Feasibility of applying post-processing techniques in triple-rule-out computed tomography angiography

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Abstract. Triple-rule-out CTA technique can evaluate the thoracic aorta, pulmonary artery and coronary artery at the same time. Some diseases of above arteries are life threatening causes of acute chest pain (ACP), which belong to most frequently symptoms of patient in the emergency departments. Triple-rule-out CTA can not only reduce radiation dose, but also contrast volume. Furthermore, it reduces the cost and time of examinations. Post-processing techniques include multi-planar reconstruction, curved-planar reconstruction and volume rendering technique. Post-processing techniques are effective methods to evaluate thoracic aorta, pulmonary artery and coronary artery in triple-rule-out CTA.

1. Introduction
In emergency departments (ED), Acute chest pain (ACP) is one of the most frequently symptoms, it accounts for 5-20% ED visits [1-3]. Acute chest pain (ACP) center almost exists in every third-grade class-A hospital. Although many diseases can cause acute chest pain, acute coronary artery disease (CAD), pulmonary embolism (PE) and acute aortic syndromes (AAS) are still life threatening causes of ACP [4-7]. Information acquired from physical examination, cardiac biomarkers or ECG is always not enough for distinguishing those causes of ACP. Computed tomography angiography is an effective technique to diagnose CAD, PE or AAS. CTA is performed as regarding to consider one disease, such as aortic CTA is used during evaluating aortic diseases. However, diseases of coronary artery and pulmonary artery can’t be diagnosed in aortic CTA. Therefore, in conventional process, CTA of aortic, pulmonary and coronary artery could be performed during differentiating CAD, PE and AAS. Three examinations will increase radiation dose and contrast volume, which is harmful to patients. Based on above disadvantages, triple-rule-out (TRO) CTA technique has been introduced to solve these problems [8-9]. Compared to conventional coronary CTA technique, this protocol could evaluate the thoracic aorta, pulmonary artery and coronary artery at the same time. This triple-rule-out CTA can not only reduce radiation dose, but also contrast volume. Furthermore, it reduces the cost and time of examinations [10-11].

The purpose of this study was to assess the ability of triple-rule-out CTA in differentiation diseases of CAD, PE and AAS with acute chest pain. Post-processing techniques are effective methods to evaluate thoracic aorta, pulmonary artery and coronary artery in triple-rule-out CTA.
2. Materials and methods

2.1. Patient characteristics
From October 2018 to March 2019, 187 patients considering ACP were enrolled into our study. All patients were underwent examination of triple-rule-out CTA for evaluating acute chest pain, such as PE or AAS. Patients with arrhythmia, renal failure, contraindication to beta-blockade, allergy to contrast agent, and without breath during examinations were not included.

2.2. Computed tomography protocol
Triple-rule-out CTA were performed on 256 slice CT (Brilliance iCT), which equipped with rotation time of 0.27 s, a total coverage of 80 mm. Scanning parameters included low pitch with 0.2 acquisition, slice thickness of 0.9 mm, the tube voltage of 120 kVp, tube current of 800 mAs, and the FOV of 250 mm. Scanning range was from apices of the lung to the diaphragm. The automated bolus tracking technique was used in triple-rule-out CTA, when CT value of region of interest surpassed 150 Hu, scanning was triggered, and the acquisition was started with a delay of 4-7 s. The retrospectively ECG-gated helical acquisition method was performed.

2.3. Post-processing technique
Axial section was evaluated in images of all patients, besides observing on workstation, a film with 48 axial sections from lung apices to the diaphragm. Multi-planar reconstruction was used during assessing aortic artery and pulmonary artery, a film with 9 MPR sections was printed, which included whole counter of thoracic aorta, main pulmonary artery, left pulmonary artery, right pulmonary artery, right upper lobe pulmonary artery, right middle lobe pulmonary artery, right lower lobe pulmonary artery, left upper lobe pulmonary artery, left lower lobe pulmonary artery. Curved-planar reconstruction was performed during assessing coronary artery, a film with 24 CPR sections was printed, which included 6 sections of left anterior descending artery, 6 sections of left anterior descending artery, 6 sections of right coronary artery, 3 sections of obtuse marginal branch and 3 sections of diagonal branches. Furthermore, volume rendering technique was used during assessing three arteries, which included 9 sections of pulmonary artery and aortic artery, 9 sections of coronary artery.

3. Results and Discussions

3.1. Patient characteristics
PE was found in 20 patients in Group Females and in 15 patients in Group males. CAS was found in 23 patients in Group females and in 15 patients in Group males. AD was diagnosed in 18 patients in Group Females and in 15 patients in Group males. Penetrating atherosclerotic ulcer of aorta was diagnosed in 23 patients in Group Females and in 15 patients in Group males. Intramural hematoma was diagnosed in 23 patients in Group Females and in 15 patients in Group males.

3.2. Thoracic aortic diseases
Thoracic aortic diseases included intramural haematoma (IMH), aortic dissection (AD), and penetrating atherosclerotic ulcer (PAU). Within IMH, bleeding progress along the aortic media would cause aortic dissection, and bleeding progress trans-mural through the wall could cause PAU. As shown in Fig.1a, penetrating atherosclerotic ulcer was observed in the proximal segment of aorta (white arrow). Fig.1b showed moderate stenosis in the proximal segment of RCA (white arrow). Fig.1c showed normal imaging of right lower lobe pulmonary artery. Fig.1d showed VR imaging of three arteries.
3.3. Diseases of pulmonary artery
Diseases of pulmonary artery included pulmonary artery stenosis, abnormal origin of pulmonary artery, pulmonary embolism. CT imaging features of coronary artery embolism would show low density in the lumen with conception of filling defect. As shown in Fig.2a, pulmonary embolism was observed in the proximal segment of right and left pulmonary artery (white arrow). Fig.2b showed normal coronary artery. Fig.2c showed normal imaging of aorta. Fig.2d showed VR imaging of three arteries.

3.4. Diseases of coronary artery
Diseases of coronary artery included coronary artery stenosis, abnormal origin of coronary artery, coronary artery dissection. CT imaging features of coronary artery stenosis would show low density in the lumen, which could induce mild stenosis, moderate stenosis and sever stenosis. As shown in Fig.3a, white arrow showed moderate stenosis in the proximal segment of RCA. Fig.3b showed normal coronary artery. Fig.3c showed normal pulmonary artery. Fig.3d showed VR imaging of three arteries.
Fig. 3 CTA features of coronary stenosis. (a) Coronary stenosis (white arrow). (b) Normal pulmonary artery. (c) Normal aorta. (d) VR of three arteries.

4. Conclusion
Based on above results and discussions, the conclusions of this study are achieved as below:

(1) Technique of triple-rule-out CTA can assess the thoracic aorta, pulmonary artery and coronary artery at the same time.

(2) Diagnosis of triple-rule-out CTA can differentiate among diseases with symptom of acute chest pain, such as coronary artery stenosis, pulmonary embolism, aortic dissection, penetrating atherosclerotic ulcer and intramural haematoma.

(3) Post-processing techniques are effective methods to evaluate thoracic aorta, pulmonary artery and coronary artery in triple-rule-out CTA.

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