EFFECT OF SURGICAL CLOSURE OF ATRIAL SEPTAL DEFECT ON TRICUSPID REGURGITATION – A RETROSPECTIVE ANALYSIS

THESIS PROJECT

BY

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DECLARATION

I hereby declare that this thesis entitled, **"EFFECT OF SURGICAL CLOSURE OF ATRIAL SEPTAL DEFECT ON TRICUSPID REGURGITATION – A RETROSPECTIVE ANALYSIS"** has been prepared by me under the capable supervision and guidance of

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My gratitude and sincere thanks to all the patients who are the part of my study.

Last, but not the least, I express my heartiest gratitude and sincere regards to my parents and sister for their support and encouragement throughout my educational career.

Date:

Dr. Chirag S.P

Place: Thiruvananthapuram

DEDICATION

My humble effort I dedicate to my loving mother & father,

Dear mom and dad,

Many things have changed in my life over time, but your constant love, support and encouragement has never failed me. Thank you for backing my every decision, Thanks for being there always…….

Along with all hard working and respected

TEACHERS.

CONTENTS

List of abbreviations

1. ASD: Atrial Septal Defect
2. OS-ASD: Ostium secundum Atrial Septal Defect
3. RV: Right Ventricle
4. PAP: Pulmonary Artery Pressure
5. TR: Tricuspid Regurgitation
6. PAH: Pulmonary Artery Hypertension
7. PVR: Pulmonary Vascular Resistance
8. CPB: Cardio-Pulmonary Bypass
9. NYHA: Newyork Heart Association
10. TEE: Transesophageal Echocardiography
11. RA: Right Atrium
12. IVC: Inferior Vena Cava
13. VC: Vena Contracta
14. PISA: Proximal Isovelocity Surface Area
15. RVID: Right Ventricular Internal Dimension

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ORIGINALITY REPORT

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SIMILARIT Y INDEX

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STUDY PROFORMA

Preoperative details:

- Patient details: Name, age, sex, registration number, date of surgery
- Diagnosis
- History: Recurrent respiratory infections, DOE, CCF, infective endocarditis, paradoxical embolism, etc
- Medications
- Examination: auscultation, any other
- Echo: ASD, RA-RV volume overload RVID, RVSP, TR, TAPSE, direction of ASD shunt, any other associated anomalies.

- Intraop echo: TEE – Severity of TR, RVID, PAH

Surgical details:

- Ostium secundum ASD closure
- Tricuspid valve repair
- Any other complication

Post-CPB details:

- Echo: Residual ASD, TR, PAH, RVID

Postoperative:

- Hemodynamic parameters
- Reexploration/ Any complication

OPD FOLLOW UP

I st visit (3 months)- Echo findings

Physical examination

2 nd visit (1 year) Echo findings

Physical examination

INTRODUCTION

Atrial septal defect (ASD) is one of the most commonacyanotic congenital heart defect just next to bicuspid aortic valve. Its incidence is approximately 1 per 1500 live births and it constitutes 10-20% of total congenital heart diseases. ASDs are mainly classified as ostium secundum ASDs(OS-ASD), Sinus venosus ASDs and Ostium primum ASDs. OS-ASDs are the commonest accounting for 75% of all ASDs, in which 30-40% are presented in adult age group.[1] Ostium secundum is a normal feature in fetal atrial septum which helps in shunting of oxygenated blood from maternal placenta via fetal umblical vien , righ atrium to left atrium and finally into the fetal systemic circulation, after birth once neonatl lungs takes over respiratory function left atrial pressure builds up and ostium secundum which is bordered by limbus (septum secundum) gets fused with septum of foramen ovale (remnant of septum primum), failure of this mechanism leads to persistence of OSASD.[2,3] It is a acyanotic defect with left to right shunting, due to presence of high pulmonary vascular resistance shunting will not be prominent in early part of life, as the pulmonary vascular resistance fall within few months of birth, shunting will gradually predominate, That's why early neonatal or pediatric general workup have high tendency to miss the diagnosis as these individuals are asymptomatic with subclinical signs. As per natural history of atrial septal defects most of this defect tend to close spontaneously by 3-6 years , Hence even early diagnosis may go neglected expecting spontaneous closure. Due to right ventricular compliance this shunting is hemodynamically very well tolerated which keeps most of patients asymptomatic until their adulthood.[4] This shunt volume across ASD depends upon relative right ventricular

compliance, size of the defect and atrial pressure difference. Long term hemodynamic consequences include right ventricular (RV) volume overload and pulmonary over circulation. A significant left to right shunt across ASD leads to pulmonary hypertension which further increases pressure load on RV in addition to volume overload initiating right ventricular remodelling, which includes increase in RV dimensions with RV dilation and hypertrophy, this further stretches tricuspid annulus leading to non coaptation of leaflets and functional tricuspid regurgitation. This in turn, causes more volume load on RV and thus forms a vicious cycle, i.e more RV volume begets more volume. Majority of adult patients develop symptoms of reduced functional capacity and shortness of breath beyond the fourth decade of life. [5,6]

Echocardiography is the diagnostic modality of choice for quantification of ASD size and its hemodynamic consequences i.e RV volume overload, pulmonary artery pressure (PAP) and tricuspid regurgitation (TR). Latest European Society of Cardiologists (ESC) guidelines state that defects causing significant shunt with Pulmonary vascular resistance < 5 wood units or PAP less than two third of systemic pressure require surgical intervention. The literature mentions about prognosis of surgical closure of ASD in adulthood which is less favorable as compared to pediatric population due to persistence of hemodynamic sequelae. Previous studies have documented the persistence of residual pulmonary hypertension and tricuspid regurgitation after surgical repair of ASD without addressing tricuspid valve which led to reduced exercise tolerance in the postoperative period.[8,9,10] However, there are handful of studies to demonstrate the long term benefit of isolated ASD closure which causes reverse remodelling of right ventricle and fall in pulmonary arterial pressure(PAP) which in turn reduces the grade of

TR in long term. Some studies mention better outcomes in patients who underwent tricuspid annuloplasty in addition to patch closure of ASD for resolution of significant TR, but conclusive results are yet to be determined. Although there is a general consensus for a better outcome if ASD is operated before 25 years of age but the debate regarding benefit of tricuspid annuloplasty still continues. [23]

REVIEW OF LITERATURE

Ostium secundum atrial septal defects are the common type of ASDs with a incidence of 560 per million live births, It is a defect in fossa ovalis which constitutes 28% of the normal atrial septum, in fetal life placental oxygenated blood shunts from right heart to left heart through this ostium secundum, but after birth once neonatal lung takes over function of oxygenation and left atrial pressure raises and causes closing up of shunting by flap valve mechanism of septum secundum over septum primum. Persistence of this defect postnatal can be due to shortening of the valve of the foramen ovale, excessive resorption of the septum primum, or deficient growth of the septum secundum. Spontaneous closure of this defect is also noted, but its incidence declines from about one third during the first three decades of life to about one quarter during the fourth through eighth decades.[4] Due to gradual fall in pulmonary resistance and complaint nature of right ventricle, clinical picture of this defects with left to right shunt gets hidden until later age group. They are asymptomatic and have subtle clinical findings, 20-40% of this patients present at their adult age.[5,6]

In a natural history, with left to right shunt volume overload over RVand increase in pulmonary blood flow leading to changes in pulmonary vasculature and further right ventricular remodeling which includes right ventricular dilation, annular dilation, reduction in tricuspid valve coaptation surfaces leading to tricuspid insufficiency, further volume overload causes interventricular septal bulge into left ventricle causing fall in stroke volume further leading to cardiac failure, later once pulmonary vascular resistance

suprasystemic eisenmengerisation sets in with shunt reversal increasing rate of morbidity and mortality.[7,8]

Hansing CE et al studied the hemodynamics and pathogenesis of TR, based on their angiographic studies in 100 patients, they concluded over distended right side of heart is a causative factor for tricuspid insufficiency and this retrograde escape of blood from right ventricle serves as safety mechanism in preventing progressive overload of pulmonary circulation.[9]

Surgical ASD closure in adults had showed reassuring outcomes, for example Murphy et al in his study on long term outcomes after surgical repair of isolated ASDs included 123 patients and followed up for 30 years and concluded patients who were operated at or before 25 years have excellent prognosis, though older patients required more careful and regular supervision.[10]

Closure of ASD causes reverse remodeling in RV in terms of decrease in RV diameter, Kort et al studied among 38 patients with atrial septal defects, the right atrial and RV volume were measured before closure, then immediately post procedure at 24hrs, followed by 3-6 months and at 12 months using transthoracic echocardiogram and found to have significant regression in right ventricular dimensions.[11] Similarly Gosh et al in their retrospective analysis of 89 patients, whose age above 35 years, and compared the outcome in patients of 35-50 years with >50 years and concluded ASD closure in adults can improve clinical status and prevent RV dilation, but this benefits were pronounced in younger patients when compared with older age group.[12] Berbarie et al measured RV volumes before and after closure of ASD in 10 patients using multi slice CT and showed significant regression in right ventricular volume post procedure at the end of 3 months,

this study group included both device and surgical closure of ASD.[13] Abnormal RV size and ventricular septal motion were found in some patients following ASD closure, Pearlman et al demonstrated this finding in his study using echocardiogram and catheter based studies which included 31 patients with dilated RV and their study showed no correlation with pre operative RV dimensions, but patients presented at older age group tend to have this persistence of RV dilation even after closure of shunt.[14] Attenhofer et al in his study on remodeling after surgical repair of ASD, analyzed 101 adult patients with mean age of 35 years found persistence of right heart dilation in their study group is due elevated levels of brain natriuretic peptide.[15] Pulmonary arterial hypertension (PAH) tend to regress along with RV reverse remodeling following closure of ASD, Salehi et al in his retrospective analysis of 96 patients with patients above 40 years showed significant regression in PAH and decrease in RV diameter following surgery, along with improvement in functional status.[16] Studies by Zabala et al and Ruiz et al concluded, pulmonary pressure and RV size overrides the short circuit from left to right and the volumetric overload of the RV.[17,18] Consequently, pulmonary pressure and the size of the RV must be reduced following closure of an ASD surgically or by percutaneous procedure. But study by Liberthson et al included 20 adult patients with ASD and gated cardiac blood pool scanning were evaluated along with correlation of pre and post operative clinical findings and cardiac catheter based data, mean age group of 25 years and followed up for 6 month, found younger patients with low grade of PAH showed regression in RV dimension improvement in RV function and resolution of PAH, but older patients with higher PAH though showed mild to moderate RV dysfunction post operatively, decrease in RV diameter along with improvement of functional status were

noted.[19] Similarly Maatouk et al studied 102 patients with age group ranging from 1-62 years, where 34 patients were above 20 years showed regression in RV dimension in most of patients who underwent surgical closure of ASD but persistence of dilated RV was noted in patients above 40 years and PAH above 40mmHg at the time of surgery.[20]

Resolution of TR post ASD closure still continues to be a debate, studies have shown significant reverse remodeling remodelling post closure. Humenberger et al in his study about impact of age on benefit of ASD closure evaluated 236 patients with mean age of 49 years and concluded ASD closure at any age is followed by symptomatic improvement and regression of PAP and RV size and also reduction in degree of TR.[21]Jemielity et al retrospectively analyzed 76 patients whose age ranged between 40-62 years, pre and post operative follow up studied showed post ASD closure regression in RV dimension, reduction in PAP, though 10 among 37 required tricuspid valve repair, all showed significant reduction in TR at the end of their follow up.[22] Jose M Oliver et al in their study of 280 patients, noted association between TR and ASD, frequently found in adults, etiology more likely to be result of hemodynamic changes in RV, annular dilation and mechanical dysfunction of subvalvular apparatus.[23] They noted degree of TR is greater in patients above 25 years when compared with younger age group, Their study showed better regression of PAP and RV dilation in patients who underwent surgery before 25 years and also showed degree of TR was similar among patients who underwent surgery after 25 years and those adult patients who did not undergo surgery. Hanseus and Oliver et al, in their studies on cross sectional echocardiographic measurement of right atrial and right ventricular size in ASD before and after surgery showed relative increase in pulmonary pressure ie. RV after load in patients who undergo

surgery after 25 years of age due to,

Presence of an increase in arteriolar pulmonary resistance that persists after surgery or by increase in passive resistance due to elevation of pressure in the left atrium and pulmonary capillary, or else decrease in the elastic properties of the pulmonary arteries caused by chronic dilatation and concluded residual dilatation of the RV in the absence of a volume overload also indicates an increase in afterload and a decrease in systolic function. Persistent RV dilatation causes geometric changes that tend to be progressive and can affect the competence of the tricuspid valve and interact with the function of the left ventricle. Study by De Meester et al evaluated 25 patients who underwent ASD closure and concluded TR post operatively found more frequently in older patients and in patients with higher mean PAP.[24]Chandraratna et al study mentions about persistence or further worsening of TR in post ASD closure may be due to increase in leaflet prolapse of tricuspid valve. [25]

