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Predictors of Persistent Functional Tricuspid Regurgitation After Transcatheter Closure of Atrial Septal Defect and its Relationship to Tricuspid Valve Remodeling

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Abstract

Objectives: **The aim of this study is assessment of persistent functional tricuspid regurgitation in patients with atrial septal defect before and after successful device closure and its relationship to tricuspid valve remodeling.**

Methods: **The current study was conducted on 60 patients referred to Tanta University Hospital Cardiology Department with the provisional diagnosis of atrial septal defect secundum type for transcatheter closure from December 2017 to December 2019. All patients were subjected to history taking, clinical examination, 12 lead electrocardiography, plain chest X-ray, full two dimension transthoracic echocardiography (for assessment of tricuspid regurgitation severity) before and at 3, 6 months after transcatheter closure.**

Results: **Tricuspid regurgitation was decreased significantly after atrial septal defect closure due to remodeling in the right side. Age, estimated systolic pulmonary artery pressure, right atrium end systolic area, right ventricular end diastolic area, tricuspid valve tenting area and height, tricuspid septal leaflet angle and tricuspid annular diameter were predictors of persistent tricuspid regurgitation after 3 and 6 months of closure. Only estimated systolic pulmonary artery pressure, tricuspid septal leaflet angle and tricuspid annular diameter were independent predictors of persistent tricuspid regurgitation after 3, and 6 months of closure.**

Conclusion: **Tricuspid regurgitation significantly improved after transcatheter atrial septal defect closure despite its significance at baseline due to remodeling in right side and tricuspid valve.**

Keywords: Tricuspid regurgitation, Atrial septal defect, Tricuspid septal leaflet angle

1. Introduction

Atrial septal defect (ASD) accounts for 10% of congenital heart diseases [1]. Secundum ASD is a common type of ASD that causes shunting of blood between the systemic and pulmonary circulations [2].

While surgical repair has excellent results in the medium and long terms [3], percutaneous device closure is the preferred method in the management of the majority of secundum ASDs [4].

Functional tricuspid regurgitation (TR) often occurs in patients with ASD due to failure of tricuspid valve (TV) to properly coapt as a result of longstanding left-to-right shunting with subsequent right heart enlargement, tricuspid annular dilatation, papillary muscle displacement and tethering of tricuspid leaflets which are the main mechanisms of functional TR [4].

The aim of this study is assessment of persistent functional TR in patients with ASD before and after successful device closure and its relationship to tricuspid valve remodeling.

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2. Materials and methods

This study included 60 Egyptian patients with congenital ASD regardless to the age referred to cardiology department Tanta University for percutaneous transcatheter closure from December 2017 to December 2019.

2.1. Study approval

A) Ethics

Permission obtained from Research Ethics Committee as a part of Quality Assurance Unit in Faculty of Medicine at Tanta University to conduct this study and to use the facilities in the hospital.

B) Consent

Informed written consent was obtained from all patients after a full explanation of the benefits and risks of the study.

2.2. Inclusion criteria

Patients with secundum ASD with left to right shunt and an increased right ventricular volume overload or presence of right ventricular dilatation and suitable for percutaneous transcatheter closure, sinus rhythm.

2.3. Exclusion criteria

Primary TR, residual ASD after device closure, associated other congenital heart disease, primum and venosus type ASDs, eisenmenger's patients, bad echo window, irregular rhythm and left ventricular ejection fraction <50%.

3. Methods

All patients were subjected to the following: history including: age, sex, body surface area and symptoms suggestive of significant ASD. Full general and local cardiac examination. Twelve leads surface electrocardiography (ECG). Plain chest x-ray poster anterior view. Routine laboratory investigations: complete blood picture, International normalized ratio, clotting time, bleeding time, renal function tests,C-reactive protein and virology.

