Long-term results of atrial correction for transposition of the great arteries

Comparison of Mustard and Senning operations

Few data exists on the differences in long-term outcome between Mustard and Senning operations. We reviewed available data of all hospital survivors of these operations and assessed risk factors for late death and sinus node dysfunction. Of those patients undergoing the Mustard operation, 60 were hospital survivors (46 simple transposition, 14 complex); of those patients undergoing the Senning operation, 62 were hospital survivors (43 simple, 19 complex). Median duration of follow-up was 16 years (maximum 25 years) for Mustard operation, 11 years (maximum 20 years) for Senning operation. No reoperations were done, except for pacemaker implantation. No differences were found between the two groups with regard to baffle-associated problems, right ventricular failure, sudden death (6 % in both groups), and functional status at final follow-up (New York Heart Association class I or II, except for four patients). For patients undergoing the Mustard operation, survival at 16-year follow-up was 91 % with simple transposition and 60 % with complex transposition ($p = 0.027$); for both groups of patients undergoing the Senning operation, survival at 16-year follow-up was 78 %. Survival in the absence of rhythm disturbance at 16-year follow-up was 18 % for Mustard operation and 53 % for Senning operation ($p < 0.001$). In multivariate analysis, significant independent risk factors for late death turned out to be complex transposition (versus simple) and active arrhythmias. The only significant risk factor for the occurrence of sinus node dysfunction was the Mustard operation. We conclude that apart from the difference in the loss of sinus rhythm, no differences were found in the long-term clinical results of the two types of operations. (J THORAC CARDIOVASC SURG 1994;108:363-72)

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Several techniques are currently available for the surgical correction of transposition of the great arteries. Because of the theoretic advantage of anatomic correc-

tion and good short-to-mid-term results,¹⁻⁵ the arterial switch operation has become the operation of choice in many centers.

In a limited number of patients, anatomic problems (e.g., coronary artery anatomy or pulmonary stenosis) prevent the use of this technique. In others, the presence of neonatal disease can contraindicate one-step arterial switch.⁶ Atrial correction may still be of use in these patients.

Differences between the two possible techniques for atrial correction⁷⁻¹⁰ could well be the cause of differences in the long-term outcome in these patients. Comparison of the results of both techniques has been difficult because most reports focus on a single technique. In 1977, Quaegebeur, Rohmer, and Brom⁹ drew attention to the good

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Table I. Right ventricular function: echocardiographic assessment and criteria

Right ventricular function	Criteria		
	Dimensions	Septal motion	Contraction pattern
Normal	As normal left ventricle	Paradoxic	Good
Moderately depressed	Enlarged	Flat	Depressed
Severely depressed	Severely enlarged	Normal	Poor

Table II. Risk factor analysis (univariate) for the occurrence of rhythm disturbances after atrial correction for transposition of the great arteries

Risk factor	HR	95% CI
Mustard operation*	2.5	1.52-4.12
Senning operation	1	
Simple TGA	1.08	0.61-1.89
Complex TGA	1	
Year of birth*	0.75	0.91-0.99
Year of operation		
Continuous*	0.92	0.88-0.97
Before 1973*	1	
1973-1978*	0.56	0.33-0.96
1978-1987*	0.31	0.15-0.65
Age at operation	1	0.99-1.01
Balloon septostomy	0.67	0.38-1.20
Banding pulmonary artery	0.98	0.31-3.13
Blalock-Hanlon septectomy	1.50	0.93-2.43
Extent of hypothermia	0.97	0.95-0.99
Preoperative hemoglobin level	1.01	0.92-1.12

HR, Hazard ratio; CI, confidence interval; TGA, transposition of the great arteries.

*Statistically significant risk factor ($p \leq 0.05$)

hemodynamic state of a small number of patients a long time after the Senning operation. This attention led to a revival of the use of this technique. Long-term follow-up is now available regarding the first patients described at that time and patients who underwent consecutive operations with the Senning technique since then. We compared the results of these patients with those of all patients who underwent the Mustard operation in our institution to identify differences between the results of both techniques and risk factors for late deterioration.

