



Evaluation of cardiac function in children after percutaneous closure of atrial septal defect using speckle tracking echocardiography

Mehdi Ghaderian⁽¹⁾ , Bahar Dehghan⁽²⁾ , Mohammad Reza Sabri⁽³⁾, Alireza Ahmadi⁽¹⁾, Ali Sadeghi-Lotfabadi⁽²⁾

Original Article

Abstract

BACKGROUND: Atrial septal defect (ASD) is among the most common congenital anomalies that its neglect may cause severe right ventricular (RV)-associated cardiac dysfunction. Percutaneous closure of ASD is an efficient technique used commonly worldwide. Varieties of techniques have been used to assess postoperative changes of cardiac function. The current study has aimed to assess outcomes of percutaneous ASD closure using two-dimensional speckle tracking echocardiography (2D-STE).

METHODS: This non-experimental research was conducted on 22 patients who volunteered for percutaneous ASD closure between 2016 and 2018. Cases were assessed three times including prior to percutaneous ASD closure, after 24 hours, and a month after procedure. Cases outcomes were assessed and compared during the time.

RESULTS: Strain rate in RV middle septal wall was significantly different ($P < 0.050$) between before and one month after the procedure. Comparison of indices post procedure and one month later showed better RV strain pattern but they did not have a significant difference ($P > 0.050$).

CONCLUSION: Based on this research, STE is a quick simple method of assessing cardiac chambers and function in details. It seems that this method can replace other traditional echocardiographic methods for cardiac function tests; thus, further studies with larger groups and longer follow-up duration are strongly recommended.

Keywords: Atrial Septal Defect; Vascular Closure Devices; Echocardiography

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Introduction

Atrial septal defect (ASD) is one of the most common congenital anomalies which accounts for 10%-15% of all congenital heart diseases (CHDs) and uncorrected remnants of ASD account for up to 30% of adult heart anomalies.¹ Most of ASD-affected children are asymptomatic while in untreated cases, it may turn to ventricular tachyarrhythmia, right ventricular (RV) dysfunction, and pulmonary hypertension (PHTN).²

Percutaneous closure of ASD has been raised by in 1974 for the first time. Performance of this procedure before the age of 25 years accompanies acceptable RV morphology, exercise physiology, and positive effects on remodeling function

and dimension;³ thus, it poses normal life expectancy.⁴ Percutaneous approaches of ASD closure have been considerably promoted through the years and assessment of post procedure outcomes plays an important role in detecting short- and long-term quality and efficacy of ASD closure;^{1,5} however, information in this regard is poorly explained.⁶

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1- Associate Professor, Pediatric Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran

2- Assistant Professor, Pediatric Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran

3- Professor, Pediatric Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran

Address for correspondence: Bahar Dehghan; Assistant Professor, Pediatric Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran; Email: dr.bahardehghan@gmail.com

Echocardiographic methods have been notably developed in recent decades and provided high quality of assessing RV and left ventricular (LV) function. Furthermore, new techniques have opened new windows of quantifying global and regional ventricular functions. Two-dimensional speckle tracking echocardiography (2D-STE) is a relatively new echocardiography technique for myocardial deformation evaluation.⁷⁻⁹ The percentage of myocardial functioning is achieved using STE. This index is presented as strain rate measuring regional myocardial deformation per specific unit of time. Then global strain pattern is recorded using average of segmental values.¹⁰ Information about use of 2D-STE for assessing outcomes of percutaneous ASD closure on four chambers function is limited in children. One study on adult patients has shown that strain rate of RV worsened after 24 hours of device closure.⁵ This study has aimed to assess RV and LV functioning following percutaneous closure of ASD in children.