3.1. Transcatheter ASD closure

This was the first time of intervention for all patients. The main limitation of transcatheter ASD closure was either insufficient or absent either superior and posterior rims together or

Abbreviation

ASD	Atrial septal defect
CI	Confidence intervals
ECG	Electrocardiogram
ESPAP	Estimated systolic pulmonary artery pressure
FAC	Fractional area change
OR	Odds ratios
PISA	Proximal isovelocity surface area
RA	Right atrium
SD	Standard Deviation
TA	Tricuspid annulus
TAD	Tricuspid annulus diameter
TALA	Tricuspid anterior leaflet angle
TAPSE	Tricuspid annular plane systolic excursion
TEE	Trans esophageal Echocardiography
TTE	Transthoracic Echocardiography

TSLATricuspid septal leaflet angle ,TR
Tricuspid septal leaflet angle ,TRTricuspid regurgitation
2DTTETwo dimension transthoracic Echocardiography,3D
Two dimension transthoracic Echocardiography,3DThree dimension.

Inferioposterior (IVC) rim alone, so these cases were excluded from our study. The procedure was performed under general or local anesthesia using both echocardiographic and fluoroscopic guidance. TTE was used to document complete occlusion of the defect and TEE was used in some cases mostly adults. Vascular access was obtained from the right femoral vein using a 5 F or 6 F sheath, right femoral artery was accessed if needed. The same approach in the standard ways was done in all patients but in cases with deficient aortic rim modified techniques like the pulmonary vein deployment technique or left atrial roof deployment method was used especially in adults. Amplatzer devices were used in 75% of patients while Occlutech devices were used in 25% patients with size range from 12 to 38 mm. All patients received short term antibiotic and antiplatelets (for 6 months) after the procedure.

3.2. Full two dimension transthoracic echocardiography (2D TTE)

All patients underwent TTE 12–24 h before as well as 3 and 6 month after successful closure (Vivid E9, General Electric Corporation). All measurements were assessed offline by single observer and averaged from 5 consecutive cardiac cycles. Right ventricular (RV) function was measured by fractional area change (FAC), tricuspid plane annulus systolic excursion (TAPSE) and systolic velocity of tricuspid annulus ($S^{\prime}$wave). Right atrium (RA) area was measured at end-systole and RV area was measured in both end-diastole and end-systole at apical 4-chamber view [5]. The apical four-chamber, RV inflow, parasternal short-axis, and subcostal views were used for assessment of tricuspid valve, TR was measured by visual assessment of Color-flow TR jet:(trivial/mild: small, central jet– moderate: intermediate jet-severe: very large central or eccentric wall impinging jet), shape and intensity of continuous wave Doppler of TR jet signals: (trivial/mild: faint/parabolic – moderate: dense/parabolic - severe: dense triangular with early peaking), vena contracta width: (trivial/mild: less than 3 mm – moderate: 3–6.9 mm - severe: 7 mm or more) and PISA radius (trivial/mild: 5 mm or less – moderate: 6–9 mm - severe: more than 9 mm). In presence of conflicting parameters we depend on color-flow TR jet and the shape and intensity of continuous wave Doppler of TR jet signals because the results of these two parameters were nearly similar in assessment of grades of TR [6]. (Fig. 1). Estimated systolic pulmonary artery pressure (ESPAP) was calculated using the TR jet method [5]. The tenting area, tenting height, tricuspid septal (TSLA) and anterior leaflet angles (TALA) were measured in apical 4 chamber view in mid systole, tricuspid annulus diameter (TAD) was measured in the same view at an end-diastole (Fig. 2) [7].

3.3. Statistical analysis

The collected data were statistically analyzed by SPSS version 20 (IBM, Chicago, Illinois, USA). The qualitative variables were described by mean, standard deviation and range which were compared by student "*t*-test, while the qualitative parameters were described by number of frequency and percentage, and chi square or Fisher's exact test was used for data analysis. All tests of statistical significance were adopted at $p < 0.05$. Univariate and multivariate logistic regression analyses were performed to identify predictors of persistent TR after the procedure. Odds ratios (OR) are shown with 95% confidence intervals (CI).

