CARDIOVASCULAR HAEMODYNAMIC INVESTIGATIONS IN SINGAPORE

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CARDIAC CATHETERIZATION

The procedure known as Cardiac Catheterization had its origin in 1929 when Dr. Forssman of Germany catheterized his own heart by inserting an urethral catheter into the basilic vein and advancing it in to the right atrium. The work remained of academic interest until 1944, when Cournand and Ranges (1) in the United States of America popularized the procedure. Cardiac catheterization is now a well established procedure in investigation and research in cardiovascular diseases in many countries and has been recently introduced in Singapore. The purpose of this article is to outline the broad indications for catheterization and the method and to describe the result of 200 cardiac catheterizations.

INDICATIONS

Until recently the exact diagnosis of a heart murmur had little practical significance. Patients with heart murmurs could be broadly classified into either suffering from congenital or rheumatic heart disease. However, with the rapid progress in cardiac surgery, the exact diagnosis of the nature of heart murmurs is not any more of academic interest but of real practical value. Abnormalities of the heart such as those due to congenital or rheumatic heart disease can be precisely diagnosed and the severity can be assessed by means of cardiac catheterization. Intracardiac defects where there is communication between different chambers of heart as in ventricular septal defect, atrial septal defect and patent ductus can be precisely located by analysis of blood oxygen collected from different chambers by means of cardiac catheterisation. Obstruction to flow of blood as in valvular stenosis can be diagnosed and located by the abnormal pressure elevation produced in the chamber proximal to the obstruction.

Generally speaking two groups of patients are suitable for cardiac catheterization. In the first group are those patients who have heart murmurs the exact nature of which is unknown. Patients belonging to the second group, the nature and location of the murmur is known but the severity is difficult to assess *e.g.* in V.S.D. In the latter the clinical diagnosis is reasonably certain but the degree of shunting through the defect and the severity of the lesion is not known. Cardiac catheterization in such cases would not only estimate the degree of shunt through the defect but also enable one to decide whether surgical correction of the defect is required urgently or not. It also enables us to assess objectively the improvement following surgery.

MATERIAL AND METHOD

Selection of patients

Selection of patients for cardiac catheterization is made at the weekly cardiac conference. Patients selected for catheterization are admitted in the ward 24 hours before. Routine investigations include electrocardiograms, skiagrams of the chest, haemoglobin and E.S.R.

Methods

The routine method in right heart catheterization is essentially the same as of other workers and deserves comments only on the following points:—

Sedation and Anaesthesia

We have tried to investigate these patients as much as possible under basal conditions. Premedication is not routinely used except for children under ten years of age or nervous patients. Adult patients are given 3 grains of sodium amytal the night before and children under ten years of age receive an intramuscular injection of pethidine hydrochloride, chlorpromazine and promethazine hydrochloride one hour before the procedure, the exact amount received is calculated according to the body weight. Children below five years of age usually require general anaesthesia.

Catheterization Technique

The Cournand catheter is introduced into the median basilic vein under local anaesthesia. (The catheter sizes used ranged from 5 to 8 but usually a No. 7, 100 cm. catheter is employed in adults.) We have encountered a few difficulties during catheterization. In two instances the catheter could not be introduced into the Superior Vena Cava owing to the awkward angle of the subclavian vein, and in both these occasions the lateral basilic vein was used. Either arm has been used for the insertion of the catheter but it seemed easier to enter the Superior Vena Cava from the left, probably because of the more favourable angle between the left innominate vein and Superior Vena Cava. Manipulation of the catheter once inside the thorax is done under fluoroscopic control with continuous E.C.G. monitoring.

For fluoroscopy an image intensifier is used. Pressure is recorded in a multi-channelled pressure recorder (NEP), Riley's needle is used for systemic arterial cannulation. Bloodanalysis for oxygen is performed by Waters Oximeter and also by the Scholander microsyringe method. Dye dilution study is done by injecting Evans blue into a suitable chamber and sampling the dye in the ear lobule by ear curvette and recording on a direct writing Waters oximeter recorder. The oxygen consumption is determined with a standard metabolic apparatus immediately after the catheterization. Cardiac output is calculated by the direct Fick method. The zero line of reference is taken as half the thickness of the chest measured at the angle of Louis.

Transeptal left heart catheterization was performed in 5 patients and retrograde and selective angiocardiograms were done in 22 patients.

