing contrast media amount according to BMI, LAD HU and SNR values showed statistically significant difference ($p<0.001$). If contrast medium amount is determined considering effective contrast, we may be able to minimize side effects of patients. Yang and Shin (2012) reported that when 130 mL or over contrast media was used, side effects arose most frequently and the less contrast media dose was the less frequently side effects arose. Lee *et al.* (2011) reported that diluting contrast medium with saline could reduce dose dependent side effects by reducing contrast media amount to be used while image quality increased. Kim *et al.* (2008) reported that CT could develop to be a safe and reliable test if we can reduce contrast media amount without sacrificing the quality of image, thinking risk factors of contrast media side effects increasing with development of CT. As shown in previous studies we could get high quality SNR even when we injected less amount of contrast media considering BMI at cardio CT in this study.

However, as we used patients as subjects, we could not perform different tests on the same patient. This remains as restrictions of this study. Further, studies should be followed to supplement it.

CONCLUSION

LMA HU and SNR values were different according to BMI and contrast media dose. We could good enough images with high enough HU and SNR even when we used less amount of contrast media than specified in test manual. When testing using contrast media at CT we need to use different amount of contrast media according to BMI of patients.

A protocol to check BMI of patients in patient medical information before executing CT and to determine as least contrast media amount as possible for the test should be developed. Based on the results of this study, we need to minimize contrast medium side effects while acquiring excellent SNR by selecting the most optimal contrast media amount considering BMI of patients.

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