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Research Article

Assessing the Diagnostic Value of Dual-source CT angiography for Congenital Thoracic Vascular Anomalies

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Abstract

Background and objectives: Congenital thoracic vascular anomalies are associated with great risk of mortality and morbidity. Their growing incidence is assumed to originate mainly from the increased accuracy of the diagnostic methods used. Although classic angiography is considered the gold standard diagnostic method, various diagnostic methods have been proposed. Dual-source computed tomography (DSCT) angiography is the most recently introduced CT technology with confirmed diagnostic accuracy in adult population. The present study is aimed to determine the diagnostic value of DSCT in children with congenital thoracic vascular anomalies compared with the gold standard CTA.

Materials and methods: The present cross-sectional study investigated the diagnostic accuracy of DSCT in 100 pediatric patients who referred to Shahid Rajaie Heart Center with congenital anomaly of major thoracic vessels and underwent DSCT and angiography from March 2011 to September 2014. DSCT images were reviewed by one radiologist to confirm the accuracy of reports. Next, parameters of diagnostic value of these methods were compared using IBM SPSS version 22.

Results: A total of 142 cardiovascular anomalies were diagnosed by angiography. The diagnostic accuracy of DSCT was 97.1%, considering 2 cases of left superior vena cava and 2 patent ductus arteriosus missed by DSCT among the 142 anomalies diagnosed by angiography. DSCT also provided important additional findings (n = 26) which were not reported by angiography.

Conclusion: DSCT is a highly accurate diagnostic method for detecting congenital vascular anomalies, obviating the need for invasive modalities.

Keywords: Computed Tomography Angiography; Congenital Abnormalities; Sensitivity and Specificity

Introduction

Congenital thoracic vascular anomalies, associated with great risk of mortality and morbidity, include a variety of vascular abnormalities, which mainly include congenital coronary artery anomalies and occur alone or in combination with different forms of congenital heart diseases (CHD) [1]. The incidence of CHD seems to be about 1–2% in the hospitalized pediatric population[2-3]. The global incidence of congenital thoracic vascular anomalies is about 1–2% of the total population; accurate statistics are not available for the prevalence of congenital thoracic vascular anomalies in Iran. Meanwhile, the incidence is increasing worldwide, which is mainly assumed to originate from increased accuracy of the diagnostic methods used [4].

Various diagnostic modalities have been proposed for thoracic vascular anomalies, and several techniques are being proposed [5]. Cardiac catherization, known as angiography, is considered the gold standard diagnostic method for vascular anomalies, but is associated with considerable risk of complications due to its invasive nature [6]. Thus, several imaging techniques have been introduced, which are mainly based on cardiac computed tomography (CCT).

Introduced in the 1970s, computed tomography angiography (CTA) is suggested as a less invasive diagnostic method; however, it is associated with several risks, such as the risk of intravenous contrast administration and radiation exposure[7]. Multidetector computed tomography (MDCT) with the possibility of 2- and 3-dimensial processing[8,10] and magnetic resonance angiography (MRA) [11-12] is conventionally used for diagnosis of congenital thoracic vascular anomalies with favorable results and has several advantages; however, each of the proposed techniques may be associated with its own limitations and complications [13].

Dual-source computed tomography (DSCT) angiography is the most recent CT technology. It is equipped with two X-ray tubes, and simultaneous acquisition of data enables a high temporal resolution of 83 ms [14]. Dual-source has several advantages over single-source CT, including higher heart rates that do not require pre-examination β-blockade, which is a great benefit over MDCT and can thus provide

significantly better image quality without motion [15-17]. Reviewing the diagnostic accuracy of DSCT showed a sensitivity of 99% and specificity of 89% for adult patients with coronary artery disease [18]. Comparison of diagnostic accuracy of DSCT in a population with extensive coronary calcifications has shown promising results as well [19]. Although initial studies have evaluated the diagnostic accuracy of cardiac DSCT angiography in adult population it is necessary to evaluate the diagnostic accuracy of DSCT in a pediatric population suffering from congenital thoracic vascular anomalies, considering the fact that diagnosis is an important component of congenital heart diseases, which can result in better treatment outcomes, and the significant mortality and morbidity rates of congenital thoracic vascular anomalies [1], and the suggested advantages of DSCT in other cardiac pathologies. As far as the authors are concerned no study has spotted this issue so far.

