Rarity of isolated pulmonary embolism and acute aortic syndrome occurring outside of the field of view of dedicated coronary CT angiography: evidence against the widespread use of triple rule-out protocol in patients with nonspecific acute chest pain

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Purpose

Triple rule-out CT angiography (TRO) to simultaneously evaluate acute coronary syndrome (ACS), pulmonary embolism (PE), and acute aortic syndrome (AAS) is increasingly being performed in many institutions equipped with 64-slice or greater multi-detector CT (MDCT). The scan range for TRO and dedicated coronary CT angiography (DCTA) extends from the thoracic inlet to costophrenic angles and from the tracheal carina to the base of heart, respectively (1). Therefore, TRO is inevitably associated with increased radiation exposure due to extended z-axis coverage compared with DCTA, resulting in increased risk of radiation induced cancer. Multiple recent studies have indicated that TRO is valuable to evaluate patients with nonspecific acute chest pain in whom diagnosis of PE or AAS as well as ACS are simultaneously considered (1-7). One review article has suggested that most of PE and aortic dissection is identifiable on DCTA (8). However, this assumption has not been assessed in a systematic way. We hypothesized that isolated AAS or PE that is not in the field of view (FOV) of DCTA is uncommon.

Thus, the purpose of this study was to determine the frequency of exclusion of findings of AAS and PE when using a restricted DCTA FOV.
Methods and Materials

Study population

Institutional review board approval was obtained and informed consent was waived for this study. This study was performed by retrospectively reviewing clinical and radiological data in a large university hospital. We identified 107 consecutive patients with acute PE between September 2006 and September 2009. A diagnosis of acute PE was made if there was an intra-luminal filling defect within the pulmonary arteries on contrast enhanced CT in the absence of findings of chronic PE (i.e., an intra-luminal filling defect adherent to the wall of pulmonary arteries or abrupt narrowing or web in the pulmonary arteries). Four patients with acute PE were not included in this study because respiratory motion artifact (n=3) or poor contrast enhancement (n=1) could not be excluded as a cause of the apparent filling defect in these cases. Thus, 103 patients with acute PE (male/female, 57/46; mean age, 57.7 ± 16.4) were included in this study. We also identified 50 consecutive patients (male/female, 28/22; mean age, 62.1 ± 15.2) with the diagnosis of AAS between September 2004 and September 2009. Acute aortic syndrome cases consisted of intramural hematoma (n=5), penetrating atherosclerotic ulcer (n=7), and aortic dissection (n=38). A diagnosis of aortic dissection was made if there was an intimal flap traversing the lumen of aorta. A diagnosis of intramural hematoma was made if there was a crescent shaped high attenuation in the aortic wall on pre-enhanced CT image without evidence of aortic dissection or penetrating atherosclerotic ulcer after enhancement. Penetrating atherosclerotic ulcer was considered to be present if there was an ulcer penetrating through the aortic wall accompanied by adjacent intramural hematoma. An aortic ulcerlike outpouching in the absence of adjacent intramural hematoma (i.e., saccular pseudo-aneurysm) is often asymptomatic and can be an incidental finding, and such cases were not included in this study (9, 10). Only one case of saccular pseudo-aneurysm occurred during the study period.

CT technique

Dedicated pulmonary CT angiography and aortic CT angiography were performed on 16-slice multi-detector CT (MDCT) (Somatom Sensation 16, Siemens, Forchheim, Germany) or 64-slice MDCT (Light-speed VCT, General Electrics Healthcare, Milwaukee, WI, USA). Scanning parameters of dedicated PE and aortic CT angiography were as follows: non-ECG gating, 120 kV, 200-400 mA, 0.625 mm collimation, 1.5 mm increment, 3 mm reconstruction, 32 cm field of view, and 0.35 or 0.40 s gantry rotation time. Contrast enhancement was performed with the intravenous injection of 60-100 ml of Ioversol
(Optiray 350 mg/ml, Tyco healthcare, Montreal, Canada) based on the patient's body mass index. The scan range for dedicated PE and aortic CT angiography extended from the thoracic inlet to adrenal glands and from the thoracic inlet to femoral heads, respectively. A trigger delay of 5 sec and bolus tracking of contrast material were used. Scanning was started when the contrast bolus arrived in the main pulmonary artery or ascending aorta (threshold>100 Hounsfield units) according to the targeting artery. Multi-planar reformatted images such as volume rendering, maximal intensity projection or curved multi-planar reformatted images as well as transaxial CT images were available in this study.

