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PROJECT REPORT

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DM Cardiology

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DEPARTMENT OF CARDIOLOGY

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DECLARATION

I , Dr. Bhavesh Harivadan Roy, hereby declare that the project in this book were undertaken by me under the supervision of the faculty, Department of Cardiology, Sree Chitra Tirunal Institute of Medical Sciences and Technology.

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GENERAL CONTENTS

Report I

INCIDENCE AND PREDICTORS OF PERMANENT PACEMAKER IMPLANTATION AFTER AORTIC VALVE REPLACEMENT

CONTENTS

Introduction

Conduction abnormalities are commonly associated with aortic valve disease (1) (2). Surgical replacement of the aortic valve has been known to worsen baseline conduction abnormalities, including progression to Complete Heart Block (CHB) necessitating the implantation of PPM postoperatively (3). Though need for a PPM is uncommon, it significantly increases the length of hospital stay and the overall costs Information with regard to the potential risk of PPM requirement associated with certain clinical variables would have signi? cant impact on clinical practice, including preoperative counseling and planning.

Aims & Objectives

The aim of our study is to de?ne the current incidence of Permanent Pacemaker (PPM) implantation following Aortic Valve Replacement (AVR) and attempt to identify clinical predictors of PPM implantation

Review of Literature

Conduction disturbances requiring permanent pacemaker implantation after heart surgery occur in about 1.5% of patients. It is more frequent after valve surgery (ranging from 3–6%) than after isolated coronary artery bypass grafting (0.8%). (4) (5)

Incidence of PPM requirement after AVR is variously reported between 3 to 8%. Sam Dawkins et al (6), studied 342 patients who had AVR done and reported 8.5% incidence. Hieu Huynh et al (7) have reported an incidence of 7.2 % in their study of 207 patients, while G Limongelli (8) have reported incidence of 3.2 % in 276 patients. This variation in reported incidence of PPM shows that patients undergoing AVR may be a heterogeneous population and the sample size may not be adequate to truly reflect the incidence.

This Incidence of PPM after isolated AVR is higher than that after isolated CABG surgery. Incidence of PPM requirement after CABG surgery was reported as 0.8 % by Bareman et al (2) and 0.7 % by Goldman et al (3). For patients undergoing isolated MVR surgery, incidence was 3.3% as reported by Goldmann et al (3) and 4% by Berdajs et al. (9)

Apart from the complete heart block or high grade AV block requiring permanent pacemaker, various conduction abnormalities like prolongation of PR interval (13%), Right Bundle Branch Block (RBBB) (6.7%), Left Bundle Branch Block (LBBB) (6.7%), Left Anterior Hemi fascicular Block (LAHB) and Intraventricular conduction disturbance

(IVCD) has been reported to occur after AVR. Acquired LBBB after AVR has been reported with significantly increased incidence of syncope, CHB and sudden death.

Thomas et al, (10) in a series of 133 patients undergoing AVR reported 31.6% (42 patients) incidence of intra operative Left bundle conduction block. There were 13 deaths in the group of 42 patients with left bundle conduction block compared to eight deaths in the group of 91 patients without LBBB ($p < 0.01$). Sudden death occurred in five of 42 patients with postoperative Left bundle conduction block and two of 91 patients with normal intra ventricular conduction ($p < 0.025$). Fournial et al (11) reported an incidence of 33% of new conduction disturbances after AVR, LBBB being the most common. Long term follow up of those patients with LBBB after AVR has shown increased incidence of sudden cardiac death among these patients. Dawkins et al (6), showed in their study that persistent bundle branch block after AVR was the only predictor of adverse events during follow up. The highest incidence was seen in those who developed new LBBB after AVR. Fifty seven percent (57%) of the adverse events occurred in the first 6 months of follow up and 71% occurred one year after surgery.

The significance of new LBBB after CABG has been studied by Y Caspi et al (12), with 55 of 316 patients developing post operative LBBB. Development of new LBBB was correlated with left main coronary stenosis and prior myocardial infarction.

The pathophysiology behind development of conduction disorder in aortic valve disease is well elucidated. Surgical procedures close to the sinoatrial or atrioventricular nodes or the His bundle might result in physical trauma to the

conduction system. Autopsy reports of those who died after surgery had reported direct trauma to the conduction system.

Fukuda at el (13) reported histo-pathologic study of the cardiac conduction system performed in 57 patients who died within 30 days after AVR. The most common basis for trauma of the conduction tissue was 1) laceration by sutures, observed in 16 of the 19 cases with traumatic injury 2) Residual calcific material of the aortic annulus in four cases, and 3) Compression by the seat of the prosthesis, the least common cause of trauma, in two cases.

Secondly, extensive coronary artery disease might compromise myocardial protection during intraoperative cardioplegic arrest, resulting in ischemic effects to the conduction system.

The AV node is located within the right atrium at the apex of the triangle of Koch, (14) It penetrates through the membranous septum and central fibrous body as the bundle of His, emerging in the ventricles on the crest of the ventricular septum, where it gives rise to the fascicles of left bundle branch. Noncoronay cusp of aortic valve, posterior-medial commissure of the anterior mitral leaflet and the septal leaflet of the tricuspid valve are in close proximity to the AV node. Debridement of the annular tissue at these areas decreases the distance between the AV node and anchoring sutures, thereby increasing the chance for injury to the conduction system. Continuous sutures rather than interrupted sutures have been shown to increase the incidence of postoperative AV conduction abnormalities and PPM. (15)

In the study by Maugenest et al (16), patients who had new onset Bundle branch block had higher mean distance from the proximal end of the Frame of the valve prosthesis to the lower edge of noncoronary cusp, than those without new-onset bundle branch block. (10.3±2.7mm vs. 5.5±3.4mm respectively). Ergodan et al (17), in 465 patients with a mean age 49.9±17.2 years, who underwent AVR, reported that, 19 (14.1%) required PPM. Severe annular calcification was documented in 78.9% of them and was found to be a significant risk factor for PPM ($P<0.01$). However, valvular calcification was not found to be associated with requirement for PPM, reflecting the effect of mechanical trauma during PPM implantation.

Several attempts have been made to find out predicting variables before AVR, with studies focusing on various pre operative variables like age, sex, diabetes, hypertension, dyslipidemia, aortic stenosis versus regurgitation as an indication for surgery, LV function, rheumatic etiology vs. degenerative calcific disease versus congenital etiology, preoperative conduction block, prior infective endocarditis, prior aortic valve surgery, elective surgery versus emergency surgery, and per operative variables like prosthesis valve type used and its diameter, cardioplegia details, associated mitral valve surgery , associated CABG, root replacement surgery, cross clamp time, bypass time, lowest attained temperature, tricuspid valve intervention, decalcification procedure, annular dilatation procedure, with inconsistent results.

