Original Article

UNIFORM FOUR CHAMBER CONTRAST OPACIFICATION IN ATRIAL SEPTAL DEFECT PATIENTS UNDERGOING CARDIAC MDCT EXAMINATION

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ABSTRACT:

OBJECTIVE: To assess distribution of iodinated contrast in all four cardiac chambers in ASD patients undergoing Cardiac MDCT examination.

MATERIAL & METHOD: Ninety-nine known patients of ASD (47 male and 52 female) undergoing Cardiac CT examination were included in the study. Patients with other congenital heart diseases were excluded from the study. All patients underwent Cardiac CT examination with GE Lightspeed VCT. Patients were administered iodinated contrast at 1-5 ml/sec according to patients' weight for 12 seconds. Retrospective ECG gated acquisitions were carried out using a bolus tracking method. Scanning was triggered when aortic contrast reached at 100 Hounsfield value with a scanning delay of 5 seconds. Cardiac reformatting was done using double oblique method to generate four chamber views. Contrast opacification of all four chambers was quantitatively evaluated using 10x10 pixels ROI. All four chambers were also visually evaluated. Average CT values of all four chambers were quantitatively compared using one-sided ANOVA test.

RESULTS:Patients' mean age was 24.28± 17.43 years. One patient had Primum, 60 patients had Secundum and remaining 38 patients had Sinus Venosus ASDs. Average Hounsfield values of RA, RV, LA and LV were 368.82, 370.54, 373.47, and 369.95 respectively. No significant differences were noted between of four chambers CT values on ANOVA. Visual analysis revealed uniform contrast opacification in all four chambers of 97/99 patients.

CONCLUSION: Uniform opacification of all cardiac chambers is observed in almost all patients with ASD. This finding in a cardiac MDCT exam should always alert to the possibility of underlying ASD.

KEY WORDS:Atrial Septal Defect (ASD); Multi-detector Computed Tomography (MDCT); Contrast opacification

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INTRODUCTION

Atrial Septal Defect (ASD) is a common congenital abnormality presenting in adulthood. Transthoracic and trans esophageal echocardiography are very useful tools for diagnostic evaluation of ASD patients prior to surgical or percutaneous therapy. However, in difficult echocardiography cases, use of cardiac CT is appropriate for accurate diagnosis of this condition and other associated pulmonary venous anomalies. Cardiac CT has high sensitivity (60-100%) and high specificity (86-100%) for evaluation of atrial septal defects. Use of iodinated contrast is mandatory for evaluation of cardiac morphology and function with cardiac CT. Iodinated contrast is usually administered as a rapid bolus followed by a saline chaser to enhance the opacification of cardiac chambers. There are two prevalent methods of intravenous contrast administration prior to cardiac MDCT: timing bolus and bolus track methods. In timing bolus method, a small bolus (10-20ml) of iodinated contrast is injected at the same rate as intended for cardiac examination and dynamic CT acquisition is carried out with the scan localizer placed at the level of ascending aorta and main pulmonary artery. From this dynamic acquisition, the timings for optimum opacification of aorta and pulmonary artery are determined (figure 1). In the bolus tacking method, no timing bolus is carried out. Rather, the intended amount of contrast is injected intravenously and monitored at the level of aorta and pulmonary artery and the actual scan acquisition is triggered on reaching optimum level of aortic and pulmonary opacification with a set delay of 3-5 seconds. No matter what method is used for contrast administration for cardiac CT, there is difference in contrast opacification of right and left sided cardiac chambers in most of the

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cases as there is a delay of almost 6 seconds between peak pulmonary contrast opacification and aortic contrast opacification unless there is a shunt between right and left sided cardiac chambers (figure 1). If one aims at imaging of left sided cardiac chambers, the contrast is mostly washed out from right-sided chambers by the time it reaches at optimum levels in left-sided cardiac chambers. On the other hand, if one aims at right-sided cardiac chambers, there may be poor contrast opacification of left sided chambers on account of early scan acquisition. If one aim to study both right as well as left sided cardiac chambers simultaneously, prolonged contrast administration may be mandatory.In non-shunt cases, no matter whatever you do for bilateral contrast opacification, it would be very unlikely to get uniform contrast opacification of all for cardiac chambers due to different timings of contrast passage through these chambers. However, the situation is different for patients with atrial septal defect patients where there is recirculation of iodinated contrast from left atrium to right atrium through the defect. This type of recirculation to right sided cardiac chambers through ASD is very well documented in first-pass nuclear medicine studies for evaluation of cardiac shunts.[1-5] The recirculation of contrast will result in a plateau in contrast curve recorded over pulmonary artery (figure 1). The bigger the atrial septal defect, more would be the recirculation. This recirculation of contrast from left atrium to right atrium can theoretically result in uniform mixing of contrast in all four chambers.

