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BRIEF REPORT

Point-of-care Focused Cardiac Ultrasound for the Assessment of Thoracic Aortic Dimensions, Dilation, and Aneurysmal Disease

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Abstract

Objectives: Thoracic aortic aneurysm and thoracic aortic dissection are related and potentially deadly diseases that present with nonspecific symptoms. Transthoracic echocardiography (TTE) may detect thoracic aortic pathology and is being increasingly performed by the emergency physician at the bedside; however, the accuracy of point-of-care (POC) focused cardiac ultrasound (FOCUS) for thoracic aortic aneurysm and thoracic aortic dissection has not been studied. The objective of this pilot study was to explore the agreement, sensitivity, and specificity of FOCUS for thoracic aortic dimensions, dilation, and aneurysm compared with CT angiography (CTA) as the reference standard.

Methods: This study was a retrospective pilot analysis of image and chart data on consecutive patients presenting to an urban, academic emergency department (ED) between January 2008 and June 2010, who had both a FOCUS and a CTA for suspicion of thoracic aorta pathology. Thoracic aorta dimensions were measured from recordings by three ultrasound-trained emergency physicians blinded to any initial FOCUS and CTA results. CTA measurements were obtained by a radiologist blinded to the FOCUS results. Using cutoffs of 40 and 45 mm, we calculated the sensitivity and specificity of FOCUS for aortic dilation and aneurysm with the largest measurement on CT as the reference standard. Bland-Altman plots with 95% limits of agreement were used to demonstrate agreement for aortic measurements, kappa statistics to assess the degree of agreement between tests for aortic dilation, and intraclass correlation for interobserver and intraobserver variability.

Results: Ninety-two patients underwent both FOCUS and CTA during the study period. Ten FOCUS studies had inadequate visualization for all measurements areas. Eighty-two patients were included in the final analysis. Mean (±SD) age was 58.1 (±16.6) years and 58.5% were male. Sensitivity, specificity, and the observed kappa value (95% confidence interval [CI]) between FOCUS and CTA for the presence of aortic dilation at the 40-mm cutoff were 0.77 (95% CI = 0.58 to 0.98), 0.95 (95% CI = 0.84 to 0.99), and 0.74 (95% CI = 0.58 to 0.90), respectively. The mean difference (95% limits of agreement) for the Bland-Altman plots was 0.6 mm (–5.3 to 6.5) for the sinuses of Valsalva, 4 mm (–2.7 to 10.7) for the sinotubular junction, 1.5 mm (–5.8 to 8.8) for the ascending aorta, and 2.2 mm (–5.9 to 10.3) for the descending aorta.

Conclusions: In this retrospective pilot study, FOCUS demonstrated good agreement with CTA measurements of maximal thoracic aortic diameter. FOCUS appears to be specific for aortic dilation and aneurysm when compared to CTA, but requires further prospective study.

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Nonspecific chest pain is the fourth most common reason for emergency department (ED) visits in the United States.[1] Aneurysmal disease of the thoracic aorta represents an uncommon but deadly disease that may present with chest pain. Accounting for over 13,000 deaths annually, aneurysmal disease is more common in patients older than 65 years, and its incidence is expected to increase as our population ages.[2,3] In addition, thoracic aneurysmal disease is associated with aortic dissection, a time-sensitive diagnosis with a mortality of over 50% in the first 48 hours.[4]

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Multiple imaging modalities including computed tomography angiography (CTA), transthoracic echocardiography (TTE), and transesophageal echocardiography are available for the evaluation of the thoracic aorta each with advantages and limitations in the acute care setting.[3] TTE is increasingly available as a point-of-care (POC) test and, in comparison with other imaging modalities, is quick and noninvasive and allows accurate measurement of the proximal ascending aorta.[5–7] The objective of this study was to explore the agreement, sensitivity, and specificity of POC focused cardiac ultrasound (FOCUS) for thoracic aortic dimensions, dilation, and presence of aneurysm compared with CTA as the reference standard.

METHODS

Study Design

This pilot study was a retrospective analysis of image and chart data. Prior to the initiation of the study, its protocol was approved and the requirement for informed consent was waived by the institutional review board.

