ORIGINAL ARTICLE

Management of Pulseless Upper Limb in Supracondylar Fracture Humerus in Children

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Abstract

Aim: ***To develop an appropriate management strategy for children with a supracondylar humerus fracture who have a pulseless but well-perfused hand after the fracture has been reduced and fixed.***

Subjects and methods: ***This study was conducted on 30 children with supracondylar fracture of the humerus and pulseless hand. The study took place at the Orthopedic Department at Al-Azhar University and Saidnawy Hospital.***

Results: ***The physical examination indicated six fractures, each accompanied by a neurological deficiency. Out of the six fractures, four (13.3%) resulted in median nerve palsy, one (3.3%) resulted in radial nerve palsy, and one (3.3%) resulted in ulnar nerve palsy. All patients (100%) showed intact arterial continuity with no evidence of rupture or transection, as confirmed by postoperative duplex ultrasonography. Every patient included in the study (100%) experienced neurological improvement during the follow-up period after the surgery. There was a varus deformity in only one case, accounting for 3.3% of the total.***

Conclusion: ***Immediate investigation is necessary for children with supracondylar fractures of the humerus accompanied by a warm and pulseless hand. Treating children with pink, warm hands and good capillary refill through stabilization using K-wires and observation is a viable treatment option. This approach eliminates the need for early revascularization procedures, which can lead to a high incidence of asymptomatic reocclusion and residual stenosis of the brachial artery exploration.***

Keywords: lower end of the humerus; supracondylar humerus fractures; pulseless upper limb

1. Introduction

A supracondylar humerus fracture is a metaphyseal fracture of the lower end of the humerus. The fracture line passes through the flat, broadened lower end of the shaft of the humerus, just above the upper border of the Olecranon fossa, usually lying at the anterior and posterior capsular origins .[1]

Supracondylar humeral fractures result in nerve damage in approximately 10% to 20% of cases. In most instances, nerve damage is a form of traction neurapraxia that normally cures spontaneously over time. If a patient has a pulseless limb with a median nerve deficit following a supracondylar fracture, there should be a high level of suspicion for arterial injury. Due to the close proximity of the median nerve to the brachial artery, damage to one structure can indicate damage to the other .[2]

Neurovascular assessment has implications for determining whether open exploration of the brachial artery should be considered in cases where the upper extremities lack a pulse and have poor blood flow. It is important to thoroughly examine the motor and sensory functions of the radial, ulnar, and median nerves, including the anterior interosseous nerve. This examination should be done to the extent that the child allows, as neurapraxia is a common occurrence in both extension-type (involving the anterior interosseous nerve and radial nerve) and flexion-type (involving the ulnar nerve) injuries. It is also worth noting that iatrogenic injury, particularly during medial percutaneous pinning, can also affect these nerves, especially the ulnar nerve .[3]

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If a child experiences elbow pain or refuses to use their upper extremity after a fall, it is important to evaluate them with a high level of suspicion for elbow fractures. Patients will exhibit different levels of swelling and discomfort upon examination, as well as a limited range of motion in the elbow. The most common limitation is in extension due to the high occurrence of extension-type injuries. The presence of a visible deformity or skin tenting is contingent upon the extent of the injury. The presence of bruising on the front part of the arm indicates that the spike of the broken bone fragment has pierced through the brachialis muscle, causing the skin to pucker. The term used to refer to this is 'the brachialis sign.' Neurovascular damage is highly likely in these situations, and closure reduction is typically challenging .[3]

The main objective of the current study is to provide an appropriate therapeutic strategy for children who have a supracondylar humerus fracture and experience a lack of pulse but have a warm and well-perfused hand after the fracture has been reduced and fixed.

2. Patients and methods

This study was conducted on a group of 30 children who were admitted to the Orthopedic Department at Al-Azhar University and Saidnawy Hospital. These children had a displaced supracondylar fracture with a pulseless hand. The purpose of the study was to assess the management and outcome of cases with a warm pulseless hand in supracondylar humeral fractures in children.

