

H. Meisner
E. Feder
E. Struck
A. Zacharias da Silva Jr.
F. Sebening

TRANSPOSITION OF GREAT ARTERIES: ATRIAL INVERSION - THE SENNING VERSUS THE MUSTARD PROCEDURE

In six years, 175 patients with simple and complex d-TGA have been treated operatively. In simple TGA after atrial inversion the mortality was 3%, while after complex TGA it was 14%. Comparison of two groups of patients after Mustard operation (n = 102) and after Senning procedure (n = 73) revealed no significant difference in results, as far as mortality, postoperative rhythmic disturbances or right ventricular function are concerned.

Complete transposition of the great arteries occurs in 3% of all cardiac congenital anomalies¹. The persistence of an open foramen ovale is necessary for survival of the newborn; in 40% a VSD can be found. A left ventricular outflow tract obstruction (LVOTO) is present in about 46% with an intact ventricular septum and in about 30% with a VSD¹.

Medical management consists in oxygenation and treatment of acidosis. Prostaglandin E infusion may be life-saving. Immediate cardiac catheterization should be associated with balloon atrioseptostomy in order to improve atrial admixture. After the third month this Rashkind manoeuvre is no longer possible. Hence, other operative interventions such as atrioseptectomy of Blalock-Hanlon or a functional correction must be considered. The medical and surgical procedures for these infants are summarized in table Ia. When functional correction is indicated we prefer atrial inversion using extracorporeal circulation and deep hypothermia, if necessary, within the first two weeks of life. The Mustard operation has been the technique of choice for surgical treatment of TGA for more than fifteen years. During the past four years, the Senning technique has again received recognition; since 1978 the "Switchover" - procedure or arterial inversion of Jatene² has gained increased interest. If a VSD is present, the scheme of operative management changes (table Ib): after an atrioseptostomy pulmonary banding is generally necessary. After the third month of age we prefer early correction through a transatrial ventricular septal patch closure and atrial inversion, using deep hypothermia and circulatory arrest. Certainly arterial inversion presents another procedure of choice, but we

believe that at this moment it should be only performed in advanced centers with good data keeping since the high mortality of this procedure does not justify general application. The Rastelli-operation³, using an extracardiac conduit, has a disadvantage because sometimes requires a secondary operation. The problem of the palliative Mustard operation implies some philosophical considerations and will not be discussed in this presentation⁴⁻⁶.

TABLE I (a+b) - Medical and surgical management in Infants with TGA.

TABELA Ia

TGA: Medical and surgical MANAGEMENT in infants

- incubator (40 - 60 % O₂)
- treat acidosis
- PROSTAGLANDIN E₁
- furosemid (1 - 3 mg/ kg) + digitalis
- incubation→artificial respiration
- emergency cardiac catheterization
- balloon atrioseptostomy
- and VSD: →banding
- + coarctation → resection
- LVOTO → aorto - pulmonary shunt

hematokrit >65% → correction
O₂ aorta < 50%

TABELA Ib

TGA AND VSD

- balloon atrioseptomy
And banding (3 months)
 - transatrial VSD patch and
atrial inversion (4 - 6 months)
 - VSD patch, arterial inversion (Jatene)
 - transventricular VSD patch + conduit
(Rastelli) (5 years)
- palliative Mustard:
pulmonary vascular resistance 8 units / m²

PATIENTS AND METHODS

Between April 1974 and June 1981, 175 patients with simple and complex d-TGA have been treated operatively

(table II). In 102 cases, a Mustard-operation, with the modification described by Brom using a trouser-shaped dacron patch, was performed (fig. 1). Since April 1977, 73 patients were submitted to the Senning procedure as modified by Bron. In 126 patients with simple TGA and atrial inversion, three died (2.4%). The causes of early death after the Senning procedure were intraoperative pulmonary edema and low cardiac output syndrome on the 7th and 29th postoperative day. After the Mustard operation, one patient died from low output syndrome in the initial postoperative days; post-mortem examination revealed the diagnosis of cardiomyopathy. There were four late deaths, one child died seven months after Senning-inversion from tachycardia (despite pacemaker treatment), another died 13 months after surgery from stroke and two from unclear causes at home. The overall mortality of the patients with VSD is 14 %. The surviving g patients are routinely seen in our pediatric outpatient departments, with a 100% follow-up. In the presence of rhythm disturbances, a long-term (24 hrs) ECG monitoring is imitated. Postoperative invasive electrocardiographic or cineangiographic studies are performed if indicated.