Koplan et al (18) formulated a simple risk score for predicting requirement of PPM in patients undergoing valve surgery. This score included RBBB, LBBB,

prolonged PR interval >200 mlsec, multivalve surgery, TV surgery, prior valve surgery and age > 70 years. The risk score was validated later by the same group of authors with risk score from 0 to 6 identified patients with incidences of PPM of 1.9%, 5.2%, 8.7%, 11.5%, 21%, 36%, and 50%, respectively. In their study they found RBBB as a more powerful predictor of PPM than LBBB, which is likely due to a higher rate of injury to the left bundle than the right bundle during aortic or mitral valve surgery, resulting in complete atrioventricular block when RBBB is already present.

Sam Dawkins et al (6) analyzed 342 patients undergoing AVR, out of which 29 patients 8.5% required PPM. The indications for PPM were persistent complete AV block (n = 25), sinus bradycardia (n = 3), and atrial fibrillation (required to prevent bradycardia while controlling faster rates, n = 1). After surgery, the mean time to PPM implantation was 13 days (range, 6 to 57 days). Twenty-six patients (90%) received PPM during the index admission, a mean duration of 11 days after aortic valve surgery (range, 6 to 25 days). Logistic regression analysis demonstrated presence of preoperative conduction system disease as the only independent predictor of requirement for PPM. Aortic valve regurgitation as a indication for AVR also predicted need for PPM after AVR (16% versus 7%; $p = 0.01$) The size of the aortic valve prosthesis was associated with PPM requirement; the best cutoff prosthetic aortic valve diameter for separating patients according to PPM requirement was 24 mm, patients with aortic regurgitation received larger prosthetic valves (24.9 _ 2.8 mm) as compared with the rest of the study group. Following variables were not associated with an in increased requirement for PPM, age,

sex, aortic stenosis or endocarditis as indication for surgery, elective or emergency procedure, valve type (mechanical or bioprosthetic), lowest operative temperature, and total cross-clamp or bypass time.

Hieu huynh et al (7) reported patients who underwent PPM implantation after AVR had significantly higher rates of documented first-degree AV block with or without left anterior fascicular block (LAFB) or nonspecific intraventricular conduction delay (IVCD) (26.7% vs. 5.2%, P = 0.01) and postoperative cardiac arrest (20% vs. 4.7%, P = 0.04). In addition, patients having mitral valve replacement in addition to aortic valve had higher chance of requirement for the PPM. The patients requiring postoperative PPM had the device implanted at 6.1 ± 2.3 days after the procedure. Device interrogation review showed seven (70%) of patients as PPM dependent.

G Limongelli et al (8) analyzed data of 276 AVR patients and multivariate logistic regression analysis in their study identified preoperative aortic regurgitation ($p < 0.005$; odds ratio (OR) 6.6, 95% confidence interval (CI) 1.6 to 12.2), myocardial infarction ($p < 0.0005$; OR 15.2, 95% CI 6.3 to 19.9), pulmonary hypertension ($p < 0.005$; OR 12.5, 95% CI 3.2 to 18.3), and postoperative electrolyte imbalance ($p < 0.01$; OR 4.5, 95% CI 1.3 to 6.4) as risk factors for permanent pacing. Mechanism behind the conduction block was explained as chronic and progressive mechanical stretch on AV node due to annular ectasia associated with AR, pulmonary hypertension affecting electrophysiological properties of fibers on RV side of septum. In addition, a previous myocardial infarction may contribute to further injury of the conduction system. On the background of

structural heart disease, external triggering factors such as electrolytic disorders could play a part in the development of irreversible conduction disorders.

Keefe et al (19) evaluated 102 consecutive patients undergoing isolated AVR. Postoperative CHB was common, occurring in 18 (18%) patients. Six (6%) patients required PPM before discharge, and a further 3 patients (3%) required late PPM (median follow- up, 4.2 years). The study could not predict any clinical or operative variables for early development of complete AV block.

There is not much trial specifically addressing the need for PPM after dual valve replacement or AVR with CABG. However in study by koplan et al (18) dual valve replacement patients had higher incidence of PPM than patients with only AVR.

Mitral valve replacement is more complex and it sometimes results in longer ischemic times, which has been postulated as being responsible for the postoperative incidence of the AV node block, however, the exact mechanism of the postoperative AV node block is still not understood. The mitral valve annulus is anatomically in close proximity to the atrioventricular conduction system, particularly the posterior-medial commissure of the anterior mitral leaflet, which lies close to the atrioventricular node. These anatomical arrangements might have important relation with development of conduction disturbances after manipulation in these areas.

Koplan et al (18) also noted that AV node artery in some cases approaches the annulus fibrosus of the mitral valve. Independent from the dominance or the origin, in 13 (23%) cases the AV node artery approached the P3 section of the posterior leaflet and

passes frequently just near the posterolateral part of the mitral valve annulus. They postulated that damages to AV node artery become very probable during the mitral valve ring annuloplasty or prosthesis implantation and this may be the reason for need for PPM after MVR. The risk of developing a conduction disturbance after MVR is more likely to be an AV Block (61.3%) rather than bundle branch block (38.7%). According to the hemodynamic effects, neither the stenotic neither the regurgitant valves were identified as predisposing factors for the AV Block.

Patients undergoing repeat cardiac surgery have been reported to have higher incidence of PPM. (20) Joseph et al (20) reported 9.7 % incidence of permanent pacemaker implantation among undergoing repeat cardiac surgery, approximately a fourfold increase compared with similar primary operations reported in other series. Factors strongly related to this need included valve replacement surgery, preoperative endocarditis, number of reoperations, advanced age, and degree of hypothermia during cardio pulmonary bypass. A multivariable analysis showed that the need for PPM was more common in those patients with tricuspid valve annuloplasty / replacement associated with aortic/mitral valve replacements, preoperative prosthetic endocarditis, greater number of reoperations, and lowest core temperature during cardiopulmonary bypass, and advanced age. They mentioned that The AV node lies close to the noncoronary cusp of the aortic valve, the posterior-medial commissure of the anterior mitral leaflet, and the septal leaflet of the tricuspid valve. Debridement of annular tissue at these areas decreases the distance between the AV node and anchoring sutures, thereby increasing the chance

for conduction injury. Careful attention to this anatomy combined with judicious debridement and choice of a valvular prosthesis commensurate with the clinical setting may lessen this problem.

There are conflicting reports on the impact of total bypass and cross-clamp time, degree of myocardial cooling (9) (21), and method of cardioplegia. (22) These presumably reflect severity of ischemic damage to the conducting system. Dawkins et al (6) reported that none of these factors predicted need for PPM following AVR.

Although systemic hypothermia appears to have a salutary effect on myocardial protection during aortic cross clamping, injury to the conduction system may parallel the level of reduced temperature. In one series, (22) cold myocardial "protection" (core cooling to 28° C plus cold cardioplegia) produced greater injury to the conduction system than a warm delivery system (normothermic perfusion and cardioplegia). Postoperative conduction defects were significantly more common with cold cardioplegia: 57.6% versus 27.5% immediately after operation, 41.3% versus 9.2% Post op day 1, 32.6% versus 4.2% post op day2, and 19.6% versus 1.7% at hospital discharge ($p<0.001$).

