Arm ischemia in a 4-year-old boy with supracondylar fracture of the humerus due to constraining bands over the brachial artery

Keyuree Satam, BA,[a] Anand Brahmandam, MBBS,[b] Michael Leslie, DO,[c] Tomer Avraham, MD,[d] *and* Cassius Iyad Ochoa Chaar, MD, MS,[b] *New Haven, CT*

ABSTRACT

Supracondylar humerus fractures are common in children and can compromise the brachial artery in 5% to 15% of cases. A 4-year-old boy with a left supracondylar fracture developed upper extremity ischemia after pinning of the fracture. Computed tomography angiography revealed cutoff of flow in the brachial artery. Intraoperatively, he was found to have bands tethering the artery into the fracture, obstructing the blood flow. The orthopedic pins were removed, and the constraining bands were lysed to free the artery, with reconstitution of flow confirmed by intraoperative angiography. The fracture was reduced and stabilized, and the patient recovered well with normal arterial flow on follow-up ultrasound after 3 months. (J Vasc Surg Cases Innov Tech 2023;9:101218.)

Keywords: Arterial entrapment; Brachial artery; External fixation; Pediatric vascular surgery; Supracondylar fracture

A supracondylar fracture of the humerus from falling on an outstretched hand comprises 15% of pediatric fractures.[1] Of these patients, 5% to 15% will have neurovascular compromise from proximity to the brachial artery and anterior interosseous nerve.[1] Most studies have reported that brachial artery injury or thrombosis after supracondylar fracture will be treated by thrombectomy.[2-6] In one study, among 17 patients with a pulse abnormality, 2 had intimal tears requiring a reversed vein graft and 1 had arterial kinking. The remaining cases resolved after reduction and fixation.[7] In the present report, we describe the challenging nature of this common operative fracture with neurovascular compromise and a multidisciplinary surgical team response to the patient's needs. The patient's parents provided written informed consent for the report of his case details and imaging studies, with all identifying information omitted.

CASE REPORT

A 4-year-old boy presented to an outside facility after falling on his outstretched left arm. He had a supracondylar fracture on plain radiographs and underwent closed reduction with percutaneous stabilization in a community hospital (Fig 1). Intraoperatively, the surgeon noted that the hand became ischemic, and the patient was transferred to our tertiary center for management. On presentation, his radial and ulnar pulses were not palpable. The ulnar artery had a weak monophasic signal. He had intact range of motion of his digits and normal capillary refill. A computed tomography angiogram demonstrated a segmental cutoff in the brachial artery around the fracture area with distal reconstitution (Fig 2, *A*). After discussion with orthopedic and plastic surgery, the decision was made for surgical exploration. The patient was already anticoagulated with a heparin infusion.

In the operating room, ultrasound showed a patent brachial artery to the fracture area, where the artery could no longer be visualized. The artery was accessed retrograde, and angiography showed cutoff at the fracture site with reconstitution of the radial and ulnar arteries distally (Fig 2, *B*). A longitudinal lazy S incision was made over the brachial artery. The bicipital aponeurosis was divided, and plastic surgery explored the nerve and found no injury. The brachial artery was dissected, and bands were seen constraining it in a twisted configuration, trapping it between bony fragments of the fracture (Fig 3). The orthopedics team removed the pins. The artery was mobilized anteriorly, and the tethering bands were lysed. The artery appeared to be intact externally, and a pulse was appreciated. Multiphasic Doppler signals were present in the artery and distally. Completion angiography showed some residual narrowing (Fig 4, *A*). Papaverine was placed on the vessel and injected intravascularly through the proximal sheath. Additional bands were encountered and lysed, and the final angiogram showed excellent flow in the brachial artery with brisk filling of the radial and ulnar arteries (Fig 4, *B*). Orthopedic surgery reduced the fracture and replaced the pins under direct vision of the insertion of the wires. Protamine was given at the end of the case, and pulses were appreciated. The patient was shielded with a lead apron before the case. Only 10 mL of iodinated contrast was given. To minimize

From the Yale School of Medicine[a]; Division of Vascular Surgery and Endovascular Therapy,[b] Yale Department of Orthopaedics and Rehabilitation,[c] and Division of Plastic and Reconstructive Surgery,[d] Department of Surgery, Yale School of Medicine.

