Razavi Int J Med. 2016 June; 4(2):e36212. doi:10.30483/rijm.2016 .116390

Published online 2016 May 16. **Research Article**

Eccentricity Index Identifies the Severity of Left to Right Shunt in Patients With Secundum Type Atrial Septal Defect

Afsoon Fazlinezhad,[1,*] Fatemeh Moodi,[2] and Azra Izanloo[3]

[1]Associate Professor of Cardiology, Razavi Hospital, Mashhad University of Medical Sciences, Mashhad, IR Iran
[2]Cardiologist, Cardiovascular Center, Research and Education Department, Razavi Hospital, Mashhad, IR Iran
[3]Research and Education Department, Razavi Hospital, Mashhad, IR Iran

[*]*Corresponding author*: Afsoon Fazlinezhad, Associate Professor of Cardiology, Razavi Hospital, Mashhad University of Medical Sciences, Mashhad, IR Iran. Tel: +98-5116668888, Fax: +98-5116668887, E-mail: fazlinejada@mums.ac.ir

Received 2016 January 10; **Revised** 2016 March 29; **Accepted** 2016 April 27.

Abstract

Background: One of the inclusion criteria for applying atrial septal defect (ASD) closing procedure is an increased pulmonary-to-systemic blood flow ratio (Qp/Qs). Eccentricity index (EI) is associated with ventricular dysfunction in patients with pulmonary hypertension.
Objectives: As ASD patients have overload volume and pressure in their pulmonary arteries, we tried to test this hypothesis if EI and Qp/Qs ratio are possibly associated.
Patients and Methods: This study is a correlation study. 64 patients with primary diagnosis of secundum type ASD enrolled in this study and echocardiography was performed for all of them. Data were analyzed by SPSS as well as descriptive and statistical tests.
Results: Bivariate correlation test showed that there was a positive and significant association between Qp/Qs ratio and EI ($r = 0.502$, $P = 0.001$). Linear regression analysis showed that there was a linear association between Qp/Qs ratio and EI (Beta = 1.765, $P = 0.001$).
Conclusions: We found that EI and Qp/Qs ratio are significantly and positively associated and Qp/Qs ratio can be easily estimated by measuring EI in secundum type ASD patients.

Keywords: ASD Secundum, Echocardiography, Eccentricity Index, Shunt

1. Background

Atrial septal defect (ASD) is a congenital heart disease that can be routinely diagnosed by echocardiography. The flow of blood through the atrial septal defect usually causes left to right shunt which can be estimated by the pulmonary-to-systemic blood flow ratio (Qp/Qs). The greater the left-to-right blood flow is, the greater the risk of long-term complications will be. As reviewed by Krasuski (1), one of the inclusion criteria for applying ASD closing procedure is an increased Qp/Qs ratio, and it is recommended to close the defect if the pulmonary blood flow is at least 50% greater than the systemic blood flow (Qp/Qs $\geq$ 1.5). However, determination of the ratio of pulmonary blood flow to systemic blood flow is a challenging procedure and calculating this ratio by an alternative and easier method would be desirable. The eccentricity index (EI), measure of septal displacement, could be calculated in the parasternal short-axis view at both end-systole and end-diastole (2). This has been reported with adverse outcomes in patients with primary pulmonary hypertension (3). As ASD patients with high EI are most closely associated with the overload volume and pressure in their pulmonary arteries and also EI is associated with the ventricular dysfunction in patients with pulmonary hypertension, we tried to test this hypothesis if EI and Qp/Qs ratio are possibly associated.

2. Objectives

As ASD patients have overload volume and pressure in their pulmonary arteries, we tried to test this hypothesis if EI and Qp/Qs ratio are possibly associated.

3. Patients and Methods

3.1. Study Population

This study is a correlation study. The study participants were selected from those subjects with primary diagnosis of ASD who had been referred to the adult clinic of echocardiography in Razavi Hospital, Mashhad, Iran during the year 2013. All the patients with isolated secundum type ASD were included in this study. These patients had no previous history of smoking, hypertension, chronic obstructive pulmonary disease, diabetes mellitus, ischemic, myocardial or valvular heart disease, prior cardiac surgery, the pacer or defibrillator wire, RVOT obstruction, and PAH $\geq$ 55. The

patients also had no apparent major disease. Finally, 64 patients fulfilled the inclusion criteria and enrolled in the study (82% Females and 18% males).