4. Results

1) Patient characteristics:

The age of the patients ranged from 2 to 45 years. They were 30% males and 70% females. 78% were symptomatic.

2) 2D transthoracic echocardiography:

A) Echocardiographic parameters of reverse remodeling:

RA end-systolic area, RV end diastolic, RV end-systolic area Tricuspid valve (TV) tenting area, tenting height, TSLA, TALA, tricuspid annulus diameter and ESPAP were significantly decreased after 3 and 6 months post closure. As regard RV function, there was significant decrease in FAC, TAPSE at 3 and 6 months after closure also there was significant decrease S$^{/}$wave 3 and 6 months after closure but there was non-significant change after 3 months as compared to 6 months after closure (Tables 1 and 2).

B) Tricuspid regurgitation:

We demonstrated that TR was decreased significantly at 3 and 6 months after ASD closure (Table 3), but there was non-significant difference between improved and persistent TR between 3 and 6 months after ASD closure. (Table 4).

C) Predictors of persistent TR:

☒ Univariable logistic regression analysis for determinants of persistent TR at 3 and 6 months after closure:

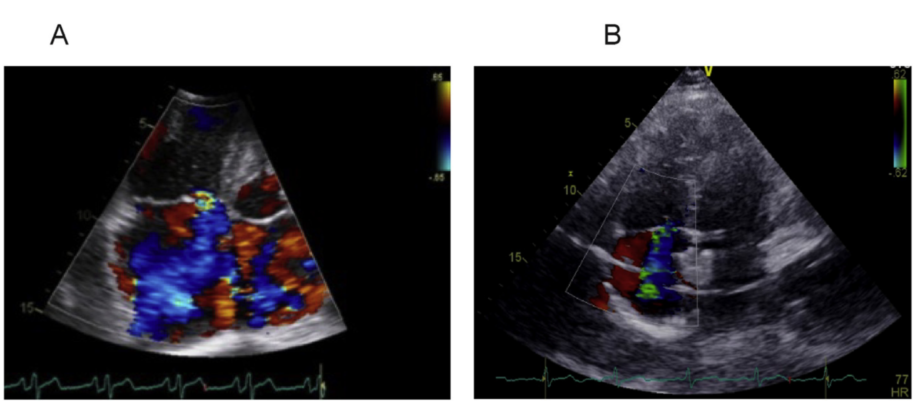

Fig. 1. Assessment of TR in patient No. (40) (A) Severe TR before closure. (B) Moderate TR at 6 months after closure.

