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Relationship Between Transthoracic Echocardiography and Transesophageal Echocardiography in the Anatomic and Hemodynamic Assessment of Secundum Atrial Septal Defects in Children and Adults

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ABSTRACT

Objective: To determine the relationship between transthoracic and transesophageal echocardiography in the anatomic and hemodynamic assessment of secundum atrial septal defects in children and adults.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Paediatric Cardiology, National Institute of Cardiovascular Diseases, Karachi Pakistan, from Jul 2020 to Jun 2021.

Methodology: Seventy-seven patients above three years of age with secundum atrial septal defects were included. Linear regression was used to determine any statistically significant difference between transthoracic and transesophageal echocardiography approaches.

Results: Of 77 patients, there were 37(48.1%) male and 40(51.9%) female. No significant difference was noted in terms of any of the clinical parameters during transthoracic echocardiography and transesophageal echocardiography. As per transthoracic echocardiography, 35(45.5%) were noted to be deviceable, while in transesophageal echocardiography, 36(46.8%) patients were found to be deviceable (p=0.872). No emergency exploration or deaths occurred. Linear regression showed no statistically significant difference between transthoracic echocardiogram and transesophageal echocardiography findings in terms of atrial septal defects size (p=0.226), total septal length (p=0.930), RV systolic pressure (p=0.440), RV functions and TAPSE (0.748) except LV ejection fraction function findings (p<0.001).

Conclusion: Anatomic and hemodynamic assessment of secundum atrial septal defects in children and adults correlated well with transthoracic and transesophageal echocardiography.

Keywords: Atrial septal defect, Transthoracic echocardiography, Transesophageal echocardiography.

How to Cite This Article: *Rehman MU, Sathio S, Chand R, Shaikh AS, Ahsan AK, Rehman F, Patel N. Relationship Between Transthoracic Echocardiography and Transesophageal Echocardiography in the Anatomic and Hemodynamic Assessment of Secundum Atrial Septal Defects in Children and Adults. Pak Armed Forces Med J 2023; 73(3): 715-719. DOI: https://doi.org/10.51253/pafmj.v73i3.7591*

INTRODUCTION

Atrial septal defects (ASD) is one of the most common acyanotic congenital heart defects (CHD) and accounts for approximately 8-10% of CHDs with a prevalence of 1-2%/1000 live births.[1,2] The principal treatment options for ASD closure include open-heart surgery under cardiopulmonary bypass and transcatheter device closure using echocardiography and fluoroscopy. Although both treatment options give excellent clinical outcomes, both have immediate and long-term complications.[3,4] Percutaneous transcatheter closure of the second ASD is an increasingly widespread alternative to surgical closure.[5]

Traditionally, transesophageal echocardiography (TEE) is the imaging modality for transcatheter closure of ASDs because of its better-resolution images.[6] However, it requires either conscious sedation, with the attendant aspiration risk in a supine patient or general anaesthesia, with endotracheal intubation, and there is a risk of oesophagal trauma. Studies suggest that Transthoracic echocardiography (TTE) is a good alternative to TEE.[7,8] TTE is a noninvasive, easily available, reliable and cost-effective alternative modality which can be used as an excellent imaging tool to guide transcatheter closure of ASDs in selected cases.[9,10]

Studies are necessary to evaluate whether TTE can reliably be used as an excellent alternative to TEE. Therefore, this study was designed to compare TTE to that TEE in guidance for transcatheter device closure of ASD secundum and to know whether TTE can reliably be used for deciding transcatheter closure of ASD secundum to avoid the complications associated with TEE. In addition, we aimed to determine the clinical relation between TTE and TEE in the anatomic and hemodynamic assessment of secundum ASDs in children and adults.

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Received: 31 Nov 2021; revision received: 05 Jan 2022; accepted: 11 Jan 2022

METHODOLOGY

The cross-sectional study was conducted at the Department of Paediatric Cardiology National Institute of Cardiovascular Diseases (NICVD), Karachi Pakistan, from July 2020 to June 2021. Approval from Institutional Ethical Committee was taken (Certificate number: ERC 003/2021, dated: 07/05/2021). A sample size of 77 cases was calculated using the formula: n=z2 **p**(1-*p*)/e2, where: *p*=90.7%,[10] (percentage of successful devices closure in ASD).

Inclusion Criteria: Patients of either gender, aged above three years with secundum ASDs were included in the study.

Exclusion Criteria: Patients having ASD premium, sinus venosus ASDs, coronary sinus ASDs or those with other associated CHDs were excluded from the study.

Non-probability consecutive sampling technique was adopted. In addition, patient demographic data, including age and gender, were noted. Among all patients, the size of the defect, its location, rims of the defect, total septal length, right ventricular size and function and right ventricular pressure were measured by TTE. Subsequently, all patients were planned to undergo TEE.