Inclusion criteria:

Children (2-12 years) suffering from supracondylar humerus fractures associated with warm pulseless hands.

Exclusion criteria:

Exclusion criteria are: Age more than 12 years and less than 2 years, pulseless hand which is pale and cold, patients had postoperative pulse recovery immediately. Absent capillary circulation of the hand, open fractures more than grade 1 or patients showing postoperative progressive elbow swelling.

Methods:

Preoperative evaluation findings that were documented were the patient's age, gender, affected side, fracture type, preoperative nerve impairment, and medical history. Upon admission, plain radiographs were taken, and all fractures were classified using the Wilkins Modification of Gartland's classification.

Preoperative assessment:

Prior to surgery, every patient underwent a thorough preoperative assessment to assess for any neurovascular damage. The sensory evaluation was conducted initially to establish trust with the kid, as it does not induce pain. The sensitivity of the median nerve was assessed by examining the pulp of the index finger, followed by the ulnar nerve sensation in the pulp of the little finger, and finally, the radial nerve sensation in the dorsum of the first web gap. Motor function was evaluated using the "Paper, rock, scissors, OK" test for the radial, median, ulnar, and anterior interosseous nerves, respectively. Certain individuals experienced a delay in their operation because they had a medical issue or significant swelling that needed to be managed before the surgery could take place.

All cases in our study had preoperative tests, including blood analysis, prothrombin time assessment, concentration measurement, and arterial duplex examination. Standard radiographs (anterior-posterior and lateral views) were taken and categorized using Wilkins Modification of Gartland's categorization. Several patients presented with type III fractures, whereas others had type II fractures.

Surgical procedures:

General anesthesia was administered to all patients with upper limb injuries while they were positioned at the side of the table. The wounded elbow was positioned on the image intensifier plate suitable for the surgery, as the elbow is modest in size. The assistant prepared and positioned the limb, along with the image intensifier, for the reduction and fixation of the fracture. This was done using 2 or 3 lateral pins under the guidance of the image intensifier. After the procedure, the pulse was examined. If there is no response, we assess the vitality, warmth, color of the hand, and capillary refilling. If the hand exhibits warmth, good capillary filling, and adequate oxygen saturation as measured by an oximeter, the elbow is immobilized using an above-elbow posterior slab in a 120-degree extension. All instances in which the pulse returned immediately after the procedure were excluded from the research. Patients were closely monitored in the orthopedic department for 5 days after surgery to detect any evidence of peripheral ischemia. The temperature and the time it took for capillaries to refill were consistently monitored. If the patient's condition is satisfactory, they will be released from the hospital and scheduled for weekly follow-up appointments. The k-wires were extracted after duration of 4 weeks and the pulse was monitored till its restoration.

Follow-up schedule: Immediately postoperatively, then daily for 5 days postoperatively, then patients discharged home.

After that, the patients followed up one, two, three, and four weeks postoperatively, then 1.5, 2, 3 months, and 6 months postoperatively.

Neurological and vascular examinations are the methods used for clinical follow-up. The extent of movement, malformation, and rigidity, perform arterial duplex examinations every two weeks and plain X-ray examinations at 3 weeks, followed by additional X-ray examinations every 2 weeks until the bone has fully healed.

3. Results

This prospective cohort study included 30 patients with displaced supra-condylar fracture with warm pulseless hand, 19 of them were males (63.3%) and 11 of them were females (36.7%). Their ages ranged from (2.5-10) with mean ± SD 4.15 ± 2.47.

Table 1. Demographic data among the studied patients

VARIABLE	PATIENTS (N=30)
AGE (YEARS):	
MEAN ± SD	4.15 ± 2.47
RANGE	(2.5 – 10)
SEX: (N. %)	
- MALE	19 (63.3%)
- FEMALE	11 (36.7%)
SIDE (N. %)	
- RIGHT	18 (60%)
- LEFT	12 (40%)

Table (1) shows demographic data of the studied patients. As regard the side of injury, 18 patients (60%) had right elbow injury while 12 (40%) had left elbow injury.