Tricuspid valve surgery has also been associated with increased need for the pacemaker after cardiac surgery. Jokinen et al (23) published data of 136 patients who had undergone Tricuspid valve replacement or repair with or without other cardiac surgery. The incidence pacemaker therapy was 21% over long term with mean time of implantation 562 +/- 954 days (range, 5 to 3108 days). However 54% of pacemakers were done during index hospitalization. Among the tested variables they found following

5 variables statistically significant (1). Need for temporary pacing during the immediate postoperative period, (2) female gender, (3) lack of adequate cardiac rhythm on the first postoperative day, (4) use of TV annuloplasty ring rather than TV replacement or De Vega annuloplasty to repair TR, and (5) LBBB before the operation. 24% of their patients had AVR done.

Patients & Methods

This study is a retrospective study of the patients who had undergone aortic valve replacement at tertiary cardiac care center between January 1998 and December 2009. In the computer data base, well maintained by the hospital, search was made for entry of word "AVR" or "aortic valve replacement" or" double valve replacement (DVR) or DVR". This search yielded 1276 entries, detailed records of which were analyzed. Out of these 1276 entries 814 patients had aortic valve replacement done during the study period which formed the study population. After that medical records of all 814 patients were collected from the medical record department and analyzed for the study.

All the patient records were analyzed for the clinical variables, indication for AVR, etiology of aortic valve disease, associated other surgeries, preoperative electrocardiogram, per operative cardioplegia and perfusion time details, post operative electrocardiogram, need for any pacemaker, and pacemaker details. Patients who had pacemaker done prior to surgery were excluded from the study.

Development of any new conduction block after AVR was noted which included prolongation of PR interval, new LBBB, new RBBB and increase in QRS duration after AVR. Patients, who had mitral valve replacement (MVR) and CABG done along with AVR, were also included in the study.

Predominant pathology of aortic valve was analyzed from the echocardiogram report (rheumatic aortic valve, severely calcific valve, bicuspid aortic valve, aortic root

dilatation, sinus of valsalva aneurysm), histopathology report of excised valve specimen or surgical operative notes

Dominant hemodynamic lesion was noted as 3 categories: dominant aortic stenosis, dominant aortic regurgitation, mixed lesion.

Per operative details were noted for emergency vs. elective surgery, type of valve used (mechanical vs. bioprosthesis), size of the prosthesis used, whether redo surgery or first surgery, cardioplegia details, aortic cross clamp time and cardio pulmonary bypass time.

The follow up details were also noted from the hospital records, as recorded during their regular follow up visits to surgical and cardiology clinic.

The detailed pre-operative evaluation in these cases included a comprehensive echocardiographic examination in all and coronary angiogram in patients above 40 years. All surgeries were performed under standard cardiopulmonary bypass established between ascending aorta and bicaval venous cannulation. Moderate systemic hypothermia with cold crystalloid prime and after that cold blood ante grade cardioplegia repeated every 30 minutes was maintained for myocardial protection. Continuous monitoring with electrocardiography and central venous and arterial monitoring was done for all patients, who underwent temporary epicardial pacing following rhythm disturbances after weaning from cardio pulmonary bypass. Electrocardiography was

performed daily in all the patients who developed rhythm disturbances post-operatively. All these patients also had a 12-lead electrocardiogram recorded on the day of discharge.

Out of total 814 patients complete data was available for 731 patients. Only these patients were included in the final statistical analysis, excluding 83 patients for the reason of missing data. Although demographic and other details were available for these 83 patients, main reason for their exclusion was unavailable ECG, and operative details.

Out of these 731 AVR patients, 23 patients required pacemaker after AVR. These 23 patients were also studied for the same variables.

STATISTICS

Continuous variables are expressed as mean ± SD and compared using the independent *t* test. Categorical variables are compared with Fischer's exact test. A *p* value <0.05 was considered significant. Univariate and Multivariate logistic regression analysis was done using cutoff value of $p < 0.2$ to find out variables predictive of permanent pacemaker implantation. Statistical analysis was done using SPSS for Windows, Version 11.0.

Observations & Results

Out of 731 patients of aortic valve replacement, 23 patients had undergone PPM (3.14%).

Characteristics of the patients in PPM group and that of patients without PPM are shown in table 1.

Etiology for aortic valve disease requiring AVR was rheumatic heart disease in 48.3% cases, degenerative aortic valve disease in 24.8% cases and bicuspid aortic valve disease in 16.4% cases. Average age was 42.2 ± 15 years.

29.5 % patients had predominant aortic stenosis, 37.9% patients had aortic regurgitation and 32.7 % patients had mixed lesion. 24 patients had AVR done as emergency. Associated MVR surgery was in 166 (22.7%) patients and associated CABG was in 73 (10%) patients. 29 (4%) patients had redo AVR. 42 patients had new development of first degree heart block, 21 patients had new onset RBBB and 22 patients had new onset LBBB.

Table 1. Characteristics of patients who had undergone AVR, divided into 2 groups according to requirement of pacemaker after surgery.

Characteristic	All Patients number (%) (n=731)	PPM (n=23)	No PPM (n=708)	*p* Value
Age	42.2 ± 15	48.7±11.6	42±15	0.036
Sex (female/male)	206/523 (28.3/71.7)	11/12 (47.8/52.2)	195/511 (27.6/72.4)	0.034
HTN	95 (13)	5 (21.7)	90 (12.7)	0.205
DM	79(10.8)	1(4.3)	78 (11)	0.311
EF (%)	62.7±11.7	64.1±11.7	62.7±11.7	0.576
Rhythm (SR/AF)	663/59 (91.8/8.2)	18/1 (94.7/5.3)	645/58 (91.7/8.3)	0.639
Indication for AVR				
AS	216 (29.5)	12 (52.2)	204 (28.8)	0.016
AR	277(37.9)	6(26.1)	271(38.2)	0.051

AS + AR	239(32.7)	5(21.7)	234(33.1)	0.491
Etiology				
Rheumatic	353 (48.3)	8 (34.8)	345 (48.7)	0.188
Degenerative	181(24.8)	7(30.4)	174(24.6)	0.522
BAV	120(16.4)	6 (26.1)	114(16.1)	0.489
Conduction abnormality				
1st degree AV block	57 (7.8)	4 (17.4)	53 (7.5)	0.081
LBBB	24 (3.3)	6 (26.1)	18 (2.5)	P<0.001
RBBB	21 (2.9)	2 (8.7)	19 (2.7)	0.089
Elective/ emergency	705/24	19/4	686/20	P<0.001
Mechanical/bioprosthetic valve	656/72 (90.1/9.9)	22/1 (95.7/4.3)	634/71 (89.9/10.1)	0.366
Prosthetic valve dm	22.6±2.6	22.7±3.2	22.6±2.6	0.895
MVR	166 (22.7)	3 (13)	163 (23)	0.261
CABG	73 (10)	4 (17.4)	69 (9.7)	0.229

Redo surgery	29 (4)	2 (8.7)	27 (3.8)	0.238
Cross clamp time (min)	92.5±33.3	93.4±42	92.5±33.3	0.896
Bypass time (min)	134.4±48.2	144.4±75.6	134.1±47.1	0.321
Cardioplegia amount (ml)	1826±740	1835±666	1825±742	0.952

Predictors of PPM implantation

Among the demographic variables female gender $p = 0.034$ and older age $p = 0.03$ were significantly associated with PPM implantation.

