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Original Research Article

Assessment of Right Heart Function and Dimensions following Device Closure of Atrial Septal Defect in Tertiary Medical Centre

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Abstract

Introduction: ASD closure causes electrical and mechanical reverse remodelling after shunt closure. There haven't been many studies to determine whether surgical closure or device closure is better for regressing right heart volumes. In comparison to secundum ASD closure, transcatheter ASD closure has shown to be more affordable while eliminating the common risks of surgical closure, such as cardiac trauma and wound problems.

Aim and Objective: To assess right heart function, right atrial and right ventricular dimensions pre and post transcatheter closure of atrial septal defect (ASD).

Materials and Methods: From August 2021 to December 2022, 50 research participants participated in this descriptive longitudinal study at the LPS Institute of Cardiology in Kanpur, Uttar Pradesh. All ostium secundum ASD patients who were referred for closure were examined. Patients of both sexes are chosen for the investigation. For each patient, pertinent history, a clinical examination, pulse oximetry, a chest X-ray, and an ECG were performed. Each patient had a thorough transthoracic and transoesophageal echocardiogram performed.

Results: At immediate post-closure, one week, and three months after closure, the mean RV longitudinal measurement was 6.31 cm, 6.07 cm, and 5.96 cm, respectively. $F=359.324$, $P < 0.001$, indicates that there is a significant difference between the 4 occurrences. Further numerous comparisons of the occasions reveal that every pair differs considerably. The mean MPI was 4.173, however, it fell to 3.93, 3.592, and 3.199 at the immediate, 1-week, and 3-month post-closure times. Further numerous comparisons of the occasions reveal that every pair differs considerably. $F=444.425$, $P< 0.001$ indicates that there is a significant difference between the 4 occurrences.

Conclusions: Comparable positive effects are shown on hemodynamics, right heart dimensions, and functional capacity. Immediately upon device closure, the highest favourable effects on right cardiac functions, remodelling, of heart functions and the advantage is still there three months later.

Keywords: ASD, Ostium Secundum, Right Ventricle, Right Atrium.

Introduction

The most common congenital heart disease to afflict adults is ASD. One factor contributing to the delay in diagnosis may be the fact that the majority of newborns and children with ASD are asymptomatic and have normal medical outcomes. Due to increased pulmonary flow, chronic right ventricular volume overload brought on by long-term exposure results in RV dilatation, pulmonary hypertension, and right heart failure. ASD closure causes an electrical and mechanical remodelling that is reversed once the shunt is withdrawn. Few comparisons have been performed to determine whether surgical closure or device closure decreases right heart volumes more efficiently. Transcatheter ASD closure has been demonstrated to be a less expensive alternative to secundum ASD closure with reduced cardiac stress and wound problems. Because of the RV's fundamentally complex structural construction, evaluating its operation is still challenging. The CMR's multiplanar imaging capabilities are used to accurately assess shunts, RV ventricular volumes, and function. [1]

ASD has been demonstrated to have major effect on ventricular remodelling and function, with RV volume overload and dysfunction under extreme circumstances, and in rare cases, progression to LV dysfunction. Blood flow to the left ventricle increases when an atrial septal defect (ASD) is corrected with a medical device, and there may be slight aberrations in systolic and diastolic function. In contemporary clinical research in cardiac mechanics, evaluations of short- and long-axis LV and RV function and ejection fraction are being replaced by investigations of two- and three-dimensional (2D and 3D). Unlike conventional methods, which primarily concentrate on radial function, these methods allow for the assessment of longitudinal, radial, and circumferential myocardial motion and deformation. ASD device closure patients also showed better LV and RV longitudinal deformation than ASD surgical closure patients, according to strain imaging research. To balance the early advantage of RV unloading with the operation's safety, many studies have examined the most efficient timing of ASD closure [2].

Reduced ejection fraction is frequently observed in ASD patients who have substantial RV volume overload. Angiogram studies demonstrate anomalies in the systole and diastole functions of the LV. ASD appears to have a more consistent effect on how RVs operate. Although radiological studies indicating a delayed RV contraction in the absence of conduction system issues, echocardiographic examination has demonstrated that RV function is either normal or exaggerated. [3]

We've developed a method recently that combines elements of percutaneous closure with open surgical repair. We have had positive results with this method, transthoracic minimally invasive device closure of atrial septal defects. Many publications have been published on the ultrasonographic evaluation of clinical outcomes after transthoracic minimally invasive device closure of atrial septal defect [4]

As a result, we assessed the right heart's pre- and post-surgery dimensions and functions, carefully monitored them following the procedure, and then checked in with them a week, a month, and three months later to see how the surgical closure had fared.

