Examination of Signal Intensity According to the Alteration of Contrast Media Concentration during Computed Tomography

Sung-Hun Jeong[1], Cheong-Hwan Lim*[2]

[1]*Public Health of Doctor, SeoSan JungAng General Hospital, Seosan-si, 31962, Korea*

[*2]*Professor, Dept. of Radiological Science, Hanseo University, Seosan-si, 31962, Korea*

*Jeungshun@naver.com[1], lch116@hanseo.ac.kr[*2]*

Abstract

Background / Objectives: *Generally speaking, it is shown that many medical institutions use contrast agents for both children and adults without distinguishing the concentration of the contrast agent, and many healthcare providers use the same contrast agent regardless of the examination site as identified on the patient. This is a factor that can increase the side effects by proceeding the test without considering the sensitivity, the concentration of the contrast agent, the injection speed, etc., depending on the patient's constitution that causes the side effects of the contrast agent. For this reason, the purpose of this study is to obtain the image according to the concentration of CT contrast agent and test condition, to identify the change in signal intensity, and to determine the appropriate test condition according to the contrast agent concentration and to provide the study results thereof as the basic material in the study on the image concentration according to the change of the test condition.*

Methods / Statistical analysis: *The equipment used in this study was MDCT and contrast agents were used at concentrations of 250, 300, 320, 350, 370, and 400mgI/ml. In this case, the contrast agent was measured after placing the Conical Tube on the table of MDCT without dilution. Here, the measurement conditions were measured at 37, 75, 100, 150, 320mAs for tube current mAs and 80, 100, 120, 135kVp.*

Findings: *The findings revealed that as the tube voltage increased at tube currents of 75mAs, 100mAs, 150mAs, and 320mAs, the signal strength of the image was noted to be lowered in this case. In addition, the signal strength of the image was lowered as the tube voltage increased according to the contrast agent concentration.*

Improvements / Applications: *It is considered that further studies will be needed for the test protocols that can lead to the improvement of the image quality safely and steadily, as the study of the appropriate contrast agent concentration and the test conditions for each test is continued to help improve patient outcomes.*

Keywords- *Iodide contrast agent, Signal Intensity, Contrast agent side effects, Contrast Concentration, Computed Tomography*

1. INTRODUCTION

Computed Tomography, which is rapidly increasing in prevalence and frequency in many medical instit utions with the implementation of national health insurance benefits; as an invaluable diagnostic tool,has c ome a long way. Especially noted in the 2000s, Multi Detector Row Computed Tomography (MDCT), is i nstrumental and it is possible to shorten test time and various test sites for the analysis of human disease [1-3]. As the area of examination increased, the diagnostic range was widened, and the use of iodinated co ntrast agent increased as the diagnosis of various types of diseases increased, and the accuracy and efficie ncy of the use of CT examination also was seen to have increased [4-6]. For this reason, it is noted that a round 70% of CT scans are performed using contrast agents. However, as the frequency of use of contrast agents increases, so too are there increases noted in the many side effects which can occur for the patient s in regard to the use of these contrast agents [7-9]. According to the Korea Consumer Consumption Cont rast Safety Survey (Abnormal Cases, Suspected Drug Report), the side effects of contrast medium increase d from 14,572 cases in 2014 to 18,24 cases in 2016, which is the fourth highest result after the use of ant ipyretic, analgesic, anti-inflammatory and antibiotics. Consequently, the causes of the side effects was attri buted to the increased frequency of administration of these agents, which was due to the generalization of nonionic contrast agents and the increase of health examinations [10]. However, it is shown that the non-i onic iodine contrast agent may cause very serious side effects. even when a small amount of contrast agen t is added because the sensitivity of the contrast agent is changed according to the patient's constitution. In this way, the side effects of contrast agents have many factors, but include osmotic pressure, contrast age nt concentration, injection volume, and injection speed. In particular, the concentration of contrast agent is one of the important factors causing side effects in patients undergoing this diagnostic procedure. Therefor e, the concentration and dose of contrast medium should be appropriately selected according to the test sit e, test technique, and overall patient condition [11-12]. However, many medical institutions use it for child ren and adults without distinguishing the concentration of contrast agent, and use the same contrast agent r egardless of the area being analyzed, such as with a Brain CT, Abdomen CT, or with an Angiography CT . This is a factor that can increase the side effects of a patient by proceeding the test without considering the sensitivity of the patient, the concentration of the contrast agent, the injection speed, etc., which causes the side effects of the contrast agent [13-14]. Therefore, this study is to identify the type of contrast medi um used in many medical institutions, to acquire images according to the concentration of CT contrast age nt and test condition, and to determine the appropriate test condition according to the change of signal inte nsity and contrast concentration. The objective of this study is to provide basic data on studies of contrast medium concentrations to help patient health outcomes going forward.

