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How Computed Tomography Contrast Media and Magnetic Resonance Imaging Contrast Media Affect the Changes of Uptake Counts of ^{201}Tl

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The purpose of the study is to investigate how uptake counts of ^{201}Tl of radioisotopes in the human body could change, when taking computed tomography and magnetic resonance imaging right after injecting contrast media. ^{201}Tl radioisotope substances of iodine contrast medium, which is a computed tomography contrast medium, and paramagnetic contrast medium, which is an magnetic resonance imaging contrast medium, were used as study materials. First, ^{201}Tl was put into 4 cc of normal saline in test tube, and then a computed tomography contrast medium of Iopamidol® or Dotarem®, was put into 2 cc of normal saline in test tube. An magnetic resonance imaging contrast medium of Primovist® or Gadovist® was also put into 2 cc of normal saline in test tube. Each contrast medium was distributed to make ^{201}Tl as 3 mCi, with a total of 4 cc. Gamma camera, low energy high resolution collimator, and pinhole collimator were used to obtain images. The uptake count of ^{201}Tl was measured with 1000 frames of images, and obtained after 10 times of repetition. This study revealed that the use of Gadovist®, which is an magnetic resonance imaging contrast medium, showed the smallest number of uptake count, after measuring ^{201}Tl uptake count by low energy high resolution collimator. On the other hand, the use of Iopamidol®, which is a computed tomography contrast medium, showed the biggest difference in uptake count, when measuring ^{99m}Tc uptake count by Pinhole collimator. When examining with gamma camera, using contrast medium and ^{201}Tl, identifying the changes of uptake count is very important for improving the value of diagnosis.

Keywords : computed tomography contrast media, magnetic resonance imaging contrast media, ^{201}Tl isotope, uptake counts

1. Introduction

The outbreak of ischemic heart disease in Korea is increasing, causing higher death rate from the total cause of death [1]. Since the first clinical sign of ischemic heart disease could cause myocardial infarction or untimely death, it is important to foresee or catch these diseases early. High-tech diagnostic methods are used, such as Coronary Angiography, CT (computed tomography), MRI (magnetic resonance imaging), and nuclear medicine exam [2-4]. Coronary Angiography, CT, and MRI use a contrast medium to raise an image's contrast, and the contrast medium helps to diagnose the various lesions, by raising the contrast of indistinguishable blood vessel and soft tissue in radiography. After it was discovered that sodium iodide has an enhancement effect, sodium iodide contrast medium has become an important factor that improves the diagnostic rate in the radiation field. Therefore, the use of sodium iodide contrast medium has rapidly increased [5]. Depending on the experimental methods and types of lesions, the features of contrast media are different. For example, from nuclear medicine examination, a radioactive isotope is used as a contrast medium. In particular, myocardial perfusion scintigraphy using ^{201}Tl has become an important examination that helps diagnose ischemic heart disease, decide the treatment plan, and foresee the prognosis. Gould *et al.* [6, 7] have revealed the diagnostic usability of coronary artery disease, by conducting myocardial perfusion scintigraphy with ^{201}Tl-chloride, using dipyridamole. As a result, the use of myocardial perfusion scintigraphy has been generalized. The Gamma camera detects two-dimensional coordinates when

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a γ-ray phantom interacts with a detector in a large surface. In the gamma camera, the outcomes obtained during the exposure build up an image, after being accumulated. This study is ultimately to see the uptake count of radioisotopes in the human body.

There are several factors that affect the uptake count in nuclear medicine examination, and the contrast medium is one of them. The use of sodium iodide contrast medium, in particular, was controversial, because this could affect the attenuation correction [8, 9]. However, there were no reports of influences of uptake as a result of conducting other examinations, except PET/CT (positron emission tomography/computed tomography) filming. In general, patients take CT or MRI with contrast media, and then were examined with nuclear medicine. In particular, nuclear medicine examination using gamma camera is now favored. Therefore, the aim of the study is to investigate how uptake counts of ^{201}Tl of radioisotopes in the human body could change, when taking CT and MRI.

2. Materials and Methods

2.1. Experimental Method

^{201}Tl radioisotope substances of iodine contrast medium, which is a CT contrast medium, and paramagnetic contrast medium, which is an MRI contrast medium, were used as study materials. Depending on the chemical structure, contrast media are categorized into 4 kinds: Ionic monomer, ionic dimer, nonionic monomer, and nonionic dimer. The contrast media used for this study are nonionic contrast media of Iopamidol® and Dotarem®.