3.2. Cardiac Imaging

Standard resting transthoracic echocardiographic examination was done for all the patients. The used equipment included VIVID 7, GE Vingmed Ultrasound (USA), as well as RA and LA area indexes were measured from Apical 4 chamber view by planimetry. Pulmonary Artery Systolic Pressure (PASP) was estimated from the systolic pressure gradient between the right atrium and right ventricle by the peak continuous-wave doppler velocity of the tricuspid regurgitation jet using the modified Bernoulli equation, and then this value was added to the right atrial pressure estimated from the inferior vena cava size and collapsibility with respiration, as previously validated and described in other studies (4, 5). To assess the Qp/Qs ratio, we used the recommended method by American society of echocardiography (6). Ventricular septal position was quantified using the EI described by Ryan et al. (2). Briefly, after identifying an appropriate end-diastolic stop frame, the following diameters were drawn using electronic calipers: D1 is the diameter bisecting the papillary muscles and D2 is the diameter orthogonal to D1, and finally EI equals the ratio D2/D1. It should be noted that a value of 1.0 for EI means a perfectly circular left ventricle.

3.3. Statistical Analysis

Data were expressed as mean ± SD (for parameters with a normal distribution). We performed a regression analysis to investigate the correlation between EI and Qp/Qs. The P value < 0.05 was considered significant.

4. Results

The mean age of the subjects was 36.34 ± 13.03 that it showed most patients were middle aged. The echocardiographic findings of the patients have been presented in Table 1. of the subjects with Qp/Qs ≤ 1.5 were also normal. In patients with secundum ASD, it was determined that defects were usually eccentrically shaped rather than circular; which 17 of them (26.5%) had a defect with major axis length/ minor axis length > 1.5 (in case of presenting multiple defects, only the largest defect was assessed for eccentricity). None of the patients had defects with extreme eccentricity (major/minor axis length > 2.30). When Bivariate correlation (pearson correlation) was performed between Qp/Qs and other variables, we found that there was an interestingly positive and significant association between Qp/Qs ratio and EI, confirming our hypothesis (r = 0.60, P = 0.001) and RA/LA (r = 0.41, P = 0.001) (Table 2). When linear regression was performed, we found that there was a linear association between Qp/Qs ratio and EI (Beta = 1.765, P = 0.001, 95% confidence interval 1.504 - 3.69). This result yielded the following equation:

$$\frac{\mathrm{Qp}}{\mathrm{Qs}}\mathrm{ratio} = 1.765 \times \mathrm{EI} \quad (1)$$

Table 1. Echocardiographic Measurements of the Patients

RA area (mm)	**22.69 ± 9.51**
LA area (mm)	14.83 ± 4.14
RA/LA area	1.54 ±0.39
Defect Size (mm)	2.34 ± 0.93
PAP (mmHg)	45.72 ± 11.68
Qp/Qs Ratio	2.78 ± 0.86
EI index	1.41 ± 0.25

Abbreviations: EI, eccentricity index; LA, left atrium; PASP, pulmonary artery systolic pressure; RA, right atrium.

Table 2. Correlation Between Eccentricity Index and Other Variables[a]

Variable	r	P Value[b]
Age	0.8	0.535
RA area	0.36	0.006
LA area	0.9	0.486
RA/LA area	0.41	0.001
Defect Size	0.30	0.038
PAP	0.43	0.001
Qp/Qs Ratio	0.502	0.001

Abbreviations: EI, eccentricity index; LA, left atrium; RA, right atrium; PAP, pulmonary artery pressure.
[a]Spearman's correlation test was used for analysis.
[b]Correlation is significant at the 0.05 level (2-taited).

