BANDING OF THE PULMONARY ARTERY*

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Infants with a ventricular septal defect and a large left-to-right shunt may develop progressive cardiac failure which does not respond to medical treatment. In seriously ill infants under the age of 1 year, corrective surgery has a high mortality; as management, preliminary banding of the pulmonary artery is preferred to improve the clinical status. The band obstructs egress of blood from the right ventricle, diminishes the left-to-right shunt and pulmonary blood flow and reduces the distal pulmonary artery pressure, thereby protecting the muscular pulmonary arteries from the development of progressive intimal changes.[1-4]

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The purpose of this paper is to report clinical experience with pulmonary artery banding in 7 patients and serial haemodynamic studies before and immediately after surgery.

CASES AND METHODS

The clinical profiles of the patients are shown in Table I. The ages of 6 of the patients at the time of initial study ranged from 2 to 15 months; one patient of 3 years had multiple defects of the ventricular septum and was considered to be unsuitable for definitive repair.

TABLE I. SUMMARY OF CLINICAL FINDINGS

Patient	*Sex*	*Race*	*Age at onset of symptoms*	*Symptoms*	*Age at first study*	*Weight at first study*	*Age at surgery*	*Age at postop. study*	*Weight at postop. study*	*Diagnosis*
D.G.	F	C	Infancy	Heart failure, failure to thrive	8½ months	8 lb. 10 oz.	8½ months	2 weeks later	8 lb. 10 oz.	VSD
C.S.	F	C	4 months	Heart failure	5 months	11 lb.	5½ months	3 years	52 lb.	ECD
S.N.	M	B	Infancy	Repeated resp. infections, heart failure	3 years	29 lb.	3 years	4 years	31 lb.	Multiple muscular VSD
S.D.	M	C	Infancy	Repeated resp. infections, heart failure	2 months	7 lb. 10 oz.	5½ months	10 months	8 lb.	VSD
B.W.	F	W	Infancy	Heart failure, resp. infections, failure to thrive	3½ months	6 lb.	6½ months	9 months	13 lb.	VSD
H.R.	F	W	Infancy	Heart failure	15 months	16 lb.	16 months	39 months	27 lb.	VSD
V.L.	M	I	Infancy	Heart failure	6 months	10 lb. 6 oz.	6¼ months			

C = Coloured; B = Bantu; W = White; I = Indian.

TABLE II. HAEMODYNAMIC DATA

Patient		Age	Right ventricular pressure (mm.Hg)	Pulmonary artery pressure (mm.Hg)	Aortic pressure (mm.Hg)	Pulmonary blood flow (litre/min./sq. m.)	Systemic blood flow (litre/min./sq. m.)	$\frac{PBF}{SBF}$%	Pulmonary vascular resistance (units/sq. m.)	Systemic vascular resistance (units/sq. m.)	$\frac{PVR}{SVR}$%
D.G.	Pre-op.	8½ months	100/2	100/50	100/60	8·0	3·0	2·7	6·5	28·0	23
	Postop.	8½ months	90/3	45/28	90/37	3·8	4·1	0·92	7·8	15·0	52
C.S.	Pre-op.	5 months	75/3	75/15	75/45	5·5	1·7	3·2	7·3	29·0	25
	Postop.	3 years	90/10	50/20	90/60	4·3	2·4	2·05	0·85	27·0	3
S.N.	Pre-op.	3 years	75/50	75/25	75/50	15	2·85	5·3	2·7	17·5	15
	Postop.	4 years	85/5	30/10	95/65	4·5	2·1	2·1	2·8	32·0	9
S.D.	Pre-op.	2 months	88/3	82/40	100/63	7·2	2·7	2·7	5·5	26·0	21
	Postop.	10 months	65/5	20/10	65/40	5·5	2·9	1·9	1·8	10·0	1
B.W.	Pre-op.	3½ months	88/2	88/12	88/45	8·2	2·2	3·7	4·7	29	16
	Postop.	8½ months	87/0	12·5/7·5	87/50	3·5	3·5	1·0	0·6	20	3
H.R.	Pre-op.	15 months	60/10	60/40	100/75	8·5	2·3	3·7	4·4	38·0	12
	Postop.	39 months	60/3	30/15	125/75	4·8	3·3	1·45	3·7	30·0	12
V.L.	Pre-op.	6 months	90/6	85/50	90/70	5·9	2·2	2·7	11·0	34	32

All the infants had failed to thrive, were underweight, had repeated respiratory tract infections and, although in hospital, were in cardiac failure resistant to intensive medical care. Investigation—cardiac catheterization and selective cine-angiocardiography—was undertaken only in patients who did not respond to conservative medical treatment. The size of the left-to-right shunt and the pulmonary vascular resistance were calculated from oxygen saturation determinations and measurements of pressure in various chambers and vessels.

