Angiographic Determination of Arterial Patency after Percutaneous Catheterization in Infants and Small Children

ROGER A. HURWITZ, M.D., EDMUND A. FRANKEN, JR., M.D., DONALD A. GIROD, M.D., JOHN A. SMITH, M.D., AND WILBUR L. SMITH, M.D.

SUMMARY Patency of the femoral artery of infants and children who previously had percutaneous arterial catheterization at a weight of <25 kg was studied angiographically. During the study period, 118 patients had repeat arterial catheterization, 48 from the opposite leg. Femoral artery occlusion was found in four patients, while 44 of the 48 studied from the opposite leg had complete patency. At the later study, all four with blockage were asymptomatic and possessed good pedal pulses, while two had decreased femoral pulsations. When events surrounding initial catheterization were retrospectively analyzed, three of four had decreased pedal pulsations beyond six hours. It is concluded that 3-8% of patients weighing <25 kg have arterial occlusion after catheterization. This complication may be entirely asymptomatic, but these patients will require continued observation for possible late vascular problems.

LEFT HEART CATHETERIZATION is often essential to define the precise anatomy of certain congenital heart defects; the necessity for this study has increased in infants and small children with the advent of early total correction. The retrograde approach, often through the femoral artery, is commonly used to study the left heart. Catheters may be inserted by cutdown or percutaneously. Early evaluation has shown limb ischemia to be extremely rare; however, as high as 40% of smaller children have decreased pulsations.1-4 The present study was devised to define more precisely the extent of vascular injury by angiographic visualization of the femoral artery in infants and small children who had been subjected to percutaneous arterial catheterization.

Materials and Methods

Patients were those at Riley Hospital for Children undergoing a necessary repeat left heart catheterization. The group, studied over an 18-month period, consisted of 118 patients who had previous percutaneous arterial catheterization at a weight of <25 kg. Both studies were performed by standard procedures, employing thin-walled #19-21 needles, dilator, and teflon catheters inserted over stainless steel guidewires.5-6 Arterial catheters were sized according to patient's weight: #4 Fr for <7 kg; #5 Fr for 7-15 kg; #6 Fr for >15 kg. Heparin flush (total administration 30-100 units) was used to maintain catheter patency.

Chart review of all notations pertaining to arterial patency and/or injury at the initial study was done on all patients. At repeat catheterization, 48 patients (including when possible all with a suggestion of arterial injury during initial catheterization) were studied from the leg not previously used. To provide a short cineangiographic study of the iliac area through which previous catheterizations were performed, 3-4 cc of contrast material (Hypaque) was injected at the aortic bifurcation. Prior to catheterization, femoral, dorsal pedal, and posterior tibial pulse excursus was routinely determined by palpation; blood pressures were measured by sphygmomanometer and/or by use of an Arteriosonde Doppler sensing mechanism. When evidence for arterial compromise was noted by angiography, measurements of leg girth (calf and thigh) and length (anterior iliac spine to medial malleolus) were obtained.

Results

During the period of this study, 118 patients underwent repeat left heart catheterization, 48 from the leg opposite to that previously used. Anatomy could be well visualized only from a catheter in the leg opposite to that being studied. Thus, the group of 48 were definitively evaluated. At initial catheterization (fig. 1) all weighed <25 kg; 80% were <10 kg; and 26% were neonates (<six weeks of age). Cyanotic lesions were present in 19 patients and 20 had signs of low cardiac output or congestive heart failure.

Patients were re-catheterized six months to nine years after initial study. At the succeeding investigation, 44 had complete patency, while four had arterial blockage. There was complete occlusion of the femoral artery in all four, with extensive hypogastric collateralization reconstituting the femoral artery approximately 3-4 cm below the inguinal ligament (figs. 2 and 3). At the prior catheterization, these four patients weighed 7 kg or less, and three had decreased cardiac output (table 1). In three cases where pulsations were transiently decreased (<6 hours) at initial study, repeat catheterization was not performed from the opposite leg.

