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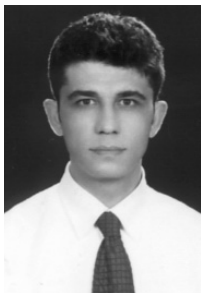
Iatrogenic Brachial and Femoral Artery Complications Following Venipuncture in Children



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ABSTRACT

Introduction. Catheter- or noncatheter-related peripheral arterial complications such as arterial pseudoaneurysm, embolus, or arteriovenous fistula may be seen in the pediatric age group. The most common etiologies defined for arterial complications are peripheral arterial puncture performed for a routine arterial blood gas analysis, arterial catheters placed for invasive monitorization of children, or catheterization performed for diagnostic purposes through the peripheral arterial system, most commonly the femoral artery.

Materials and Methods. Nine children with peripheral arterial complications, whose ages varied between 2 months and 2.5 years, were enrolled in this study. All patients were treated surgically. Following physical examination, Doppler ultrasonography, computed tomography angiography, magnetic resonance angiography, or digital subtraction angiography were used as diagnostic tools. We studied thrombophilic panels preoperatively. Six patients had brachial artery pseudoaneurysms that developed accidentally during venipuncture, 1 had a brachial arteriovenous fistula that developed after an accidental brachial artery puncture during routine peripheral blood analysis. In the remaining 2 patients, peripheral arterial embolic events were detected. One had a left brachial arterial embolus and the other had a sudden onset right femoral artery embolus that was detected via diagnostic interventions.

Results. No morbidity such as amputation, extremity loss, or mortality occurred due to the arterial events or surgery. All patients were discharged from the hospital in good clinical condition. In all patients, follow-up at 3 or 6 months revealed palpable peripheral artery pulsations of the ulnar and radial arteries at wrist level.

Conclusion. Because the incidence of peripheral arterial complications is relatively low in children compared to adults, the diagnostic and therapeutic approaches are extrapolated from the adult guidelines. We proposed that early diagnosis and surgical approach prevented the complications from further developing in the affected extremity in these particular cases.

INTRODUCTION

Little information is available regarding peripheral arterial complications during peripheral venipuncture, which is routinely performed [Norcross 1988; Criado 1997]. Vascular injuries of the extremities are very rare in children and usually develop due to accidental arterial puncture during or after routine peripheral blood gas analyses. Infrequently, blunt and/or penetrating trauma may lead to an arterial pseudoaneurysm, distal embolic events, or arteriovenous fistula (AVf). However, the incidence of symptomatic arterial events following catheterization through the femoral artery is 40% in children younger than 10 years of age and less than 5% in the older age group. In addition to this finding, the most common etiology of arterial thromboembolic disease is an arterial catheter placed for invasive monitorization, especially in cardiac surgery patients. Noncatheter-related arterial thrombotic or embolic events are relatively rare and occur in the same manner as in Takayasu arteritis and as complications of some forms of congenital heart diseases, particularly in the cyanotic forms. Arterial thrombosis may also rarely be related to inherited thrombophilias, but is usually related to mild hyperhomocystinemia. Inherited thrombophilias have been shown to be associated with deficiency of major anticoagulant proteins such as antithrombin III, protein C, or protein S.

Here, we report on 9 pediatric cases with accidental brachial artery or femoral artery injuries. Six of these patients had brachial artery pseudoaneurysm, one had AVf, and the others had brachial or femoral artery thrombus. Pseudoaneurysm of the brachial artery following venipuncture is rare and, to our knowledge, just 3 cases have been reported previously [Rey 1987; Demircin 1996; Dzepina 2004].

PATIENTS AND MANAGEMENT

Nine children with brachial artery pseudoaneurysm (BAP), brachial AVf, or acute peripheral arterial embolus were referred to our institute from other hospitals between March 2004 and 2005. Incidental arterial complication developed after attempts to treat the affected area in our institute in only 2 cases, and the remaining were referred from other hospitals.

