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Evolution of Senning Procedure: Mid-Term Outcome in a Single Center Experience

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Abstract

Objectives: Evaluate our midterm outcome after Senning procedure for physiologic repair of Simple Transposition.

Patients and Methods: a retrospective study on patients who were diagnosed as simple Transposition and were not allocated to arterial switch operation. The patients enrolled in the study were operated between 2000 and 2018 and the operative data were obtained from patient's files and the midterm outcome were obtained from outpatient's records.

Results: 88 patients were done at this period, of whom only 43 patients were followed as the missing patients either following up in other centers in remote areas or may die and no data available for follow up records. The 43 patients had operated by 2 techniques either the standard Senning (26 patients) or the modified in situ pericardial Senning (17 patients). The 5-year survival in the standard group was 88.5% and 94% In pericardial insitu Senning, P value (0.89).5 years freedom from Arrythmias was 76.9% in Standard Senning and 88.2% in modified in situ pericardial Senning, P value (0.21). 5 years freedom from Significant TR was 69.2% in Standard Senning and 82.3% in modified in situ pericardial Senning, P value (0.73). 5 years freedom from Significant RV dysfunction was 65.3% in Standard Senning and 88.2% in modified in situ pericardial Senning, P value (0.52). There was no significant difference among the studied groups regarding midterm outcome.

Conclusion: In developing countries selection criteria limits the standard anatomical correction of simple Transposition. For those patients who had complex coronary artery anatomy, neonatal medical condition that precludes anatomical repair of simple TGA; the atrial switch still have a role for physiologic repair of simple TGA.

Keywords: Atrial Switch • Simple TGA • Senning • Transposition of the Great Arteries • Mustard

Abbreviations: d-TGA: Dextro-Transposition of the Great Arteries

Introduction

The evolution of repair of simple Transposition started at the mid of 20th century as in 1950 Blalock-Hanlon operation was introduced to improve mixing at the atrial level, in 1952, Walton Lilleheianastomosed the RPV to RA and the IVC to the LA [1,2].

In 1955 by Dr Harold M. Albert a paper published the idea of physiologic correction of transposition [3].

In 1956, Thomas G. Baffles, working with Willis J. Potts in Chicago, described his technique [4].

In 1957, Alvin Merendino, first attempted to clinically apply a modified Albert's technique [5].

In 1959 Ake Senning successfully performed the complete physiological repair or the atrial switch operation [6].

In 1961 Schumacker HB Jr. introduced a new modification of Senning [7].

In 1964 Mustard WT. introduced a procedure which abandoned Senning for the sake of simplicity [8].

In 1977 Quaegebeur JM, published a preliminary report on recent experience of Senning procedure [9].

In 1979 J A Waldhausen, W S Pierce , W Berman Jr, and V Whitman introduced Modified Shumacker repair of transposition of the great arteries [10].

In 1980 Jonas RA, Mee RB introduced the Senning as the first choice over the Mustard [11].

During the mid-1980s, the atrial switch operation was gradually replaced by Jatene's arterial switch [12].

In 1990 Ilbawi MN, introduced the Senning procedure as a part of anatomical correction of the CCTGA [13].

In the last decade of the 20th century many authors popularized the double switch procedure for CCTGA [13-15].

In developing countries difficulty in resources play a role in wide spread of anatomical correction of simple transposition, as neonates with low birth wight had difficulties in postoperative managements, neonatal sepsis and associated other system anomaliesm [16-18]. Nowadays the number of arterial switch procedure had exceeded the number of atrial switches in our country, by times the atrial switch may not be approached by the new generations in spite of its main role in the anatomical correction of congenitally corrected transposition [19].