Nonionic contrast media are hypo-osmotic contrast media that substitute amide for carboxylic acid radical. Also, nonionic contrast media of Primovist® and Gadovist® were used as MRI contrast media. MRI contrast media consist of paramagnetic compounds, and T_1 contrast media are paramagnetic contrast media that represent Gd^{3+}. Fig. 1 shows the contrast media used for this study are shown. First, ^{201}Tl was put into 4 cc of normal saline in test tube, and then a CT contrast medium of Iopamidol® or Dotarem® was put into 2 cc of normal saline in test tube. An MRI contrast medium of Primovist® or Gadovist® was also put into 2 cc of normal saline in test tube. Each contrast medium was distributed, to make ^{201}Tl as 3 mCi, with a total of 4 cc (Fig. 2). In sequence, to thoroughly mix the contrast medium in the test tube, it was shaken for 2 minutes by bio-free shaker.

2.2. Obtaining Imagery

Gamma camera (GE Healthcare. Milwaukee. WI, USA), LEHR (Low energy high-resolution) collimator (GE Healthcare. Milwaukee. WI, USA) and Pinhole collimator were used to obtain images. The contrast medium distributed to obtain images in a test tube was located 1 m high from the floor, and 50 cm away from the detector. When obtaining images, the LEHR collimator and Pinhole collimator's

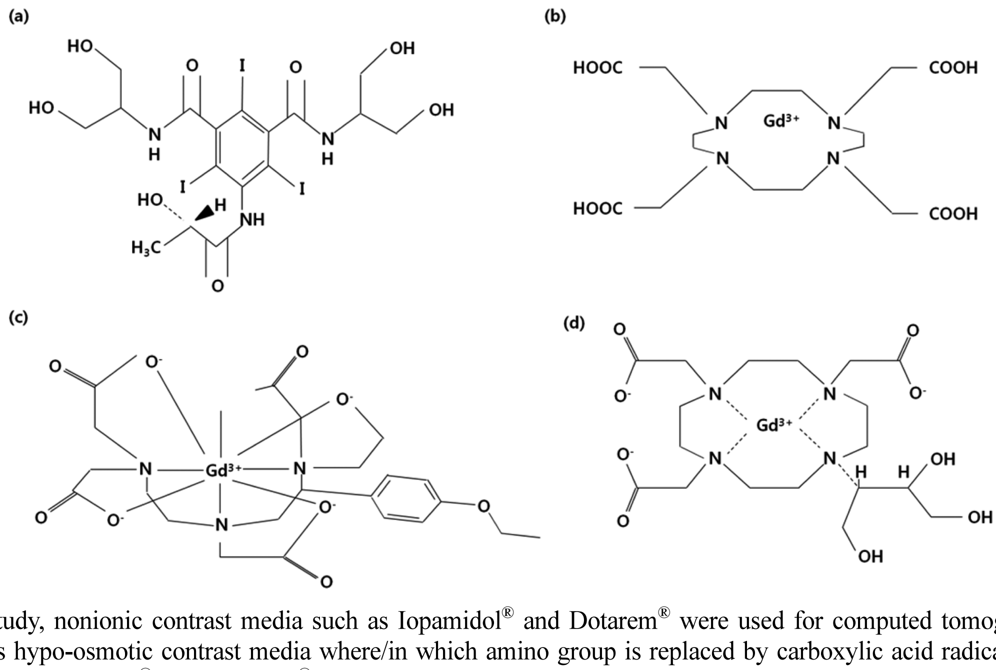

Fig. 1. In this study, nonionic contrast media such as Iopamidol® and Dotarem® were used for computed tomography. Nonionic contrast media is hypo-osmotic contrast media where/in which amino group is replaced by carboxylic acid radical. Nonionic contrast media such as Primovist® and Gadovist® were used for magnetic resonance imaging. Magnetic resonance imaging contrast media is composed of paramagnetic compounds and paramagnetic compounds contrast media represented by Gadolinium Gd^{3+} is T_1 contrast media.