Aim and Objectives

1. To assess right heart function, right atrial and right ventricular dimensions pre and post-transcatheter closure of atrial septal defect (ASD)
2. To assess magnitude of resolution of right heart enlargement, and impact on right ventricular function by

echocardiography using 2D and tissue Doppler imaging.
3. To compare the final outcomes after 3 months of percutaneous transcatheter closure of atrial septal defect with that of surgical closure.

Methodology

A longitudinal descriptive research was carried out between August 2021 and December 2022 at the LPS Institute of Cardiology in Kanpur, Uttar Pradesh on 50 study subjects. Every patient with an ostium secundum ASD and recommended for closure were recruited. The research enrolls patients of both sexes. Each patient had a thorough physical examination, relevant medical history, pulse oximetry, chest X-ray, and ECG. A thorough transthoracic and transesophageal echocardiography was performed on each subject. The echocardiogram was performed using a Philips HD7XE echocardiographic instrument.

We looked closely at the size, distribution, and number of septal aneurysms. The individuals who qualified for device closure underwent thorough inspection. Referred for surgical closure were those whose rims were excessively loose or inadequate for device closure. Prior to device closure, we measured the dimensions of the right atrium using major and minor dimensions, the dimensions of the right ventricular chamber using basal, mid, and longitudinal diameters, the main pulmonary artery dimension (MPA), the Tricuspid annular plane systolic excursion (TAPSE), the Myocardial Performance Index of the Right Ventricle (MPI).

Inclusion Criteria:

1. Study subjects with Ostium secundum ASD more than 12 mm.
2. Biventricular function should be normal.
3. Study subjects with Left to Right shunts.

Exclusion Criteria:

1. Patients with primum or sinus venosus defect.
2. Irreversible pulmonary artery hypertension.
3. Patients with other associated shunts (VSD/PDA).
4. Patients with a major non-cardiovascular disease.
5. Age less than 12 years.
6. Patients with coronary artery disease.
7. Unwilling to give consent.

Results

Among the 50 patients optimally selected for ASD device closure by percutaneous transcatheter method after fulfilling the inclusion and exclusion criteria the baseline characteristics are discussed.

Table 1: Distribution of study subjects as per AGE

Age distribution	no	%
11-20 yrs	10	20
21-30 yrs	22	44
31-40 yrs	10	20
41-50 yrs	8	16
Total	50	100

Table 1 shows Distribution of study subjects as per AGE, 44% of the research participants were between the ages of 21 and 30; 20% were between the ages of 31 and 40; and 16% were between the ages of 11 and 20. With a range of 15 years, the mean age was 28.4 years. In the current research, women outnumbered men by a margin of 14 to 36 (28 to 72%).

Table 2: Distribution of study subjects as per NYHA Class pre and post closure

NYHA CLASS	PRE-CLOSURE	POST CLOSURE
I	0(0%)	20(40%)
II	25(50%)	30(60%)
III	25(50%)	0(0%)
TOTAL	50(100%)	50(100%)

Tab 2 shows Distribution of study subjects as per NYHA Class pre and post closure, In the pre-closure period, 50% of the study participants had NYHA class II, while 50% had NYHA class III. In the post-exposure period, however, 40% of the research participants had NYHA class I, while 60% had NYHA class II, and none had NYHA class III.

Table 3: The RV BASAL Diameter pre and post device closure values

	N	Minimum (cms)	Maximum (cms)	Mean	Std. Deviation
RVB-Pre closure	50	3.9	4.6	4.297	**0.1847**
RVB-Post closure immediate	50	2.7	3.8	3.167	**0.2202**
RVB-Post closure 1 week	50	2.7	3.7	3.167	**0.2233**
RVB-Post closure 3months	**50**	**2.5**	**3.6**	**2.893**	**0.5813**

Tab 3 shows The RV BASAL Diameter pre and post device closure values. There is a significant difference between the 4 times, F=164.228, P0.001. The mean RVB Pre-closure was 4.29 cm, and it decreased to 3.167 cm, 3.167 cm, and 2.893 cm at the immediate post closure, 1 wk, and 3 month post closure. All pairings are substantially different at the 0.05 level, according to a subsequent multiple comparison of instances.

