Iliofemoral Arterial Complications of Balloon Angioplasty for Systemic Obstructions in Infants and Children

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The medical and radiological records of 64 consecutive infants and children who underwent transfemoral balloon dilation of the aorta or aortic valve were reviewed to determine the incidence, nature, and post-treatment outcome of acute iliofemoral complications. Balloon dilation angioplasty or balloon valvotomy was performed with 8F and 9F catheters without an arterial sheath. Patients ranged in age from 5 days to 15.4 years (mean, 6.4 years). Of 64 patients, 29 (45.3%) had an acute iliofemoral complication, including thrombosis (18 of 64), complete disruption (five of 64), incomplete disruption (three of 64), and arterial tear (three of 64). The arterial pathology was confirmed in 23 of 29 patients by one or a combination of surgical exploration and repair (18 of 29), angiography (six of 29), and magnetic resonance imaging (three of 29). Of eight patients, three with arterial disruption had acute hypotension requiring transfusion and immediate surgery; the other five had absent pedal pulses after the procedure. Of these five, three developed bleeding during thrombolytic therapy and underwent surgical exploration, and two were diagnosed by angiography after ineffective thrombolytic therapy. Angiography in three patients with iliac artery avulsion showed tapered occlusion in two and an aneurysm in one. In patients with iliofemoral thrombosis, angiography showed occlusion from the puncture site to the origin of the external iliac artery. Eleven patients (17% of the entire group and 38% of the group with acute iliofemoral complications) had reduced or absent pedal pulses at the time of discharge. A significant correlation was found between increased incidence of iliofemoral thrombosis and disruption (as well as abnormal pedal pulses at hospital discharge) and low patient weight. (Circulation 1990;82:1697–1704)

Complications involving the iliac and femoral arteries occur relatively frequently after diagnostic catheter procedures in infants and children, especially in those weighing less than 15 kg.1-6 Long-term sequelae of iliofemoral thrombosis, including lower-extremity growth disturbance, have resulted in some patients, although attempts to determine the incidence of such complications have yielded varying results.7-15 To avoid these complications, pediatric cardiologists have modified the techniques used in cardiac catheterization in small children by using systemic heparinization16 and smaller catheters17 and by avoiding femoral arterial cannulation by transvenous, transseptal left heart catheterization.17 With the use of transfemoral balloon catheter techniques for treating systemic cardiovascular obstructive lesions, the incidence of femoral arterial complications has again risen.18,19 To some extent, the acute iliofemoral arterial complications appear to be reversible with the use of intravenous thrombolytic agents.18

This review was undertaken to determine the incidence, nature, and outcome of acute iliofemoral complications resulting from transfemoral balloon angioplasty in infants and children with aortic stenosis and coarctation restenosis.

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Methods

The retrospective review included 64 consecutive patients who underwent transfemoral balloon angioplasty for the treatment of aortic stenosis and coarctation restenosis between 1984 and 1987. The review excluded six additional patients, who were taken to the cardiac catheterization laboratory for the purpose of balloon dilation angioplasty but in whom the procedure was not performed because of technical difficulties or who died within 24 hours of undergoing the procedure. All balloon angioplasty procedures were performed by experienced staff pediatric cardiologists with the patient under general anesthesia. The first four patients in this series underwent arterial cannulation directly after arterial cutdown, with subsequent vascular repair performed by a cardiovascular surgeon. The catheters were inserted percutaneously in the other 60 patients. The procedures involved initial insertion of vessel dilators and an introducing sheath, through which catheters were passed for the hemodynamic and angiographic study. The sheath was then removed over a stiff guide wire, and, usually without further vessel dilatation, the balloon catheter was inserted directly over the guide wire. The balloons were not inflated before insertion. After performing the angioplasty, the balloon catheter was exchanged for a dilator and sheath, and an angiographic catheter was inserted over the guide wire for angiography and hemodynamic measurement. The balloon catheters were 8F and 9F with varying balloon diameters (Mansfield Scientific, Inc, Mansfield, Mass.). Patients were given a bolus of heparin sulphate (150 units/kg) at the time of femoral arterial cannulation, and additional heparin was administered if the procedure was still in progress 2 hours later. The effects of heparin were reversed with protamine sulphate in most patients before removing the catheters. The routine postcatheterization policy regarding femoral arterial complications at this institution was followed. Pedal pulses were checked before and after the procedure; if the pulses were not palpable after removing the catheter, an intravenous heparin infusion was begun. If pedal pulses were not palpable after 24 hours of intravenous heparin therapy, the cardiovascular surgery service was consulted, and in the absence of contraindications, the patient was admitted to the intensive care unit for intravenous thrombolytic therapy. Surgical exploration, thrombectomy, and repair were undertaken for poor response to heparin and thrombolytic therapy, for arteriotomy site bleeding that was difficult to control, and for suspected arterial disruption.