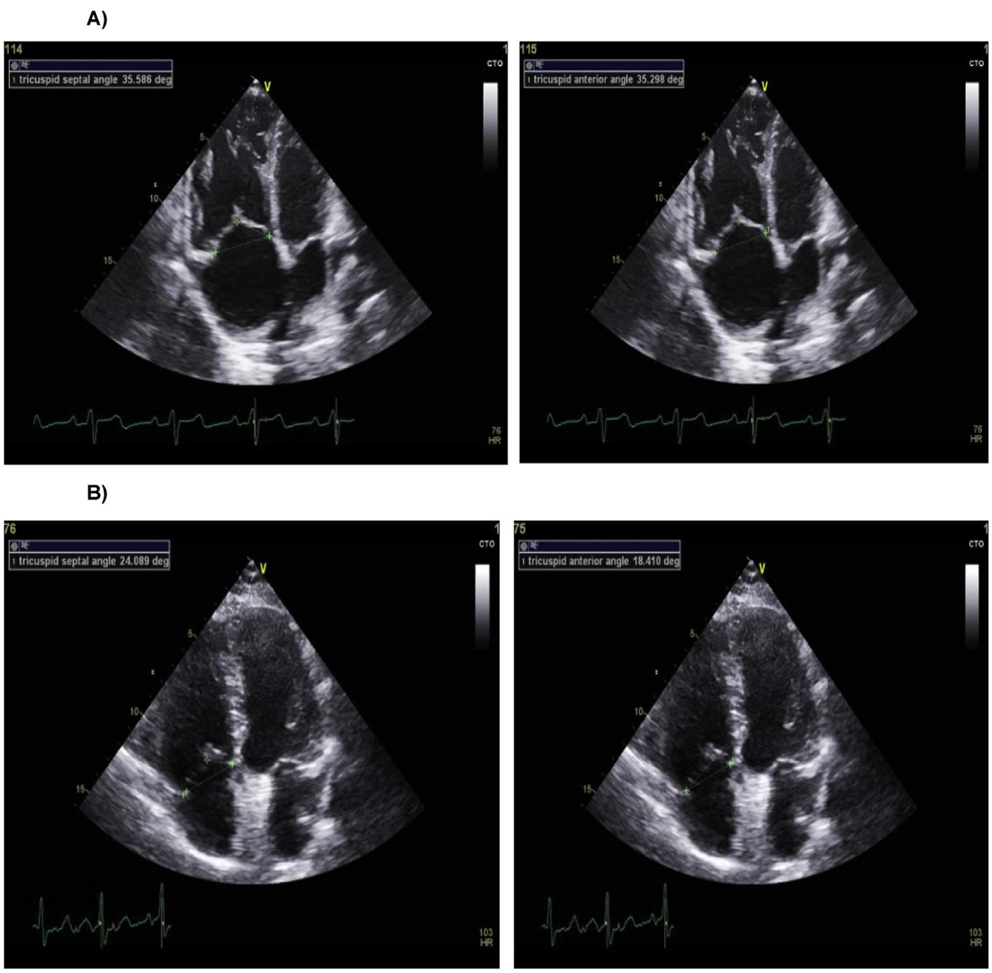

Fig. 2. Measurement of TSLA and TALA in patient No. (40) (A) TSLA and TALA before ASD closure measured 35°. (B) TSLA and TALA after 6 months of ASD closure measured 24° and 18° respectively.

The variables used were chosen based on clinical expertise, past literature and data availability. The age, ESPAP, RA end systolic area, RV end diastolic area, TV tenting area, TV tenting height, TSLA and tricuspid annular diameter were predictors of persistent TR after 3 and 6 months of closure (Table 5).

- Multivariable logistic regression analysis for determinants of persistent TR at 3 and 6 months after closure

In multivariable analysis performed using the significant variables, ESPAP, TSLA and tricuspid annulus diameter at 3 and 6 months after ASD closure were independent predictors associated with persistent TR (Table 6).

5. Discussion

The current study was done on 60 patients with congenital ASD regardless to the age undergone to percutaneous transcatheter closure. We have shown a significant decrease in RA end systolic area, RV end diastolic and end-systolic area at 3 months and 6 months post closure. In many previous studies, the results of transcatheter closure of ASD on right heart chamber size have been evaluated which were concordant with our study, **Beata Kucinska et al. 2010,** demonstrated a significant decrease in RA and RV dimensions after 24 h and 1 month after transcatheter closure of ASD [8]. Also **Vidya Sagar Akula et al.2016,** reported that RA end systolic area and RV size were decreased significantly up to 6 months after closure [9].

As regard RV function, there was significant decrease in FAC, TAPSE at 3 and 6 months after closure also there was significant decrease S′wave at 3 and 6 months after closure but there was non-significant change at 3 months as compared to 6 months after closure. **Oliver Monfredi et al. 2013,** demonstrated that FAC, TAPSE and S′wave decreased over 2 months post closure procedure which were concordant with our study [10]. **Vidya**

ORIGINAL ARTICLE

Table 1. Comparison between RA end-systolic area, RV end-diastolic area, RV end-systolic area, FAC, TAPSE and $S^{/}$wave velocity before, 3 and 6 months after closure.

