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Influence of Iodinated Magnetic Resonance Contrast Media and Isotope ^{99m}Tc on Changes of Computed Tomography Number

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The purpose of the study was to identify how isotope and magnetic resonance imaging (MRI) contrast media impact on noise to computed tomography (CT) examination. For the study, divide the phantoms to two groups: 1) saline, saline + different kinds of contrast agent without ^{99m}Tc administration; 2) ^{99m}Tc administration: saline, saline + different kinds of contrast agent with ^{99m}Tc administration. CT contrast agent was used for Iopamidol® and Dotarem. And MRI contrast agent was used for Primovist® and Gadovist®. To obtain an image, we used CT scanner. With an obtained image, we set the 1 cm^2 region of interest in the middle of bottle to measure the noise and CT number. As a result, there was no difference in CT number before and after inserting ^{99m}Tc into all contrast media including Normal Saline. However, when it comes to Noise, there was a difference before and after inserting ^{99m}Tc into every contrast media except MRI contrast media such as Primovist® and Gadovist®.

Keywords : computed tomography contrast media, magnetic resonance imaging contrast media, ^{99m}Tc isotope substance, computed tomography number, noise

1. Introduction

Recently, the onset age of adult disease is getting younger due to the life style change and the life quality improvement [1]. Therefore, more and more examination methods are being developed to find and diagnose the lesions as precise and early as possible; various image examinations such as CT, MRI, and nuclear medicine test are being used to diagnose the lesion [2-4]. When performing MRI and CT, we use contrast media to increase the image's contrast; contrast media is the substance that helps to increase the diagnose ability of lesion by increasing the contrast of soft tissues or blood vessels that are hard to distinguish. Contrast media has been continuously developed since 1920's in which we first discovered that iodide has a contrast effect, so lately the usage of contrast media is increasing in MRI and CT [5]. Although we are able to diagnose various lesions with contrast media, those examinations are used to diagnose lesions by identifying the anatomic changes, which means there is a limitation in functional evaluation and diagnosis. On the other hand, nuclear medicine examination is kind of examinations that diagnose the disease by making injected radioisotope (RI) identify proceeding functional disorder than lesion's anatomical disorder through a quantitative analysis of intake rate distribution according to each organ's physiological mechanism [2, 3]. Especially, nuclear medicine gamma camera examination releases a low energy γ-ray, and uses ^{99m}Tc isotope substance that has a relatively short half life. ^{99m}Tc is used for most of gamma camera examinations such as bone's status check as well as functional evaluations of thyroid, gallbladder, and kidney. With the test using isotope substance, we are able to evaluate organ's function by analyzing quantitatively [6-9]. However, when performing gamma camera examination, we should insert a certain substance that releases radiation to the body, therefore, not only the radiation exposure to the body is unavoidable but it is hard for us to diagnose a minor lesion that requires a high definition image with a low spatial resolution [10]. That's why, there are more various examinations are being done mutually for more precise diagnosis; these days, various

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examinations are being preformed at the same time thanks to the One-Stop service of hospital to improve patient's convenience. Unfortunately, there was no single report about how computed tomography test is influenced. Therefore, the study was to find out how MRI contrast media and CT contrast media impact on Noise when performing computed tomography test.

2. Study Materials and Method

2.1. Study Material

As study materials, we used ^{99m}Tc isotope substance erupted from 9Mo-^{99m}Tc Generator, CT's iodine contrast media, and MRI's paramagnetic contrast media. Contrast media is largely composed of the following 4 kinds: ionic monomer, ionic dimer, nonionic monomer, and nonionic dimer. In this study, we used nonionic contrast media such as Iopamidol® or Dotarem® as CT contrast media. Nonionic contrast media is a hypo-osmotic contrast media that replaced amide to carboxylic acid radical. As MRI contrast media, we used nonionic contrast media such as Primovist® or Gadovist®. MRI contrast media is composed of paramagnetic compound and paramagnetic contrast media that is typically known to be Gd^{3+} is T1 contrast media. We put 102 cc of Normal Saline in a bottle, and then we added 2 cc of Iopamidol®'s computed tomography contrast media and 100 cc of Normal Saline. In addition, we put 2 cc of MRI contrast media such as Dotarem®, Primovist® and Gadovist® and 100 cc of Normal Saline. We managed each contrast media to have 102cc capacity and prepared another bottle. In another bottle, we put ^{99m}Tc 10 mCi in 102 cc of Normal Saline, and then we put 2 cc of Iopamidol®'s computed tomography contrast media and 100 cc of Normal Saline. Also we put 2 cc of magnetic resonance image contrast media such as Dotarem®, Primovist®, and Gadovist® and 100 cc of Normal Saline. Each contrast media has a total of 102 cc capacity, and we distributed ^{99m}Tc 10 mCi to be 10 mCi. Then, we shook the distributed test tube's contrast media to be well mixed, by using bio-free shaker.