Regarding type of fracture, 27 (90%) were extension type while 3 (10%) were flexion type and the direction of the distal fragment was posteromedial in 16 patients (53.3%) and postero-lateral in 14 patients (46.7%). (Figure 1)

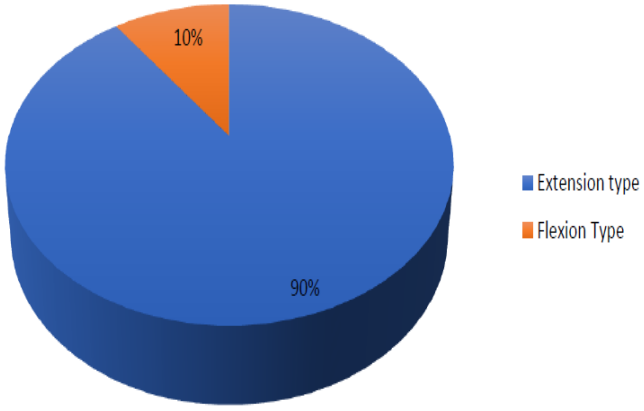

Figure 1. Type of fracture among studied patients (n=30)

As regard Gartland classification, none of patients were type I while 17 patients (56.7%) were type II, 10 patients (33.3%) were type III and 3 patients (10%) were type IV. (Figure 2)

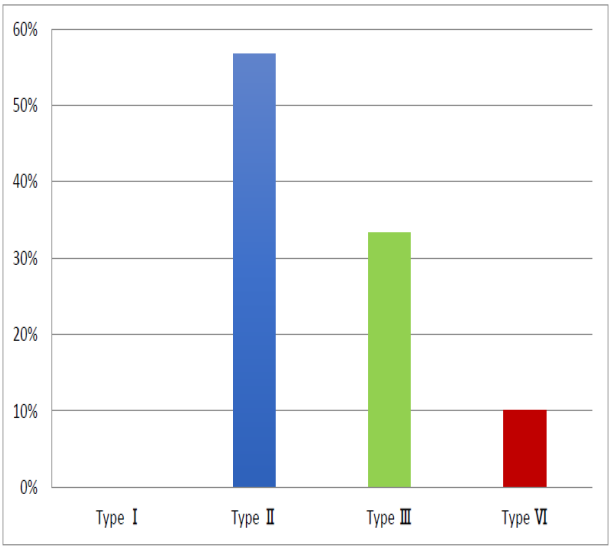

Figure 2. Gartland classification among studied patients

The physical examination identified six fractures, all of which were associated with neurological impairment. Among these fractures, four (13.3%) resulted in median nerve palsy, with three patients (10%) experiencing anterior interosseous nerve palsy and one patient (3.3%) experiencing median sensory nerve palsy. One child (3.3%) experienced radial nerve palsy, while another child (3.3%) experienced ulnar nerve palsy. (Figure 3)

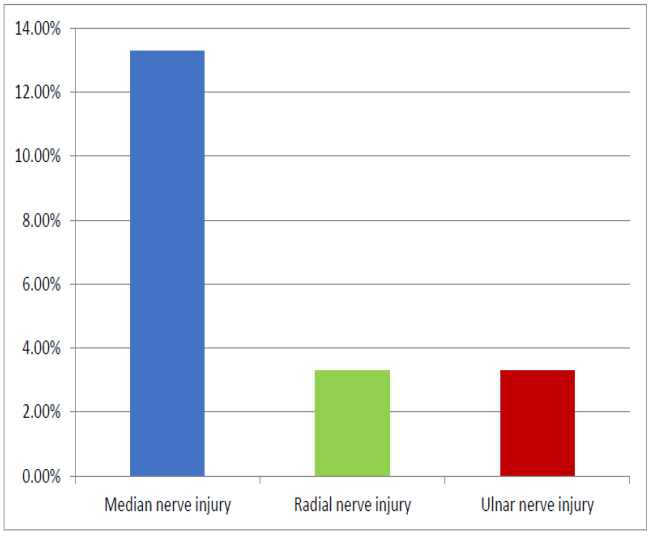

Figure 3. Frequency of nerve injuries among studied patients

Pre-operative duplex ultrasonography identified brachial artery compression, leading to a reduction in the inner diameter and decreased blood flow velocity in 22 patients (73.3%). Thrombus development was observed at the

fracture site in two cases, accounting for 6.7% of the total. (Table 2)