The technique of banding of the pulmonary artery is well established: At left thoracotomy ¼-in. nylon tape was used to encircle and constrict the pulmonary artery to reduce the pressures distal to the band by about 50%, whereupon the band was secured with transfixing sutures. Postoperative haemodynamic and cine-angiocardiographic studies were undertaken 1 - 10 months after surgery to measure the objective results of surgery.

RESULTS

Five patients had isolated ventricular septal defects, 1 had an associated persistent ductus arteriosus (which was divided and ligated at the time of pulmonary artery banding) and 1 had a ventricular septal defect as part of a complete endocardial cushion defect.

The haemodynamic information is shown in Table II. Before operation the patients had a pulmonary to systemic blood flow ratio which ranged from 2·7:1 to 5·2:1. Pulmonary arterial hypertension was due mainly to the increase in pulmonary blood flow, and the ratio of pulmonary to systemic vascular resistance ranged from 16 to 32%. The patients' clinical state improved after operation and, although they still required digitalis and diuretics, all began to grow and the incidence of respiratory infections was reduced. Heart size was not altered, but pulmonary plethora diminished radiographically (Fig. 1). Two patients deteriorated later.

Postoperative investigation was undertaken in 6 of the infants. Three showed appreciable reduction in the volume of the left-to-right shunt, 1 had no detectable shunt and another had a small right-to-left shunt at ventricular level, while in the infant with a complete endocardial cushion defect with a bidirectional shunt the size of the left-to-right shunt was reduced. Six had a significant gradient at the level of the band; in these the systolic pulmonary artery was reduced and the pulmonary vascular resistance is now normal (Fig. 2).

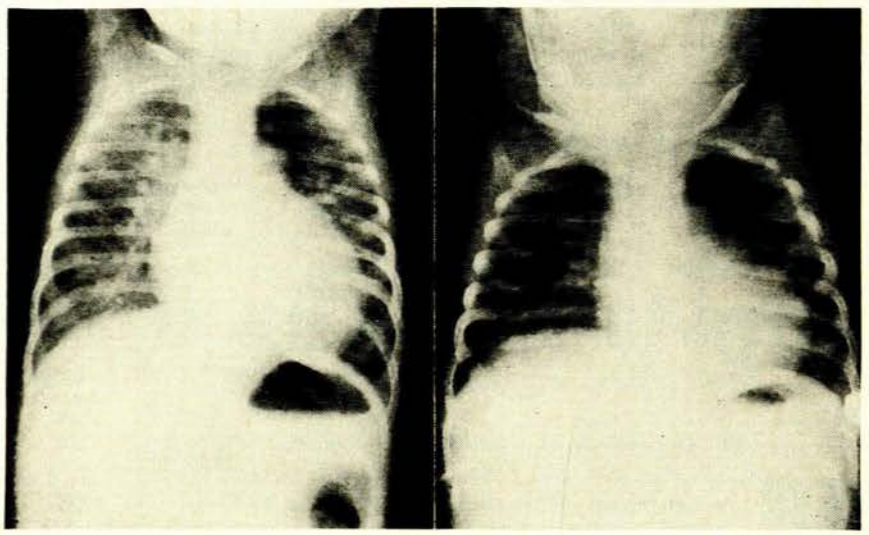

Fig. 1(a). Anteroposterior view of chest X-ray of patient D.G. before surgery, showing cardiomegaly, pulmonary plethora and dilated main pulmonary artery.

Fig. 1(b). 3 months after banding of the pulmonary artery. Heart size has not altered but the plethora has improved.

One patient deteriorated 3 months after the post-operative study and further investigations showed that the gradient had disappeared; the band across the pulmonary artery probably disintegrated. The patient now has a slightly elevated pulmonary vascular resistance.