It is well known that the right ventricle morphology has difficulty in supporting the systemic circulation, the same applied to the tricuspid valve when it is the systemic AV valve [20]. The incisions and multiple suturing on both atria attribute to the occurrence of early and late postoperative arrhythmias in addition to new onset RV dysfunction. Both the Senning and the Mustard procedures has their drawbacks in long term regarding the baffle leaks and

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baffle obstruction, this obstruction may affect both the systemic and the pulmonary pathways [21-23]. The mid and long-term outcome of Senning procedure are widely discussed, in the below Table 1 the recent results of long-term outcome after atrial switch procedure based on the known confounding factors, we are trying in this work to evaluate our patients operated by Senning procedure and evaluate our modified in situ pericardial Senning.

RV dysfunction

The issue of assessing right ventricular function is still challenging. The right ventricle has an unusual shape, making quantitative assessment of right ventricular volumes challenging. In patients with normal physiology, low pulmonary arterial pressures require relatively low stroke work in the right ventricle. Chronic heart failure typically increases loading conditions on the right ventricle, and the right ventricle becomes conditioned to increase stroke work. Unfortunately, a number of factors then combine to cause right ventricular dysfunction post-operatively either in the early and late postoperative course [24,25].

Diagnosis of Right Ventricular Failure

Clinical signs

The clinical signs of right ventricular failure are mainly determined by backward failure causing systemic congestion. In advanced forms, the right heart dilates and, through interventricular dependence, the left ventricular filling will be impaired, reducing LV performance and causing forward failure (i.e. hypotension and hypoperfusion). This backward failure presents as elevated central venous pressure with distension of the jugular veins and may lead to organ dysfunction and peripheral edema. The association between systemic congestion and renal, hepatic and gastrointestinal function in heart failure has been extensively studied. Elevated central venous pressure is the main determinant of impaired kidney, hepatic ang gastrointestinal functions in acute heart failure [26].

Echocardiography

The main imaging modality of the (failing) right ventricle is echocardiography. A detailed assessment of the anatomy and function of the right side should include left heart function, pulmonary hemodynamics, the tricuspid valve and the right atrium. Transthoracic assessment by echocardiography is sufficient to describe the right ventricular morphology and function adequately.

Cardiac MRI

It become the standard reference method for right heart acquisition as it is capable of visualizing anatomy, quantifying function and calculating flow. In addition, it is useful in cases where image quality by echocardiography is limited. In spite these benefits there are some limitations to the cardiac MRI mainly due to the thinning of the right ventricular wall, which can make it challenging to differentiate it from surrounding tissues. In addition, pacemakers or pacemaker leads may interfere with image acquisition during MRI and lead to artefacts that impair visualization of the right ventricular walls [27-42] (Table 1).

Study design

A retrospective study done on patients diagnosed as simple transposition and were not allocated to the anatomical correction (Arterial switch) between year 2000 and 2018. The protocol was approved by the ethical committee at our Institute in 8/2018 based on our institutional regulations the present study was conducted in compliance with the ethical standards of the responsible institution on human subjects. The operative data were obtained from the operative records and the postoperative course were obtained from the ICU records, as a routine all operated pediatric cardiac patients are following in the pediatric cardiac outpatient unit one month after surgery then on regular 6 months follow up visits the follow up work includes chest x-ray, bed side 12 lead ECG and bed side transthoracic echocardiography by a dedicated pediatric echo cardiographer, for those patients who present with rhythm disturbances Holter monitoring and electro physiologic studies with the corresponding team. For patients who had RV dilatation and RV impairment the recently introduced CMR was done.

The complete data were obtained only from 43 patients due to missed data. The cause may bethe patients are following up in near cardiac centers and loss of contact number.

