# A Study on Radiation Dose and Image Quality using Dual Energy Computed Tomography ECG Gating High Pitch Chest Pain Protocol Mode

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**ABSTRACT**

This study compared the aortic root image by using the ECG gating and non-ECG gating methods. We observed the presence or absence of progression of the aortic root image in the images examined by the high pitch (flash) chest pain protocol method and in the patients tested without ECG gating by the conventional method. The AAPM phantom was scanned by using high pitch (flash) chest pain protocol and general chest pain protocol. CTDI values were compared. By ECG gating, the blurring of ascending aorta was significantly reduced compared to the existing non-ECG gating test method, and the image quality of the aortic root was improved. Within the parametar range that did not show differences in noise, uniformity, and high contrast resolution, CTDI values were lower when tested with the high-pitch chest pain protocol. It was found that there is an advantage in dose reduction, and if it is applied and applied to diagnostic fields such as dissection using the dose reduction mode in the cardiac field, it is a very important test for patients who need rapid diagnosis and prompt treatment as well as a dramatic reduction in exposure dose. It is presumed to be a method.

Keyword: ECG gating, high pitch(flash) chest pain protocol, ascending aorta dissection, CTDI

## I. INTRODUCTION

Cardiac computed tomography(CT) examination has become highly diversified to the extent of considering it as a customized examination method due to the rapid advancement of technologies applied to the CT equipment, thereby offering a wide range of options[1,2]. Obviously, all these options are deemed the results of efforts put in to minimize exposure to radiation in relation to the movement of the patient's heart. Accordingly, cardiac examination methods in accordance with such rapid advancement in the relevant equipment were applied to dissection examination. According to 'the Stanford Classification System', dissection is classified into 2 types according to the determination of whether a surgical interventive procedure is necessary[3].

First is type A dissection, which is for the cases of expansion to the aortic root, the pericardium or the coronary artery that requires an expedient surgical interventive procedure and accounts for approximately 60~70% of total dissection patients[4]. If treatment is not rendered expediently, a mortality rate of more than 50% within 48 hours has been reported[5]. Type B dissection includes the area from the descending thoracic aorta to the left subclavian artery, which accounts 30~40% of total dissection patients. Although these can be treated with drugs, a surgical interventive procedure is required if accompanied by complications[6]. In the case of Type A, although an

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expedient surgical interventive procedure is necessary, severe wavering of not only the supra-aorta, but also of the coronary artery results, if scanned with the existing angio-dissection examination methods, occurs[7].

Motion artifact is the key factor that degrades the image quality in cardiac examination. Furthermore, it is an important artifact factor that affects all the neighboring organs. There have been rapid technological advancements for CT equipment after having begun with single channel and progressing to 128 channel dual energy MDCT through the developments of 16, 64 and 128 channels[8]. At the same time, rotation time has continually been shortened to reduce motion artifact, which is a direct factor for the improvement of temporal resolution[9]. Currently, a fast rotation speed of 0.3 sec/rotation is reducing a significant portion of the motion artifact. However, regardless of the continued development of even shorter rotation times, there are limitations in examining a heart that moves in real time. ECG gating is the method developed to supplement this shortcoming. Accordingly, static cardiac images are obtained by conducting the examination through the focusing of the diastole or systole pulsing range with the least movement of the heart by means of ECG grating. Due to the hearts movement, motion artifacts with forms similar to dissection in the aortic root section are generated in the existing dissection examination method[10]. However, the image of the aortic root section is dealt with as a very important information for expedient procedures to be conducted for the patient in dissection.

Therefore, this study aims to examine the usefulness and diagnostic value of an ECG gated high-pitch chest pain protocol capable of quick examination of areas from the aortic arch to the iliac artery without the wavering of the supra-aorta in order to acquire optimal images of dissection and to render treatments based on expedient diagnosis through the use of the high-pitch mode technique of dual source CT equipment.

## II. MATERIAL AND METHODS

### 1. ECG Gating and Non-ECG Gating Methods for Comparison of Aortic Root Images

In this study we used two CT equipment. One is MDCT (Multi Detector Computed Tomography) 128 detector row dual source; SOMATOM Definition Flash (Siemens medical system: Germany) for chest pain protocol. The other is MDCT 256 detector row single source; SOMATOM Definition AS+ (Siemens medical system: Germany) equipment for high-pitch chest pain protocol.