Although percutaneous closure of ASD has been well-established worldwide to preserve children's cardiac function, especially RV, studies assessing post-procedural outcomes are limited. Most of them have evaluated general function of heart post-procedurally but not in detailed indices. Most of the previous studies assessed RV ejection fraction (EF) as main index of cardiac function.^{5,11} Echocardiography strain imaging known as deformation imaging is a quantifying technique of imaging that practically assesses myocardial function. These techniques have been previously utilized for assessment of ischemic diseases, cardiomyopathy, and even cardiac function following use of cardiotoxic chemotherapy remedies.^{12,13} 2D-STE is one of the deformation techniques which is a simple quick means of assessing physiological and pathophysiological cardiac conditions.¹⁴

Materials and Methods

This non-experimental study was conducted on 26 patients who were candidates of percutaneous ASD closure referred to Imam Hossein and Shahid Chamran Hospitals affiliated to Isfahan University of Medical Sciences, Isfahan, Iran, between 2016 and 2018. Inclusion criteria were: a) age less than 18 years old, b) presenting indications of ASD closure, and c) willingness of patients' parents for participation in the study. Indications of ASD closure include one of these factors: a) significant shunt known as pulmonary flow index (Qp)

compared to systemic flow index (Qs) (Qp/Qs) ≥ 1.5 , b) significant shunt with diastolic rumble during auscultation of the tricuspid valve, c) signs of RV hypertrophy and RV enlargement in electrocardiogram (ECG), and d) signs of cardiomegaly or increased vascular markings in chest X-ray.¹⁵ None of the patients had any symptom or exercise intolerance. Patients who did not refer for follow-up assessments after percutaneous ASD closure and those who had concurrent cardiac complex anomalies that need operation such as ventricular septal defect (VSD), pulmonary stenosis, and patent ductus arteriosus (PDA) were excluded.

Following proposal approval by Ethics Committee of Isfahan University of Medical Sciences (code: IR.MUI.REC.1396.3.721), all study processes were presented for patients' parents and they were requested to sign written consent form of their child participation in the study. Then patients were accurately examined by a pediatric cardiologist and their data such as age, gender, time of ASD diagnosis, and consumed medical remedies were recorded in a checklist. Then patients underwent STE by the pediatric cardiologist. In order to minimize inter-observer bias, all of STE steps were performed by a pediatric cardiologist fellow.

STE was performed measuring RV and LV function through assessment of basal lateral, middle lateral, apical lateral, apical septal, middle septal, basal septal, and global using strain and strain rate method. In order to perform echocardiography, patients were in supine or left lateral decubitus comfortable position using Echo 7 machine (Samsung, Korea), equipped with a 2-7 MHz probes and frame rate was 88 frames per second (fps). Controls were examined once while cases underwent echocardiography in a day prior to ASD closure and then 24 hours after closure. The last assessment was performed after one month of procedure. In order to save data, images of each patient and movie clips were stored on the echocardiography device. We used standard four-chamber view to obtain longitudinal strain and strain rate for RV and LV. Strain software thereafter was utilized to analyze saved data. This software is able to track endocardial borders derived from 2D longitudinal circumferential views. The endocardial border was drawn by the operator and then followed automatically frame by frame. The position of speckles was detected by operator based on the point's spatial coherence (Figure 1).

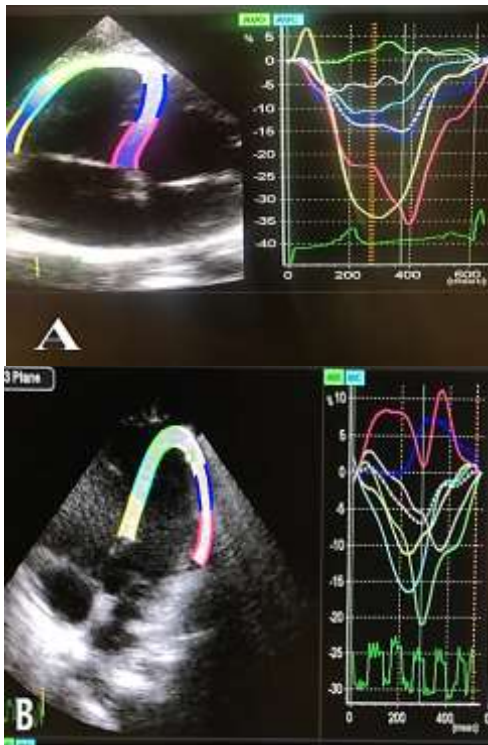


Figure 1. Speckle tracking in right ventricle (RV) (A) and left ventricle (LV) (B)

Then patients underwent percutaneous ASD closure. Echocardiography was performed within 24 hours and once again one month after the procedure. Data mentioned above were reassessed and recorded in the checklist.