In adult patients with ASD, following RV remodeling and presence of PAH present with significant grade of TR , there are conflicting studies on this issue weather tricuspid valve to be addressed surgically at the time of ASD closure or just ASD closure will suffice. Shigenobu et al in their study among 13 patients concluded tricuspid valve repair should be performed for the patients with significant tricuspid insufficiency at the time of surgical closure of ASD.[26] A study on persistent TR in adults after closure of ASD by Tonoyo et al included 32 patients in their study group, they showed only PAP of more than 60mmHg predicted persistent TR with 100% sensitivity and 63% of specificity and concluded corrective surgery for tricuspid valve should be considered at ASD closure in adult patients with moderate or severe tricuspid regurgitation and concomitant PAH.[27]

Fang et al studied predictors of mid term functional tricuspid regurgitation after device closure of ASD in 64 patients and followed up for 3 months, they measured tricuspid valve parameters using echocardiogram and concluded nearly half of their patients who underwent closure had TR post procedure and it is related to excessive preoperative remodeling in tricuspid valve rather than changes in RV, Hence this study recommends indirectly that TR in adult ASD is due pathological process in valvular apparatus and alarms need for its surgical correction rather than correcting the primary pathology and waiting for TR to settle on its own gradually while RV modeling ensues.[28] Maltais et al in their study, 83 patients were assessed for effects on tricuspid regurgitation on RV remodeling, patients were followed up for 30 days following tricuspid valve repair and concluded a concomitant tricuspid valve procedure effectively reduces TR and promotes reverse remodeling of RV. Sugimoto et al in their study on long term evaluation of functional TR showed significant correlation between tricuspid annular diameter and tricuspid regurgitant jet velocity in patients with atrial septal defect preoperatively and concluded stating functional TR is originated by RV pressure or volume overload, Development of TR causes volume overload on RV by TR itself along with dilation of tricuspid annulus, though TR grade reduced following ASD closure in most of adult patients, but patients with tricuspid annular diameter of more than 50mm require tricuspid valve repair for better long term outcomes and reverse RV remodeling.[30] Jang et al studied outcomes of significant TR after closure of ASD in adults. Their retrospective study involved 223 patients with mean age of 50 years and followed up for 1 year and concluded significant TR may decrease after ASD closure without tricuspid annuloplasty, but a combined tricuspid annuloplasty helps to prevent remnant of TR.[31] According to the

Society of Thoracic Surgeons, Tricuspid valve surgery is a valve operation with the highest operative risk. Bernal reported a hospital mortality of 35.1% in patients undergoing reoperations on the TV. The current ESC-guidelines recommend TV surgery in patients with severe TR (class I, Level C) and in patients with mild or moderate secondary TR, with an annulus ≥40 mm or 21 mm/m2 in the echocardiographic four-chamber view at the time of surgery. It is further stressed that that additional TV surgery does not elevate the operative risk). According to the guidelines of the American College of Cardiology (ACC) and American Heart Association (AHA), concomitant TV surgery for patients who have less than severe TR, PAH or tricuspid annular dilatation, is a Class IIb, Level C indication.[33]

There are limited articles and studies mentioning regarding tricuspid insufficiency association in adult ASD patients more commonly functional type, due to annular dilation as a consequence of right ventricular dilation and pulmonary arterial hypertension. Our focus of study to observe the resolution of tricuspid regurgitation following isolated ASD closure who had severe to moderate and moderate grades of TR at the time of surgery and need for tricuspid valve surgery is evaluated.

AIMS & OBJECTIVES:

Primary objective:

1. To study the resolution of tricuspid regurgitation following OSASD surgical closure in adult patients.

Secondary objective:

1. To study the change in RV dimensions and pulmonary arterial hypertension following OSASD surgical closure in adult patients.
2. To study the development of any new symptom upto 1 year following OSASD surgical closure in adult patients.

MATERIALS AND METHODOLOGY

Retrospective, single-center, observational case series at atertiary referral center (SCTIMST), which included patients operated for OSASD in our institute between, January 2010 to January 2015.

Inclusion criteria:

Patients with

1.OS ASD with no other congenital/acquired cardiac disease with TR.

2. Age group above 13 years.

Exclusion criteria:

Cases where

1. OSASD was associated with other complex congenital or severe valvular heart diseases requiring surgical address.
2. Age group < 13 years.

➢ After obtaining permission from IEC, data including TR status, RV dimensions, PAH in follow up echos with immediate post op, 3 months & 1 year follow up, were collected from the medical records of patients along with their clinical status in terms of functional class (NYHA) & evaluated by principle investigators or co-investigators. Patient details were kept confidential & data analyzed.

After complete evaluation & confirmation of diagnosis, with isolated OSASD and with significant TR ranging from moderate to severe grade were planned electively,

angiogram done in patients with severe PAH also had surgically acceptable PVR. Our patients more commonly had standard midline or thoracotomy approach, pericardium harvested, aorto-bicaval cannulation, on total bypass after arresting heart with root antegrade cardioplegia and topical cooling for myocardial protection, Right atrium opened after assessing anatomy, OSASD was repaired with tanned pericardial patch using continuous prolene sutures. TR status was assessed pre CPB by transesophageal echocardiogram and end result was also studied after termination of CPB along with estimation RV dimensions and PAH. Transthoracic echocardiogram were carried out before discharge, at 3 months and at end of 1 year and documented in patient's records along with their functional class using NYHA classification based on symptoms and clinical findings on OPD basis and compared with pre operative transthoracic echo reports.

Echocardiographic grade of regurgitation

0 = absent

1 = trivial

2 = mild

3 = moderate

4 = severe

Any patient with severe TR or organic type of TR undergo surgical repair along with ASD closure in our institution, Hence excluded from our study population.

Some echo reports read TR4+ and TR3+ in same patients evaluated at different time periods pre operatively, those patients were revaluated with transesophagial echo at the time of surgery and if found to be less than TR4+, they are considered to be TR3-4+ and isolated ASD closure is carried out. This modification is done to optimize the interobserver differences in our study group. Similarly in our follow up period, patients found to have more than 3+ of TR were revaluated and patients with such doubtful findings between TR3+ and TR4+ were categorized as TR3-4+.

Table 1: Severity of pulmonary hypertension *(mean PAP)*

Mild	=	25-40mmHg
Moderate	=	41-55mmHg
Severe = > 55mmHg		

The American Society of Echocardiography published reference ranges for the apical four-chamber RV end-diastolic and end-systolic area are 11 to 28 cm^2 and 7.5 to 16 cm^2respectively as shown in Table 2.

Table 2 : Right Ventricular Size and Function

Reference limits and partition values of right ventricular size and function as

measured in the apical 4-chamber view				
	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
RV diastolic area, cm^2	11–28	29–32	33–37	≥38
RV systolic area, cm^2	7.5–16	17–19	20–22	≥23
RV fractional area change, %	32–60	25–31	18–24	≤17
TAPSE, (cm)	1.5-2.0[2]	1.3-1.5[4]	1.0-1.2[4]	<1.0[4]

- **RV, Right ventricular.**
- **TAPSE, tricuspid annular plane systolic excursion**

Table 3: Severity of Tricuspid regurgitation

Echocardiographic and Doppler parameters used in grading tricuspid regurgitation severity

Parameter	Mild	Moderate	Severe
Tricuspid valve	Usually normal	Normal or abnormal	Abnormal/Flail leaflet/Poor coaptation
RV/RA/IVC size	Normal*	Normal or dilated	Usually dilated
Jet area-central jets (cm^2)§	< 5	5-10	> 10
VC width (cm)Φ	Not defined	Not defined, but < 0.7	> 0.7
PISA radius (cm)ψ	≤ 0.5	0.6-0.9	> 0.9
Jet density and contour–CW	Soft and parabolic	Dense, variable contour	Dense, triangular with early peaking
Hepatic vein flow	Systolic dominance	Systolic blunting	Systolic reversal

STATISTICAL ANALYSIS

Categorical and quantitative variables were expressed as frequency (percentage) and mean ± SD respectively. Comparison of TR and PAH at different time interval was carried out using Friedman Testand Wilcoxon Signed Rank Test. Comparison of RVID at different time interval was carried out using Repeated measure ANOVA and post hoc test. Association of TR and PAH with age was carried out using Kruskal Wallis Test and Mann-Whitney U Test. Association of RVID with age was carried out using One way ANOVA test and Scheffe Multiple Comparisons (post hoc test). P value less than 0.05 was considered the threshold for statistical significance. Statistical analysis was performed by using a statistical software package SPSS, version 17.0.

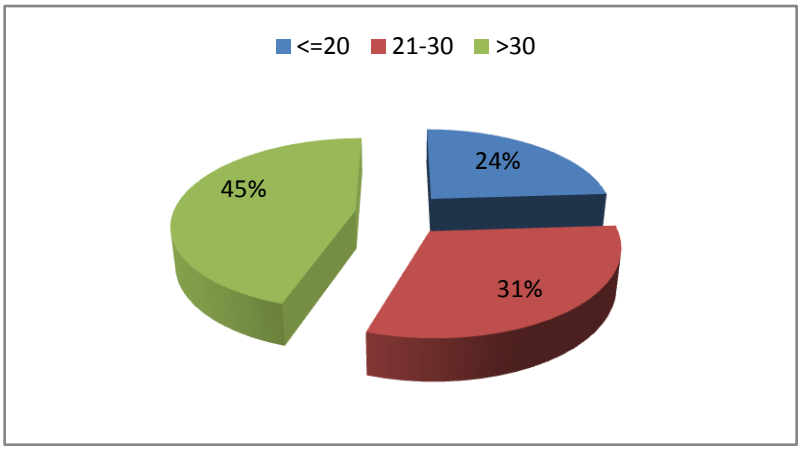
RESULTS AND OBSERVATION

In our retrospective observational study, total of 97 patients met our inclusion criteria, none of them were drop outs in our follow up time period of January 2010 to September 2015.Mean age was 32.3±13.2, with a range of 13 to 65 years. To evaluate effect of age of presentation on post op follow, patients were grouped as <20 years with 24%, 21-30 years with 31% and >30 years with 45% of patients, as showed in table 4 and fig.1

Table 4: Percentage distribution of the sample according to age

Age (Years)	**Count (n)**	**Percent %**
<=20	23	24.0
21 – 30	30	31.0
>30	44	45.0
Mean ± SD	32.3 ± 13.2	

Fig.1 Percentage distribution of the sample according to age

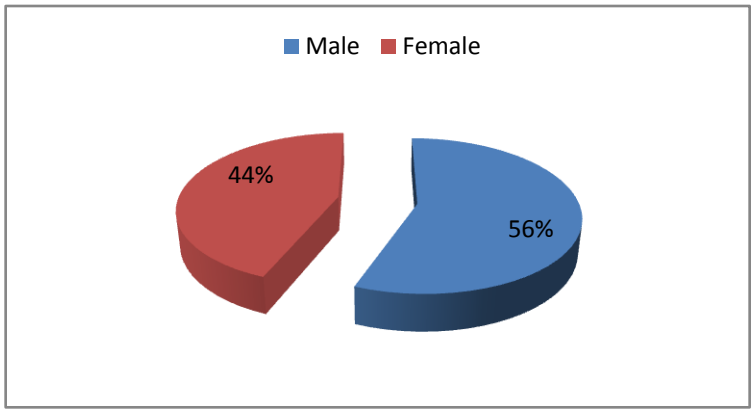


There were 54 females (56%) and 43 males (44%) in the study group, as showed in table 5 and fig.2

Table 5: Percentage distribution of the sample according to sex

Sex	Count (n)	Percent%
Male (n)	43	44.0
Female (n)	54	56.0

Fig. 2 Percentage distribution of the sample according to sex



Echocardiographic evaluation conducted at immediate post op, at 3 months and 1 year were compared with pre op echocardiography findings in terms of TR, PAH and RV dimension.

At the time of surgery 75 (77%) patients had moderate TR(3+) and 22(23%) had moderate to severe TR(3-4+) as per echocardiographic pre op evaluation.

Immediate post op echocardiography showed regression of TR in 15% of patients to TRO, 31% to trivial and 30% to mild grade TR, with 15% remained moderate(3+) and 9% (T3-4+).