2. STUDY SUBJECTS AND METHODS

2.1. *Research subjects*

2.1.1 Research Equipment

In this case, the equipment used in this study used MDCT (Aquilion 128 slice, Canon, Japan) in S Hospi tal, S, Republic of Korea, for image measurement (Fig. 1), and contrast agent concentrations of 250, 300, 320, 350, 370, A nonionic contrast agent of 400 mgI/ml was used (Fig. 2). Also, it is noted that the Conical Tube (50ml) and the support to support the Conical Tube were used to contain the contrast agent (Fig. 3). Additionally, the Image J (Ver. 1.46) was used to measure the signal strength by editing and setting ROI to a constant size.

Figure 1. MDCT

Figure 2. Nonionic contrast agent

2.2 *study method*

2.2.1. Measuring method

In this study, 250, 300, 320, 350, 370, 400mgI / mL contrast agent, which is used in medical institutions, was placed in a conical tube 50ml in a clockwise direction without diluting with saline solution (Fig. 3). Next, the conical tube was placed on the MDCT table and measured by matching the conical tube center with the axial scan line. Finally, the measurement conditions were Brain CT's standard algorithm, with milliampere per second of 37, 75, 100, 150, 320mAs, and kilovolt peaks of 80, 100, 120, and 135kVp. While measuring (Fig. 4).

Figure 3. Conical Tube(50㎖)

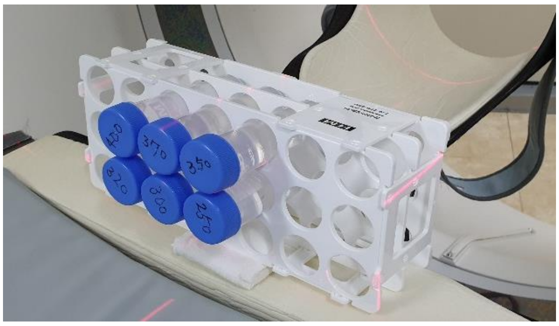

Figure 4. Image measurement

2.2.2. Image Analysis Method

As has been seen, the measured images were analyzed using Image J program and acquired in the form of DICOM file in PACS System (G3 PACS, Infinity, Korea). In addition, the Fourier spatial filtering of spatial image was performed with a custom filter after converting the acquired image into Tiff file (Fig. 5) and (Fig. 6). Next, the intensity distribution measurement was a filtered image, and ROI was set for each contrast medium, and the average was measured 10 times at the center of the image.

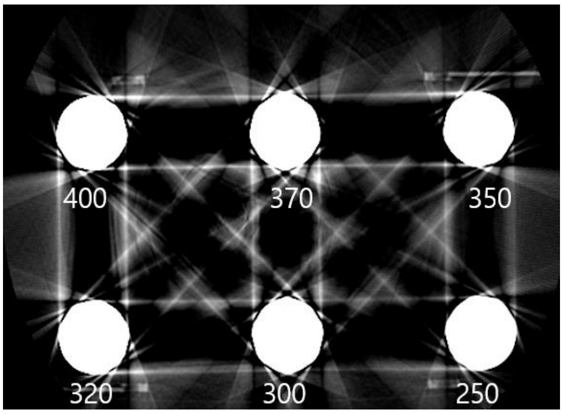

Figure 5. Contrast image by concentration.

