Waterston anastomosis

Comparison of results of operation before and after age 6 months

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The results of 40 Waterston aortico-to-pulmonary anastomoses are reviewed from the experience at The Hospital for Sick Children, Toronto, between June 1966 and October 1969. Over the age of 6 months there was one death associated with the procedure in 12 cases. Under the age of 6 months the mortality associated with the operation in cases of tetralogy of Fallot was 50%. This represents the severer degree of defect as well as the increased technical difficulties in the younger age group.

Systemic-to-pulmonary arterial anastomosis in infants with cyanotic congenital heart disease and severe oligoemia allows them to survive and grow until a corrective operation can be carried out. The methods of anastomosis commonly used are the Blalock-Taussig (Blalock and Taussig, 1945, subclavian to pulmonary artery), Potts (Potts, Smith, and Gibson, 1946, descending aorta to left pulmonary artery), and, more recently, the Waterston (1962, ascending aorta to right pulmonary artery) procedures. The Waterston anastomosis is easily constructed, simple to close at the time of total correction, and unlikely to become thrombosed. For these reasons it is now being used at The Hospital for Sick Children, Toronto, for the treatment of tetralogy of Fallot in infants under 6 months of age. It is also used in infants over 6 months in whom small vessels preclude a Blalock shunt or a previous shunt is insufficient and the child is too small for total correction. Because of recent reports (Somerville, Yacoub, Ross, and Ross, 1969) of excellent results with this procedure in infants all over 6 months of age, we compared the results of the Waterston anastomosis performed in infants under 6 months of age with the results obtained in children over that age.

METHOD

At The Hospital for Sick Children, Toronto, a Waterston anastomosis was performed on 40 patients with cyanotic congenital heart disease and oligoemia between June 1966 and October 1969. Their ages ranged from less than 24 hours to 13 years. The

cardiac anomalies present are shown in Table I. Five patients with tetralogy of Fallot had been unimproved after previous shunt operations, and two (one with transposition of the great vessels and one with tricuspid atresia) had had previous Rashkind atrial septostomies. The main indications for the Waterston procedure were increasing cyanosis in 24 cases and hypoxic spells in 16.

TABLE I
WATERSTON PROCEDURES
(40 patients)

Cardiac Anomaly	Age (mth)	
	< 6	> 6
Tetralogy of Fallot	17	12
Tricuspid atresia	5	1
Single ventricle pulmonary atresia, PDA	2	
Laevocardia, pulmonary atresia, ASD, VSD, PDA		1
Right ventricular hypoplasia, ASD, VSD	1	
Transposition of the great vessels, VSD, PS	1	
Total	26	14

ASD = atrial septal defect
VSD = ventricular septal defect
PDA = patent ductus arteriosus
PS = pulmonary stenosis

Preoperative cardiac catheterization and angiocardiography were performed in all 40 patients. The anastomosis technique is essentially similar to that described by Waterston (1962).

FOLLOW-UP

The follow-up period varied from three months to 5.6 years (mean 2.5 years). There were 20 deaths and a necropsy was performed on all but two cases who died at a remote distance from the hospital.

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RESULTS

PATIENTS UNDER 6 MONTHS OF AGE The results are summarized in Table II. In patients under the age of 6 months 26 Waterston anastomoses were carried out. Six are excluded as they died from non-cardiac congenital abnormalities such as renal hypoplasia, obstructive nephropathy, hydrocephalus, and bowel obstruction following repair of an omphalocele.

TABLE II

OUTCOME OF WATERSTON ANASTOMOSIS FOR CYANOTIC CONGENITAL HEART DISEASE
(40 patients)

Lesion	Age at Operation (mth)			
	Under 6		6 and over	
	Died	Alive	Died	Alive
Tetralogy of Fallot	6	6	1	11
Tricuspid atresia	2	2		
Single ventricle + pulmonary atresia	2			
Laevocardia + pulmonary atresia				
Right ventricular hypoplasia + ASD, VSD		1		
Transposition of the great vessels, VSD, PS	1			
Total	11	9	1	11

Tetralogy of Fallot Twelve cases of tetralogy of Fallot remained after excluding the five who died from fatal non-cardiac congenital anomalies. Of these 12, six are progressing well and six are now dead.