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Patient Characteristics*

Patients	Age	Vascular Complication	Other Diagnoses	Time after Injury	Treatment
Case 1	2 mo	Left BAP	Niemann-Pick	Over 3 wk	Primary suture
Case 2	2.5 mo	Right BAP	—	2 d after	Primary suture
Case 3	4 mo	Left BAP	—	3 d after	Primary suture
Case 4	5 mo	Right BAP	I-cell disease	20 d after	Primary suture
Case 5	2.5 y	Left BAE	TOF and PA	Unknown	Embolectomy
Case 6	2 y	Right AV fistula	Undetermined	Unknown	Surgical closure
Case 7	2.5 y	Right FE	Cranial AV fistula	After DSA	Embolectomy
Case 8	6 mo	Left BAP	—	2 wk after	Primary suture
Case 9	2 y	Left FAP	—	5 d after	End-to-end anastomosis

*BAP indicates brachial artery pseudoaneurysm; BAE, brachial artery embolus; TOF; Tetralogy of Fallot; PA, pulmonary atresia; AV, arteriovenous; FE, femoral artery embolus; DSA, digital subtraction angiography; FAP, femoral artery pseudoaneurysm.

The patients' ages ranged from 2 months to 2.5 years (patient characteristics are summarized in the Table). Two patients were female. Body weights ranged from 4500 g to 12000 g. Six patients had BAP. The BAP were on the right antecubital region in 2 cases, and were on the left side in the remaining 4. One case also had chronic liver disease, and another also had I-cell disease. Protein S deficiency was noted in 1 patient with BAP. Examination revealed that the pseudoaneurysms developed after a venipuncture on the affected side following a time interval ranging from 2 days to 3 weeks. We informed the patient's parents that the masses at the affected regions formed after attempts to access the antecubital and/or femoral area for routine peripheral blood analyses.

The common symptoms were a pulsatile large mass and swelling of the affected region, agitation, and pain. The distal pulses were patent in all cases with BAP. The patient who had a right brachial AVf was referred to our institution for evaluation of a vascular murmur and a thrill at the right antecubital region after routine peripheral blood analysis.

Preoperative Doppler ultrasonography (USG) was used for detection of these described complications as a noninvasive diagnostic technique. Digital subtraction angiography (DSA) was used in only the patient with brachial AVf. Further analysis recorded the level of the thrombophilic risk factors in all cases. Protein S activity was high in 1 of the patients with BAP, whereas his thrombin time and D-dimer levels were normal.

All patients were operated on under general anesthesia. Following hematoma resection, arterial continuity was restored by repair of the arterial wall using a polypropylene suture in patients with BAP, except one. The left brachial artery was anastomosed in an end-to-end fashion for this latter patient. In the case with AVf, the "H" connection between the brachial artery and the vein was ligated.

The 2 cases with peripheral arterial emboli were treated with an embolectomy procedure using a Fogarty catheter (Edwards Lifesciences, Irvine, CA, USA). One of these children had a left brachial artery embolus (Figure 1), and the other had a right femoral artery embolus. Embolectomy procedure and the placement of a left modified Blalock-Taussig shunt were performed at the same time through the left posterolateral thoracotomy in the first case with tetralogy of Fallot, and multislice computed tomography angiography postoperatively confirmed that the modified Blalock-Taussig shunt was patent (Figure 2). The brachial artery was supplied from the upper collateral system in this case and the upper extremity arteries were equally palpated. Embolectomy was also performed in the other children who had an acute common femoral artery thrombus. Postoperative flow patterns were good, and the common femoral artery was patent in the Doppler ultrasonographic examination. All of our patients were postoperatively discharged from the hospital with a good clinical condition.

The following are accounts of 5 of the 9 cases we experienced and the details of the diagnostic techniques used and our successful surgical results.