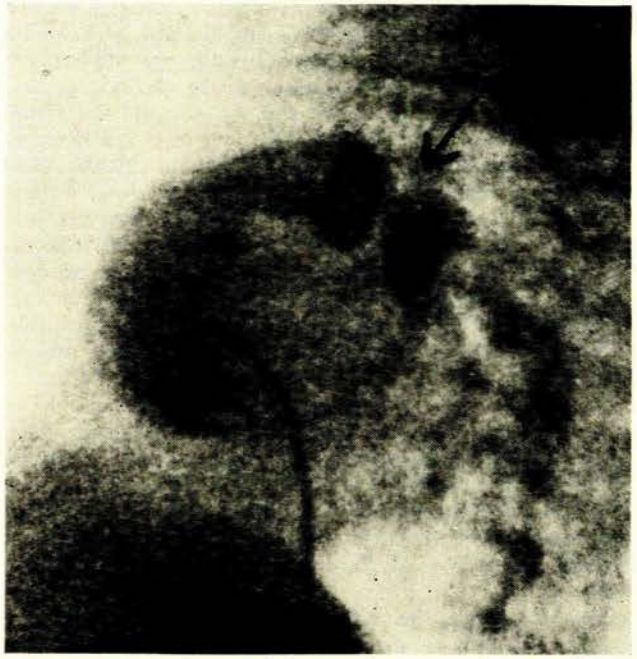

Fig. 2. Lateral view of right ventriculogram showing effective banding of the pulmonary artery (arrow).

The patient with a complete endocardial cushion defect died in chronic heart failure 2½ years after banding. At autopsy there was no evidence of constriction of the pulmonary artery. Presumably the band had disintegrated.

The other 5 patients maintained their improvement and are all thriving and out of hospital.

DISCUSSION

The natural history of ventricular septal defects may be modified by several factors: Functional reduction in the size of the defect, often with complete closure;[5] progressive pulmonary vascular changes;[6,7] progressive obstruction to the outflow tract of the right ventricle;[8] and intercurrent chest infection and cardiac failure which may lead to death. In the majority of patients symptoms improve as the children grow older. However, there is a small group of patients in whom the large left-to-right shunt leads to repeated respiratory tract infections and cardiac failure which require inpatient hospital care and treatment. Pulmonary artery banding is indicated in these infants and is often life-saving. Where facilities are available, these infants with heart failure are best treated for long periods in hospital with intensive medical treatment and the use of digoxin, diuretics and low-salt diet.

Frequent upper and lower respiratory tract infections may precipitate admission to hospital or may prolong stay in hospital. Careful follow-up is then needed. Most of our patients live in remote areas far from the major hospitals. Return visits for follow-up are irregular; drug therapy is often stopped or the incorrect dose is given and the infants fare poorly. In our environment, therefore, patients with a large left-to-right shunt and significant pulmonary hypertension are admitted to hospital if they develop heart failure or respiratory infections. Investigation is undertaken if they do not respond to medical treatment, and banding of the pulmonary artery is undertaken as a preliminary operation.

The results in this selected group of patients have been rewarding and are in keeping with other reports in the literature.[2-4,9-12] There has been no operative mortality and all the patients showed symptomatic improvement; 5 are now very well and the pulmonary arteries are protected from a high pressure and torrential blood flow. The band disintegrated in 2 patients: one developed severe heart failure and the other one died.

It is unlikely that a palliative operation will increase the risk of subsequent corrective surgery. Two problems will be encountered: the pericardium may have been opened so that adhesions may be present. If the banded pulmonary artery segment is very small, an inlay gusset will be needed to enlarge the vessel.

Ideally we would like to undertake corrective surgery in the very small infant; improvement in open heart techniques will make this feasible, but until then banding of the pulmonary artery will improve these critically ill infants.

SUMMARY

Pulmonary artery banding was undertaken in 7 small children: 5 had simple ventricular septal defect with refractory cardiac failure, 1 had multiple defects of the ventricular septum and 1 had complete endocardial cushion defect. All had a large pulmonary blood flow and similar systolic pressures in the two ventricles.

The children improved after surgery, and postoperative cardiac catheterization and cine-angiocardiography confirmed that the distal pulmonary artery pressure and flow had been reduced significantly. Late disintegration of the band occurred in 2 patients: heart failure returned in both and 1 died 2½ years later.

Pulmonary artery banding is a satisfactory preliminary operation in these very ill children.

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