Anaesthetic consideration

All patients were premedicated with midazolam 0.5 mg/kg orally 15 minutes before transfer to the operating room (OR). On arrival to OR 5-leads electrocardiogram (ECG) and pulse oximeter were connected to the patients and continuously displayed on the monitor (Drager Infinity Kappa, Danvers, USA). The patients received sevoflurane 1% in 2 litre oxygen while inserting peripheral intravascular cannulaand an arterial line if possible. Induction of anaesthesia consisted of 2% sevoflurane in 80% oxygen, fentanyl 5 ug/kg and pancuronium 0.1 ug/kg to facilitate endotracheal intubation. After intubation the patients were connected to the anaesthesia machine (Drager Primus, Lubeck, Germany). Patients were ventilated with 60% inspired oxygen in air before cardiopulmonary (CPB) and 80% after bypass. Anaesthesia was maintained by 1% isoflurane in oxygen-air mixture and 1 ug/kg fentanyl every 30 minutes before and after CPB, and during CPB with midazolam 0.1 mg/kg and 1% isoflurane.

Surgical procedures

Through midline sternotomy, the pericardial cavity was entered after partial thymectomy. A large piece of pericardium was harvested and treated with 2% glutaraldehyde for 5minutes in Standard Senning. The ascending aorta, proximal arch, the root of the neck vessels and both pulmonary artery and its branches were dissected to full mobilization. After going on bypass, a state

Table 1. General results of recent series.

N	Study/year	Number of patients	Late Mortality	Follow up years
1	Marx et al, 1983(28)	57	4%	1.1 y range 0.02–3 y
2	Litwin et al, 1987(29)	40	5%	range 0.5–5 y
3	Rubay et al, 1987(30)	26	0%	4 y range 0.08–8 y
4	Bender et al, 1989(31)	93	1%	3.8 y range 0.8 –9.4 y
5	Helbing et al, 1994(32)	68	16%	11.0 y range 0.1–20 y
6	Reddy et al, 1996(16)	54	0%	6.4 y range 0.5–12.1 y
7	Kirjavainen et al, 1998(33)	100	8%	12.8 y range 6.2–18.4 y
8	Sarkar et al, 1999(34)	141	9%	13.4 y range 0.32–17.9 y
9	Wells et al, 2000(35)	173	14%	10.0 y
10	Moons et al, 2004(36)	339	7.7%	30 y
11	Dodge-Khatami et al/ 2005(37)	345	8%	15.4 y range 0.7–33.3 y
12	Vejlstrup et al 2015(38)	468	38%	26 y range 0.4–60 y
13	A. Raissadati et al 2017(39)	211	24%	43 y

of moderate hypothermia is maintained during a state of cardioplegic arrest. The state of cardioplegic arrest was achieved by either multiple doses of St Tomas cardioplegia solution before 2012 or a single dose of Custidiol after 2012. The dose is effective for three hours of continuous cardioplegic arrest.

Two techniques were used in our center for Senning procedure the standard Senning involved most patients operated between 2000 and 2012. The other technique and is our modified Insitu pericardial Senning procedure. This technique involves harvesting the pericardium over its pericardiophrenic pedicle to ensure potential growth. The step of pericardial preparation starts before cardioplegic arrest. In Cardio Alex meeting 2014 we presented our first 5 cases of modified Insitu pericardial Senning procedure, in this modification we incised the ostium of both right pulmonary veins and put two fixation suture in each lip of the incised vein to the pericardial flap under the phrenic pedicle this widened the pulmonary inflow by the double as illustrated in the Figure 1 below.

Exclusion criteria

- TGA and VSD (larger than 3 mm).
- TGA, VSD and PS (gradient >30 mm hg).
- DORV, Taussig Bing Type.
- Heterotaxia and atrial isomerism.

Intraoperative Epicardial Echocardiography

In all cases of e-echo and subsequent transthoracic echocardiograph examinations were performed using Phillips HD11XE ultrasound systems (Phillips, Andover, MA) and in the last year of the study a new machine was available (Phillips EPIQ7C) using higher frequency probes (5-12 MHz).

Epicardial images may only be obtained by an operator who is wearing a sterile gown and gloves within the operative field as described in the guidelines.

The guidelines describe seven e-echo imaging planes consistent with the American society of echocardiography.