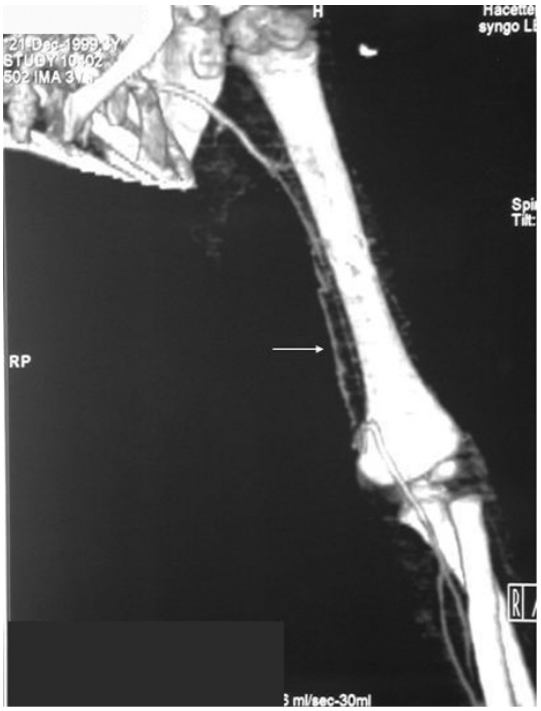

Figure 1. The thrombosed left brachial artery, which is supplied from the left upper extremity collateral arteries, is shown with the use of 16-slice multidetector computed tomography angiography. The white arrow indicates the collateral artery that is separated from the brachial artery.

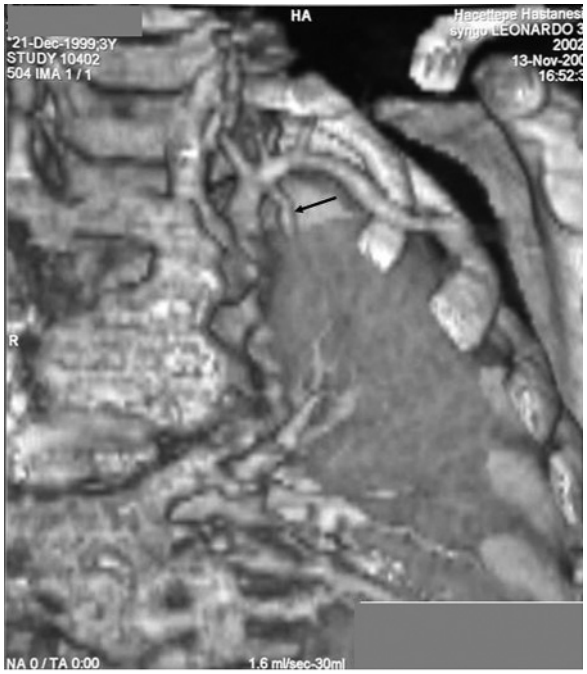

Figure 2. Patent left modified Blalock-Taussig shunt is clearly seen by means of multidetector computed tomography angiography in this figure after the operation. The black arrow indicates the patent shunt material that is between the subclavian and the left pulmonary artery.

CASE 1

A 2-month-old male child was first admitted to the pediatric gastroenterology department with hepatosplenomegaly and a mass in the left antecubital fossa. There were signs of prolonged bleeding at the site of venipuncture, which had occurred at another hospital. A pulsatile mass had probably developed over a 3-week period. The prothrombin time was prolonged and continuous bleeding was observed at the site of injection. The patient was diagnosed with chronic liver disease. In the examination, the pulsatile mass was measured about 5 cm in diameter in the left antecubital fossa. No bruit could be auscultated. A diagnosis of false aneurysm of the brachial artery was considered. A Doppler USG revealed a hypoechogenic oval zone in the left antecubital fossa measuring 45 × 50 mm with signs of turbulent flow, and the diagnosis was confirmed. Exploration was performed under general anesthesia, and vascular control was provided. The false aneurysm sac was opened and the hematoma was evacuated, and defects in the arterial wall were repaired with interrupted direct sutures. The radial pulses remained palpable.