Presence of preoperative conduction block was seen 134 out of 731(18.33 %) patients. Out of which, pre operative RBBB ($p = 0.089$), and LBBB ($p < 0.001$) were significant predictor of PPM requirement after AVR. 42 patients had new development of first degree heart block, 21 patients had new onset RBBB and 22 patients had new onset LBBB.

Univariate analysis using the cutoff value of $p < 0.05$, showed following variables to have significant predictive value for PPM: female gender ($p=0.04$, odds ratio [OR] 2.4), pre operative LBBB ($p<0.01$, OR 13.52), aortic stenosis ($p=0.02$, OR 2.70), age ($p=0.04$).

variables which were not significantly predicting of PPM were diabetes, Hypertension, preoperative rhythm(sinus rhythm/atrial fibrillation), etiology of aortic valve disease, associated surgery (MVR, CABG or others), isolated aortic regurgitation or mixed lesion, mechanical vs. bioprosthetic valve, specific type of mechanical valve , valve diameter, redo surgery, type of cardioplegia, cross clamp time, perfusion time.

Multivariate stepwise logistic regression analysis (table 3), using the cutoff value of $p<0.2$, showed that only female gender (p= , OR 2.67 [95% CI 1.06-6.74]), pre operative LBBB (p= , OR 6.74[95% CI 1.35-33.52]) and pre operative RBBB (p= , OR 15.63 [95% CI 5.14-47.57]) having independent predictive value.

Table 2. Univariate analysis for predicting pacemaker requirement after AVR

Variables	S.E.	P value	Odds ratio
Female gender	0.43	0.04	2.40
Diabetes	1.03	0.33	0.37
Hypertension	0.52	0.21	1.91

AF vs. SR	1.04	0.64	1.61
First degree AV block	0.57	0.09	2.60
LAHB	1.04	0.84	-
RBBB	0.78	0.11	3.45
LBBB	0.53	<0.001	13.52
Rheumatic etiology	0.44	0.19	0.56
Degenerative etiology	0.46	0.52	1.34
Congenital heart disease (BAV)	0.49	0.18	1.95
Aortic stenosis	0.43	0.02	2.70
Aortic regurgitation	0.48	0.24	0.57
AS + AR	0.51	0.26	0.56
Emergency surgery	0.60	< 0.001	7.22

Mechanical valve / bioprosthetic	1.03	0.38	2.45
MVR	0.62	0.27	0.50
CABG	0.56	0.24	1.95
REDO surgery	0.77	0.25	2.40

Table 3. Multivariate logistic regression analysis

variable	S.E.	P value	Odds ratio (95% CI)
Female gender	0.47	o.o4	2.67 (1.06 - 6.74)
LBBB	0.82	0.02	6.74 (1.35 - 33.52)
RBBB	0.57	<0.01	15.63 (5.14 - 47.57)

Discussion

Incidence of requirement of PPM in patients undergoing isolated AVR, reported in various study is between 1 to 8.5 %. (3) (8) (17) (18) (4) (7) (19) (6). In our study incidence is 3.1% suggestive of low risk of PPM requirement after AVR in contemporary practice including DVR patients and patients having CABG with AVR.

Contrary to the studies from developed countries, the major indication for AVR in our country is rheumatic heart disease rather than degenerative aortic valve disease, as reflected by 48 % of AVR patients having rheumatic etiology. Also average age of patient undergoing AVR is less than that in western countries reflecting the difference in etiology of aortic valve disease. As the patients undergoing AVR in developing countries differ in many ways compared to western countries, the incidence and predictors of PPM after AVR reported in these studies from developed countries may not reflect the risk in our population.

One of the common predictor of need for PPM after AVR found in various studies across the world is pre existing conduction block. Histological abnormalities of the conducting system are well documented in patients with aortic valve disease (13) and prolonged HV interval is reported in patients with aortic stenosis (24). Ischemia during surgery and mechanical trauma during valve replacement may further damage the already diseased conduction system and lead to complete heart block.

Huynh et al (7) in their study of 197 patients found that preexisting Atrioventricular, intrafascicular or intraventricular conduction disease predicts PPM. Sam

dawkins et al (6) reported that the only independent predictor of PPM requirement is preoperative conduction block but from the sample size of 342 patients they were not able to identify a specific conduction abnormality that presented the greatest risk. Deborah L. Keefe et al (19) in 102 patients were unable to find any independent variable predicting PPM. Bruce Koplan (18) and et al found that pre existing RBBB is significantly associated with requirement of post operative PPM and they suggested that preoperative damage to Left bundle branch leads to complete heart block in patients already having RBBB. Follath and Ginks (25) demonstrated that intraventricular conduction defects were common after aortic valve surgery (26%).

Our study of 731 patients has confirmed that in our population presence of pre existing conduction block, both RBBB and LBBB have independent predicting value for requirement of PPM after AVR.

Old age was not a significant predictor of PPM requirement after AVR in our study. Kohl et al reported incidence of 6 %for PPM after AVR in 83 octogenarian patients. Morell and Colleagues reported 6.5% incidence in 46 patients (range, 75 to 88 years) undergoing AVR.

G Limongelli (8) et al found that aortic regurgitation is significant predictor for PPM and this was believed to be due to larger annular diameter in this patients, requiring larger prosthesis with consequent more damage to conduction tissue, however in many

similar trial (6) (7), implanted prosthetic valve diameter was not found to have any significant predictive value for the PPM requirement.

Addition of blood to an established crystalloid cardioplegic solution is reported to enhance enhanced myocardial protection significantly by reducing arrhythmias, improving rate of recovery of myocardial function and maintaining myocardial high-energy phosphate content during ischemia (26), and SR Gundry et al (27) reported data effect of type of cardioplegia on incidence of conduction disturbances in patients undergoing CABG. Forty-one (23%) of 179 patients with crystalloid cardioplegia had conduction disturbances versus 141 (49%) of 289 patients with blood cardioplegia (p less than 0.001). However our study did not find signicant association of blood cardioplegia with development of conduction abnormality, this may be due to enhanced myocardial protection and shorter surgery time at tertiary center. Study by G Limongelli (8) specifically focused on per operative variables did not find type of cardioplegia as a significant variable.

