Application of post-processing technique in diagnosis of coronary computed tomography angiography imaging

Tianqi Zhang, Nannan Xu, Tingting Gong, Bo Li, Jianhua Liu, Qinghai Yuan, Lei Wang*
Department of Radiology, the Second Hospital of Jilin University, Changchun, 130041, China
Corresponding author: Wanglei_gy@sina.com

Abstract. Coronary artery disease (CAD) as a common chronic disease, acute myocardial infarction (AMI) is one of the most urgent manifestations of CAD which had a highly mortality. Coronary computed tomography angiography (CCTA) combined with post-processing technique was the best way to diagnosis CAD in routine examination. By various post-processing techniques, such as Volume rendering (VR), Curved planar reformations (CPR) techniques can speed up the complicated processing of CCTA and improve the diagnostic accuracy of radiologists.

1. Introduction
Coronary artery disease (CAD) as a common chronic disease, hemodynamic changes during the active period usually lead to serious consequence [1]. Acute myocardial infarction (AMI) was one of the most urgent manifestations of CAD. Many patients will appear symptoms such as heart failure as well as shock, and if without proper treatments, patients will die in a short time. Due to the rapid progress of the disease, the mortality rate of AMI still hover in a high level, and even in developed countries, which accounts for one-third of all deaths. According to 2017 data, about seven million people were suffered this disease every year [2]. Although combined with clinical symptoms, echocardiography (ECG) and cardiac enzymes results can diagnosis AMI [3], clinicians preferred using imaging diagnosis methods to assess the degree of coronary artery stenosis before infarction. There were many kinds of imaging methods, such as magnetic resonance (CMR), digital subtraction angiography (DSA) and cardiac coronary computed tomography angiography (CCTA) [4-6]. However, DSA as an invasive examination, patients needed to face the risk of higher dose radiation, anesthetics shock and massive hemorrhage [7-9]. Furthermore, there were also insurmountable drawbacks in CMR, for example, MRI cannot be performed after cardiac stenting, so it was impossible to evaluate the postoperative situation of patients. Although CCTA can overcome the above shortcomings, the axial section cannot accurately evaluate the coronary stenosis. Appearance of post-processing technology changed this situation. By transforming the axial section with post-processing software, the diagnostic ability of CAD can be improved and the occurrence of AMI can be avoided to some extent.

The purpose of this study was to explore the application of various post-processing techniques in CCTA and to evaluate its diagnostic ability for different CAD.

2. Patients and methods

2.1 Patients
From September 2019 to October 2019, 415 patients were accepted in this study. All of them underwent examination of CCTA and had a history of chest tightness, precordial pain, or coronary stenting. Patients excluded the relevant contraindications for CCTA before the examination, such as arrhythmia, iodine allergy, severe renal failure or organ failure.

2.2 Computed tomography protocol
All CCTA were performed on a 256 slice CT (Brilliance iCT, Philips), which related parameters included: tube voltage of 100 kVp, tube current of 800~1000 mAs, rotation time of 0.27 s, the slice thickness 0.9 mm, reconstruction matrix of 512×512, the FOV of 250 mm and retrospective ECG gating. All patients took supine position, the scanning range from upper edge of manubrium sterni to the diaphragm after respiratory training. Contrast agent (Omnipaque, 350 mg/ml) 85~100 ml at 4.5 ml/s. We placed region of interest (ROI) in the aortic root, and automatic bolus tracking was used to trigger scanning after 5s when the CT value of ROI reached the threshold of 120 HU.

2.3 Post-processing techniques
Axial section image can be used to diagnose CAD, but each slice only shows a small segment of coronary artery rather than whole structure, and usually 24 axial sections were given to show the basic condition of patients. Volume rendering (VR) technology can display the anatomy structure of each part in different colours, just like the real heart. At the same time, it can highlight the anatomical structure of by cutting and rotating on the basis of retaining 2-dementional image information, so that images is simpler and more intuitive. VRT was the best way to diagnose the origin and distribution of coronary artery abnormalities. Routine CCTA provided 9 VRT sections including 6 sections of heart and 3 sections of coronary tree in different angle. Curved planar reformations (CPR) technique was used to evaluate coronary plaque, degree of stenosis, internal condition of coronary stent and anatomical relationship between coronary artery and myocardium. CPR was the most important method to evaluate vascular details.