Secundum ASD was described as an abnormally large opening in the septum primum at the site of the foramen ovale in the region of the fossa ovalis. An Aplio i600 ultrasound system performed TTE examinations with three and 5MHZ phased array transducers. An experienced sonographer performed TTE, totally blind to TEE study results. A sweep speed of 100 was kept for the Doppler study, and an average of three findings was calculated for each study variable. TEE examination was performed on Toshiba xario 200 by an experienced echocardiographer, completely blind to TTE results, and an average of 3 findings were calculated for each of the study variables measured.

ASD type was viewed in subxiphoid long-axis view (coronal or frontal), subxiphoid short-axis view (sagittal), apical four-chamber view and parasternal short-axis view on TTE. ASD size was viewed in the subxiphoid long-axis view (coronal or frontal), subxiphoid short-axis view (sagittal), apical four-chamber view and parasternal short-axis view on TTE. The total atrial septal length was viewed in the subxiphoid long-axis view (coronal or frontal), subxiphoid short-axis view (sagittal), apical four-chamber view, and parasternal view short-axis view on TTE. Shunt direction was viewed in subxiphoid long-axis view (coronal or frontal), subxiphoid short-axis view (sagittal), apical four-chamber view and parasternal short-axis view by colour Doppler on TTE. RA and RV Dilatation were viewed in subxiphoid long-axis view (coronal or frontal) and apical four-chamber view on TTE, while on TEE, these were viewed in Four chamber view (Mid-esophagus level, angle of 0o, 15o, 30o). AV Valve rims were viewed in subxiphoid long-axis view (coronal or frontal) and apical four-chamber view on TTE, while on TEE; these were viewed in four chamber view (mid-oesophagus level, angle of 0o, 15o, 30o). SVC rim was viewed in subxiphoid short-axis view (sagittal), on TTE while on TEE, it was viewed in Basal transverse view (at 0, 15, 30, and 45 at mid-to-upper oesophagus) and bical view (mid-to-upper oesophagus and deep transgastric at an angle of 90o, 105o, and 120o). IVC rim was viewed in subxiphoid short-axis view (sagittal), on TTE while on TEE, it was viewed in bical view (Mid- to the upper oesophagus and deep transgastric at an angle of 90o, 105o, and 120o). The aortic rim was viewed in parasternal short axis view on TTE, while on TEE, it was viewed in short axis view (mid-to-upper-oesophagus level, at an angle of 30o, 45o, 60o, 75o) and Basal transverse view (at 0, 15, 30, 45 at mid- to the upper oesophagus).

The posterior atrial wall rim was viewed in a parasternal short-axis view on TTE, while on TEE, it was viewed in Four chamber view (Mid-esophagus level, angle of 0o, 15o, 30o) and Short axis view (Mid to upper-oesophagus level, at an angle of 30o, 45o, 60o, 75o). The superior or RUPV rim was viewed in subxiphoid long-axis view (coronal or frontal) on TTE, while on TTE; it was viewed in Basal transverse view (at 0, 15, 30, and 45 at mid- to the upper oesophagus). RV Pressure was viewed in the subxiphoid long-axis view (coronal or frontal) and the apical four-chamber view from the tricuspid regur-gitation jet on TTE, while on TEE, it was viewed in Four chamber view (mid-esophagus level, angle of 0o, 15o and 30o).

All study data were analysed using Statistical Package for the Social Sciences (SPSS) version 26.00. Mean+SD were calculated for the numerical variables, while percentages and frequencies were calculated for categorical variables. The chi-square test was used to compare qualitative variables, while paired sample t-test was used for quantitative variables. Linear regression analysis was used to analyse the agreement between TTE and TEE. The *p*-value less than or equal to 0.05 was taken as significant.

RESULTS

Of 77 patients, 37(48.1%) were male, and 40 (51.9%) were female. Overall, the mean age was noted to be 20.04±13.0 years. Table-I is showing clinical parameters noted during TTE and TEE. No significant difference was noted regarding any clinical parameters during TTE and TEE. As per TTE, 35(45.5%) cases were noted to be deviceable, while in the remaining cases, they were undecided. In TEE, 36(46.8%) patients were found to be device-able, while the remaining 41(53.2%) were non-device-able (p=0.8716). No emergency exploration or deaths occurred. Table-II is showing the linear regression analysis, with upper and lower limits and a 95% confidence interval (CI) between TTE and TEE findings regarding ASD size (95% CI: -7.24 to 6.14), total septal length (95% CI: -11.39 to 11.70), RV systolic pressure (95% CI: -1289 to 10.47), RV functions and TAPSE (95% CI: -12.88 to 10.46), and LV ejection fraction (95% CI: -5.32 to 12.95). Linear regression showed no statistically significant difference between TTE and TEE findings in terms of ASD size (p=0.226), total septal length (p=0.930), RV systolic pressure (p=0.440), RV functions and TAPSE (0.748) except LV ejection fraction function findings (p<0.001).