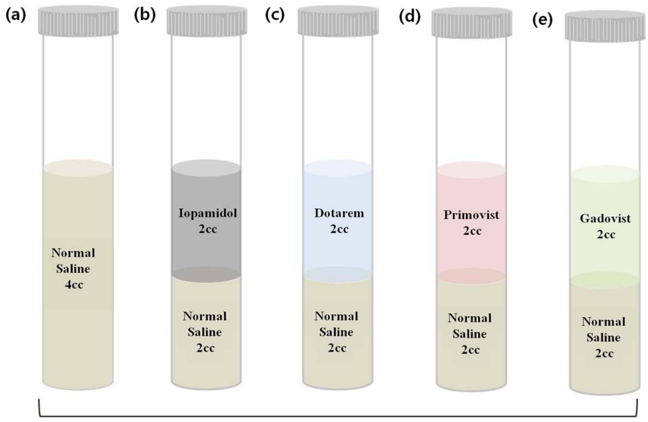

Fig. 2. (Color online) ^{99m}Tc was added to 4 cc normal saline in a test tube. Then, 2 cc of computed tomography contrast media such as Iopamidol® and Dotarem® were diluted with 2 cc normal saline, and 2 cc of magnetic resonance imaging contrast media such as Primovist® and Gadovist® were diluted with 2 cc normal saline. Each distributed contrast media was a total of 4cc and included 3 mCi of ^{201}Tl.

matrix size was set to 128 × 128, and zoom was set to 1, and then 100 frames of images were obtained with 1 frame per second; 1000 frames of images were obtained, after 10 times of repetition. Since radioisotopes collapse with intervals, the study was conducted by making the test tube with the same method for every examination. The obtained images were sent to Xeleris Functional Imaging Workstation (GE Healthcare. Milwaukee. WI, USA) to measure the uptake counts of ^{201}Tl. The size of the area of interest was an average of 4096 pixels, which included as much image as possible (Fig. 3). ANOVA-test (ANOVA SPSS win 17.0, USA, Chicago) was used to measure the average value of uptake count that was taken by LEHR collimator and Pinhole collimator. P of less than 0.05 was considered a significant statistical difference. Bland-Altman analysis was conducted to compare normal saline before using contrast media with the uptake count, with that after using each contrast medium.

3. Results

3.1. Use of the LEHR collimator

After measuring the uptake counts of ^{201}Tl by LEHR collimator in each contrast medium, normal saline, which was not mixed with the contrast medium, was measured as 8527.66 ± 91.52. In addition, it was 7566.96 ± 89.30 when blended with Iopamidol®, 7474.83 ± 85.39 when blended with Dotarem®, 7817.15 ± 85.38 when blended with Primovist®, and 7107.09 ± 88.89 when blended with Gadovist®.

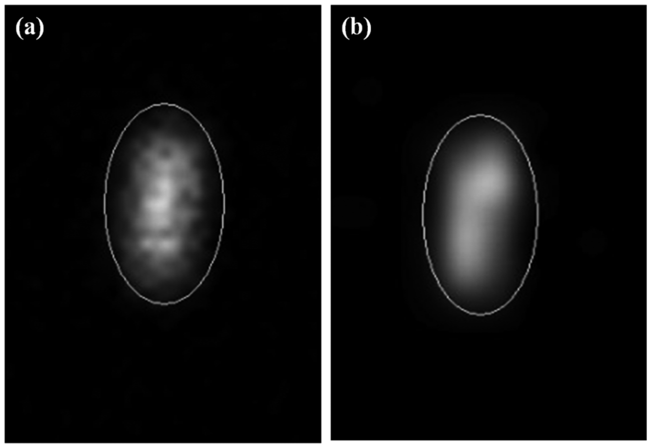

Fig. 3. In acquired images, the uptake counts of ^{201}Tl were measured by low energy high resolution Collimator (a) and pin-hole collimator (b). The size of the region of interest was an average of 4096 pixels and it included as many images as possible.

When comparing the gap between each contrast medium's count on the basis of normal saline that was not blended with contrast medium, the contrast medium blended with Gadovist® showed the most difference, of −1420.57 ($p < 0.01$) (Table1).

In conclusion, use of the MRI contrast medium Gadovist® showed the biggest difference when it comes to uptake counts. Bland-Altman analysis revealed that the range limit of accordance between normal saline and Iopamidol® was from −710.3 to −1211.1, and the average value was −960.7. The range limit of accordance between normal saline and Dotarem® was from −809.6 to −1296.1, and the average value was −1052.8. The range limit of accordance between normal saline and Primovist® was from −464.5 to −956.5, and the average value was −710.5. The range limit of accordance between normal saline and

Table 1. The uptake counts of ^{201}Tl using the low energy high resolution collimator in accordance with the type of contrast media.

