

Management of acute 'pink pulseless' hand in pediatric supracondylar fractures of the humerus

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The management of a persistent pink pulseless hand after a satisfactory closed reduction in a pediatric supracondylar fracture of the humerus is controversial. Several recent publications have recommended vascular exploration in contrast to a more conservative approach accepted traditionally. We report the results of seven patients with a mean follow-up of 36.6 months with a persistent pulseless, but well-perfused hand postreduction. All patients were managed conservatively without vascular exploration. A palpable return of the radial pulse was seen in six patients at 3 weeks and at 6 weeks follow-up in the other patient with no long-term dysfunction. We believe that the management of a persistent pink pulseless hand remains a 'watchful expectancy'. Surgical exploration should be

recommended only if there is either severe pain in the forearm persisting for more than 12 h after the injury or if there are signs of a deteriorating neurological function. *J Pediatr Orthop B* 20:124–128 © 2011 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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Introduction

The pink pulseless hand, with or without a neurological deficit after a Gartland extension type III supracondylar fracture is either very uncommon or is under-reported [1]. Most surgeons manage these cases expediently with immediate closed reduction with Kirschner (K) wire stabilization. Return of the radial pulse is commonly observed. There is no dispute regarding the need for surgical exploration in the patient with a supracondylar fracture and a cool white hand. However, management strategies have differed in patients with an absent radial pulse and a well-perfused pink hand despite achieving a successful reduction [2–7]. Recommended treatment options include observation [8], immediate exploration of the artery [9,10], exploration if the pulse has not recovered by 24 h [11], immediate angiography [12] and transfemoral brachial artery urokinase thrombolysis [13]. The purpose of this study was to evaluate the outcome in children with a pink pulseless hand managed without vascular exploration after a displaced supracondylar fracture of the humerus.

Patients and methods

We retrospectively reviewed Gartland extension type III closed supracondylar fractures of the humerus in 105 children with a mean age of 7.9 years (range 5–12 years). There was a higher incidence in boys than in girls, with 61 boys and 44 girls treated in our hospital between 2001 and 2006. Of this overall sample, 15 patients (14.3%) had a well-perfused hand, but with an absent radial pulse at

initial presentation. The dominant arm was involved in six patients. Three patients had concomitant median nerve injury and two patients presented with deficit to the anterior interosseous nerve. Doppler sonography, peripheral oxygen saturation with a pulse oximeter along with periodic palpation of the radial pulse was used to assess the vascular status of the hand.

All 15 patients with a pink pulseless hand underwent emergency surgical treatment within an average of 108 min after arrival at the hospital (range 45–135 min). These patients were treated between 1.5 and 16 h (mean 6.3 h) after the injury. Closed reduction of the fracture and lateral pinning of the fracture was achieved in all cases. Surgical exploration of the brachial artery was not attempted in any patient. The elbow was immobilized at 45° of flexion for 6 weeks with an above elbow cast with a window cut at the level of the wrist for the evaluation of the radial pulse. Postoperatively, the patients were observed for vascular status and possibility of compartment syndrome. The mean duration of hospital stay was 4.3 days (range 3 to 7 days). At 6 weeks, the cast and the K-wires were removed and the rehabilitation programme was initiated. Follow-up was carried out at 3 weeks, 6 weeks, 3 months and subsequently, at every 6 months. Mean follow-up period was 36.6 months, with a range of 20–52 months. At final review all children were evaluated for the presence of arm pain, claudication, functional limitation and range of motion, carrying angle, neurological recovery and the status of radial pulse. The summary of patient data is represented in Table 1.

Table 1 Summary of 15 patients with a pink pulseless hand treated by urgent closed reduction and lateral pinning

