256 Slice Multi-detector Computed Tomography Thoracic Aorta Computed Tomography Angiography: Improved Luminal Opacification Using a Patient-Specific Contrast Protocol and Caudocranial Scan Acquisition

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Clinical Relevance Statement: Caudocranial scan direction and contrast injection timing based on measured patient vessel dynamics can significantly improve arterial and aneurysmal opacification and reduce both contrast and radiation dose in the assessment of thoracic aortic aneurysms (TAA) using helical thoracic computed tomography angiography (CTA).

Objectives: To investigate opacification of the thoracic aorta and TAA using a caudocranial scan direction and a patient-specific contrast protocol.

Materials and Methods: Thoracic aortic CTA was performed in 160 consecutive patients with suspected TAA using a 256-slice computed tomography scanner and a dual barrel contrast injector. Patients were subjected in equal numbers to one of two contrast protocols. Patient age and sex were equally distributed across both groups. Protocol A, the department's standard protocol, consisted of a craniocaudal scan direction with 100 mL of contrast, intravenously injected at a flow rate of 4.5 mL/s. Protocol B involved a caudocranial scan direction and a novel contrast formula based on patient cardiovascular dynamics, followed by 100 mL of saline at 4.5 mL/s. Each scan acquisition comprised of 120 kVp, 200 mA with modulation, temporal resolution 0.27 seconds, and pitch 0.889:1. The dose length product was measured between each protocol and data generated were compared using Mann-Whitney *U* nonparametric statistics. Receiver operating characteristic analysis, visual grading characteristic (VGC), and κ analyses were performed.

Results: Mean opacification in the thoracic aorta and aneurysm measured was 24 % and 55%, respectively. The mean contrast volume was significantly lower in protocol B (73 ± 10 mL) compared with A (100 ± 1 mL) ($P<0.001$). The contrast-to-noise ratio demonstrated significant differences between the protocols (protocol A, 18.2 ± 12.9; protocol B, 29.7 ± 0.61; $P < 0.003$). Mean effective dose in protocol B (2.6 ± 0.4 mSv) was reduced by 19% compared with A (3.2 ± 0.8 mSv) ($P < 0.004$). Aneurysmal detectability demonstrated significant increases by receiver operating characteristic and visual grading characteristic analysis for protocol B compared with A ($P < 0.02$), and reader agreement increased from poor to excellent.

Conclusions: Significant increase in the visualization of TAAs following a caudocranial scan direction during helical thoracic CTA can be achieved using low-contrast volume based on patient-specific contrast formula.

Key Words: 256 slice MDCT, thoracic aortic CTA, thoracic aortic aneurysms, patient specific contrast formula

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Thoracic computed tomography (CT) angiography (TCTA) has become a robust clinical tool for the diagnosis and exclusion thoracic aortic aneurysms (TAA).[1–3] This is mostly due to the high sensitivity and negative predictive value of the test.[3] Recent concerns about the radiation exposure of the patient led to the introduction of low-dose protocols for TCTA.[4] Currently, no system is in place to track a patient's lifetime cumulative dose from medical sources,[5,6] and questions have arisen regarding the possible threat to public health from the widespread use of CT and the efficacy of the test ordered.

The efficacy of TCTA and particularly its ability to quantify the entire luminal sac is completely reliant on effective contrast administration protocols.[7] Contrast media protocols should be designed to incorporate 4 key variables: anatomical coverage, scan time, time to peak (TTP) at the thoracic aorta (cardiovascular circulation), and contrast injection flow rate. Predetermined contrast volumes (CVs) (based on user experience) ranging from 15 to 150 mL and injection rates from 2 to 5 mL/s have been reported[8]; however, these studies did not use a holistic approach to contrast administration where the variables would change seamlessly to the changing patient, protocol, and contrast media injection rate. Therefore, resulting in limited translation into clinical practice,[9–11] due to complexities and end-user knowledge. Based on these changing variables, the aim of this TCTA study is to investigate the impact of patient-specific contrast administration protocols on TAA and visualization of the thoracic vasculature.

MATERIALS AND METHODS

Study Population

The institutional review board approved this study and written informed consent was waived because all studies were clinically indicated and patient data was evaluated anonymously. Between November 2012 and January 2014, 160 consecutive patients (mean age, 77 years; range, 55–99 years; 100 men, 60 women) were included in this study (Table 1). Patients were referred from the emergency department with suspected TAA after clinical assessment and determined by evaluating mediastinal widening on a chest x-ray.[12]

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