Blunt femoropopliteal trauma in a child: Is stenting a good option?

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Vascular injuries resulting from blunt trauma are uncommon in the pediatric age. In children, there are particular factors that should be taken into account when vascular traumatic lesions are treated: small vessel size or vessel spasm, a higher risk of infection, a tendency for restenosis, and rapid body growth. The endovascular procedure is a minimally invasive, quick technique that restores blood flow immediately. The stent's fate is the Achille's heel of this technique; this is the reason why a careful follow-up and further studies are required. (J Vasc Surg 2006;44:201-5.)

Vascular injuries resulting from blunt trauma are rare in children, and for this reason the best surgical treatment is still unknown. Direct arterial repair with or without end-to-end anastomosis, interposition of an autogenous reversed saphenous vein graft, and ligation have been reported. A literature search did not yield any reports of endovascular procedures to date. We describe herein a case of femoropopliteal blunt trauma in a 13-year-old boy, who was treated by endovascular stenting and who has been followed up so far for 12 months.

CASE REPORT

A 13-year-old white boy (height, 135 cm; weight, 45 kg) fell on a water tap while running in his home garden. After 3 hours he was admitted to our vascular division with pain localized to the left leg.

Physical examination showed pallor of the foot, and the leg was cold from the distal third of the thigh. The femoral pulse was present, but the popliteal and pedal pulses were absent. He also had a huge posttraumatic hematoma of the thigh, and laboratory data showed the loss of 1 point of hemoglobin. The child was immediately submitted to an echo color Doppler (ECD) examination, which demonstrated occlusion of the distal superficial femoral artery (SFA).

After 2 hours from admission, despite the administration of medical and anticoagulation therapy with heparin, his clinical symptoms had worsened. The patient was taken to the operating room, where angiography confirmed the occlusion of the distal SFA and showed the absence of the anterior tibial artery. The angiogram also demonstrated a short artery occlusion, which suggested the need for arterial stenting (Fig 1). The rationale for choosing stenting vs a direct vascular reconstruction was based on the arterial caliber (approximately 4 mm) and the size of the great saphenous vein (approximately 2 mm) at the ECD, which led to the decision to defer further surgery until the child was older and the arteries and veins to be used for the reconstruction had grown larger.

An endovascular approach was decided upon, therefore, and a 2-cm exposure of the left common femoral artery, followed by catheterization via an antegrade approach, was performed. After systemic anticoagulation therapy with 5000 U of heparin, a Jostent (5.0×20-mm nitinol stent; Jomed) was implanted in the distal superfacial femoral artery.

The patient was discharged 4 days later with palpable pedal pulses and a prescription for oral therapy with ticlopidine 250 mg twice a day. Physical and ECD examination, performed every 3 months for 1 year, showed the presence of distal pulses, the patency of the stent without any sign of restenosis, and a normal waveform. The ankle-brachial index was always greater than 1 (Fig 2). At 12 months, there was also no difference in length between the two legs, although the child grew 10 cm.

DISCUSSION

Vascular injuries in infants and children are rare, accounting for approximately 1% of pediatric trauma admissions in one multicenter experience.[1] Age, sex, behavior, and environment are the principal factors related to childhood injuries. Male children younger than 18 years of age have higher injury rates as a result of their more aggressive behavior and exposure to contact sports. In the infant and toddler age group, falls are a common cause of severe injuries, whereas bicycle-related mishaps are the main cause of injury among older children and adolescents. Moreover, as in our case, most significant injuries happen at home—usually considered the most safe and comfortable place for children. No less important are iatrogenic injuries, which are increasing together with the adoption of minimally invasive techniques.[2-6]

Vascular lesions require early diagnosis and treatment to prevent severe complications. A lesion of a major artery of the limb, if not rapidly identified, may produce prolonged ischemia, leading to gangrene, compartment syndrome, and Volkmann contractures, with ensuing long-term disability and growth retardation of the limb. In addition, when not combined with bone injuries, a vascular lesion can often go undiagnosed, and more than 6 hours' delay in diagnosis could compromise the limb's viability.[1,7]

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Fig 1. Angiographic pictures show a 2-cm occlusion of the distal superficial femoral artery and the absence of the anterior tibial artery, thus suggesting a posttraumatic thrombosis with distal embolization.