Table 4: RV Longitudinal dimensions measured pre and post device closure.

	N	Minimum (cms)	Maximum (cms)	Mean	Std. Deviation
RVL Pre closure	50	8.0	8.9	8.647	**0.2374**
RVL Post closure immediate	50	5.2	7.0	6.310	**0.4536**
RVL Post closure 1 week	50	4.9	6.8	6.070	**0.4757**
RVL Post closure 3 months	**50**	**4.8**	**6.9**	**5.963**	**0.4867**

Tab 4 shows The RV Longitudinal Diameter pre and post device closure values. The mean RV longitudinal preclosure measurement was 8.65 cm, and at the time of immediate postclosure, one week, and three months later, it was 6.31 cm, 6.07 cm, and 5.96 cm, respectively. F=359.324, P<0.001, indicates that there is a significant difference among the 4 instances. Further numerous comparisons of the occasions reveal that every pair differs considerably.

Table 5: The right atrial major dimensions in (cms) pre and post deviceclosure results

	N	Minimum	Maximum	Mean	Std. Deviation
RA MAJOR pre closure	50	5.1	5.6	5.350	**0.1408**
RA MAJOR-post closureimmediate	50	4.1	5.2	4.653	**0.3501**
RA MAJOR post closure 1 week	50	4.0	5.1	4.450	**0.3893**
RA MAJOR-post closure3months	**50**	**3.9**	**5.0**	**4.283**	**0.3742**

Tab 5 shows The Right atrial major Diameter pre and post device closure values. At immediately after closure, one week, and three months after closure, the mean right atrial preclosure falls to

4.65 cm, 4.45 cm, and 4.28 cm, respectively. Further numerous comparisons of the occasions reveal that every pair differs considerably. F=180.003, P<0.001 indicates that there is a significant difference between the four occurrences.

Table 6: Comparison of myocardial performance index(MPI) pre and post asd device closure

	N	Minimum	Maximum	Mean	Std. Deviation
MPI Pre closure	50	3.3	4.8	4.173	0.4245
MPI post closure immediate	50	3.2	4.9	3.933	0.4141
MPI postclosure 1 week	50	3.0	4.6	3.592	0.5115
MPI post closure 3 months	50	2.7	4.6	3.199	0.4823

Table 6 shows MYOCARDIAL PERFORMANCE INDEX (MPI) pre and post device closure. The mean MPI was 4.173, however it fell to 3.93, 3.592, and 3.199 at the immediate, 1-week, and 3-month post-closure times. Further numerous comparisons of the occasions reveal that every pair differs considerably. F=444.425, P<0.001 indicates that there is a significant difference between the 4 occurrences.

Discussion

16% of study participants had ages ranged from 21 to 50, 20% for those between 31 and 40, and 44% for those between 21 and 30. The SD was 15 years, with a mean age of 28.4 years. The median age of patients receiving device closure was 33.73± 13.06 years, compared to 35.33± 15.18 years for patients receiving surgical closure. The two groups did not differ statistically significantly from one another, (P = 0.75). In the current investigation, a total of 14 (28%) men and 36 (72%) women were included. In the study by Amr Mansour *et al*. [1], female patients made up the majority (66.7%) of the participants.

NYHA class

50% of participants in the current study had NYHA classes II and III. Even so, 40% of study participants had NYHA classes I and II after exposure, 60% had NYHA classes II, and none had NYHA classes III. Amr Mansour *et al* study found that most patients in both groups had NYHA class I after device closure, compared to 13 of 15 (86.7%) and 12 of 15 (80%) of the patients who received device closure who had NYHA class II at baseline.

Dimensions of the RV BASAL

Before closing, the mean RVB was 4.29 cm; after closing, one week later, and three months later, it was 3.167 cm, 3.167 cm, and 2.893 cm, respectively. There is a statistically significant difference between the four time interval (F=164.228, P<0.001). Additional repeated comparisons of the events show that all pairs are statistically distinct at the 0.05 level. The RV GLS and RV free wall LS significantly decreased 24 hours after closure and kept doing so a month later, according to research by Areej Alkhateeb *et al* [2]. The RV's function is said to have normalized as a consequence of the hyperkinetic wall of the RV. The size and geometry of the LV cavity and wall before closure has been changed, which significantly increased LV-GLS in ASD patients compared to the control group. The LV-GLS also had a statistically significant decline 24 hours after the ASD device was shut off, and then a statistically significant increase in the same measurement 1 month following the intervention compared to the values at that time. According to Vidya Sagar Akula *et al*. [5] research, the RV's basal diameter, which was 16% smaller than baseline, RV major dimension, which was 8% smaller than baseline, RV's subcostal wall thickness, which was 12% smaller than

baseline, RVOT proximal diameter, which was 21% smaller than baseline, RVOT distal diameter, which was 15% smaller than baseline, and RV/OT were all statistically significant decreases one month after closure.

