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CASE REPORT

Entrapment of the brachial artery in the cancellous bone in pulseless supracondylar humerus fractures with well-perfused hands: Report of three cases

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ABSTRACT

Management of pediatric pulseless supracondylar humerus fractures is a point of continuous debate. In this article, we present three cases admitted to the emergency department with pulseless, but well-perfused hands. The fractures were reduced and fixed using the antecubital approach. Prior to reduction, the brachial arteries of all three patients were entrapped in the cancellous bone of the proximal fragment segment. The arteries could only be released after freeing the adventitia by carefully scraping the adjacent bone with the tip of a hemostat. One case required thrombectomy through an arteriotomy using No. 3 Fogarty catheter. In two cases, the pulse returned after a brief period of waiting with no need for vascular intervention. Proceeding with closed reduction, as proposed by the recent guidelines, would result in further damage to the entrapped vasculature, which may go unnoticed due to collateral circulation.

Keywords: Antecubital approach, brachial artery, pulseless, supracondylar humerus fracture.

The status of peripheral circulation as an indication for open reduction for treatment of displaced supracondylar humerus fractures (SHFs) in children is a point of continuous debate. The approach to a pulseless extremity in a child differs significantly from adults due to rich collateral circulation. Approach to a poorly-perfused pulseless hand in a child with SHF, although gentle traction is well established.[1,2] In these cases, emergent open reduction and vascular exploration is indicated. Decision making in a well-perfused hand is still controversial, placing a great burden on the orthopedist managing the patient.

Although the absence of pulse at presentation and weak or no recovery after reduction historically have been considered as indications for neurovascular exploration, there has been a shift in paradigm to closely monitor the patient, unless hand perfusion deteriorates. In cases where radial pulses do not return following closed reduction and fixation, some surgeons advocate immediate vascular exploration, whereas the authors such as Weller et al.[3] prefer close monitoring and watchful waiting, if the hand perfusion is achieved despite no recovery of the pulses. In our clinic, we accept the absence of pulse, despite gentle reduction as a sign of vascular compromise and proceed with open reduction. We prefer antecubital approach, which provides excellent exposure of the fracture line and allows vascular repair and extension of the incision, if required.

In this article, we present three cases of SHF with pulseless, well-perfused hands, which would result in

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detrimental outcome if closed reduction and fixation was attempted.

CASE REPORT

All three children had pulseless, but well-perfused hands and atypical fracture patterns, as described by Bahk et al.[4] and Lim et al.[5] The elbows were extremely swollen, as expected, with a positive dimple sign. After attempting gentle reduction, there was still no pulse, as confirmed by Doppler ultrasound. Urgent surgery with antecubital open reduction was planned and cardiovascular surgeons were informed for potential intraoperative consultation.

Case 1- A five-year-old boy had a fracture with a high degree of lateral obliquity on the coronal plane, exceeding 45 degrees. There was prominent medial spike on the ulnar corner of the proximal fragment, with a medial spike angle of <45 degrees (Figure 1).

The surgery was performed through a transverse antecubital approach without attempting closed reduction. The proximal fragment had partially pierced the brachialis muscle, whereas the distal fragment was posterior to the brachialis and biceps brachii and could not be initially visualized. The anterior surface of the distal edge of the proximal segment was clearly exposed by placing small Hohmann retractors for evaluation, if neurovascular bundle was interposed between the fracture segments. The brachial artery was kinked and entrapped in the cancellous bone of the proximal fracture segment (Figure 2). The artery could only be released after freeing the adventitia by carefully scraping the adjacent bone with the tip of a hemostat.

The fracture was reduced and fixed with lateral divergent Kirschner wires (K-wires) under fluoroscopic guidance. High obliquity of the fracture made it impossible to achieve adequate bone purchase in the proximal fragment with a medial pin. The quality of reduction was checked by palpating the columns and visually inspecting the fracture line. Following stabilization of the elbow, cardiovascular surgeons joined the operation to check the vascular integrity. Although the brachial artery was intact, no pulse was present with Doppler in the radial and ulnar arteries in the wrist. There was no pulse in

FIGURE 1. Preoperative anteroposterior X-ray of the first patient. Note the high degree of obliquity and a very sharp medial spike. Distal segment of the proximal fragment is marked to better delineate the fragment edges superposed on proximal radius.