The medical and radiological records of each patient with a femoral arterial complication after balloon angioplasty were reviewed. The following data were accumulated: age, weight, diagnosis, treatment of the femoral arterial complication, complications of treatment, surgical procedure and findings, status of the femoral and pedal pulses at the time of discharge and at follow-up, and findings at angiography and magnetic resonance imaging. An attempt was made to determine the nature of the femoral arterial injury in each patient. Findings from surgery or angiography, if available, were listed as the final diagnosis. All patients had a femoral arterial "tear" after cannulation with a large balloon catheter; they were classified according to the symptoms that required treatment. Patients who had diminished pedal pulses that improved after thrombolytic therapy were classified as having iliofemoral arterial thrombosis. Those who required thrombectomy because of diminished pedal pulses were classified as having femoral arterial thrombosis, whereas those referred for femoral arterial repair because of persistent bleeding or pulsatile hematoma were classified as having a femoral arterial tear, providing the arterial wall defect involved less than 50% of the vessel circumference. The term "complete disruption" was applied if the two ends of the damaged artery were completely separated. The term "incomplete disruption" was applied to various forms of severe injury in which continuity of part of the vessel wall was present, ranging from a transmural tear of more than 75% of the vessel circumference to circumferential disruption of the intima and media, held together by a portion of adventitia.

Statistical Analysis

Data are presented as range, mean, and mean±SD. Between-group comparisons were made with the Student’s nonpaired t test. A p value less than 0.05 was accepted as significant.

Results

The 64 consecutive patients ranged in age from 5 days to 15.4 years (mean, 6.4 years) and in weight from 4.0 to 60.9 kg (mean, 24.6 kg). Thirty-eight patients underwent balloon valvotomy for aortic valve stenosis, and 26 underwent balloon dilation angioplasty for postoperative obstructions involving the aortic arch and proximal descending aorta. Among the 64 infants and children, 29 (45.3%) developed an acute iliofemoral arterial complication. The underlying nature of the arterial complication was thrombosis in 18, complete disruption in five, incomplete disruption in three, and arterial tear in three. Confirmation of the arterial injury was obtained by surgical inspection in 18 patients. Angiography was performed in six patients and magnetic resonance imaging in three.

Treatment of Complications

Among the 29 patients with arterial complications, 20 received intravenous heparin infusion, and 15 received thrombolytic therapy. Eighteen patients underwent surgical exploration and repair; seven of these had received prior heparin and thrombolytic therapy. No specific treatment was instituted in two patients.

Surgical Findings

The findings at surgical exploration included complete arterial disruption in four, severe damage without loss of continuity (incomplete disruption) in three, an arteriotomy defect of varying size with
intraluminal thrombus in nine, and an arteriotomy defect with surrounding hematoma in two patients.

The patients who were diagnosed as having femoral arterial tear and thrombosis underwent thrombectomy, usually with saphenous vein patching.