The qualitative variables were expressed as the number and percentages. The quantitative variables were expressed as mean and standard deviation (SD). Kolmogorov-Smirnov test (K-S test) was used

to check whether the variables had a normal distribution or not. Repeated measures analysis of variance (ANOVA) with post hoc was used for evaluation of the effect of procedure during time. SPSS software (version 22.0, IBM Corporation, Armonk, NY, USA) for further analysis was used for analyzing data. P-value less than 0.05 was considered as significant.

Results

Four cases were excluded from the study as they refused to participate in follow-up visits. Thus, study analysis was performed on 22 remained cases.

Mean \pm SD of cases' age was 63.54 ± 60.00 (8-192) months and 11 were male (50%) and 11 were female (50%).

Comparison of indices post procedure showed better RV strain pattern and strain rate immediately after procedure and at one-month follow-up; however, RV strain rate changed to better state one month later as compared with findings obtained in a day after ASD closure (Table 1). In middle septal before the procedure and one month after the procedure, significant differences were seen ($P = 0.032$) although in other parts significant differences were not seen.

Discussion

In the current study, comparison of indices postoperatively showed better RV function indices after the procedure. Following the ASD closure, volume load on both ventricles changes, and this unloading of RV is the absolute benefit of ASD closure that can improve its function and prevent long-term further complications.¹⁶

Table 1. Comparison of right ventricular (RV) function indices before, one day, and one month after procedure

Variable		Before	The day after	One month after	P			P*
		procedure (1)	procedure (2)	procedure (3)	1 and 2	1 and 3	2 and 3	
Strain	Global	-16.94 \pm 9.36	-18.69 \pm 4.81	-19.18 \pm 3.54	0.460	0.430	0.700	0.298
	Basal septal	-34.25 \pm 11.83	-29.64 \pm 16.54	-33.57 \pm 9.09	0.780	0.750	0.410	0.332
	Middle septal	-21.71 \pm 11.02	-21.74 \pm 9.22	-22.41 \pm 11.12	0.980	0.840	0.680	0.942
	Apical septal	-11.00 \pm 10.19	-11.71 \pm 9.85	-9.57 \pm 10.92	0.940	0.320	0.370	0.572
	Basal lateral	-20.55 \pm 5.59	-20.58 \pm 5.28	-21.70 \pm 7.02	0.950	0.800	0.600	0.734
	Middle lateral	-15.67 \pm 5.54	-17.31 \pm 4.10	-18.58 \pm 3.52	0.330	0.013	0.340	0.051
	Apical lateral	-11.40 \pm 5.74	-9.85 \pm 7.69	-10.52 \pm 8.31	0.440	0.440	0.900	0.614
Strain rate	Global	-1.41 \pm 0.34	-1.54 \pm 0.24	-1.61 \pm 0.30	0.230	0.230	0.540	0.234
	Basal septal	-2.13 \pm 0.31	-1.87 \pm 3.78	-2.07 \pm 3.61	0.100	0.120	0.630	0.142
	Middle septal	-1.69 \pm 0.94	-1.70 \pm 0.58 ¹	-1.71 \pm 0.69 ¹	0.130	0.032	0.340	0.045 ^{**}
	Apical septal	-1.23 \pm 0.02	-1.25 \pm 0.71	-1.13 \pm 0.34	0.240	0.470	0.850	0.464
	Basal lateral	-1.68 \pm 0.58	-1.70 \pm 0.69	-1.73 \pm 0.76	0.740	0.660	0.620	0.878
	Middle lateral	-1.31 \pm 0.53	-1.48 \pm 0.68	-1.53 \pm 0.51	0.670	0.800	0.690	0.709
	Apical lateral	-1.19 \pm 0.60	-0.87 \pm 0.28	-1.18 \pm 0.91	0.530	0.600	0.600	0.464