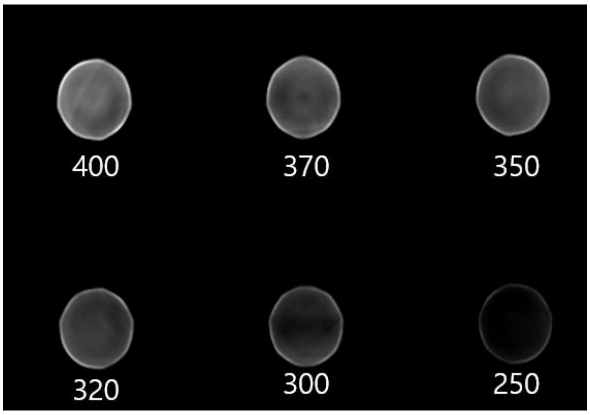

Figure 6. Costum filtering image

3. RESULTS

3.1. *Intensity Distribution of Contrast Agents with Different kVp*

As a result of analyzing the intensity distribution of the contrast medium according to the change in tub e current, the contrast intensity distribution was the highest at 80kVp 400mgI/ml to 7904 and the lowest at 250mgI/ml to 4934. This brings us to understand that the intensity distribution increased with increasing mAs, which was the highest at 8861 at 320mA. In this way, the signal intensity of 100kVp was also incre ased as contrast medium was increased, and the signal intensity was measured highest at 100mAs and 150 mAs. Therefore, the signal intensity of the image increased with the increase of the contrast agent with th e change of 125kVp and 135kVp (Table 1).

Table 1. Intensity Distribution of Contrast Agents with Different kVp (unit: average, S.D)

kVp	mAs / density	37	75	100	150	320
80	400	7904(±448)	8676(±527)	8741(±492)	8857(±508)	8861(±508)
	370	6876(±304)	7339(±226)	7599(±318)	7732(333±)	7736(±333)
	350	7088(±397)	7370(±303)	7630(±362)	7733(±354)	7732(±355)
	320	6653(±341)	7022(±319)	7095(±324)	7202(±324)	7207(±323)
	300	5621(±433)	5960(±489)	6179(±496)	6314(±487)	6317(±487)
	250	4934(±282)	5105(±216)	5308(±255)	5399(±249)	5399(±251)
100	400	7084(±140)	7121(±133)	7123(±131)	7119(±128)	7115(±128)
	370	6263(±307)	6318(±193)	6327(±151)	6327(±140)	6324(±136)
	350	6049(±143)	6070(±138)	6072(±136)	6072(±134)	6071(±134)
	320	5820(±154)	5852(±147)	5848(±146)	5844(±145)	5842(±144)

	300	5200(±231)	5238(±168)	5240(±159)	5237(±154)	5235(±151)
	250	4283(±160)	4299(±158)	4301(±156)	4301(±156)	4389(±253)
125	400	5568(±126)	5559(±122)	5518(±135)	5558(±116)	5556(±115)
	370	4956(±126)	4949(±126)	4883(±128)	4948(±124)	4947(±123)
	350	4757(±128)	4751(±125)	4700(±112)	4750(±122)	4749(±121)
	320	4572(±134)	4567(±132)	4490(±113)	4567(±129)	4567(±127)
	300	4088(±142)	4084(±141)	4009(±109)	4085(±136)	4084(±135)
	250	3383(±145)	3380(±145)	3319(±145)	3381(±143)	3381(±142)
135	400	4792(±127)	4790(±123)	4791(±120)	4791(±117)	4777(±115)
	370	4267(±125)	4265(±121)	4266(±120)	4268(±119)	4256(±117)
	350	4103(±123)	4101(±120)	4102(±118)	4103(±117)	4093(±114)
	320	3942(±128)	3942(±126)	3943(±124)	3945(±122)	3939(±122)
	300	3522(±134)	3521(±131)	3523(±129)	3524(±127)	3520(±127)
	250	2931(±137)	2932(±136)	2932(±135)	2932(±133)	2927(±133)

3.2. *Intensity Distribution of Contrast Agents with Different Tube Currents*

In this study, the intensity distribution of contrast medium was measured by varying tube current to 37, 75, 100, 150, 320mAs. The results showed that it was measured as low. At 37mAs, however, higher kVp decreased the intensity distribution of the contrast agent. In this way, the higher the contrast concentration at 75mAs, the higher the intensity distribution of the contrast medium. Similarly, the intensity distribution of contrast medium decreased as 75mAs and 37mAs and kVp increased. Here, the concentration of contrast was highest at 400mgI/ml and lowest at 250mgI/ml even at 100, 150 and 320 mAs(Fig. 7), (Table 2).

