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Original Research Paper

Evaluation of CT angiography of the thoracic aorta with ECG gating in cases of dissection

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Abstract
Type A aortic dissection is a longitudinal tear separating the intima layer from the aortic media and is often not clearly visible due to cardiac motion which can reduce image quality and misrepresent the lumen so that the flowing blood causes several problems such as the aortic root and ascending aorta. CT angiography with ECG gating was chosen to reduce the images of cardiac movement. The purpose is to evaluate the examination procedure and anatomical description of the CT Angiography examination with Gating ECG. The research method is descriptive qualitative research with a case study approach with samples selected based on the examination diagnosis with type A aortic dissection. Observation, documentation, interviews did data collection. Data analysis is described in a descriptive narrative, and a conclusion is drawn. The result of the study is that CT angiography examination with ECG gating provides accurate information that the coronary arteries originate from the true lumen. In this phase, there are no lines that show a significant picture of heart movement disorders so that the coronary arteries can be assessed properly. The anatomical features of MIP, CPR, and VRT visualize the aortic root region until the coronary arteries are displayed more informatively than heart movement disorders. The conclusion is that CTA examination with ECG gating can show the aortic root in cases of type A dissection located at the root or ascending aorta and minimize heart movement interference with MIP, CPR and VRT.

Keywords: aortic dissection; CT Angiography; ECG gating; post processing

1. Introduction

Aortic dissection is the most dangerous complication of thoracic aortic disease and the leading cause of death in aortic disease. This life-threatening condition has recently been categorized as acute aortic syndrome (Dewi, 2020). Aortic dissection is a dangerous condition with very high mortality: 20-50% of patients die within the first 24-48 hours, and up to 75% within the first 2 weeks. It is considered to be one of the major problems with a wide range of symptoms. because the diagnosis is difficult and an examination is needed with fast and correct treatment (Melvinsdottir et al., 2016). Aortic dissection occurs due to a longitudinal tear separating the intima layer from the media layer of the aorta (Chandra et al., 2016). Aortic dissection produces a false lumen so that the flowing blood causes several problems (Marbun, 2016). The most commonly performed tests to diagnose aortic dissection and its complications are CT scan, transesophageal echocardiogram (TEE), and magnetic resonance imaging (MRI). All three tests are highly accurate in diagnosing aortic dissection. Supportive examinations need to be accurate and as quick as possible. For this reason, TEE and CT scans are often used. Multidetector-row computed tomography (MDCT) with electrocardiographic gating (ECG-gated MDCT) has been used in the acute emergency setting as a powerful clinical tool,

which enables rapid and specific diagnosis of aortic pathologies. ECG-gated MDCT significantly reduces motion artifact and avoids potential pitfalls in the diagnosis of Acute aortic syndromes (AAS). The aim of this review is to evaluate the role of MDCT imaging in the assessment of aortic dissection (AD) and to discuss the differentiation of this spectrum of aortic diseases with reference to the key imaging findings (Duran et al., 2019). CTA full-phase ECG-gated lebih akurat dalam mendeteksi Intimal tear pada Aortic dissection dan Ulcer-like projection pada Intramural hematoma, dibandingkan CTA non-ECG-gated dan single-diastolic-phase ECG-gated CTA (Yanagaki et al., 2020). In 5 patients, ECG-gated repeat CTA revealed artifacts in the pre-referral scans that had led to false-positive diagnosis and referral for emergent surgery. In the first case, the patient proceeded to surgery. In 4 subsequent cases, ECG-gated CTA was ordered because a false-positive diagnosis was suspected. We found that ECG-gated CTA rather than echocardiography provided sufficient information to rule out A aortic dissection (AAD) in each of these cases. Comparison between pre-referral non-ECG-gated scans and ECG-gated repeat CTA demonstrated the wide range of artifacts that may give rise to a diagnosis of AAD (Kornberger et al., 2018). ECG-gated DSCT allows for the assessment of the precise location and size of the intimal tear and to find additional tears. The intimal tears in type A and B dissection can be located in the aortic arch. The size of entry in type A and B dissection is comparable. The additional tears in the thoracic aorta are significantly more frequent in the dissection type A (Michalowska et al., 2019). the potential technical and diag-nostic pitfalls is essential when interpreting chestCTA studies in the evaluation of suspected acuteaortic syndromes. Understanding the acute aorticsyndrome entities and their causes, typical andatypical imaging findings, and complications isessential when interpreting examinations to avoid pitfalls and facilitate prompt accurate identifica-tion and management of these life-threateningevents (Ko et al., 2021).

