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Comparison of CT Angiography and Digital Subtraction Angiography in the Diagnosis of Aortic Coarctation

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Abstract: There are several methods for the diagnosis and evaluation of coarctation of the aorta. Digital Subtraction Angiography (DSA) is the standard detection method, though it entails complications and side-effects. The aim of the present study was to compare Computed Tomography (CT) angiography with DSA for diagnosing aortic coarctation. We performed a cross-sectional study of 15 patients (11 males and four females aged between two and 30 years) referred to Tabriz Shahid Madani Hospital and Imaging Center between August 2005 and February 2006 with suspected aortic coarctation. All patients were subjected to DSA and CT angiography for diagnosis of aortic coarctation. The mean age of the patients was 14.6 years; 11 were male (74.4%) and four (26.6%) were female. The DSA and CT angiography results were comparable in all patients in terms of diagnosis and the detection of complications, particularly cardiovascular complications. However, CT angiography was less time-consuming to perform than DSA ($p<0.0001$). In conclusion, CT angiography, comparableto DSA, diagnosed coarctation of aorta in all the patients. However, CT angiography is a non-invasive, cost effective procedure that takes significantly less time to carry out than DSA. Therefore, CT angiography is recommended as an appropriate method for diagnosing the coarctation of aorta.

Key words: Coarctation of the aorta, catheterization, reconstruction techniques, multiplanar reformation, three-dimensional

INTRODUCTION

Aortic coarctation is the fourth most common congenital heart disease, accounting for approximately 6-8% of congenital heart abnormalities, with prevalence reaching 35% in conditions such as Turner syndrome (Lipton *et al*., 2008). It requires catheterization and corrective surgery during the first year of life (Beekman, 2008); without surgery, 90% of patients die before the age of 50 with 50% of such deaths occurring before 10 years of age due to heart failure (Kouchoukos *et al*., 2003). Aortic coarctation can be split into two types: preductal and postductal. Patients with preductal coarctation (infantile coarctation) normally present with symptoms during infancy. Postductal coarctation, the more common subtype, becomes symptomatic in older children and adults (Kumar *et al*., 2003). Blood pressure increases as a result of coarctation in the proximal part of the aorta, large arteries and lower extremities. If untreated, the left ventricle becomes hypertrophied and more than 60% of patients will suffer from left ventricular dysfunction and congestive heart failure at the fourth decade (Child and Friedman, 2005).

There are several methods for the diagnosis and evaluation of coarctation of the aorta (Dwivedi *et al*., 2002). Digital Subtraction Angiography (DSA) is the standard detection method, though it entails complications and side-effects including arterial wall injury, arterial thrombosis, cholesterol embolization, hematoma and pseudoaneurysm and damage to peripheral nerves, spinal cord and other organs (Killius and Nelson, 2000). Therefore, a less invasive and time-consuming method with greater or equivalent diagnostic accuracy (e.g., CT angiography) is required (Farmer *et al*., 1984). Currently, CT angiography supplies valuable information when DSA is difficult to perform or when appropriate information cannot be obtained by echocardiography (Stueckle *et al*., 2004). Furthermore, there are reports that non-invasive methods such as CT angiography and MRI are more appropriate

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than invasive methods such as DSA for detecting aortic coarctation (Okada *et al*., 2002; Beslic and Dalagija, 1999). Nowadays, in cases that are well defined by echocardiography, CT or MRI, diagnostic catheterization is not usually required prior to surgery (Godart *et al*., 2002; Didier *et al*., 2006). Moreover, due to lower levels of radiation and its accessibility for patients of all ages, CT angiography is preferred in detecting aortic coarctation in some centers (Hamaoka *et al*., 1999; Makaryus and Boxt, 2009; Turkvatan *et al*., 2009; Di Sessa *et al*., 2009). The aim of the present study was to compare CT angiography with Digital Subtracted Angiography (DSA) for diagnosing aortic coarctation. In addition, vascular complications and the duration of each method were evaluated. To the best our knowledge, no previous study has hitherto investigated comparison between efficacy of CT angiography and Digital Subtracted Angiography (DSA) in diagnosing the aortic coarctation.

MATERIALS AND METHODS

We conducted a cross-sectional study of 15 patients aged 2-30 years with clinically suspected aortic coarctation, referred to Tabriz Shahid Madani Hospital and Imaging Center between August 2005 and February 2006. CT angiography was carried out by physicians at the catheterization laboratory of the Shahid Madani Education and Treatment Center in Tabriz; 16-slice spiral CT scans were performed using a Multi Slice CT Scan Light speed 16 Slice in the Hafez Imaging Center (Miabi *et al*., 2006; Midia and Miabi, 2007). DSA was carried out using pigtail and NIH catheters, which were inserted into the heart cavity via the femoral artery, the aorta and its branches. In eight patients with severe aortic stenosis, the left radial artery was used for catheterization. Contrast material (76 mL) was injected automatically at a flow rate of 15 mL sec^{-1} using a Medrad Mark V Plus injection system.

Written consent was obtained from patients or their guardians before CT angiography was performed. Approximately 100 mL of Ultravist contrast material was injected into the cubital vein at a flow rate of 30 mL sec^{-1}. Care Blas software was utilized to perform 2×4 mL scans and Pitch 07 Collimation; scanned images were assessed using a Hard and Soft Copy multi-detector scanner.