No patient exhibited early or late signs or symptoms suggesting tissue damage due to vascular insufficiency. After initial catheterization the affected leg was never cold to touch (though frequently cooler than the opposite leg); there was essentially normal color, manifest by good capillary filling; and there was no evidence of pain or diminished movement. When re-evaluated, there were no symptoms of claudication or evidence of abnormal gait or posture. Leg girth in both extremities appeared similar and by measurement (difficult to standardize) there was no significant difference. Leg length measurements showed a variation of 3-6 mm, with the previously catheterized leg shorter in three of four cases. This discrepancy was found in other patients, and is probably a normal variant or error in the method.
Though 2/4 had a weaker femoral pulse when evaluated at repeat catheterization, all had pedal and posterior tibial pulses of equal magnitude in both legs (table 1).

Chart analysis of the 48 patients studied angiographically revealed 25 with normal pulses, nine without mention, presumably implying normal pulses, and 10 with decreased or absent distal pulses following initial catheterization (fig. 4). This group of 10 was serially evaluated, with none necessitating surgical intervention. By 24 hours, only two had decreased pulsations and both were subsequently shown to have vascular blockage; two with normal pulses the day following catheterization were eventually proven to have arterial occlusion. All three patients with decreased pulsations more than six hours after catheterization demonstrated arterial occlusion at the succeeding study.

**Discussion**

Vascular complications have been a worry since the advent of retrograde left heart study. Previous authors have explored the incidence of these problems in children being catheterized by cutdown and percutaneous technique; decreased pulsation or vascular compromise necessitating surgical embolectomy have occurred in 0–50% of cases. Actual postcatheterization anatomy of small children has been visualized only recently; three of 10 catheterized at under one year of age had complete occlusion. The present study was devised to delineate the arterial anatomy in those patients catheterized when weighing <25 kg, concentrating on the group <10 kg. Initial catheterization was performed by standard percutaneous techniques, with “flush” heparinization only reducing partial thromboplastin time 20–40%. This does not produce “total systemic heparinization.” During a 10-year experience, we found no evidence of tissue damage in patients undergoing percutaneous arterial catheterization. Though distal pulses have been weak in some patients, leg function and motion were good, capillary filling was adequate, and by the day following catheterization most pulses were palpable. Thus, we sent no patient for surgical embolectomy prior to the current investigation.

The present study has identified a group of patients who had permanent femoral artery occlusion. Although 48 patients were catheterized from the opposite leg, it would seem from the angiographic anatomy to be impossible to insert a catheter into a blocked femoral artery at a later catheterization. In many cases spasm at entry site occurs; thus, angiographically determined anatomy of the leg being catheterized is not adequate. Certainly the recatheterized femoral artery could have partial occlusion, but we found only minimal suggestion of such a complication in two patients, who had no increase in collateral flow. Thus, the realistic incidence of complete femoral artery occlusion in the patients weighing <25 kg would be in the 3–4% range (4/118).

Angiography was performed on 30 patients who weighed <7 kg at initial catheterization with a 13% incidence of total femoral occlusion. An additional 28 children who weighed <7 kg at their first study were recatheterized but had no arterial angiography. Since four of the total group had occlusion, complete femoral blockage would presumably have occurred in 7% of those weighing <7 kg.

Small patients have previously been shown at greater risk for catheterization-induced vascular complications. Although no neonate in the present study had occlusion, none with block was larger than 7 kg, and three of four with occlusion had low cardiac output. Cyanotic patients are prone to venous occlusion, but only 1/19 cyanotic patients developed arterial blockage. Prolonged attempts (with resultant hematoma and spasm) at catheter insertion are worrisome, but in only one of four of those with proven femoral artery blockage was there difficulty with catheter insertion and all four catheterizations were of average duration (60–90 minutes).

It is difficult to determine why occlusion occurs. When contrast was injected into a few small patients and the femoral artery harboring the catheter was studied, there was poor arterial filling, often with complete femoral blockage and spasm at the catheter entry site (fig. 3). Certainly clot formation at this site may occur, with propagation into the