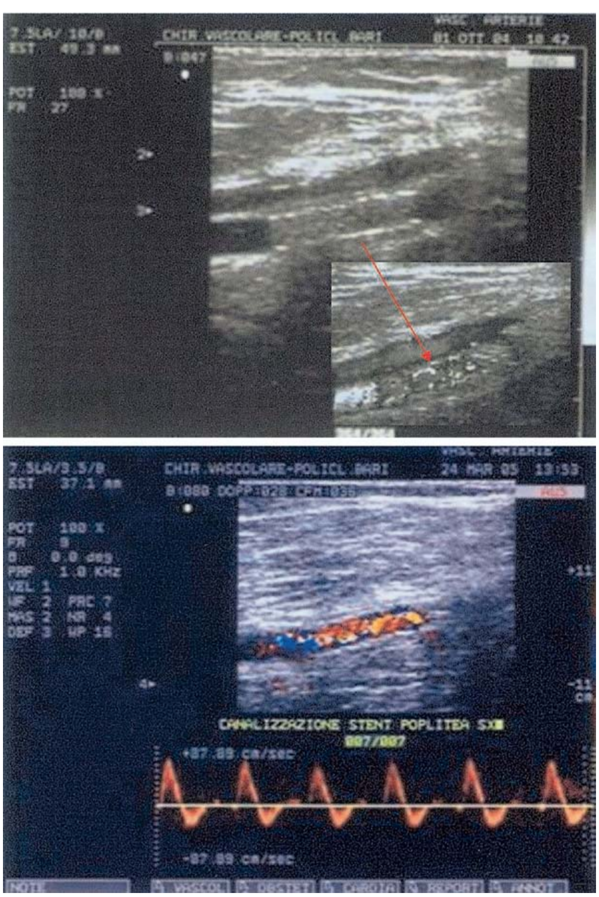

Fig 2. The echo color Doppler examination showed patency of the stent, with no sign of restenosis and with a normal waveform.

Vasospasm has been proposed as a parameter in the differential diagnosis with thrombosis but has up to now been confined to cases of catheterization of small children with cardiac diseases and has been secondary to irritant stimulus of the catheter against the endothelium. In cases of thrombosis, there is evidence that adequate fibrinolytic treatment could reopen segments of freshly thrombosed arteries and veins. In this case, we did not consider the use of thrombolytics because of the presence of a huge post-traumatic hematoma of the thigh and the loss of 1 point of hemoglobin.

The physical examination should always be associated with an ECD, and according to our experience and in view of the medicolegal implications, angiography should be performed in all difficult cases and when an operative procedure has to be planned. It should be performed in the operating room for faster performance, if necessary, of either endovascular or open procedures.

In older children or adults, a different approach is usually required. In the pediatric population, there are particular factors that should be taken into account when vascular traumatic lesions are treated: small vessel size or vessel spasm, a higher risk of infection, a tendency for restenosis,[5,8] and rapid body growth.

Depending on the anatomic location of the injury, there may be differences between the incidence of arterial ischemia in children and adults. In fact, peripheral vascular injuries, which may result in limb loss in adults, rarely do so in infants and children because there is a rapid development of collateral circulation, which allows limb preservation without surgical intervention, even if this collateral circulation is not always adequate to ensure normal limb growth patterns. Conversely, in blunt trauma involving the popliteal artery, if the repair is delayed by more than 6 hours, it may lead to a nonfunctioning limb or may necessitate amputation, as it does in adults.[9]

The importance and difficulty of ensuring normal limb growth patterns have aroused some controversy with regard to the indications for surgery. In 1983, Flamingan et al[10] reported a 23% incidence of lower limb length discrepancy in patients who did not undergo surgical intervention, vs 9% when the injuries were treated aggressively.