OBJECTIVES:

To assess distribution of iodinated contrast in all four cardiac chambers in ASD patients.

MATERIAL AND METHODS:

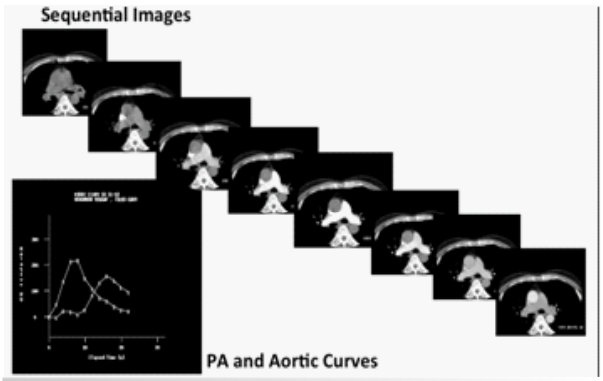
This cross sectional observational study was performed at Department of Cardiovascular Imaging, Punjab Institute of Cardiology Lahore from January 2010 to December 2013. An approval from Hospital Ethical Committee was taken before this study.

Patients of either sex with age up to 60 years with the diagnosis of ASD on trans-thoracic or trans-esophageal echocardiography or Cardiac MDCT with or without associated anomalies of pulmonary veins were included. Patients with other associated congenital cardiac anomalies, impaired renal function (serum creatinine >2.0mg/dl) and with known hypersensitivity to iodinated contrast agent were excluded.

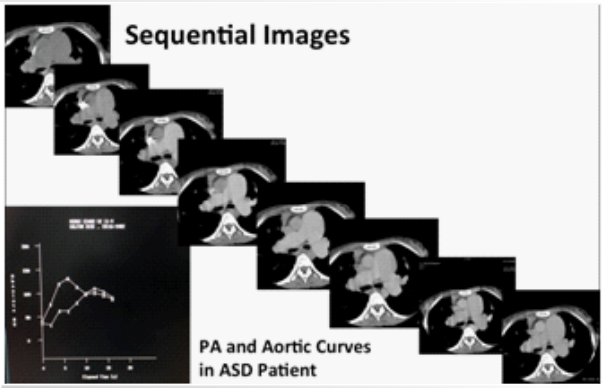
All patients underwent Cardiac CT examination with GE Lightspeed VCT.Patients were administered iodinated contrast at a rate of 1-5 ml/sec according to patients' weight for 12 seconds. Retrospective ECG gated acquisitions were carried out using a bolus tracking method. Scanning was triggered when aortic contrast reached at 100 Hounsfield value with a scanning delay of 5 seconds. Cardiac reformatting was done using double oblique method to generate four chamber views. Contrast opacification of all four chambers was quantitatively evaluated using 10x10 pixels ROI. All four chambers were also visually evaluated for presence or absence of uniform contrast opacification.

Data were analyzed with statistical package for social sciences for windows (SPSS) version 16. Qualitative variables were described as frequencies. Average CT values of all four chambers were quantitatively compared using one-sided ANOVA

Figure 1: Aortic and pulmonary artery timing bolus curves in a patient without ASD (A) and a patient with ASD (B). It is note worthy that, aortic and pulmonary curves are crossing each other in a patient without ASD (A) while these curves plateau at the same level in a patient with ASD (B).



A: Timing Bolus in a patient without ASD



B: Timing Bolus in patient with ASD

test.

RESULTS:

Ninety-nine known patients of ASD (47 male, 52 Female) undergoing Cardiac CT examination were included in the study. Patients with other congenital heart diseases were excluded from the study.The mean age of patients was 24.28+ 17.43 years (figure 2).

The most common type of ASD among these patients was secundum ASD (60) followed by sinus venosus ASD (38) and primum ASD (figure 3).

Figure 2: Age distribution of ASD patients undergoing Cardiac MDCT.

