Percutaneous Right and Left Heart Catheterization in Children

Experience with 1,000 Patients

By Harvey Simovitch, M.D., Arno R. Hohn, M.D., Henry R. Wagner, M.D., Peter Vlad, M.D., S. Subramanian, M.B., and Edward C. Lambert, M.D.

SUMMARY

One thousand patients, ranging in age from 4 months to 26 years, underwent percutaneous catheterization of the femoral artery and femoral vein. Cardiac catheterization was combined with selective angiocardiography in all patients.

The catheter entered the right ventricle in 972 of 990 patients (98%) and the left ventricle in 832 of 856 (97%), including 82 of 89 patients (92%) with aortic stenosis.

There were no deaths, perforations of the heart, or loss of tissue. The peripheral pulse was decreased in 6% (49 of 856) and absent in 2% (17 of 856). Other complications included two uneventful perforations of the aortic arch, two lacerations of the femoral artery, three lacerations of the femoral vein, a false aneurysm of the femoral artery, and a cerebrovascular accident.

Our findings indicate that, in children more than 2 years old and weighing more than 10 kg, the percutaneous method is safe, informative, and associated with less arterial circulatory complications than the approach from the surgically exposed artery.

Additional Indexing Words:
Arteriography Aortic stenosis Complications

SELdinger's percutaneous technic has become increasingly popular in the angiographic investigation and cardiac catheterization of adults. Limited experience with it in the study of children, however, has been reported. Instead, the catheter is more often introduced into the surgically exposed vessels.

In 1963, Lurie and associates described their experience with a modification of the original Seldinger technic and concluded that "the examination of the vascular system in children by the percutaneous method was practical and valuable." Use of this approach in arterial catheterization, however, is decreasing.

Impairment of arterial circulation following cardiac catheterization is a problem regardless of the technic used. While not fully reported in all series, absent pulses after retrograde arterial catheterization has been found to be variable (1 to 33% of cases). In a previous report from our laboratory Vlad and coworkers noted loss or diminution of peripheral pulsation following open arteriotomy in approximately one third of 500 infants and children, 26% of whom were less than 2 years of age. In an effort to overcome this problem, we adopted the percutaneous method in 1964 for patients older than 2 years of age and have

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carried on a prospective study of its efficacy and its complications.

**Methods**

One thousand patients were studied between January 1964 and August 1969. All of them were studied by, or under the direct supervision of, the authors. The procedures were thus performed by several individuals, including the trainees. Patients' ages varied between 4 months and 26 years (fig. 1). Two thirds of them (64%) were between 4 and 12 years. The smallest patient weighed 5 kg and the largest 103 kg. Only 23 patients weighed less than 10 kg; the majority (63%) weighed between 15 and 40 kg.

Retrograde arterial and venous catheterization was attempted simultaneously in 856 of the 1,000 patients (fig. 1). In 10, arterial catheterization alone was done, while in 144 only venous catheterization was performed. Selective angiocardiography with several injections was made in each case. While patients were selected for this approach according to age and weight, the severity of the cardiac abnormality was not considered a contraindication to its use.

The procedure employed in our laboratories was the modification of the Seldinger technic described by Lurie and associates. Following the procedure the status of the posterior tibial and dorsalis pedis pulses was recorded systematically in space provided on the catheterization report forms. They were reexamined again later that day and at the time of discharge.

**Results**

**Right Heart Catheterization**

In 17 of 990 attempts the right ventricle could not be entered. The success rate was, therefore, 98%. Four of these failures were due to altered anatomy which prevented access to the right heart.

**Left Heart Catheterization**

There were 856 attempts. In seven patients the femoral artery could not be satisfactorily punctured. In eight patients the presence of a coarctation of the aorta prevented passage of the catheter into the aortic arch (a total of 21 patients with coarctation of the aorta were studied). In nine instances the aortic valve could not be crossed; seven of these were associated with aortic stenosis. Thus, there were 832 successful entries into the left ventricle in 856 attempts, for a success rate of 97%.

**Aortic Stenosis**

Eighty-nine patients had aortic stenosis. The left ventricle was entered successfully in 92%. The seven failures were equally divided among the mild, moderate, and severe cases.

**Morbidity and Mortality**

**Diminished or Absent Peripheral Pulses**

The peripheral pulse remained diminished in 49 patients (6%) (table 1). It occurred in two of three patients who were less than 1 year old and five of 18 children who were between 1 and 2 years of age. Among patients

![Figure 1](image_url)

*Of this total in 102 patients the left ventricle or aorta was entered with the venous catheter.
over the age of 2 years, this incidence decreased sharply.

The peripheral pulse remained absent in 17 of 856 patients (2%) (table 1). Absence of pulses was found for the most part in the younger and smaller children (table 2). No arterial pulse was lost in patients older than 10 years, who represent one fourth of the total group.

Ten patients catheterized in the past 2 years in whom an absent pulse persisted underwent surgical exploration of the femoral artery within 8 hours following arterial catheterization. The Fogarty thrombectomy resulted in restoration of pulse and flow.

Cerebrovascular Accident

A patient, age 5 years, with severe supravalvar aortic stenosis became unresponsive while the catheter was manipulated in the left ventricle. Right hemiparesis with slight residual impairment resulted. The nature of the cerebrovascular accident was not apparent.