Time	RA end systolic area (cm^2)						Comparison.	Differences		Paired Test	
	Range			Mean	±	SD		Mean	SD	t	P-value
Before	7.5	–	29	16.447	±	5.993	Before-After3 months	5.023	1.687	23.058	<0.001*
After 3 Months	4	–	23	11.423	±	5.007	Before-After 6 months	8.340	3.005	21.499	<0.001*
After 6 Months	3	–	19.2	8.107	±	3.634	After3-After 6 months	3.317	1.840	13.961	<0.001*
Time	RV end diastolic area (cm^2)						Comparison.	Differences		Paired Test	
	Range			Mean	±	SD		Mean	SD	t	P-value
Before	9.5	–	38.5	23.247	±	8.321	Before-After3 months	7.717	2.504	23.872	<0.001*
After 3 Months	6.1	–	30	15.530	±	6.569	Before-After 6 months	12.708	4.363	22.562	<0.001*
After 6 Months	4	–	26	10.538	±	4.657	After3- After 6 months	4.992	2.438	15.862	<0.001*
Time	RV end systolic (cm^2)						Comparison.	Differences		Paired Test	
	Range			Mean	±	SD		Mean	SD	t	P-value
Before	5.6	–	23.5	13.563	±	5.143	Before-After3 months	3.868	1.487	20.150	<0.001*
After 3 Months	3.8	–	22	9.695	±	4.325	Before-After 6 months	6.908	2.590	20.663	<0.001*
After 6 Months	2.5	–	16.6	6.655	±	2.991	After3- After 6 months	3.040	1.559	15.104	<0.001*
Time	FAC %						Comparison	Differences		Paired Test	
	Range			Mean	±	SD		Mean	SD	t	P-value
Before	39	–	46	42.033	±	1.983	Before-After 3 months	4.300	1.169	28.497	<0.001*
After 3 Months	35	–	40	37.733	±	1.191	Before-After 6 months	5.433	1.500	28.059	<0.001*
After 6 Months	35	–	39	36.600	±	0.906	After3-After 6 months	1.133	0.747	11.750	<0.001*
Time	TAPSE (cm)						Comparison.	Differences		Paired Test	
	Range			Mean	±	SD		Mean	SD	t	P-value
Before	2	–	3.5	2.718	±	0.21	Before-After 3 months	0.480	0.116	32.010	<0.001*
After 3 Months	1.7	–	2.7	2.238	±	0.21	Before-After 6 months	0.888	0.185	37.171	<0.001*
After 6 Months	1.5	–	2.2	1.830	±	0.191	After 3-After 6 months	0.408	0.114	27.762	<0.001*
Time	$S^{/}$wave (cm/sec)						Comparison.	Differences		Paired Test	
	Range			Mean	±	SD		Mean	SD	t	P-value
Before	15	–	24	18.950	±	1.899	Before-After 3 months	1.683	1.228	10.617	<0.001*
After 3 Months	12	–	22	17.267	±	2.082	Before-After 6 months	1.733	1.191	11.270	<0.001*
After 6 Months	12	–	22	17.217	±	2.100	After3-After 6 months	0.050	0.220	1.762	0.083

FAC: Fractional area change, **RA**: Right atrium, **RV**: Right ventricle and **TAPSE**: Tricuspid annular plane systolic excursion.

Sagar Akula et al 0.2016, reported that there were statistically significant decrease in FAC, TAPSE and $S^{/}$wave 1 month post closure.6 months post closure, there were no significant differences in $S^{/}$wave in comparison with 1 month post closure which is concordant with our study, but no significant differences in TAPSE and FAC in comparison with 1 month post closure which is disconcordant with our study [9].

Also tricuspid valve tenting area, tenting height, TSLA, TALA, tricuspid annulus diameter were significantly decreased at 3 and 6 months post closure. **Agustin C et al. 2020** demonstrated that, there was a significant decrease in TV annular diameter, TV tenting height and TV tenting area at 6 months and 1 year after closure [11].