Table 2. Intensity Distribution of Contrast Agents with Different mAs (unit: average, SD)

mAs	kVp / density	80	100	120	135
37	400	7904(±448)	7084(±140)	5568(±126)	4792(±127)
	370	6876(±304)	6263(±307)	4956(±126)	4267(±125)
	350	7088(±397)	6049(±143)	4757(±128)	4103(±123)
	320	6653(±341)	5820(±154)	4572(±134)	3942(±128)
	300	5621(±433)	5200(±231)	4088(±142)	3522(±134)
	250	4937(±282)	4283(±160)	3383(±145)	2931(±122)
75	400	8676(±527)	7121(±133)	5559(±122)	4790(±123)

	370	7339(±226)	6318(±193)	4949(±126)	4265(±121)
	350	7370(±303)	6070(±138)	4751(±125)	4101(±120)
	320	7022(±319)	5852(±147)	4567(±132)	3942(±126)
	300	5960(±489)	5238(±168)	4084(±141)	3521(±131)
	250	5105(±216)	4299(±158)	3380(±145)	2932(±136)
100	400	8741(±492)	7123(±131)	5518(±135)	4791(±120)
	370	7599(±318)	6327(±151)	4883(±128)	4266(±120)
	350	7630(±362)	6072(±136)	4700(±112)	4102(±118)
	320	7095(±324)	5848(±146)	4490(±113)	3943(±124)
	300	6179(±496)	5240(±159)	4009(±109)	3523(±129)
	250	5308(±255)	4301(±156)	3319(±145)	2932(±135)
150	400	8857(±508)	7119(±128)	5558(±116)	4791(±117)
	370	7732(±333)	6327(±140)	4948(±124)	4268(±119)
	350	7733(±354)	6072(±134)	4750(±122)	4103(±117)
	320	7202(±324)	5844(±145)	4567(±129)	3945(±122)
	300	6314(±487)	5237(±154)	4085(±136)	3524(±127)
	250	5399(±249)	4301(±156)	3381(±143)	2932(±133)
320	400	8861(±508)	7115(±128)	5556(±115)	4777(±115)
	370	7736(±333)	6324(±136)	4947(±123)	4256(±117)
	350	7732(±355)	6071(±134)	4749(±121)	4093(±114)
	320	7207(±323)	5842(±144)	4567(±127)	3939(±122)
	300	6317(±487)	5235(±151)	4084(±135)	3520(±127)
	250	5399(±251)	4389(±253)	3381(±142)	2927(±133)