Average ^{201}Tl activity (mCi)	Contrast media	Uptake count	P
3.07 ± 0.00	Normal Saline	8527.66 ± 91.52	
3.06 ± 0.08	Iopamidol®	7566.96 ± 89.30	
3.08 ± 0.00	Dotarem®	7474.83 ± 85.39	
3.07 ± 0.00	Primovist®	7817.15 ± 85.38	
3.08 ± 0.00	Gadovist®	7107.09 ± 88.89	0.00
	Iopamidol®-Normal Saline	−960.70	
	Dotarem®-Normal Saline	−1052.83	
	Primovist®-Normal Saline	−710.51	
	Gadovist®-Normal Saline	−1420.57	

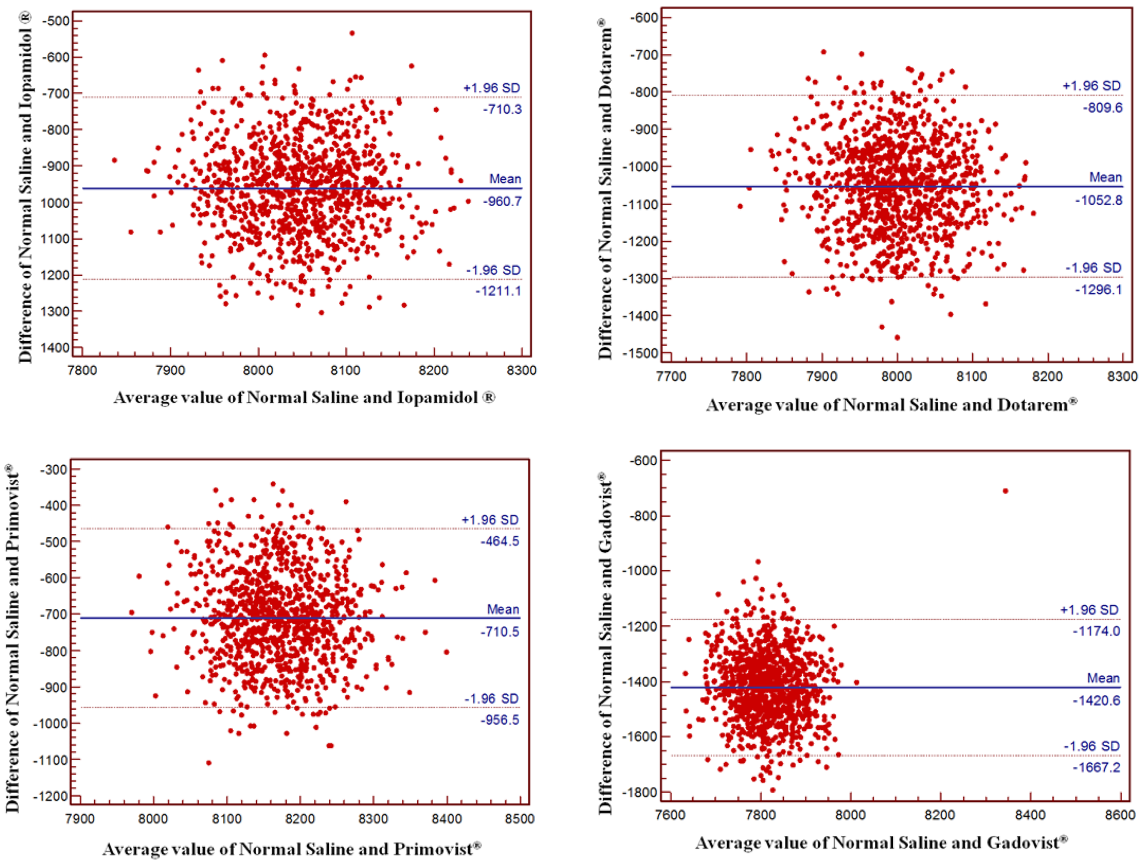

Fig. 4. (Color online) Bland-Altman analysis of the uptake counts of ^{201}Tl using the low energy high resolution collimator.