It should be also underlined that limb length discrepancy depends greatly on the age when the injury occurs. If it occurs before 13 or 14 years of age, when the growth spurt usually takes place, children should be submitted to surgical reconstruction to prevent limb shortening whenever possible. However, if the injury occurs at an older age—15,16, or 17 years of age—more conservative treatment can be performed provided that the ischemia is not severe. Small children (<6 years of age) with non–limb-threatening ischemia can safely be followed up until they reach 11 to 14 years of age and can then be revascularized to prevent permanent limb shortening.[11]

In 1981, Smith and Green[12] reported that good operative outcomes occurred less often in children younger than 2 years, and in 1982, Klein et al[13] supported nonsurgical management of iatrogenic vascular injuries in very small children, because surgical therapy yielded disappointingly poor results. The authors stressed the importance of close observation, with the possible need for delayed surgical reconstruction later in life.

In 2001, Cardneau et al[14] published data on a series of 14 children with a mean age of 7.3 years (range, 2-14 years) in whom a saphenous vein bypass was performed 5.7 years after the ischemic event. A remarkable improvement was obtained in five children with limb length discrepancy after late revascularization.

Analysis of these data confirms that all these authors agree that surgical reconstruction is indicated in all patients except for the very young. In fact, however, the use of fine microvascular reconstruction techniques under the microscope has demonstrated that small vessels (1 mm in diameter) can be successfully reconstructed by using fine 8-0 to 10-0 sutures.[15] Of course, in very small children with limb-threatening ischemia and in poor general condition, thrombolytic agents should be considered as the initial therapeutic approach. Nevertheless, the timing of surgery in cases of chronic vascular insufficiency remains controversial. Considering our experience with traumatic lesions at the femoropopliteal level, we think that the presence of acute ischemia with worsening clinical symptoms within a period of 2 hours to a maximum of 5 hours should be considered a proper indication for immediate surgical intervention.

The type of conduit to use for the bypass has also been debated. The type of conduit recommended is the saphenous vein, with Dacron (DuPont, Wilmington, Del) or expanded polytetrafluoroethylene conduits reserved for older children.[16,17]

The endovascular procedure is a minimally invasive, quick technique that allows immediate restoration of the blood flow, thus avoiding a femoropopliteal bypass below the knee and its possible complications. Moreover, open revascularization can be performed when the endovascular technique fails. The antegrade approach, with exposure of 2 cm of common femoral artery, is helpful when a femoropopliteal bypass has to be performed, and it avoids all the complications related to percutaneous catheterization.[2-5,10,12] These complications were amply explored in a recent work by Lin et al,[6] who described a 2% incidence of complications such as pseudoaneurysm, arteriovenous fistula, hematoma/hemorrhage, and acute and chronic ischemia in the last 15 years at their institution.

The durability and the patency of the stent are the Achilles heels of this technique. Nowadays, a wide range of stents are available for the SFA. Recent reports of SFA stents using self-expanding nitinol designs have shown improved 1- to 2-year primary and secondary patency, but the secondary reintervention rates for occlusion or in-stent restenosis remain high (20%-30% at 1 year).[18]

Nevertheless, these results seem to be superior to those reported with balloon-expandable and first-generation self-expanding stents.[19] In the SIROCCO (SIROlimus-Coated Cordis SMART nitinol self-expanding stent for the treatment of Obstructing superficial femoral artery disease) trial, the only evaluation of drug-eluting stent performance in the SFA, no significant 6- to 12-month SFA in-stent restenosis was reported with sirolimus-coated stents in phase I and II studies.[20]

Covered polytetrafluoroethylene stents (Haemobahn, Gore Medical Products, Flagstaff, Ariz) seem to yield results comparable to those with surgical prosthetic bypass.[16,21] It should, however, be underlined that they were tested in relatively small series of patients. A comparative study between endovascular placement of the stent graft and surgical bypass would help to provide evidence supporting the use of this technique.