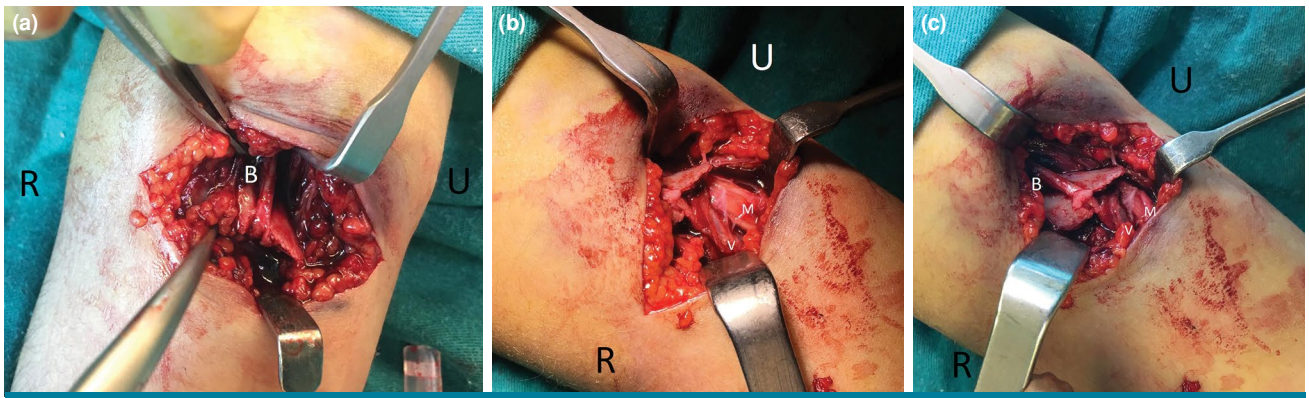

FIGURE 2. Exposure through the antecubital approach. **(a)** Note the brachial artery with the adventitia entrapped in the cancellous bone. **(b)** Deep veins of the arm and median nerve interposed between medial spike and the pierced brachialis muscle. **(c)** The adventitia of the brachial artery is freed by scraping the adjacent cancellous bone with the tip of a hemostat. The artery can now be mobilized so that it will not be impinged during reduction.
B: Brachial artery; V: Deep vein of the arm; M: Median nerve; U: Ulnar side; R: Radial side.

the brachial artery in close vicinity of the fracture, either. After a brief period of waiting, the situation did not change and diagnosis of intimal damage or arterial thrombus was made. Thrombectomy was performed through an arteriotomy by using No. 3 Fogarty catheter. The pulse returned and the artery was sutured with 8/0 prolene primarily. The patient was started on antithrombotic agents and discharged on Day 5 without neurovascular deficit.

Case 2- A four-year-old girl had a fracture with high sagittal obliquity (>20°) which was unstable in all directions (Figure 3). Antecubital approach was used without closed reduction attempt. She had similar intraoperative findings, with brachial artery tethered in the cancellous bone. After freeing the artery, the fracture was reduced and fixed with two lateral and one medial pin. As opposed to the first case, the vascular structures were intact and