All patients had preoperative, intraoperative (epicardial or transesophageal echocardiography) then pre-discharge echocardiography. Follow up visits were done on three months interval by pediatric cardiology and pediatric cardiac surgeon. Subsequent, late echocardiograms were performed at our institution in all patients at least 6 months postoperatively. All studies were reviewed by 3 cardiologists (R.A.M.) to assess the degree of tricuspid

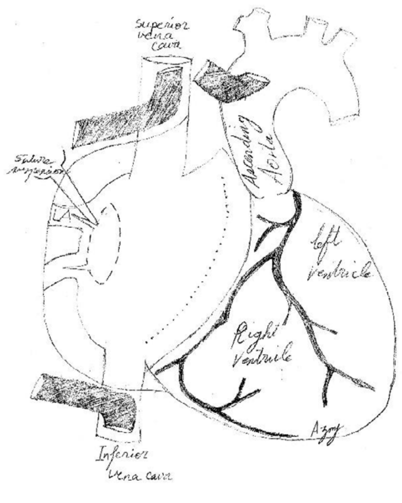

Figure 1. Our modification involved PV incision and suture resuspension of the Insitu pericardial technique [Longitudinal Rt pulmonary veins incisions and suspension sutures].

regurgitation (TR), RV size, and systolic dysfunction. The degree of TR was assessed by standard techniques (width of vena contracta, density of Doppler waveform, and hepatic venous flow changes). Tricuspid regurgitation was graded as 0, none; 1, trivial; 2, mild; 3, moderate; and 4, severe. Qualitative assessments for RV enlargement and systolic dysfunction were made using a similar scale: 0, normal; 1, borderline; 2, mild; 3, moderate; or 4, severe enlargement or dysfunction [40].

Statistical Methods

All data were collected, tabulated and statistically analyzed using the Statistical Package for the Social Sciences (IBM SPSS version 25). Continuous variables were summarized as mean +/- standard deviation if normally distributed. Non-normally distributed continuous variables were summarized as median and inter-quartile range (IQR). Categorical variables were summarized as proportions and frequencies. Normality was assessed by the Kolmogorov Smirnov tests and Shapiro - Wilk test. Student t-test was used for normally distributed variables and Mann-Whitney U test for non-normally distributed variables. Chi-Square test (X^2) was used to test categorical variables (results were presented as percentages and the corresponding P value).All tests were two-sided, p<0.05 was considered statistically significant, and p ≥ 0.05 was considered non statistically significant.

Results

In our study, total 43 patients with TGA subjected to surgical repair; 26 repaired with Standard Senning Technique, 17 repaired with modified insitu Pericardial Senning technique).

Demographic data: Median age of cases subjected to Standard Senningwas10 months (min 7-max 85 months) while median of age of cases subjected to modified insitu Pericardial Senning was 10.5 ms (min 8 – max 67 months)

Median of weight (Kg) of cases subjected to Standard Senning 7 Kg (min 5-max 22 Kg)Median of weight (Kg) of cases subjected to Pericardial Senning 7.5 Kg (min 6.5-max 18 Kg), Median of length –height (cm) of cases subjected to Standard Senning 67 cm (min 62-max 119 cm) Median of length –height (cm) of cases subjected to Pericardial Senning 68.5 cm (min 64-max 106 cm), Median of body surface area (m2) of cases subjected to Standard Senning 0.37 m2 (min 0.3-max 0.85 m2) Median of body surface area (m2) of cases subjected to Pericardial Senning 0.38 m2 (min 0.35-max 0.73 m2) Median of BMI of cases subjected to Standard Senning 15.7 (min 11.3-max 19.5) Median of BMI of cases subjected to Pericardial Senning 15.87 (min 13.7-max 18.5) the demographic data and their statistical assessment are summarized in Tables 2 & 3.

The presence of small nonsignificant VSD and nonsignificant pulmonary stenosis are illustrated in Table 4 and there was no statistical difference between the studied groups. The preoperative procedure like atrial septostomy were done in 5 patients in standard Senning and in 2 patients in group of patients who received pericardial Senning, these data and their statistical analysis is summarized in Table 5.