Methods

Medical records, Holter monitor recordings, echocardiograms, cardiac catheterizations, and exercise test reports of all patients who underwent atrial correction for transposition of the great arteries between 1961 and 1987 were reviewed. Reported data are those of patients who survived for more than 30 days after the operation. Data were grouped according to anatomic category: simple transposition of the great arteries (without ventricular septal defect requiring surgical closure or pulmonary stenosis) and complex transposition of the great arteries (with surgically closed ventricular septal defect or pulmonary stenosis). Patients with associated anomalies other than persistent arterial duct or secundum type atrial septal defect were excluded,

Table III. Risk factor analysis (univariate) for death after atrial correction for transposition of the great arteries

Risk factor	HR	95% CI
Mustard operation	1	
Senning operation	1.17	0.42-3.25
Simple TGA	1	
Complex TGA*	3.29	1.23-8.82
Active arrhythmias*	4.16	1.41-12.24
Year of birth	1.08	0.98-1.20
Year of operation	1.10	0.97-1.25
Age at operation	0.99	0.96-1.01
Balloon septostomy	0.96	0.27-3.37
Blalock-Hanlon septectomy	0.58	0.19-1.71
Extent of hypothermia	1.01	0.96-1.06
Preoperative hemoglobin level	0.98	0.84-1.14

For abbreviations, see Table II.

*Statistically significant risk factor ($p \leq 0.05$)

ed, as were those with pulmonary vascular disease, precluding corrective surgery.

For interpretation of rhythm disturbances, according to Kuglers¹¹ criteria for sinus node dysfunction for surface electrocardiograms, standard 12-lead electrocardiograms obtained at every visit in every patient were used. Active arrhythmias (supraventricular or junctional tachycardia, atrial flutter, and atrial fibrillation) were diagnosed only when confirmed on 24-hour electrocardiogram monitoring. Time of occurrence of rhythm disturbances was defined as the interval between operation and the first of two or more consecutive electrocardiograms showing evidence of the rhythm disturbance.

Tricuspid regurgitation was defined important if a tricuspid regurgitation murmur coincided with diminished functional status (New York Heart Association class II or worse) and pulmonary venous engorgement on chest roentgenogram or with evidence of more than minimal tricuspid regurgitation from color-coded Doppler echocardiography. Transthoracic two-dimensional and color Doppler echocardiography were used for assessment of right ventricular and "baffle" function. The criteria used for the assessment of right ventricular function are given in Table I.^{12,13}

Exercise tests were performed with a bicycle ergometer. Starting from a level of 30 to 60 watts, the workload was increased stepwise with 10 to 20 watts/min until maximum exercise level was reached. The surgical technique for both types of operations was as described by Quaegebeur, Rohmer, and Brom.^{9,10} All operations before 1978 were performed under hypothermia and circulatory arrest. Thereafter cardioplegia was part of all procedures.

Data collection was completed in October 1992.

Table IV. Characteristics of survivors of atrial correction for transposition of the great arteries from 1961 to 1987 (n = 122)

	Simple			Complex		
	Mustard	Senning	p Value*	Mustard	Senning	p Value*
Hospital survivors (n)	46	43		14	19	
Gender (n)						
Male	34	30		3	8	
Female	12	13	0.663	11	11	0.278
Age at operation (mo)						
Median	28.5	8.0		55.5	11.0	
Range	4-73	1-93	<0.001	27-166	2-133	0.009
Duration of follow-up (mo)						
Median	201	80.5		140	131	
Range	1-300	2-239		4-196	2-191	

*See Statistics section.

Table V. Interventions before atrial correction for transposition of the great arteries from 1961 to 1987 (n = 122)

Intervention	Simple			Complex		
	Mustard (n = 46)	Senning (n = 43)	p Value*	Mustard (n = 14)	Senning (n = 19)	p Value*
Blalock-Hanlon septectomy	30	5	<0.001	13	4	<0.001
Rashkind balloon septostomy	31	42	0.002	10	16	0.4
Blalock-Taussig shunt	—	—		—	2	
Banding pulmonary artery	—	1		3	1	

*See Statistics section

Statistics. Differences in demographic variables between groups were assessed with the χ^2 test or Fisher's exact test for categorical variables and the Wilcoxon test or *t* test for continuous data. A *p* value of 0.05 or less was considered statistically significant. The log-rank test was used to compare Kaplan-Meier curves for overall cardiac survival and survival in the absence of rhythm disturbances. In the case of non-cardiac death or loss to follow-up, the patients were censored from the analysis at the time of death or loss to follow-up. Survival analysis was based on all hospital survivors.