Associated mitral valve surgery is reported to be a negative factor for requirement for PPM, although p value insignificant, the reason behind this is not clear. In our study also patient having DVR were less likely to have need for PPM but not to the level of significance. One reason may be that patient going for DVR may have primarily severe mitral valve disease necessitating surgery and the aortic pathology being moderate in severity neither mild enough to leave alone nor severe enough to cause conduction abnormality. As the 48.5% of our patients had rheumatic etiology in which mitral

involvement is well known to be more severe than aortic valve involvement, this may be the reason for lesser need for PPM in DVR patient. Patient going for the CABG with AVR had higher requirement of PPM after surgery however it was statistically not significant. Higher requirement of PPM may be due to higher chances of ischemic damage to the conduction tissue due to preexisting coronary ischemia or preexisting myocardial infarction induced conduction tissue damage.

New variable emerged in this large study is the female gender as an independent variable for the PPM requirement after AVR.

Study Limitations

1) It is a retrospective study with collection of data from the medical records of surgical admissions, preoperative surgical notes and pacemaker follow up clinic notes.
2) A single center study, some patients might have undergone PPM implantation in another centre and would not have been enrolled in this study

Conclusion

Rheumatic heart disease is a major indication for the AVR, requiring AVR at younger age in contrary to developed countries. The pre existing conduction blocks RBBB and LBBB both are having independent significant predicting value for requirement of PPM after AVR. Female gender is emerged as the new variable to have significant predicting value, necessitating further study to find out the cause for that.

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GLOSSARY

AF	Atrial Fibrillation
AR	Aortic regurgitation
AS	Aortic Stenosis
AV	Atrio Ventricular
AVR	Aortic valve Replacement
BAV	Bicuspid Aortic valve
CABG	Coronary Artery Bypass Graft
CHB	Complete Heart Block
CI	Confidence Interval
DM	Diabetes Mellitus
DVR	Double Valve Replacement
ECG	electrocardiogram
EF	ejection Fraction
HTN	Hypertension
IVCD	Intra Ventricular Conduction Block
LAFB	Left Anterior Fascicular Block
LAHB	Left Anterior Hemi Block
LBBB	Left Bundle Branch Bllock
LPHB	Left Posterior Hemi Block
LV	Left Ventricle
MR	Mitral Regurgitation

MS	Mitral Stenosis
MVR	Mitral Valve Replacement
PPM	Permanent PaceMaker
RBBB	Right Bundle Branch Block
RV	Right Ventricle
SR	Sinus Rhythm
TV	Tricuspid Valve

Report II

INTERMEDIATE AND LONG TERM FOLLOW-UP OF PATIENTS WITH TRANSCATHETER CLOSURE OF OSTIUM SECUNDUM ATRIAL SEPTAL DEFECTS

CONTENTS

Introduction

Atrial Septal Defect (ASD) is a common congenital heart defect with an estimated prevalence of 3.78/10 000 live births and ranks as the fourth most common form of congenital heart disease with 5.9% of cases of congenital heart disease in the pediatric population. In adulthood also, it is one of the most common congenital heart defects (1; 2; 3) .

Short term and intermediate term follow up results of transcatheter device closure of ASD are encouraging and presently, if closure of ASD is indicated clinically, then transcatheter device closure of ASD is the class I indication according to guidelines. (4).

Initial reports of successful transcatheter closure of ASD were with the Amplatzer Septal Occluder device (ASO), and presently, at least 5 different devices based on the design almost similar to ASO are in clinical use, result of which is assumed to be similar to ASO.

Aims & Objectives

To review the intermediate and long term safety and efficacy of transcatheter closure of ASD with various available devices.

Review of Literature

The earliest reported transcatheter device closure of ostium secundum ASD was by King and Mills in 1976 (5; 6), and then by Rashkind in 1983 (7).

However these early attempts did not met clinical acceptance due to high profile of device, high rate of residual leaks, device fractures and embolization rates, need for large delivery sheaths with its associated complications, (8; 9).

since the description of first clinical trials with the ASO in 1995 and 1997 (10; 11), there have been many reports of successful ASD closure with the ASO device (12; 13; 14; 15; 16; 17; 18; 19).

The advantage of the ASO device is its simpler technique of implantation, ability to reposition even after opening, self centering mechanism, very low incidence of residual shunt and complications on follow up.

Since then, there have been various other devices in use, made by different manufacturers based on the similar basic design but with minor modifications, procedural result and long term follow up of which is not much known, but assumed to be similar to ASO device.

The reported procedure success rate of ASD closure in various reports approaches to 95% and depends on careful patient selection and ASD assessment with transesophageal echocardiography (TEE).

Reported complications of the procedure includes device embolization (device migration), air embolism, thromboembolisms, arrhythmia, access site related complications – deep vein thrombosis, transient ischemic attack, cerebrovascular accidents, acute coronary event, infective endocarditis, residual leaks (11; 13; 18; 20).

There are report of minor elevation of cardiac troponin I after transcatheter ASD closure (21), amount of troponin released having relation with the device size. However the absolute levels of troponin were very low, suggestive of minor damage. This minor elevation in cardiac biomarker may be due to mild myocardial lesion caused by stretching of the interatrial septum by the sizing balloon or device waist or by device rims.

There are reports of failed endothelialisation (22), even after 2 years of device implantation as documented by gross examination in patient with ASD device closure done and later on going for cardiac surgery for other reasons. Contrary to this, there are reports of complete endothelialisation as well (23; 24), documented on gross and histopathological examination of surgically retrieved device.

Most of the studies reporting follow up have shown excellent results on long term follow-up. Complete occlusion without residual shunts has been reported in

85 % on the first day of implantation, which increased up to 98.7 % at the end of 3 months. Studies also have shown significant resolution of the right heart enlargement, within 3-6 months of the procedure. After 6 months, significant regression of RA RV size does not occur. The resolution of right heart enlargement is significantly more in younger patient. Closure of ASD is also shown to be associated with subsequent reduction in LA volumes (25).

The incidence of long term complications after ASD device closure has been very few, such as late device embolization, thromboembolic complications, right atrial to aorta fistula (18; 11). There is theoretical risk of Nickel toxicity however there is no conclusive evidence to substantiate nickel toxicity. Late embolization and erosion of cardiac structure by device are mentioned only as rare case reports (26).

Device closure of an ASD before the onset of atrial arrhythmias may protect against the subsequent development of arrhythmia, in particular in patients less than 55 years of age. (27)

There are reports of transient Atrioventricular (AV) conduction block during transcatheter device closure of ASD. It is believed to be due to compression of conduction tissue by the rims of the device. This is particularly pertinent in small children with large devices. However there are no reports of persistent high grade

AV block requiring need for pacemaker after device closure of ASD, and transient arrhythmia are most common only in early periods after device closure (11).

Late occurrence of atrial arrhythmia are reported in patients who had undergone ASD device closure, however it is difficult to establish the causal relation as the ASD patients are at high risk of atrial arrhythmia even after successful closure with surgical methods and believed to be due to atrial stretch with atrial enlargement and some degree of fibrosis which fails to reverse after ASD closure.

