Comparison of 64-Slice EKG-Gated CTA, TTE, and TEE for Detection and Complete Characterization of Anomalous Coronary Arteries in Infants with Comorbid Congenital Cardiac Malformations

Shravan Sridhar MS IV[1], Randy R. Richardson MD[1,2]

[1]University of Arizona College of Medicine – Phoenix, [2]Department of Radiology, St. Joseph's Hospital and Medical Center

Abstract

In this study, we investigated the efficacy of computed tomographic angiography (CTA), transthoracic echocardiography (TTE), and transesophageal echocardiography (TEE) in the detection and complete characterization of coronary artery anomalies (CAAs) in infants. Imaging and surgical data for 27 patients who presented for evaluation of congenital heart disease from 2006 to 2011 were evaluated. Sensitivity (SN), specificity (SP), positive predictive value (PPV), negative predictive value (NPV), and accuracy (ACC) of each modality in the detection of CAAs were computed. Concordance between imaging findings and the gold standard (surgical/conventional angiographic results) was assessed. Rate of documented limitations for each modality was assessed. CTA demonstrated highest sensitivity and accuracy while TEE demonstrated highest specificity. CTA outperformed TEE in characterizing anatomy of anomalous coronary arteries. Among the three modalities, CTA demonstrated highest limitation rate, though sample sizes varied for each modality.

Introduction

CAAs have a prevalence of 1% in the general population and 15.11% in patients with comorbid congenital cardiac malformations.[1,2] In children with CAAs and comorbid cardiac malformations, the rate of mortality due to sudden death is as high as 59%.[3] Early detection of life-threatening anomalies is therefore desirable. Typically, CAAs are detected later in life with onset of symptoms including dyspnea, syncope, angina, or sudden death.[1,4] In such cases, CTA is preferred for coronary artery imaging. In infants, the decision to perform CTA is complicated by concern over radiation exposure and risk of contrast reactions. TEE has been used to diagnose CAAs in infants, but there is concern over procedural invasiveness and associated risks. Although TEE offers a radiation-free method to image coronary arteries, its low spatial resolution can lead to misdiagnosis or lack of diagnosis of CAAs. Understanding the diagnostic capabilities of CTA, TTE, and TEE in detecting and properly characterizing CAAs in infants can help guide appropriate ordering of imaging to minimize the number of misdiagnosed or undiagnosed cases of CAAs. In this study, we evaluate the ability of CTA, TTE, and TEE to detect and completely characterize coronary artery anomalies in infants 0-24 months of age with comorbid congenital cardiac malformations.

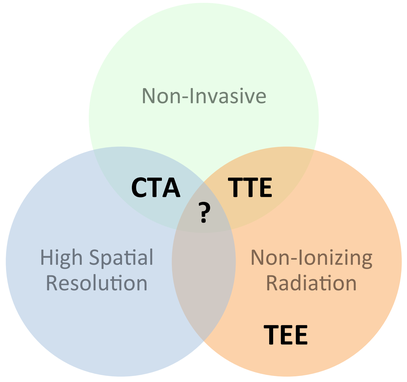

Figure 1: *It is ideal that the imaging modality employed for first-line imaging, detection, and complete characterization of CAAs in infants is non-invasive, has a high spatial resolution, and does not use ionizing radiation.*

Methods

Imaging and surgical data for 27 patients who presented for evaluation of congenital heart disease between 2006 and 2011 were evaluated. Patients had a mean age of 2.2 ± 0.7 months at initial evaluation and had undergone EKG-gated 64-slice cardiac CTA with 3D reconstruction in addition to multiple TTE and TEE studies. Performance metrics (including sensitivity, specificity, positive predictive value, negative predictive value, and accuracy) of each modality in CAA detection were computed. Concordance between each modality and surgical/conventional angiographic diagnosis in the characterization of anatomy along the origin, course, and termination of anomalous coronary arteries was evaluated. The rate of limitations of each modality in the imaging and interpretation of coronary anatomy was also measured.

Results

Using surgical/angiographic diagnosis as the gold standard, CTA produced a sensitivity, specificity, and accuracy of 80%, 50%, and 74%, respectively. TTE produced a sensitivity, specificity, and accuracy of 20%, 50%, and 26%, respectively. TEE produced a sensitivity, specificity, and accuracy of 27%, 100%, and 42%, respectively. CTA outperformed TTE and TEE at characterizing anatomy at the origin and course of an anomalous coronary artery. At characterizing anatomy at the termination of an anomalous coronary artery, CTA outperformed TEE but did not significantly outperform TTE. CTA had a higher rate of documented limitations to imaging/interpretation compared to TTE and TEE but a lower rate when compared to conventional angiography.