Among the eight patients with arterial disruption, seven underwent surgical exploration. Three were taken to the operating room from the cardiac catheterization laboratory with the diagnosis of vascular disruption and retroperitoneal hematoma. All three had transient hypotension that responded to transfusion and manual compression of the groin. In two of these three patients, a catheter was inserted into the damaged artery over the guide wire to cause hemostasis. The other five patients with vascular disruption had decreased femoral and pedal pulses after balloon angioplasty and were initially diagnosed as having femoral arterial thrombosis. Three developed pulsatile hematomas during intravenous streptokinase infusion in the intensive care unit and were transferred to the operating room for urgent surgical exploration. Two patients did not respond to intravenous streptokinase and were referred for selective arteriography and possible local streptokinase infusion. The diagnosis of iliac artery disruption was made at the time of angiography in both; one was referred for surgical exploration, whereas the other received no further treatment.

Among the five patients with complete arterial disruption, there was avulsion of the common iliac artery in two, the external iliac artery in two, and the common femoral artery in one. At surgical exploration, the avulsed segment was displaced cephalad in the patient with femoral arterial avulsion; in the remainder, the avulsed segment was displaced downward toward the inguinal ligament. One patient with external iliac artery avulsion also had extensive intimal dissection distal to the avulsion so that the femoral arterial lumen was occluded by a plug of intima. This artery was deemed nonreparable and was ligated. The other three patients had excision of the damaged segment and reanastomosis. The three patients with severe arterial damage without loss of continuity (incomplete disruption) had involvement of the superficial femoral artery in one, the external iliac artery in one, and the common femoral artery in one. All underwent surgical repair, involving excision of the damaged vessel and reanastomosis or vein patch.

**Angiographic Findings**

Angiography was performed in three patients with iliac artery disruption and in three patients with iliofemoral arterial thrombosis. In one infant with surgically confirmed external iliac artery avulsion, aortography showed tapered occlusion of the common iliac artery with flow from the contralateral to ipsilateral internal iliac arteries and resulting extravasation from the exposed tear in the external iliac artery (Figure 1). Intravenous digital subtraction angiography after surgical repair demonstrated occlusion of the external iliac and common femoral arteries. The other two patients with iliac artery avulsion who underwent angiography were studied about one week after the transfemoral balloon angioplasty procedure. In one, angiography showed an aneurysm of the common iliac artery with no filling of the common iliac or common femoral arteries (Figure 2). Although this patient did not undergo confirmatory surgical exploration, complete disruption seemed to be the most plausible explanation for the presence of an aneurysm in that location. The other patient had a tapered occlusion of the common iliac artery (Figure 3). After passing a guide wire and then a 3F catheter into the occluded segment for low-dose streptokinase infusion, contrast injection opacified a hematoma cavity. The patient's clinical condition did not change. Surgical exploration confirmed the presence of avulsion of the common iliac artery with additional severe traumatic changes more distally above the puncture site.

Angiography performed in three patients with femoral arterial thrombosis demonstrated occlusion from the origin of the external iliac artery to the distal common femoral artery with collaterals from the internal iliac artery to the profunda femoris artery. Two patients underwent repeated angiography after successful thrombolytic therapy. Intravenous digital subtraction angiography performed in one patient 10 months after treatment demonstrated patent iliac and femoral arteries that were slightly smaller than those on the uninvolved side (Figure 4). The other patient underwent intraarterial streptokinase treatment; repeated angiography after 24 hours showed patency of the iliofemoral arteries with slight residual narrowing and extravasation at the puncture site.