Transient ST Elevation is the major complication reported with the potential for myocardial infarction or cerebral event or even death (26). It is due to air embolism occurring during passage of large venous sheath through the large sized venous puncture. This complication was initially reported in patients who had device closure attempted under deep propofol sedation without mechanical ventilation, with patient spontaneously breathing. It is due to negative intrathoracic pressure generated during deep inspiration which sucks the air in the large venous sheath and, because of presence of ASD, it can travel to left heart. In supine position air can travel to right coronary artery as the ostium of this artery at higher level than left coronary artery, and this can cause transient ST elevation in inferior leads.

One reported complication of sizing the ASD with balloon prior to transcatheter device closure is laceration of atrial septum (28)

Indication of ASD closure

Small ASDs with a diameter of less than 5 mm and no evidence of RV volume overload do not impact the natural history of the individual and thus may not require closure unless associated with paradoxical embolism (29). Larger defects with evidence of RV volume overload on echocardiography usually only cause symptoms in the third decade of life, and closure is usually indicated to prevent long-term complications such as atrial arrhythmias, reduced exercise tolerance, hemodynamically significant TR, right to left shunting and embolism during pregnancy, overt congestive cardiac failure, or pulmonary vascular disease that may develop in up to 5% to 10% of affected (mainly female) individuals.

Sinus venosus, coronary sinus, and ostium primum type defects are not amenable to device closure. An ASD with a large septal aneurysm or a multi fenestrated atrial septum requires careful evaluation by and consultation with interventional cardiologists before device closure is selected as the method of repair (4).

Materials & Methods

This study was conducted in a tertiary care referral center. Patients diagnosed to have clinically significant ASD, mandating closure, were considered for transcatheter ASD closure. Patient underwent Trans thoracic and if feasible transesophageal study to look for feasibility of transcatheter closure of ASD. Anatomy of the defect was evaluated in terms of it rims and its relation to important structures. Pathophysiology was evaluated in terms of pulmonary hypertension and right ventricular function, mitral regurgitation and pulmonary stenosis.

This study included all the patients who had transcatheter closure of ASD between 1998 and 2005.

Exclusion Criteria :

Patients who had ASD with inadequate rims,

Patients with associated other cardiac defects requiring open heart surgery,

Patients not willing for transcatheter closure of ASD,

Patients with ostium primum ASD,

Patients with sinus venosus defect,

Patients with coronary sinus type of ASD,

Patients with multiple defects,

Patients with severe PAH and Eisenmenger syndrome.

All the selected patients underwent clinical assessment, followed by chest x-ray, electrocardiogram. Patients were then subjected to detailed right heart catheterization study along with sizing of ASD with amplatzer balloon. After finding suitable hemodynamic and suitable anatomy, patient underwent transcatheter ASD closure.

Device description.

The Amplatzer septal occluder is a self expanding, self centering, and repositionable double disc device constructed of a mesh of 72 Nitinol (a nickel titanium alloy) wires. A 3–4 mm short cylindrical waist connects the two round discs and this waist has to correspond to the so called "stretched" diameter of the ASD, determined by a balloon sizing catheter. Additionally, polyester fibers are sewn into the device promoting thrombosis and complete defect occlusion. Twenty seven different sizes with waist diameters from 4–40 mm are available. For devices between 4–10 mm the left atrial disc is 12 mm larger than the waist and the right

atrial disc is 8 mm larger. For bigger devices the left atrial disc is either 14 mm larger than the waist (waist diameter 11–30 mm) or 16 mm larger than the waist (waist diameter 32–40 mm). The right atrial disc is 10 mm larger than the waist for devices of 11–40 mm. Devices up to 10 mm are made up of nitinol windings of 0.004 inches (0.10 mm); thicker windings of 0.005 inches (0.13 mm) are used in devices from 10 mm to 20 mm, while devices with a diameter greater than 20 mm have thicker windings of 0.006 inches (0.15 mm) for added strength. For transvenous implantation of the Amplatzer occluder, the manufacturer provides a loader, a delivery cable, and a 6–12 French long sheath. Before loading the device into the long sheath it is connected to the delivery cable by a micro screw fixed to the right atrial disc. This screw attachment is laser welded to the nitinol frame.

Description of technique

In the catheterization laboratory and before catheterization, a biplane TEE was done under general anesthesia. An anomalous pulmonary vein connection was excluded by TEE and if required by angiocardiography. The maximum diameter of the defect, the septal length, and the distance of the edge of the defect from the right pulmonary veins, the orifice of the coronary sinus, and the mitral valve were measured using the transverse plane. The distances from the superior and inferior

caval vein were measured from the sagittal or vertical plane. Images of the anterior rim adjacent to the posterior border of the aorta were obtained using both the horizontal and vertical plane. Vascular access was obtained from the femoral vein, and patient was anticoagulated with unfractionated heparin (100 IU/kg). After making a complete hemodynamic evaluation, the "stretched" diameter of the ASD was measured using an Amplatzer sizing balloon (AGA Medical Corporation) or NMT Medical balloon. A device with a waist diameter similar to, or in large defects up to 2 mm bigger than the stretched ASD diameter was chosen. After introducing the long sheath over the exchange guide wire into the left upper pulmonary vein, the device was inserted and deployed under fluoroscopic and TEE guidance. The selected ASO device was attached to the delivery wire by the screw mechanism and was loaded by withdrawing into the loader by traction on the delivery wire. The collapsed ASO device was then advanced through the long sheath that had previously been positioned in the left atrium. Under fluoroscopic control the left atrial disc was extruded by advancing the delivery wire. The sheath and the delivery wire were withdrawn in unison until resistance was met when the extruded left atrial disc was opposed to the atrial septum. The ASO device was then fully deployed by withdrawing the sheath over the delivery wire to extrude the right atrial disc. Once the device was fully deployed across the ASD, its position and stability were assessed by fluoroscopy and TEE. Its position was deemed

optimal if the device was stable and did not obstruct the right pulmonary veins, coronary sinus, caval veins, or the mitral valve. Any residual shunt was documented using color flow Doppler on TEE. The ASO device was then released by anticlockwise rotation of the delivery wire. Before this release, the device could easily be retrieved by withdrawing it into the sheath by traction on the delivery wire. A final assessment of the position of the device was performed by TEE following its release. The patients were monitored for hypoxia, ventricular ectopic, access site related complication. Patients received antiplatelet for 6 months duration post procedure. A repeat transthoracic echocardiography, electrocardiography, and chest *x* ray were performed the next day before discharge. Follow up was arranged for one month, three months, and one year after the implant.

Description of data collection

Post procedure patients were followed up after 1 month, 3 months and 6 months with echocardiography to see the device position and any residual flow across inter atrial septum. All the patients were followed up annually thereafter with clinical examination, electrocardiogram, echocardiography and if required any further investigation.

Follow up note was made in patient records regarding his/her functional class, any embolic events, and any cardiac symptoms like palpitation, dyspnea or syncope. Patients and their record were reviewed to collect the data.

All the patients were reviewed annually thereafter for any clinical events, complication. They underwent detailed TTE to see for the device position, residual leak, development of PAH and new development of aortic regurgitation or obstruction to any flow. Some of the patients also underwent TEE as part of another study.