Computed Tomography (CT Scan) is an x-ray imaging that is equipped with a data processing computer and is able to display cross-sectional images of the body. Imaging with CT plays a central role in the diagnosis to allow expedited management. Diagnosis can be made using locally available expertise with optimized scanning parameters, making full use of recent advances in CT technology. Each imaging centre must optimize their protocols to allow accurate diagnosis, to optimize radiation dose and in particular to reduce the risk of false-positive diagnosis that may simulate disease (Vardhanabhuti et al., 2016). The technique used in CT Scan is X-ray tomography rays that pass through the axial cross-section of the body. This technique is the first non-invasive imaging method capable of displaying images of the inside of the human body unaffected by the superposition of different anatomical structures.(Kartawiguna & Rusmini, 2017). CT Angiography is an examination technique to visualize blood vessels using contrast media (Seeram, 2016). There are many CT Angiography examinations, one example is CT Angiography of the Aorta. CT angiography is the imaging modality of choice to evaluate suspected aortic dissection, with sensitivity and specificity approaching 100%.

To assess the acute and chronic thoracic aorta, CT Angiography examination is usually performed with or without ECG. ECG is a tool to record heart rate or heart rate per unit time (bpm)/ beat per minute. The normal heart rate in adults is between 60-100 bpm. The optimal heart rate for CT angiography examination is 60-65 bpm during data acquisition. An unstable heart rate may cause image quality to decrease. (Susanti et al., 2020). With the addition of ECG gating, it can clearly show type A aortic dissection, especially the expansion of the proximal mural flap and the connection with the aortic root, coronary ostium, and aortic valve. (Wu et al., 2009). CT Aortic Angiography with ECG gating is also useful for pre-procedural Transcatheter Aortic Valve Implantation (TAVI) (Horehledova et al., 2020).

Motion and metal artifacts are the most common artifacts on CT examinations. Motion artifacts include cardiac, respiratory and patient movement (Kalisz et al., 2016). Artifacts due to movement

may affect measurement quality and diagnosis of aortic dissection or luminal irregularities (Pierro et al., 2018). In patients undergoing CT evaluation with suspected aortic dissection or ascending aortic aneurysm, vessel motion may cause blurred lines, especially at the aortic root and proximal ascending aorta. In addition, the aortic valve and coronary arteries are often not clearly visible. Cardiac motion can be minimized with the use of ECG gating. Because in the cardiac cycle there are periods of stationary time where the heart is in a relatively motionless state which corresponds to the systole and diastole phases of the heart (Seeram, 2016). Metal artifacts on CT angiography are usually metal stents, pacemaker leads, implantable cardioverter defibrillators (ICDs) and surgical clips (Kalisz et al., 2016).

Computed tomography (CT) is the gold standard for evaluating acute thoracic aortic diseases, with CT angiography (CTA) replacing diagnostic angiography]. CTA is widely available, is near the emergency room, has high sensitivity and specificity for detecting acute thoracic aortic diseases, and can detect other findings, enabling it to rule out a plethora of diseases. Despite being widely used to diagnose ascending aortic dissection [4,5,6,7,8,9], CTA may provide false-positive results, as factors such as streak artifacts, pericardial recesses, the left brachiocephalic vein, thickened pleura, and, most importantly, motion artifacts from the pulsating aorta may simulate an intimal flap or false channel.

Electrocardiographic (ECG) gating/triggering eliminates cardiac pulsation motion artifacts, thus improving the diagnosis of an acute aortic dissection, enabling clinicians to precisely localize and characterize the site of the primary intimal tear, with important clinical implications. Moreover, due to increased image quality, removal of pulsation artifacts and measurement reproducibility the ECG gated CTA represents the current standard for pre-TAVI procedures but not yet for acute aortic syndromes. This study aims to evaluate examination procedures, reconstruction techniques, and anatomical images from Thoracic Aorta CT Angiography examinations in Dissection Cases with ECG Gating.