CASE 2

A 2.5-month-old male child was hospitalized due to aspiration pneumonia and was treated medically in the pediatric infectious diseases unit. Two days after he was discharged from the hospital, he was brought to the Emergency Room with a mass in his right antecubital fossa, at the site of a previous venous catheter puncture. He had fever and leucocytosis, and his erythrocyte sedimentation rate was 51 mm/hr. The mass was nonpulsatile and his whole arm was hot and tender on palpation. Surface USG revealed a possible abscess. A cotton swab was introduced into the cavity following a skin incision. Sudden onset arterial bleeding began. Our department was consulted for assessment. Distal pulses were weakly palpable. Considering the amount of blood lost and the age of the child, we decided on surgical intervention. Unfortunately, the preoperative images of the pseudoaneurysm formed in the brachial region could not be obtained because the patient was operated on under emergency conditions. The child was taken to the operation room. Exploration following an "S" shaped incision over the site revealed a tiny puncture on the brachial artery. The defect was about 1 mm in size and was repaired with a single 7/0 polypropylene suture. There was no evidence of distal arterial thrombus, and distal radial and ulnar pulses were strongly palpable. Routine peripheral blood analyses were taken, and he had protein S deficiency and a high level of factor VIII. The other coagulation factors were normal. The patient was discharged on the fourth postoperative day with his distal pulses satisfactorily palpable. Doppler ultrasound was performed to show the blood flow in the brachial artery, which had a very small diameter.

Two months after this incident, the child was brought to the hospital again with a tender mass on his right inguinal fossa. He was hospitalized and the site was examined with Doppler USG. We learned from the parents that the mass at the femoral region was formed after an invasive procedure on the femoral vein at another institution. Local compression was done to treat the swelling recognized after the intervention, and the patient was referred to our hospital. USG was performed but thrombosed pseudoaneurysm or hematoma discrimination could not be done. Because any invasive diagnostic procedure could lead to a new aneurysm formation, DSA was not performed. It was very difficult to discriminate whether the mass was a thrombosed pseudoaneurysm or a hematoma by means of USG. The diagnosis was made by observing the increase in the diameter of the mass. A thrombosed pseudoaneurysm sac that was 18 × 22 × 25 mm in size was detected in the Doppler USG (Figure 3). The size of the

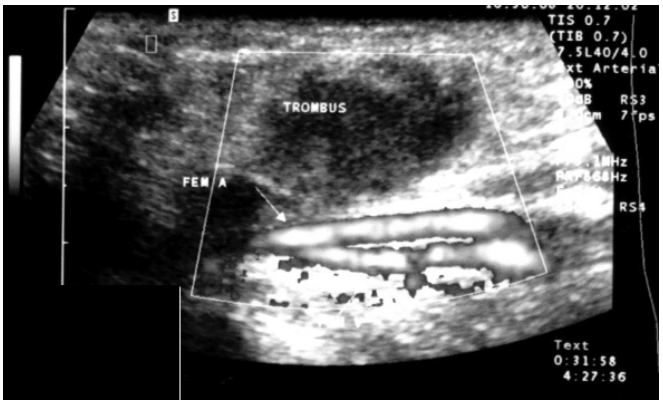

Figure 3. Doppler ultrasonography showing the thrombosed pseudoaneurysm sac at the right femoral region. Patent femoral artery and femoral vein are intact. Doppler reveals that there is no evidence of turbulent flow within the femoral artery. Fem A indicates superficial femoral artery; trombus, thrombosed pseudoaneurysm sac.

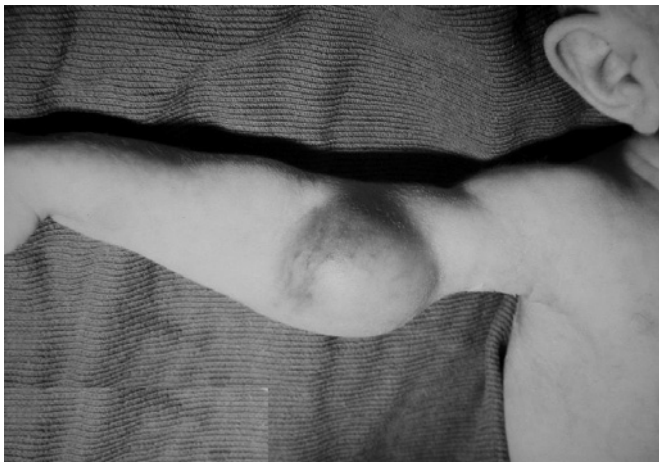

Figure 4. Illustrative photograph showing a large mass at the region of the affected right antecubital fossa in a female child with I-cell disease.

pseudoaneurysm sac decreased in the clinical follow-up, and the patient was discharged from the hospital in good clinical condition. Doppler USG revealed that both the femoral artery and vein were intact 3 months after the patient was discharged from the hospital.