Study Setting and Population

The study was conducted in an urban, academic ED with over 70,000 annual visits and a well-established emergency ultrasound program. From the hospital picture archiving and communication system and the ultrasound program imaging database, we identified all patients between January 2008 and June 2010 who had a POC FOCUS and CTA for suspicion of thoracic aortic pathology

Study Protocol

After identification of the study patients, dynamic ultrasound images were analyzed by three study investigators (RAT, RVT, CLM) with ultrasound fellowship training using a DICOM (Digital Imaging and Communications in Medicine, Rosslyn, VA) viewing system (Showcase v5.3, Trillium Technology, Ann Arbor, MI). Images were recorded as cineloops in DICOM format using one of three ultrasound machines (Philips HD11XE US scanner, Philips Envisor HD US scanner [Royal Philips Electronics, Amsterdam, The Netherlands], or Zonare One Ultra SP [Zonare, Mountain View, CA]) with their corresponding broadband phased array probes. Twenty studies were reanalyzed by a second investigator (RAT) to determine interobserver variability and an additional 20 studies were assessed on a different day to determine intraobserver variability. CTA studies were performed on a 64-slice multidetector CT scanner (GE VCT, GE Healthcare, Little Chalfont, UK) and over-read by a radiologist (IO) with specialty training in cardiothoracic imaging to obtain data regarding aortic size at specified locations corresponding to the echocardiographic measurements. Except for the radiologist knowing the CTA study indication, all investigators were blinded to other imaging results and to clinical presentation. After the imaging data were collected, descriptive data were abstracted from chart review of patients meeting the above-defined study inclusion criteria. Data were obtained by two investigators (RVT and RAT) using standardized abstraction forms.

Measures

Echocardiographic measurements were obtained from a parasternal long-axis orientation. Ascending aortic diameter was measured using a leading-edge to leading-edge method at the three following locations: sinuses of Valsalva, sinotubular junction, and the largest visible portion of the proximal ascending aorta. All measurements were taken during diastole. Cutoffs for dilation and aneurysm were defined as an aortic measurement greater than 40 and 45 mm, respectively. The descending thoracic aorta was measured by an outer wall to outer wall approach. CTA measurements for aortic diameter were obtained from outer wall to outer wall at the corresponding FOCUS locations. Data were collected describing patient demographics, clinical presentation, and risk factors for aortic aneurysmal disease and dissection.

Data Analysis

Data were recorded in Excel and statistical analysis was performed using Excel and VassarStats (http://faculty.vassar.edu/lowry/VassarStats.html). Descriptive data where applicable were expressed as mean ± SD. Using cutoffs of 40 and 45 mm, we calculated the sensitivity and specificity of FOCUS for thoracic aortic dilation and aneurysmal disease using the largest measurement on CT as the reference standard. Bland-Altman plots with 95% limits of agreement were performed to show agreement for aortic measurements. We estimated a sample size of 80 subjects was required to obtain 95% limits of agreement with a precision of ±0.4 SDs. Limits of agreement measure the likely range of differences observed when comparing two measurement methods.[8] Kappa statistics were used to assess the degree of agreement between tests for aortic dilation, and intraclass correlation (two-way analysis of variance) was used to assess for interobserver and intraobserver variability. Normality for continuous variables was evaluated by visual inspection of histograms and normal probability plots as well as evaluation of numeric statistics (median, skewness, kurtosis). All statistical analyses were for exploratory purposes only.

RESULTS

Ninety-two patients underwent both FOCUS and CTA during the study period. Ten FOCUS studies had inadequate visualization of all measurement areas. Eighty-two patients were included in the final analysis. Demographic and clinical data are given in Table 1.

Aortic dilation on CTA of over 40 mm was present in 26 patients (31.7%), with 23 of 26 occurring in the ascending aorta. Aortic dilation of over 45 mm on CT was present in 14 patients (17.1%), with 10 of 14 occurring in the ascending aorta.