Gadovist® was from −1174.0 to −1667.2, and the average value was −1420.6 (Fig. 4).

3.2. Use of the Pinhole collimator

When measuring uptake counts of ^{201}Tl by Pinhole collimator, normal saline that was not blended with a contrast medium measured 679.96 ± 26.03 in counts. Furthermore, it measured 562.04 ± 23.59 when blending with Iopamidol®, 600.46 ± 23.04 when blending with Dotarem®, 581.57 ± 23.58 when blending with Primovist®, and 564.89 ± 24.17 when blending with Gadovist®. When comparing the count gap among each contrast medium on the basis of normal saline that was not blended with contrast medium, the contrast medium that was blended with Iopamidol® showed the most distinctive difference of −117.91 ($p < 0.01$) (Table 2). Consequently, use of the CT contrast medium Iopamidol® showed the biggest difference in uptake counts. The study conducted Bland-Altman analysis, and the range limit of accordance between normal saline and Iopamidol® was from −48.7 to −187.1, and the average value was −117.9. The range limit of accordance between normal saline and Dotarem® was from −12.2 to 146.8, and the average value was

Table 2. The uptake counts of ^{201}Tl using the pin-hole collimator in accordance with the type of contrast media.

Average ^{201}Tl activity (mCi)	Contrast media	Uptake count	P
3.07 ± 0.01	Normal Saline	679.96 ± 26.03	
3.07 ± 0.00	Iopamidol®	562.04 ± 23.59	
3.07 ± 0.00	Dotarem®	600.46 ± 23.04	
3.07 ± 0.00	Primovist®	581.57 ± 23.58	
3.07 ± 0.00	Gadovist®	564.89 ± 24.17	0.000
	Iopamidol®-Normal Saline	−117.91	
	Dotarem®-Normal Saline	−79.49	
	Primovist®-Normal Saline	−115.06	
	Gadovist®-Normal Saline	−98.39	

−79.5. The range limit of accordance between normal saline and Primovist® was from 28.1 to 168.7, and the average value was −98.4. The range limit of accordance between normal saline and Gadovist® was from −45.5 to −184.6, and the average value was −115.1 (Fig. 5). Comprehensively, when measuring the uptake count of ^{201}Tl by low energy high resolution collimator, on the basis of normal saline, uptake counts from every contrast medium