2. Research Methods

The research design was qualitative descriptive with a case study approach. This study aims to evaluate the examination procedures and anatomical features of CT Angiography examination of the Thoracic Aorta in Cases of Dissection with ECG Gating. The research was conducted at the Radiology Installation in a Jakarta hospital from September to December 2021. The study population was all CT angiography examinations in cases of aortic dissection and number of samples in this study were 2 patients who had been selected based on the inclusion: Aortic CT Angiography examination data using ECG with HR 60-65 bpm and the examination results showed type A aortic dissection and exclusion criteria: Aortic CT Angiography patient data without ECG and the examination results showed no aortic dissection. The data collection methods used were observation, documentation and interviews. The research instruments used include worksheets, Terareco software for post processing, and interview sheets. Data processing and analysis are narrative and descriptive then drawn conclusions. Research based on ethical approval number LB. 02.01/I/KE/30/796/2021 issued by the health research ethics committee of the Health Polytechnic Ministry of Health Jakarta II

3. Results and Discussion

3.1.Procedure of Aortic CTA Examination with ECG Gating

Procedure of aortic CTA examination with ECG gating using scenaria 128 type CT scan: The procedure for CT angiography of the aorta with ECG gating starts from filling in the patient data on the monitor console, then select the Whole body examination protocol and click cardiac 1scan + PDT(C) and 0.63 combination. After that click "proceed". AP and Lateral scannograms or topograms

are then performed. Set the ECG segment with the upper limit of the lung apex to the heart and set the non-ECG segment with the upper limit of overlap with the ECG segment to the symphysis pubis. Set bolus tracking at carina level. ROI on the descending aorta with HU 100. Set contrast setting parameters with contrast volume 1-1.5cc/kg BW, NaCl 50 cc, peak PSI 275 and flow rate 3.5-4 ml/sec.

Post Processing Reconstruction Technique of CTA Aorta with ECG gating: For the aortic CTA image reconstruction process with ECG gating, there is separate data between the thoracic aorta and abdominal aorta. The ascending aorta to the thoracic aorta uses ECG gating. While the abdominal aorta does not use ECG gating. So to combine the two data, select patient files data 1 and data 2, then right-click select series management and click stich data. Click Load then select CT ABD-Pelv workflow to reconstruct CTA Aorta, which must be reconstructed, namely MIP (Maximum Intensity), CPR (Curve Planar Reconstruction) and VRT (Volume Rendering Technique).

Implications: Thoracic CT angiography (CTA) for ascending aortic dissection, a life-threatening emergency, is performed routinely without Electrocardiographic (ECG) gating, therefore allowing the apparition of a pulsation artefact. ECG gated CTA shows a higher diagnostic performance for ascending aortic dissection than non-ECG gated CTA

3.2.Reconstruction Technique of Aortic CTA Post Processing with ECG Gating

3.2.1.Recontruction Maximum Intensity Projection (MIP)

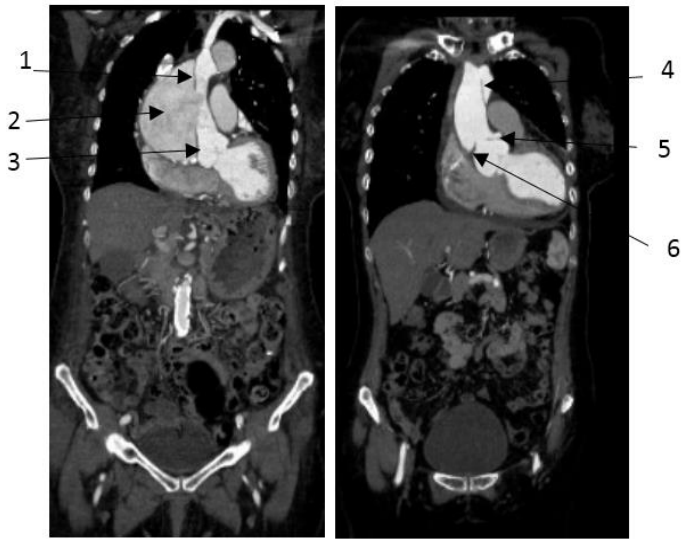

Figure 1. Coronal Section Rekonstruction MIP

Figures "1" show the dissection at numbers 1,3,4,5,6 and the aortic aneurysm. To create a MIP reconstruction on the operator's computer, first make an axial cut of the MIP. Press the F8 key then click parallel to draw a line from the lung apex to the femoral artery to form an axial cut. Set image number 24 and thickness 1 mm. Measure the diameter of the aorta in the following sections such as ascending aorta, aortic arch, descending aorta, thoracic aorta at diaphragm level, abdominal aorta at renal level, aobominal aorta before bifurcatio, right and left iliac arteries, right and left femoral arteries. Click the output scout image and write "axial" in the description field. Click preview to make sure. Once everything is correct, click output.

