Percutaneous Suprasternal Puncture
(Radner Technique) of the Pulmonary
Artery in Transposition of the
Great Vessels

By Shahbudin H. Rahimtoola, M.B., M.R.C.P.E.,
Patrick A. Ongley, M.B., Ch.B., and H. J. C. Swan, M.B., Ph.D., M.R.C.P.

SURGICAL CORRECTION on the hemodynamic abnormality in transposition of the great vessels is now being performed with increasing frequency. As with other congenital cardiac malformations, such as isolated ventricular septal defect, the status of the pulmonary vascular bed is a fundamental determinant of the immediate mortality and of the long-term benefit. Experience has shown that, in most patients with atrial septal defect, ventricular septal defect, or patent ductus arteriosus, the presence or absence of significant pulmonary vascular disease may be evident from clinical, electrocardiographic, and roentgenological findings. Thus, direct measurement of pulmonary artery pressure and pulmonary blood flow for comparison with systemic pressure and flow is not always necessary in such patients.

Recognition of the presence of pulmonary vascular disease and assessment of its severity are essential in the selection of those patients with transposition who are most likely to benefit from complete surgical repair. Since clinical, electrocardiographic, and roentgenological assessment of the state of the pulmonary vessels at present is less satisfactory in such patients than in those without transposition, the direct measurement of pressure and flow is necessary in the former. In a significant proportion of patients with transposition it is not possible to introduce a cardiac catheter into the pulmonary artery from the right atrium or the right ventricle; this is true even when an atrial septal defect or a ventricular septal defect is present. In such instances, access to the pulmonary artery may be achieved by (1) percutaneous puncture of the left ventricle and insertion of a nylon tube through it into the pulmonary artery or (2) percutaneous suprasternal puncture of the pulmonary artery. This paper reports our experience with puncture of the pulmonary artery, by a modification of the technique of Radner, in 23 patients with transposition of the great arteries. It appears that this is a safe and reliable method of obtaining the required data.

Methods

Procedure

Puncture of the pulmonary artery is carried out during cardiac catheterization in patients with transposition in whom a cardiac catheter has not entered the pulmonary artery. In cases in which the left ventricular pressure is significantly lower than the systemic arterial pressure, this procedure may not be necessary. An angiocardiogram (injection into right or left ventricle) has been performed for definition of the anatomic diagnosis, the position of the pulmonary artery in the mediastinum, and its relation to the aorta. This information is desirable in order to determine the direction of passage of the needle from the suprasternal area to the pulmonary artery. To prevent any unnecessary movements during the puncture and while the needle rests in the pulmonary artery, the patient is anesthetized and usually maintained with a mixture of 80% nitrous oxide and 20% oxygen which, with appropriate premedication, is adequate for the purposes of this study. Towels are placed under the patient's shoulders to extend the neck, and the head is turned to the right with the shoulders slightly rotated in the same direction to permit optimal definition of the pulmonary artery in the left mediastium.

From the Mayo Graduate School of Medicine and the Mayo Clinic, Rochester, Minnesota.
Technique

The skin is infiltrated with 1% lidocaine (Xylocaine), and the suprasternal notch is punctured, to the left of the trachea and approximately 1 to 2 cm cephalad to the insertion of the left sternocleidomastoid muscle. The needle, a 10-cm, 22-gauge, thin-walled needle (internal diameter, 0.022 inch) with a special bird’s-eye tip, is attached via a 25-cm length of Portex nylon tubing to a three-way stopcock and a Statham strain gauge (P23D series). Through the sidearm of the stopcock, blood samples may be withdrawn and an indicator injected for dye-dilution curves. While an observer continuously monitors the pressure at the tip of the needle, the needle is advanced under fluoroscopic control directly to the position in the mediastinum occupied by the pulmonary artery (fig. 1). Successful puncture of a mediastinal great vessel is recognized by the appearance of an arterial pressure contour.

To ascertain the nature of the great vessel so entered, particularly in cases in which the pressure in the pulmonary artery is similar to that in a systemic artery, a blood sample is withdrawn, and its oxygen saturation is compared with that of a sample drawn simultaneously from the femoral artery. Confirmation that the needle is in the pulmonary artery is best achieved by recording an indicator-dilution curve at the femoral artery after injection of indicator into the vessel punctured. If the vessel is the pulmonary artery, the dye-dilution curve will be substantially different from that obtained on injection into the aorta or right ventricle if that chamber connects directly with the peripheral circulation (fig. 2), and the appearance time will be delayed. Comparison of the oxygen saturation values may not always allow precise identification of the vessel entered because similar values will be obtained in those patients with complete mixing of the systemic and pulmonary venous bloods.