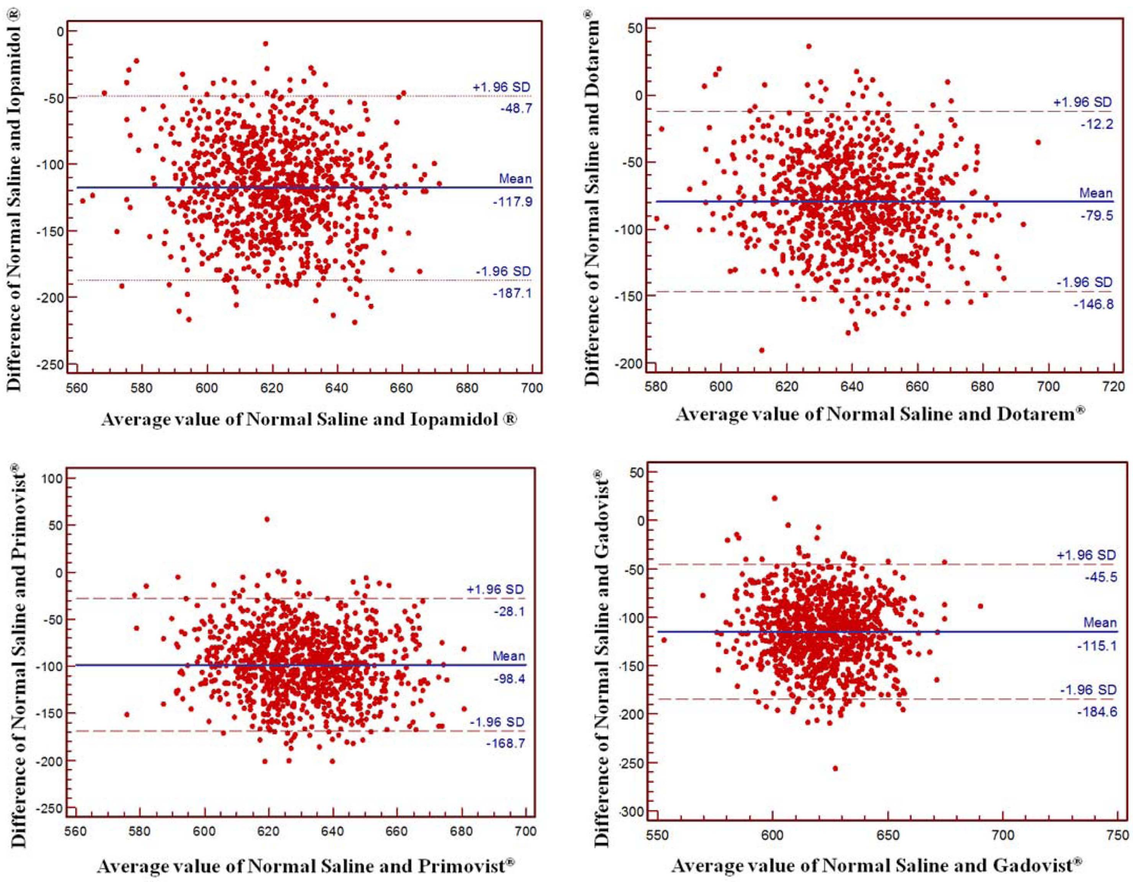

Fig. 5. (Color online) Bland-Altman analysis of the uptake counts of ^{201}Tl using the pin-hole collimator.

were small. In particular, use of the MRI contrast medium Gadovist® showed the smallest uptake count. After measuring the uptake count of ^{201}Tl by pinhole collimator on the basis of normal saline, uptake counts from every contrast media were small. In particular, use of the CT contrast medium Iopamidol® showed the most difference in uptake count.

4. Discussion

In modern medical science, in addition to nuclear medicine, X-ray, CT, and MRI examinations are conducted to improve diagnostic efficiency. In particular, contrast media are used to raise the contrast of an image, when taking X-ray, CT, or MRI. Nuclear medicine tests inject a drug with radioisotope label, measure radiation from outside of the human body, and measure the drug *in vivo* in the human body. Therefore, nuclear medicine tests could be susceptible to several factors. Hill *et al.* [10] reported that if there is a contraction of blood vessel or depression of cell metabolism, there is also a depression in the medicine's uptake count. There could also be a difference in the medicine's uptake count, depending on the total cholesterol, level of neural fat, or type of meal intake [11]. However, out of the possible factors, the contrast medium was also reported as one of the significant factors. In particular, iodide saline, which is the contrast medium used for PET/CT, was a controversial medium, because it may affect the attenuation correction [12-14]. However, there was no report about the uptake count's impact with other examinations, other than PET/CT. Therefore, this study investigated how uptake counts of ^{201}Tl, which is one of the radioisotopes in the human body, changes, when taking radioisotopes, CT, and MRI. As a result of measuring the uptake counts of ^{201}Tl with low energy high resolution collimator, the use of Gadovist®, which is an MRI contrast medium, showed the smallest number of uptake counts. As a result of measuring the uptake counts of ^{99m}Tc by pinhole collimator, the use of Iopamidol®, which is a CT contrast medium, showed the most significant difference in uptake counts. Since the pinhole collimator's sensitivity could change by the distance or entrance size of the collimator [15], it is assumed there were different outcomes, when the study was conducted with the LEHR collimator. Most of the nuclear medicine test and contrast media related studies were done in PET/CT examination. When using a contrast medium, the discovery rate of lesions improved from 63% to 90% [16], and images of PET/CT using contrast media showed a 11% higher lesion discovery rate, compared with not using contrast media [17]. In other words, when using a contrast medium, finding lesions, understating the exact shape and scope of lesions, and understanding indistinguishable aspect of the lesions in PET could be easier [18]. However, since the study was conducted by gamma camera, not PET/CT examination, and was not focused on the patients, it was impossible to find the discovery rate of lesions. Nevertheless, the study could find out the differences among each contrast medium's uptake count. Continuous study focusing on patients will be necessary.

5. Conclusion

In this study, there was a significant difference of uptake count by contrast medium when examining with gamma camera using ^{201}Tl. When examining with gamma camera using ^{201}Tl and a contrast medium, it is important to confirm the changes in uptake counts, to improve the value of diagnosis.

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