Demographic, procedural, and clinical variables that were likely to cause rhythm disturbances or affect survival were entered in a univariate analysis with the use of Cox proportional hazard regression (Tables II and III).

For the identification of independent predictors of late death and of the occurrence of sinus node dysfunction or active arrhythmias, multifactorial stepwise Cox regression analysis was performed. The fit of Cox proportional hazards model was checked for each risk factor by graphical methods.¹⁴ The statistical software used was SAS (version 6.06; SAS Institute, Inc. Cary, N.C.).

Patient characteristics. A total of 76 patients underwent the Mustard operation between 1965 and 1977. Hospital mortality was 21%. Sixty-eight patients underwent the Senning operation from 1961 until 1964 and from 1973 until 1987. Overall hospital mortality was 8.8% (75% between 1961 and 1964). The characteristics of the patients who survived for more than 30 days after the operation are given in Table IV.

Patients who underwent the Mustard operation were signif-

icantly older than Senning patients, in both anatomic categories, reflecting patient treatment in the earlier years of operation of the patients who underwent the Mustard operation. Because some patients moved abroad or were referred to another center, it was not possible to obtain complete information on 10% of the Mustard and 6% of the Senning groups.

Previous interventions. Procedures preceding the atrial switch operations are summarized in Table V. Surgical septectomy was performed more often in the Mustard group than in the Senning group because many patients who underwent the Mustard operation were treated before the introduction of Rashkind's balloon-septostomy technique, which subsequently became the method of choice for creating communication at the atrial level.

Results

Rhythm disturbances. All 122 patients were in sinus rhythm before the operation. In the Mustard group, Holter electrocardiograms were available in 22 patients; in the Senning group, they were available in 15 patients. The rhythm status at final follow-up is summarized in Table VI. Seventy-four percent of the Mustard group eventually had sinus node dysfunction, compared with 43% of the Senning group.

Kaplan-Meier curves for survival in the absence of rhythm disturbance show significant differences between

Table VI. Rhythm status at final follow-up after atrial correction for transposition of the great arteries

Rhythm	No. of patients	
	Mustard	Senning
Sinus	14	32
Junctional	20	16
Junctional + AF/runs SVT	15	6
Bradycardia (periods)	2	1
Bradycardia + AF/runs SVT	2	1
Pacemaker	6	3
Antiarrhythmic drugs	9	5

AF, Atrial flutter, SVT, supraventricular tachycardia.

patients in the Mustard and Senning groups (Fig. 1). A rapid decline in the percentage of patients in sinus rhythm occurred in the first 5 years after the operation. After this period, a continuing but more gradual decrease occurred. At 5-year follow-up, 35.6% of the Mustard group showed no signs of rhythm disturbances versus 67.4% of the Senning group. At 16-year follow-up, this percentage diminished to 17.8% in the Mustard group and 52.7% in the Senning group ($p < 0.001$). Survival in the absence of rhythm disturbances did not differ significantly between simple and complex transposition, irrespective of the type of operation ($p = 0.80$).

The items listed in Table II were entered in univariate analysis of the risk of the occurrence of sinus node dysfunction (both active and passive arrhythmias). Because of a lack of adequate data, duration of circulatory arrest or cardiopulmonary bypass time could not be included as additional items. The year of operation was entered in two ways: (1) as a continuous variable and (2) grouped in three classes: before 1973, from 1973 to 1977, and from 1978 to 1987. The classes correspond to the initial period of atrial correction (when Mustard operations were mainly performed), the period of revival of the Senning operation (when both the Mustard and Senning techniques were used), and the period when the Mustard technique had been replaced completely by the Senning operation and cardioplegia had been introduced, respectively.

In this univariate analysis, the Mustard operation, year of birth, and year of operation, both as a continuous variables and grouped in classes, were found to be significant risk factors for sinus node dysfunction (Table II). The same items (Table II) used for univariate analysis were entered in multivariate analysis. In this study, the Mustard operation was identified as the only independent risk factor predicting an increased chance of developing rhythm disturbances (hazard ratio 2.50 [95% confidence interval 1.52 to 4.12]).