Late postoperative outcome: the data obtained from the outpatients follow up ECG, Holter studies revealed no statistically significant difference between both studied groups regarding postoperative arrythmias, these are shown in Table 6. The Kaplan-Meier –curve for late postoperative arrhythmias is shown in Figure 2.

The incidence of TR, RV dysfunction, Baffle leaks and late mortality among the studied groups are summarized in Table 7-10 which show there were no significant statistical difference among the studied groups, Kaplan-Meier curve for freedom from Late Mortality and RV dysfunction and TR are shown in Figures 3-5 respectively (Tables 6-10).

The incidence of baffle obstruction late postoperative revealed higher

Table 2. This table illustrate quantitive data of the studied groups.

			Statistics					
Group			**Months**	**Kg**	**Cm**	**M2**	**BMI**	**Vent_days**
Stand_Senning	N	Valid	26	26	26	26	26	26
		Missing	0	0	0	0	0	0
	Median		10.000	7.000	67.000	.3700	15.7300	3.00
	Range		78.0	17.0	57.0	.55	8.22	8
	Minimum		7.0	5.0	62.0	.30	11.31	2
	Maximum		85.0	22.0	119.0	.85	19.53	10
Pericard_Senning	N	Valid	17	17	17	17	17	17
		Missing	0	0	0	0	0	0
	Median		10.500	7.500	68.500	.3800	15.8700	2.00
	Range		59.0	11.5	42.0	.38	4.86	6
	Minimum		8.0	6.5	64.0	.35	13.73	2
	Maximum		67.0	18.0	106.0	.73	18.59	8
Nonparametric Tests: MWU test P Value			0.299	0.427	0.370	0.323	0.364	0.240

Table 3. Gender distribution on the studied groups.

Crosstab				
		Sex		Total
		Male	Female	
Group	Stand_Senning	17	9	26
	Pericard_Senning	12	5	17
Total		29	14	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.722

Table 4. Distribution of associated lesions.

Crosstab					
		Associted_Lesion			Total
		No	VSD	PS	
Group	Stand_Senning	16	5	5	26
	Pericard_Senning	12	3	2	17
Total		28	8	7	43
Pearson Chi-Square		Asymptotic Significance (2-sided)			.781

Table 5. Previous balloon atrial septostomy.

Crosstab				
		Balloon_Sept		Total
		No	Yes	
Group	Stand_Senning	9	17	26
	Pericard_Senning	1	16	17
Total		10	33	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.029

Table 6. Incidences of late Arrythmias.

Crosstab				
		Arrythmia Late		Total
		No	Yes	
Group	Stand_Senning	20	6(23%)	26
	Pericard_Senning	15	2(11%)	17
Total		35	8	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.351

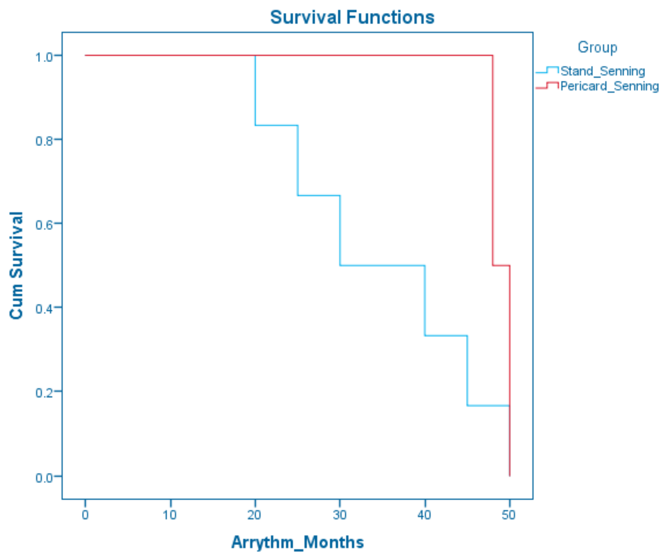

Figure 2. Kaplan-Meier – curve this figure shows the midterm freedom from Arrythmias after Atrial switch by both techniques. P value (0.212).