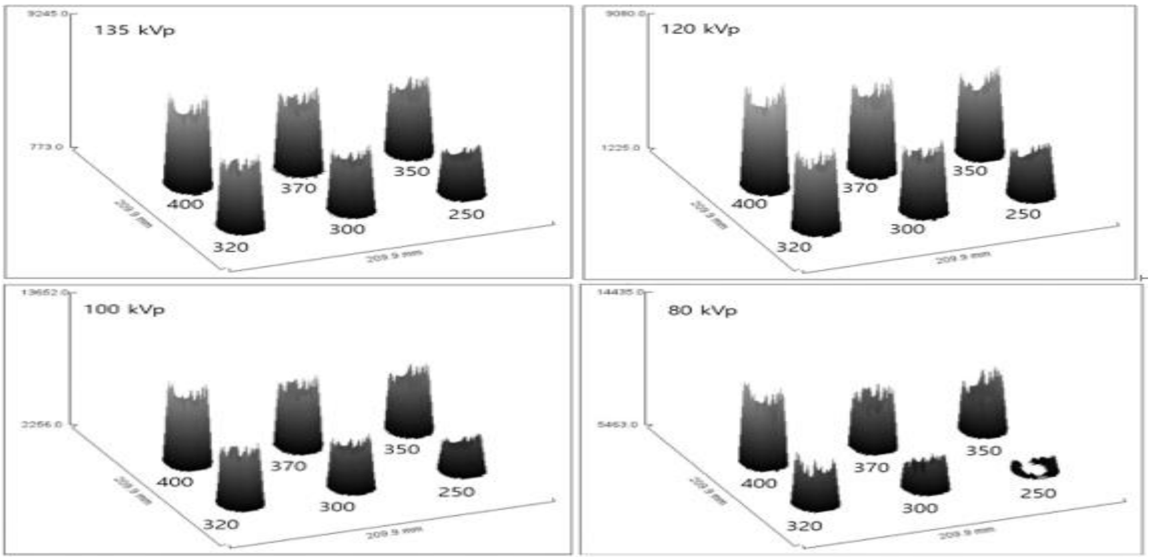

Figure 7. Intensity change according to kVp change

4. DISCUSSION

Generally speaking, the CT scan is a test that can easily recognize the change of human anatomical stru cture, by reconstructing the image of the human body into a cross-sectional image. In conducting these CT scans, contrast agents are a tool that is often used to identify more accurate anatomical structures. In this way, the use of a contrast agent is with one of the drugs that improve the quality of image, by increasing the contrast between target organ and surrounding tissues [5]. In this sense in relation to contrast agents, Yoo Sung-min reported that 46.8% of the males and 53.2% of the females had higher contrast side effects , 62.9% had skin and appendage disorders, 15.4 had gastrointestinal symptoms, and 7.0% had respiratory s ymptoms. [14]. The cause of the side effects of the contrast agent is the constitution of non-dependent sid e effects and the osmotic pressure, iodine concentration, injection amount, and injection rate of the contras t agent, which are dependent side effects. Therefore, it is important to note that the proper concentration a nd dose of contrast medium needs to be administered as according to the test site, test technique, and pati ent's condition, which may go a long way to reduce side effects. In a study comparing the iodine concentr ation and amount of CT contrast media by iodine concentration, the results were compared by diluting pur e contrast medium and physiological saline by concentration. It is noted that these results were not statistic ally significant. In addition, the patient's area of interest (ROI) was measured on the images examined usin g contrast media Iopamidol 300, 320, 370 mgI/ml with different iodine concentrations. In short, there was no difference ($p = 0.443$) reported [15]. In the present study, the signal intensity of the image was measur ed by changing the contrast condition, and there was no difference noted from 400 mgI/ml of high contras t medium to 7904, 370 mgI/ml to 6876 and 350 mgI/ml to 7088. In addition, it was seen that the low con centration of contrast medium 320 mgI/ml to 6653, 300 mgI/ml to 5621, 250 mgI/ml to 4934 appeared to be the same as the results of the research paper as described in the study of the researcher Kim Yun Gi. I n addition, the CT equipment are installed and operated for accurate medical treatment. The status of speci al medical equipment of the Health Insurance Review & Assessment Service is increasing to 1,889 units i n 2015, 1,937 units in 2016, 1,964 units in 2017 and 1,984 units in 2018 [16]. As the equipment increase d, the number of inspections also increased, with a measurement of 9,377 noted in 2017 and 10,370 in 20 18 [17].This increase in inspection has led to the development of various test techniques and the use of hi gh contrast contrast agents to obtain higher quality images. In a paper entitled "Evaluation of Usefulness o f Low Tube Voltage Technique in CT Imaging with Low Concentration Contrasts," Kang said, the mean d ose change by kVp and mAs changes decreased by 10.7mGy at 100kV compared to 120kV. Inaddition, th e HU values of 648 and 650 were measured at the depth of 100kV phantom, and it has been reported that low concentrations and low kVp use have improved dose reduction and image quality over high kVp [18] . In this study, the signal intensity of kVp and mAs was measured at the same concentration. However, as the kVp increases, the signal strength decreases as the kVp increases. The higher the kVp, the lower the signal strength may be due to the higher transmittance and higher contrast. Likewise, advances in CT equi pment have improved the quality of inspections with the improvement ofvarious inspection techniques and image quality. For this reason, in order to improve the quality of theimage, various contrast agents have b een developed, and high concentrations of contrast agents are preferred. However, consideration should be given to the high conditions and the use of high contrast concentrations, as the patient's exposure and adve rse effects on contrast agents will also increase. In addition, the study on the appropriate contrast agent co ncentration and test conditions for each test will continue to be conducted, and more studies will be neede d for the test protocol that can bring about a safe and improved image quality going forward.

5. Conclusion

This study measured the signal intensity of the image according to the contrast agent concentration as u sed in the study. In this context, the signal intensity of contrast medium according to tube current change was highest at 400 mgI/ml, and lowest at 250 mgI/ml. Accordingly, the signal strength according to kVp c hange was higher at lower kVp, and lower at higher kVp. In addition, it is noted that thesignal intensity o f contrast medium was high under high kVp and low mAs.

Currently, studies on the side effects of contrast agents are actively reviewed and analyzed, but studies on clinical imaging according to the concentration of contrast agents are still insufficient, needing further atten tion. Therefore, the clinical research should be continued according to the contrast agent concentration and the effects of this application.

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