2.2. Image Acquisition

To acquire an image, we used 20 channel CT Scanner (Biography mCT 20, Siemens, Germany). With 20 channel CT Scanner, we examined the followings: kVp: 80, mAs: 55, FOV: 350 mm, pitch: 0.6, thickness: 5 mm, matrix: 512 × 512, collimator 16 × 1.2 (1.92 cm), and rotation time: 0.5 sec (Table 1). We tested the bottle that did not contain ^{99m}Tc, and then we were able to obtain the image. We acquired an image by repeating each test 30 times. Considering the characteristic of a radioisotope, it disintegrated with a certain amount of time interval/So every time we performed a repetitive examination, we made another bottle with the same technique, and then we performed an

Table 1. The parameter of computed tomography scanner.

Scanner	kVp	mAs	FOV (mm)	Pitch	Thk/Gab (mm)	Matrix	Collimation	Rotation time (sec)
20Channel	80	55	350	0.6	5	512 × 512	16 × 1.2 (1.92 cm)	0.5

FOV: Field of View, Thk/g: Thickness/gap

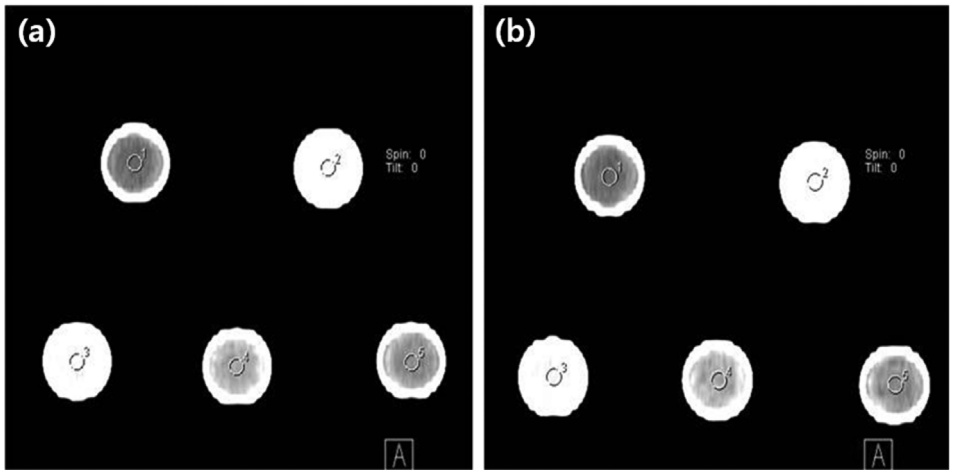

Fig. 1. (a) As the image that compounds ^{99m}Tc to computed tomography image and computed tomography, we measured computed tomography number and noise by setting 1 cm^2 region of interest in the middle of the bottle.

examination. With the obtained image, we measured the CT number and noise by setting every 1 cm^2 region of interest in the middle of the bottle (Fig. 1). The difference of average value of CT number and noise before and after inserting ^{99m}Tc to each bottle that is compounded with contrast media was measured by using paired T-test (SPSS win 17.0, USA, Chicago). P was considered to be significant when it was less than 0.05 ($P < 0.05$).

3. Study Result

3.1. Signal to Noise Ratio of each and every contrast media before and after the distribution of T1 Sequence's ^{99m}Tc and CT number of each and every contrast media before and after the distribution of ^{99m}Tc

As a result of measuring CT number using computed tomography, Normal Saline that was compounded with ^{99m}Tc was measured as 31.96 ± 3.02, and Normal Saline that was not compounded with ^{99m}Tc was measured as 32.23 ± 2.61. Iopamidol® that was compounded with ^{99m}Tc was measured as 269.34 ± 3.16, Iopamidol® that was not compounded with ^{99m}Tc was measured as 269.24 ± 2.30. Dotarem® that was compounded with ^{99m}Tc was measured as 101.64 ± 4.57, and Dotarem® that was not compounded with ^{99m}Tc was measured as 102.43 ± 4.86. Primovist® that was compounded with ^{99m}Tc was measured as 70.78 ± 4.66, and Primovist® that was not compounded with ^{99m}Tc was measured as 70.20 ± 4.10. Gadovist® that was compounded with ^{99m}Tc was measured as 190.19 ± 4.34, Gadovist® that was not compounded with ^{99m}Tc was measured as 190.81 ± 3.94. There was no average difference in CT number of each and every contrast media before and after the distribution of ^{99m}Tc ($p > 0.05$) (Table 2) (Fig. 2).