**Outcome**

Eleven patients had absent or diminished pedal pulses at the time of hospital discharge. This constitutes 17% of patients undergoing systemic transfemoral balloon angioplasty and 38% of patients with acute iliofemoral complications. The outcome according to the method of treatment is presented in Table 1. The relation between the incidence of iliofemoral complications and weight is presented in Figure 5. The mean weight of 26 patients with iliofemoral thrombosis or disruption was 10.7±5.2 kg, whereas that of 38 patients without these complications was 34.0±16.9 kg. This difference was significant by nonpaired Student's t test. The mean weight of 11 patients with diminished pedal pulses at the time of discharge was 8.8±5.0 kg, whereas that of 52 patients with normal pulses was 28.2±17.0 kg. This difference was also significant. As Figure 5 demonstrates, patients weighing less than 20 kg had a 60–90% incidence of acute iliofemoral complications, and 60% of patients weighing less than 10 kg had diminished pulses at the time of discharge. Only one patient weighing more than 20 kg developed iliofemoral thrombosis. Complications in larger patients consisted of prolonged bleeding.
FIGURE 1. Avulsion of the right external iliac artery in a 7.7-kg, 7-month-old boy with acute hemorrhage during catheter removal. Panel A: Aortogram of the aortic bifurcation; transvenous left ventricular contrast injection shows tapered occlusion (arrowhead) of the right common iliac artery and extravasation (curved arrow) from the iliac bifurcation. Guide wire is still in place across the disrupted segment. Panel B: Aortogram obtained after insertion of a catheter over the right femoral artery guide wire; contrast injection in the aorta shows retrograde filling of the right internal iliac artery branches. Opacified internal iliac artery is separated from the catheter in the external iliac artery. Contrast-filled bladder is deformed by the large pelvic hematoma. (The left femoral artery was temporarily occluded after attempts to cannulate it percutaneously.) Panel C: Diagrammatic representation of the injury, confirmed at surgical exploration. ii, internal iliac artery; UB, urinary bladder.
The eight patients who suffered arterial disruption are listed in Table 2. Six of the eight patients weighed less than 13 kg; none had normal lower-extremity pulses at the time of discharge. Two larger (19 kg) patients with incomplete disruption had successful surgical repair with normal pulses.

Discussion

The goals of percutaneous balloon procedures in aortic stenosis include improvement in the left ventricular outflow tract gradient and avoidance of multiple surgical valvotomies to treat a progressive incurable disease. In coarctation restenosis, balloon angioplasty often produces an effective increase in the diameter of the aortic narrowing and relief of the gradient with minimal risk of aortic rupture, thus avoiding the need for repeated thoracotomy. Unfortunately, the rate of acute traumatic complications involving the iliofemoral arteries is high, especially in children weighing less than 20 kg. Mechanisms of injury are probably related to the small size of the femoral artery compared with the large size of the angioplasty catheters (8F and 9F shafts) and the irregular contour of the deflated balloons. Mansfield et al described disruption of the posterior vessel wall at the puncture site and a “snowplow” of intima during catheter insertion for diagnostic cardiac catheterization.

This mechanism is most likely aggravated by the high profile of the balloons. Also, femoral arteries of small children tend to constrict around catheters, especially with manipulation, further narrowing the vascular lumen. Pressure from the large catheter can injure the intima above the puncture site, increasing the potential for thrombosis after removing the catheter. Iliofemoral thrombosis is a recognized complication of femoral arterial catheter procedures, particularly in children weighing less than 10–15 kg. Although there is some controversy about the long-term effects of femoral arterial thrombosis in infants and young children, most series report a significant incidence of decreased lower-extremity growth. Absence of palpable lower-extremity pulses 3–6 hours after catheter removal has been shown to correlate well with femoral arterial thrombosis. Later, the presence of palpable pulses and the lower-extremity blood pressures are not reliable in predicting patency of the iliofemoral arteries because of collateral blood supply.

More severe injuries, including iliofemoral perforations and avulsions, have not been frequently reported with diagnostic catheter procedures. In our series, most severe arterial injuries occurred near the bifurcation of the iliac artery or just above the arterial entry site. Avulsions that occurred during catheter removal were associated with extreme difficulty in withdrawing the catheter, probably because the “high-profile” deflated balloon was being pulled against the constricted, or spastic, external iliac artery. A similar mechanism of arterial injury was probably active in those patients in whom the injury occurred during catheter insertion, where the irregular balloon is “pushed” against the narrowed femoral artery. Surgical exploration generally demonstrated severe arterial damage distal to the iliac avulsion, including dissection, inversion of a “sleeve” of endothelium occluding the lumen, and displacement of the torn end of the vessel inferiorly.

