Double-Lumen Flotation Catheter for Use in Complex Congenital Cardiac Anomalies

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SUMMARY
The use of the Swan-Ganz flow-directed right heart catheter should be a considerable aid in obtaining diagnostic information in complex congenital heart disease. It is safe and requires little technical expertise. Its use should decrease considerably the amount of radiation exposure to both patient and operator.

Additional Indexing Words:
Swan-Ganz catheter Cyanotic heart disease

A DOUBLE-LUMEN flotation catheter* is now used regularly in myocardial infarction research units to obtain right heart pressures in acutely ill patients. It has proven a safe and reliable method of obtaining right heart pressures without fluoroscopy. The technique is simple: A 5-French double-lumen catheter with a small inflatable rubber balloon just proximal to the tip is inserted into a peripheral vein and advanced centrally. The pressure is then monitored by means of one lumen and a conventional pressure transducer. The balloon is then inflated by the second lumen and carried by blood flow through the right heart into the pulmonary artery. Within a few heart cycles and with little or no manipulation, pressures of pulmonary wedge position and pulmonary artery can be obtained.1

Entry into various parts of the circulation in complex congenital heart disease, such as transposition of the great vessels, by means of conventional catheters often requires considerable technical skill and extended fluoroscopy. Even with special techniques2,3 the pulmonary artery pressure, which is essential when a patient with transposition is considered for corrective surgery, is often not obtained. This may also be true for patients with malrotation of the heart or considerable right atrial dilatation.

The purpose of this report is to show how, as predicted,1 the balloon-tipped, flow-directed, Swan-Ganz catheter may be used in complex congenital heart disease. It has been tried successfully in some 40 patients over a period of 1 year. No complications have occurred from its use. Examples where its use is helpful plus the technique which we now use are detailed below.

Technique
The catheter is advanced to the right atrium with fluoroscopy and then inflated with 0.6 to 0.8 cc of carbon dioxide. It is placed in the desired position by a combination of manipulation, with fluoroscopy, and flotation.

Complex Congenital Heart Disease
Transposition of the Great Vessels
Transposition of the great vessels was present in three patients. Two of these

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1Swan-Ganz catheter—Edwards Corp., Santa Ana, California 92705.
Figure 1

The catheter is in the main pulmonary artery in a 12-month-old patient with transposition and pulmonary stenosis. Contrast material partially fills the main pulmonary artery and outlines the inflated balloon.

Figure 2

The patient is 6 months of age and has dextrocardia, single ventricle, transposition, and pulmonary stenosis. The catheter with the balloon inflated is shown by the arrow. Contrast is streaming from the end hole around it to outline the distal pulmonary arteries.

Patients were aged 1 year and 18 months, respectively, and had previously undergone atrial septostomy so that catheterization through the left saphenous vein was required.
The balloon catheter was guided into the left atrium. It floated into the left ventricle but required minor manipulation in the left ventricle before the pulmonary artery could be entered. The total time taken was only a few seconds. The third case, a boy 12 years old, with transposition of the great vessels, pulmonary stenosis, venous abnormalities, and a ventricular septal defect, had previously undergone five cardiac catheterizations but the pulmonary artery pressure had not been measured. Cardiac entry was obtained from the left arm through a left-sided superior vena cava which connected to the left atrium. The balloon floated with manipulation into the pulmonary artery, was withdrawn and later manipulated into the aorta. Two of the three patients had obstruction across the right ventricular outflow tract, one moderate and one severe, but this in no way retarded the flotation of the balloon nor did it impinge on nor further obstruct the stenotic area. In one patient with transposition and pulmonary stenosis, the catheter position is shown in the main pulmonary artery (fig. 1). It is an unlikely position of entry for a conventional semirigid catheter. Thirteen patients who had previous Mustard repair were studied postoperatively. The age range was 2½ to 12 years. All had had at least two previous cardiac catheterizations. In all the pulmonary artery was entered easily by the balloon catheter usually via the left femoral vein percutaneous approach.

Dextrocardia and Dextroversion

An infant 6 months of age had dextrocardia, situs inversus single ventricle with transposition and infundibular stenosis. The balloon catheter was manipulated into the pulmonary artery as shown in figure 2. Another patient had dextroversion with fibrous subaortic stenosis. The exact anatomy and position of the cardiac chambers prior to catheterization were not known. The Swan-Ganz catheter easily entered the pulmonary artery, and a wedge position was obtained within a few seconds after right atrial entry.

Endocardial Cushion Defects

A sixth patient, aged 12 months, had an endocardial cushion defect. In these patients it is often difficult to enter the right heart and pulmonary artery from the inferior approach but with the flow-directed catheter it progressed easily through the pulmonary artery into a wedge position. A further patient, aged 14 years, had a single atrium, pulmonary stenosis, complete heart block, and a huge heart. He also had stenosis of the inferior vena cava which had previously prevented passage of conventional catheters. The balloon was inflated in the inferior vena cava and floated to the right atrium. It was manipulated into the right ventricle and then to the pulmonary artery. With conventional catheters it would have been extremely difficult, if not impossible, to obtain the necessary data from the groin catheterization.

Aneurysm of Right Ventricular Infundibulum

Another patient, 7 years old, had an aneurysm of the right ventricular outflow tract and was studied 1 year after corrective surgery for tetralogy of Fallot. Conventional catheters could not be passed into the pulmonary artery from the right groin. The balloon catheter, however, was quickly manipulated into the pulmonary artery.

Paroxysmal Arrhythmia

We have also been able to enter the aorta in an infant with an atrial septal defect and paroxysmal supraventricular tachycardia and to obtain pressures and samples easily and quickly from all heart chambers. No arrhythmia was initiated by its use.

Comment

In our institution venous catheterization is routinely done with percutaneous introducers in the femoral vein. This technique obviates a cutdown, does not compromise veins, and is advantageous for patients with complex congenital heart disease who may require several investigations. The Swan-Ganz catheter will fit snugly through a size-6 introducer through which it can easily be manipulated.

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In infants and younger children venous cutdown is the method of choice. The catheter equivalent to a size-6 French may be introduced directly. We have used this catheter in the newborn via a femoral vein cutdown. Obviously, regular use in this age group is inadvisable but, when conventional methods fail, data vital to the baby's management may be obtained by use of the balloon catheter.

Although right heart pressures in adult patients with myocardial infarction are obtained with no fluoroscopy or manipulation, we have found that in complex congenital heart disease it is necessary to manipulate the catheter as it moves along the usual flow-directed path. Attempts to enter chambers and vessels without manipulation have been unsuccessful. It is important that the tip of the catheter does not impinge on trabeculae and that it is pointing in the approximate direction required. Once this is achieved, the flow of blood will quickly direct this catheter into the position desired. We have inflated the balloon with carbon dioxide so that should the balloon rupture there would be no danger of systemic air embolism. Balloon rupture has not been encountered in our relatively small series. The frequency response of these catheters has been measured. They appear to compare very favorably with conventional semirigid catheter systems. Although the lumen is small, it is quite adequate for blood sampling, indocyanine green dye injection or sampling, and, in infants, for hand-injection of contrast media to outline specific portions of the cardiac anatomy. The incidence of ectopic beats on ventricular entry is much less with the flow-directed catheter than with more conventional catheters, so that it should be useful in patients with Wolff-Parkinson-White syndrome, Ebstein's anomaly, and in other patients liable to arrhythmia where the episode is often initiated by catheter manipulation.

References
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