Author conflict of interest: none.

Correspondence: Keyuree Satam, BA, Yale School of Medicine, 333 Cedar St, New Haven, CT 06510 (e-mail: ksatam@outlook.com).

The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

https://doi.org/10.1016/j.jvscit.2023.101218

Fig 1. Anteroposterior radiographic view showing pins placed to treat a supracondylar fracture at an outside hospital.

radiation to this young patient, the angiographic runs were limited, with a total fluoroscopy time of only 150 seconds and an overall radiation dosage of 6.09 mGy.

The patient was transferred to the pediatric intensive care unit with a well-perfused hand and subsequently discharged home on postoperative day 4. He was not prescribed anticoagulation therapy or aspirin because no thrombosis or intimal injury had occurred. He presented for follow-up 3 months later with normal pulses and hand function. Ultrasound showed normal flow in the brachial artery (Fig 5).

DISCUSSION

A supracondylar humerus fracture after falling on an outstretched hand is a common pediatric injury, often causing neurovascular compromise to the brachial artery and nerve from anatomic proximity. We report a unique case of acute hand ischemia following fixation of a supracondylar fracture caused by tethering soft tissue bands surrounding the brachial artery.

Numerous studies have discussed brachial artery injury or thrombosis after supracondylar fracture, highlighting the serious complications associated with this injury. A feared complication is Volkmann ischemic contracture, in which unrecognized prolonged loss of blood flow leads to eventual deformity of the hand, fingers, and wrist.[8] Most initial presentations of hand ischemia after supracondylar fracture resolve after closed reduction and percutaneous pinning, because the brachial artery is often kinked over displaced fracture fragments, tethered by the ulnar-sided supratrochlear branch.[9] During fixation, flexing the elbow and applying gentle traction can restore the pulse by relieving tension from the anterior structures. This can separate the sharp edge of the proximal fragment from the brachial artery.[10]

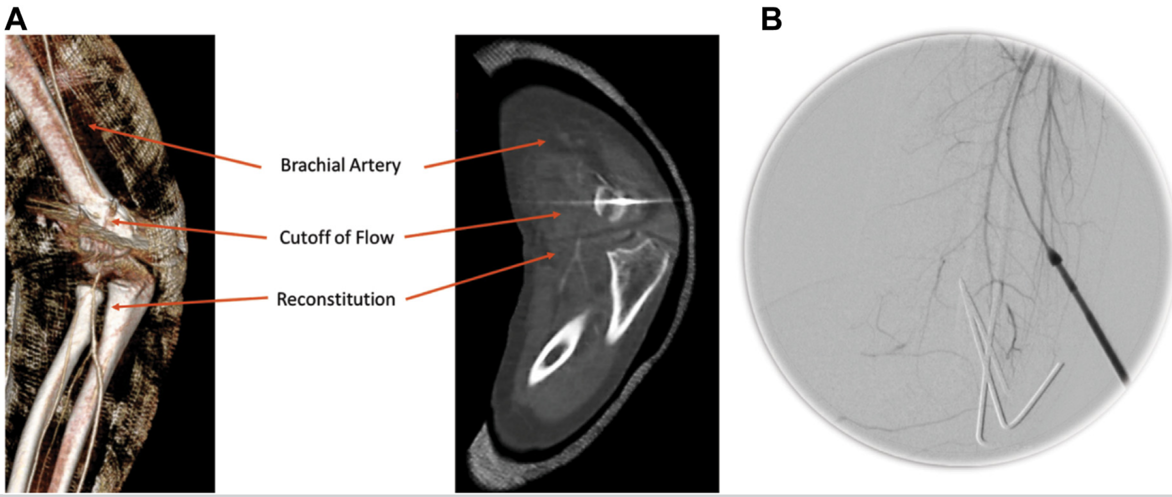

Fig 2. A, Computed tomography angiogram showing cutoff of flow from the brachial artery at the elbow at the level of the fracture on both three-dimensional rendering and two-dimensional scans. **B,** Initial angiogram showing lack of flow distally in the brachial artery.