CASE 3

A 5-month-old female child was referred to the pediatric clinic with swelling and a nontender mass in the right antecubital fossa (Figure 4). Physical examination revealed a large, nonpulsating fusiform 4 × 4 cm mass at the right elbow. An enlarged right arm that had increased slowly in size was first observed by her parents 20 days before admission. All peripheral pulses were fully and equally palpable. There was no thrill or bruit. Because of the increasing size, a vascular origin was suspected, and Doppler USG was performed and a large BAP formation was recorded. There were no clinical signs of thromboembolism on the postoperative day. We were informed by the parents that I-cell disease had been diagnosed previously. Exploration was performed under general anesthesia. The false aneurysm sac was resected, and the defect in the arterial wall was repaired with interrupted direct sutures of 7/0 polypropylene. The postoperative course was uncomplicated. The radial pulses remained palpable. The wound healed satisfactorily, and the patient was discharged on the fourth postoperative day.

CASE 4

A 2-year-old male child with swelling in the right arm was referred from another hospital. The continuously increased swelling was first observed by his mother 6 months after a peripheral routine blood analysis in another hospital. Results of blood examinations were in normal ranges. Chest x-ray and electrocardiographic findings were also normal. Two-dimensional echocardiography showed no congenital cardiac abnormalities or ventricular and atrial overload. All peripheral pulses were palpable. Because of a palpable thrill, a vascular problem was suspected and a Doppler USG was performed. A brachial AVf in the right upper extremity was detected. There was no clinical sign of thromboembolism in the hand or cardiac overload due to the AVf. The patient also had no cardiac symptoms or right heart overload findings.

There was a possibility that this arterial puncture had been performed accidentally during the peripheral blood analysis. A systolo-diastolic continuous murmur was heard on his right antecubital fossa. DSA was performed with a catheter introduced into the left brachial artery and revealed a quite well-defined opacity of the circulation of the upper extremity. The early phase of the angiogram showed a direct opacification of the contrast medium into the brachial and basilic veins immediately after the opacification of the brachial artery (Figure 5). The communication channel of the AVf seemed to be short but large in diameter. The patient had been followed-up in another institution with regular cardiovascular check-ups for spontaneous closure of the fistula. Surgical intervention was planned as an alternative therapy because a large connection was seen between the brachial artery and the vein. Exploration was performed under general anesthesia, and the AVf was visualized clearly. The AVf was between the brachial artery and the brachial vein and there was a large connection. The AVf was double ligated and a transfiction suture was placed without complication. The postoperative course was uncomplicated. Palpable thrill was lost after the operation. The wound healed satisfactorily and the patient was discharged on the fifth postoperative day.

Figure 5. The early phase of the right upper extremity angiogram shows a direct opacification of the contrast medium into the brachial and basilic veins immediately after the opacification of the brachial artery. The communication channel of the brachial arteriovenous fistula seems to be short (white arrow).

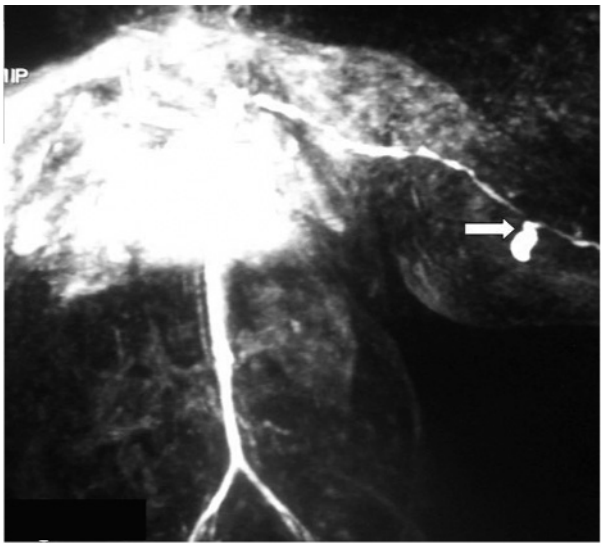

Figure 6. Magnetic resonance imaging anterior view shows the large pseudoaneurysm and hematoma. Extravasation of the contrast medium from the left brachial artery is shown in this picture.