Table-I: Clinical Parameters (n=77)

Clinical Parameters	Transthoracic Echocardiography (TTE)	Transesophageal Echocardiography (TEE)	*p*-value
Atrial septal defect size (mm)	18.19±5.1	18.81±4.6	0.4295*
Total septal length (mm)	42.97±5.6	42.82±5.6	0.8682*
Atrioventricular valve rim size deficient	18(23.4%)	16(20.8%)	0.6976**
Posterior atrial wall rim size deficient	20(26.0%)	19(24.7%)	0.8529**
Superior vena cava rim size deficient	20(26.0%)	23(29.9%)	0.5900**
Inferior vena cava rim size deficient	34(44.2%)	35(45.5%)	0.8713**
Aortic rim size deficient	15(19.5%)	15(18.2%)	1**
Superior or right upper pulmonary vein rim deficient	22(28.2%)	23(29.9%)	0.8594**
Right atrium dilatation	76(98.7%)	75(97.4%)	0.5599**
Right ventricular dilatation	74(96.1%)	75(97.4%)	0.6494**
Right ventricular systolic pressure (mmHg)	32.78±6.9	33.99±6.4	0.2610**
Right ventricular functions and tricuspid annular plane systolic excursion (mm)	25.86±8.3	25.35±7.1	0.6826*
Left ventricular ejection fraction Functions (%)	64±4	61±2	<0.001*
Device-able	35(45.5%)	36(46.8%)	0.8716**

**Independent sample t-test applied; **Chi-square test applied*

Table-II: Linear Regression Analysis Between Transthoracic Echocardiography and Transesophageal Echocardiography Findings (n=77)

Echocardiographic Features	Unstandardized B	Coefficient of Standard Error	Standardized Coefficient Beta	95% Confidence Interval		*p*-value
				Lower Limit	Upper Limit	
Atrial septal defect size (mm)	0.104	0.085	0.140	-7.24	6.14	0.226
Total septal length (mm)	0.013	0.143	0.010	-11.39	11.70	0.930
Right ventricular systolic pressure (mmHg)	0.089	0.115	0.089	-12.89	10.47	0.440
Right ventricular functions and tricuspid annular plane systolic excursion (mm)	0.031	0.097	0.037	-12.88	10.46	0.748
Left ventricular ejection fraction (%)	1.356	0.146	0.731	-5.32	12.98	<0.001

DISCUSSION

In this study, we found that 51.9% of cases with ASD were female. Our results are consistent with local findings from Rawalpindi, where researchers evaluated 425 children and adults and noted that 60.5% of cases were female.[11] A study from China also revealed that most cases (54.9%) with ASD were female.[10]

We found that clinical findings in TTE and TEE were very similar, while cases noted to be device-able were almost similar (45.5% vs 46.8%, p=0.8716). We also noted no clinically significant difference correlating clinical findings between TTE and TEE regarding ASD size, total septal length, RV systolic pressure and RV functions and TAPSE. A randomised clinical trial conducted by Bartakian *et al.* comparing outcomes of percutaneous ASD closure among cases with ASD found that a 100% success rate was achieved in cases of both study groups.[12] Research done by Li *et al*. described successful device deployment among 98.4% of cases in the TTE group, which shows that TTE is a very efficacious approach among patients undergoing transcatheter closure of ASD.[13] Baruteau *et al*. from the UK, analysing the anatomical and hemodynamic suitability of TTE and TEE among patients with secundum ASD, concluded that the TTE imaging approach was as efficient as TEE. They further added that TTE is a safe procedure that can be performed in spontaneously breathing subjects.[14] Some studies only included adult patients.[12,15] Akaji *et al*. from Japan proposed colour Doppler TTE as an effective way of assessing the presence of ASD, chamber dilatation, estimation of pulmonary artery pressure, shunt ratio and other coexisting heart diseases with efficient sensitivity and specificity in real-time, which is very consistent with the present findings.[16]

Quite a few imaging tools are used for guidance of transcatheter device closure of secundum ASD, like TEE, TTE and intra-cardiac echocardiography (ICE), whereas TEE has been considered to be the standard imaging tool.[17,18] We found TTE to be an easy-to-perform, reliable and safe imaging modality that does not require general anaesthesia aiming guidance of device closure of secundum ASD. Some researchers also claimed that TTE could reduce procedure time and the risk of radiation exposure.[11] Present study is the 1st of its kind from Pakistan, where we revealed that anatomic and hemodynamic assessment of secundum ASDs correlated well with transthoracic and transesophageal echocardiography.

LIMITATIONS OF STUDY

As we had selected a cohort who had undergone TTE and subsequently TEE, and we have used only TEE for device deployment, it was impossible for us to compare procedural time and device deployment success rate between the two methods. We could not compare the operator factor and its effect on TTE and TEE outcomes. Finally, no short-term or long-term follow-up data were included.

CONCLUSION

Anatomic and hemodynamic assessment of secundum atrial septal defects in children and adults correlated well with transthoracic and transesophageal echocardiography.

Conflict of Interest: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

MUR & SS: Data analysis, drafting the manuscript, critical review, approval of the final version to be published.

RC & ASS: Conception, study design, data interpretation drafting the manuscript, approval of the final version to be published.

AKA & FR: Critical review, data acquisition, approval of the final version to be published.

NP: Critical review, data acquisition, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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