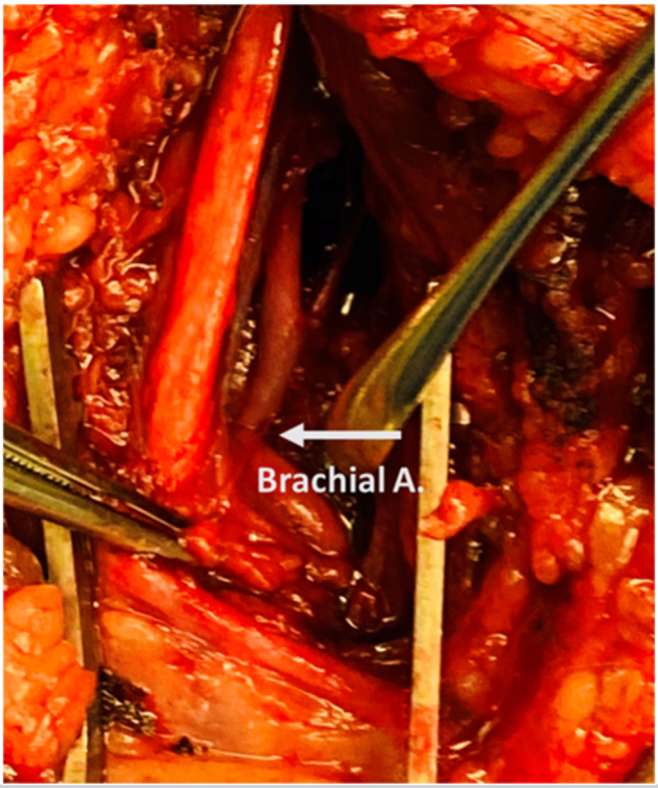

Fig 3. Surgical exposure of the brachial artery after removal of the orthopedic pins. Bands can be seen pinning the artery into the fracture. These were lysed, with restoration of distal flow.

In some cases, pulselessness persists, indicating arterial injury, thrombus, or entrapment that warrants open exploration.[11] Approaches vary, however, when the hand at risk is pink and pulseless but seems perfused. Some use watchful waiting because slow flow can be attributed to vasospasm. However, recent literature encourages more aggressive early revascularization to avoid detrimental long-term sequela.[4,6] In some cases, delayed presentation of ischemia is due to late thrombus formation in the brachial artery, as reported by Ege et al.[11] We considered the presence of late thrombus; however, the angiography findings suggested external compression rather than occlusive thrombus.

Reports of reduced pulses after repair are limited, however, because closed reduction and fracture stabilization usually normalize vascular flow. Reigstad et al[12] described a case series of five patients who presented with completed primary repair of supracondylar fracture and lack of forearm pulses. Four patients were found to have primary arterial injury, two of whom underwent direct repair and two underwent interposition grafting with the great saphenous vein. In the fifth patient, who had had pulses before pinning but lost them after the initial intervention, exploration of his brachial artery showed entrapment within the fracture, which was freed after removal of cross-pin fixation. The investigators suggested that the initial reduction could have pulled the artery into the fracture, leading to loss of pulse.[12] However, the artery in our patient was not trapped in the fracture but tethered by surrounding bands constraining it and pulling it into the orthopedic reduction. These bands were thought to be related to soft tissue surrounding the artery; likely a combination of the sheath covering the neurovascular bundle and surrounding tendinous structures that became entrapped with closed reduction of the fracture. In addition, the prior case did not use angiography to document flow and ensure that no dissection had occurred in the trapped artery.[12] In our case, angiography was useful in demonstrating continued