**Image analysis**

Two experienced radiologists (10 years of experience in cardiovascular imaging and 11 years of experience in body CT imaging) who were blinded to clinical information independently analyzed dedicated PE and aortic CT angiography images, retrospectively. If there was disagreement between the two readers about MDCT findings, a third reader's (10 years of experience in cardiovascular imaging) opinion was sought for final decision. Dedicated PE or aortic CT angiography images from the tracheal carina to the base of heart were used to simulate the FOV of DCTA. The imaginary upper and lower end of FOV of DCTA was identified by using a cross reference tool on the PACS monitor. The cross reference tool on a particular trans-axial CT image allowed us to obtain the corresponding horizontal line on the scanogram of the chest AP view. The upper end of the FOV of DCTA (Fig. 1) was defined as a horizontal line tangential to apex of tracheal carinal angle on the scanogram of the chest AP view.
Fig.: Fig. 1 The imaginary upper end (a) of the field of view (FOV) of dedicated coronary CT angiography (DCTA) is marked by a dotted line on the CT scanogram.

References: - Bundang/KR
Fig.: Fig. 1B. Note transaxial CT image (b) corresponding to the dotted line in a.

References: - Bundang/KR

The lower end of the FOV of DCTA was defined as a horizontal line tangential to the cardiac base on the scanogram of the chest AP view. We analyzed the incidence of isolated PE and AAS excluded from the DCTA FOV. We recorded the largest pulmonary artery in which a pulmonary embolus was identified. The location of pulmonary embolus was classified as involving the main, lobar, segmental, or subsegmental pulmonary artery. We also analyzed the nature of the presenting symptoms and the presence of right ventricular enlargement and straightening of inter-ventricular septum in patients with PE. Right ventricular enlargement was considered to be present if the diameter of the right ventricle on transaxial CT image at the level of tricuspid valve was at least 1.5 times larger than that of the left ventricle on transaxial CT image at the level of mitral valve. Straightening of the inter-ventricular septum was considered to be present if there was a loss of normal bowing of inter-ventricular septum toward the right ventricle or abnormal bowing of inter-ventricular septum toward the left ventricle. In patients with AAS, the Stanford classification type of AAS was recorded. We also analyzed the presence or absence of carotid or subclavian artery involvement by a dissection flap that may be missed if DCTA rather than TRO is performed.
Statistical methods

Statistical analysis was performed using commercially available software (SAS version 4.1, SAS Institute Inc., Cary, NC, USA). All data were expressed as mean ± standard deviation (SD) for continuous variables and percentages or frequencies for categorical variables. Inter-observer agreement (kappa statistics) of each CT finding (i.e., isolated PE or AAS outside of the DCTA FOV, largest pulmonary embolus, right ventricular enlargement, straightening of inter-ventricular septum, and carotid or subclavian artery involvement by dissection flap) was calculated.
Images for this section:

**Fig. 0:** Fig. 1B. Note transaxial CT image (b) corresponding to the dotted line in a.

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**Fig. 0:** Fig. 2 Isolated subsegmental pulmonary embolism in the posterior segment of the right upper lobe in a 70-year-old woman. An intra-luminal filling defect of low attenuation (arrow) is noted in the subsegmental pulmonary artery in the posterior segment of the right upper lobe on contrast enhanced transaxial CT image at the level of distal trachea. There was no evidence of pulmonary embolus in the remainder of pulmonary arteries.

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**Fig. 0:** Fig. 3 Pulmonary embolism excluded from the field of view of dedicated coronary CTA in a 72-year-old man. Pulmonary embolus (white arrowheads) is seen in the left main pulmonary artery on a contrast enhanced transaxial CT image at the level of the left main pulmonary artery. Fibrotic consolidation (black arrowheads) due to previous tuberculosis is also noted in the left upper lobe

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Fig. 0: Fig. 4 Stanford type A aortic dissection visualized in the field of view of dedicated coronary CTA in a 71-year-old woman. (a) Intimal flap (arrows) is noted on a contrast enhanced transaxial CT image at the level of the right main pulmonary artery within the field of view of dedicated coronary CTA. Note both hemothorax (black arrowheads) and hemopericardium (white arrowheads) suggesting aortic rupture.

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**Fig. 0:** Fig. 4B. Intimal flap (arrows) extends into the field of view of dedicated coronary CTA as seen on a coronal multi-planar reformatted image.

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**Fig. 0:** Fig. 5 Stanford type B aortic dissection visualized in the field of view of dedicated coronary CTA in a 67-year-old man (a) Intimal flap (arrows) is noted on a contrast enhanced transaxial CT image at the level of the left atrium. This image is within the field of view of dedicated coronary CTA.

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Fig. 0: Fig. 5B. Intimal flap (arrows) extends into field of view of dedicated coronary CTA as seen on a coronal multi-planar reformatted image.