3.2.2. Recontruction *Curve Planar Reconstraction*

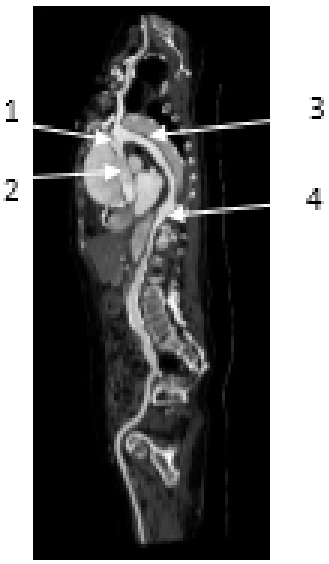

Figure 2. Sagital Section Rekonstruction CPR

Figure "2" as shown in number 1 shows aortic dissection, number 2 shows a large tear, number 3 shows false lumen, and number 4 shows true lumen. To reconstruct the CPR, click the image and select CPR, press the shift key and the aorta will be reconstructed simultaneously. The curve line will automatically follow the curve along the aorta. To save click the camera icon and save.

3.2.3. Rekonstruksi 3D VRT

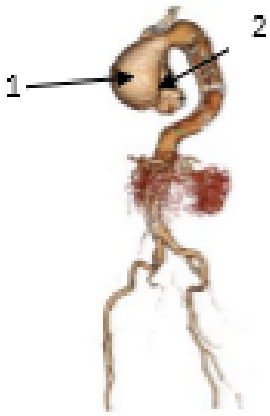

Figure 3. Rekonstruction 3D VRT

In Figure "3" as shown number 1, a large aneurysm is apparent and number 2, an aortic dissection is apparent. VRT/3D is usually used by surgeons to view the external anatomy layout. VRT images are created by double clicking on the VRT image, clicking remove bone which aims to make the bone image disappear. To be clearer, the background is changed to white by right-clicking then background and selecting white. to remove unnecessary parts, can be removed by clicking the free ROI tools and pressing the shift key and dragging the part you want to remove. Rotate all sides so that

unnecessary parts can be removed. If you want to save, click capture on the image where there is a camera icon and save.

Anatomical information of thoracic aorta dissection with ECG gating: The use of ECG Gating on CT Angiography examination with dissection cases can show the shape and size of the dissection clearly, as shown in the picture below.