RESULTS

Two hundred catheterizations have been carried out in 197 patients. Of these 115 were females and 82 males. Their age and sex incidence is shown in Table I. The highest number of patients catheterized were between the ages of 10 to 19. The distribution of cases is shown in Table 2. In chronic rheumatic heart disease mitral stenosis had the highest incidence and in this small series 68 (34%) were mitral valvular lesion. Of the congenital lesions atrial septal defect with or without anomalous pulmonary vein was detected in 33 patients. Haemodynamic findings were normal in 11 patients and the procedure was abandoned for various reasons in two patients.

Mitral Stenosis

Of the 68 with mitral valve disease, 4 had incomplete study and 3 were predominantly mitral incompetence. Of the remaining 61 patients with mitral stenosis, 21 had mild pulmonary venous hypertension (PCP < 20), 20 had moderate elevation of the pulmonary venous pressure (PCP $= 20$-25) and in 20 patients the pulmonary capillary pressure or the wedged pulmonary artery pressure was raised to more than 25 mm. Hg. The mean pulmonary artery pressure was less than 30 mm. Hg. in 24 patients, between 30-49 in 22 patients and more than 50 mm. Hg. in 15 patients. This is shown in Table 3. Of these 61 mitral stenosis, 9 were under the age of 20 and 22 were below the age of 30.

CONGENITAL HEART DISEASE

Atrial septal defect

There were 33 patients (16.5%) in this group. In 10 of the 33 patients, direct passage of the catheter through the septal defect was obtained. The others showed a large difference in the oxygen content between atrial and caval blood—the average being 2 volumes per cent. Anomalous pulmonary vein was entered in 10 patients (30%). Pulmonary arterial systolic pressure was raised to more than 60 mm. Hg. in six patients. The pulmonary systolic flow ratio and its relation to pulmonary arterial systolic pressure is shown in Table 4. In all these patients the shunt was from left to right.

Patent Ductus Arteriosus

There were 27 patients (13.5%) in this group. Of these 27 patients, 3 had incomplete data and in 4 haemodynamic confirmation was not obtained on catheterization and by angiogram and as such are excluded from the series. In 6 of the 20 cases direct confirmation of the diagnosis was obtained by passage of the catheter through the ductus. In the remaining 14 patients there was evidence of significant left to right shunt at the aorto-pulmonary level, the average difference in the oxygen content between the

TABLE 1

Age and Sex distribution of 197 patients with 200 Cardiac Catheterizations

Age in years	Sex		No. of Patients
	M	F	
0- 9	14	22	36
10-19	34	34	68
20-29	8	21	29
30-39	17	20	37
40-49	6	13	19
50-59	3	5	8
Total	82	115	197

TABLE 2

DIAGNOSES OF 200 CARDIAC CATHETERIZATIONS (197 PATIENTS)

CONGENITAL		RHEUMATIC		MISCEL-LANEOUS		ABAN-DONED	NORMAL
Cyanotic	8	Mitral Stenosis	65	Pulmonary Hypertension (Unknown)	6	2	11
A.S.D.	33	Mitral Stenosis & Regurgitation	3	Cons. Pericarditis	1		
P.D.A.	27	Aortic Regurgitation	2	Idiopathic Dilatation of Pulm.-Artery	1		
V.S.D.	17			Cardiomyopathy	1		
P.S.	10			Renal Artery Stenosis	1		
Coarctation of Aorta	2			Thyrotoxicosis	1		
Coronary Art. Fistula	1			Miscellaneous	2		
Ruptured Sinus of Valsalva	1						
Peripheral A-V Fistula	1						
Ebstein Malformation	1						
	101		70		13	2	11