We have shown that TR was decreased significantly after closure due to remodeling in right side and TV anatomy; of all 60 patients: 23.33% and 10% of patients had persistent TR after 3 and 6 months after closure respectively. Age, ESPAP, RA end systolic area, RV end diastolic area, TV tenting area, TV tenting height, TSLA and tricuspid annular diameter were predictors of persistent TR after 3 and 6 months after closure. Only ESPAP, TSLA and tricuspid annular diameter were independent predictors of persistent TR after 3, and 6 months post closure. **Chen et al. 2018**, reported significant TR reduction at 1 and 6-month after closure which is correlated with age, left atrial diameter and volume, ESPAP, RA and RV volume but only age and EPASP were independent determinants of persistent TR at follow up [12]. **Fang et al. 2015**, a significant TR reduction after 3 months post closure. RV end diastolic area, tricuspid annular diameter, tricuspid tenting area and TSLA were predictors of persistent

Table 2. Comparison between tricuspid valve tenting area, tenting height, TSLA, TALA, tricuspid annulus diameter and ESPAP before, 3 and 6 months after closure.

Time	Tenting area (cm^2)				Comparison.	Differences		Paired Test	
	Range	Mean	±	SD		Mean	SD	t	P-value
Before	0.3 – 2.8	1.187	±	0.575	Before-After 3 months	0.383	0.225	13.205	<0.001*
After 3 Months	0.3 – 2	0.803	±	0.391	Before-After 6 months	0.630	0.364	13.399	<0.001*
After 6 Months	0.2 – 1.7	0.557	±	0.260	After3 months-6minths	0.247	0.189	10.105	<0.001*
Time	Tenting height (cm)				Comparison.	Differences		Paired Test	
	Range	Mean	±	SD		Mean	SD	t	P-value
Before	0.4 – 1.6	0.797	±	0.274	Before-After 3 months	0.210	0.124	13.069	<0.001*
After 3 Months	0.3 – 1.2	0.587	±	0.183	Before-After 6 months	0.360	0.173	16.127	<0.001*
After 6 Months	0.2 – 0.9	0.437	±	0.134	After 3-After 6 months	0.150	0.083	13.938	<0.001*
Time	Annulus diameter (cm)				Comparison.	Differences		Paired Test	
	Range	Mean	±	SD		Mean	SD	t	P-value
Before	2.2 – 4.5	3.543	±	0.682	Before-After 3 months	0.580	0.178	25.195	<0.001*
After 3 Months	1.8 – 4.1	2.963	±	0.673	Before-After 6 months	0.982	0.233	32.601	<0.001*
After 6 Months	1.5 – 3.9	2.562	±	0.634	After 3-After 6 months	0.402	0.147	21.208	<0.001*
Time	Tricuspid septal leaflet angle (TSLA) (Degree)				Comparison.	Differences		Paired Test	
	Range	Mean	±	SD		Mean	SD	t	P-value
Before	22 – 48	32.883	±	6.173	Before-After 3months	7.933	3.359	18.294	<0.001*
After 3 Months	19 – 35	24.950	±	3.771	Before-After 6 months	13.833	4.698	22.807	<0.001*
After 6 Months	15 – 24	19.050	±	2.273	After 3-After 6 months	5.900	2.199	20.779	<0.001*
Time	Tricuspid anterior leaflet angle (TALA) (Degree)				Comparison.	Differences		Paired Test	
	Range	Mean	±	SD		Mean	SD	t	P-value
Before	18 – 38	24.983	±	5.014	Before-After 3 months	4.983	2.288	16.868	<0.001*
After 3 Months	15 – 29	20.000	±	3.319	Before-After 6 months	8.933	3.030	22.836	<0.001*
After 6 Months	12 – 23	16.050	±	2.727	After 3-After 6 months	3.950	1.512	20.238	<0.001*
Time	ESPAP (mmHg)				Comparison	Differences		Paired Test	
	Range	Mean	±	SD		Mean	SD	t	P-value
Before	25 – 60	41.050	±	10.355	Before-After 3 months	13.150	4.449	22.897	<0.001*
After 3 Months	15 – 48	27.900	±	9.189	Before −After 6 months	23.317	7.984	22.621	<0.001*
After 6 Months	15 – 40	17.733	±	4.317	After 3 M- After 6 months	10.167	6.641	11.858	<0.001*