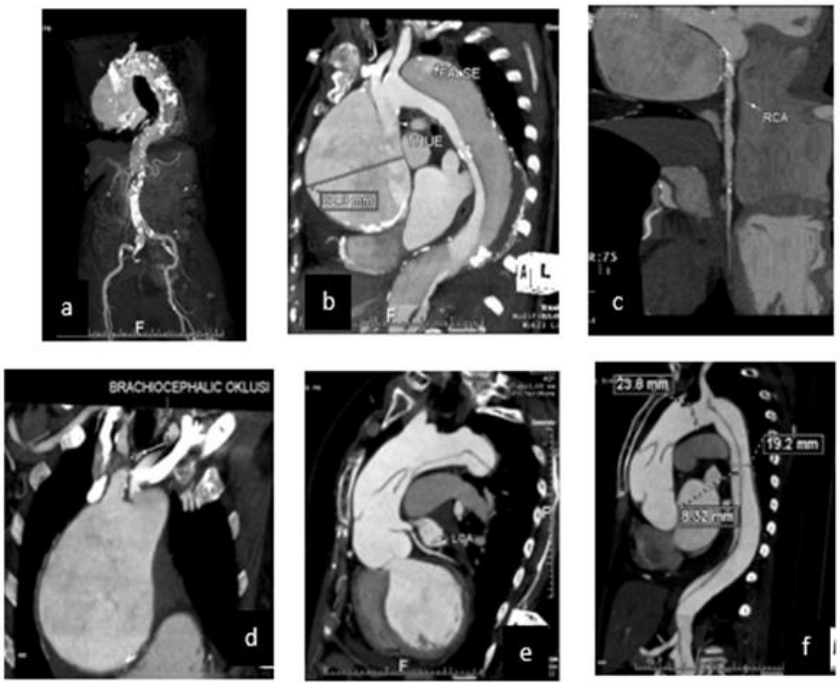

Figure 4. Shape of Dissection in Aorta

Figure 4. Images of ascending to abdominal aorta (a), dissection and large aneurysms of ascending aorta and descending aorta (b), RCA involved aortic dissection (c), brachiocepalic artery occlusion (d), multiple dissections of ascending aorta (e), dissection of descending aorta (f). Based on the picture above, in picture (a) there is atherosclerosis of the thoracic to abdominal aorta, particularly the infrarenal aorta. Figure (b) shows an 82.9 mm ascending aortic aneurysm with a long dissection process from the right sinotobular junction. This is classified as Debakey type 1 dissection, Stanford A. The size of the true lumen is smaller than the false lumen. Figure (c) shows the RCA affected by the dissection process of the ascending aorta. The RCA originated from the true lumen. Figure (d) shows occlusion of the brachiocephalic artery. Figure (e) shows multiple dissections of the ascending aorta with the Left Mean (LM) exposed to the dissection process. Figure (f) shows a long dissection from the ascending to the thoracic aorta with an aortic arch diameter of 23.8 and a true lumen size in the thoracic aorta of 8.32 mm and a false lumen size of 19.2 mm.

Analysis of motion artifacts in the image results of CT Angiography of the Aorta with ECG gating in cases of aortic dissection: Artifact is something that appears on the image that is not present in the object being scanned. Artifacts can degrade image quality, affect the perception of details, or even cause misdiagnosis. Artifacts that usually occur due to movement are called motion artifacts. Patient movement can be both controlled and uncontrolled. Patient-controlled movements such as swallowing or breathing movements. Uncontrolled movements by the patient such as peristalsis and heart movements.

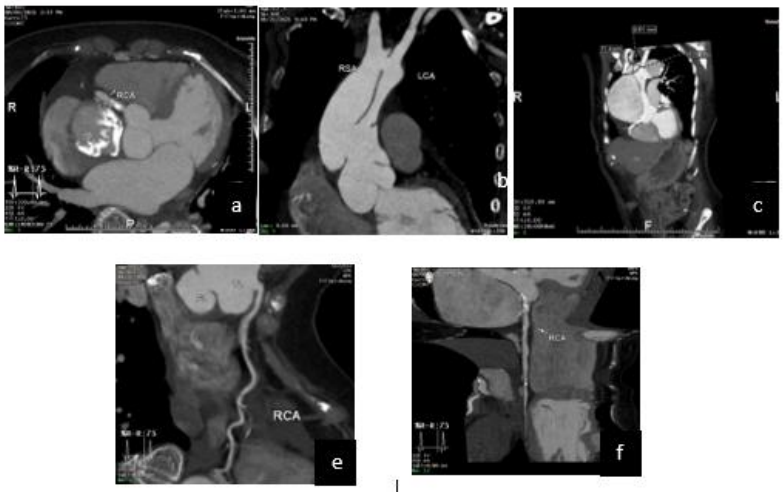

Figure 5. Images Dissection of Aortic Root, Coronary Artery and Right Coronary Aartery Anatomy

Figure 5 is shown: Root aorta, coronary artery and dissection clearly visible (a,b,c), RCA clearly visible with minimal pulsation artifacts (e,f). Based on the figure above, the aortic root, ascending aorta and coronary ostium are clearly visible. There are no lines or double layers on the aortic root and ascending aorta. The RCA is clearly visible without the lines that often look like faults. Minimal pulsation artifacts are visible.

3.3. Discussion

ECG gated CTA plays a significant role in the correct diagnosis of ascending aortic dissection with the benefit of removing the motion artifact of the ascending aorta and increasing diagnostic precision.ECG gated CTA shows a higher diagnostic performance for ascending aortic dissection than non-ECG gated CTA regardless MIP is to increase the enhancement of contrast so that the contrast at the tissue or vascular level will be more prominent than others (Duran et al., 2019).

MIP to show spot films usually for review studies, showing images from the aortic root to the thoracic if abnormalities are found, then images are taken with a certain thickness. Thin slabs are usually used to assess abnormalities in more detail. Thick slabs or more than 5 mm are usually to show the full anatomy but increase superposition and difficulty in interpretation. The ability of MIP to display only the brightest pixels can help to visualize small branch blood vessels. MIP is also useful for distinguishing contrast densities and calcifications.