Table 2. Vascular assessment by duplex ultrasound among studied patients

VARIABLE	PATIENTS (N=30)
BRACHIAL ARTERY LESION (N. %)	
NONE	6 (20%)
COMPRESSED	22 (73.3%)
THROMBUS FORMATION	2 (6.7%)

The average time from injury to operation was 11.2±3.2 hours. Regarding duration of the operation, it ranged from 25 minutes to 80 minutes with mean ± SD (45.12 ± 9.2). As regarding the recovery of the radial pulse it ranged from 3 to 22 hours with mean ± SD (8.36 ± 1.53). (Table 3)

Table 3. Operative data among studied cases

VARIABLE	PATIENTS (N=30)
TIME TO PROCEDURE (HOURS)	
MEAN ± SD	11.2 ± 3.2
RANGE	(8 – 15)
DURATION OF OPERATION (MIN.)	
MEAN ± SD	45.12 ± 9.2
RANGE	(25 – 80)
TIME TO RECOVERY OF RADIAL PULSE (HOUR)	
MEAN ± SD	8.36 ± 1.53
RANGE	(3 – 22)

All patients (100%) showed intact arteries with no signs of rupture or transection, as confirmed by post-operative duplex ultrasonography. Neurological recovery was shown in all of the patients (100%) who were studied during the post-operative follow-up. Every patient had normal elbow joint function and no signs of ischemic contractures, growth disturbances, exercise-induced ischemia, cold intolerance, or any other abnormalities were detected. Varus deformity was observed in only one patient, accounting for 3.3% of the total. (Table 4)

Table 4. Post-operative data among studied patients

VARIABLE	PATIENTS (N=30)
HOSPITAL STAY (DAYS)	
MEAN ± SD	7.2 ± 2.8
RANGE	(5 –11)
VASCULAR PATENCY (N. %)	30 (100%)
NEUROLOGICAL RECOVERY (N. %)	30 (100%)
DEFORMITY (N. %)	1 (3.3%)

Twenty nine patients (96.7%) had satisfactory results with 56.7% graded as excellent or good according to the Flynn criteria for the carrying angle. The only patient who experienced unsatisfactory outcomes had an 8 degree varus deformity. Additionally, despite still having a functional range of motion of 125 degrees, this patient also had disappointing results in terms of range of motion. (Figure 4)

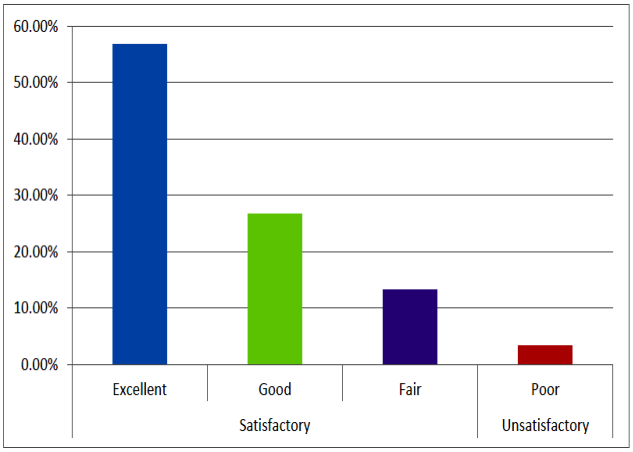

Figure 4. Flynn's criteria among studied patients

4. Discussion

Approximately 10% of all orthopedic injuries in children involve fractures around the elbow joint, with supracondylar humeral fractures making up 50-70% of all elbow fractures. The treatment is determined by the extent of the fragment displacement and the occurrence of neurovascular damage. Approximately 10% of juvenile supracondylar fractures of the humerus are associated with vascular problems. Instances of complications occurring after supracondylar fractures are exceedingly uncommon. One of the most significant complications is the one that was described by Volkmann in the nineteenth century. Fractures in the distal part of the upper limb that result in a disruption of blood flow (indicated by a pulseless, pallid, and cold hand) necessitate an examination of the cubital fossa .[4]