3. Results and Discussions

3.1 Patients
Atherosclerosis minor stenosis (diameter stenosis ≤50%) was found in 163 patients, which included 4 cases of myocardial bridge. Moderate stenosis (diameter stenosis 50%~75%) was found in 132 patients, which included 2 cases of myocardial bridge. Severe stenosis (diameter stenosis >75%) was diagnosed in 117 patients. Coronary artery bypass grafting and coronary stenting was diagnosed in 44 patients which included by the severe stenosis group mentioned. Anomalous origin of coronary artery of aorta was diagnosed in 3 cases.

3.2 Coronary atherosclerosis
The degree of coronary atherosclerosis includes minor, moderate and severe. The degree of stenosis in minor patients was less than 50%, moderate was between 50% and 75%. DSA should be performed and appropriate treatment measures should be taken if the degree of stenosis was more than 75% in severe group. As shown in Fig.1a, mixed plaque was formed in the left anterior descending branch, and the degree of stenosis was about 40%. Fig.1b showed the lesion located in the proximal left anterior descending branch. Fig.1c showed minor stenosis of the left anterior descending branch and the relationship between cardiac and artery. In Fig.1d, it shown the origin of coronary artery was normal.
Fig. 1 (a) CCTA axial section images of coronary atherosclerosis in minor degree (white arrow). (b) CPR technique showed the location of lesion (white arrow). (c) VR technique showed the relationship between cardiac and artery. (d) VR of coronary tree.

3.3 Myocardial bridge
Myocardial bridge of coronary artery was a kind of abnormal vascular development, which referred to the phenomenon that the coronary artery passes through part of the heart muscle and myocardial ischemia occurs when the heart contracts. As shown in Fig. 2a, the left anterior descending branch was buried under the myocardium. Fig. 2b CPR technique showed the length of myocardial bridge in the proximal left anterior descending branch. Fig. 2c VR technique showed myocardial bridge of the left anterior descending branch and the relationship between cardiac and artery. In Fig. 2d, it shown the origin of coronary artery was normal.

Fig. 2 (a) CCTA axial section images of myocardial bridge (white arrow). (b) CPR technique shown the length of myocardial bridge (white arrow). (c) VR technique shown the relationship between cardiac and artery (white arrow). (d) VR of coronary tree.

3.4 Coronary artery bypass grafting
The left internal mammary artery was used as the bypass vessel, to provide extra blood supply for the heart to relieve the myocardial ischemia, which caused by the complete occlusion of the left anterior descending branch. As shown in Fig. 3a, changing the direction of left internal mammary artery. Fig. 3b CPR technique can show the patency of bridging vessel. Fig. 3c VR technique showed the connection between the bridging vessel and the posterior branch of left ventricle. In Fig. 3d, it shown the bridging vessel originated from the left subclavian artery.
Fig. 3 (a) CTA axial section images of bridging vessel (white arrow). (b) CPR technique showed the condition of bridging vessel (white arrow). (c) VR technique showed the connection of bridging vessel and posterior branch of left ventricle (white arrow). (d) VR of bridging vessel.

3.5 Origin of coronary artery abnormality and coronary stent

Under normal circumstances, the left and right main coronary arteries originate from the left and right coronary sinus respectively. The abnormal origin of coronary arteries usually did not have serious clinical manifestations, but special attention needed to be paid on the choice of surgical path when performing cardiac interventional therapy. In Fig. 4a, both the left and right coronary arteries originated from the left coronary sinus. Fig. 4b CPR technique showed the coronary stent of left anterior descending branch. Fig. 4c and 4d showed the origin of coronary artery abnormality and coronary stent directly.

Fig. 4 (a) CTA axial section images of origin of right coronary artery abnormality (white arrow). (b) CPR technique showed the interior condition of coronary stent (white arrow). (c) VR technique showed relationship of left coronary sinus (white arrow) and coronary stent (black arrow). (d) VR of coronary tree.

4. Conclusion

According to the results and analysis of many cases above, we finally made the following conclusions: CTA allowed for a more accurate assessment of coronary artery stenosis, even after coronary stenting or coronary artery bypass grafting. Post-processing techniques were essential methods of CTA, which can greatly improve the accuracy of diagnosis of CAD.

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