After 3 months follow up study showed further regression in TR was noted, which showed 25% with TR(0), 28% with TR(1+), 36% with TR (2+), 7 % with TR(3+), 4% with TR (3-4+).

At the end of 1 year 32% regressed to TR(0), 34% had TR(1+),27% had TR(2+), 3% had TR(3+) and 4% remained with TR(3-4+) .

With the use of Friedman test and Wilcoxon signed rank test, statistically significant regression of TR severity after surgery was noted in their immediate post op, at three months and 1year follow up echo cardiographic studies. As per table 6.

While comparing rate of regression between before surgery and immediately after surgery, 76% of patients had less than moderate TR ie. Nil-mild grade, which is statistically significant with p value <0.001. When compared at 3 months of follow up 89% of patients had less than moderate TR, with p value: <0.001, On comparison at 1 year 93% regressed from moderate TR, with p value <0.001 & it is statistically significant. Further comparison between immediate post op and after 3 months echocardiography showed statistically significant regression in TR among 45% of patients. Similar results were found at the end of 1 year.

When compared between 1year & 3months follow up 36% patient showed further regression from moderate TR and found to be statistically significant. Rate of regression is high in immediate post op period though continues to regress further at 3 months and 1year.

Table 6: Comparison of TR at different time interval

TR	Nil	Trivial	Mild	Moderate	Severe	χ^2\$	p
Before surgery n (%)	0 (0)	0 (0)	0 (0)	75 (77)	22 (23)	215.45**	**0.000**
Immediately after surgery n (%)	15 (15)	31 (31)	30 (30)	15 (15)	9 (9)		
3 months after surgery n (%)	25 (25)	28 (28)	36 (36)	7 (7)	4 (4)		
1 year after surgery n (%)	32 (32)	34 (34)	27 (27)	3 (3)	4 (4)		

\$ Friedman Test **: - Significant at 0.01 level

Before surgery Vs Immediately after surgery Z# = 7.89, p = 0.000

Before surgery Vs 3 months after surgery Z# = 8.45, p = 0.000

Before surgery Vs 1 year after surgery Z# = 8.58, p = 0.000

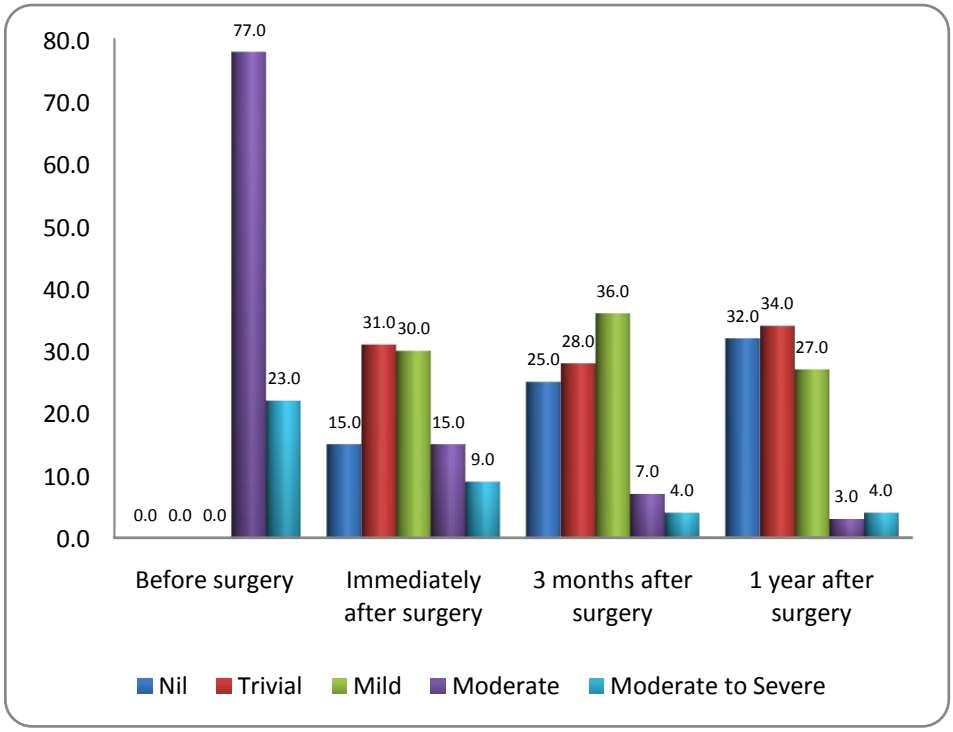
Immediately after surgery Vs 3 months after surgery Z# = 4.59, p = 0.000

Immediately after surgery Vs 1 year after surgery Z# = 5.55, p = 0.000

3 months after surgery Vs 1 year after surgery Z# = 3.06, p = 0.002

Wilcoxon Signed Rank Test

Fig. 3 Comparison of TR at different time interval



Patients with significant TR are grouped as A &B where A were moderate TR(3+) and B with moderate-severe grade(3-4+), at the end of one year only 1% of the patients remained with moderate TR, where in Group B 9% patients regressed to moderate grade and 18% remained to be in their pre operative TR grade of 3-4+ without worsening, as shown in table 7.

Table 7: Shows division of patients in two groups based on pre-operative grade of TR and their subsequent follow-up assessment at 1 year after ASD closure

Pre-operative Groups n	**Post-operative Grade of TR n (%)**				
	0	**1+**	**2+**	**3+**	**3-4+**
Group A – 75	26 (35)	29 (39)	19 (25)	1 (1)	
GROUP B – 22	4 (18)	5 (23)	7 (32)	2 (9)	4 (18)

Group A: moderate TR (3+); Group B: moderate-severe TR (4+)

Abbreviations: TR, tricuspid regurgitation; ASD, atrial septal defect

Group A shows statistically significant improvement in grade of TR (P value =0.000)

* *p value by McNemar test*

At the time of surgery all patients from 13-30 years had moderate TR and 50% of patients above 30years had moderate TR and remaining 50% had moderate-severe TR(Fig 4). Comparison of effectiveness of intervention on TR based on age of patient shows regression of TR to 0 in 54.2% in age group <20 years, 31.3% in age group 21-30 years and 20.5 % in age group >30 years. Patients with trivial TR had age distribution of 20.8% in below 20yrs, 46.9% in patients between 21-30 years, 31.8% in patients above 30years. Mild degree of TR in 25% of patients below 20 years, 18.8% in patients between 20-30years, 34.1% in age group above 30 years. Moderate degree persisted in 3.1% in age

group of 21-30 years and 4.5% in patients with age above 30 years. Moderate to severe TR found in age group above 30 years constituting 9.1% of total population. Showing statistically significant regression in TR in patient age group of <20 years compared with age group >30 years, using Kruskal Wallis test & Mann Whitney U test. As shown in table 8& figure 5.

Table 8:Comparison of effectiveness of ASD closure on TR based on age of patient

TR	**Age (Years)** **<=20**		**21 - 30**		**>30**		**χ^2\$**	**p**
	Count	Percent	Count	Percent	Count	Percent		
Nil	13	54.2	10	31.3	9	20.5	14.25**	0.001
Trivial	5	20.8	15	46.9	14	31.8		
Mild	6	25.0	6	18.8	15	34.1		
Moderate	0	0.0	1	3.1	2	4.5		
Severe	0	0.0	0	0.0	4	9.1		

$Kruskal Wallis Test

<20 Vs 21-30 Z# = 1.12, p = 0.261

<20 Vs >30 Z# = 2.77**, p^* = 0.006

21-30 Vs >30 Z# = 2.18**, p^* = 0.030

Mann-Whitney U Test **: - Significant at 0.01 level, *: - Significant at 0.05 level

Fig. 4Comparison of effectiveness of intervention on TR before surgery based on age of patient

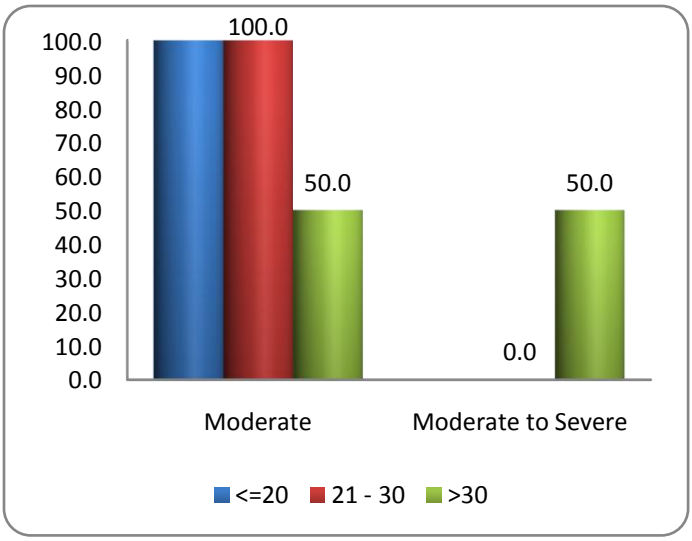
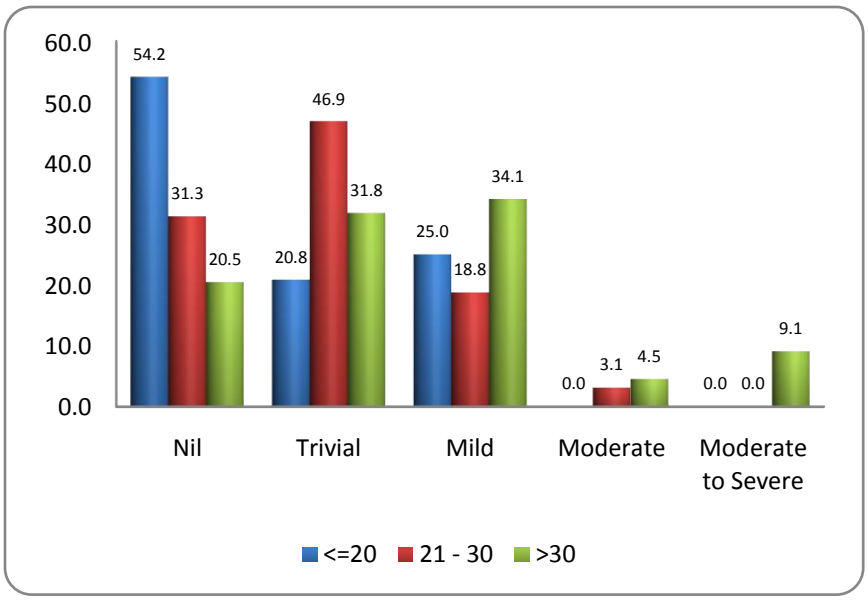


Fig 5. Comparison of effectiveness of intervention on TR based on age of patient at the end of one year follow up



Echocardiographic estimation of PAH before surgery was compared with immediate post op surgery, at 3months and 1 year. At the time of surgery 32% of patients had severe PAH, 27% with moderate , 39% with mild & only in 2% there was no PAH. Immediately after surgery only 14% remained with severe PAH, at the end of 3 month follow up showed reduction in number of patients with severe PAH to 10%, finally after 1 year only 2 % of patients had severe PAH, with p value <0.001, which is statistical significant as per Friedman test & Wilcoxon signed rank test. Even when compared between 3months follow up and 1 year follow up, significant regression of PAH was found. It is depicted in figure 6, table 9.