3.2. CT Noise of each and every contrast media before and after the distribution of ^{99m}Tc

As a result of measuring CT Noise with computed tomography, Normal Saline that was compounded with ^{99m}Tc was measured as 8.44 ± 0.99, and Normal Saline that was not compounded with ^{99m}Tc was measured as 7.90 ± 1.18. Iopamidol® that was compounded with ^{99m}Tc was measured as 9.12 ± 1.27, and Iopamidol® that was not compounded with ^{99m}Tc was measured as 7.81 ± 1.18. Dotarem® that was compounded with ^{99m}Tc was measured as 10.94 ± 2.61, and Dotarem® that was not compounded with ^{99m}Tc was measured as 8.41 ± 1.42 ($p < 0.05$). Primovist® that was compounded with ^{99m}Tc was measured as 9.99 ± 1.70, and Primovist® that was not compounded with ^{99m}Tc was measured as 9.45 ± 1.44, which indicated that there was no average difference. Gadovist® that was compounded with ^{99m}Tc was measured as 13.53 ± 1.82, and Gadovist® that was not compounded with ^{99m}Tc was measured as 12.93 ± 2.56, which also indicated that there was no average difference ($p > 0.05$) (Table 3) (Fig. 3).

4. Discussion

After computed tomography was developed in 1970's, its clinical usage is getting increased with the advance of equipment capacity according to the development of technology. When comparing the annual test usage with medical treatment expense of Health Insurance Review and Assessment Service, it was 344,000 million in 2004, 823,500 million in 2009, and 1,042,300 million in 2013 [11], which shows that the number is going up. In computed tomography, we put contrast media to have a better image by enhancing the contrast of blood vessels or soft tissues, so we could have a clear distinction between normal tissue and lesion as well as we could improve the

Table 2. An average value of computed tomography number in each and every contrast media before and after the distribution of ^{99m}Tc when performing computed tomography

Average ^{99m}Tc activity (mCi)	Contrast media	Computed tomography Number	p
10.20 ± 0.07	Normal Saline (^{99m}Tc) Normal Saline	31.96 ± 3.02 32.23 ± 2.61	0.734
10.18 ± 0.08	Iopamidol® (^{99m}Tc) Iopamidol®	269.34 ± 3.16 269.24 ± 2.30	0.899
10.18 ± 0.09	Dotarem® (^{99m}Tc) Dotarem®	101.64 ± 4.57 102.43 ± 4.86	0.529
10.20 ± 0.09	Primovist® (^{99m}Tc) Primovist®	70.78 ± 4.66 70.20 ± 4.10	0.639
10.19 ± 0.11	Gadovist® (^{99m}Tc) Gadovist®	190.19 ± 4.34 190.81 ± 3.94	0.574