When the identity of the vessel has been established, simultaneous pressure records are obtained with cardiac catheters placed in the right or left ventricles or both and in a femoral artery (fig. 2). Blood samples obtained from the pulmonary artery, systemic artery, and vena cava are carefully analyzed for oxygen saturation to determine the pulmonary and systemic blood flows.

The pulmonary artery is usually punctured to the left of the aorta. When the pulmonary artery lies directly behind the aorta, it may be necessary to puncture it by passing through the latter vessel. Rarely, it is easier to puncture the right main pulmonary artery to the right of the aorta (fig. 3).

After successful determination of pulmonary artery pressure and blood oxygen saturation, the needle is withdrawn from the mediastinum. A standard thoracic roentgenogram is routinely obtained on the evening of the procedure and on the following morning.

Results

Figure 2 shows left ventricular and intravascular pressures and indicator dilution curves from one patient. Table 1 lists the pertinent data on the 23 patients studied. The ages of the patients ranged from 1½ to 20

Figure 1

Anteroposterior (left) and lateral (center) roentgenograms of patient 9, showing the suprasternal puncture needle with its tip (arrow) in the pulmonary artery. The tip of the catheter lies in the left ventricle (pressure, 113/0 mm Hg), having traversed an atrial septal defect. Lateral frame of angiocardiogram (right) performed from the left ventricle prior to the suprasternal puncture. The left and center panels show that the needle tip is lying in the pulmonary artery beyond the surgically produced pulmonary artery obstruction.
years. The aorta was entered in seven patients, the atria in two, and the common ventricle in one. In one other patient with transposition and pulmonary atresia, in whom pulmonary arteries could not be demonstrated by selective ventricular angiocardiography or

**Figure 2**

*Left ventricular and intracardiac pressures (left) and indicator-dilution curves (right) in a case of transposition of the great vessels. The systolic pressures in the left ventricle and pulmonary artery are similar and a little higher than in the systemic artery. The pulmonary artery dilution curve has a small peak concentration and a prolonged disappearance slope due to the slow release of indicator to the systemic circulation. In addition, the appearance time is prolonged and the dilution curve is different from the right ventricular dilution curve. The aortic dilution curve would be similar to the right ventricular curve in this condition.*

**Figure 3**

*Selected anteroposterior (left) and lateral (right) frames from left ventricular angiogram of a patient with dextrotransposition, pulmonary stenosis, and ventricular and atrial septal defects. The presence of pulmonary stenosis, the site of origin of the pulmonary artery, and the position of the aorta in the thorax have resulted in the right main pulmonary artery being most easily accessible for percutaneous suprasternal puncture.*
by aortography, a puncture was attempted without success; whether pulmonary arteries exist in this patient is not known.

Complications
The complications noted (table 2) were probably due to extravasation of blood into the mediastinum. The only complication of clinical significance was in patient 1, a severely disabled girl in whom systemic hypotension developed 15 minutes after the needle was withdrawn. The episode lasted 45 minutes. All patients who had complications had significant pulmonary vascular disease.

Comment
Measurement of pulmonary artery pressure allows assessment of the severity of pulmonary stenosis if left ventricular pressure is also known; the pulmonary vascular resistance can be calculated from the pressure and pulmonary blood flow. In figure 4 are angiocardiograms of two patients (patients 9 and 8, 3 and 5 years old, respectively) who had had a surgically created atrial septal defect and banding of the pulmonary artery done elsewhere at the ages of 2 and 4 months, respectively. At the time of this study, the obstruction to the pulmonary artery at the site of the band appeared to be significant in both patients, yet patient 9 (fig. 4 left) had a peak systolic gradient of only 15 mm Hg between the left ventricle and the pulmonary artery beyond the band, the pulmonary resistance beyond the band being 9.7 units m². In patient 8 (fig. 4 right), the peak systolic gradient was 53 mm Hg, and the pulmonary resistance beyond the band was 4.2 units m². This demonstrates the necessity of obtaining flow, pressure, and resistance values in assessing the status of the pulmonary vascular bed.