Outcome measures:

Safety was defined as avoidance of death or major complications like cerebral embolism, cardiac perforation, air embolism, device embolization, and endocarditis.

Efficacy was defined as successful closure of the ASD without any residual shunt or only trivial shunt.

Residual shunts were classified as follows

Trivial: < 1 mm in diameter

Small: 1-2 mm in diameter

Moderate: 3-4 mm in diameter

Large: > 4 mm in diameter

Statistical analysis:

Descriptive analysis was done using Microsoft excel statistical package. All results were expressed as mean +/- standard deviation.

Observations & Results

All patients diagnosed to have secundum ASD on transthoracic echocardiography, had right heart catheterization study done along with sizing of the ASD with static balloon. Adult patient had transesophageal echocardiography in addition to see for the suitability of the device closure. Total of 112 patients underwent Trans catheter closure of ASD.

Baseline clinical characteristics:

The mean age of the patients was 23 years ± 15 years (range 4-70 years). 38 were male and 77 patients were female with female to male ratio of 2.02.

Fig. 1 age distribution of patients

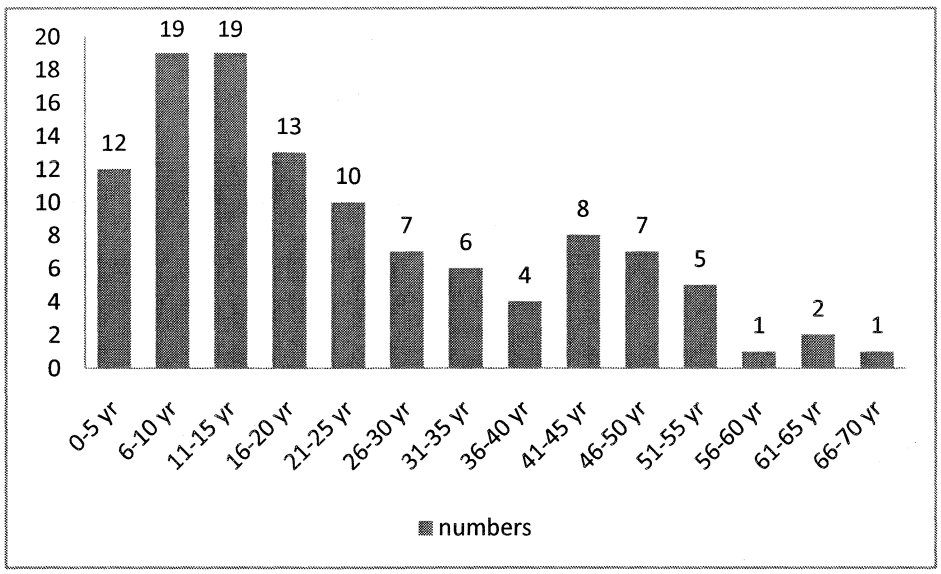
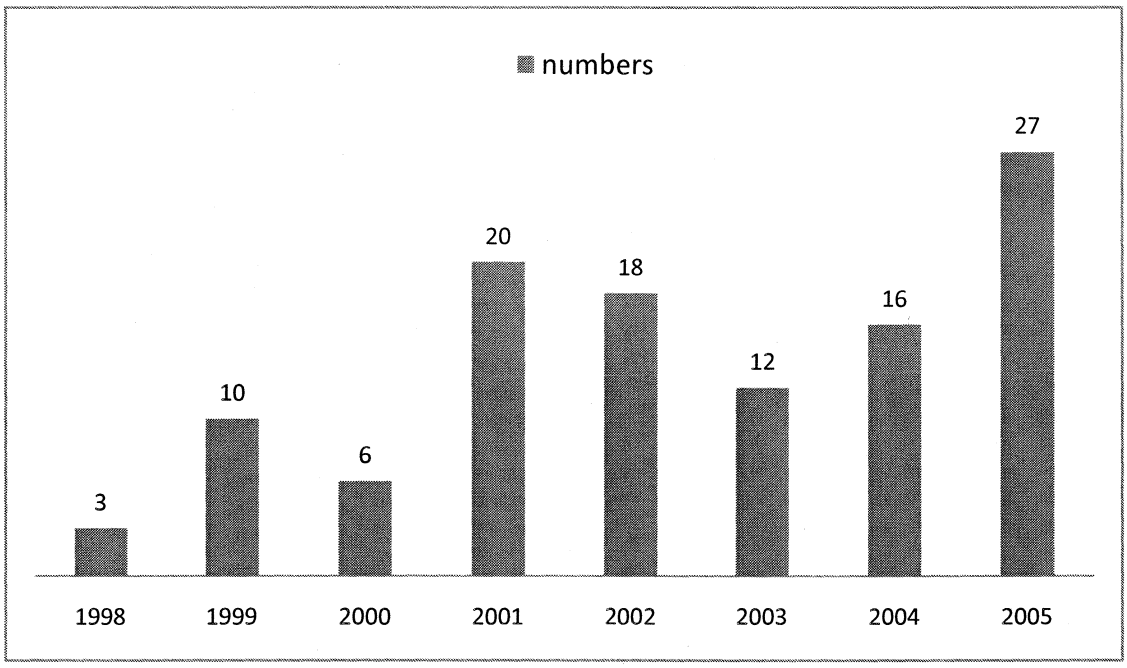


Fig.2 Number of procedure per year



Average body surface area of the patients was 1.27 meter square. All of the patients were either in functional class I or II. None of the patient had Class III or class IV symptoms. All the patients were in sinus rhythm.

Baseline Echocardiography

All patients had evidence of RA RV volume overload on echocardiography. Average size of ASD on trans thoracic Echo was 15 mm ± 3.4 mm, range 9 mm to 28 mm , and on Trans esophageal echocardiogram ASD measured at 18 mm average with range 11to 28 mm. RV internal dimension was 29.22 ± 6 mm , against the LV dimension of 35 mm ± 7 mm.

Baseline catheterization data

Average Qp: Qs ratio was 2.13 ± .4, (range 1.03 to 5.9). None of the patient had right to left intracardiac shunt. Average Right Ventricular systolic pressure was 31 ±6 mm Hg, with range 15 mm to 82 mm. Only one patient had mild pulmonary stenosis, not requiring intervention on the pulmonary valve. None of the patient had any other intervention done in the same sitting. Average PA

pressure was 16 ± 6 mm Hg. Average calculated Pulmonary vascular resistance came to 1.23 woods unit and highest PVR was 6.72 woods units, with mean PA pressure of 16 ± 3.5 mm Hg. Balloon sizing of the defect with the static balloon showed average diameter of the defect 21. ± 64 4 mm with largest 32 mm and smallest 10 mm. Average size of the device used was 23 ± 4 mm (range 11 to 32 mm). Average up gradation from the measured defect on balloon sizing to ASD device size was 1.5 ± 1 mm (range 0 to 3 mm). 16 patients had Blocaid device implanted while rest of the patient had AGA Amplatzer device deployed. Post procedure the device position was found optimal by TTE and fluoroscopy in all patients.