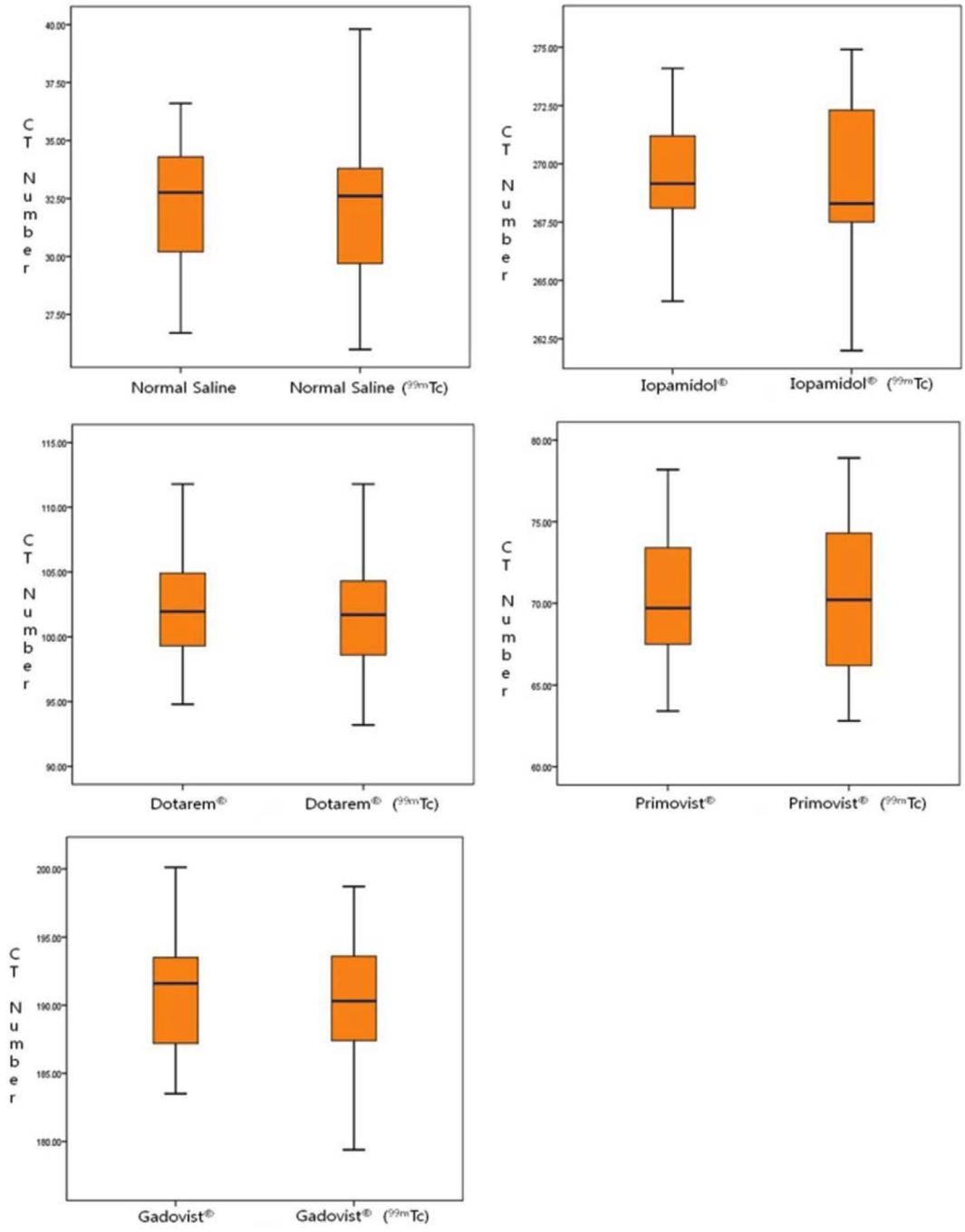

Fig. 2. (Color online) Computed tomography number's average of each contrast media in computed tomography.

diagnostic ability by comparing contrast enhancement image of artery, portal venous radicle, and lagicubation using the mechanism in which contrast media moves via blood stream [12]. In computed tomography, factors that affect diagnostic ability are noise, artifact, and resolution. The factors that affect noise are the size of the subject, scattered rays, tube voltage, tube current, the size of pixel, and reconfiguration method [13]. Although some studies about how these various factors affect Noise are being reported [14], there was no report on how radioisotope affects Noise. Therefore, the study investigated how radioisotope impact on CT number and Noise. As a result of measuring CT number before and after the distribution of radioisotope ^{99m}Tc, there was no difference in each and every contrast media including Normal Saline. As a result of measuring Noise before and after the distribution of

Table 3. An average value of Noise in each and every contrast media before and after the distribution of ^{99m}Tc when performing computed tomography

Average ^{99m}Tc activity (mCi)	Contrast media	Noise	p
10.20 ± 0.07	Normal Saline (^{99m}Tc)	8.44 ± 0.99	0.044
	Normal Saline	7.90 ± 1.18	
10.18 ± 0.08	Iopamidol® (^{99m}Tc)	9.12 ± 1.27	0.000
	Iopamidol®	7.81 ± 1.18	
10.18 ± 0.09	Dotarem® (^{99m}Tc)	10.94 ± 2.61	0.000
	Dotarem®	8.41 ± 1.42	
10.20 ± 0.09	Primovist® (^{99m}Tc)	9.99 ± 1.70	0.182
	Primovist®	9.45 ± 1.44	
10.19 ± 0.11	Gadovist® (^{99m}Tc)	13.53 ± 1.82	0.238
	Gadovist®	12.93 ± 2.56	

^{99m}Tc, there was a difference in each and every contrast media except for MRI's contrast media such as Primovist® and Gadovist®.