Test characteristics of FOCUS for aortic dilation using cutoffs of 40 and 45 mm by CTA were calculated. For dilation of 40 mm or greater, the TTE sensitivity was 77% (95% confidence interval [CI] = 56% to 90%), specificity was 95% (95% CI = 84% to 99%), and kappa

Table 1
Characteristics of Study Patients

Characteristic	Patients (*n* = 82)
Age (yr), mean (±SD)	58 ± 16
Male sex (%)	58
Aortic aneurysm or dissection risk factors (%)	
Hypertension	71
Coronary artery disease	30
Inflammatory disease*	5
Prior aortic aneurysm	16
History of cocaine use	15
History of aortic dissection	1
Other†	7
Indication for study (%)	
Chest pain	67
Shortness of breath	15
Back pain	29
Syncope	6
Neurologic complaint	12
Other‡	10

*Rheumatoid arthritis, vasculitides, infectious causes, etc.
†Bicuspid aortic valve, aortic coarctation, recent trauma, recent bypass graft, history of aortic dissection, recent cardiac catheterization, etc.
‡Hypotension, pulse deficit, abnormal chest x-ray, etc

was 0.74 (95% CI = 0.58 to 0.90). For dilation of 45 mm or greater, the TTE sensitivity was 64% (95% CI = 35% to 86%), specificity was 99% (95% CI = 90% to 100%), and kappa was 0.71 (95% CI = 0.48 to 0.93). Three of six aortic dilations and three of five aneurysms seen on CT and not TTE were of the descending aorta without adequate views on TTE. Three aortic dilations were seen on TTE and not on CTA.

The mean differences in aortic diameter with 95% limits of agreement for the Bland-Altman plots were 0.6 mm (–5.3 to 6.5) for the sinuses of Valsalva, 4 mm (–2.7 to 10.7) for the sinotubular junction, 1.5 mm (–5.8 to 8.8) for the ascending aorta, and 2.2 mm (–5.9 to 10.3) for the descending aorta and are illustrated in Figure 1.

The intraclass correlation between observers for FOCUS measurements were at the sinuses of Valsalva 0.94, sinotubular junction 0.92, ascending aorta 0.83, and descending aorta 0.74, and for intraobserver variability, at the sinuses of Valsalva 0.95, sinotubular junction 0.88, ascending aorta 0.93, and descending aorta 0.95.

DISCUSSION

This is the first study that we know of to look at POC FOCUS measurements of the thoracic aorta for detection of dilation and aneurysm. Determination of thoracic aortic size may have several important clinical implications in the acute care setting, including detecting patients at thresholds for surgical prophylaxis against aneurysmal rupture, typically between 4.5 and 5.5 cm, and serving as a useful adjunct for decision-making in patients with chest pain.[3,9] In this retrospective pilot study on patients suspected of acute aortic disease, FOCUS of the thoracic aorta for the detection of dilation and aneurysmal disease was in substantial agreement and highly specific when compared to CTA