Data are presented as mean \pm standard deviation (SD)

* Repeated measures analysis of variance (ANOVA) with Bonferroni post hoc was used, ** $P < 0.050$ sets as significant

In our study, this improvement was seen especially in the middle septal segment of RV (the part which was more under the loading pressure due to specific RV geometry). Although our results indicate clinical improvement in RV function which has begun from middle lateral segment, it is not significant statistically.

Our results are similar to the study conducted by Agha et al.¹⁷ which demonstrated that remodeling of both RV and LV was reversible after percutaneous ASD closure in pediatric group; however, their study was performed in older children.

Xu et al.¹⁸ evaluated RV myocardial strains by STE after percutaneous ASD closure in children. They reported that RV strains were significantly higher in children before device closure. At 1 day after closure, all these measures decreased accordingly. This discrepancy between their findings and ours can be due to the differences in ages and ASD dimensions before procedure though they concluded that transcatheter device closure of ASDs improved RV strain indices, so its function recovered to normal over 3 months.

Bussadori et al.⁵ performed a similar study on older population following ASD closure. They presented significant improvement of RV functions as the fluid volume decreased but immediately it got worse after closure. They presented this improvement in six-month follow-up as well which may be attributed to the chronic long-term effects of ASD on cardiac function (the mean age of patients was in the third decade). However, benefit of ASD closure on LV function was not statistically significant. Ding et al.,¹¹ Akula et al.,¹⁹ and Pascotto et al.²⁰ performed other studies on outcomes of percutaneous ASD closure using echocardiography for function assessments. They presented similar outcomes as RV volumes diminished and EF improved while LV functions improved following intervention but not significantly.

The other study conducted by Vitarelli et al.²¹ evaluated the efficacy of three-dimensional (3D) and 2D speckle tracking on assessing outcomes of ASD closure and its ability in prediction of further paroxysmal atrial fibrillation (AF) progression. Their study findings were consistent with our findings regarding RV function improvement. Furthermore, they presented that speckle tracking could successfully predict paroxysmal AF progression among patients with ASD. Ozturk et al.³ performed another study assessing efficacy of speckle tracking in adults for evaluation of ASD closure outcomes. They presented that all RV-related aspects including

right atrium (RA) volume and RV end-diastolic diameter (RVEDD) improved significantly following percutaneous ASD closure. Indices related to left side of heart showed significant decrease in left atrial (LA) diameter postoperatively while LV end-diastolic diameter (LVEDD) remained unchanged. Furthermore, RV longitudinal strain increased significantly following ASD closure.

Compared to other studies, most of them on adults, our study was conducted on children. Considering the better compliance of pediatric hearts, it seems that the improvement of cardiac function in children is faster than adults. The difference in the results of the measurements found in different parts of the RV is due to the fact that we have had more non-symmetric RV hypertrophy and a lower pulmonary pressure in some patients. More improvements in other indices may appear in subsequent pursuits and long-term follow-up. Due to volume overload effect on the RV in comparison to LV, atrial septal correction had further effects in the right side of heart and improved its function more.

Conclusion

Based on this research, our findings indicate improvement of RV function post intervention. As STE is a quick simple method of assessing cardiac chambers and function in details, it seems that this method can replace other traditional echocardiographic methods for cardiac function tests.

Limitations: According to our knowledge, very few studies are currently available using this method in children. Small number of sample population and short-term follow-up are the most significant limitations of our study. Further multicenter studies with larger sample population and long-term follow-up are recommended.

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Conflict of Interests

Authors have no conflict of interests.

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