Table 9: Comparison of PAH at different time interval						
PAH	Nil	Mild	Moderate	Severe	χ^2\$	**p**
Before surgery	2 (2)	39 (39)	27 (27)	32 (32)	157.3**	**0.000**
Immediately after surgery	6 (6)	42 (42)	38 (38)	14 (14)		
3 months after surgery	43 (43)	29 (29)	18 (18)	10 (10)		
1 year after surgery	**52 (52)**	**26 (26)**	**20 (20)**	**2 (2)**		

\$ Friedman Test

Before surgery Vs Immediately after surgery Z# = 3.25**, p = 0.001

Before surgery Vs 3 months after surgery Z# = 7.38**, p = 0.000

Before surgery Vs 1 year after surgery Z# = 8.21**, p = 0.000

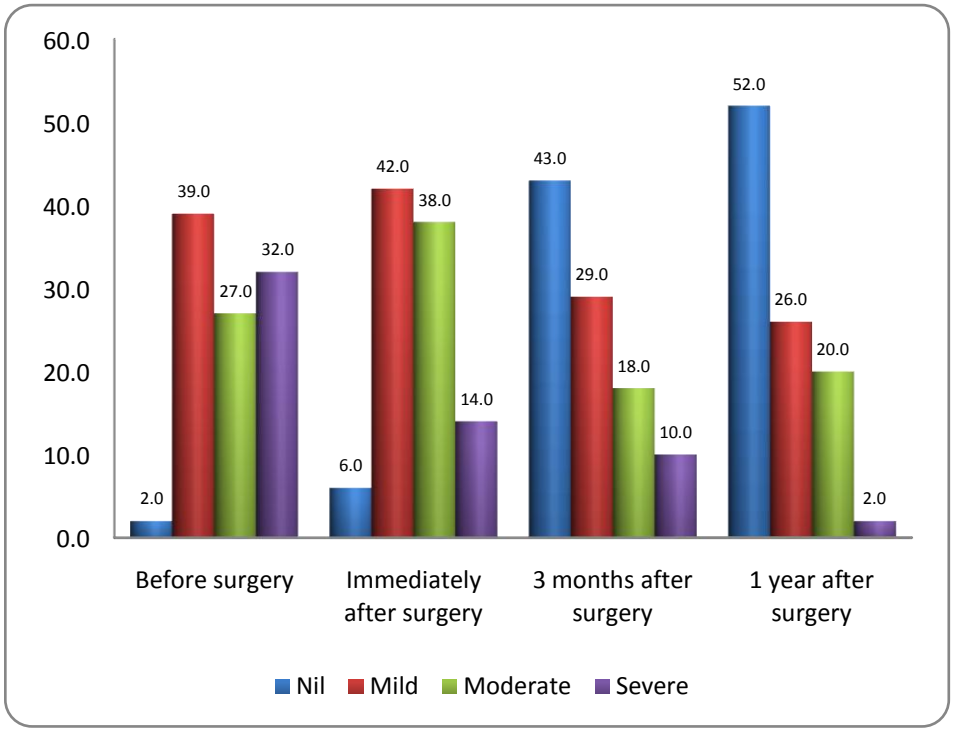
Immediately after surgery Vs 3 months after surgery Z# = 5.65**, p = 0.000

Immediately after surgery Vs 1 year after surgery Z# = 7.08**, p = 0.000

3 months after surgery Vs 1 year after surgery Z# = 4.6**, p = 0.000

Wilcoxon Signed Rank Test **: - Significant at 0.01 level

Fig 6. Comparison of PAH at different time interval



At age less than 20 years had no PAH among 8.3% of patients, 66.7% were noted to be mild, 16.7% to be moderate and 8.3% to be severe. In age group between 20-30 years, 37.5% with mild grade, 43.8% were moderate and 18% were severe. Similarly in patients above 30 years 25% were with mild PAH, 20.5% with moderate and 54.5% with severe PAH(Fig 7). Regression of PAH estimated based on age of presentation, among patients with age group <20 years 19(79.2%) regressed to no PAH, 4(16.7%) had mild PAH, 1(4.2%) with moderate PAH, and none remained in severe PAH. Similarly among age group 21-30 years, 18(56.3%) had no PAH, 8(25%) with mild PAH, 6(18.8%) continued

to have moderate PAH and none with severe PAH. Among patients with age group >30yrs 15(34.1%) regressed to no PAH, 14 (31.8%) to mild PAH, 13(29,5%) with moderate PAH and 2(4.5%) remained with severe PAH. Our study showed statistically significant fall in PAH in younger age group with p value <0.01 as per Mann-whitney u test and is shown in table 10 and fig 8.

Table 10. Comparison of effectiveness of intervention on PAH based on age of patient

PAH	**<=20**		**21 – 30**		**>30**		**χ^2\$**	**p**
	Count	Percent	Count	Percent	Count	Percent		
Nil	19	79.2	18	56.3	15	34.1	9.54**	0.008
Trivial	4	16.7	8	25.0	14	31.8		
Mild	1	4.2	6	18.8	13	29.5		
Moderate	0	0.0	0	0.0	2	4.5		

$Kruskal Wallis Test

<20 Vs 21-30 Z# = 1.9, p = 0.057

<20 Vs >30 Z# = 3.65**, p = 0.000

21-30 Vs >30 Z# = 2.02*, p = 0.043

Mann-Whitney U Test **: - Significant at 0.01 level, *: - Significant at 0.05 level

Fig. 7 Comparison of effectiveness of intervention on PAH before surgery based on age of patient

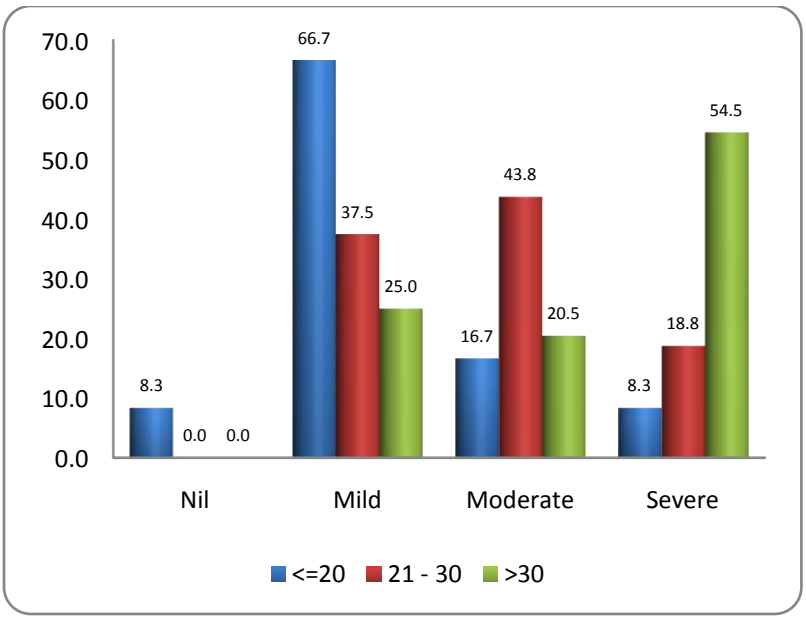
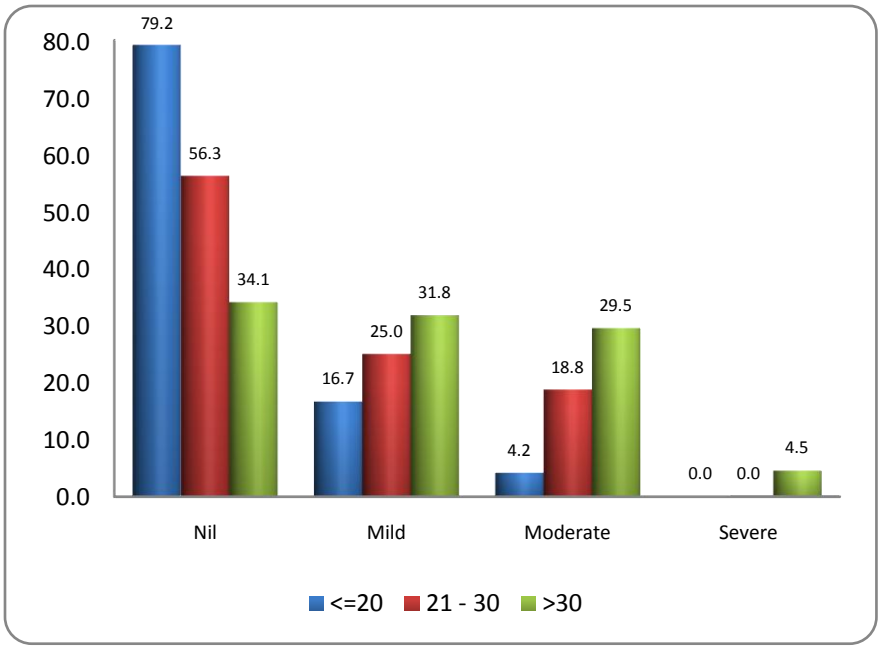


Fig. 8 Comparison of effectiveness of intervention on PAH based on age of patient at end of one year

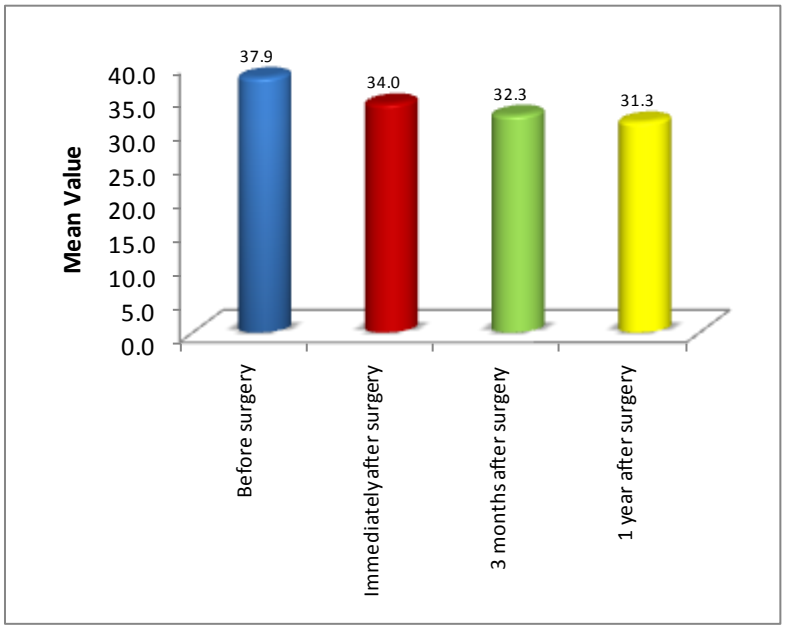


Right ventricular internal diameter measured in millimeters at the time of surgery using echocardiography is compared with measurements immediate post operative, follow up at 3 months and at 1 year. Before surgery RVID measured with a average of 37.9mm , with range 28mm-50mm. Immediate post operative findings showed a mean of 34 mm with standard deviation of 5.5, at 3 months 32.3 mean with standard deviation of 5.3, at the end of one year mean right ventricular dimension is 31.3 with standard deviation of 5.4. When compared with pre op and immediate post dimensions, regression showed statistically significance with p value <0.01 similar when compared with three months and 1 year follow up echocardiographic studies. Statistically significant regression in right ventricular dimensions were noted when compared among 3 months and 1 year follow up measurements as shown in table 11.

Table 11. Comparison of RVID at different time interval								
RVID (mm)	**Mean**	**SD**	**N**	**Friedman**	**P**	**Pair**	**Mean Diff.**	**p**
Before surgery (A)	37.9	5.1	100	245.64**	0.000	A &B	3.9*	0.000
Immediately after surgery (B)	34.0	5.5	100			A & C	5.6*	0.000
3 months after surgery (C)	32.3	5.3	100			A & D	6.61*	0.000
1 year after surgery (D)	31.3	5.4	100			B & C	3.9*	0.000
						B & D	2.71*	0.000
						C & D	6.61*	0.000

*: - Significant at 0.05 level

Fig.9 Comparison of RVID at different time interval



RVID in patients less than 20years had average of 34.2mm, where 36.9mm in patients between 21-30 years and 40.8mm in patients above 30 years age group as per fig 10.

Age group of less than 20 years had regression of RV dimensions almost near normal with mean of 27.4mm with standard deviation of 3.8, among 21-30 years age group regressed mean 30.5 with standard deviation of 4.3, in age group of more than 30 years mean dimensions were 34.1 with standard deviation of 5.4. Older age groups when compared with patients below 20 years and 20-30 years showed statistical significant regression of RV dimension at the end of 1 year using Scheffe multiple comparison testand shown in fig 11 and table 12.