| Case | Age/sex | Nerve injury | Postreduction return of pulse | | Neurological recovery | Follow-up (months) | Deformity |
|------|----------|--------------|-------------------------------|----------------|-----------------------|--------------------|-------------------|
| | | | Immediate | Late | | | |
| 1 | 10/male | AIN | No | 3 weeks review | 6 months review | 52 | – |
| 2 | 5/female | – | Yes | – | – | 48 | – |
| 3 | 7/male | – | No | 6 weeks review | – | 33 | – |
| 4 | 8/male | Median | Yes | – | 6 months review | 45 | – |
| 5 | 6/female | AIN | No | 3 weeks review | 3 months review | 49 | – |
| 6 | 9/male | – | No | 3 weeks review | – | 20 | – |
| 7 | 7/male | – | Yes | – | – | 32 | 10° cubitus varus |
| 8 | 9/female | Median | No | 3 weeks review | 6 months review | 31 | – |
| 9 | 7/male | – | No | 3 weeks review | – | 27 | – |
| 10 | 9/female | – | Yes | – | – | 47 | – |
| 11 | 6/female | Median | Yes | – | 6 months review | 35 | – |
| 12 | 8/female | – | No | 3 weeks review | – | 23 | – |
| 13 | 12/male | – | Yes | – | – | 43 | – |
| 14 | 8/male | – | Yes | – | – | 44 | – |
| 15 | 7/male | – | Yes | – | – | 20 | – |

AIN, anterior interosseous nerve.

Results

Postoperatively, 12 radiographs showed a near anatomical reduction and three showed a minor gap between the fracture fragments. Baumann's angle [14] was restored satisfactorily in all 15 cases.

Return of the radial pulse was observed in eight (53.3%) patients immediately after closed reduction and K-wire fixation. In the remaining seven patients, reduction failed to restore the radial pulse as confirmed by Doppler ultrasonography. However, the hand continued to remain well perfused and with a good capillary refill with 99% peripheral oxygenation saturation as assessed by the pulse oximeter. Further, there was no evidence of compartment syndrome or disproportionate pain in any of the children managed expectantly with careful observation till their discharge from the hospital.

All fractures united within 6 weeks. Cubitus varus deformity of 10° was observed in one patient. Four patients with neurological deficit recovered completely at 6 months while early recovery of the anterior interosseous nerve function was observed at the 3-month follow-up in one patient.

A palpable return of the radial pulse was seen in all but one patient at 3 weeks while the other patient had a normal radial pulse at the 6-weeks review. At the final follow-up, all children were asymptomatic with a normal radial pulse, good range of motion, normal carrying angle (except one with cubitus varus deformity), normal neurology and no arm claudication with exercise.

Discussion

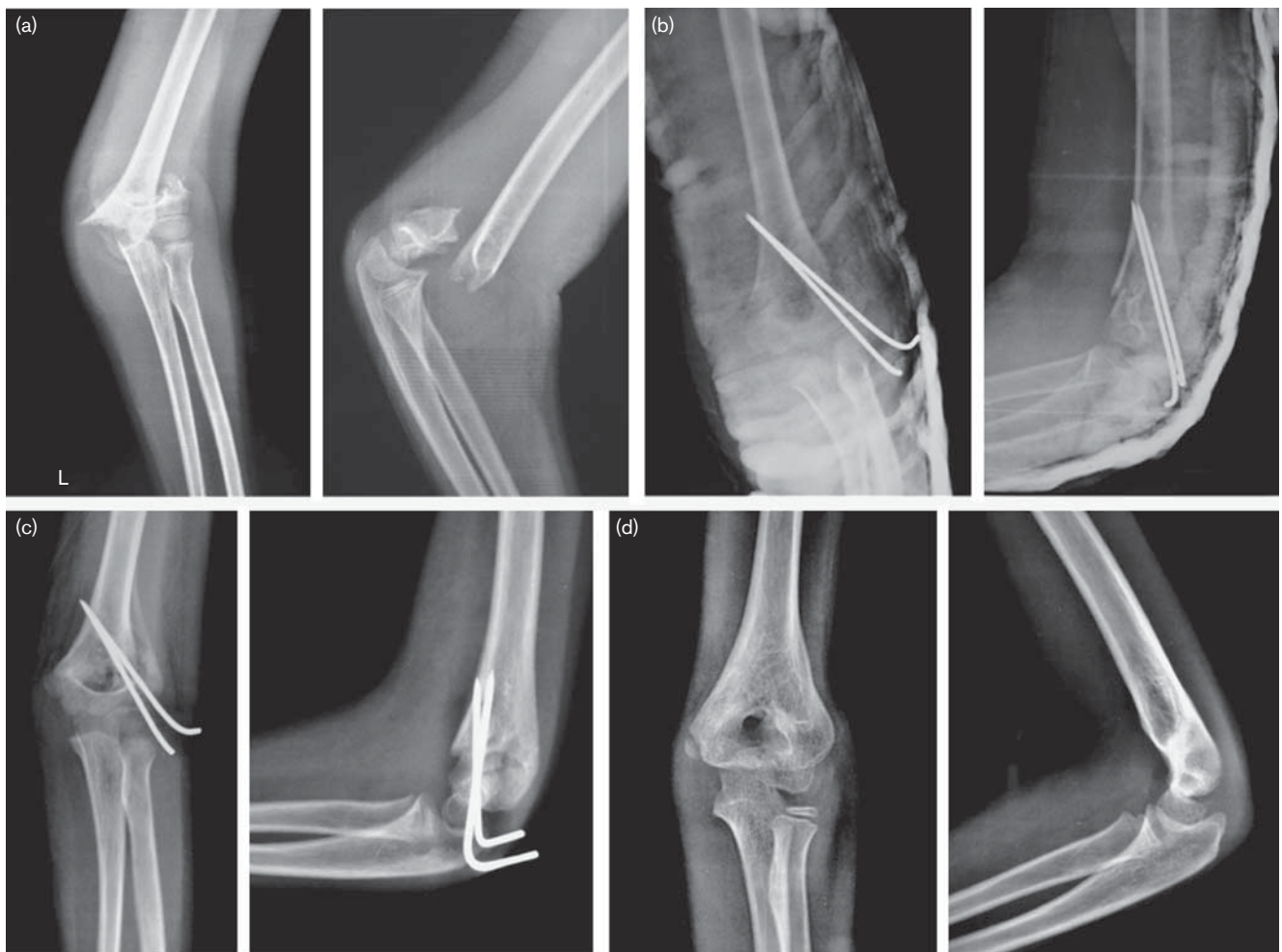
Neurovascular complications most frequently occur with Gartland type III extension supracondylar fractures [14]. Most surgeons concur that a pink pulseless hand needs immediate closed reduction and stabilization. Louahem *et al.* [15] described 26 patients with a pink pulseless hand in a series of 210 patients with severely displaced