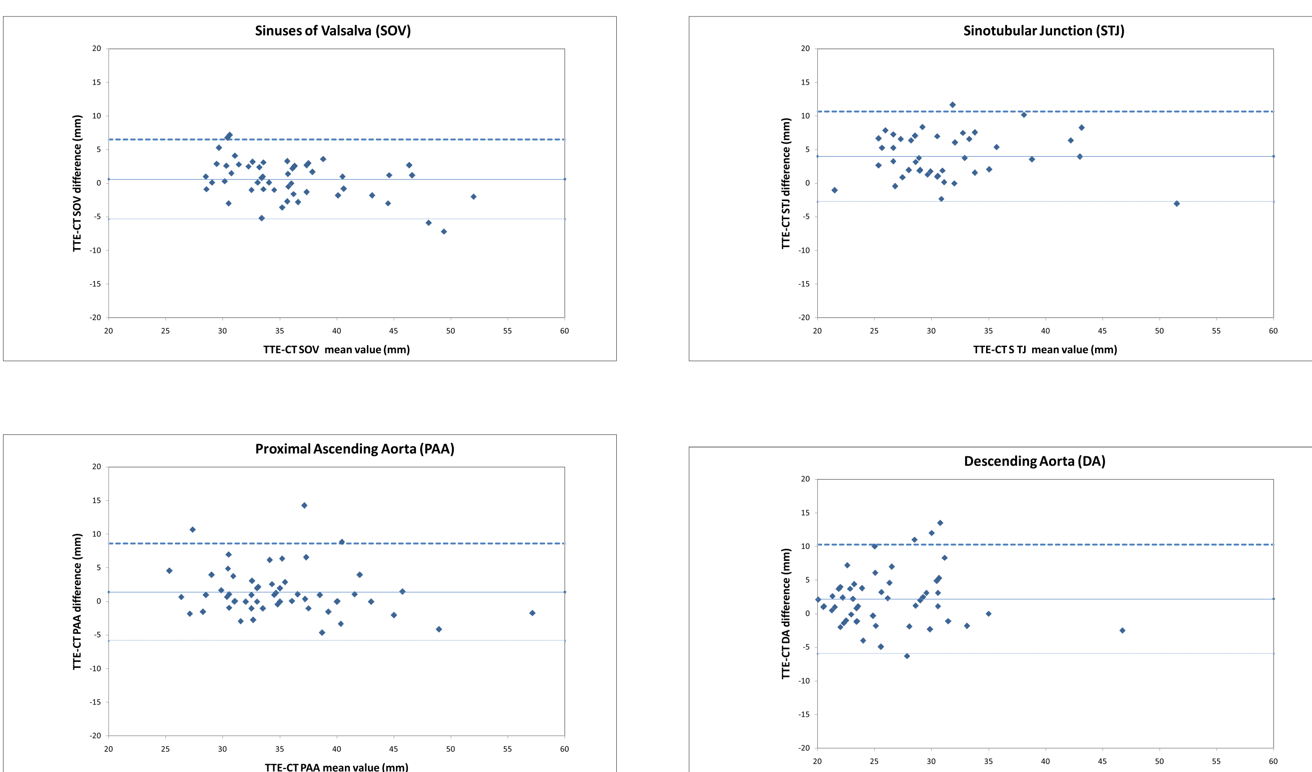

Figure 1. Bland-Altman plots. Mean difference and 95% limits of agreement plotted as solid and dashed lines, respectively. TTE = transthoracic echocardiography.

as the reference standard. The high specificity suggests that FOCUS may be helpful in determining the presence of aortic pathology in patients who present with nonspecific chest pain.

For FOCUS measurement comparisons with CTA, the 95% limits of agreement reflect a range of differences of approximately 1 to 1.5 cm for all measurements, with slight improvement when considering only the ascending aorta. Clinically, if one were wanting to increase specificity of detection of dilation, these data indicate it would require setting a potential threshold for FOCUS at 5 to 5.5 cm; however, there are likely other factors contributing to this wide range, including the intrinsic limitations of each test, variation in measurement technique (CTA measurements were performed from outer wall to outer wall, while FOCUS was from leading edge to leading edge), and the retrospective nature of the study. Further evaluation in the form of a prospective study is needed to determine whether a dedicated protocol looking for aortic pathology can improve the range of differences. Data for measurements involving the descending aorta were in less agreement, likely secondary to variation in measurement location between FOCUS and CTA and in defining the walls on FOCUS because of its depth and the resultant inferior axial resolution. Interobserver and intraobserver variability data demonstrate FOCUS for thoracic aortic examination to be a reproducible method.

LIMITATIONS

As may occur with any study using retrospective data, not all pertinent data for each study subject were available. Eleven percent of patients on whom FOCUS exams were performed had inadequate views for thoracic evaluation.

Interpretation of our results is limited by the small sample size and wide CIs and needs elucidation through further study. Although the study observers of the ultrasound and CTA images were blinded to each other's outcome, the radiologist over-reading the CTA was not blinded to the patient's indication for the diagnostic test, which could be a potential source of bias. Also, descriptive data, while obtained after the above image data were collected, were gathered by investigators involved in reviewing the ultrasound images.

Ultrasound review and analysis was performed by three observers with considerable experience in echocardiography, and the generalizability of the study to all physicians who perform POC FOCUS may be questioned. However, in the authors' opinion, most physicians who perform FOCUS exams are accustomed to obtaining the parasternal long-axis view necessary for measurements. In addition, the measurements are similar to methods employed for fetal dating (e.g., biparietal diameter) and evaluation of the abdominal aorta.

CONCLUSIONS

In this retrospective pilot study, point-of-care focused cardiac ultrasound demonstrates good agreement with computed tomography angiography measurements of maximal thoracic aortic diameter. Focused cardiac ultrasound appears to be specific for aortic dilation and aneurysm when compared to computed tomography angiography, but requires prospective study.

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