In our experience, introduction of a cardiac catheter into the pulmonary artery is attained

Figure 4
Selected lateral frames of left ventricular angiocardiograms from two patients with transposition of the great vessels in whom an atrial septal defect had been created and the pulmonary artery had been banded. The gradients across the band were 15 (patient 9, left) and 53 mm Hg, (patient 8, right) although angiocardiographically the obstruction appears to be significant in both. The frames in the left and right panels are systolic and diastolic, respectively.
### Table 1

**Pertinent Data on All Patients**

<table>
<thead>
<tr>
<th>Pt.</th>
<th>Age (yr)</th>
<th>Pressure, mm Hg</th>
<th>O$_2$ saturation, %</th>
<th>Aorta entered*</th>
<th>Other sites entered*</th>
<th>Complications*</th>
<th>Diagnosis†</th>
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<tr>
<td>1</td>
<td>19</td>
<td>141/80 128/70</td>
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<tr>
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<td>5</td>
<td>95/59 102/50</td>
<td>70 77</td>
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<tr>
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<td>97/50 95/59</td>
<td>66 79</td>
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<td></td>
<td>+</td>
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</tr>
<tr>
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<td>4</td>
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<td>67 93</td>
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<td>5</td>
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<td>120/67 98/62</td>
<td>72 87</td>
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<td>+</td>
<td>VSD, DT, PVD†</td>
</tr>
<tr>
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<td>5</td>
<td>93/61 86/55</td>
<td>78 91</td>
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<td>7</td>
<td>86/65 86/65</td>
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<tr>
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<td>64 92</td>
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<td>108/35 102/36</td>
<td>50 87</td>
<td></td>
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<td>VSD, PVD, DT, CHB</td>
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in approximately 20% of all patients with transposition and in approximately 30% of those who have a ventricular septal defect with the transposition. Entry into the pulmonary artery is probably related to the sizes of the ventricular septal defect and the pulmonary artery, the position of the pulmonary artery relative to the septal defect, and the presence of infundibular or valvular pulmonary stenosis. Our percentages are much smaller than those found by Noonan and co-workers who reported entry into the pulmonary artery in 23 of 50 cases (46%) of transposition and in 23 of the 37 of those cases (62%) in which ventricular septal defect was associated. In 18 of these 23 cases, however, the diagnosis of transposition was considered to be proved because the oxygen saturation in the pulmonary artery was higher than that in the systemic artery, but this series could conceivably have included examples of common (or single) ventricle or origin of both great vessels from the right ventricle because in both of these conditions the oxygen saturation in the pulmonary artery may exceed that in systemic arteries.

The technique employed in this study allows the obtaining of the required information (pressure, oxygen saturation, and indicator-dilution curve). There is a high success rate, and the technique usually can be performed easily and quickly. There were no fatalities, and the complication rate was low with no long-term ill effects. Percutaneous puncture of the left ventricle with passage of a nylon tube through it to a great vessel is an alternative procedure, but it has not thus far been reported for the purpose discussed in this paper. When percutaneous puncture of the left ventricle was performed in patients with aortic stenosis, it was successful in 93 to 100% of cases, and the incidence of significant complications was 0 to 6%. However, use of a larger needle, which is necessary for the passage of a tube through it to the aorta, resulted in significant complications in more than 14% of the cases, and a mortality of 5.5% has been reported. The mortality and in-
creased incidence of complications could have been related to the use of a larger needle.\textsuperscript{9} Furthermore, in patients with transposition, the right ventricle is hypertrophied and the left ventricle, therefore, may be relatively inaccessible from the anterior chest wall, making percutaneous puncture of the left ventricle more difficult. All of these considerations support our preference for the method reported herein.

**Summary**

Introduction of a cardiac catheter into the pulmonary artery from the right heart is not possible in a substantial proportion of patients with transposition of the great vessels. It is necessary to obtain the pulmonary artery pressure and oxygen saturation value to evaluate the degree of pulmonary stenosis and the pulmonary vascular resistance. Twenty-three patients are described in whom this was accomplished by percutaneous suprasternal puncture. There was no mortality and there were no significant complications. The technique appears to be safe and reliable.

**References**


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SHAHBUDIN H. RAHIMTOOLA, PATRICK A. ONGLEY and H. J. C. SWAN

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