supracondylar fractures. In 21 cases, the pulses returned immediately after closed reduction of the fracture. However, the management of a persistent pink pulseless hand after successful closed reduction has been a subject of controversy (Fig. 1).

Traditionally, authors have favoured observation as the treatment of choice [4,16,17]. More recently, several authors have discouraged this method of treatment and have suggested that all patients with a persistent pulseless well-perfused hand to undergo surgical exploration of the vascular injury [2,3,7]. Korompilias *et al.* [7] reported on five patients with a pink pulseless hand and recommended vascular exploration for the restoration of brachial artery patency, even in the presence of a viable well-perfused hand after an attempt at closed reduction. Mangat *et al.* [3] reviewed 19 patients over a 14-year period and found a coexisting anterior interosseous or median nerve palsy to be a predictive indicator of nerve and vessel entrapment. They strongly recommended early exploration in these cases.

Blakey *et al.* [2] examined the outcome in 26 children referred to their institution after a mean delay of 3 months after the fracture. Of these, 23 children presented with established Volkmann's ischaemic contracture. Satisfactory outcome was achieved in two children with conservative stretching. Upon referral they explored the brachial artery in the remaining 21 children to assess nerve, vessel and muscle damage and to relieve entrapment with the aim of improving the function of the hand and forearm. Intraoperatively, the authors found 12 vessels to be constricted by dense scar tissue while in nine it was trapped within the fracture. Pulsatile flow of the radial artery returned in all after release or decompression. Ischaemic fibrosis of the muscles of the forearm and hand were found in all patients, particularly of the flexor muscles that either necessitated extensive muscle slide procedures or tendon transfers. They also identified 56 lesions involving the major nerves of the forearm that

Fig. 1



Illustrative case: (a) a displaced supracondylar Gartland extension type III fracture in a 7-year boy who presented with a well-perfused hand with an absent radial pulse. (b) Immediate closed reduction and Kirschner wire fixation was performed with cast immobilization. (c) Exuberant callus formation is seen at 3 weeks, postoperatively. (d) Radiograph of the same patient at 27 months postoperatively showing complete union of the fracture with good remodeling of bone.

were resultant of either fibrosis, entrapment in the fracture or because of transection of the nerve.