Table 1. CT image parameters for chest pain protocol and high-pitch chest pain protocol

| | Chest pain protocol | High-pitch chest pain protocol |
|---|---|---|
| Slice thickness | 2 mm | 2mm |
| Collimation | 128×0.6 mm | 128×0.6 mm |
| Pitch | 0.6 pitch | 3.2 pitch |
| Effective mAs | 175 mAS | 300 mAs |
| kVp | 120 kVp | 120 kVp |
| Recon increment | 2 mm | 2mm |

Table 1 shows CT Image parameters according to chest pain protocol and high-pitch chest pain protocol. Automatic triggering was situated at the aortic arch with 100 HU and 30 ml normal saline was injected additionally at the rate of 3-4 ml/sec along with 120 ml of contrast medium, and the vein was secured with a 20 gauge Needle for IV injection. In the case of chest pain protocol, automatic triggering and contrast medium injection were performed in the same manner as the high-pitch examination method. The both scan range was set to include the area from the apex of the lung to the iliac artery.

### 2. High-pitch ECG Gating and ECG Gating Methods for Dose Comparison

Scanning was performed by applying the ECG gated high-pitch chest pain protocol and the ECG gated chest pain protocol with the same parameters through the use of AAPM (American Association of Physicists in Medicine), which was CT Performance Phantom 610. Tube voltage was fixed at 120 kVp and care dose 4D was used. Scanning was performed by converting quality reference mAs/rotation to 250 mAs, 300 mAs and 350 mAs. Scan range was set at 36 cm, that sufficiently includes.

Contrast resolution was measured cylindrical diameter 6th evaluate the shape of a circle obtained a mean value and a standard deviation of diameters, the spatial resolution of the group of source, including acceptance criteria automatically extracted result as a result of both the number of the extracted **circular. It** appeared. For an estimation of the CT radiation dose, the CT volume dose index (CTDIvol), the dose-length-product (DLP) and the scan length were recorded, as previously shown[2].

## III. RESULT

### 1. Comparison Results of the Dose Reductions (High-Pitch and Chest pain protocol)

The effective dose of CTCA (coronary angiography) was derived from the product of the dose-length product and a conversion coefficient for the chest according to a method proposed by the European Working Group for Guidelines on Quality Criteria in CT[11].

Fig.1 shows Images of mean values of AAPM scanned in Chest pain protocol and Images of mean values of AAPM scanned in high-pitch chest pain protocol. When the AAPM phantom is scanned in the high pithc chest pain protocol, mean values were obtained for 17.55 (350 mAs/rotation), 15.63 (300 mAs/rotation) and 14.55 (250 mAs/rotation), as shown in Table 1. On the other hand, mean values was 16.5, 14.73 and 13.88 by scanning phantom in chest pain protocol, respectively. The average value obtained with chest pain protocol was 14.88 while it was 15.91 in high-pitch chest pain protocol in accordance with the noise ratio.

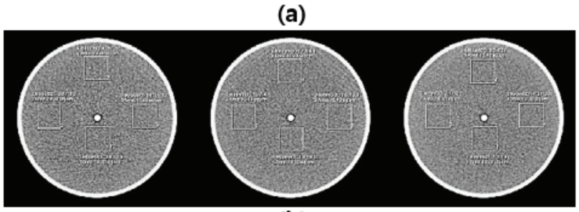
Table 2. Noise ratio mean values of AAPM scanned in ECG gated chest pain protocol and gated high-pitch chest pain protocol

| | Average | 350 mAs | 300 mAs | 250 mAs |
|---|---|---|---|---|
| High-pitch Chest pain protocol | 15.91 | 17.55 | 15.63 | 14.55 |
| Chest pain protocol | 14.88 | 16.50 | 14.73 | 13.88 |

As shown in Fig.1 and Table 2, when the image qualities of the chest pain protocol and gated high-pitch chest pain protocol are compared, there is no significant difference in the average value in accordance with each mAs/rotation. High-pitch chest pain protocol can be seen that the noise is lower by about 1. In other words, in the two examination methods, there was no significant difference in the graphical quantitative evaluation.

Table 3 shows noise ratio mean values of AAPM scanned in gated chest pain protocol and gated high-pitch chest pain protocol. Since the CTDI/DLP value obtained when examined in the gated high-pitch chest pain protocol is approximately 2 times lower than that in the gated chest pain protocol, it can be seen that there is an advantage in spite of dose reduction.