Stent fracture has also been reported, and the cause of this strut fracture is still under investigation but seems to be related to mechanical stress and metal fatigue of the stent as a result of the biomechanical forces affecting the SFA. In the SIROCCO trial, strut fracture was noted in both the control arm and the drug-eluting stent arm (18.2%). It also seems to be related to long stented segments with multiple overlapping stents; this may increase the axial stiffness of the stented segment.[10]

Mechanical stress also causes stent dislocations, which may be avoided by using a very flexible endovascular device with a tissue-friendly inner surface that promotes rapid stent endothelialization to counter the biological effects of motion and microtrauma.[17] Preservation of all muscular perforating side branches, which will be occluded by the use of a covered stent, was one of the goals in designing the spiral covered aSpire stent (Vascular Architects, San Jose, Calif). This kind of device also responds to the flexibility requirements within the SFA to eliminate recoil, compression, or both.

Infection of the stent and consequent aneurysmal degeneration of the SFA is a rare complication, first described by Walton et al.[22] Absorbable stents are currently being investigated as a means of achieving temporary mechanical vessel support rather than long-term implantation. They should also remove a potential trigger for late restenosis. In this study, even if limited by the small number of patients, the primary clinical patency after 3 months and the limb salvage rates suggest a promising performance even in the treatment of below-knee lesions in critical limb ischemia patients.[23]

In our case, the stent was patent at 12 months, without any sign of restenosis or lower limb discrepancy, although the child grew 10 cm in 1 year. We think that in these kinds of patients, the patency might be guaranteed because the arteries are normal and not atherosclerotic, the runin and the runoff are good, and the endothelium function is maintained.

In-stent restenosis is the result of a healing process that induces neointimal hyperplasia through mechanisms that are still not understood. Results in animal studies in which stents were implanted into normal coronary arteries demonstrate that they could not be compared with those obtained in atherosclerotic patients with endothelial dysfunction. The inhibitory effect of endothelium on vascular smooth cell proliferation has long been recognized, and a large number of in vitro or in vivo studies addressing the antiproliferative action of endothelium-derived factors have been published.[24] In our case, we may conclude that the endothelial function of the child was not altered, as it is in atherosclerotic patients or in patients with atherosclerotic risk factors. This may play an important role in preventing restenosis, but more evidence is needed to confirm this hypothesis. However, the stent's fate is unknown, and for this reason careful follow-up at 5 to 10 years after vascular reconstruction is required. Conversely, growth and a tendency toward restenosis may lead to stent occlusion, but this could also be asymptomatic, bearing in mind the strong tendency to create collateral circulation in children.

We are currently monitoring our patient every 3 months because we know that the stent will not expand more than 5 mm, whereas the SFA caliber is approximately 6 mm in an adult. Moreover, if the radial expansion of the stent will not accommodate to that of the artery and the patient experiences a symptomatic occlusion of the stent (acute ischemia, claudication, and lower limb discrepancy), we plan to perform a new endovascular approach if feasible; otherwise, we will apply a saphenous vein interposition graft.

Biodegradable stents may be a solution to stent-related problems, but they are still under investigation.[23] At the moment, close follow-up with physical and ECD examination is all that is required.

In conclusion, we consider that treating blunt femoral trauma by stenting is a safe and effective option in children, considering that after 1 year the child we operated on is clinically normal with palpable pedal pulses. The stent is patent with no sign of restenosis, ECD examination shows a normal waveform, and the ankle-brachial index is greater than 1. Moreover, stenting could also be considered a bridge procedure to delay open surgery in smaller children, in whom a traditional operation may well be more successful when the child is older and, hence, the arteries and veins to be used in the reconstruction are larger.

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