Loss of Dilator or Filament

On one occasion a dilator and on another a filament were temporarily lost into the vein. They were recovered by cutdown on the femoral vein. Since then a metal connector has been attached to the dilator to prevent its loss, and the filaments were made longer.

Perforation of the Aortic Arch

Two perforations of the aortic arch occurred as the guide wire was used in traversing the aortic arch. These were associated fluoroscopically with transient widening of the medias-

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Patients</th>
<th>Diminished pulses</th>
<th>Absent pulses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Patients</td>
<td>%</td>
</tr>
<tr>
<td>0–1</td>
<td>3</td>
<td>2</td>
<td>66</td>
</tr>
<tr>
<td>1–2</td>
<td>18</td>
<td>5</td>
<td>28</td>
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<tr>
<td>2–4</td>
<td>66</td>
<td>8</td>
<td>13</td>
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<tr>
<td>4–8</td>
<td>316</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>8–10</td>
<td>138</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>10–26</td>
<td>315</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>856</td>
<td>49</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1

Diminished or Absent Peripheral Pulses

Table 2

Patients with Arterial Thrombosis

A cyanotic

2 10 Aortic stenosis
2 11 Ventricular septal defect
3 15 Mitral regurgitation
4 13 Ventricular septal defect (banded)
5 15 Ventricular septal defect (banded)
5 16 Ventricular septal defect
5 16 Atrial septal defect
6 17 Ventricular septal defect
7 12 Pulmonic stenosis
9 32 Aortic stenosis

Cyanotic

3 10 Ventricular septal defect (banded)
4 12 Truncus arteriosus
4 11 Tetralogy of Fallot
5 17 Ventricular septal defect (banded)
6 20 Transposition of the great arteries
8 19 Tetralogy of Fallot
9 21 Tetralogy of Fallot

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Laceration of the Vein

Three lacerations of the vein which resulted in abdominal wall hematomas were associated with pain but required no treatment.

False Aneurysm of the Femoral Artery

The complications included one false aneurysm of the femoral artery. A pulsating mass persisted in the groin. On surgical exploration a false aneurysm of the femoral artery was found and resected.

Hematoma

Hematomas, usually small in size, were encountered frequently. In one patient the presence of a persistent mass in the groin led to surgical exploration; a hematoma was found.

Deaths

There were no deaths.

Discussion

The results obtained employing the percutaneous technic confirm its value in entering the respective ventricles in the presence of congenital and acquired heart disease and its successful adaptation to the pediatric age group.

The right ventricle was successfully entered in 98% of children. In addition, the pulmonary artery was entered as frequently with the percutaneous technic as following cutdown. A recent advance in the percutaneous approach has been the use of a sheath for catheter introduction. A Teflon sheath\textsuperscript{24} has been employed on the venous side in the last 588 cases. It allowed rapid introduction and exchange of a variety of catheters (open-tip, angiographic catheters, and catheter-electrodes). It has not been associated with an increase in the number of complications or excessive bleeding.

The left ventricle was successfully entered in 97% of the patients studied. A comparable series reported previously\textsuperscript{7} in which open arteriography was employed indicated a 92% success rate in 500 infants and children.

In the presence of aortic stenosis the left ventricle was successfully entered in 92% of the patients. These data compare favorably with the earlier study reported by our group.\textsuperscript{7}

In the presence of coarctation of the aorta, the aortic arch was not entered in eight of 21 patients. In the presence of this anomaly approach from the arm by brachial or axillary arteriomy may, therefore, be preferred.

The hazard of arterial insufficiency is always present after the introduction of catheters into a peripheral artery, whatever the approach. The frequency of diminished and absent pulses has varied widely in recent reports from various centers.\textsuperscript{13-22} It seems obvious that the frequency of residual arterial thrombosis depends in part upon the skill of the operator and in part upon the accuracy and care with which the examinations are made and reported following the arterial catheterization. The excellent "Cooperative Study on Cardiac Catheterization"\textsuperscript{18} has been questioned as being adequate with regard to reporting of diminished or absent peripheral pulses.\textsuperscript{29} In the present prospective study the observation and recording of peripheral pulses was an important integral part. Seventy-five of our early cases were studied by oscilometry. They are the subject of a previous paper.\textsuperscript{6} We believe that the frequency of diminished and absent pulses as determined by palpation reported herein is accurate, inasmuch as this was a deliberate prospective study, and representative because the procedures were performed by several physicians, including trainees.

The small number of arterial occlusions were concentrated in the small patients and those with cyanotic congenital heart disease. As a consequence we no longer use this technic in children weighing less than 10 kg.

We now believe that an effort should be made to restore pulse and flow. A Fogarty thrombectomy has been performed within 8 hours with success in each of the 10 recent cases, even when there was no other evidence of impaired arterial circulation.

The relative infrequency (2%) of loss of peripheral pulses in our series, together with the efficacy of thrombectomy, apparently
make the hazard of persistent arterial insufficiency resulting from this approach very small.

References
Percutaneous Right and Left Heart Catheterization in Children: Experience with 1,000 Patients

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