(a)



(b)

Fig. 1. (a) Images of Mean values of AAPM scanned in Chest pain protocol (b) Images of Mean values of AAPM scanned in high-pitch chest pain protocol.

Table 3. CTDI and DLP of AAPM scanned in gated high pitch chest pain and chest pain protocol

| | | 250 mAs | 300 mAs | 350 mAs |
|---|---|---|---|---|
| High pitch chest pain protocol | CTDI | 3.27 | 3.80 | 4.31 |
| | DLP | 132 | 154 | 175 |
| Chest pain protocol | CTDI | 6.51 | 7.23 | 9.54 |
| | DLP | 248 | 275 | 363 |

As shown in Table 3, CTDI values in the case of examination in the high-pitch chest pain protocol are 3.27, 3.80 and 4.31 mGy for 250 mAs, 300 mAs and 350mAs, respectively. DLP values in accordance with the aforementioned CTDI values are 132, 154 and 175 mGy·cm, respectively. In the case of scanning in chest pain protocol, CTDI values are 6.51, 7.23 and 9.54 mGy in accordance with the same mAs order with ensuring DLP values of 248, 275 and 363 mGy·cm, which is approximately 2 times higher than those in the high pitch chest pain **protocol.**

As the dose value increased, the noise ratio value decreased. That is, it can be seen that the image quality deteriorates when the dose value increases. However, in the chest pain protocol and the high-pitch chest pain protocol, the radiation dose value was reduced by 2 times, but there was little difference in image quality.

### 2. Results of Comparison of Supra-Aortic Images of ECG Gating and Non-ECG Gating Methods

The ECG (ElectroCardioGram) gating was executed to minimized artifacts by the movement of the heart. The ECG gating comparison with the image obtained on the supra-aortic area with the high-pitch method.

When the images of the existing non-ECG gated dissection protocol and images examined with ECG gated high pitch chest pain are compared, ECG gating substantially reduced the wavering of the supra-aorta, thereby making observation of the presence of intrusions of dissection to the coronary artery easier. Fig.2 (a) illustrates images of non-ECG gating and severe wavering of the supra-aorta can be seen. On the other hand, as illustrated in Fig.2 (b). it can be seen that there is almost no wavering of the supra-aorta in the images of ECG gating.

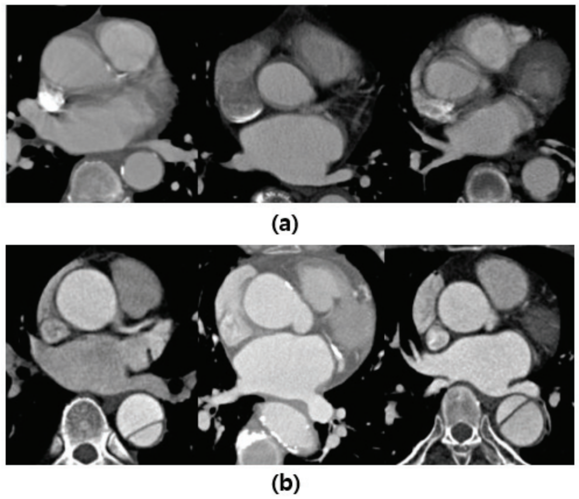



Fig. 2 (a) Images of non-ECG gating chest pain protocol (b) Images of ECG gated high pitch chest pain protocol

## IV. DISCUSSION

This study demonstrated that image quality and radiation dose of free-breathing high-pitch dual-source spiral pediatric cardiothoracic CT were comparable between non-ECG synchronized scans and prospectively ECG-triggered scans.

This finding is in accordance with previous studies comparing between non-ECG-synchronized and prospectively ECG-triggered scan modes of high-pitch dual-source spiral CT of the aorta in adults.

According to the study of dissection, it is important to minimize movement artifacts in the supra-aorta section. So, ECG gated chest pain protocol used as a cardiac examination method is applied to the dissection examination method. However, this method also has a long scanning time, thereby generating artifacts due to other movements induced by the breathing of the patient and having the limitation of increasing radiation exposure doses[12].

Dissection type A refers to the situation in which dissection occurs on the supra-aorta, which typically necessitates an emergency interventive procedure, and the expansion of the separation phenomenon towards the aortic root, pericardium or coronary artery needs to be prevented through the execution of relevant the procedure[13]. If treatment is not rendered expediently, a mortality of more than 50% within 48 hours is displayed[14].