The incidence of severe arterial complications can probably be diminished or avoided by the use of smaller low-profile catheters introduced through a femoral artery sheath. Such catheters were not available with sufficient balloon diameter during the period reported here. Presently, there is a commercially available 5F catheter with a balloon diameter up to 8 mm, which can be passed through a 6F introducer sheath. This could be used in infants weighing less than 10 kg. Possibly, the bifemoral approach using two such catheters is preferable to using a single large catheter in children weighing between 10 and 20 kg. Other techniques that have been used to reduce femoral arterial trauma include the transvenous transseptal approach, which is difficult in small infants and has the potential for mitral valve damage and an umbilical artery approach in the newborn infant.

Our data demonstrate that iliofemoral disruption does not always manifest with clinically catastrophic hemorrhage. Such a presentation occurred in only three of eight patients in this series. The other
**FIGURE 3.** Avulsion of the left external iliac artery in a 6.5-kg, 2-month-old girl who had absent pedal pulses. Panel A: Digital subtraction aortogram by way of the left axillary artery shows tapered occlusion of the external iliac artery (large arrow) and collateral flow to the femoral artery (fa) through ipsilateral internal iliac branches. Panel B: Contrast injection through a 3F catheter passed into the occluded segment for low-dose streptokinase infusion opacifies an extraluminal hematoma cavity. Surgical exploration confirmed left external iliac artery avulsion with additional traumatic changes distal to the avulsion.

**FIGURE 4.** Intravenous digital subtraction arteriogram performed 10 months after balloon angioplasty confirms patency of the right iliac and femoral arteries, which are slightly smaller than the contralateral vessels. Right iliofemoral arterial thrombosis in a 5.6-kg, 7-month-old boy with return of pedal pulses after intravenous streptokinase infusion.
TABLE 1. Results of Treatment of Iliofemoral Complications After Balloon Angioplasty

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Patients (n)</th>
<th>Patients with diminished pulses at discharge (n)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treatment</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>Heparin only</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Thrombolytic only</td>
<td>8</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Surgery only</td>
<td>11</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>Thrombolytic plus surgery</td>
<td>7</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>Surgery with or without medical</td>
<td>18</td>
<td>7</td>
<td>39</td>
</tr>
<tr>
<td>Thrombolytic with or without surgery</td>
<td>15</td>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>Total patients with acute iliofemoral complication</td>
<td>29</td>
<td>11</td>
<td>38</td>
</tr>
<tr>
<td>Total patients</td>
<td>64</td>
<td>11</td>
<td>17</td>
</tr>
</tbody>
</table>

FIGURE 5. Bar graph of relations between patient weight and incidence of iliofemoral complications; surgical treatment and early outcome of acute iliofemoral arterial complications are illustrated. % Occlusion, patients with arterial thrombosis and disruption; % Dim Pulse, patients with absent or diminished lower-extremity pulses at the time of hospital discharge.

TABLE 2. Patients With Arterial Disruption

<table>
<thead>
<tr>
<th>Patient</th>
<th>Weight (kg)</th>
<th>Diagnosis</th>
<th>Disruption</th>
<th>Access</th>
<th>Catheter size (F)</th>
<th>Balloon diameter (mm)</th>
<th>Treatment</th>
<th>Abnormal lower-extremity pulses after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>AS</td>
<td>Complete</td>
<td>Percutaneous</td>
<td>8</td>
<td>10</td>
<td>Thrombolytic</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>6.5</td>
<td>AS</td>
<td>Complete</td>
<td>Percutaneous</td>
<td>8</td>
<td>8,10</td>
<td>Thrombolytic and surgery</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>7.7</td>
<td>AS</td>
<td>Complete</td>
<td>Percutaneous</td>
<td>8</td>
<td>12</td>
<td>Surgery</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>8.2</td>
<td>AS</td>
<td>Complete</td>
<td>Percutaneous</td>
<td>8</td>
<td>12</td>
<td>Surgery</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>12.1</td>
<td>AS</td>
<td>Complete</td>
<td>Percutaneous</td>
<td>9</td>
<td>15,18</td>
<td>Thrombolytic and surgery</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>12.1</td>
<td>AS</td>
<td>Incomplete</td>
<td>Percutaneous</td>
<td>9</td>
<td>15</td>
<td>Thrombolytic and surgery</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
<td>AS</td>
<td>Incomplete</td>
<td>Percutaneous</td>
<td>9</td>
<td>15,18</td>
<td>Thrombolytic and surgery</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>19.1</td>
<td>AS</td>
<td>Incomplete</td>
<td>Percutaneous</td>
<td>9</td>
<td>18</td>
<td>Thrombolytic and surgery</td>
<td>No</td>
</tr>
</tbody>
</table>