CASE 5

A 6-month-old male child was transferred to our institution with swelling in the left arm. The increased swelling had been detected at another hospital 2 weeks after a peripheral blood analysis. Chest x-ray and electrocardiographic findings were normal. All peripheral pulses were palpable. Because there was a palpable mass on the left arm, a vascular problem was suspected and magnetic resonance angiography was performed as a noninvasive method. A brachial pseudoaneurysm (about 4 cm in size) in the left upper extremity was recorded (Figure 6). Fortunately, there was no clinical sign of complications in the left hand. There was a possibility that this arterial puncture had been performed accidentally during the previous peripheral blood analysis. Murmur due to vascular complication was not heard and thrill was not palpable on his antecubital fossa. Surgical intervention was planned as a therapeutic option because the diameter of the mass was 4 cm in size. Exploration was performed under general anesthesia, and the pseudoaneurysm sac was clearly visualized. The hematoma and sac were resected and a direct arterial suture was placed without any complication. The postoperative course was uneventful. The palpable mass disappeared after the operation. The wound healed satisfactorily, and the patient was discharged home on the sixth postoperative day.

DISCUSSION

We herein report our experience with 9 children who had iatrogenic peripheral artery injuries during venipuncture or invasive interventions and the relative diagnostic and surgical approaches. Accidental BAP following venipuncture developed in six of the cases. One of the remaining had AVf after 1 set of blood tests was performed. The brachial and the femoral artery thrombus were detected in the remaining 2 children.

BAP and AVf are extremely rare complications caused by accidental arterial puncture during attempted peripheral venipuncture for routine blood analysis in children. Although the most common cause of arterial pseudoaneurysm is cardiac catheterization, an invasive arterial monitoring catheter, an umbilical arterial catheterization, or a cannulation for cardiopulmonary bypass can also cause this complication [Thalhammer 2000]. However, pseudoaneurysm of the brachial artery is extremely rare and, to our knowledge, only 3 cases have been reported [Rey 1987; Demircin 1996; Dzepina 2004]. In addition, a few case reports of BAP due to blunt trauma have been previously reported by Jutte et al [2002] and Yetman et al [1992] in the English literature. An AVf due to venipuncture is extremely rare, and limited reports are available in the literature [Ino 2001], and most of these reports have been published as case reports.

The incidence of an AVf secondary to venipuncture is less than 0.003% [White 1968]. The pathogenic mechanism of an AVf secondary to vessel puncture still remains uncertain, but the close anatomic position of the brachial artery and the median cubital vein play an important role. In this clinicopathology, congestive heart failure and right heart overload may occur if the patient has a large AVf. Ino et al have reported a medical follow-up in a case with AVf [Ino 2001], but they had recorded a small arteriovenous connection in their case. Although rare, congestive heart failure may occur if a large shunt exists. Fortunately, the patient who required the left-to-right shunt had a right brachial artery AVf that was small, and a good early surgical outcome was obtained. We preferred surgical intervention for our patient with AVf because there was a large connection between the artery and the vein, and, also, spontaneous closure could not be achieved in his chronic follow-up even though a spontaneous closure may occur in cases with a small AVf shunt flow. We therefore suggest early surgical ligation of an arteriovenous shunt because the surgery may be performed easily and safely in these cases.

Pseudoaneurysms result from the disruption of a vessel wall that causes bleeding into the surrounding tissue and circulating blood to enter a cavity surrounded only by adjacent tissues, fascia, and thrombus, but not by normal arterial endothelium and other vessel wall components, as in true aneurysms. The signs and symptoms of a pseudoaneurysm may include a pulsatile mass in the affected area, spontaneous or traumatic rupture, hemorrhage, neuropathy, and distal vascular insufficiency. The causes of a mass in an area of previous trauma include abscess formation or an infected hematoma. Attempted drainage or biopsy of the mass is contraindicated in such patients. Some diagnostic methods can be used in this condition, such as Doppler ultrasound or DSA. Especially in children, noninvasive techniques such as Doppler examination should be kept in mind for evaluation of similar masses whenever possible.