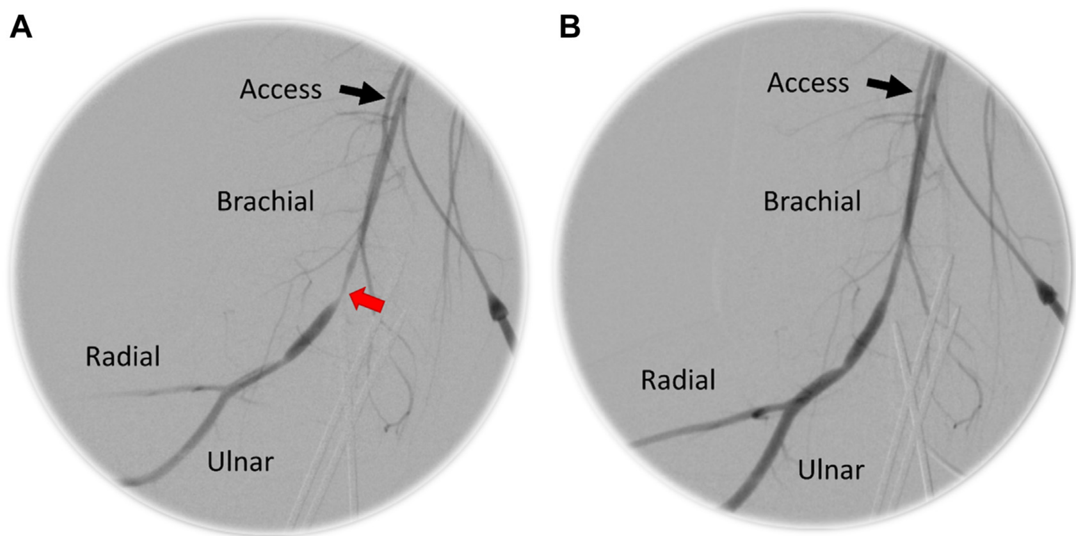

Fig 4. **A,** Angiogram after dissection of the artery, showing some residual narrowing (*red arrow*). **B,** Completion angiogram at conclusion of the case showing resolution of flow in the brachial artery with brisk filling of the ulnar and radial arteries.

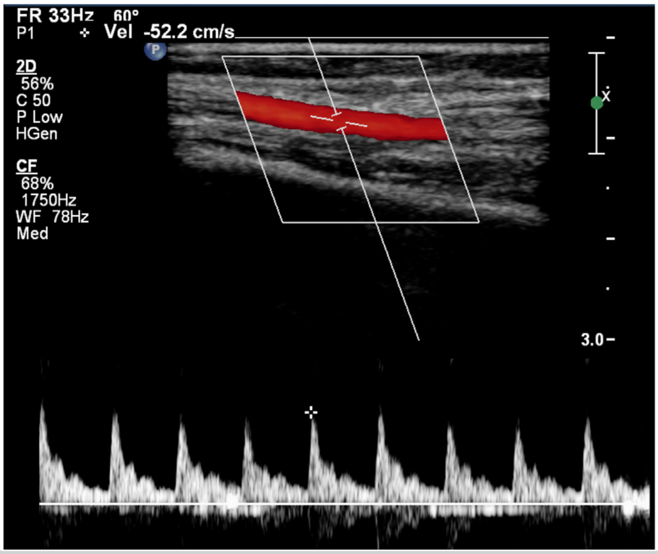

Fig 5. Follow-up ultrasound showing good flow through the brachial artery at the level of the mid-humerus.

constriction, which could have been related to the additional bands, which were also lysed, or to vasospasm that resolved after administration of papaverine.

