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Iatrogenic Arteriovenous Fistula in the Arm in an Infant: Diagnostic and Therapeutic Considerations

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Abstract

Iatrogenic arteriovenous fistulas (AVF) are well described in adults; however, this complication is rarely described and reported in infants. We report the case of a 3-month-old infant with complicated gastroschisis requiring multiple venipunctures who presented with signs and symptoms suggestive of traumatic arteriovenous fistula. Ultrasound imaging confirmed the presence of a wide-necked AVF between the brachial artery and vein. The fistula was surgically repaired. This case report describes the clinical imaging and treatment options for infants with iatrogenic AVF.

Keywords

Doppler ultrasound; arteriovenous fistula; venipuncture

Iatrogenic arteriovenous fistulas (AVF) occurring after venous and arterial puncture are well described in adults; however, this complication is rarely identified in infants. Physical findings associated with AVF are often nonspecific and frequently pose a diagnostic challenge. Presenting symptoms can be as mundane as skin discoloration and edema. A definitive diagnosis is required before treatment options are considered. This report illustrates a clinically significant iatrogenic AVF involving an infant as a complication of venipuncture and highlights the use of Doppler ultrasound imaging (DUS) in directing definitive therapy.

CASE REPORT

A 3-month-old male infant was initially hospitalized for treatment of gastroschisis complicated by colonic atresia. His clinical course involved the need for long-term parenteral nutrition via peripherally inserted central catheters. Due to multiple line infections and dependency on long-term parenteral nutrition, several peripherally inserted central catheters lines were required, some of which were placed without image guidance.

Three months into his hospitalization, his nurse noticed the development of purplish discoloration and swelling of the distal two-thirds of the left forearm (Figure 1). The child's family expressed concern for nonaccidental trauma citing that the circumferential ecchymotic discoloration of the child's arm appeared to correspond to the grip of an adult hand. As a result, a child abuse specialist was asked to examine the child to assess the potential for nonaccidental trauma. At a glance, most of the child's left forearm appeared bruised. On closer inspection and with gentle side-to-side distraction, the skin findings were realized to be a dense network of fine, superficial capillaries instead of an ecchymosis. X-ray evaluation of the limb confirmed no fractures. Further physical examination demonstrated a hyperdynamic precordium, and a palpable thrill and audible bruit were found in the left antecubital fossa. DUS demonstrated a wide-necked AVF between the brachial vein and brachial artery. Pulsed Doppler spectrum analysis showed a pulsatile (arterialized) waveform at the fistula with a peak systolic velocity of 240 cm/s. The brachial vein outflow had a monophasic waveform with a peak velocity of 60 cm/s (Figure 2A–C).

The confirmatory diagnosis of an AVF, likely the complication of peripheral venipunctures in the antecubital fossa, prompted a definitive surgical repair of the fistula. The surgical correction involved dissection of the aneurysmal dilatation between the brachial vein and artery, which corresponded with the Doppler US findings. The brachial vein entering the aneurysm was divided proximally and distally. The aneurysm was opened and the fistula was closed with a 7-0 suture under direct vision (Figure 3). The leaflets of the aneurysmal dilation were closed with a running 7-0 suture to obliterate the aneurysmal sac. No vein patch was required. Postoperatively, the infant's neurovascular exam was normal and he recovered without complication.

DISCUSSION

Iatrogenic AVFs in the pediatric population are rarely reported.¹⁻⁴ They are typically the result of venous and arterial punctures and most commonly occur in the femoral and antecubital vessels. The presumed pathogenesis is initiated by the development of a hematoma after an arterial or venous puncture. Associated healing and fibrosis lead to adhesions between the artery and vein. Subsequent punctures may lead to fistula formation.

Diagnosis of an iatrogenic AVF in a child can be difficult due to infrequent presentation as well as the nonspecific findings on physical exam. The appearance can mimic other conditions such as vascular malformations or nonaccidental trauma, whose clinical presentation includes ecchymosis with underlying fractures often of variable age. Distinguishing features of AVF on clinical exam include circumferential discoloration

composed of a dense network of fine superficial capillaries with no associated bleeding. Additional physical examination findings include a palpable thrill, an audible bruit, and prominent veins returning cranially in the proximal forearm. In this setting, a hyperdynamic precordium and a murmur are suggestive of an AVF. The acute onset of these changes in our patient was somewhat concerning initially but the time to presentation for traumatic AVF can range from 2 days to several months.⁵