The peripheral venous or arterial interventions in children performed for diagnostic purposes may lead to the development of pseudoaneurysms or arterial thromboembolic events and may manifest as life-threatening complications of the affected extremity [Klein 1982; Coen 1990]. Differential diagnoses include simple hematoma, tissue edema, thrombosed pseudoaneurysm, and lymphadenopathy. Diagnosis is assisted

by color-coded duplex Doppler scanning. A false aneurysm typically presents weeks to months after arterial blunt or penetrating trauma [Morrison 1992]. The symptoms of pseudoaneurysm may include rupture, hemorrhage, distal vascular insufficiency, and neuropathy caused by pressure on an adjacent nerve. Clinical manifestation differs, but usually local distending pain and limb mobility limitation may be present. In fact, the diagnosis of AVf is especially difficult in asymptomatic children. In a patient with penetrating injury history, BAP can be diagnosed by mass and a systolic blowing murmur. AVf can be diagnosed if continuous systolic murmur, palpable thrill, superficial vein exposure, or varicose and hypertrophic extremity is present. In one of our cases, the patient's family detected a thrill on the child's antecubital region and the patient was referred 6 months after the accidental arterial puncture.

Direct surgical arterial repair, as in our patients, resection of the affected arterial sites and end-to-end anastomosis, and ultrasound-guided compression (especially in adult cases) have emerged as first-line treatment options for pseudoaneurysms. Dzepina and colleagues have reported the resection of the involved part of the brachial artery and end-to-end anastomosis with a microsurgical technique in 3 children [Dzepina 2004]. For patients who are not suitable for conservative management, less invasive treatments such as the use of thrombin injection and endovascular repair techniques are being applied, mostly in femoral artery pseudoaneurysms [Brophy 2000; Thalhammer 2000]. We did not plan an intracavitary thrombin injection because of its complications in children, which have been reported previously [Lennox 1998]. Direct early surgical repair was done in all cases, except one, as soon as the diagnosis was made because of easy tolerability and less postoperative complications. The brachial artery was not suitable for the primary suturing in the last case, so arterial continuity was obtained by end-to-end anastomosis with the use of a microsurgery technique.

The advantages of early operation are as follows: lowest adhesion and vascularization, which facilitates surgical approach, protection from arterial embolic events and secondary infection of hematoma caused by rupture, avoidance of AVf regurgitation in cases of increasing cardiac load, and reduction in the amount of damage to muscles and nerves.

Because of the lack of reports regarding iatrogenic vascular complications secondary to a venipuncture attempt, an accurate incidence of this complication is not known. Peripheral embolic events or acute arterial thrombosis were the most common complications of the arterial pseudoaneurysm or AVf in children after attempted venipuncture. When the etiology of the embolic events is considered, potential causes are determined to be small arterial diameters, the relatively inproportionate diameter of the arterial cannulas, the predisposition to thrombosis caused by the foreign body cannulas, the intimal damage caused during insertion of the catheters, and, rarely, hyperhomocystinemia and inherited thrombophilias such as protein C, protein S, and antithrombin III deficiencies.

In thromboembolic cases, treatment of the arterial thromboemboli is usually effective in preventing tissue ischemia, claudication, and possible amputation requirement. Inherited thrombophilias have been associated with deficiencies of major anticoagulant proteins such as antithrombin III, protein C, and protein S. Interestingly, protein S deficiency was found in one of our pseudoaneurysm cases. The patient was diagnosed as having chronic liver disease and another patient had I-cell disease. In the case with protein S deficiency, paradoxical development of the pseudoaneurysm is an interesting finding. This case is still being clinically followed-up in terms of venous thrombocytosis.

In this clinical article, we described extremely rare complications of upper extremity arteries in children, the diagnostic techniques used, and our successful surgical results. Direct surgical repair of the affected extremity artery seems to be a very good modality of treatment in the early period. We conclude that percutaneous catheterization or accidental arterial punctures during venipuncture may lead to serious vascular complications. This phenomenon needs to be readily recognized by those providing care to sick children who require different invasive procedures for monitoring, diagnosis, and treatment so it may be promptly diagnosed and successfully treated.

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