The high-pitch acquisition mode of dual-source systems recently introduced into CCTA permits imaging of the entire heart within one heart beat by continuous and fast movement of the table during CT data acquisition. It is an examination method capable of attaining 3 important advantages including images of the aortic root with a high definition, fast scanning time (approximately 1.5 sec) and a dose reduction. Using the high-pitch data acquisition mode with prospective ECG-gating with second-generation dual source CT, radiation exposure for CCTA can be reduced to around 1 mSv.

Particularly, ECG gated high pitch chest pain protocol is the method that can solve the 2 limitations found in the chest pain protocol and the artifact due to the movement of the aortic root. This ECG gated High-pitch chest pain protocol, unlike the chest pain protocol that makes examination by dividing the pulsing sector over several sessions, completes the cardiac examination in a single pulsing sector in principle. It can scan quickly from the aortic arch to the iliac artery due to a fast scanning time.

In previous studies, they reported the effect of tube current saturation on radiation dose reduction by comparison of chest pain protocols for dual-source cardiothoracic CT in Children and Adults[15]. In this study, we estimated CTDI and DLP of AAPM scanned in ECG gated high pitch chest pain and chest pain protocol. Overall radiation dose reduction achieved by high pitch chest pain protocol of dual source CT was 50.0% compared with the radiation dose of chest pain protocol. Although this study wanted to clinical research for comparison of dose reduction between ECG-gating and Non-ECG gating, AAPM phantom was replaced due to over-exposure.

This is because a dose equivalent to a 1/4 of this dose occurs even when the quality reference is fixed at 300 mAs/rot in the case of ECG gating. Nonetheless, since the image quality is substantially high in the important area of interpretation and approximately a 1/3 of the dose reduction in comparison to an examination with a non-ECG gating is displayed, it is deemed that the ECG gated high-pitch chest pain protocol is very useful for a dissection examination.

## V. CONCLUSION

Through this study, it was discerned that the high-pitch chest pain protocol has the advantages of not only reducing the radiation exposure dose but also determining the invasion of the supra-aorta of dissection, for which early-stage diagnosis is considered important, and the ability to complete the examination in about 1.45 sec by minimizing the artifact due to movement. Therefore, it is deemed that such advantages would be greatly helpful in the improvement of prognosis and treatment planning by quickly and accurately diagnosing the expansion, types and complications of dissection.

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# 이중 에너지 전산화 단층촬영 ECG Gating High Pitch Chest Pain Protocol 모드를 이용한 방사선량과 영상 품질에 관한 연구

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## 요 약

본 연구는 심전도 게이팅을 한 방법과 심전도 게이팅 없이 검사하는 방법으로 검사하여 대동맥 뿌리 영상을 비교하는 것이며 high pitch(flash) chest pain protocol 방법으로 검사한 영상들과 기존의 방식으로 심전도 게이팅 없이 검사한 환자의 대동맥 뿌리 영상의 질환 유무를 관찰하였다. High pitch(flash) chest pain protocol과 일반적인 chest pain protocol로 AAPM 팬텀을 스캔하였으며 이렇게 획득된 팬텀 영상을 가지고 동일한 영상 품질을 가지는 파라메타 값을 조절하고 방사선량, 즉 CTDI 값을 비교해 보았다. 심전도 게이팅을 함으로 해서 상행대동맥의 이미지 왜곡은 기존의 심전도 게이팅을 하지 않은 검사방법보다 월등하게 감소시킬 수 있었고 대동맥 뿌리의 영상 품질은 향상되었다. 영상 이미지 품질의 차이를 보이지 않는 파라메타 범위 내에서, high-pitch chest pain protocol로 검사하였을 때 CTDI 값이 더 낮게 나왔으므로 방사선량 감소에도 이점이 있음을 알 수 있었다. 심장과 관련된 분야에서 선량 감소 모드를 이용하여 대동맥 박리와 같은 진단 분야에 응용하여 적용한다면 획기적인 피폭선량 감소 효과뿐만 아니라 빠른 진단과 함께 신속한 치료가 필요한 환자들에게 매우 중요한 검사방법이 될 것으로 사료된다.

중심단어: ECG gating, high pitch(flash) chest pain protocol, ascending aorta dissection, CTDI

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