Operative technique - The infants are operated in total circulatory arrest and deep hypothermia (17-20°C) using

TGA: Results after atrial inversion

diag.	N	Sennig e.+ I.		Mustard e.+ I.		e.	I.
TGA	126	62	2 1	64	1 1	2.4%	1.6%
TGA + VSD	49	11	2 1	38	5 1	14%	4.8%
total	175	73		102			

Table II – Results after inversion for patients with simple TGA and TGA and VCS

extracorporeal circulation and mattress for cooling⁷. If the patient's weight is over 10kg, they were operated using conventional extracorporeal circulation and mild hypothermia. In the Mustard procedure, the dacron patch (fig. 1) is implanted using continuous sutures according to the modification of Brom. In the Senning operation, the atrial incision is placed in the area of the crista terminalis, a second incision on the right pulmonary venous chamber along the interatrial groove (fig. 2a + b). A flap is constructed of the remnants of the septum, suturing it with continuous stitches to the upper rim of the orifice of the left pulmonary veins. Despite a previous Rashkind procedure, in only 20% of all patients it was

necessary to complete the septal flap with a small dacron patch.

The systemic venous chamber was completed by using continuous stitches along the Eustachian rim (if present), leaving the coronary sinus on the left side. In most patients the pulmonary venous chamber could be constructed without foreign material; in only five patients the pericardium, left in situ, was used for enlargement. In order to prevent late obstruction due to inadequate growth we used reabsorbable glycol threads; in some cases, interrupted sutures were applied.

In the presence of LVOTO, the stenosis was removed successfully via the pulmonary ar-

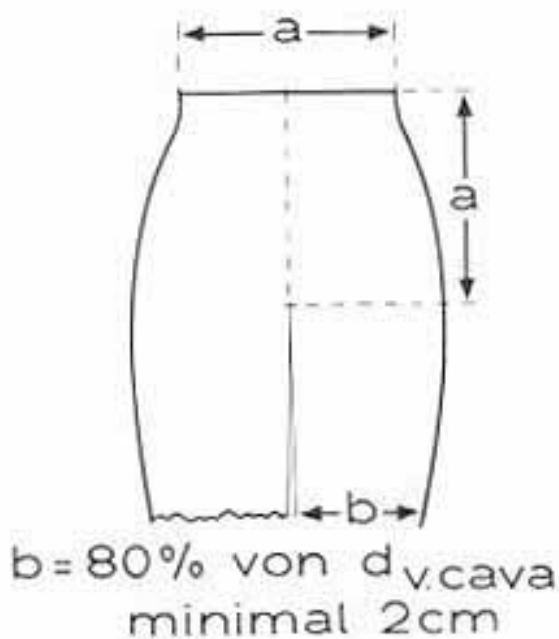


Fig. 1 - Shape and size of dacron patch used for Mustard-Brom atrial inversion.