Peri Procedure Complications

In one patient, despite repeated attempts, Device closure was unsuccessful due to inadequate rims, as the Device was repeatedly coming to right atrium easily and hence backed out. One patient had device embolization detected on the next day due to desaturation. Stretched diameter of the ASD on balloon sizing was 25.5 mm and 28 mm device was deployed in this case. The device had migrated to Pulmonary artery, which was immediately retrieved and surgical closure of the

ASD was done. One patient developed transient ST elevation in inferior leads, which settled down within few minutes, without any significant sequel.

Post procedural and late complications:

One of the patients had abdominal wall hematoma, related to high femoral puncture and drug induced thrombocytopenia.

Average follow up duration of the patient was 46.54 ± 8 months. During this follow up period none of the patient had any major complication.

One patient who had ASD size of 24.4 mm on balloon sizing, closed with 26 mm of ASD device; was, on follow up found to have prolapse of Left Atrial disc on the Right Atrium side at the point of aortic rim. Patient underwent detailed evaluation with transesophageal echocardiography. Residual shunt across the defect was small, and patient was kept under medical follow up. None of the patient had more than small residual shunt across the device. None of the patient had any documented cerebrovascular accident or any other embolic phenomenon. None of the patient developed new aortic regurgitation on follow up. One patient had grade 2 aortic regurgitation prior to procedure, which remained same on follow up. Etiology of mild aortic regurgitation in this patient was rheumatic fever. None of the patient had aortic erosion or aortic-atrial fistula. None of the patient on follow up was found to have Brady arrhythmia or Atrio ventricular conduction

disorder requiring intervention. One of the patients had pre existing severe pulmonary hypertension with Right ventricular pressure of 82 mm Hg with calculated Qp: Qs of 1.44, she underwent device closure with 20 mm sized device, as PAH was thought to be unrelated to small size of the atrial septal defect. Patient did not have right ventricular dysfunction in the next 12 months follow up.

Discussion

Tran catheter closure of secundum ASD using the amplatzer septal occluder and various other similar available devices has become a standard practice for closure of these defects in modern pediatric cardiology practice. Large number of studies has been reported in literature stating safety and efficacy the procedure (30; 11). The result of this study confirms this observation of the other previous reports. Safety and efficacy of the procedure was at par with that reported from other countries.

In a study of 236 patients with ASD, G Fischer et al (13) have shown successful closure of ASD in 84.7% of consecutive patients, with excellent intermediate results. Results of residual shunt reported by this group was 17% immediate after the procedure which decrease to 7 % on follow up, majority of which were trivial. Our results are similar in terms of very minimal rate of residual shunt. A peculiar complication reported by this group is the cobra head deformity of the device. When relatively large device is deployed in the small sized patient, there may not be enough space available for the disc to take its shape, and disc may remain elongated. Downsizing the device, if acceptable, may solve the problem. This investigator also studied the fluoroscopic pattern of device on long term follow up. The heart cycle dependent movement of the elastic Nitinol wire mesh directly after implantation of the occluder could no longer be seen in any of the

implanted devices on the cine sequence taken one year after implantation. These lacks of movement of elastic nitinol wire mesh was correlated with complete endothelialisation. There were no events of impingement of important surround structures in our study which included significant number of small patients with average body surface area of only 1.2 meter square, as also in this large study in which they didn't noticed any event of impingement of surrounding structure.

In a study by Jojef Masura (11), 151 patients were studied for safety and intermediate term follow-up after ASD device closure. Results reported were excellent with no deaths, cardiac perforations, device embolizations or malpositions, thrombus formations or thromboembolisms, significant arrhythmias, infective endocarditis or other morbidity during the entire follow-up period ranging from 56 to 108 months (median 78 months). None of the patient had significant residual shunt on follow up, similar to the results from our study. Late complications reported by other groups are also very rare (31; 32; 33). Rare late complications like late cardiac perforation or aortic to right atrial fistula and thrombus formation over the disc have been reported (34; 35; 36; 37). One case report of thrombus formation over the LA disc of device, causing cerebral emboli 3 years after implantation has been published (38). There is a case report of delayed embolization of device by verma et al (39). None of our patient has such a complication. One of our patients had transient ST elevation during the procedure

which subsided without any significant sequel. There are reports of acute coronary event occurring during the procedure as a result of air embolism (40). Spontaneous breathing during the procedure which entails large venous sheath is considered responsible. There is sucking of air in the venous sheath due to negative intrathoracic pressure, which then travels to the arterial system through ASD and reaches to coronaries. Use of general anesthesia with controlled positive pressure ventilation is used to prevent this complication.

There are reports of infective endocarditis occurring on the device (41). Use of strict aseptic precaution during the procedure is must to prevent such a complication.

Development of transient AV block has been reported in literature (42), however this AV block are almost always transient, and none of the patient so far required pacemaker therapy for the AV block caused by device. In our study also, none of the patient had significant AV block.

In a study by S P Schoen et al (43), incidence of development of new aortic regurgitation was studied. In this study, author found that 9 % of ASD device closure patients developed aortic regurgitation. Etiology proposed by the author for the development of new AR was, overgrowth of the device by tissue, leading to changes in interatrial septal geometry and traction on the root of the noncoronary

aortic cusp. However 19 % of the patients had pre existing aortic regurgitation, and majority of new development AR was mild only. In our study only one patient had pre existing AR, which was mild and remained same on follow up

Study Limitations

1. This study is not designed as a prospective study of all comer ASD patients. What percentage of ASD patients were planned for the percutaneous closure is not known and hence a selection bias exist in the cohort of patients who had ASD device closure done. It is possible that small ASD or the very suitable defects selected for the device closure, while more challenging defects planned for surgical closure.

2. Follow up Transesophageal echo to see for device thrombus, device migration, micro-erosion, residual shunt, was done only in minority of the patients.

3. Follow up fluoroscopy was not done to see for any strut fracture and type of device movement.

4. Procedure was not compared with surgical closure of ASD.

Conclusion

Tran catheter closure of ostium secundum ASD is safe and effective in vast majority of patients in whom procedure is indicated.

Intermediate term and long term results are excellent with very low incidence of residual shunt or any other major life threatening complications.

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GLOSSARY

AR	Aortic Regurgitation
ASD	Atrial Septal Defect
ASO	Amplatzer Septal Occluder
AV	Atrio-Ventricular
LA	Left Atrium
LV	Left Ventricle
PA	Pulmonary Artery
PAH	Pulmonary Artery Hypertension
PVR	Pulmonary Vascular Resistance
Qp:Qs	ratio of Pulmonary Blood Flow and Systemic blood flow
RA	Right Atrium
RV	Right Ventricle
RVSP	Right Ventricullar Systolic Pressure
SVR	Systemic Vascular Resistance
TEE	Trans Esophageal Echocardiography
TTE	Trans Thoracic Echocardiography