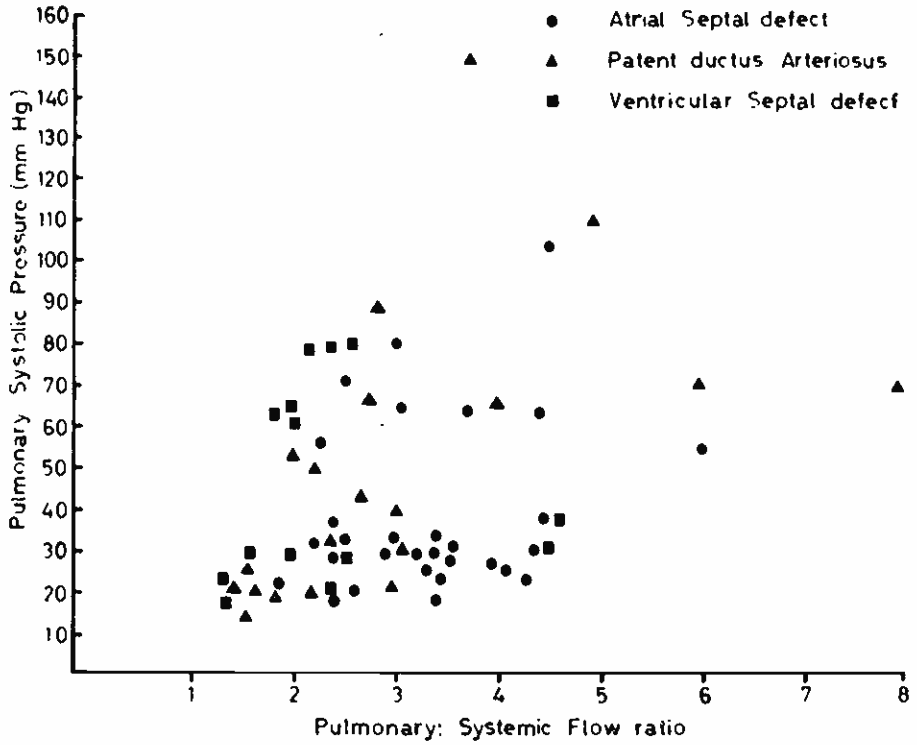
TABLE 3

PULMONARY HYPERTENSION IN 61 PATIENTS WITH NITRAL STENOSIS

	Pulm. Venous Hypertension	Pulm. Arterial Hypertension
Mild	21	24
Moderate	20	22
Severe	20	15
	Mild = P.C.P. < 20	Mild = mean P.A. < 30 mm. Hg.
		Moderate = ,, ,, (30-49 Hg.)
	Moderate = P.C.P. (20-25)	Severe = ,, ,, > 50
	Severe = P.C.P. > 25	
	Incomplete data in 3 patients	

Table 4.

Pulmonary Systemic Flow ratio and its relation to Pulmonary Artery Systolic Pressure.



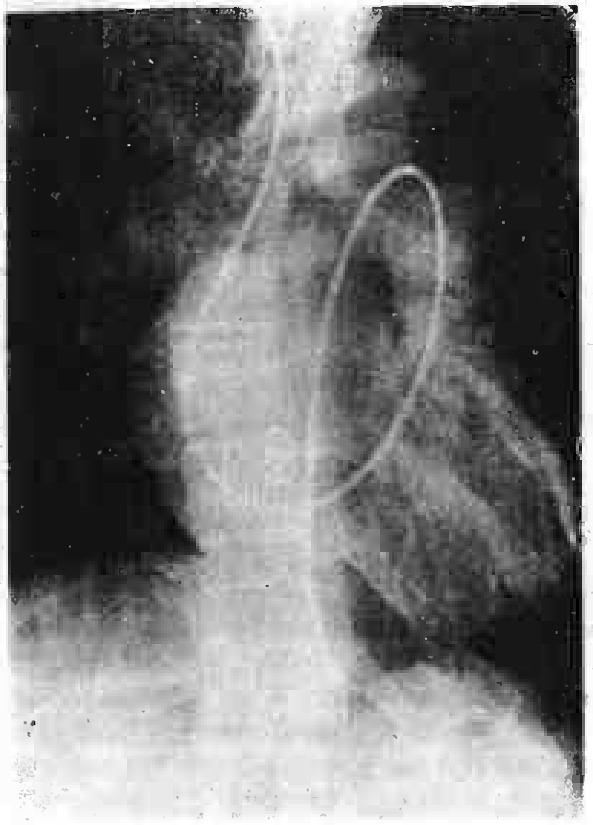


Fig. 1. X-ray chest in a case of Patent ductus arteriosus showing the catheter tip in the Aorta from the Pulmonary Artery through the patent ductus.