Table 12 Comparison of RVID based on age of patient

Age (Years)	**Mean**	**SD**	**n**	**Friedman Test**	**P**	**Scheffe Multiple Comparisons**		
						Pair	F`	p
<=20 (A)	27.4	3.8	24	16.22**	0.000	A &B	2.9	0.061
21 - 30 (B)	30.5	4.3	32			A & C	15.5**	0.000
>30 (C)	34.1	5.4	44			B & C	5.4**	0.006

**: - Significant at 0.01 level

Fig.10 Comparison of RVID based on age of patient before surgery

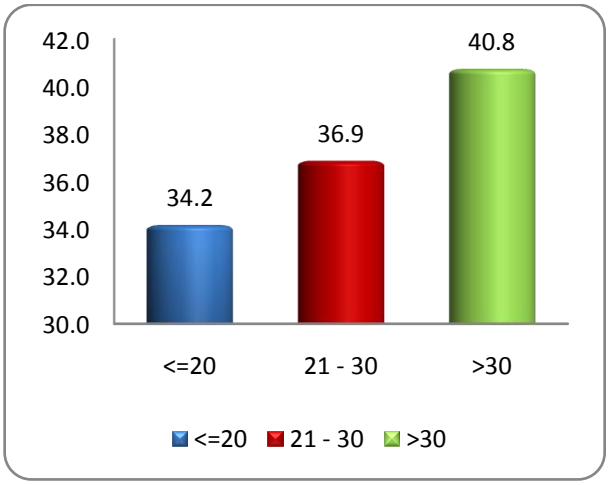
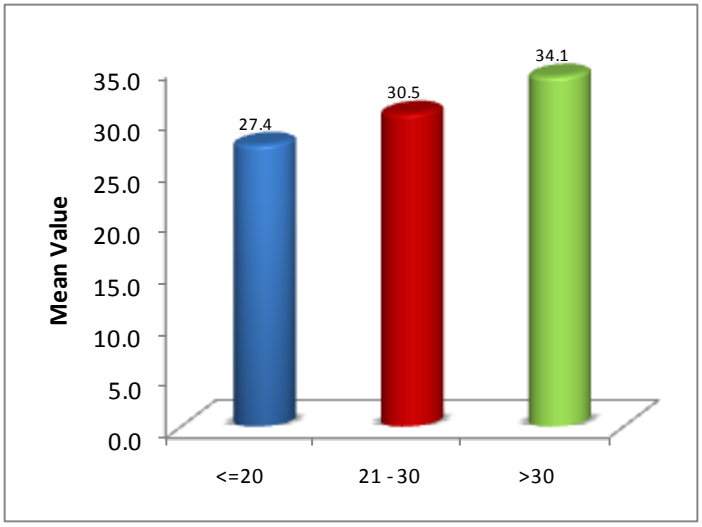


Fig.11 Comparison of RVID based on age of patient at the end of 1 year



Severe TRs and organic mechanism of TR were excluded from our study group, As they undergo concomitant surgical repair of tricuspid valve during ASD closure.

Only 2 patients in our study series were in atrial fibrillation which was present pre operatively, and they continue to be on anticoagulation medication, and 2 patients with moderate- severe TR are on digoxin with no history of heart failure symptoms in their 1year follow up period, all patients were asymptomatic with 3-4 patients with functional class II. None of patients required surgical attention for tricuspid valve in their follow up period.

DISCUSSION

Due to the surgical correction of left-to right shunting of blood flow in ASD closure, there is reduction in pulmonary blood flow, which in turn favors the regression of changes in pulmonary vasculature and optimization of pulmonary vascular resistance. Therefore, following surgical closure of ASD, there is reduction in volume overload (preload) as well as pressure overload (afterload) on RV leading to reverse remodeling of RV. However, reverse remodeling of RV is not a universal rule especially in adults where these changes tend to persist even after surgical correction of ASD. One of the major permanent sequelae in adult patients is persistence of tricuspid regurgitation in the post-operative period. It is important to understand the etio-pathogenesis of tricuspid regurgitation in case of ASD. In majority of cases, TR is functional in nature due to RV dilation leading to secondary changes in tricuspid annulus and non-coaptation of tricuspid valve leaflets. In few cases, organic changes in tricuspid valve apparatus have been realized in form of annular dilation, increase in tenting area and height of valve leaflets. It seems logical to assume resolution of TR following ASD closure in association with reverse RV remodeling due to inherent functional cause. Even though there are studies in literature documenting the resolution of TR, PAH and clinical symptoms but data does not substantiate the fact that isolated ASD closure is just enough to correct all pathological consequences. Hence, the debate continues whether or not to perform tricuspid annuloplasty in adult group of patients in presence of conflicting studies.

The current study aims to add more clinical evidence focusing on postoperative outcomes following ASD closure in adult patients. In our retrospective study, the authors found improvement in functional status in all the patients after surgery. Only 3% of the patients

were having functional class II, and the rest were asymptomatic. The results are quite similar to the study by Jemietly et al [22]who also showed improvement in functional status of 82.4% of adult patients.

EFFECT OF ASD CLOSURE ON RV DIMENSIONS

In our study group we found regression in RVID following surgery from mean of 37.9mm±5.1 to 31.3mm±5.4 at the end of one year, which is statistically significant. When compared with younger patients (13-20years) rate of regression in RV diameter is similar in older patients (>30years) from immediate postop up to the end of 1year echocardiogram follow up. Gosh et al[12] grouped ASD patients as 35-50 years as 1 group and 2nd group above 50 years and followed up after surgical ASD closure patients up to 11 years, they found significant regression in RV diameter in 1st group than 2nd group, though our study group was of almost same size 100 v/s 89, we had evaluated only 10 patients above 50 years in comparison to 38 patients in their study. Even Oliver et al[23] concluded favorable regression in patients <25years than patients with >25 years. Kort et al[11] studied regression of Right heart dimensions using echocardiogram pre and post closure and followed up for 2 years by device closure and found similar results in comparison to our study along with rate of RV regression at 3-6 months , 1 year and 2 years, but they noted persistent RA dilation a causative factor for atrial arrhythmias in their study group but in our study RA dimensions were not noted hence could not be commented further. Our study group had only 2 patients with atrial fibrillation and was present from their pre operative period, so RA dimensions may be of limited importance. Berbarie et al[13] in their 3 months follow up study, included both surgical and device ASD

closure patients above the age of 19 years and found favorable regression in terms of RV end diastolic volume in their study group using multi slice computed tomography volumetric analysis, which substantiates our study results of regression in RV dimension even with other imaging modality. But authors like Pearlman et al[14] in their study showed abnormal increase in RV diameter following ASD repair and concluded positive correlation with age of presentation but no correlation with pre operative RV dimension or the shunt size. In comparison to our study none of our patients had abnormal interventricular septal motion which was noted in their pre operative and post operative study group, the strength of their study is less which involved only 31 patients, Our study lacks detailed mention about interventricular septal motion and cath evaluation which might have helped us for further elaborative comparison. Attenhofer et al[15] in his article mentioned despite closure of ASD closure RV reverse remodeling is not found in all the patients, persistence of RV dilation was correlated with elevated levels of brain natriuretic peptides in blood. Concomitant estimation of BNP in our study group with long term follow up may help in correlating better with Attenhofer's findings.

EFFECT OF ASD CLOSURE OVER PAH

In our study group 59% of patients had significant PAH at the time of surgery and among them 54.5% were above 30 years of age and at end of one year only 22% remained with moderate-severe PAH following surgery, where only 4.5% of patients above 30 years remained with severe PAH. Maatouk et al[20] in their study on RV dilation after ASD closure showed regression in RV dimension in younger age group. The 37 patients who had persistent RV dilation in their study found to have higher PAH (>40mmHg) at the time of surgery and later presentation at older age group (>40 years),

In comparison to with our study we had better regression in RV diameter with higher PAH and presentation at later age group, 26 patients in our study group were above 40 years with PAH of moderate and severe grade with average of 44 mm of RV diameter before surgery and at the end of one year only 14 patients persisted with severe PAH and moderate PAH, still regression of RV diameter to average of 36.32mm was noted. Further imaging analysis and catheter based study may be necessary to evaluate more about PAH and RV dimensions correlation, even the race of selected study population and their genetic workup may pose significant variation in the long term post operative outcomes. Study by Salehi et al[16] in patients above 40 years showed similar results in comparison to our study and showed significant reduction in pulmonary arterial pressure (PAP) and RV dimensions following surgical closure. Though they showed 36.64% of their study group regressed to normal range of PAP at the end of their follow up of 16 years, we had only 7% of patients >40 years with total regression PAH to normal range, further long term follow up is required to achieve similar reduction in PAH in our study population. Liberthson et al[19] in their study showed regression in RV dimensions and improvement in functional class post ASD closure even with patients with moderate-severe PAH which parallels our study results, but he also stressed on persistence or development of some degree of RV dysfunction in such patients. Our study lacks this observation as we had limited data on RV function and has to be taken into account in view at long term outcomes in adult ASD patients. Above study had limited follow up time period of 6 months, further follow up would have thrown better light on progress of RV function.

EFFECT OF ASD CLOSURE ON RV REMODELLING AND FUNCTIONAL TR

In our study 78% were moderate TR (3+) and 22% moderate to severe TR (3-4+) at the time of presentation, at the end of 1 year follow up echo cardiogram showed regression in TR among 93% of our patients, maximum regression was found in immediate post study, more in younger age group. But gradual regression is also noted in patients who are more than age of 30 years. By the end of 1 year only 13.6% remained with moderate TR, with a better functional class and these results were statistically significant. Humenberger et al[21] in their study showed similar results as in our study which noted significant regression in RV dimension reduction in PAH, though their study group had only 12% of patient with significant TR before surgery showed decrease in degree of TR due to reverse remodeling of RV along with improvement in functional status in any age group undergoing ASD closure. Study by Berger et al on quantitative assessment of pulmonary hypertension with TR by echocardiogram stressed that most of cases with TR are functional in nature due to dilation of tricuspid annulus rather than intrinsic involvement of leaflets and pulmonary hypertension regardless of its etiology is considered to be the major cause of this functional TR, Hence the remodeling of RV due to PAH culminates in significant TR and similarly in our study group patients with TR before surgery had significant PAH and at end of one year, all patients with significant TR had persistent moderate-severe PAH. Even study by De Meester et al[24] concluded persistence of TR following surgery is due to presence of PAH. Though Oliver et al[23] showed favorable remodeling following ASD closure in patients <25 years in terms of reduction in PAH and decrease in RV diameter when compared to older patients, still gradual but slow reverse remodeling was noted in these subsets. In our study age did not

play much significant role in reverse remodeling, all patients showed fall in PAH , RV diameter and TR grade irrespective of age of presentation. Our improvement in TR status were significantly better in their comparison, which concluded degree of TR after surgery is similar in patients who undergo surgery at 25 years of age and patients without surgery. As they might have included only TR 4+, there is no mention about the type of TR either functional or organic and also patients with TR constituted only 9% of their study group their conclusion will not hold much significance. Jemielity et al[22] also showed better outcome following adult ASD closure who showed fall in RV dimension, reduction in PAH, also reduction in TR grade spontaneously following surgery, but they showed need of tricuspid annuloplasty in 27% of patients with TR, Here also type of TR is not mentioned and they had included all patients with severe and moderate TR in their study group.

NEED FOR CONCOMITANT TRICUSPID VALVE REPAIR

Toyono et al[27] mentions need for tricuspid valve repair in patients with significant TR because the persistence of PAH is invariably found in such patients, presence of TR will cause further overloading of RV inderhing the reverse remodeling and further increase in RV dimension annular dilation and further non coaptation of TV leaflets and more TR. Increase in PAH, finally deterioration of RV function and RV failure. Our study included patients with moderate TR, though patients with moderate TR at the end of 1 year found to have persistent moderate-severe PAH, majority of patients even with significant PAH and TR at the time of surgery regressed to mild TR at the end of one year without deterioration of functional status in any of our patients necessitating need for surgery or medical attention. Though study by Maltais et al[29] included patients who

required VADs, significant reverse remodeling in RV was found following TV repair with pre operative TR and improvement in clinical functional status of patient and RV function echocardiographically. Fang et al[28] in their article showed TR in ASD patients are not due to RV remodeling but it is due to remodeling in tricuspid valvular apparatus which involves annular dilation, increase in tenting area and height of valve leaflets but their study did not contain any mention about correction of tricuspid valve, In comparison to our study we had no detailed data regarding tricuspid valvular apparatus, their study seems to be focusing on organic transformation of functional TR and our study excludes organic type of TR, All their patients underwent device closure unlike our surgical patients, hence further comparison is not possible. Gilles D. Dreyfus *et al*[34] *showed*that in their follow- up study, patients who underwent tricuspid annuloplasty had a progressive reduction in the degree of TR, while patients without tricuspid annuloplasty had progressive TR. Consequently, they proposed that tricuspid annuloplasty to be done at the time of initial surgery when the diameter of the annulus is greater than 21 mm/m^2, and this was found to improve functional capacity without increasing perioperative morbidity and/or mortality. This study was conducted in TR with mitral valve pathology, Hence proposal by Dreyfus may not be considered for ASD surgical pathophysiology.

Sugimoto et al[30] in their study on functional TR showed regression in TR following isolated ASD closure similar to our results, but they showed strong correlation between tricuspid annular diameter and TR velocity and concluded need of concomitant annuloplasty along with ASD closure in patients with annular diameter >45mm and isolated ASD closure will suffice for tricuspid annulus <45mm. Similarly Jang et al[31] also showed regression in TR severity following isolated ASD closure and when compared

with patients who underwent concomitant tricuspid annuloplasty there was no significant difference in clinical benefit, but they concluded in favor of ASD+TV repair in view of better long term prognosis. Though none of our patients deteriorated in their TR status or functional status, a detailed echocardiogram description on TV annular dimensions should be considered at the time of ASD closure.