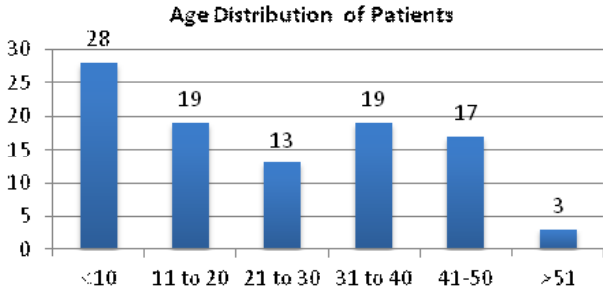


Figure 3: Type of ASD among study patients

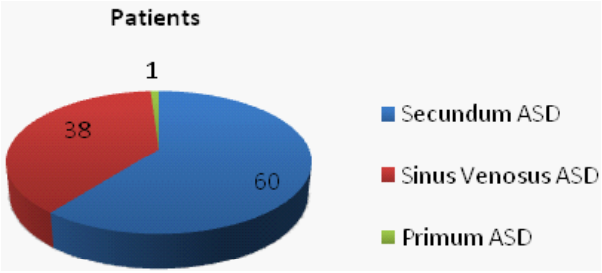
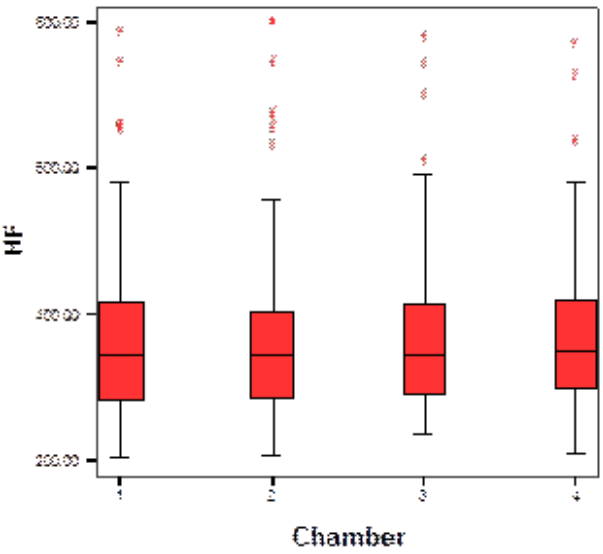
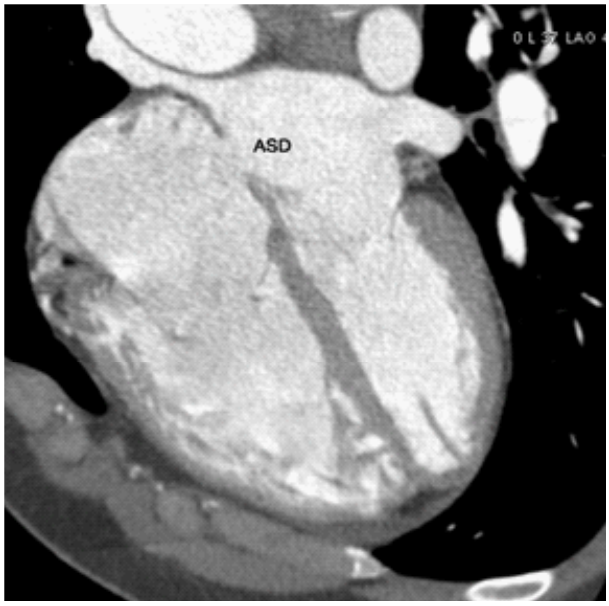


Figure 4: Comparison of mean contrast Hounsfield (HF) values of all four chambers in ASD patients. 1: right Atrium, 2: right Ventricle, 3: Left Atrium, 4: Left Ventricle.



Contrast Opacification in all four chambers is shown in figure 4. The mean Hounsfield values of contrast in right atrium, right ventricle, left atrium and left ventricle were 368.82+118, 370.54+115, 373.47+110, 369.95+107 respectively. Analysis of variance (ANOVA) revealed no significant difference between all four chambers of heart (p=0.968). Figure 5 is showing examples

Figure 5: Examples of secundum and sinus venosus ASD patients showing uniform contrast opacification on Cardiac MDCT.



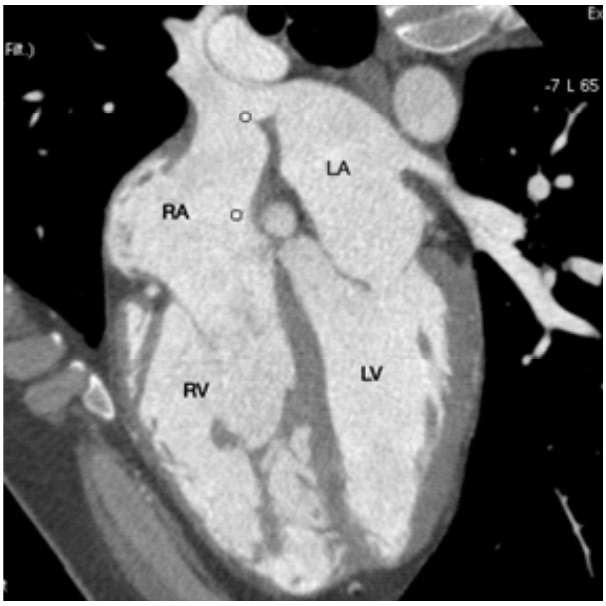


Figure 6: ASD cases with uniform and non uniform opacification of contrast in four chambers on cardiac MDCT