Table VII. Residual problems after atrial correction for transposition of the great arteries

Residual problem	No. of patients	
	Mustard (n = 42)	Senning (n = 28)
Baffle obstruction (gradient ≥ 5 mm Hg)	3	1
Small shunt atrial level	4	9
Small shunt ventricular level	2	6
Pulmonary stenosis		
Gradient 15-30 mm Hg	5	4
Gradient 31-60 mm Hg	4	5

A separate analysis was made for the risk of developing active arrhythmias with the same items as entered in previous analyses and introducing sinus rhythm and passive arrhythmias as additional, time-dependent items. In both univariate and multivariate analysis, passive arrhythmias were shown to be the only (independent) risk factor for developing active arrhythmias, increasing this risk by a factor 3.29 (confidence interval 1.54 to 7.04; multivariate). The influence of the other factors did not reach statistical significance.

Late mortality. In the Mustard group, 10 patients died 1 month to 15 years after the immediate postoperative period with at random distribution of time of death. Four patients died suddenly and unexpectedly 2 to 78 months after the operation. One of these four patients was known to have atrial fibrillation with episodes of supraventricular tachycardia. Right ventricular failure was the cause of death in one patient. In two patients, the cause of death is unknown, and three deaths were due to non-cardiac causes.

Ten patients in the Senning group died between 2 months and 16 years after their operation. Two died of right heart failure, one as the result of postpericardiectomy syndrome with therapy resistant pericardial effusion, another patient presented in ventricular fibrillation and could not be resuscitated. Four patients died suddenly 2 to 139 months after the operation, two of whom were known to have atrial fibrillation with episodes of supraventricular tachycardias. There were two noncardiac deaths.

The overall survival for patients in the Mustard group with simple transposition is 93% at 5 years and 90.6% at 10 and 16 years after the operation (Fig. 2). For patients in the Mustard group with complex transposition survival is significantly lower: 75.5% at 5 and 10 years and 60.4% at 16-year follow-up ($p = 0.027$).

Survival at 5-year follow-up for patients after the Senning operation for simple transposition is 97.6%. At 10- and 16-year follow-up, the survival probability is 94.8% and 77.8%, respectively (Fig. 3). Figures for complex

Table VIII. Right ventricular function; echocardiographic assessment; atrial switch operations from 1961 to 1987

Right ventricular function	Simple		Complex	
	Mustard (n = 46)	Senning (n = 43)	Mustard (n = 14)	Senning (n = 19)
Normal	19	22	4	9
Moderately depressed	11	12	2	5
Severely depressed	6	3	2	3
Unknown	10	6	6	2
p Value*	0.54		0.91	

*See Statistics section.

transposition are 84.2% at 5-year follow-up, and 78.6% for 10- and 16-year follow-up. For patients in the Senning group, the differences between survival probability for simple and complex transposition did not reach statistical significance ($p = 0.17$). Differences in survival between patients in the Mustard and Senning groups who underwent operation for simple transposition did not reach statistical significance.

The items listed in Table III were used in univariate and multivariate analysis of the risk of late death. In multivariate analysis of (overall) patient survival, complex transposition (versus simple) and the occurrence of active arrhythmias, included as time-dependent covariate, turned out to be the only independent risk factors for late death with hazard ratios of 2.89 (95% confidence interval 1.07 to 7.82) and 3.56 (95% confidence interval 1.21 to 10.5), respectively.

Residual problems. Seventy of the 122 patients underwent cardiac catheterization and angiography in the first weeks after the operation. Results of these investigations are given in Table VII. Differences in the percentages of residual problems were not statistically significant. None of these patients underwent reoperation, and none died during follow-up.

Tricuspid regurgitation. Important tricuspid regurgitation was found in six patients in the Mustard group (two simple, four complex) and nine patients in the Senning group (five simple, four complex). In three patients in the Mustard group and two patients in the Senning group, tricuspid regurgitation was established at cardiac catheterization in the immediate post-operative period; in the remaining patients, tricuspid regurgitation was detected noninvasively at an average of 216 (Mustard) and 121 (Senning) months after the operation. The occurrence of tricuspid regurgitation did not differ statistically significantly between anatomic categories or operation types ($p = 0.52$). None of these patients underwent reoperation because of tricuspid regurgitation.

