Original Article

# The conservative management of the pink pulseless hand in supracondylar humeral fracture in children: A prospective cohort study

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## ABSTRACT

**Introduction:** Following a pediatric supracondylar humeral fracture, the management of the pink, pulseless hand (PPH) is debatable. After closed reduction and fracture fix, some surgeons advise close monitoring; nevertheless, if the radial pulse cannot be felt, others advise surgical exploration. Our study aims to assess functional and vascular outcomes of conservative management of the PPH after supracondylar humeral fracture and to identify factors associated with safe, conservative management.

**Patients and Methods:** A cohort study including 32 children presenting with a PPH after supracondylar humeral fracture. Before and after reduction and fixation, hand-held Doppler and a pulse oximeter were utilized to evaluate distal circulation conditions in all patients. An attempt was made to repair the fractures with an urgent closed reduction. A careful examination of the compensated PPH was conducted.

**Results:** Out of the 32 study cases, 22 cases restored peripheral pulsations after reduction and fixation, while 10 cases were still pulseless. One of them underwent brachial artery exploration. The remaining nine cases were managed conservatively, where no major complications occurred during follow-up with perfect limb movement.

**Conclusion:** Our research shows that treating juvenile supracondylar humeral fractures with a PPH requires just cautious monitoring following urgent closed reduction and fixation. Provided that the hand is warm and has adequate blood flow, surgical exploration is not required. When evaluating and predicting whether a child with a PPH needs brachial artery exploration, hand-held Doppler and pulse oximeters are helpful tools.

**Key Words:** Doppler, neurovascular injuries, pink pulseless, pulse oximeter, supracondylar humeral fractures.

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## INTRODUCTION

The most frequent fractures of the elbow in children are extension supracondylar fractures of the humerus[1]. The most susceptible group is the age range when the supracondylar bone is still developing and has a weak and thin cortex[2].

There are two varieties: flexion and extension. Usually, a fall onto an outstretched hand causes these fractures by driving the humeral distal metaphysis into an extension type. Falls using flexed arms rarely ever result in fractures. Nonetheless, primary and secondary iatrogenic neurovascular lesions may develop in both types of fractures[3]. When children appear with a Gartland's type III fracture, the incidence of an absent radial pulse ranges from ~8 to 10%[4].

Complications of the supracondylar humeral fracture vary from immediate to long-term complications[5]. They include vascular insufficiency that could result in compromise of the brachial artery[6–8]. The most common long-term complications are Volkmann's ischemic contracture and Cubitus varus deformity[9].

Diagnosis of supracondylar humeral fracture is confirmed by radiograph anteroposterior and lateral views[1]. Assessment of vascular complications in supracondylar fractures is commonly done through physical examination and hand-held Doppler[10].

While it is obvious that the cubital fossa should be explored when a patient has a cold, white, pulseless hand, there is still debate on how to treat patients who have a pulseless hand but otherwise have good perfusion[11]. Exploration of the fracture and artery is recommended if reduction and repair are successful, but the hand's perfusion is still inadequate[12].

The issue of what to do in the event that, despite the hand being warm and well-perfused, the radial pulse does not return following a sufficient reduction, also known as

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the "pink, pulseless hand (PPH)" remains. After closed reduction and fixation of the fractures, some advice careful observation; if the radial pulse is absent, others advise surgical exploration[13].

Therefore, we aimed to evaluate a conservative treatment strategy in kids with a pink but nonpulsating hand caused by a supracondylar humeral fracture when the palpable radial pulse does not return following fracture reduction and fixation.

## PATIENTS AND METHODS:

This is a prospective cohort study conducted in the Emergency Unit at a Tertiary Hospital during the period from April 1, 2021 to the October 1, 2021 and included 32 cases coming to the emergency unit with a supracondylar humeral fracture and PPH. The study included children (2–10 years old) after a supracondylar humeral fracture with adequate hand perfusion and Doppler radial signals or adequate wave and saturation on pulse oximetry. We excluded patients with intact radial pulse after a supracondylar humeral fracture, those with absent radial pulse after a supracondylar humeral fracture and no Doppler signals or no good waveform with the pulse oximeter and children with absent radial pulse and poorly perfused hand after supracondylar humeral fracture fixation requiring urgent exploration.

**Ethical consideration:** the research protocol was reviewed and permitted by the institutional research and ethics committee. After participants were adequately briefed on the study's goals, their written informed consent was obtained. The participant was free to withdraw from the study at any moment; participation was entirely voluntary. According to the Declaration of Helsinki, all steps of data collecting, entry, and analysis were conducted in a highly confidential and private manner.

### *Steps of the procedure*

All patients were subjected to full history taking from the caregiver involving personal, present, past history, and mode of trauma. A meticulous physical examination was done, including a vital signs assessment, ensuring isolated trauma to the elbow and excluding other body parts trauma. A local examination of the traumatic upper limb was done, with inspection first for swelling, open wound, hematomas, ecchymosis, and deformities. Also, checking radial and ulnar pulses, capillary refill test, motor power, and sensation assessment, and comparing temperature between limbs and tenderness were done.

Radiological assessment was done through radiograph of the distal humerus, elbow, and forearm in anteroposterior and lateral view, as well as using a hand-held Doppler and pulse oximeter to detect adequate blood flow to the hand.