Curve Planar Reconstruction (CPR) is created with MPR, usually used for advanced analysis. Doctors need CPR reconstruction for further actions such as TEVAR, EVAR or pro surgery. With CPR, the image is more detailed and not overlapping with other objects. CPR is often used for coronary artery post processing. Straight CPR forms a straight line. CPR is used for visualization of vascular structures, namely the lumen of blood vessels. In the CPR image results, it can show the inner/inner lumen of the blood vessels from the ascending aorta to the abdominal aorta by tracking the desired area.

VRT/3D is usually used by surgeons to see the outer/layout anatomy. VRT not only displays vascular anatomy but also displays soft tissue, muscle, bone, displays color and provides a more comprehensive understanding of the pathology, this is in accordance with the theory contained in the journal Volume Rendering Versus Maximum Intensity Projection in CT Angiography: What Works Best, When and Why. This VRT is used to determine the height of the location of the pathology. Making it easier for doctors when performing surgery.

CT angiography provides accurate information on true and false lumen size, can localize intimal folds including entry and re-entry sites, extent of dissection and aneurysm dilatation. With the

addition of ECG gating, it can clearly show type A aortic dissection, especially the expansion of the proximal mural flap and its association with the aortic root, coronary ostium and aortic valve. CT angiography of the aorta should use ECG gating to optimally depict the aortic root region. Besides, CT angiography of the aorta is the golden standard to visualize the aorta quickly and accurately. Evaluation of anatomical images of CT angiography of the aorta with ECG gating with dissection cases includes coronary arteries, aortic root, ascending aorta, aortic arch and its three major branches namely brachiochepalik artery, left carotid common artery, left subclavian artery, descending aorta, abdominal aorta and its branches namely coeliac artery, SMA, renal artery and IMA, common iliac artery, and femoral artery. This examination using additional ECG gating aims to assess the root aorta and coronary arteries that may be involved in aortic dissection.

Motion artifacts consist of cardiac, respiratory and patient movement (Kalisz et al., 2016). Motion artifacts can affect the quality of measurement and diagnosis of aortic dissection or luminal irregularities (Pierro et al., 2018). Artifacts due to movement of heart pulsations can be minimized by the use of ECG gating. In addition, heart rate plays an important role in obtaining informative results. A stable heart rate will minimize the appearance of artifacts in CT scan reconstruction results. With a normal heart rate, the diastolic phase of the heart tends to be longer so that the movement of the left ventricle, root aorta and coronary arteries is minimal. Double layer lines in the ascending aorta are often seen in normal aortic examination. This double layer usually leads to misinterpretation between artifact or aortic dissection. The aortic root is well visualized so that the coronary estuary is clearly visible at 75% diastolic phase. With the addition of ECG gating, the doctor knows that the coronary artery originates from the true lumen. In this phase, there were no visible lines indicating a significant pulsation artifact so that the coronary arteries could be assessed properly. The images in both patients did not show any metal artifacts, as this examination was performed in preparation for bental surgery.

Advantages of CT Angiography of Thoracic Aorta with ECG Gating in Aortic Dissection Case: Able to visualize the aortic root, ascending aorta and coronary arteries well compared to ordinary CT aorta, useful for planning further actions such as bental surgery, TAVI (Transcatheter Aortic Valve Implantation) and Disadvantages: The cost is more expensive because it is like doing two examinations simultaneously, namely aortic CTA and coronary CTA, the radiation dose is higher because the ECG segment uses a low pitch of 0,2334

4. Conclusion

The use of ECG gating synchronized with CT Scan is useful for monitoring HR continuously. The HR value is very influential on the image quality related to artifacts. In this case, ECG gating helps to determine the systole and diastole phases of the heart. In the systolic phase, the LV pumps blood through the aortic valve so that the aortic valve area and its surroundings experience significant movement.

MIP images, especially oblique sections, are able to show the complete contour of the aorta, making it easier to analyze and measure the area of the aortic root, ascending aorta, aortic arch and its branches, descending aorta, abdominal aorta and its branches and also bilateral common optic arteries. CPR images are able to show the entire contour of the aorta inner/in the lumen of the aorta. This CPR method is able to show the aortic dissection well so that it can identify the tear well. The VRT image is able to show the anatomy/layout from the outside as well as the location of the pathological height

On a CT scan with the addition of ECG gating, the doctor knows that the coronary arteries originate from the true lumen. In this phase, no visible lines indicate the presence of significant artifact pulsations so that the coronary arteries can rated well. The imaging results in the two patients did not show any metal artifacts

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