Therefore, the present study aimed to determine the diagnostic value of DSCT in congenital thoracic vascular anomalies, in comparison with the gold standard CTA.

Materials and methods

Study design

The present cross-sectional study investigated the diagnostic accuracy of DSCT in 100 patients who referred to Shahid Rajaie Heart Center with congenital anomaly of major thoracic vessels, from March 2011 to September 2014. The protocol of the study was approved by Ethics committee of Iran University of Medical Sciences. All principles of Helsinki guidelines were met throughout the study and the patients' information were kept confidential and analyzed anonymously.

Patients of any age and sex with congenital anomaly of major thoracic vessels, including pulmonary arteries, superior vena cava (SVC), inferior vena cava (IVC), brachiocephalic, azygous, and pulmonary veins, who had undergone digital subtraction angiography (DSA) and DSCT from March 2011 to September 2014 were included in the study by convenient sampling method. Any patient who had other co-morbidities were excluded from the study. Demographic characteristics of participants, such as age, and sex, were recorded from the medical records. DSA and DSCT were performed by 64-slice dual-source CT (Somatome Definition flash; Siemens Medical Solutions, Forchheim, Germany).To confirm the accuracy of DSCT reports, all scans were reviewed by one radiologist. Diagnostic accuracy of DSCT was determined by comparing the results with the results of DSA.

Statistical analysis

Results of quantitative variables were reported by mean ± standard deviation (SD), and categorical variables by frequency (percentage). The diagnostic accuracy was reported by sensitivity. For the statistical analysis, the statistical software IBM SPSS version 22.0 was used. P values less than 0.05 were considered statistically significant.

Results

Of 100 children with congenital anomalies, 60% were boys and 40% were girls. Mean and SD of age of participants was 3.33±3.8 years (range 3–16 years).

A total of 142 anomalies were diagnosed by DSA; of these 4, 2 cases of patent ductus arteriosus (PDA) and 2 cases of LSVC, were not diagnosed by DSCT. Thus, the sensitivity (diagnostic accuracy) of DCST was 97.1%.

In addition, DSCT reported 26 anomalies that were not reported by DSA, including 8 cases of LSVC, 4 cases of overridden aorta on sub aortic VSD, 2 cases of dilated LAD with fistula to right ventricle, 2 cases of right aberrant subclavian artery, 2 cases of right-sided aortic arch, 2 cases of interrupted IVC and hemiazygos vein continuation, and 2 cases of abnormal origin of coronary vessels.

The frequencies of anomalies detected by DSA and DSCT are shown in (Table 1). An example of known case of VSD, pulmonary hypertension and ASD is illustrated in (figure 1) and another case of known case of subaortic VSD and pulmonary valve atresia is illustrated in (figure 2)

Discussion

In a pediatric population (n = 100) aged 3–16 years with congenital thoracic vascular anomalies, a total of 142 anomalies were diagnosed by DSA, 4 of which were not diagnosed by DSCT, resulting in a sensitivity of 97.1% for DCST. Also, there were 26 cases diagnosed by DCST that were not observed by DSA.

Previous studies have confirmed the accuracy of DCST in adult population with various cardiac pathologies. Scheffel et al. investigated adults with coronary artery disease (CAD) with mean age of 63.1±11.3 years; the results of DSCT with invasive coronary angiography showed a sensitivity of 96.4%, and specificity of 97.5%, positive and negative predictive value of 85.7% and 99.4%, respectively, for evaluating CAD [19]. Plass et al. have also determined a sensitivity of 91%, specificity of 99%, a positive predictive value of 92% and a negative predictive value of 99% for evaluating CAD by DSCT[20]. A systematic review of 25 studies on the diagnostic accuracy of DSCT showed a sensitivity of 99% and specificity of 89% for adult patients with coronary artery disease with a median age of 63 years [18]. The results of these studies are consistent with the present study, indicating high sensitivity of DSCT; as in the present study all cases of coronary abnormalities were correctly diagnosed by DSCT.