Table 7. Incidences of Late TR.

Crosstab				
		Outpat TR		Total
		No	Yes	
Group	Stand_Senning	18	8(30%)	26
	Pericard_Senning	14	3(17%)	17
Total		32	11	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.335

Table 8. Incidences of baffle leaks.

Crosstab				
		Baffle_Leak		Total
		No	Yes	
Group	Stand_Senning	23	3(11.5%)	26
	Pericard_Senning	16	1(6%)	17
Total		39	4	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.532

Table 9. Incidences of Right ventricular dysfunction.

Crosstab				
		RV Dysfunct		Total
		NO	Yes	
Group	Stand_Senning	17	9(34%)	26
	Pericard_Senning	15	2(12%)	17
Total		32	11	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.093

Table 10. Incidences of late mortality.

Crosstab				
		Late Mortality		Total
		NO	Yes	
Group	Stand_Senning	23	3(11%)	26
	Pericard_Senning	16	1(6%)	17
Total		39	4	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		.532

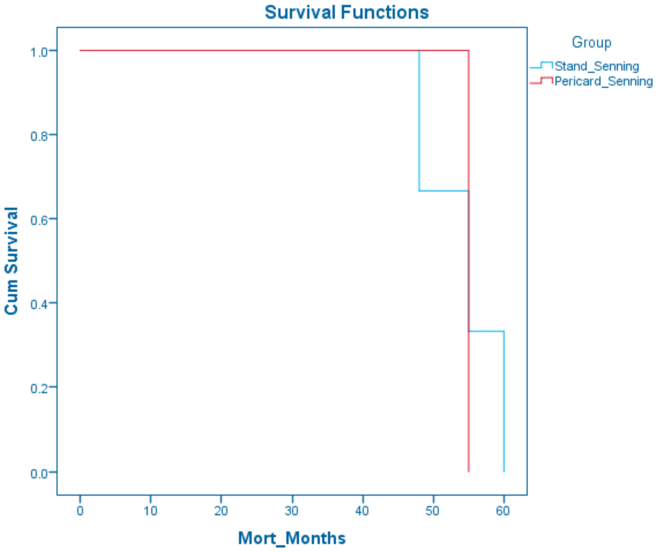

Figure 3. Kaplan-Meier – Survival this figure shows the midterm survival after Atrial switch by both techniques. P value (0.896).

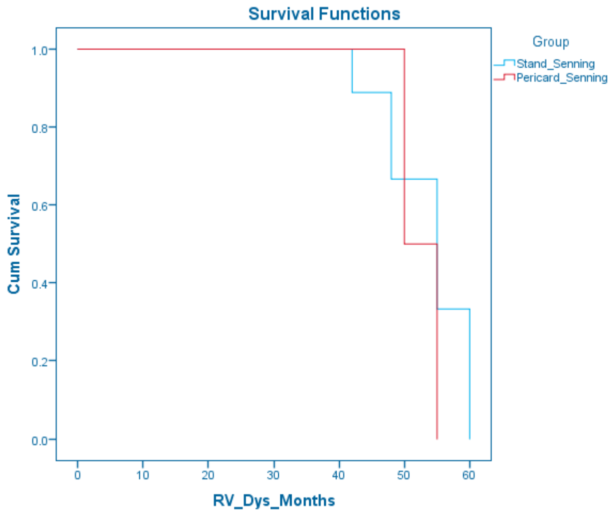

Figure 4. Kaplan-Meier – curve this figure shows the midterm freedom from Significant RV dysfunction after Atrial switch by both techniques. P value (0.521).