It is important to note that, unlike the patients reported in this series, all of Blakey's patients recollected having intense pain in the first 12 h after injury that was not confined to the elbow, but also felt in the whole forearm and hand. Further, the excruciating pain was often resistant to standard analgesia. On the basis of their findings, the authors concluded that persistent and increasing pain with a progressive nerve lesion was indicative of critical ischaemia that required urgent exploration of the vessel and nerve [2].

The exuberant collateral circulation around the elbow has been credited with maintaining the vascularity of the limb in patients managed without vascular exploration [4,16–18]. The radial recurrent artery arises distal to the

elbow and anastomoses with the radial collateral branch of the profunda brachii. The superior ulnar collateral artery is the other main descending collateral. It arises from the brachial artery, a little below the middle of the arm and anastomoses with the posterior ulnar recurrent and inferior ulnar collateral arteries [19].

Sabharwal *et al.* [4], in a series of 13 children, observed that early revascularization procedures were associated with a high rate of asymptomatic reocclusion and residual stenosis of the brachial artery. Colour flow duplex scanning was done in all children, whereas 10 of them underwent magnetic resonance angiography. An occluded distal brachial artery with reconstitution of forearm flow through the collateral circulation giving a good antegrade flow was observed. The authors inferred that the extremity would have remained viable even without

vascular reconstruction owing to the adequacy of the collateral circulation. This has implications on the normal radial pulse of patients treated by vascular reconstruction. It can be attributed to the lush collateral circulation, as evidence of a patent brachial artery using vascular studies has not been confirmed in these reports [2,3,7].

An absent radial pulse may be because of complete vascular injury, thrombosis, partial tears, entrapment, spasm or kinking [10,20]. Noaman [20] believed that kinking or spasm of the brachial artery improves with reduction. In contrast, Luria *et al.* [6] explored 11 patients with persistent pulselessness postreduction and found two cases of arterial spasm. Vascular spasm may persist for 24–48 h, which may hence make an exploration of the brachial artery during this period unnecessary [19]. This then questions the timing of surgical exploration in the setting of a well-perfused pulseless hand.

The efficacy of vascular assessment techniques has also been debated. Several studies have concluded that angiography is often unnecessary and at times can have deleterious effect on the management of supracondylar fractures. There is a potential for delay in fracture reduction with an associated risk of arterial damage at catheter insertion and the possibility for an allergic reaction to the contrast material [9,10,21]. The other noninvasive modalities of vascular assessment include duplex ultrasound, colour flow duplex imaging and magnetic resonance angiography. However, the literature is unclear on whether these are truly comparable with the sensitivity and specificity of an angiogram [18]. Griffin *et al.* [18] also caution against using them in isolation as they may be subject to misinterpretation resulting in unnecessary exploration of an intact vessel. Thus, management currently depends largely upon clinical findings.

Successful conservative treatment of a pink pulseless hand has been reported earlier [15,16,22]. Gosens and Bongers [22] reported spontaneous return of pulses at the time of discharge and no functional deficit at short-term review. All four patients in their series had supracondylar fractures of the humerus without pulses, but with good capillary refill and a warm hand. A similar observation was made by Garbuz *et al.* [16] in five patients treated conservatively. In the series of Louahem *et al.* [15], failure of restoration of the radial pulse was seen after closed reduction in only five of the 26 patients with a pink pulseless hand. Good distal perfusion and adequate oxygen saturation in the limb were recorded in these patients managed without surgical exploration.

In our series, we had seven patients with a well-perfused hand, but with an absent pulse even after reduction. As these patients had a good capillary refill and no evidence of compartment syndrome or worsening neurology, they were managed without surgical exploration, contrary to

what has been suggested in recent literature [2,3,7]. The authors however, caution that the patients in this series did not have excruciating pain distal to the elbow that persisted beyond 12 h after the injury unlike that reported by Blakey *et al.* [2]. This entertains the plausibility of a milder form of injury with no ischaemic symptoms in which this modality of treatment is indicated. All seven patients regained a normal radial pulse within 6 weeks and a normal neurological function within 6 months. On the basis of our results we believe that the management of a pink pulseless hand remains a 'watchful expectancy' even after a successful closed reduction. Surgical exploration of the vessel or the affected nerve(s) should be recommended only if perfusion of the hand does not improve, the pain does not diminish or there are signs of a deteriorating neurological function. Normal vascularity of the upper limb without long-term dysfunction can be expected with this form of management.

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