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Results

**Pulmonary embolism**

Presenting symptoms of acute PE in 103 patients included chest pain (n=42), dyspnea (n=56), syncope (n=4), and deep vein thrombosis (n=15). The largest pulmonary embolus was demonstrated in main (n=50), lobar (n=24), segmental (n=23) and subsegmental pulmonary artery (n=6), respectively. There were two cases of isolated PE (2/103, 1.9%) that occurred outside of the FOV of DCTA. One case of PE presenting with deep vein thrombosis was isolated to the subsegmental pulmonary artery in the posterior segment of the right upper lobe (Fig. 2).

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**Fig.** Fig. 2 Isolated subsegmental pulmonary embolism in the posterior segment of the right upper lobe in a 70-year-old woman. An intra-luminal filling defect of low attenuation (arrow) is noted in the subsegmental pulmonary artery in the posterior segment of the right upper lobe on contrast enhanced transaxial CT image at the level
of distal trachea. There was no evidence of pulmonary embolus in the remainder of pulmonary arteries.

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In the second case, pulmonary embolism in the left main pulmonary artery in a patient presenting with dyspnea was located out of the FOV of DCTA because the left main pulmonary artery was retracted upwardly by fibrotic scar in the left upper lobe due to prior tuberculosis (Fig. 3).

![Fig. 3 Pulmonary embolism excluded from the field of view of dedicated coronary CTA in a 72-year-old man. Pulmonary embolus (white arrowheads) is seen in the left main pulmonary artery on a contrast enhanced transaxial CT image at the level of the left main pulmonary artery. Fibrotic consolidation (black arrowheads) due to previous tuberculosis is also noted in the left upper lobe](image)

**Fig.:** Fig. 3 Pulmonary embolism excluded from the field of view of dedicated coronary CTA in a 72-year-old man. Pulmonary embolus (white arrowheads) is seen in the left main pulmonary artery on a contrast enhanced transaxial CT image at the level of the left main pulmonary artery. Fibrotic consolidation (black arrowheads) due to previous tuberculosis is also noted in the left upper lobe

**References:** - Bundang/KR

There was no case (0/42 patients) of pulmonary embolus occurring outside of the DCTA FOV among patients who presented with chest pain. The classification of the largest pulmonary embolus and isolated PE outside of the DCTA FOV was identical between two readers in all patients (100%; excellent inter-observer agreement, kappa=1.0). There were 19 and 17 patients with the right ventricular enlargement and straightening of inter-ventricular septum, respectively. There were two cases with disagreement in the interpretation of the presence of the right ventricular enlargement and straightening
of inter-ventricular septum between the two readers (98.1%; excellent inter-observer agreement, kappa=0.927). The two cases with isolated pulmonary embolus outside of DCTA FOV did not demonstrate right ventricular enlargement or straightening of inter-ventricular septum.

**Acute aortic syndrome**

Stanford type A and B aortic dissection was found in 20 and 30 patients, respectively. All of these patients were presented with acute chest pain. There was no case of AAS (0/50) which was only visible outside of the DCTA FOV (Fig. 4 and 5).

![Fig. 4 Stanford type A aortic dissection visualized in the field of view of dedicated coronary CTA in a 71-year-old woman. (a) Intimal flap (arrows) is noted on a contrast enhanced transaxial CT image at the level of the right main pulmonary artery within the field of view of dedicated coronary CTA. Note both hemothorax (black arrowheads) and hemopericardium (white arrowheads) suggesting aortic rupture.](image)

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Fig.: Fig. 4B. Intimal flap (arrows) extends into the field of view of dedicated coronary CTA as seen on a coronal multi-planar reformatted image.

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**Fig.**: Fig. 5 Stanford type B aortic dissection visualized in the field of view of dedicated coronary CTA in a 67-year-old man (a) Intimal flap (arrows) is noted on a contrast enhanced transaxial CT image at the level of the left atrium. This image is within the field of view of dedicated coronary CTA.

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Fig.: Fig. 5B. Intimal flap (arrows) extends into field of view of dedicated coronary CTA as seen on a coronal multi-planar reformatted image.

References: - Bundang/KR
The extension of a dissection flap into the carotid or subclavian artery was identified in five patients with Stanford type A aortic dissection. Interpretation of isolated AAS outside of the DCTA FOV and the extension of dissection flap into the carotid or subclavian artery was identical between the two readers in all patients (100%; excellent inter-observer agreement, kappa=1.0).
Conclusion

As isolated PE and AAS outside of the DCTA FOV rarely occur, DCTA may replace TRO in the evaluation of patients with nonspecific acute chest pain, but a low pretest probability of PE or aortic dissection.
References