Both the American College of Cardiology/American Heart Association and the European Society of Cardiology (ESC) guidelines[33] give a class I recommendation for TV repair in patients with severe TR undergoing MV surgery and class IIb recommendation for patients with less than severe TR. The ESC guidelines give a class IIa recommendation for concomitant TV repair in patients with a TA diameter >40 mm or moderate TR and also for patients with symptomatic and isolated TR following left-sided valve surgery at later days, but in the absence of LV or RV dysfunction and also without severe pulmonary hypertension.

These guidelines are for concomitant TR in mitral valve diseases but when surgical intervention is not indicated in asymptomatic patients with severe TR and at later date when they become symptomatic they are referred for TV surgery, when RV dysfunction has already occurred and in a functional class of NYHA III/IV, this results in worst surgical outcomes. But in conditions like ASD where this functional TR is more due to volume overload on RV unlike valvular heart diseases with increased RV afterload due to severe PAH, closure of left to right shunt reduces volume load on RV and further regression in RV diameter and optimization of TR, Hence less is need of concomitant TV repair in ASD patients with moderate degree of TR.

In our study group all TR lesions were functional in nature. Even with significant PAH and dilated RV, isolated ASD surgical closure had optimized concomitant tricuspid regurgitation over 1 year of follow up period, with improvement in functional status without need of further surgical repair of tricuspid valve. Regression of RV diameter and PAH is also been significant in our study. But 8 patients remained with significant TR following ASD closure, mean age of 46.4 years, None of them had deterioration in their TR status of functional status, only 2 are in Class II NYHA, 2 are in AF, all these patients are with persistent moderate-severe PAH, at the time of surgery their RV diameter measured average of 44.28mm and end of 1 year found to be 40.14mm. Considering above data all the patients who remained with significant TR were patients with older age group and persistent PAH and with dilated RV.

LIMITATIONS

Long term follow up study is required with much bigger study group. Prospective study with case control pattern will more informative. Limited clinical evaluation should have been elaborated. Detailed echocardiographic evaluation in terms of annular diameter, leaflet morphology both pre op and post op period should be carried out and documented. Comparative study between isolated ASD closure and ASD with concomitant tricuspid valve repair/TAP with annular diameter of >40-50mm will help us for better understanding of natural history following surgery to ASDs.

CONCLUSION

Surgical closure of ASD in adult patients leads to regression in functional TR by the end of 1 year due toreverse remodeling of RV and fall in PAH. Therefore,moderate degree TR without organic cause can be dealt with isolated ASD closure. Elderly patients with severe TR may have added organic component due to tricuspid apparatus dilation and tethering of leaflets that may persist after ASD closure. The authors recommend inspecting the mechanism of TR during the surgery in addition to the detection of severity of pulmonary artery hypertension and right ventricular dilation. The presence of organic changes in tricuspid valve may provide an indication to address the valve at the time of ASD closure, which will improve the post-operative outcome of patients. The current study had small number of patients with severe TR and hence, a larger prospective study involving examination of tricuspid valve morphology and long term follow-up is required to make a definite conclusion about the indication and necessity of tricuspid annuloplasty.

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Christine H. Attenhofer Jost[(a1)], Erwin Oechslin[(a1)], Burkhardt Seifert[(a2)], Friedrich Maly[(a3)], Renata Fatio[(a1)], Juraj Turina[(a1)] and Rolf Jenni[(a1)]

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José M Oliver[a], Pastora Gallego[b], Ana E González[a], Fernando Benito[a], Ernesto Sanz[a], Ángel Aroca[a], José M Mesa[a], José A Sobrino[a]

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Fang Fang, Jing Wang, Gabriel Wai-Kwok Yip, Yat-Yin Lam

29. Surgical treatment of tricuspid valve insufficiency promotes early reverse remodeling in patients with axial-flow left ventricular assist devices

Simon Maltais, MD, PhD, Yan Topilsky, MD, Vakhtang Tchantchaleishvili, MD, Stephen H. McKellar, MD, MSc, Lucian A. Durham, MD, PhD, Lyle D. Joyce, MD, PhD, Richard C. Daly, MD, Soon J. Park, MD, MSc.

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Takaki Sugimoto, MD, Masayoshi Okada, MD, Nobuchika Ozaki, MD, Tadashi Hatakeyama, MD, Toshihiro Kawahira, MD

31. Outcomes of Significant Tricuspid Regurgitation After Closure of Atrial Septal

Defect in Adults

Authors: Jeong Yoon Jang, Jong-Min Song, Byeong Joo Bae, Se Hun Kang, Byung Joo Sun, Dae-Hee Kim, Duk-Hyun Kang, Jae-Kwan Song, Asan Medical Center, Seoul, South Korea

32 Quantitative Assessment of Pulmonary Hypertension in Patients With Tricuspid Regurgitation Using Continuous Wave Doppler Ultrasound.

Marvin Berger, MD, FACC, Azriel Haimowitz, MD, Andrew Van Tosh, MD, Russell L Berdoff, MD, FACC, Emanuel Goldberg, MD, FACC, New York.

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34. Functional Tricuspid Regurgitation:A Need to Revise Our Understanding

Gilles D. Dreyfus, MD, PhD∗; Randolph P. Martin, MD‡; K.M. John Chan, PhD∗; Filip Dulguerov, MD∗; Clara Alexandrescu, MD‖

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A randomized clinical trial

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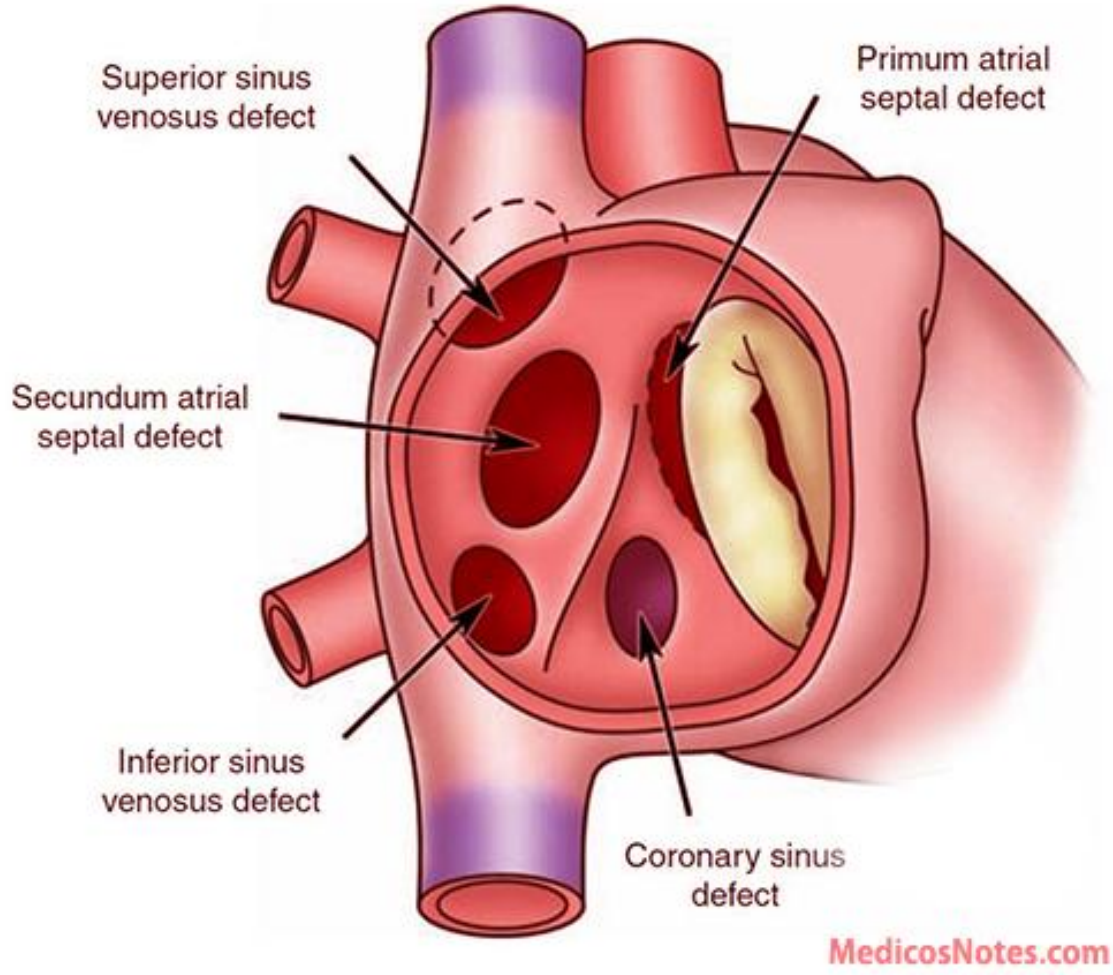
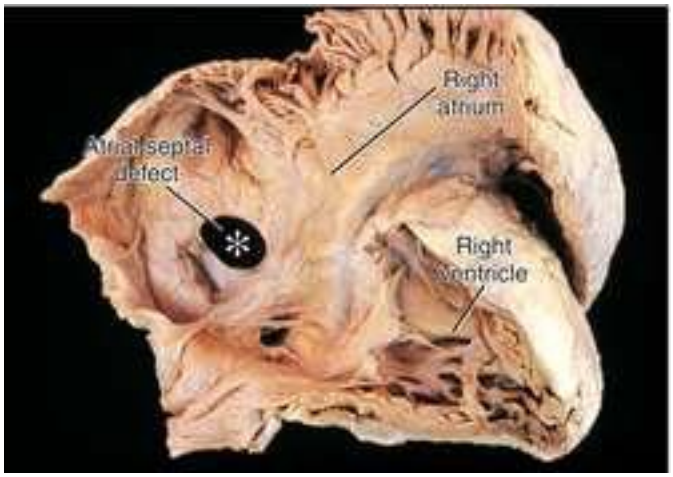

Superior sinus venosus defect
Primum atrial septal defect
Secundum atrial septal defect
Inferior sinus venosus defect
Coronary sinus defect
MedicosNotes.com


Right atrium
Atrial septal defect
Right ventricle

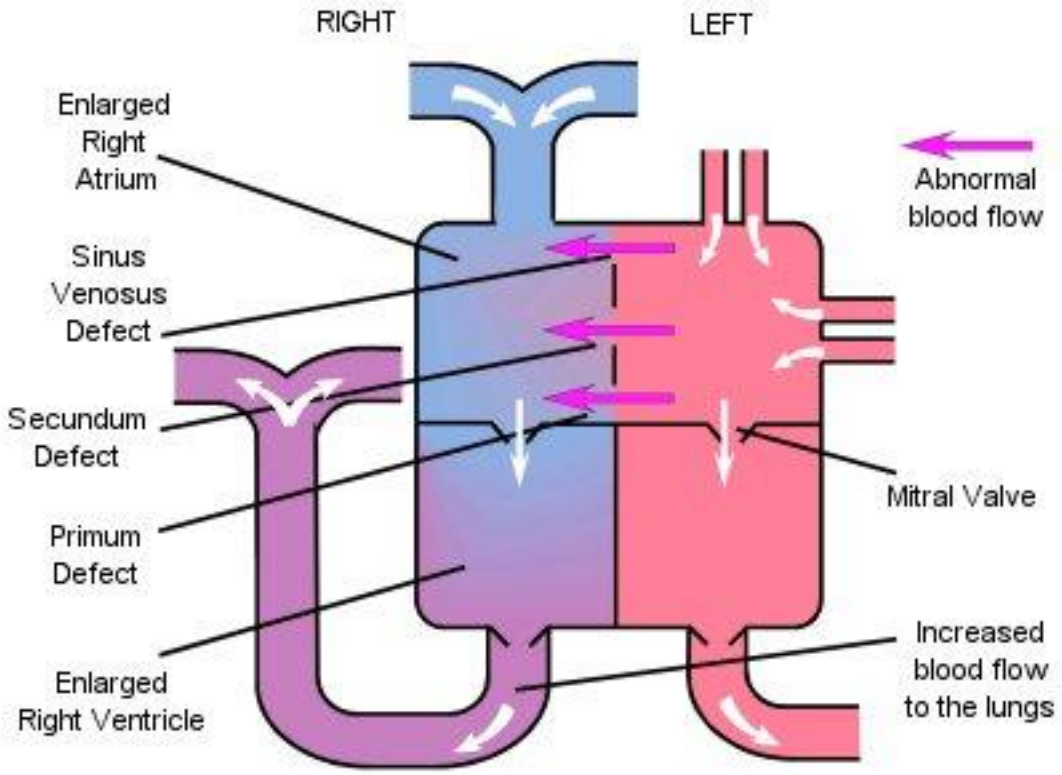
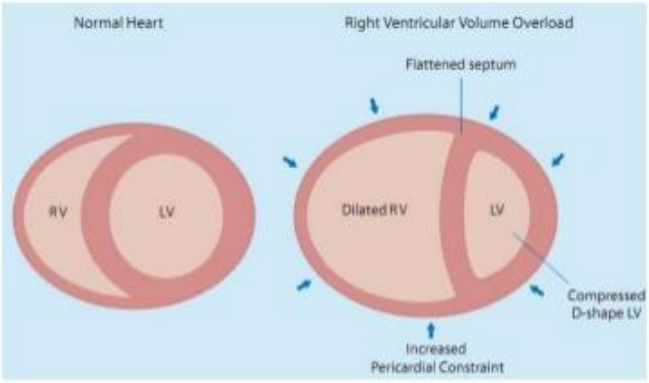