Various therapy strategies have been suggested for the management of a hand that lacks a pulse but seems pink and warm. However, many writers consider observation to be the preferred treatment approach. If the hand stays without a pulse but still has good blood flow after stabilization, it is recommended not to examine the brachial artery and instead depend on collateral circulation. A time interval of 12 to 24 hours is often provided to exclude the possibility of vascular spasm. If the radial pulse is not present after the initial 24-hour monitoring period, it suggests that the brachial artery is unlikely to regain its normal flow .[5]

The objective of this study was to develop an appropriate therapeutic strategy for children who have a supracondylar humerus fracture and experience a lack of pulse but have a warm and

well-perfused hand after the fracture has been reduced and fixed.

This study was conducted on 30 children who had a fracture in the upper part of their humerus bone and had a hand without a pulse. The study took place in the Orthopedic Department at Al-Azhar University and Saidnawy Hospital. Every patient underwent a comprehensive clinical assessment and meticulous examination. Every patient required X-ray films, specifically in the AP/lateral view.

In our study, there were 19 male patients, accounting for 63.3% of the total, and 11 female patients, accounting for 36.7%. The ages of the individuals varied from 2.5 to 10, with a mean value of 4.15 and a standard deviation of 2.47. Shtarker et al.[6] utilized electrical stimulation during medial pin insertion as a monitoring method to prevent iatrogenic ulnar nerve damage in 138 children (88 boys and 50 girls) with an average age of 5.6 years (SD ± 2.5, range 1 to 13). Krishna et al.[7] reported a total of 15 cases of closed supracondylar humerus fractures in children aged 4 to 12 years. There are 11 male children, which accounts for 73.3% of the total, and 4 female children, which accounts for 26.7% of the total.

Regarding the Gartland classification, none of the patients belonged to type I. However, 17 patients (56.7%) were classified as type II, 10 patients (33.3%) were classified as type III, and 3 patients (10%) were classified as type IV. In their study, Shtarker et al.[6] discovered that 38 fractures were categorized as type II, while 100 fractures were classified as type III. Furthermore, they identified 126 fractures as extension type and 12 fractures as flexion type. Out of the total, 126 were classified as extension type, and 12 were classified as flexion type.

During the physical examination, it was found that six fractures were present, along with neurological deficits. Out of these, four individuals (13.3%) had paralysis of the median nerve, with anterior interosseous nerve paralysis observed in three patients (10%) and sensory nerve paralysis in only one patient (3.3%). Additionally, one child (3.3%) had paralysis of the radial nerve, and another child (3.3%) had paralysis of the ulnar nerve. Atea et al.[8] discussed an appropriate care strategy for children with a supracondylar humerus fracture who have a pulseless but well-perfused hand after the fracture has been reduced and fixed. Five patients who had suffered from median nerve injury were able to recover within a period of 6 weeks, with an average recovery time of 4.2 weeks and a standard deviation. One patient experienced radial nerve injury, while another patient suffered from ulnar nerve injury. The patient experienced spontaneous recovery from radial nerve palsy within a period of 3 months, whereas the ulnar nerve healed after 1.5 months.

The mean duration from the occurrence of the injury to the surgical procedure was 11.2±3.2 hours. Shtarker et al.[6] maintained a raised position for patients with a fractured elbow for an average of 4 days after their arrival at the hospital (with a standard deviation of ±2.13) in order to reduce swelling.