Ou et al. performed DSCT angiography on 2350 patients and demonstrated 284 segments with congenital coronary artery anomalies in 225 patients and concluded that DSCT can visualize and diagnose congenital coronary artery anomalies perfectly [21], which is parallel to the results of the present study, although they reported descriptive statistics of congenital anomalies in adults and did not compare the results of DSCT with a gold standard diagnostic technique. In the present study, it was demonstrated that all coronary abnormalities diagnosed by DSA were also diagnosed by DSCT; there were no missed cases in DSCT. In addition, 2 cases of abnormal origin of coronary vessels were diagnosed only by DSCT. Although we have not followed-up the patients to see whether these cases were false negative on DSCT or were true positive cases, the results suggest DSCT as an accurate method for diagnosing various congenital thoracic vascular anomalies, including congenital coronary abnormalities. Congenital coronary artery abnormalities have also been proposed to be well diagnosed by MDCT[10]. Further studies comparing DSCT and MDCT can better clarify the differences between these two techniques.

Congenital thoracic vascular anomalies have been investigated with various CT techniques. Yamada et al., although they have not used DSCT, evaluated the diagnostic accuracy of CT for congenital disorders of the great vessels on 850 cases and suggested that it is able to detect the abnormality of these arteries well [22], which is in line with the results of the present study. Researchers have also demonstrated the diagnostic accuracy of MDCT in various congenital thoracic vascular anomalies in pediatric patients [9, 23], which is in line with the results of the present study. Further studies comparing DSCT and MDCT can better clarify the differences between these two techniques.

In addition to the high diagnostic accuracy of CT methods for congenital thoracic vascular anomalies, several advantages have been proposed for DSCT over single-source CT (15), MDCT (17), and other dual-energy CT techniques[24], such as clear images without motion and with few artifacts [16], practicality in high heart rates [25-27], and with high calcifications [19]. The radiation dose of DSCT has also been demonstrated to be safe and lower than of other dual-energy CT techniques [28]. Thus, the above-mentioned studies, along with the results of the present study, suggest that DSCT is a promising technique in detecting congenital thoracic vascular anomalies. Yet, as far as the authors

are concerned, previous studies have not evaluated the diagnostic accuracy of DSCT in congenital thoracic vascular anomalies.

The limitations of the present study included lack of follow-up for patients, and limited number of sample size. In addition, the correct diagnosis of positive cases on DSCT, which were not diagnosed by invasive angiography, should be determined by complementary techniques; following-up patients to see the surgical outcome could clarify this ambiguity.

In conclusion, DSCT has a high sensitivity for diagnosis of various congenital thoracic vascular anomalies and can be safely used as a non-invasive diagnostic method for congenital thoracic vascular anomalies in children.

Considering the inadequacy of studies on the application of DSCT on congenital thoracic vascular anomalies in pediatric population, it is suggested that future studies focus on this issue in children, with higher sample size and follow-up.

Figure 1

A 5-month old male, known case of VSD, pulmonary hypertension and ASD. Effective PA banding is seen with diameter of 4mm at bending site that is shown in the left figure. 1&2 in the right figure shows entering from right from VSD to aorta. The patient has large sub aortic VSD that LV injection at 70*20 view showed good LV contractility and enlarged LV. Coronary arteries appear with normal origin and course.