**Table 1. Patients with Femoral Artery Occlusion**

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age (yr)</th>
<th>Wt (kg)</th>
<th>Dx</th>
<th>Repeat cath</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>7</td>
<td>Tx</td>
<td>2 1/12</td>
</tr>
<tr>
<td>2</td>
<td>8/12</td>
<td>5</td>
<td>VSD, ASD</td>
<td>8/12</td>
</tr>
<tr>
<td>3</td>
<td>3/12</td>
<td>3.7</td>
<td>VSD, CHF</td>
<td>2/12</td>
</tr>
<tr>
<td>4</td>
<td>9/12</td>
<td>6.6</td>
<td>AS + CHF</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Leg unequal (&gt; 6 mm)</th>
<th>BP</th>
<th>Femoral pulse</th>
<th>Dorsal pedal &amp; tibial pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1/12</td>
<td>NO</td>
<td>N</td>
<td>ABN</td>
<td>N</td>
</tr>
<tr>
<td>1 8/12</td>
<td>NO</td>
<td>?</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>1 2/12</td>
<td>NO</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>9</td>
<td>NO</td>
<td>N</td>
<td>ABN</td>
<td>N</td>
</tr>
</tbody>
</table>

Abbreviations: VSD = ventricular septal defect; Tx = transposition of the great arteries; ASD = atrial septal defect; CHF = congestive heart failure; AS = aortic stenosis; N = normal; ABN = abnormal; ? = not obtained.
FIGURE 2. Occlusion of femoral artery in patient #4. Multiple collateral vessels from the internal iliac, gluteal, and circumflex femoral arteries reconstitute the femoral artery (arrows) below the inguinal ligament.

proximal artery. Micro-clot may begin at the arterial entry point, and form thrombus along the wall of the catheter due to fibrin deposition. Spasm alone has been implicated in efforts to explain why a leg may be cool, pulseless or have diminished pulses following retrograde catheterization; however, the present study suggests that such a situation lasting beyond 6 hours is likely to result from vessel occlusion. Furthermore, good or slightly abnormal pulsations by 24 hours postcatheterization may be present in a young patient with complete femoral artery occlusion. Though not demonstrated angiographically, such a patient has perhaps developed extensive collateralization. A patient with complete blockage may have normal arterial pulsations later: a blocked femoral allowed excellent pulsatile flow through a #18 needle in one patient (case 4) in whom a guide wire could not be passed; opposite leg study demonstrated the occlusion.

Prevention of arterial complications is obviously preferable to detection and possible treatment. However, with increased numbers of early reparative surgical procedures, probably more infants will require left heart catheterization. Some may be performed by venous catheter passed through a foramen ovale, atrial septal defect, or trans-septally. However, retrograde study will be essential in certain patients. Some centers advocate total body heparinization or use of a sheath to act as a sleeve and minimize trauma at the arterial insertion site when performing percutaneous catheterization. Question also arises as to need, indications and timing of surgical embolectomy when vascular injury seems present. Our findings of unexpected total occlusion at later catheterization have prompted more intense early postcatheterization evaluation of arterial patency. Though we have not encountered claudication and/or unequal leg growth in these patients, these findings may occur later, or be encountered during strenuous exercise. Surgical consultation has always been requested when pulse is diminished >6 hours postcatheterization. Recent embolectomy has been performed in two patients (weighing 7 and 11 kg). The distal pulses gradually returned on a schedule similar to two patients in this study who were later proven to have occlu-
POSTCATH ARTERIAL PATENCY IN CHILDREN/Hurwitz et al.

Pedal pulse evaluation following left heart catheterization. Dotted area represents patients identified at succeeding study as having femoral artery occlusion.

The questions of prevention, diagnosis, and treatment remain unanswered. However, this study has shown that arterial occlusion may occur after percutaneous (and probably cutdown) arterial catheterization and may be clinically unsuspected. As advocated by other workers, we have been selectively heparinizing many patients other than neonates. Our surgical colleagues now feel that embolectomy may be performed with a good chance for success with utilization of surgical magnifying lenses in children >5 kg. If such a child has diminished pulsations and/or a leg less warm than the control 12 hours after catheterization, we would consider surgical intervention unless general anesthesia for such a procedure poses a distinct hazard. For further answers, it will be essential to follow those patients undergoing retrograde left heart catheterization for 1) late evidence of vascular compromise causing ischemic or growth problems, and 2) for the necessity, timing, and results of arterial surgery.

References
Angiographic determination of arterial patency after percutaneous catheterization in infants and small children.

R A Hurwitz, E A Franken, Jr, D A Girod, J A Smith and W L Smith

Circulation. 1977;56:102-105
doi: 10.1161/01.CIR.56.1.102

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1977 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/56/1/102

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/