Systemic ventricular function. Two patients died of right ventricular failure after the Senning operation, for simple transposition in one and transposition with ven-

tricular septal defect and pulmonary stenosis in the other. Another patient died of right ventricular failure after the Mustard operation (transposition with ventricular septal defect). In these three patients, signs of right ventricular failure were noted 4 months, 9 years, and 15 years after the operation, respectively. All had hemodynamically important tricuspid regurgitation. Time between the occurrence of signs of right ventricular failure and death ranged from 3 months to 7 years. In one patient, takedown of the Senning operation and arterial switch was planned; this patient died shortly after the banding of the pulmonary artery for the preparation of the left ventricle for the arterial switch operation. Autopsy was performed in another of these three patients in whom the myocardium of the right ventricle showed extensive areas of fibrous tissue and a thin right ventricular free wall. Right ventricular function as assessed according to the echocardiographic criteria in Table I did not differ between the two groups or anatomic subgroups. Results of this estimate are given in Table VIII. Percentages of depressed right ventricular function were comparable in both groups. No correlation could be found between echocardiographic assessment of right ventricular function and functional status. Invasive measurements of right ventricular function were not performed routinely and were not available in most patients. Available echocardiographic data did not enable us to predict deterioration of right ventricular function during follow-up.

Baffle obstruction. The use of transthoracic echocardiography did not detect baffle obstruction in any of the patients during follow-up.

Exercise tests. Thirty-eight (24 Mustard, 14 Senning) patients underwent exercise testing at a mean of 13 years after the operation. Results are shown in Fig. 4. Maximum exercise levels are given as the percentage of the normal value expected for age, bodyweight, and gender. The median maximum exercise level for patients in the Mustard group was $82.5\% \pm 15.1\%$. For patients in the Senning group, this level was $80\% \pm 18.3\%$. Differences between anatomic categories or types of operation did not reach statistical significance. Because these

Fig. 1. Kaplan-Meier curves for survival in the absence of rhythm disturbances of hospital survivors of atrial correction for transposition of the great arteries. (*Unbroken lines*, Senning operation; *broken lines*, Mustard operation.) The *p* value for comparison between rates in the Senning and Mustard patients was calculated with the log-rank test. *Vertical lines* represent 95% confidence intervals at 5-, 10-, and 16-year follow-up. *See Statistics section for method of censoring.

Fig. 2. Kaplan-Meier curves for survival of hospital survivors of the Mustard operation. (*Unbroken lines*, Simple transposition; *broken lines*, complex transposition.) The *p* value for comparison between rates in the simple and complex transposition groups was calculated with the log-rank test. *Vertical lines* represent 95% confidence intervals at 5-, 10-, and 16-year follow-up. *See Statistics section for method of censoring.

exercise tests were not performed at the same time as echocardiographic assessment of right ventricular function, these measurements could not be correlated in most patients.

Functional status. In the Mustard group, 38 patients were in New York Heart Association class I at final follow-up, 11 were in class II, and two were in class III. In the Senning group, 41 were in class I, 16 were in class II,

Fig. 3. Kaplan-Meier curves for survival of hospital survivors of the Senning operation. (Unbroken lines, Simple transposition; broken lines, complex transposition.) The p value for comparison between rates in the simple and complex transposition groups was calculated with the log-rank test. Vertical lines represent 95% confidence intervals at 5-, 10-, and 16-year follow-up. *See Statistics section for method of censoring.

Fig. 4. Maximum exercise level (bicycle ergometer tests) expressed as percentage of normal value for age, body-weight, and gender of hospital survivors of atrial correction for transposition of the great arteries. *S.D.*, Standard deviation.

and two were in class III. Differences between the two operations or between anatomic categories did not reach statistical significance.

Discussion

The long-term results of the Mustard and Senning operations as assessed in this study show a remarkable

similarity, except for important differences in the percentages of rhythm disturbances.

The occurrence of rhythm disturbances constitutes one of the main problems after both types of atrial correction for transposition of the great arteries.¹⁵⁻¹⁸ Direct damage to the sinus node or damage to its blood supply have been suggested as the principal causes of this

problem.^{19,20} Inherent differences in techniques, with placement of numerous sutures and artificial material in the sinus node region in the Mustard operation and, as suggested by Byrum and associates,²¹ moving the sinus node "out of harms way" in the Senning technique, may give rise to differences in the observed percentages of rhythm disturbances.²¹ Few studies have addressed this problem. Deanfield and associates¹⁸ did not observe a statistically significant difference between percentages of patients in stable sinus rhythm 7 years after the operation in a prospective comparison of both techniques. However, our results are clearly different. We found the Mustard operation to be an independent risk factor for the occurrence of rhythm disturbances, thus supporting theories concerning the consequences for the sinus node with regard to the inherent differences of both techniques. From the available patient data, it was not possible to identify the exact causes for this relation.