ESPAP: Estimated systolic pulmonary artery pressure, TALA: Tricuspid anterior leaflet angle, TSLA: Tricuspid septal leaflet angle.

TR at 3 months post closure. Tricuspid annulus diameter and TSLA were independent predictors of persistent TR [7]. **Agustin C et al. 2020**, a significant reduction in the TR,6.8% and 12.3% at 6 and 12 months post closure, respectively. They found no differences in RV parameters between those with and without residual TR, this may suggest that longstanding preoperative remodeling of the tricuspid valve parameters were responsible for TR, with limited influence of RV changes This may also explain why persistent TR at 12 months was higher

Table 3. Pre-and post-closure TR grades in number and percentages.

TR	Before		After 3 Months		After 6 Months	
	Number	%	Number	%	Number	%
Trace	0	0.00	11	18.33	32	53.33
Mild	34	56.67	35	58.33	22	36.67
Moderate	18	30.00	14	23.33	6	10.00
Severe	8	13.33	0	0.00	0	0.00
Total	60	100.00	60	100.00	60	100.00
Chi-Square	Before-After 3 months		Before-After 6months		After 3 months-After 6months	
X^2	19.514		48.571		16.421	
P-value	<0.001*		<0.001*		<0.001*	

TR: Tricuspid regurgitation.

Table 4. Post procedural Improved and persistent TR.

TR	After 3 Months		After 6 Months		Chi-Square	
	Number	%	Number	%	X^2	P-value
Improved	46	76.67	54	90.00	2.940	0.086
Persistent	14	23.33	6	10.00		
Total	60	100.00	60	100.00		

Improved indicates (trace or mild), persistent indicates (moderate or severe).
TR: Tricuspid regurgitation.

Table 5. Univariable logistic regression analysis for determinants of persistent TR at 3 and 6 months after closure.

	TR at 3 months						T-Test	
	Improved			Persistent				
	Mean	±	SD	Mean	±	SD	t	P-value
Age (Years)	13.654	±	11.127	36.643	±	5.329	−7.442	<0.001*
Shunt size (mm)	20.087	±	7.330	22.500	±	8.112	−1.052	0.297
ESPAP (mmHg)	24.239	±	5.904	39.929	±	7.701	−8.094	<0.001*
RA end systolic area (cm^2)	9.487	±	3.556	17.786	±	3.628	−7.611	<0.001*
RV end diastolic (cm^2)	13.117	±	5.152	23.457	±	3.962	−6.899	<0.001*
Tenting area (cm^2)	0.657	±	0.262	1.286	±	0.361	−7.173	<0.001*
Tenting height (cm)	0.522	±	0.115	0.800	±	0.204	−6.507	<0.001*
TSLA (Degree)	23.696	±	2.772	29.071	±	3.751	−5.834	<0.001*
TALA (Degree)	19.826	±	3.164	20.571	±	3.857	−0.733	0.467
Annulus diameter (cm)	2.737	±	0.594	3.707	±	0.237	−5.942	<0.001*
	TR at 6 months						T-Test	
	Improved			Persistent				
	Mean	±	SD	Mean	±	SD	t	P-value
Age (Years)	16.687	±	12.747	40.000	±	3.633	−4.429	<0.001*
Shunt size (mm)	20.481	±	7.630	22.167	±	6.853	−0.518	0.607
ESPAP (mmHg)	16.759	±	2.248	26.500	±	7.994	−7.113	<0.001*
RA end systolic area (cm2)	7.481	±	2.998	13.733	±	4.281	−4.643	<0.001*
RV end diastolic (cm2)	9.820	±	4.040	17.000	±	5.215	−4.016	<0.001*
Tenting area (cm2	0.511	±	0.176	0.967	±	0.497	−4.762	<0.001*
Tenting height (cm)	0.415	±	0.105	0.633	±	0.207	−4.320	<0.001*
TSLA (Degree)	18.852	±	2.210	20.833	±	2.229	−2.082	0.042*
TALA (Degree)	16.222	±	2.786	14.500	±	1.517	1.482	0.144
Annulus diameter (cm)	2.480	±	0.601	3.300	±	0.434	−3.238	0.002*