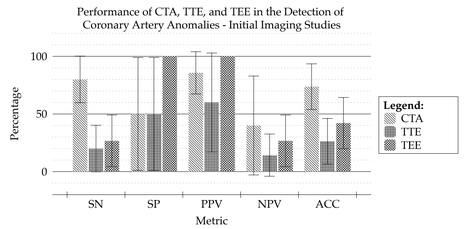

Figure 2: *The numerical values for each performance metric produced from the analysis of initial imaging studies across 19 qualifying patient cases is represented graphically. 95% confidence interval bars are depicted.*

Comparison of Performance Metrics Using Paired t-Testing

Comparison	SN	SP	PPV	NPV	ACC
CTA vs. TTE	0.00	0.99	0.19	0.19	0.02
CTA vs. TEE	0.01	0.02	0.47	0.50	0.10
TTE vs. TEE	0.77	0.02	0.15	0.50	0.41

Table 1: *P-values generated by paired t-tests between each modality of interest is shown above for each performance metric. Comparisons generating a p-value ≤0.05 were considered significant (green). Comparisons generating a p-value >0.05 and ≤0.1 were considered marginally significant (orange). Comparisons generating a p-value >0.1 were considered insignificant (red).*

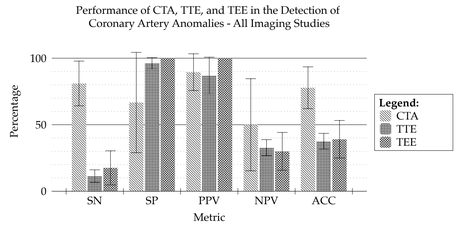

Figure 3: *The numerical values for each performance metric produced from the analysis of all imaging studies across all 27 patient cases that met original inclusion criteria is represented graphically. 95% confidence interval bars are depicted.*

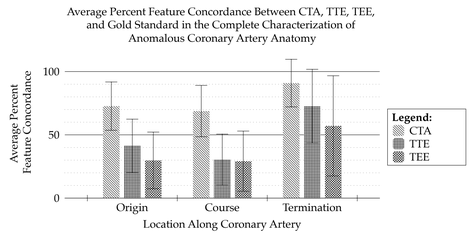

Figure 4: *Average percent feature concordance between CTA, TTE, and TEE, and the gold standard with standard error of the mean error bars are shown. Proceeding from left to right, sample sizes for each bar are as follows: 25, 23, 11, 25, 23, 11, 19, 16, 7.*

Comparison of Average Percent Feature Concordance with Gold Standard Using Test of Differing Proportions

Anatomical Distribution	Comparison Made	p-value
Origin	CTA vs. TTE	0.09
	CTA vs. TEE	0.03
	TTE vs. TEE	0.60
Course	CTA vs. TTE	0.07
	CTA vs. TEE	0.06
	TTE vs. TEE	0.95
Termination	CTA vs. TTE	0.11
	CTA vs. TEE	0.02
	TTE vs. TEE	0.38
Total	CTA vs. TTE	0.08
	CTA vs. TEE	0.03
	TTE vs. TEE	0.64

Table 2: *The p-values for each of the comparisons between CTA, TTE, and TEE in the characterization of the anatomy of the origin, course, and termination of anomalous coronary arteries are shown. Using an alpha level of 0.05, comparisons with p-values ≤0.05 were considered significant (green). Comparisons with p-values >0.05 and ≤0.1 were considered marginally significant (orange). Comparisons with p-values >0.1 were considered insignificant (red).*

Rates of Limitations Across All Imaging Studies

	Angiography	CTA	TTE	TEE
%	11.8	7.4	5.1	6.5
N	17	27	255	46

Table 3: *The percentage of studies for each patient case that contained documented limitations was calculated for angiography, CTA, TTE, and TEE and the results are shown. N represents the sample size for each modality, which was calculated as the total number of imaging studies of a particular type (conventional angiography, CTA, TTE, or TEE) across all patient cases.*

Discussion and Conclusions

CTA is a rapid, non-invasive, operator-independent imaging modality that offers high resolution, 3-dimensional imaging of CAAs in infants. The results of this study indicate that CTA is the most sensitive and accurate modality for detection of CAAs in infants and is optimal for characterizing anatomy along the entire length of an anomalous coronary artery. As such, CTA may be the optimal modality for first-line coronary artery imaging in infants with suspected anomalous coronary artery anatomy who have a high pretest probability for having a CAA.

Limitations and Future Work

Using a larger sample size may have improved the reliability of some of the comparisons made. Prospective analysis could have improved quality of data collected. Coronary MRA is an up and coming modality which offers a radiation-free method to image coronary arteries and warrants further investigation in the future.

References

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