Some important considerations arose in the present case. First, minimizing the use of intravenous contrast and radiation in children is important.[13-15] For our patient, care was taken to use the minimum amount of contrast necessary. Finally, after the brachial artery was freed from the surrounding bands, some vasospasm persisted. This was treated with topical and intra-arterial papaverine, with good results. Papaverine has similarly been described for another case of traumatic arterial spasm after supracondylar fracture in a pediatric patient.[16]

CONCLUSIONS

Brachial artery entrapment after fixation of a supracondylar humerus fracture is an uncommon, but serious, complication of orthopedic reduction and pinning. A collaborative approach involving vascular, orthopedic, and plastic surgery can provide optimal outcomes because neurovascular damage can be repaired and the orthopedic reduction adjusted. Angiography is a useful adjunct to visualize the anatomy and confirm adequate repair.

REFERENCES

1. Barr LV. Paediatric supracondylar humeral fractures: epidemiology, mechanisms and incidence during school holidays. J Child Orthop 2014;8:167-70.
2. Broudy AS, Jupiter J, May JW Jr. Management of supracondylar fracture with brachial artery thrombosis in a child: case report and literature review. J Trauma 1979;19:540-3.
3. Babala J, Horn F, Sýkora L, et al. Suprakondylická zlomenina humeru s poruchou cirkulácie [Supracondylar fractures of the humerus and disorders of circulation]. Rozhl Chir 2001;80:545-8.
4. White L, Mehlman CT, Crawford AH. Perfused, pulseless, and puzzling: a systematic review of vascular injuries in pediatric supracondylar humerus fractures and results of a POSNA questionnaire. J Pediatr Orthop 2010;30:328-35.
5. Xie LW, Wang J, Deng ZQ. Treatment of pediatric supracondylar humerus fractures accompanied with pink pulseless hands. BMC Musculoskelet Disord 2021;22:26.
6. Korompilias AV, Lykissas MG, Mitsionis GI, Kontogeorgakos VA, Manoudis G, Beris AE. Treatment of pink pulseless hand following supracondylar fractures of the humerus in children. Int Orthop 2009;33:237-41.
7. Shaw BA, Kasser JR, Emans JB, Rand FF. Management of vascular injuries in displaced supracondylar humerus fractures without arteriography. J Orthop Trauma 1990;4:25-9.
8. Meyerding HW. VOLKMANN'S ischemic contracture: associated with supracondylar fracture OF humerus. JAMA 1936;106:1139-44.
9. Noaman HH. Microsurgical reconstruction of brachial artery injuries in displaced supracondylar fracture humerus in children. Microsurgery 2006;26:498-505.

10. Badkoobehi H, Choi PD, Bae DS, Skaggs DL. Management of the pulseless pediatric supracondylar humeral fracture. J Bone Joint Surg Am 2015;97:937-43.
11. Ege T, Türkkan S, Günay C, Külahçı Y, Kürklü M. Late onset brachial artery thrombosis and total temporary peripheral neuropathy in a child with humerus supracondylar fracture: a case report. Ulus Travma Acil Cerrahi Derg 2015;21:75-8.
12. Reigstad O, Thorkildsen R, Grimsgaard C, Reigstad A, Røkkum M. Supracondylar fractures with circulatory failure after reduction, pinning, and entrapment of the brachial artery: excellent results more than 1 year after open exploration and revascularization. J Orthop Trauma 2011;25:26-30.
13. Ajami G, Derakhshan A, Amoozgar H, et al. Risk of nephropathy after consumption of nonionic contrast media by children undergoing cardiac angiography: a prospective study. Pediatr Cardiol 2010;31:668-73.
14. Siegel MJ. Pediatric CT angiography. Eur Radiol 2005;15(Suppl 4):D32-6.
15. Cheeney SHE, Maloney E, Iyer RS. Safety considerations related to intravenous contrast agents in pediatric imaging. Pediatr Radiol 2022:1-12.
16. Abbey P. Use of papaverine in traumatic arterial spasm after supracondylar fracture of humerus. Br Med J 1955;2:1604.

Submitted Feb 27, 2023; accepted May 1, 2023.