Tricuspid atresia Four cases of tricuspid atresia remained after excluding the one who died of severe non-cardiac congenital anomalies. Of these four, two are progressing well and two are now dead.

Other cyanotic lesions Both cases of single ventricle with pulmonary atresia and one with transposition of the great vessels with pulmonary stenosis died. Another child with right ventricular hypoplasia and atrial and ventricular septal defects survived.

Thus the overall operative survival rate under the age of 6 months is 9 out of a total of 20.

PATIENTS OVER 6 MONTHS OF AGE The results are summarized in Table II. There were operations on 14 children over the age of 6 months. There was no immediate mortality associated with the operation. We excluded from the study two patients, one with tricuspid atresia and one with laevocardia and associated pulmonary atresia, who

died of severe urinary tract anomalies. The one death among the 12 patients with tetralogy of Fallot occurred at home some time after discharge from hospital and was certified by the family practitioner as due to 'cardiac failure'.

POSTOPERATIVE CARDIAC FAILURE Clinically apparent postoperative cardiac failure developed in 21 of the 40 patients. All 21 were treated with digitalis and diuretics, which the 10 survivors were able to discontinue after various periods up to three months. Five children died of non-cardiac causes. Of nine infants under 6 months of age, six died of cardiac failure and three survived. In seven children over 6 months of age, there were no deaths from cardiac failure; seven survived, one of whom had a further operation reducing the anastomosis in size.

DISCUSSION

Somerville *et al.* (1969), in a series of 30 cases over the age of 11 months, reported no mortality associated with a Waterston operation. Jones, Bernhard, Litwin, Frieberg, and Gross (1969), in 61 patients over 1 year of age, reported 54 survivors. In our series of children over 6 months of age, 11 of 12 survived. Hallman and Cooley (1963), in a review of 56 Potts and Blalock procedures in infants under the age of 1 year, reported the death of 5 children as compared with 12 deaths in 136 children who had operations carried out at ages between 1 and 8 years.

The above figures indicate that the children had lived to the age of 6 months before operation and a 'trial of survival' had occurred. This is reflected in the higher mortality associated with the operation in infants under the age of 6 months.

A survival rate of 6 out of 12 cases of tetralogy of Fallot is some improvement over the survival rate following other shunt operations performed by us at this age. So, for patients under 6 months of age, rather than the Blalock operation we prefer the Waterston procedure which provides an adequate and effective anastomosis quickly and easily, particularly if the pulmonary artery is very small. We prefer a Waterston to a Potts operation because the anastomosis is easier to close at the time of total correction.

For children over 6 months we prefer the Blalock anastomosis to the Waterston operation as, at this age, the anastomosis will be of adequate diameter yet will not increase in size, thus reducing the danger of cardiac failure. A Waterston procedure is used, however, if there is a right aortic arch and a previous left Blalock operation is

inadequate or has failed ; if the subclavian or the pulmonary artery (or both) is small ; or if an emergency arises during one of the other anastomotic procedures and time is critical. In tricuspid atresia a Potts systemic-to-pulmonary artery anastomosis is preferable as it leaves the right chest untouched for a subsequent Glenn procedure.

The technical difficulty in achieving the proper size of anastomosis is indicated in the mortality rate from postoperative congestive cardiac failure. Five out of eight known causes of death following Potts procedures in 100 cases were reported as due to cardiac failure by Paul, Miller, and Potts (1961). In older age groups of patients with Blalock anastomoses, an overall incidence of cardiac failure is reported in 2.2% (Taussig, Crawford, Pelargonio, and Zacharioudakis, 1962). Fifty-two per cent of our patients who underwent Waterston operations had early clinical evidence of cardiac failure, but all those who died were under 6 months. For this reason we now put a band around the anastomosis at the time of the original operation.

Frequently there is radiographic evidence of preferential perfusion of the right lung initially, but this rapidly subsides if the anastomosis is not too far to the right, and a satisfactory balance is obtained allowing most of the right ventricular output to pass to the left lung and the shunt flow to the right lung. We have no evidence of an

Eisenmenger reaction developing in the right lung, but this hazard is real and should be remembered (Blalock and Taussig, 1945).

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