Given a child's history of multiple venous punctures in the involved region and, once a vascular abnormality is suspected based on the physical exam, noninvasive imaging is critical to confirm the diagnosis. DUS is the preferred diagnostic modality in infants and children because it is a readily available, noninvasive technique to image directly superficial vascular structures, and it does not require the use of ionizing radiation. It can be rapidly and accurately performed without the need for sedation and has the ability for realtime multiplanar imaging to elucidate the characteristics of the vascular abnormality. Sonographic criteria for diagnosing AVF include low-resistance flow in the supplying artery, high-velocity arterialized waveform in the draining vein, and turbulent high-velocity flow spectrum at the junction.⁶ The Doppler findings in this case confirmed this pattern of turbulent flow in the region of the fistula. The brachial vein served as the immediate outflow vessel and had increased pulsatile waveform consistent with an abnormal fistulous communication with the brachial artery.

Contrast MRI and MR angiography imaging techniques may be helpful in differentiating between different vascular lesions. A typical MR angiography finding of an AVF is the early enhancement of the vein in conjunction with that of the adjacent contributing artery involved. Use of MRI in the initial evaluation of AVF typically requires sedation in the pediatric population due to the long duration of the study and need for limited patient motion. Use of CT for the initial diagnosis of AVF also has some drawbacks mainly due to the exposure of the child to ionizing radiation.

Treatment options for AVF include surgical ligation, transcatheter embolization, ultrasound-guided compression, or exclusion with a covered stent. Management in children is guided by the adult literature because of the paucity of pediatric data. In the series by Kollmeyer et al, 81% of fistulas were treated surgically.² In adults, transcatheter embolizations have been found to have an overall success rate of up to 92%; however, an average of 1.6 procedures per patient was required to achieve symptom resolution.⁷ In our case, the infant's paucity of overlying soft tissue made transcatheter embolization/occlusion with the use of a metal coil or isolation of the fistula with a covered stent impractical. The coil or stent would remain palpable, or worse, leave the overlying soft tissue susceptible to skin breakdown from pressure necrosis. Furthermore, use of covered stents, while successful in various studies in adults whose vasculature are fully mature, is less well-studied in children. Moreover, stents often require anticoagulation and pose the long-term concern that the stent diameter would be insufficient to meet the limb's needs in a growing child, thus making it an untenable option in the pediatric population.¹ Although the treatment of AVF is traditionally surgical, anecdotal cases of graded compression have been reported.⁴ The use of extrinsic compression for a peripheral iatrogenic AVF in a 1,000-gram infant has been referenced by Ontell and Gauderer but involved the femoral artery.³ It is well accepted that US-guided

compression is a safe and effective nonsurgical alternative technique to treat pseudoaneurysms complicating arterial punctures.⁸ In these circumstances, the pseudoaneurysm is made up of a false lumen forming an extra-arterial sac connected by a neck that is typically narrow compared with the native underlying injured femoral artery. US compression is based on the application of direct pressure over the neck of the aneurysm and exclusion of continued flow into the false lumen, while maintaining continued distal flow. With femoral artery pseudoaneurysms, the underlying femoral head serves as a backdrop against which sufficient compression can be applied to achieve a safe and reliable success rate. In the present case, the AVF had a very wide communication, essentially the diameter of the involved brachial artery (Figure 2A–C), so that the pressure necessary to occlude its wide-necked communication would have resulted in obliterative compression of the brachial artery as well. Furthermore, the humerus is a round or ovoid structure that would not have made an ideal background osseous structure to permit persistent, stable graded compression. The relatively superficial nature of the AVF and the paucity of overlying soft tissue, as demonstrated by Doppler US imaging, led to the conclusion that direct surgical exposure with ligation was the most appropriate treatment option.

In conclusion, reports of iatrogenic AVF in children are rare and the diagnosis can be challenging. We report an unusual case of a clinically significant iatrogenic AVF that was initially mistaken for nonaccidental trauma. Physical findings and diagnostic imaging with Doppler ultrasound allowed for definitive confirmation of an AVF and helped direct therapeutic options.

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FIGURE 1.
Ventral view of the distal left upper extremity. The patient's thumb is represented by the white arrow. Ecchymotic striae are seen with a circumferential distribution.

FIGURE 2.

(A) Gray-scale US image in the antecubital region demonstrating a wide-neck communication between the brachial artery and vein. (B) Color Doppler image showing direct communication between the artery and vein. (C) Left brachial vein pulsed Doppler spectral analysis shows an arterial waveform confirming an arterial venous fistula.

FIGURE 3.

Dissection of the fistula at the antecubital fossa. The proximal arm is located to the right of the picture. The blue vessel loops encircle the brachial veins. The white asterisk marks the aneurysmal dilatation of the fistula. The proximal brachial artery is highlighted by the solid white lines.