5. Discussion

We found that there is a linear association between Qp/Qs ratio and EI, supporting our hypothesis. To the best of our knowledge, this is the first study reporting the association between EI and Qp/Qs ratio. Thereafter, instead of directly measuring Qp/Qs ratio, which is a time consuming procedure, we can assess the EI values and hence estimate Qp/Qs ratio using in Equation 1. We also observed that there is a positive association between Qp/Qs ratio and EI confirming the previous results. It has been previously suggested that systolic EI appears to be an easily obtained variable that should be routinely included in the identification

of right ventricle dysfunction in patients with pulmonary hypertension (7). In the latter study, it was found that there is a negative correlation between systolic EI, pulmonary vascular resistance, transpulmonary gradient, and cardiac index, indicating the efficacy of EI in predicting outcome of these patients (7). Another result of this study was that there was a negative correlation between age and EI. In contrast, Nielsen and colleagues found that the older age and therefore longer exposure to overload right ventricle volume did not correlate with either right ventricle pressure or EI (8). This difference can be explained by the results found in patients with primum ASD, but we have investigated this association in patients with secundum type ASD.

In conclusion, we found that EI and Qp/Qs ratio were significantly and positively associated and the regression analysis also confirmed our results. Although results of the present study should be further confirmed by other studies with larger sample size, our results indicate that instead of measuring Qp/Qs ratio, which is a challenging procedure, EI values can be helpful to estimate the Qp/Qs ratio, and this will help physicians to decide when ASD (secundum) should be fixed.

It is noteworthy that this statement as a hypothesis requires further studies with larger sample size.

5.1. Limitations

The first limitation of this study was that we assessed the association between EI and Qp/Qs only in adult patients, while investigating this association in children would be necessary in future studies. Another limitation was that we only studied patients with secondum type ASD while it is interesting to perform other studies in order to find if there is any correlation between EI and Qp/Qs ratio in patients with another ASD types, and ventricular septal defect. And the final limitation was that we did not seperate hyperkinetic patients.

Acknowledgments

We are particularly grateful to the patients and their family members who volunteered to participate in this study. The authors also thank the research and education department of Razavi hospital for support of this study.

Footnote

Authors' Contribution: Fetemeh Moodi and Afsoon Fazlinezhad design of the project, doing, and supervision of the study and Azra Izanlo analysis of data, editting the manuscript.

References

1. Krasuski RA. When and how to fix a 'hole in the heart': approach to ASD and PFO. *Cleve Clin J Med.* 2007;**74**(2):137–47. [PubMed: 17333641].
2. Ryan T, Petrovic O, Dillon JC, Feigenbaum H, Conley MJ, Armstrong WF. An echocardiographic index for separation of right ventricular volume and pressure overload. *J Am Coll Cardiol.* 1985;**5**(4):918–27. [PubMed: 3973294].
3. Raymond RJ, Hinderliter AL, Willis PW, Ralph D, Caldwell EJ, Williams W, et al. Echocardiographic predictors of adverse outcomes in primary pulmonary hypertension. *J Am Coll Cardiol.* 2002;**39**(7):1214–9. [PubMed: 11923049].
4. Currie PJ, Seward JB, Chan KL, Fyfe DA, Hagler DJ, Mair DD, et al. Continuous wave Doppler determination of right ventricular pressure: a simultaneous Doppler-catheterization study in 127 patients. *J Am Coll Cardiol.* 1985;**6**(4):750–6. [PubMed: 4031289].
5. Kircher BJ, Himelman RB, Schiller NB. Noninvasive estimation of right atrial pressure from the inspiratory collapse of the inferior vena cava. *Am J Cardiol.* 1990;**66**(4):493–6. [PubMed: 2386120].
6. Quinones MA, Otto CM, Stoddard M, Waggoner A, Zoghbi WA, Doppler Quantification Task Force of the N, et al. Recommendations for quantification of Doppler echocardiography: a report from the Doppler Quantification Task Force of the Nomenclature and Standards Committee of the American Society of Echocardiography. *J Am Soc Echocardiogr.* 2002;**15**(2):167–84. [PubMed: 11836492].
7. Lopez-Candales A, Rajagopalan N, Kochar M, Gulyasy B, Edelman K. Systolic eccentricity index identifies right ventricular dysfunction in pulmonary hypertension. *Int J Cardiol.* 2008;**129**(3):424–6. doi: 10.1016/j.ijcard.2007.06.057. [PubMed: 17692406].
8. Nielsen JC, Kamenir SA, Ko HS, Lai WW, Parness IA. Ventricular septal flattening at end systole falsely predicts right ventricular hypertension in patients with ostium primum atrial septal defects. *J Am Soc Echocardiogr.* 2002;**15**(3):247–52. [PubMed: 11875388].