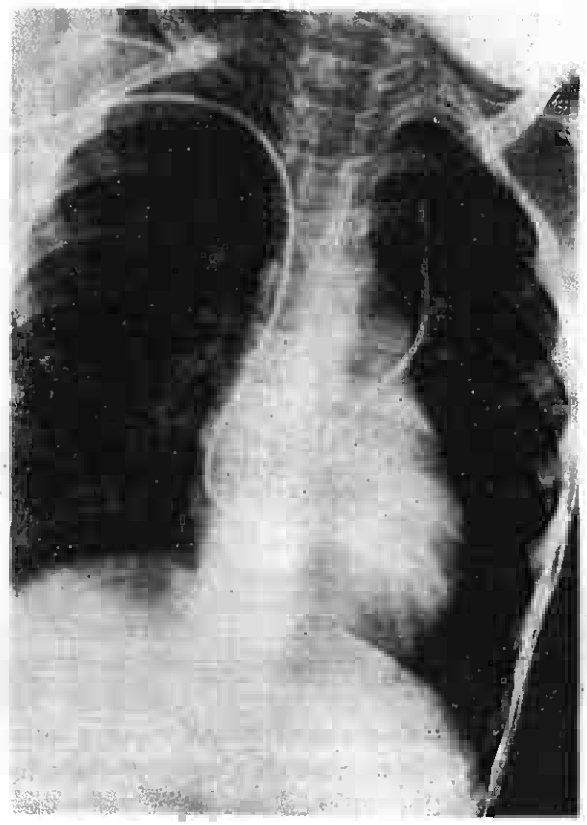


Fig. 2. X-ray chest in a case of Atrial Septal defect showing the catheter tip in the left Pulmonary Vein through the septal defect.

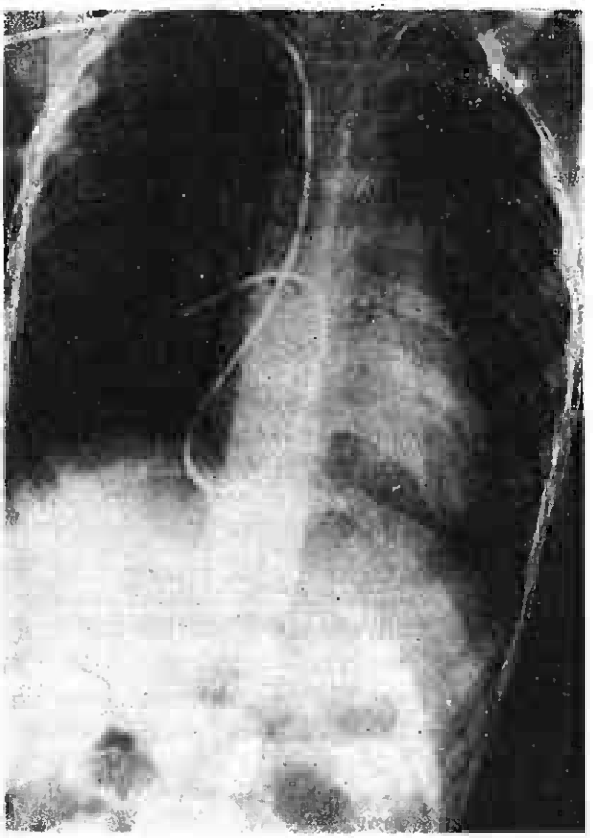


Fig. 3. X-ray chest in a case of Anomalous Pulmonary Venous drainage showing the catheter tip in the anomalous Pulmonary Vein.

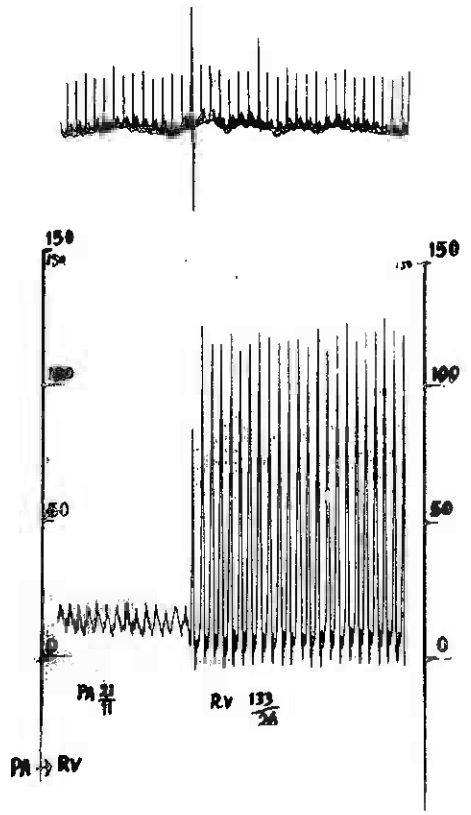


Fig. 4. Withdrawal tracing of a case of Pulmonary Valvular Stenosis showing the systolic pressure Gradient between Pulmonary artery and right ventricle.

right ventricle and pulmonary arterial sample being more than 2 volumes per cent. In 6 of these 20 patients, the pulmonary arterial systolic pressure was more than 70 mm. Hg. and the pulmonary systemic flow ratio was 3:1 or more in 9 cases. The relation between pulmonary: systemic flow ratio and the pulmonary artery systolic pressure is shown in Table 4. Catheterization was undertaken twice in 2 children as the result was inconclusive in the first study.