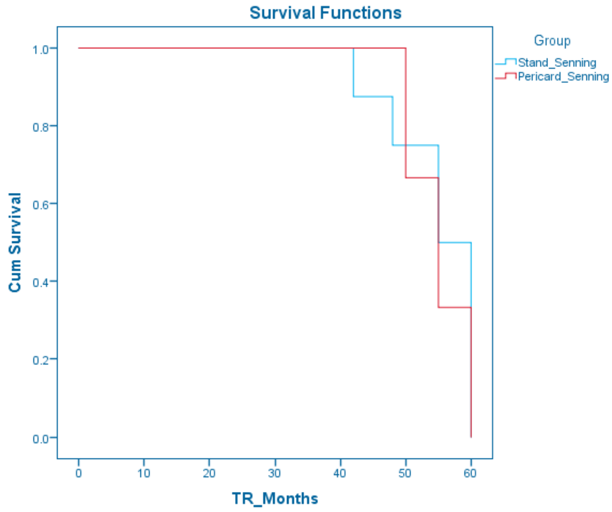

Figure 5. Kaplan-Meier – curve this figure shows the midterm freedom from Significant TR after Atrial switch by both techniques. P value (0.735).

Table 11. Incidences of Baffle obstruction.

Crosstab				
		Baffle_Obstruct		Total
		NO	Yes	
Group	Stand_Senning	20	6(23%)	26
	Pericard_Senning	17	0(0%)	17
Total		38	5	43
Pearson Chi-Square		Asymptotic Significance (2-sided)		0.032*

incidence in standard Senning than our modified insitu pericardial Senning as shown in Table 11 this difference was significantly different between both groups (Table 11) (Figures 2-5).

Discussion

Atrial switch operation had lost its role as the main management of patients with DTGA since early eighties for the sake of ASO. The number of procedures started to decline progressively with the start of the new century and in this decade the procedure became scarce [41].

There are some situations that increase the risk of the arterial switch procedure like low birth weight, severe idiopathic pulmonary hypertension and uncontrolled sepsis [37]. Those patients especially in limited resources will benefit more from deferring neonatal ASO to late Atrial switch. There is a group of patients the atrial switch offers to whom the anatomical correction as the atrial inversion anomalies and in cases who have congenitally corrected transposition (CCTGA) the atrial switch is considered part of double switch or atrial switch and Rastelli procedure [13,14].

Our study included patients who were diagnosed as simple TGA. The patients operated were categorized according the type of Senning either the standard one described by AkeSenning and its modification that revived by Quaegebeur technique versus the Waldhausen technique and our modification on it. The earlier results belong to the group one who had the standard Senning showed a higher late mortality compared to our modified Senning but the difference was not statistically significant.

The standard Senning had a late mortality incidence of 11% which reflects the expected mortality from the earlier experience and it lies in the range of the available literatures that presented in Table 12 which ranged 0%-16%.

The mortality incidence in modified Senning was 6% reflects not only refinement in the surgical technique but also improvements in postoperative

Table 12. Complications and Reoperations.

Center	Complications	Reoperation Rate	Pacemaker
Zürich Current (Dodge-Khatami et al/ 2005) (37)	3 SVC stenosis, 2 severe TI	10.2% 3 transplantations	3.80%
CHSS (Wells et al, 2000) (35)	Venous pathway complications and RV failure	6.90%	7.50%
London (Sarkar et al, 1999) (34)	1 SVC stenosis, 1 baffle leak, 2 LVOTO, 1 RV failure	3.8% venous pathway complications and LVOTO relief	1.50%
Helsinki (Kirjavainen et al, 1999) (33)	1 pulmonary vein occlusion, 1 severe TI	4% 1 pneumonectomy for pulmonary vein occlusion, 1 transplantation, 2 tricuspid valve operations	24%
Nashville (Bender et al, 1989) (31)	1 baffle leak	1.25% 1 reoperation for baffle leak	3.75%
Leiden (Helbing et al, 1994) (32)	9 TI	0%	4.80%
Boston (Marx et al, 1983) (28)	6 pulmonary vein obstructions, 7 SVC stenosis	12% for systemic and pulmonary venous complications	1.90%
Portland (Reddy et al, 1996) (16)	3 TI	3.7% LVOTO relief	0%
Milwaukee (Litwin et al, 1987) (29)	1 pulmonary vein stenosis, 1 TI	2.5%, 1 reoperation for pulmonary venous obstruction	5%
Brussels (Rubay et al, 1987) (30)	2 mild SVC obstructions	0%	NR
Belgium (Moons et al, 2004) (36)	17% arrythmias at 10 y and 46% at 20y, RV dysfunction (Mod in 8.6% and severe in 1.7%), Mod TR in 27.5% and severe in 7.4%, baffle obstruction in 1.4%	Tricuspid valve replacement in four patients, and annuloplasty in one.	14 patients (5.5%)
Sweden and Denmark (Vejlstrup et al 2015) (38)	NR	reoperation was performed in 27 patients (7%)	pacemaker implantation was performed in 63 patients (15%)
Finland:(A. Raissadati et al 2017) (39)	Arrhythmia 16%, Pulmonary stenosis 8%	16% reintervention at 30 y	19/130(14%)