Although they increase the risk of active arrhythmias,^{20,22} passive arrhythmias seem to have limited clinical importance. Most patients do not experience important limitations in daily activities and perform well in exercise testing.^{16,23}

As in several larger series, sudden death occurred in a considerable percentage of patients (6%) in both groups.^{15,22,24,25} Tachyarrhythmias increase the risk for this event.²² The exact relationship between these problems remains unclear.²⁶ It has been suggested that tachyarrhythmias may lead to impairment in ventricular function with exercise in those patients in whom the right ventricle is not able to increase stroke volume and thereby increase cardiac output.²⁶ Inadequate cardiac output with exercise might then result in sudden death. A similar mechanism might play a role in patients with baffle obstruction, also known to be at risk for sudden death.²² Therefore adequate diagnosis and treatment of diminished right ventricular function and baffle-associated problems are important tools in the prevention of sudden death, especially, but not exclusively, in patients with known tachyarrhythmias. Obstruction to venous inflow, either pulmonary or systemic, or to flow at the atrial level has been reported after both types of operations.^{22,25,27} One of the reasons for the revival of the Senning operation in the 1970s was the idea that this procedure might cause less baffle-associated obstruction than the Mustard operation.^{9,28} However, in this long-term study we could not substantiate this. The percentage of these obstructions in our patients is lower than that in several other studies.^{22,25,27} In most patients, transthoracic echocardiography was used for detection of these obstructions, which may account for some underestimation of this problem.²⁹

Approximately 45% of patients, irrespective of the type of operation, showed evidence of depressed right ventricular function, which is in agreement with data of invasive studies.^{27,30,31,32} Concern about the long-term capability of the right ventricle to support the systemic circulation is supported by extensive data.^{27,30,33,34} Although clinical evidence seems to suggest that right ventricular function deteriorates with time in some patients, several studies did not confirm these findings.^{31,32,34} Several factors may contribute to right ventricular failure: preload and afterload at systemic ventricular levels, tricuspid regurgitation, as well as preexisting factors such as preoperative hypoxia, wall motion abnormalities, and perioperative factors.^{31,33} Differences in atrial function as a result of the different surgical techniques and consequent influences on the ventricular filling characteristics might be a reason for different effects on the long-term outcome of right ventricular function after both types of operations.²⁸ This hypothesis has, to our knowledge, not been studied extensively.

Not infrequently, a discrepancy occurs between functional state and right ventricular function. All these factors make it difficult to identify patients at risk for right ventricular failure and establish the right moment for heart transplantation or conversion to arterial switch.³⁵ Serial monitoring of right ventricular function is needed. The current lack of a widely available, noninvasive technique that can be repeated easily is of great concern.

Despite all these problems, the majority of patients are in good functional status a long time after these types of operations, and the number of reoperations is small.

The arterial switch operation has largely replaced atrial corrections now. It has clear advantages over the venous switch operations. If adequate patient selection and surgical experience are available, the arterial switch is the method of choice.¹⁻⁵ Although short-term and medium-term results are good, long-term effects on morbidity and survival with regard to potential problems such as supra-valvular stenosis of the great arteries, obstruction at the level of the reimplanted coronary orifices, and the function of the pulmonary valve in the systemic circulation are as yet unknown.^{1-5,36}

In a limited number of patients, early arterial switch carries a high risk as a result of associated disease or certain coronary artery patterns.¹ Two-step arterial switch is thought to be an alternative for these patients. Initial results of this procedure are good.³⁷ However, there is concern about the function of the neo-aortic valve. Up to 90% of minimal-to-mild regurgitation is reported.³⁷ Some reports suggest that left ventricular contractility is depressed after two-stage arterial switch,³⁸ which raises concern about the long-term results in these patients.

A venous switch procedure has to be taken into consid-

eration as an alternative method with established long-term results in patients with a contraindication for one-step arterial switch. In our experience, a slight advantage exists, only with regard to rhythm disturbances, in favor of the Senning operation.

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