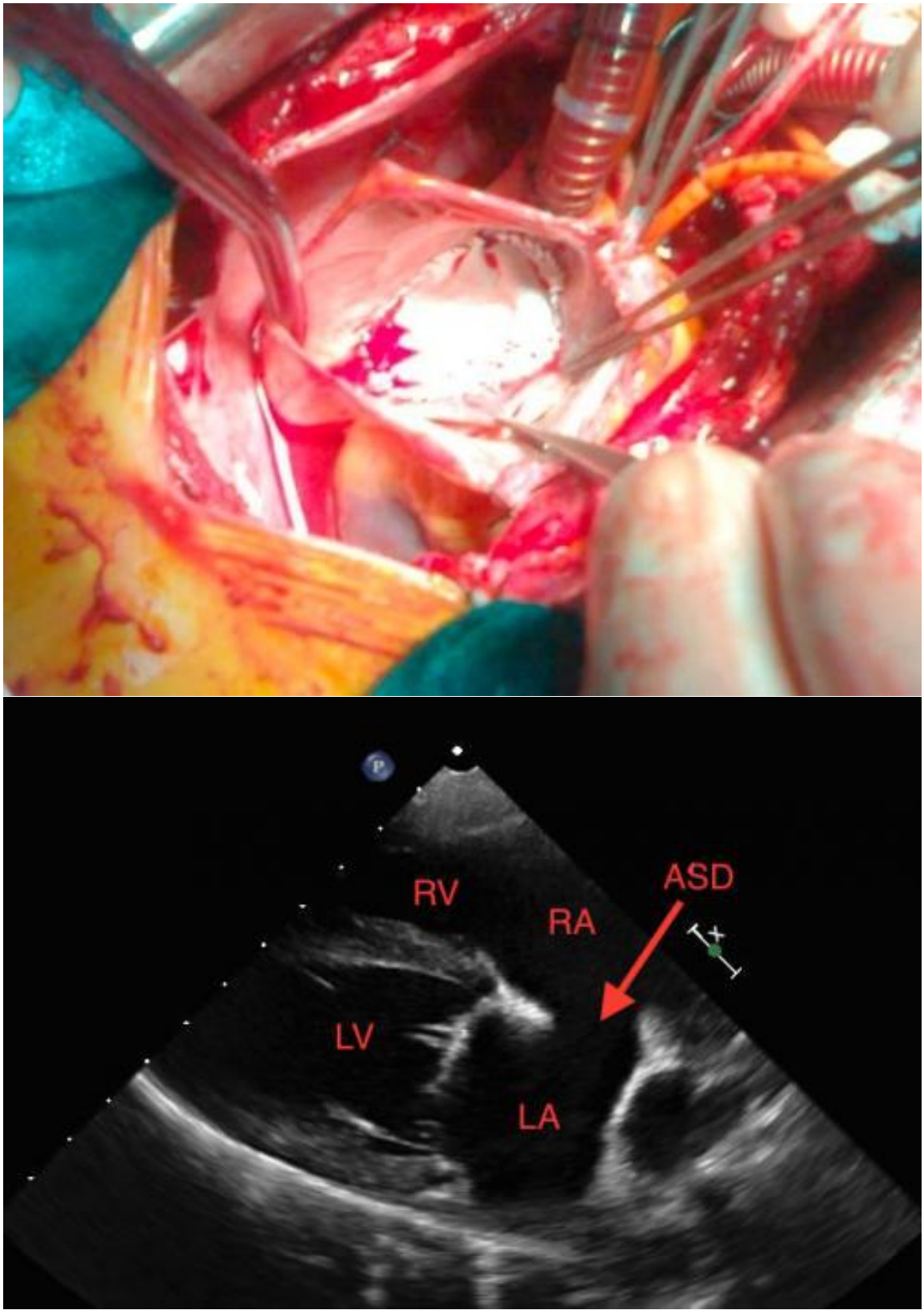
Diagram shows the heart looking at the patient

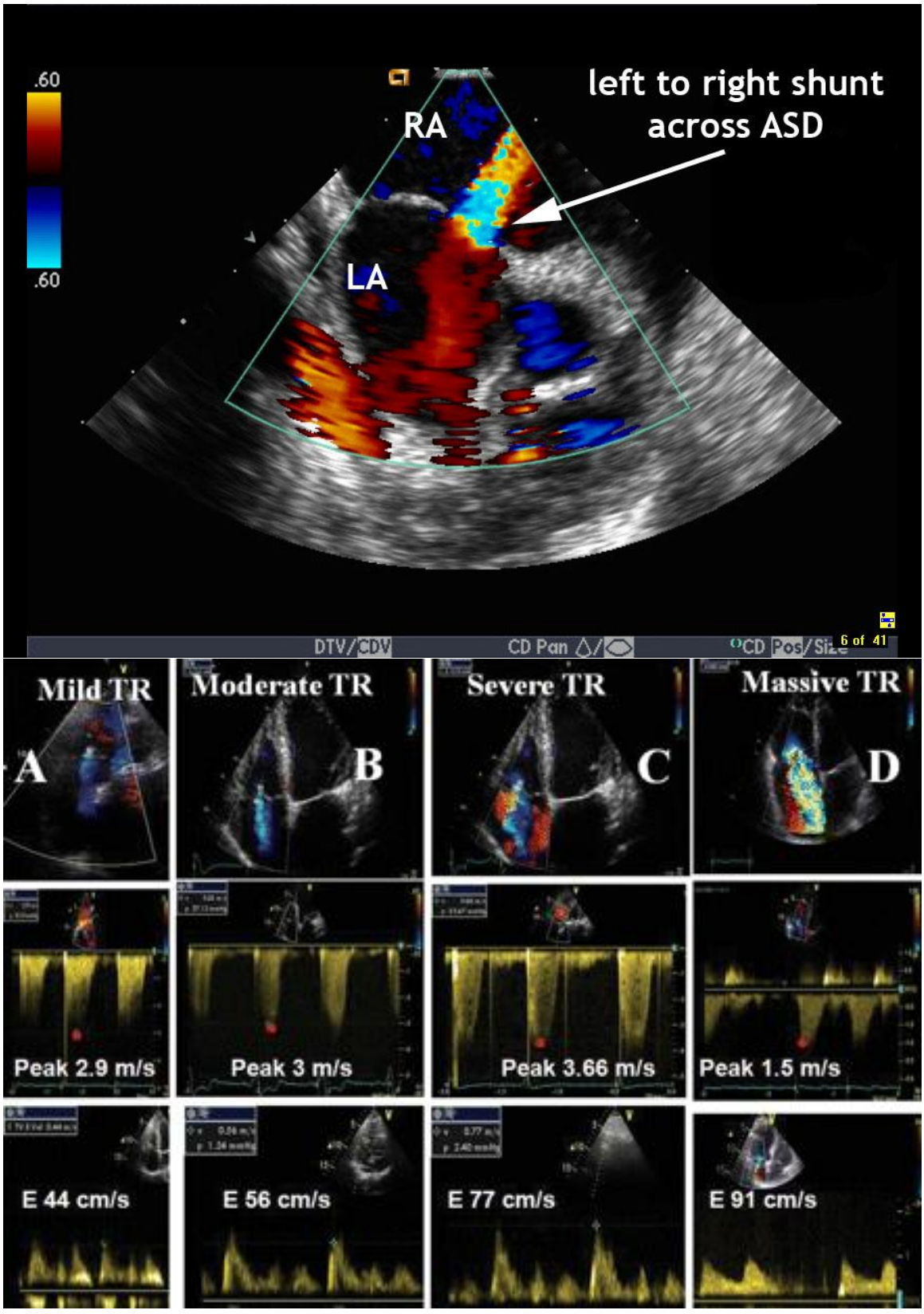
Functional TR

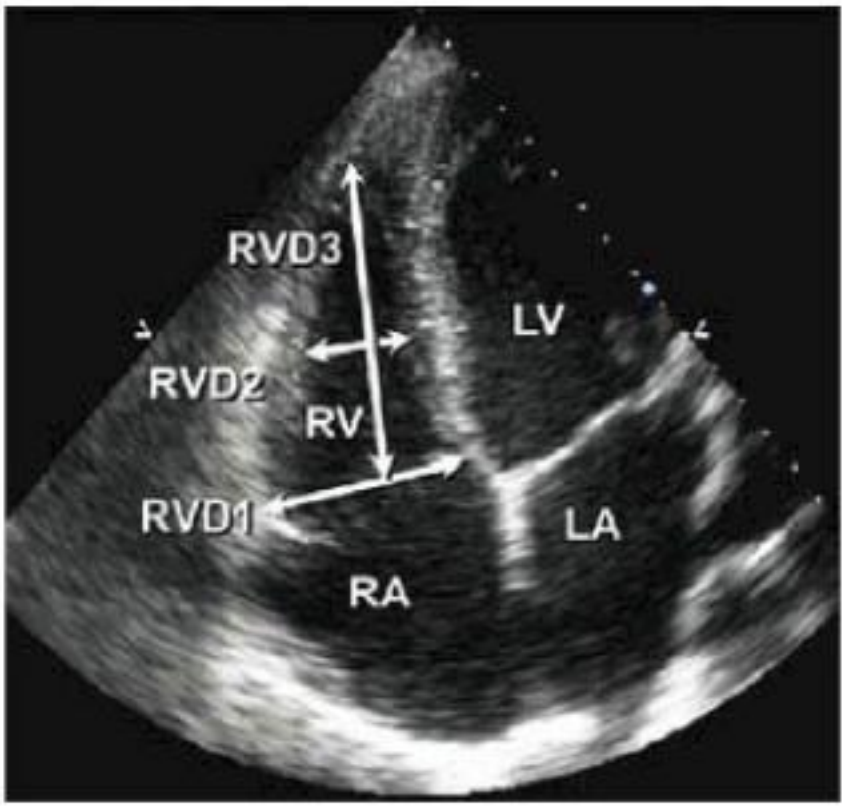


Tricuspid regurgitation that is at least moderate or greater in severity is most frequently "functional" in nature

- not related to specific tricuspid leaflet pathology
- right ventricular dilatation, distortion of the subvalvular apparatus, tricuspid annular dilatation, or all three


RV
RA
ASD
LV
LA


.60
.60
RA
LA
left to right shunt
across ASD
DTV/CDV
CD Pan
CD Pos/Size
6 of 41
Mild TR
A
Moderate TR
B
Severe TR
C
Massive TR
D
Peak 2.9 m/s
Peak 3 m/s
Peak 3.66 m/s
Peak 1.5 m/s
E 44 cm/s
E 56 cm/s
E 77 cm/s
E 91 cm/s


RVD3
LV
RVD2
RV
RVD1
LA
RA

KEY TO MASTER CHART

1. S. No:	Serial Number
2. H. No:	Hospital Number
3. DOS:	Date of surgery
4. TTE:	Transthoracic Echocardiography
5. PAH-1:	Pre-operative pulmonary artery hypertension
6. PAH-2:	Intraoperative pulmonary artery hypertension
7. PAH-3:	Post-operative pulmonary artery hypertension at 3 months
8. PAH-4:	Post-operative pulmonary artery hypertension at 1 year
9. TR –1:	Pre-operative Tricuspid regurgitation
10. TR –2:	Intraoperative Tricuspid regurgitation
11. TR –3:	Post-operative Tricuspid regurgitation at 3 months
12. TR –4:	Post-operative Tricuspid regurgitation at 1 year
13. RVID-1:	Pre-operative Right Ventricular Internal Dimension
14. RVID-2:	Intraoperative Right Ventricular Internal Dimension
15. RVID-3:	Post-operative Right Ventricular Internal Dimension at 3 months
16. RVID-4:	Post-operative Right Ventricular Internal Dimension at 1 year
17. Redo Sx:	Redo surgery