Ventricular Septal Defect

17 patients were studied in this group. The diagnosis has rested mainly on the findings of a large L-R shunt at ventricular level, the average increase in the oxygen content being 1.5 volumes per cent. In 1 patient the catheter could not be introduced into the right ventricle and in the second patient the result was doubtful. In both of these 2 patients, the clinical, radiological and electrocardiographic changes were consistent with V.S.D. but in the absence of definite proof on catheterization they have been excluded from the series. In 1 patient there was associated aortic regurgitation and pulmonary stenosis was the other significant finding in another 5 patients. The catheter entered the left ventricle through the septal defect in 1 patient. The relation between pulmonary: systemic flow ratio and the pulmonary artery systolic pressure is shown in Table 4.

PULMONARY STENOSIS

There were 10 cases of simple pulmonary stenosis with intact septum. Clinical diagnosis can be arrived at in this group with reasonable accuracy without resorting to cardiac catheterization. It is, however, necessary to resort to cardiac catheterization to determine the degree of obstruction and to locate precisely the site of stenosis. The systolic pressure in the right ventricle indicates the degree of obstruction. In this series, the lowest pressure recorded was 25 mm. Hg. and the highest 150 mm. Hg. The minimum systolic gradient between right ventricle and pulmonary artery was 10 mm. Hg. and the maximum 128 mm. Hg. Systolic pressures in the right ventricle lay between 25 and 50 in 5 cases, and betwen 90 and 150 mm. Hg. in 5 cases. The anatomic diagnosis of stenosis was confirmed in every case by locating the tip of the withdrawing catheter by fluoroscopy, in 3 cases by selective angiocardiography and in 4 cases by intracardiac electrography. This showed pulmonary valvular stenosis in 8 cases, infundibular stenosis in 1 and in 1 the result remained doubtful.

COMPLICATIONS OF CATHETERIZATION

In our small series of 200 cases, the following complications have been encountered during right heart catheterization and there has been no mortality.

CARDIAC ARRHYTHMIAS

Tachycardia up to 140 per minute may occur in children during catheterization and has been observed occasionally in our patients without any serious trouble. Nodal tachycardia has been observed on 4 occasions when the catheter was in the right atrium. This is often transient and has passed off with eye ball pressure in 2 cases. Ventricular extrasystoles is extremely common when the catheter tip is in the right ventricle and if ignored may give rise to ventricular tachycardia.

HYPOTENSION

A fall of systolic pressure of 15 to 20 mm. Hg. has been observed in 4 patients and has passed off without any treatment. Marked fall of blood pressure with shock has been encountered in 2 patients during transeptal left heart catheterization necessitating vasopressor drugs, oxygen and observation.

RIGOR AND FEVER

Fever up to 101°F has been observed in 3 patients within the first 24 hours following catheterization. This is most likely to be due to improper cleaning and sterilization of the catheter.

VENOUS SPASM

This has been encountered frequently and has been observed especially on using a large-sized catheter in a small vein or when there has been too much manipulation of the catheter or when the procedure had taken an unduly long time. This can be avoided by the proper selec-

tion of catheter, using adequate amount of local anaesthetic, avoiding unnecessary manipulation of the catheter and undue delay in the procedure.

CHEST PAIN

This was complained by two patients during transeptal left heart catheterization and haemopericardium followed in one.

CONVULSION AND HEMIPARESIS

Transient convulsion follwed by hemiparesis was noticed during catheterization of a patient with transposition of vessels and is presumably due to air embolism. Paresis disappeared within 4 hours without any treatment.

SUMMARY

The group of cases investigated in 6 months merely emphasises the magnitude and scope of the problem of heart disease in this part of the world. Our investigations have been almost entirely diagnostic. The cases and data available indicate that many virgin fields of research into cardiovascular disorders are open to workers here. With added equipment like the densitometer for rapid estimation of cardiac output, intracardiac phonocardiography, vector cardiography and cine angiography much more can be achieved in time to come.

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