LVOTO _ left ventricular outflow obstruction; nr _ not reported; RV _ right ventricle; SVC _ superior vena cava; TI _ tricuspid valve insufficiency.

follow up.

In the present study the incidence of significant Tricuspid insufficiency showed a higher incidence in the standard Senning than in Modified Senning. This finding may be related to the limited tissue in the standard Senning in contrary to the fluent utilization of pedicled pericardium in modified Senning this leads to suturing without tension.

The incidence of tricuspid insufficiency in our study appeared higher than reported other studies but this may be explained by our definition of significant Tricuspid insufficiency which included patients who have moderate and severe tricuspid insufficiency.

Baffle leaks in our study was defined as shunting across the reconstructed pathways and it showed no significant difference between both group but seems more reported in our series as we used echo Doppler definition and not by diagnostic catheter angiography (Table 12).

The right ventricular function remains the main predictor of long-term outcome after the atrial switch operation. As its occurrence represent the no go back of worse outcome and it reflects this on NYHA class of the patients and hence quality of life [20,25]. It appeared higher in the standard Senning than our modified Senning for many reasons one is the type and technique of myocardial protection used in older series, tension free suturing, and the patient population under study and improved pharmacological management in the postoperative follow up [42]. The long-term studies of atrial switch operation reflected the wide variation of practice even in the same center and times of sluggishness and revivals.

There is wide variation between the reported studies about the right ventricular dysfunction. This reflects the qualitative character of echocardiographic evaluation, the lack of uniform definitions of right ventricular function.

The retrospective character of this study implies that the evaluation of the right ventricle by pediatric and congenital cardiologists involved in the follow up of atrial switch operation is probably not done in a standardized and uniform way. This hampers the comparability of our results with other published data. The cause of RV dysfunction is presently unclear, and the available data are still inconclusive as to its implication. The etiology is probably multifactorial Given the existence of adult patients whose RV volumes, function, and response to exercise are normal long after atrial switch operation, it seems unreasonable to condemn the atrial switch operations on the basis of inevitable RV dysfunction alone(41).

The excellent utilization of pedicled pericardium and the wide opening and suspension of the pulmonary veins ostium significantly affected the incidence of Baffle obstruction in our study. the same findings of reported data from other studies which implemented the insitu pericardial Senning.

Limitations

the small number and the lost data in older records may impair the message from this work but it seems a generalized role in most older series, introduction of new cardiac surgery database programs will improve the quality of reported data specially in long term management. Absence of heart transplantation policy and the newly introduced LV retraining protocol may affect the quality of life of patients with impaired RV.

Conclusion

Congenital cardiac surgeons and cardiologists well seek always for anatomical correction. In limited resources and complex situations, the atrial switch may be safer than other procedure. the atrial switch procedure became a standard step in double switch operation in congenitally corrected transposition and LV retaining to take down old atrial switch.

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