The recovery time for the radial pulse varied between 3 and 22 hours, with a mean value of 8.36 hours and a standard deviation of 1.53 hours. Atea et al.[8] Krishna Krishna discovered that the radial pulse was restored in all patients at different durations, spanning from 1 week to 2 months, following the closure reduction and fixation of the fracture.

In our investigation, postoperative duplex ultrasonography showed that all patients (100%) had intact arteries with no signs of rupture or transection. Every single patient in the study (100%) experienced neurological improvement during the postoperative follow-up period. Every patient had normal elbow joint function, and no ischemic contractures, growth disturbances, exercise-induced ischemia, cold intolerance, or any other abnormalities were detected. Varus deformity was observed in only one patient, accounting for 3.3% of the total.

Twenty-nine patients, 96.7% achieved satisfactory results, with 56.7% being rated as excellent or good based on the Flynn criterion for the carrying angle. The only patient who experienced unsatisfactory outcomes had an 8 degree varus deformity. Additionally, despite still having a functional range of motion of 125 degrees, this patient also had disappointing results in terms of range of motion.

Matuszewski[9] obtained favorable outcomes in 91.5% of patients, according to Flynn's grading method. The researchers examined bone regeneration, elbow functionality, and the preservation of neurovascular structures. The majority of operated children (93.8%) had their fracture reduced to an anatomical position, whereas 6.2% of patients had an acceptable reduction. The average time for all fractures to heal was 4.1 weeks, with a range of 3.6 to 5.1 weeks. A complete range of motion in the limbs, along with excellent or satisfactory blood flow, was successfully attained. No reduction in limb development or vascular insufficiency during exercise was noted. Among the patient population, a total of 3 individuals (8.5%) experienced unsatisfactory or unfavorable outcomes. A single child exhibited symptoms consistent with myositis ossificans, resulting in significant impairment of mobility in the elbow

joint. The second individual, who arrived at the clinic 8 hours after sustaining the injury, presented with Volkmann's contracture. The third child experienced multi-organ damage and a complete rupture of the brachial artery, resulting in inadequate blood circulation in the lower part of the upper limb. This led to muscular atrophy, slowed growth, and impaired limb function. A vein graft utilized during a 4-year follow-up did not enhance his medical state.

Atea et al.[8] determined that the vascular condition of these patients was deemed adequate based on a physical examination that included assessment of color, temperature, capillary refill, and Doppler sonography at the hand and microsurgery outpatient clinic, in comparison to the unaffected side. The patients under research did not exhibit cold sensitivity, limb length disparity, or thrombus formation over the 1 to 5-year follow-up periods.

The present study lacks precision in determining the most effective approach to managing the absence of a radial pulse in a well-perfused hand that is related to supracondylar fractures in children. While it is believed that the extensive collateral circulation around the elbow can maintain the viability of the limb in a pulseless hand with adequate blood supply, there is no existing collection of data that demonstrates if an arm with collateral circulation has the same potential as a normal hand following damage. Furthermore, the absence of a primary dominant brachial artery in an arm might significantly jeopardize the ultimate result in the event of a potentially life-threatening vascular injury.The user's text is empty.

4. Conclusion

Supracondylar fractures of the humerus in children that are closed require immediate surgical intervention due to the presence of accompanying vascular damage. Immediate investigation is necessary for children with supracondylar fractures of the humerus accompanied by a warm, pulseless hand. Treating children with pink, warm hands and good capillary refill through stabilization using K-wires and observation is a viable treatment option. This approach avoids the need for early revascularization procedures, which can have a high risk of asymptomatic reocclusion and residual stenosis of the brachial artery exploration.

In conclusion, it is important to maintain a high level of suspicion and have a low threshold for exploring the cubital fossa when there is a lack of forearm pulses, even if the hand feels warm. This should be done before attempting to reduce a fracture, especially if there is a strong pulsating flow at or near the fracture site. This technique can help prevent the danger of iatrogenic vascular injury that is associated with manipulating fractures and incomplete reduction. By doing so, it also reduces the need for thrombectomy and graft repair in growing children.

Disclosure

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All authors have a substantial contribution to the article

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