RV longitudinal diameter measurements

The mean RV longitudinal length before closure was 8.65 cm, and immediately after closure, one week after closure, and three months later, it was 6.31 cm, 6.07 cm, and 5.96 cm, respectively. The results of F = 359.324 and P< 0.001 reveal a statistically significant difference between the four time periods. The same events are compared again and again, and each pair is revealed to be extremely different. Before surgery, the right ventricle's end-diastolic length (mm) was 70.611.2 mm. This measurement dropped to 67.4±11.2, 61.5±11.6, and 60.8±12.4 mm one week, three months, and a year following the operation. The results of the current investigation are consistent with this significant decrease in heart diameter. We observed that real-time right-to-left shunt disappeared after ASD closure, hemodynamic abnormalities were rectified, and both the tricuspid valve orifice diastolic and pulmonary valve orifice systolic blood flow velocities decreased. The tricuspid valve's diastolic blood flow velocity and the pulmonary artery's systolic blood flow velocity both markedly lowered one week following the treatment. Right ventricular volume load gradually decreased after the surgery, as evidenced by a decrease in the end-systolic length and width of the right atrium and right ventricle.

Right atrium Size before and after device closure

The right atrial preclosure mean size was 5.35 cm; one week after closure, four months after closure, and three months later, atrial sizes were 4.65 cm, 4.45 cm, and 4.28 cm, respectively. With F = 180.03, P <0.003 demonstrates that there is a significant difference among them. In their study, **Qiang Chen *et al.* [4]** found that the right atrium's end-systolic length (mm) varied from 58.6±7.5 to 54.1±7.3, 47.6±6.7 and 45.4±5.8 mm after one week, three months, and a year. These findings are consistent with the current study. The RA end-systolic area, RA minor dimension, and RA major dimension all decreased from baseline values by 9%, 18%, and 28%, respectively, in research by **Vidya Sagar Akula *et al.* [5]**

MYOCARDIAL PERFORMANCE INDEX

The mean MPI in the current study was 4.173, and it was 3.93, 3.592, and 3.199, respectively, one week and three months after closure with F = 444.425, and P< 0.001 indicates that there is a statistically significant difference among the four-time interval. The worldwide evaluation of RV function is done using the myocardial performance index (MPI). Tei *et al* [6] developed the first fundamental, readily quantifiable, noninvasive Doppler myocardial performance index (MPI) to assess general heart health. The RV is ineffective when the MPI score is greater than 0.55. All time intervals are pulsed in the tricuspid annulus, however Tissue Doppler-derived MPI is more accurate than pulsed-wave Doppler. One month after closure, a significant RV MPI change was discovered in seven patients in the current analysis, which is similar with the findings of Agac *et al*. [7] and comparable to Wu *et al*. [8] research. Six individuals had previously normal RV MPI values decline within the first month. In line with a study by Salehian *et al*. [9] who reported a high basal RV MPI value before to closure, we had three patients with normalized values following ASD closure.

TAPSE

While the mean value of TAPSE, a measure of RV systolic function, decreased

statistically substantially from 25.36 mm to 19.6 mm throughout the course of the research, it remained normal. Tricuspid annular excursion is greater before surgery because the RV volume overload is greater, allowing the right heart to offload the RV. However, after surgery, when the septal defect is closed, blood flow to the right heart system is stopped, this excess tricuspid annular excursion is no longer necessary.

Conclusions

We come to the conclusion that for patients with Ostium Secundum defects who are carefully chosen, percutaneous transcatheter device closure is a dependable, secure, and economical option. The biggest beneficial effects on the size, function, and remodelling of the right heart are noted immediately following device closure, and they continue even three months later. Comparable beneficial benefits are shown in right heart size, function, and hemodynamics as well as functional capability.

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