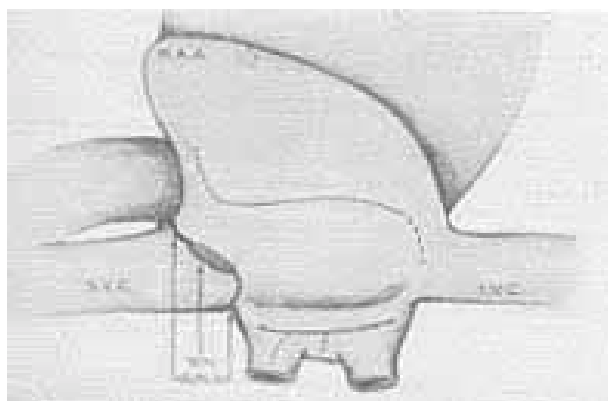


Fig. 2a

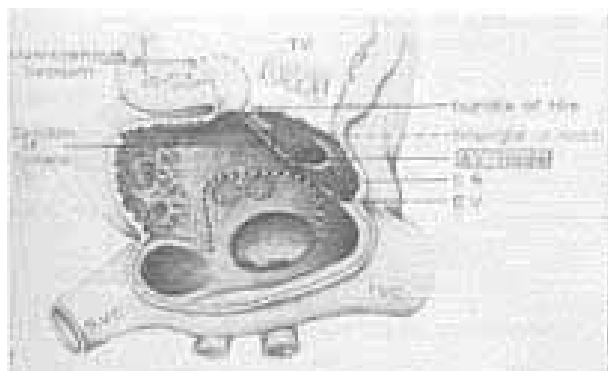


Fig. 2b

Fig. 2a + b - Schematic drawing of sinus node position, av-conduction system and incisions used for atrial inversion after Senning-Brom (modified after Anderson 1977).

tery approach. VSD's are commonly closed via the atrium using single teflon-armed U-stitches and a dacron patch. In the case of a Rastelli procedure, commercially available valve conduits (e.g. v Hancock P 100) were implanted.

DISCUSSION

In 1975 the mean age at operation was 30 months, but in recent years (1979 and 1980), it was 7 and 8 months^{8,9}. The main reason for this is the good results using the Senning technique without the application of foreign material. The Senning procedure is used preferably in infants with a preceding Rashkind manoeuvre. After the Blalock-Hanlon operation, a Mustard procedure is favoured.

Comparing the mortality after the Senning operation in the literature, it varied from zero¹⁰ and 8%^{11,12}. After the Mustard operation, mortality varied from zero³³ to 7%^{14,15}. In our series likewise the Senning operation carried no higher risk than Mustard's procedure. One previous problem of the Mustard operation - baffle obstruction - has been substantially diminished by using the trousers-shaped patch described by Brom. Rhythm disturbances after both types of operation are rarely seen¹⁶⁻¹⁸. Since the precise descriptions of sinus node anatomy and its arteries by Anderson et al.¹⁹ and Edwards & Edwards²⁰ the frequency sinus rhythm abnormalities has been rather low. According to Clarkson et al.²¹ we diagnose sinus rhythm if P-waves of uniform shape precede each QRS-complex and if the PQ-interval is constant. Useful data on this problem show an incidence of dysrhythmia after Mustard operation between 12-63% and after Senning inversion about 30%²²⁻²⁷.

Exact electrophysiologic data after the Senning operation are only available from Henglein et al of our own patients. They examined 21 patients at least one year after operation electrophysiologically measuring the maximal corrected sinus node recovery time. It was pathologic in seven patients, showing only in one patient mon-sinus rhythm and in three a sick sinus node.

It might appear that the Senning operation has primarily a higher incidence of rhythmic disturbances compared to the Mustard procedure. The number of patients electrophysiologically examined after Mustard operation, however, is much lower. One other important point of discussion is the late behavior of right ventricular function. Goodman investigated 14 patients after Mustard atrial inversion and only one with decreased contractility of the right ventricle. Graham et al.²⁸, Egloff et al.²⁹ and Hagler et al.³⁰ restudied about 50 patients. They found a decreased ejection fraction and increased right ventricular volume. Mocellin et al.³¹ studied our own patients one year or more after the Senning operation. They found no significant difference between right ventricular function pre-and post-operatively 8 months to 3 years after functional correction. It appears that the method of atrial inversion does not influence right ventricular function during the first years.

From our data we conclude that there is no distinct advantage of Senning operation so far as apparent. We prefer the Senning procedure in small infants since almost no foreign material is required for reconstruction of the atria; apparently physiological development of the atria is still possible. Present data in the literature and our own experience do not support the necessity for anatomical correction of simple transposition, as proposed by Jatene² and Yacoub³². Perhaps further experience on other centers will help to elucidate this problem.

RESUMO

Num período de 6 anos, foram operados 175 pacientes com d-transposição dos grandes artérias (TGA), simples e complexa. Na TGA simples, a mortalidade foi igual a 3%, depois da inversão atrial, ao passo que, na TGA complexa, foi igual a 14%. A comparação de dois grupos de pacientes, depois da operação de Mustard (n = 102) e do procedimento de Senning (n = 73) não revelou diferenças significantes nos resultados, assim como em relação à mortalidade, aos distúrbios de ritmo pós-operatórios ou à função ventricular direita.

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