Grading used in master sheet:

0 – Absent For **Symptoms**

1- Present **Redo surgery**

- **Male** – 0
- **Female** – 1

PAH - <25 mmHg – 0

25-40 mmHg – 1

41-55 mmHg – 2

> 55 mmHg - 3

TR: Nil – 0

Trivial – 1

Mild – 2

Moderate – 3

Moderate to severe - 4

S No	Name	Age	Sex	H No	DOS	TR-1	RVID-1	POST op	PAH-2	TR-2	RVID-2	PAH-3	TR-3	RVID-3	Symptoms	PAH-4	TR-4	RVID-4	Symptoms	Redo Sx
1	Sumakuma	34	1	302062	18-01-2010	3	34		0	1	28	0	1	28	0	0	0	30	0	0
2	Arumugatl	34	1	301255	08-02-2010	3	43		1	2	40	1	2	38	0	0	1	38	0	0
3	Chandrika	47	1	301428	25-02-2010	4	45		1	1	40	1	1	35	0	0	0	30	0	0
4	Shanmugh	45	1	274609	22-03-2010	4	48		2	4	46	3	4	45	0	3	4	45	3	0
5	Ramkumar	26	0	303626	23-03-2010	3	36		2	0	28	0	0	26	0	0	1	26	0	0
6	Shejina	13	1	307985	05-04-2010	3	36		1	0	22	0	0	20	0	0	0	22	0	0
7	Muthupan	49	0	280832	12-04-2010	4	48		2	1	40	0	1	36	0	0	0	34	0	0
8	Joshma	13	1	305848	07-05-2010	3	34		2	1	24	1	1	24	0	0	1	22	0	0
9	Sinnilekha	38	1	309789	24-05-2010	3	30		0	1	22	0	0	22	0	0	1	21	0	0
10	Panchami	41	1	303213	25-05-2010	3	35		2	1	28	1	1	28	0	1	1	28	0	0
11	Laksmana	23	0	305887	28-05-2010	3	38		1	1	30	0	1	25	0	0	1	24	0	0
12	Baburaj	38	0	311398	14-06-2010	3	35		1	2	30	1	2	30	0	1	2	30	0	0
13	Prasad	33	0	8906697	15-06-2010	3	35		1	2	32	1	1	30	0	1	1	28	0	0
14	prabhakar	47	0	310838	02-07-2010	4	42		2	1	36	0	0	30	0	0	1	25	0	0
15	sajith	13	0	302936	06-07-2010	3	34		1	2	33	1	1	32	0	0	0	30	0	0
16	santosh	41	0	303365	08-07-2010	3	42		2	3	40	1	3	38	0	1	1	38	0	0
17	asha	26	1	310945	15-07-2010	3	33		0	1	28	1	1	28	0	1	1	26	0	0
18	Prasad	45	0	16893	16-07-2010	4	42		1	2	38	1	2	40	0	0	0	36	0	0
19	Gracy	29	1	311203	23-07-2010	3	38		2	1	33	0	0	32	0	0	1	30	0	0
20	Gopidas	49	0	9608266	23-07-2010	4	42		2	4	36	0	2	30	0	0	1	30	0	0
21	Santha	49	1	312493	28-07-2010	4	44		1	2	40	1	2	35	0	1	2	35	0	0
22	sankarana	45	0	310126	30-07-2010	4	42		1	1	37	1	2	34	0	1	2	34	0	0
23	Bhadra	16	1	310522	09-08-2010	3	36		2	2	33	0	2	32	0	0	2	30	0	0
24	Sheela	40	1	313284	02-09-2010	3	35		1	2	30	1	2	30	0	1	1	30	0	0
25	Durai	51	0	281720	15-09-2010	4	42		2	4	38	2	2	40	0	2	3	40	0	0
26	Vinu	25	1	306781	28-09-2010	3	38		1	3	36	1	2	34	0	1	2	33	0	0
27	Swathi	29	1	312986	04-10-2010	3	39		1	2	35	2	2	35	0	2	2	36	0	0
28	Shamna	29	1	316415	10-11-2010	3	37		1	1	32	1	0	32	0	1	1	30	0	0
29	Abdurehm	41	0	317072	16-11-2010	3	34		1	0	30	0	1	32	0	0	0	30	0	0
30	Praveen	15	0	219494	18-11-2010	3	34		1	1	32	0	0	28	0	0	0	26	0	0
31	Haseena	23	1	318414	24-11-2010	3	40		2	2	38	2	2	36	0	2	1	36	0	0
32	Renuka	53	1	314756	31-12-2010	4	46		1	4	40	2	2	36	0	1	1	34	0	0
33	Amzar	19	0	308444	10-12-2010	3	38		1	1	36	1	1	32	0	0	1	32	0	0
34	Vijayamma	42	1	230102	15-12-2010	3	36		2	0	30	0	0	31	0	0	0	30	0	0
35	Jaxy	22	1	305215	24-02-2011	3	37		1	1	35	1	1	33	0	1	1	28	0	0
36	Nikhil	25	0	9104292	17-03-2011	3	41		1	2	38	0	2	32	0	0	1	34	0	0
37	Anaswara	15	1	326421	06-05-2011	3	36		2	1	32	0	1	30	0	1	1	30	0	0
38	Jaiju	31	0	319442	20-05-2011	3	42		2	3	40	2	2	36	0	1	2	38	0	0
39	Arul	26	0	319427	27-06-2011	3	41		1	1	38	1	1	36	0	1	1	37	0	0
40	ummusaln	22	1	328003	07-07-2011	3	34		1	0	30	0	0	28	0	0	0	27	0	0
41	Samesh	26	0	323630	02-08-2011	3	38		2	2	36	0	2	36	0	0	1	30	0	0
42	Sathiyamn	47	1	323484	03-08-2011	4	43		3	4	40	3	3	42	0	2	0	39	0	0
43	Sudha	16	1	327891	08-08-2011	3	33		1	1	31	0	1	28	0	0	0	25	0	0
44	Aruna	14	1	331206	08-08-2011	3	32		1	0	30	0	0	28	0	0	0	24	0	0
45	Latha	41	1	333068	07-10-2011	3	44		3	2	41	3	3	42	0	2	1	40	0	0
46	Suresh	46	0	338128	29-12-2011	4	42		2	2	40	2	2	38	0	2	1	36	0	0
47	Rajendrab	53	0	335822	07-02-2012	4	45		3	4	42	3	4	42	0	3	4	40	2	0
48	Rajesh	28	0	324271	23-03-2012	3	33		2	1	30	0	1	30	0	0	0	30	0	0
49	Sukanya	51	1	320460	30-04-2012	4	45		2	3	42	2	3	40	0	2	3	38	0	0
50	Sabina	24	1	316950	18-05-2012	3	36		1	2	34	1	1	32	0	1	1	30	0	0
51	Lekshmi	18	1	331556	04-06-2012	3	37		2	1	35	2	2	34	0	1	2	30	0	0
52	Akhila	20	1	261333	14-06-2012	3	35		3	0	32	0	0	30	0	0	0	28	0	0
53	Saritha	30	1	344172	13-07-2012	3	32		2	1	28	0	0	26	0	0	0	25	0	0

54	Shereefa	65	1	9704553	16-08-2012	4	48	3	3	44	2	2	40	0	2	2	40	0	0
55	Sajini	13	1	325877	27-09-2012	3	34	1	1	29	0	0	26	0	0	0	26	0	0
56	Ebidas	21	0	335475	22-10-2012	3	38	2	3	35	2	2	34	0	1	2	31	0	0
57	Samson	22	0	344897	25-03-2013	3	40	3	3	34	2	3	36	0	2	3	36	0	0
58	Anu	14	0	341658	05-04-2013	3	32	2	1	28	0	0	25	0	0	0	25	0	0
59	Sheela	25	1	354319	03-05-2013	3	29	2	2	28	0	2	26	0	0	1	26	0	0
60	Sashikuma	53	0	353668	01-05-2013	4	45	3	4	40	3	2	36	0	2	2	33	0	0
61	Jobins	20	0	348593	22-05-2013	3	28	1	1	27	0	1	26	0	0	0	24	0	0
62	Sateesh	54	0	352460	17-06-2013	4	45	2	3	40	2	3	39	0	2	2	38	0	0
63	Mahroof	18	0	341584	21-06-2013	3	32	1	1	28	1	1	27	0	0	2	25	0	0
64	Athira	19	1	350900	17-07-2013	3	34	2	2	30	0	1	30	0	0	1	30	0	0
65	Rosily	35	1	335633	23-09-2013	3	39	2	2	35	2	2	32	0	1	2	32	0	0
66	Manu	27	0	362936	10-10-2013	3	35	1	2	30	0	2	30	0	0	2	30	0	0
67	Shintomor	32	0	361290	21-10-2013	3	34	1	1	32	1	1	30	0	0	1	30	0	0
68	Sreeja	26	1	340081	25-10-2013	3	38	2	3	40	2	3	38	0	2	0	40	0	0
69	Nadeera	35	1	354825	28-10-2013	3	33	1	0	28	0	0	26	0	0	0	26	0	0
70	Murugesh	29	1	362168	26-11-2013	3	35	2	2	28	0	0	28	0	0	0	31	0	0
71	Hashim	14	0	369875	10-12-2013	3	34	0	0	26	0	0	28	0	0	0	26	0	0
72	Priyadarsh	31	1	363158	11-12-2013	3	30	1	1	30	1	1	27	0	1	2	28	0	0
73	Vinciya	17	1	364964	27-12-2013	3	32	1	1	32	1	1	30	0	0	1	30	0	0
74	Mathi	57	1	345556	07-01-2014	4	47	3	4	44	3	4	42	0	2	4	42	2	0
75	Sudheesh	34	0	346558	30-01-2014	3	36	3	2	35	0	2	34	0	0	2	34	0	0
76	Vrinda	15	1	348291	28-04-2014	3	33	1	0	28	0	0	25	0	0	0	24	0	0
77	Sindhu	28	1	370143	29-04-2014	3	49	1	3	44	1	2	40	0	1	1	40	0	0
78	Vaishnav	18	0	370954	28-05-2014	3	38	2	2	35	2	2	36	0	1	2	30	0	0
79	Parvathy	23	1	382561	02-09-2014	3	42	3	1	36	2	1	33	0	2	2	32	0	0
80	Sudha	23	1	374831	22-09-2014	3	34	0	0	30	0	0	26	0	0	0	28	0	0
81	Sunil	32	0	356149	17-10-2014	3	43	2	3	42	2	2	42	0	2	2	40	0	0
82	Reena	38	1	376802	05-11-2014	3	36	1	2	34	1	2	30	0	1	1	27	0	0
83	Balan	59	1	378068	14-11-2014	4	44	1	2	38	1	2	33	0	1	2	31	0	0
84	Priyavimal	35	1	385839	20-11-2014	3	30	2	2	28	0	0	30	0	0	0	30	0	0
85	Panchamy	24	1	183392	08-01-2015	3	38	3	3	34	3	2	32	0	2	2	32	0	0
86	Hamza	36	1	354796	19-02-2015	3	40	1	3	35	1	1	33	0	0	2	31	0	0
87	Sathil	43	1	387012	16-03-2015	4	42	3	3	44	3	2	40	0	2	1	40	0	0
88	Hussam	16	0	392171	23-03-2015	3	28	0	0	26	0	0	26	0	0	0	27	0	0
89	Laiju	36	0	393422	27-04-2015	3	47	2	2	45	2	2	41	0	2	2	40	0	0
90	Guruvamn	26	1	387879	07-05-2015	3	35	1	2	30	0	1	30	0	0	0	30	0	0
91	Soman	64	0	384022	14-05-2015	4	50	1	2	41	1	2	38	0	1	2	40	0	0
92	Akshaykur	16	0	376939	21-05-2015	3	33	2	0	27	0	0	28	0	0	0	22	0	0
93	Sulfathul	21	1	390779	25-05-2015	3	32	2	2	29	0	1	25	0	0	1	28	0	0
94	Salim	46	0	385054	29-05-2015	4	43	3	4	42	3	4	40	0	2	4	40	2	0
95	Ismail	15	0	376371	29-05-2015	3	37	3	3	36	3	2	34	0	2	2	34	0	0
96	Saleek	23	0	387836	05-06-2015	3	38	1	1	35	0	1	33	0	0	1	27	0	0
97	Rajeev	30	0	388865	16-06-2015	3	36	2	0	32	0	0	30	0	0	0	30	0	0