The reason why there was a difference in Noise before and after the distribution of ^{99m}Tc was because of attenuation phenomena of X-ray due to dense substances such as tooth and metal, which occurs artifact [15], and the more attenuation occurs, the more noise will be created. Besides, there is a study that demonstrated that there is an artifact in metal substance used for filling of teeth such as metal, gold, and titanium [16] and it is considered to have a difference in Noise due to ^{99m}Tc metal ion, which is a minute amount of VIIB radioactive metal substance melted in Normal Saline. In this study, since it was not conducted to human body, we were not able to reconfigure how radioisotope and contrast media are being

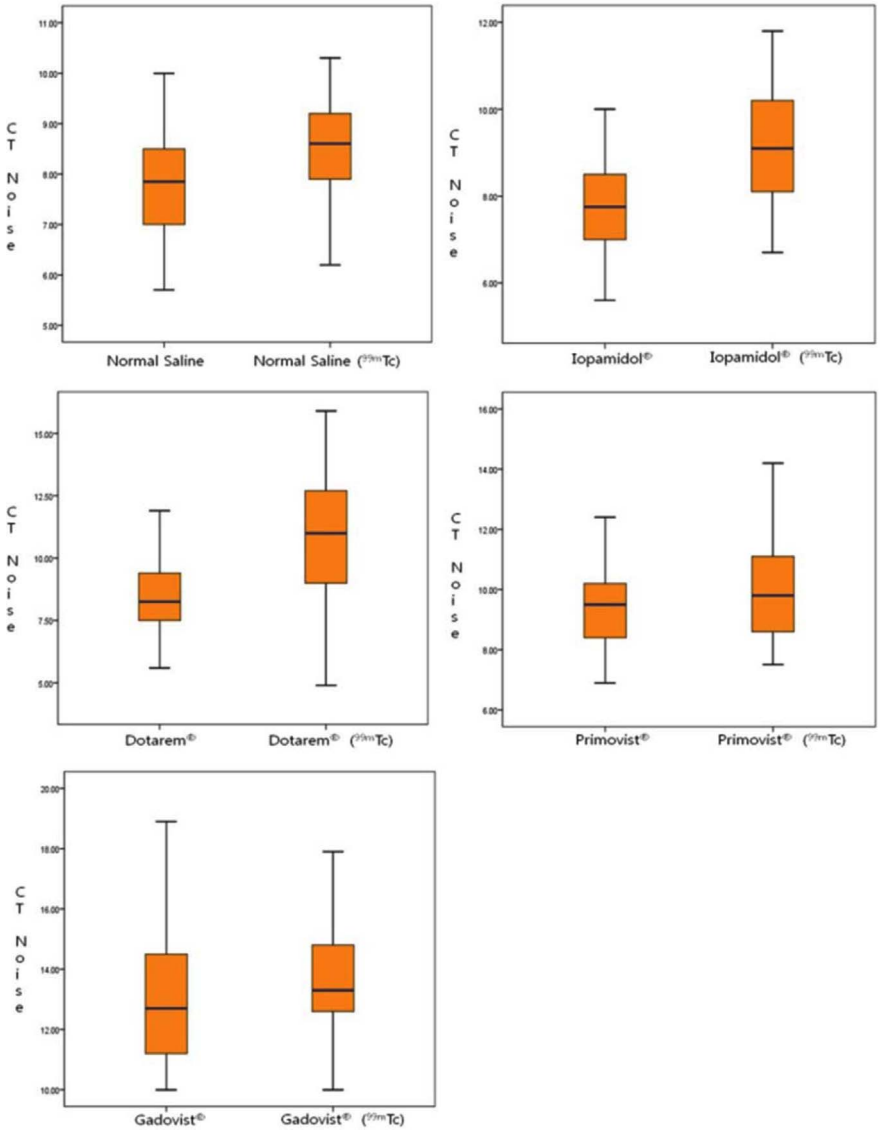

Fig. 3. (Color online) Noise's average of each contrast media before and after the distribution of ^{99m}Tc in computed tomography.

injected to the body, changed by getting blended with the blood as well as released from the body flowing through the body's physiological mechanism even though we were able to confirm how contrast media and radioisotope that are used for gamma camera, magnetic resonance image, and computed tomography impact on Noise, which represents CT equipment's image quality. Therefore, in this study, we need to consider these variables.

5. Conclusion

In this study, there was no difference in CT number before and after the distribution of ^{99m}Tc to each and every contrast media including Normal Saline. However, there was a difference in Noise before and after the distribution of ^{99m}Tc to each and every contrast media except for MRI's contrast media such as Primovist® and Gadovist®. Therefore, when it comes to performing various examinations at the same time to improve the convenience of patients, this study can be useful as a basic data to improve the convenience of patients as well as the quality of examinations by managing the test period depending on the use of radioisotope, contrast media, or equipment used for each test.

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