ESPAP: Estimated systolic pulmonary artery pressure, **RA:** Right atrium, **RV:** Right ventricle, **TALA:** Tricuspid anterior leaflet angle, **TR:** Tricuspid regurgitation, **TSLA:** Tricuspid septal leaflet angle.

compared with 6 months post [11]. **Toyono et al. 2009**, they found that significant TA dilatation and leaflet tethering (concordant with our study) were predictive of persistent TR, not RV remodeling (disconcordant with our study) [13].

Table 6. Multivariable logistic regression analysis for determinants of persistent TR at 3 and 6 months after closure.

3 months	OR	95.0% C.I	P-value
Age (Years)	1.397	0.996–2.561	0.152
ESPAP (mmHg)	1.541	0.376–2.542	0.022*
RA end systolic (cm2)	1.393	0.798–2.178	0.120
RV end diastolic (cm2)	1.453	1.249–2.461	0.091
Tenting area (cm2)	0.993	0.722–1.366	0.566
Tenting height (cm)	0.641	0.376–2.542	0.471
TSLA (Degree)	1.618	1.252–2.091	<0.001*
Annulus diameter (cm)	1.575	0.820–2.536	0.010*
6 months	OR	95.0% C.I	P-value
Age (Years)	1.066	0.849–1.200	0.199
ESPAP (mmHg)	1.358	0.734–2.224	0.011*
RA end systolic (cm2)	1.084	0.309–1.805	0.900
RV end diastolic (cm2)	1.057	0.338–1.299	0.924
Tenting area (cm2)	0.515	0.337–1.796	0.121
Tenting height (cm)	0.300	0.492–1.259	0.218
TSLA (Degree)	1.138	0.995–2.078	0.043*
Annulus diameter (cm)	1.202	0.934–1.872	0.018*

C.I: confidence interval, **ESPAP:** Estimated systolic pulmonary artery pressure, **OR:** Odds ratio, **RA:** Right atrium, **RV:** Right ventricle, **TALA:** Tricuspid anterior leaflet angle, **TR:** Tricuspid regurgitation, **TSLA:** Tricuspid septal leaflet angle.

5.1. Study limitations

Our follow up period is relatively short, also we used 2D instead of 3D echocardiography to measure TV parameters while 3D echocardiography may be more accurate to evaluate TV structures.

6. Conclusion

TR significantly improved after transcatheter ASD closure despite its significance at baseline due to remodeling in right side and tricuspid valve.

Author's contribution

Marwa Desoky Abohamar: Conception and design of Study, Literature review, Analysis and interpretation of data, Research investigation and analysis, Data collection, Drafting of manuscript, Revising and editing the manuscript critically for important intellectual contents.

Medhat Mohamed Ashmawy: Conception and design of Study, Drafting of manuscript, Revising and editing the manuscript critically for important intellectual contents.

Hanan Kamel Kasem: Conception and design of Study, Literature review, Data collection, Drafting of manuscript, Revising and editing the manuscript critically for important intellectual contents.

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Conflict of interest

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