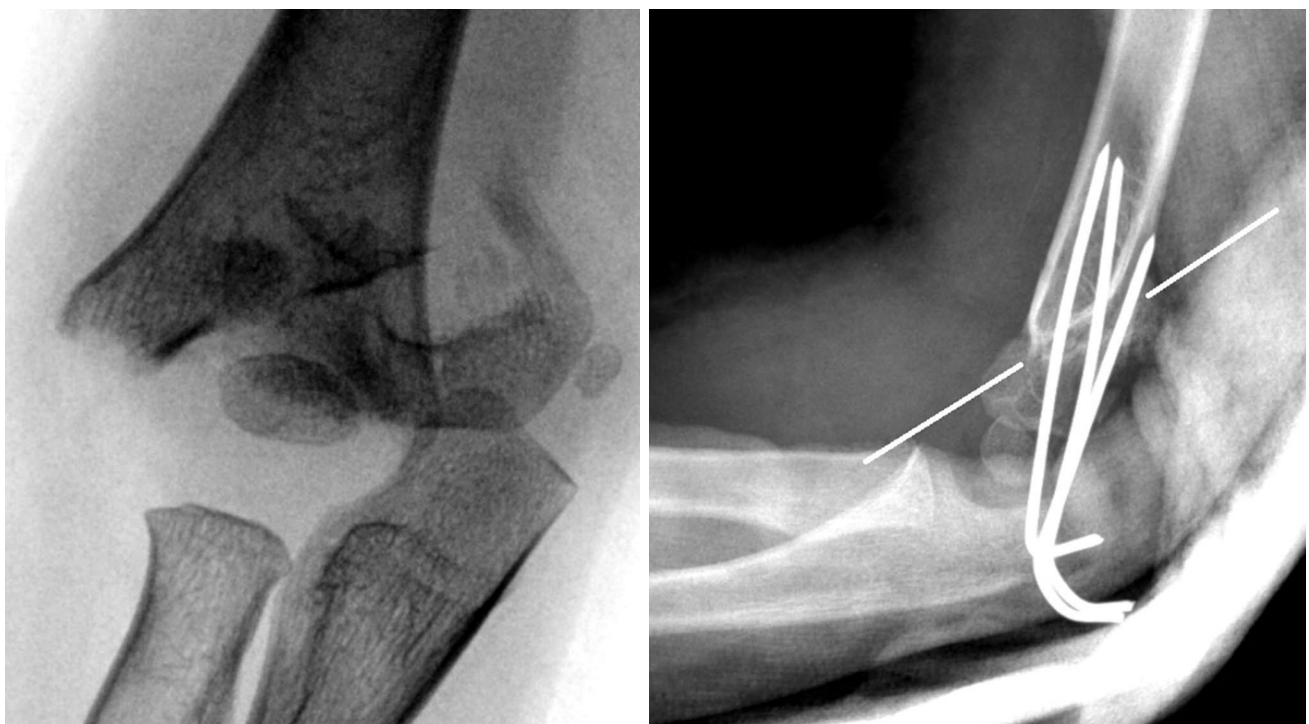

FIGURE 3. Radiographs of the second case. Supracondylar fracture with a medial spike with angle less than 45 degrees and high obliquity in the sagittal plane.

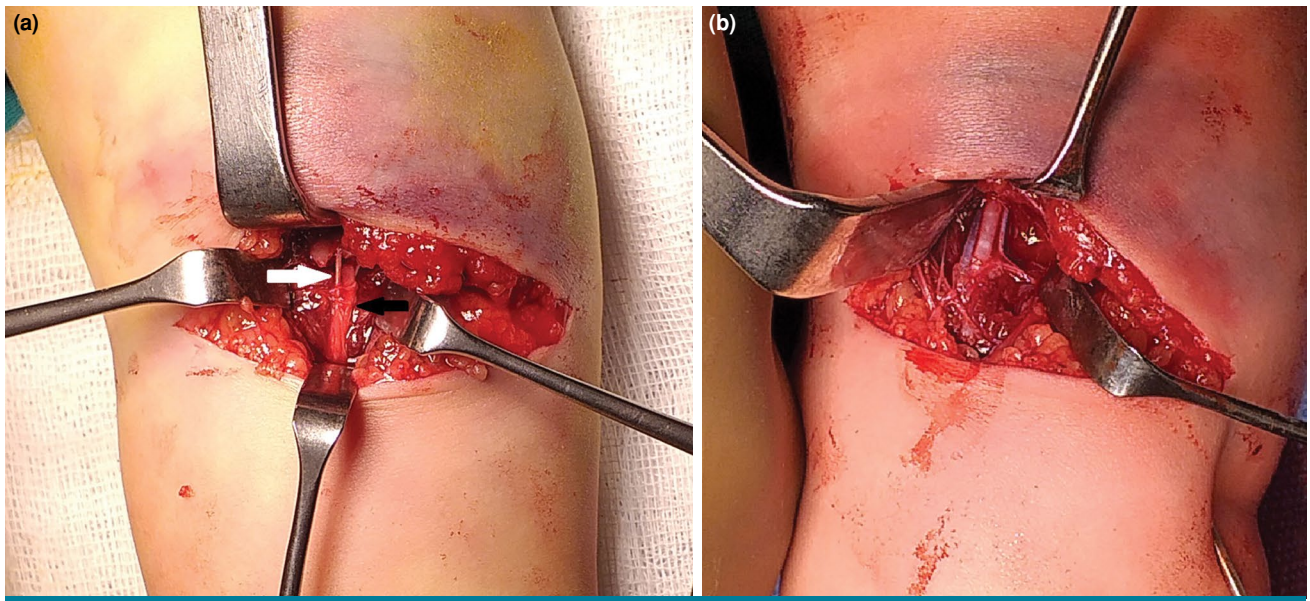

FIGURE 4. Change in the volume of brachial artery after release. **(a)** A small increase in volume of the thin strip of tissue after it was freed from the surrounding cancellous bone. **(b)** Brachial artery and the two venae comitantes became much bulkier and regained their true volume at the end of the operation.

the pulses returned after a brief period. She was discharged on Day 1 without neurovascular deficit or compartment syndrome.