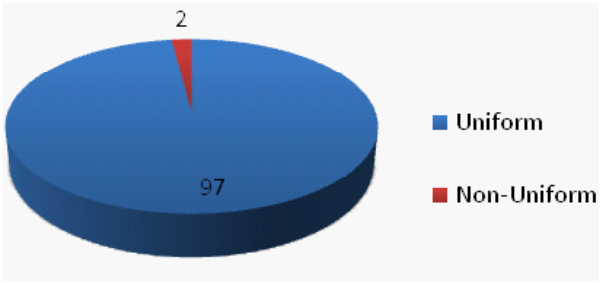
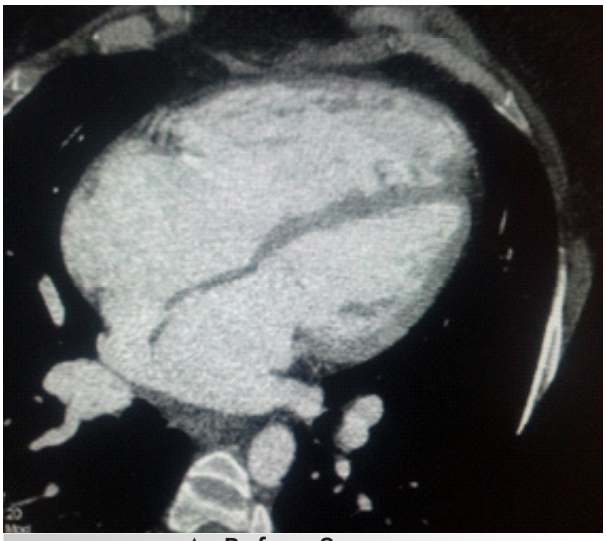


Figure 7: Uniform 4 chamber contrast Opacification in a patient with sinus venosus ASD before surgery (A) and non uniform contrast opacification in the same patient after surgery (B)



A: Before Surgery

B: After Surgery

of secundum and sinus venosus ASDs with uniform contrast distribution in all four chambers of the heart.

On visual analysis of 99 ASD patients, uniform four-chamber opacification was noted in 97 patients (figure 6).

One patient was studied before and after undergoing ASD repair. It is worth noting that uniform contrast Opacification that was observed before ASD repair disappeared after the surgery (figure 7).

DISCUSSION:

Cardiac MDCT is a useful investigation for evaluation of congenital heart diseases in patients with inadequate transthoracic and trans esophageal echocardiograms[6]. The diagnostic role of Cardiac MDCT for evaluation of technically difficult congenital heart diseases including atrial septal defect is very well established and frequently cited in the literature[7]. Cardiac MDCT is particularly useful for evaluation of pulmonary venous anomalies associated with sinus venosus atrial septal defects [8].

The phenomenon of pulmonary recirculation in patients with atrial septal defect is well described in literature and forms the basis of measurement of Qp/Qs ratio in these patients.[9] The same phenomenon forms the basis for uniform four-chamber contrast opacification in atrial septal defect patients. There is equilibrium of contrast distribution due to recirculation to right sided cardiac chambers through atrial septal defects. The authors have extensively searched the literature using different search engines but have found no mention of this finding of uniform four-chamber contrast opacification on cardiac MDCT in patients with atrial septal defects. However, this finding is even obvious in cardiac MDCT images of ASD patients given in different publications.[10-12] This study is a pioneer study of its type in this regard.

STUDY LIMITATIONS:

This study comprised patients being evaluated for pulmonary hypertension for determining the underlying cause and some patients with known ASD for evaluation of associated pulmonary venous anomalies. Most of these patients had large ASDs. This phenomenon of uniform contrast distribution has not been studied in patients with small

sized ASDs. Secondly, this study has been carried out on a 64-slice CT scanner, which required 4-5 cardiac cycles for complete cardiac CT data acquisition. These 4-5 cardiac cycles may be sufficient for contrast to equilibrate between the right and left sided cardiac chambers. It is not clear whether the same will hold true with most modern CT scanners capable of doing cardiac imaging in a fraction of second. Further studies with these ultrafast CT scanners and in patients with small ASDs are required.

CONCLUSION:

Four-chamber uniform contrast opacification is seen in nearly all cases of ASD undergoing cardiac CT.This finding should always alert to the presence of underlying ASD.

Author's Contribution

MA: Main author and contributor; TN: Analyzed studies; SYH: Data collection and compilation; NHM: Overall supervision of whole project.

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