AS, aortic stenosis.

patients were diagnosed as having femoral arterial thrombosis and were treated with thrombolytic drugs. Thrombolytic therapy unmasked the injury in three of five patients resulting in severe bleeding that required transfusion and surgery. Because iliac arterial avulsion can be clinically inapparent, the need is underscored for careful monitoring and ready availability of blood products for children undergoing postcatheterization thrombolytic therapy.

We presently believe that every effort should be made to regain iliofemoral arterial patency in children suffering complications of catheter procedures. In this series, three of three patients who received heparin only or no specific treatment still had absent or diminished lower-extremity pulses at the time of discharge. One of these children, weighing 22 kg at the time of the procedure, underwent magnetic resonance imaging that documented iliofemoral thrombosis 2 years after the procedure despite the presence of a normal ipsilateral lower-extremity blood pressure. Flanagan et al.14 followed up a number of children after catheter-related femoral arterial thrombosis and found eventual return to normal lower-extremity blood pressures in 93%, presumably by collateral vessels.

In this series, the patients treated with heparin only and fibrinolytic therapy only had the best outcome, with abnormal pulses in 25% compared with 38% for the entire group. This favorable outcome is probably due to the fact that responders did not have severe injuries. Wessel et al.15 reported excellent results of fibrinolytic therapy for femoral arterial thrombosis after diagnostic and therapeutic catheterizations, with normal pulses in 88%. Fibrinolytic therapy is probably better than surgical treatment in uncomplicated femoral arterial thrombosis, especially in smaller patients. Previous reports have demonstrated a good outcome after surgical repair in large children, but results have been disappointing in those weighing less than 12.5 kg.13,15 The data in this
series also suggest that surgical repair is unlikely to be successful in patients weighing less than 12.5 kg (Table 2).

Since 1988, most systemic balloon procedures in infants weighing less than 10 kg in this institution have been performed with a low-profile, 5F balloon catheter, through a 6F introducer sheath, and low-profile 8F balloon catheters have been used in older children. No further arterial disruptions have been observed.

Presently, thrombolytic therapy is considered the treatment of choice in this institution for iliofemoral thrombosis. Surgical thrombectomy and repair are probably not appropriate, in the absence of significant hemorrhage, for infants weighing less than 12 kg.

Conclusions

Transfemoral therapeutic procedures, with large high-profile balloon catheters, for the treatment of systemic obstructions resulted in a high incidence of traumatic complications involving the iliofemoral arteries, including arterial disruption. Patients weighing less than 20 kg were at increased risk of such complications. Medical and surgical treatment was effective in only 62% of patients. Iliofemoral disruptions can exist in the absence of major hemorrhagic manifestations and may be unmasked with fibrinolytic therapy. The angiographic demonstration of a tapered occlusion near the origin of the common iliac artery strongly suggests iliac artery avulsion. Lastly, surgical treatment of iliofemoral thrombosis, in the absence of continued bleeding, is probably not advisable for infants weighing less than 12 kg.

Acknowledgments

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References


Key Words • arterial thrombosis • iliac avulsion • thrombolysis • angiography • balloon angioplasty
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