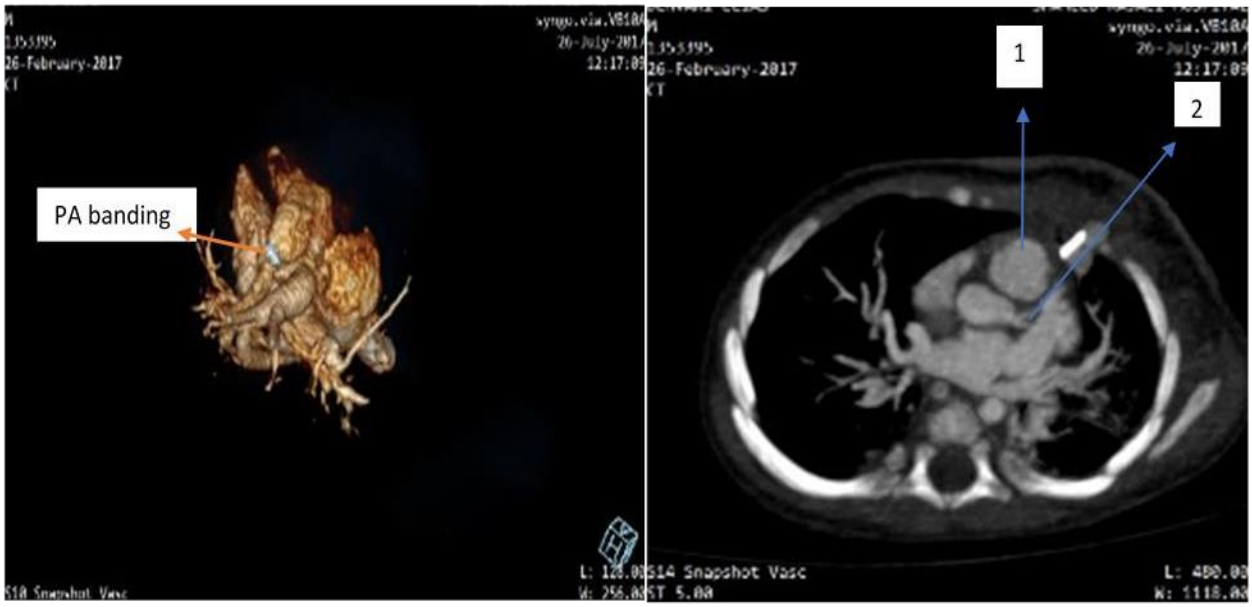

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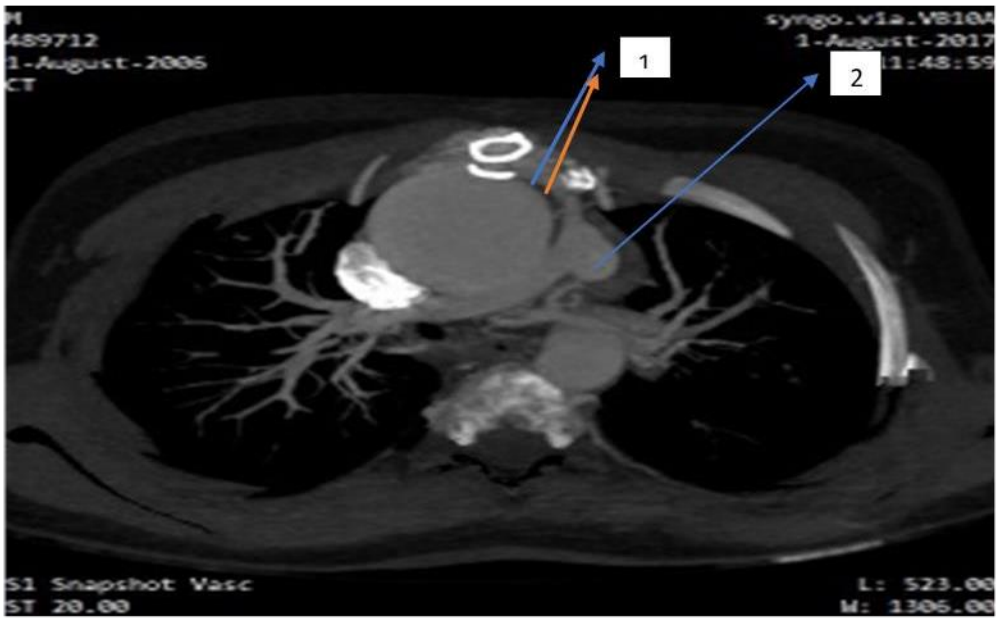
Figure 2

11 year old male known case of subaortic VSD and pulmonary valve atresia. Severe subvalvular muscular pulmonary stenosis and dome shaped pulmonary valve. In this figure hypoplastic left pulmonary artery and dilated ascending aorta is seen. Aneurysmal dilatation of the ascending aorta is seen with diameter of 43mm. 1- Aneurysmal dilation of ascending aorta(orange arrow) and dilation of AAo(blue arrow) 2- hypoplastic LPA

Figure 2



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Conflict of interest

There is no conflict of interest regarding the manuscript. There is no financial relationship with the organization that sponsored this research and we have full control of all primary data and it is available for review upon request.

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