Case 3- A two-year-old girl had a fracture with high sagittal obliquity (>20°) which could be temporarily reduced on coronal plane with traction. Nevertheless, vigorous reduction on sagittal plane was not attempted, and we proceeded with open reduction. Median nerve was interposed between fracture segments, and the vascular bundle could not be initially visualized. A very thin strip of connective tissue was stretched over and tethered onto the cancellous bone of the proximal fracture line. As it was freed by scraping the surrounding bone, it had uninterrupted continuity alongside the median nerve. Despite its extremely small diameter, we decided to proceed with caution and deflated the tourniquet to re-assess the entrapped structure. The suspected tissue increased in volume, proving that it was a vessel (Figure 4a). After the fracture line was freed from all interposed tissues, it was reduced and fixed with two K-wires. At the end of the operation, the initially thin strip of connective tissue had become much bulkier, with palpable pulsation and two venae comitantes, indicating the brachial artery without any doubt (Figure 4b). The patient, who did not show signs of perfusion disorder or compartment syndrome during follow-up, was discharged on postoperative Day 1.

DISCUSSION

It is not uncommon to find the brachial artery interposed between two fracture fragments or tethered on the sharp edge of the proximal segment. However, entrapment of the artery in the cancellous bone is rarely reported. In these three cases, the artery could only be released by scraping the surrounding bone. Attempting to reduce the fracture without freeing the adventitia first would have resulted in further damage.

These three cases represent the challenge the orthopedic surgeons face while treating this common injury, of which no definite consensus exists, and most probably will not be available in the near future. Badkoobehi et al.[2] and recent American Academy of Orthopaedic Surgeons (AAOS) Appropriate Use Criteria propose initial attempt of closed reduction and percutaneous pinning and re-assessment of peripheral circulation.[6] Even if the pulse does not recover, no exploration is indicated as long as the hand remains well-perfused, and the patient is observed closely for vascular compromise or compartment syndrome. Deterioration of perfusion and circulatory demise after reduction and fixation attempt require emergent vascular exploration and revision of reduction.

In their comprehensive systematic review, Delniotis et al.[7] reported that, in 45% of cases with poorly-perfused pale hands, either the pulses

recovered or the hand perfusion improved following reduction and fixation. From our perspective, the demerit of their finding is that, the circulation did not improve in 55% of the cases, and there is no way to exclude possibility of additional iatrogenic injury which can cause a simple occluded vessel that could be managed with simple release to evolve into a lesion that requires vascular repair. In Choi et al.'s[8] series of seven patients who presented with pale hands, hand perfusion recovered in five children following closed reduction and percutaneous pinning, although pulses did not return. However, four of these five patients required invasive procedures during the early postoperative period including angiography, fasciotomy, and vascular repair. A possible explanation for the initial recovery of hand perfusion may be that reduction aids in collateral circulation, which provides adequate hand perfusion for a brief period of time.

The three cases in our clinic had definite obstruction of blood flow in brachial artery, yet the peripheral perfusion was not compromised due to rich collateral blood supply.[9] If the guidelines of AAOS in management of SHF were followed, there would be no recovery of pulses, since the tethered brachial artery would be compressed and trapped in the fracture line permanently following reduction and fixation. Although vigorous reduction attempts wouldresult in irreversible damage to brachial artery, hand perfusion wouldnot deteriorate either, since collateral flow is already sufficient to prevent ischemia despite a non-functional brachial artery. These patients would be closely monitored for 48 h and would be discharged, if no compartment syndrome or loss of perfusion occurred.

Nevertheless, the troubling question is clear. Is the presence of hand perfusion justify not correcting a vascular pathology which would prompt emergency revascularization in other circumstances? Some authors have advocated the perfusion status as the main indication for vascular exploration, reporting that, in 100% of cases, the pulses recover in the long term as long as peripheral perfusion remains intact. On the contrary, it is reported that neuropathies may arise in the long term.[10] Report of three cases is not enough to denounce a widely-accepted algorithm, and neither the authors intend to do so; we would like to point out that permanent vascular damage may be underreported, as a result of the general approach to children with pulseless, but well-perfused hands.[11] The scarce reporting of such an entrapment as in our cases may result from low rates of anterior open reduction performed.

Another interesting finding of those cases is that all three fractures had atypical fracture patterns, either with a high obliquity in any of the planes and very narrow medial spike angle.[11] Although unease at reducing these fractures is somehow well-established and the surgeons are advocated to keep a low threshold for open reduction, their significance in incidence of vascular damage is not evaluated. Association of vascular lesions with atypical fractures in these three cases may be due to chance alone or may reflect a pattern.

In conclusion, in cases with pulseless SHFs with well-perfused hands, initial reduction in the emergency room should be performed gently. Anatomical reduction should not be attempted, since these patients need internal fixation in the operating room and such an attempt may compromise the entrapped structures, as seen in our cases. In the presence of atypical fracture patterns, the surgeon should have a low threshold to proceed with open reduction, not only for ease of reduction and stable fixation, but also to protect the integrity of the neurovascular structures. The antecubital approach is ideal, since it allows access to both columns and neurovascular structures, and can be extended if vascular grafting is necessary.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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