Two-dimensional, three-dimensional and volume rendering images were reconstructed using Work Station 4/2 GEAD W software. Cuts with an axial thickness of 0.6 mm and two-dimensional reconstructions in sagittal, coronal and oblique sections were examined by MIP (Maximum Intensity Projection), MPR (Multi Planar Reformation), CRP (Curved Planar Reconstruction) and three-dimensional reconstruction using Inspace VRT software; vascular view reconstructions were also obtained. Results obtained from CT angiography, DSA and surgery were compared, as was the time taken to carry out each of the methods. In addition, cardiovascular complications were evaluated. Data were analyzed using SPSS software and statistical analysis was calculated using Student's t test.

RESULTS

Fifteen patients, eleven males and four females, with mean age of 14.6 years (range: 2-30 years) were enrolled in the present study and clinically suspected aortic coarctation was confirmed in all patients by performing DSA. In this study, DSA was 100% effective in diagnosing aortic coarctation. CT angiography was performed on patients after undergoing DSA; the diagnosis was confirmed in all patients, demonstrating that CT angiography was also 100% effective in diagnosing aortic coarctation. No complications including vascular complications and no contrast sensitivity were reported in the patients when CT angiography and DSA were performed.

The average times taken to carry out DSA and CT angiography were 31.07±5.97 mins (22-42 mins) and 3.91±1.22 mins (3-7.5 mins), respectively. The time taken to perform CT angiography was significantly less than that taken to carry out DSA ($p<0.0001$, t test), suggesting that it could be the preferred method for assessing patients with clinically suspected aortic coarctation. In addition, CT angiography did not require hospitalization. It could be performed on outpatients and 13% of patients did not require anesthesia. DSA requires hospitalization and local anesthesia. Therefore, CT angiography is more cost-effective and time-saving than DSA for the diagnosis of aortic coarctation.

DISCUSSION

The present study reveals that CT angiography, in combination with axial and MIP views and 3-D volume rendering reconstruction, is a reliable tool for diagnosing the aortic coarctation in adults and children. To the best our knowledge, the present study is the first investigation to compare CT angiography with Digital Subtracted Angiography (DSA) for diagnosing aortic coarctation. Seven children aged between 2-13 years were included in the present study and CT angiography diagnosed aortic coarctation in all the cases. Similarly, Hu *et al*. (2008)

reported that in the evaluation of aortic coarctation in sixteen patients (15 days to 28 months), MPR and 3-D volume-rendered images performed slightly better than axial images. Likewise, a previous study that utilized MRA and 3-D MR angiography to assess 18 children with aortic coarctation concluded that CT angiography was an excellent method for non-invasive evaluation of the cardiovascular system in children (Becker *et al*., 1997). As aortic coarctation often courses obliquely rather than vertical to the imaging plane, stenosis can be missed on axial images. Therefore, we believe that 2 and 3-D reconstructions should be used to complement axial images in diagnosing vessel narrowing including the aortic coarctation.

In the present study, CT angiography diagnosed aortic coarctation in all eight adult patients aged between 15-30 years. This finding is comparable to that of a study by Turkvatan *et al*. (2009) on twenty-four adult patients with clinical suspicion of coarctation of the aorta reporting 100% overall sensitivity of 3-D multi detector CT for diagnosis of the coarctation of the aorta. They concluded that multi detector CT angiography with MPR and 3-D techniques should be the method of choice for preoperative morphologic assessment of coarctation of the aorta in adult patients (Turkvatan *et al*., 2009). Interestingly, Ilica *et al*. (2007) first reported atypical diffuse coarctation of thoracoabdominal aorta associated with bilateral renal artery stenosis clearly diagnosed by multidetector CT angiography. Furthermore, Becker *et al*. (1997) and Schaffler *et al*. (2000) concluded that the results of MIP reconstructions and catheter angiography regarding the morphometric and morphologic parameters of the postoperative aorta were comparable in the course of postoperative follow-up investigation of former coarctation. Later, Helical CT and Magnetic Resonance Imaging (MRI) have been found to be similarly useful for the noninvasive evaluation during follow-up of adults with coarctation of the aorta (Hager *et al*., 2004). Nonetheless, MRI requires the immobilization of children for long time periods, necessitating sedation (Shih *et al*., 2006).

In the current investigation, DSA and CT angiography correspondingly diagnosed the aortic coarctation in all the studied patients. However, a growing number of DSAs are performed for therapeutic purposes to reduce the need for surgery, with CT angiography as a preliminary step (Turkvatan *et al*., 2009; Schneider, 2006; Kani *et al*., 2005). On the other hand, some evidences suggest that CT angiography is replacing DSA as the method of choice for investigating vascular anomalies (Hu *et al*., 2008; Yang *et al*., 2008; Kimura-Hayama *et al*., 2010). In the present study, we observed that CT angiography took significantly less time to perform than DSA. Additionally, CT angiography was more cost-effective as DSA required hospitalization. Furthermore, DSA required anesthesia and sedation whereas only two of the cases in this study required local analgesia for CT angiography. Several studies have reported that CT angiography requires approximately half the amount of sedation of other imaging modalities (Pappas *et al*., 2000; White, 1995; Kaste *et al*., 1997), resulting in a technically less demanding, more cost-effective and quicker procedure than DSA.

In conclusion, CT angiography, comparable to DSA, diagnosed coarctation of aorta in all the patients. However, CT angiography is a non-invasive, cost effective procedure that takes significantly less time to carry out than DSA. Therefore, CT angiography is recommended as an appropriate method for diagnosing the coarctation of aorta.

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