The injury mechanism, duration between injury and first assessment, neurovascular examinations before and after orthopedic fixation, the timing of the orthopedic operation, type of orthopedic repair, and operative details were all recorded. The fractures were categorized using the supracondylar humeral fracture classification system developed by Gartland[4].

A PPH was characterized as someone without palpable wrist pulses who had appropriate hand perfusion clinically with Doppler signals in the radial or ulnar arteries or adequate waveform utilizing a pulse oximeter. Close monitoring and follow-up of the patients intraoperative and postoperative every 4 h for 2 days, then at weeks 1, 2, and 4, then at the third and sixth months by serial clinical examination and serial assessment of signals with hand-held Doppler and waveform analysis using a pulse oximeter with particular attention to the maintained hand adequate perfusion, return of radial pulse, normal elbow function, and residual neurologic deficits.

**Sample size:** The Clincalc sample size calculator for the analytic study can be used to determine the minimum sample size required to identify the impact of conservative therapy of the PPH in a supracondylar humeral fracture in children. The calculator has an alpha error of 0.05 and a power of 0.80. Thirty-two children with PPHs following a supracondylar humeral fracture make up the entire sample size that was calculated.

### *Statistical methods*

The 22$^{nd}$ edition of IBM® SPSS® (Statistical Package for the Social Sciences), Chicago, USA, version 22. Quantitative data were presented by mean, SD, median, and interquartile range and were compared utilizing the Mann–Whitney U test and the Kruskal-Wallis test. Qualitative data was presented by frequency and percentage and were compared utilizing the $\chi^2$ test. Parametric and nonparametric tests of significance were done. The logistic regression model was utilized to evaluate the parameters affecting the need for surgical intervention and time to restoration of peripheral pulsations.

## RESULTS:

This study included 32 patients who fulfilled the inclusion criteria presenting with PPH. The mean±SD age of the studied population was 5.1±2.4 years old. Among the included patients, 56.3% were males. The majority of the included patients fell on an outstretched hand (87.5%). Most of the patients (90.6%) had isolated trauma. The most common fracture type was Gartland's type III fracture (87.5%).

On admission, 100% of the included patients had absent peripheral pulsations; after reduction and fixation, 22 (68.7%) patients restored their normal pulsations at the end of 2 days of conservative management. Nine (31.3%)

patients were discharged with absent peripheral pulsation after conservative management, and one case needed surgical intervention. Using pulse oximetry, 31 (96.9%) patients had adequate waveform before and after reduction and fixation, while 100.0% had good flow signal (biphasic to triphasic) after reduction and fixation.

In the end, only one (3.1%) patient needed vascular surgical intervention as the pulse oximeter showed inadequate waveform and hand-held Doppler showed weak flow signal with clinical deterioration in hand vascularity after being adequately perfused.

Upon admission, nine patients were with an absent radial pulse as well as after 48 h of conservative management.

There was no marked variation in age, sex, the mode of trauma, isolated or polytraumatized between patients who restored their peripheral pulsation after fixation versus those who were still pulseless (Table 1).

The only case who needed vascular intervention was a 4-year-old male who fell on an outstretched hand and fracture Gartland type III supracondylar humeral fracture. He presented with PPH, with a weak flow signal by Doppler and inadequate waveform on a pulse oximeter. He underwent reduction and pinning fixation, and the hand was well-perfused clinically after fixation, and held-hand Doppler showed a good flow signal and still inadequate waveform on a pulse oximeter. Serial examination after 4 h postfixation was done. The hand was ischemic and cold, with a delayed capillary refill. Moreover no flow signal and no waveform were detected by Doppler and a pulse oximeter. Urgently, brachial artery exploration revealed contusion thrombosis of the brachial artery at the fracture site. This case underwent interposition with a saphenous vein graft, and peripheral pulsations were restored.

Patients were brought in for follow-up in the first, second, fourth weeks, third months, and sixth months after discharge; however we lost to follow-up of seven patients from total of 22 patients that were discharged with intact peripheral pulsations at first week of follow-up; however, assessment of the 15 patients revealed no change in their clinical and vascular state through the follow-up period.

Two patients were lost during follow-up from a total of nine patients in first week of follow-up that were discharged with absent peripheral pulsations. At first and second week all seven patients still had absent peripheral pulsations, however in the fourth week, peripheral pulse was restored in four patients, and at 3 months after discharge, the remaining three patients restored their peripheral pulsations without experiencing any forearm claudication, late ischemic contracture, or delayed compartment syndrome (Table 2).

**Table 1:** Factors affecting discharge with conservative treatment

| | Pulse after reduction and fixation (48 h of conservative management) | |
|---|---|---|
| | Absent [*n* (%)] | Intact [*n* (%)] |
| Sex | | |
| Male | 6 (60.0) | 12 (54.5) |
| Female | 4 (40.0) | 10 (45.5) |
| Mode of trauma | | |
| Fall on outstretched hand | 9 (90.0) | 19 (86.4) |
| Road traffic accident | 1 (10.0) | 3 (13.6) |
| Isolated or multiple trauma | | |
| Isolated | 9 (90.0) | 20 (90.9) |
| Multiple | 1 (10.0) | 2 (9.1) |
| Gartland's type of fracture | | |
| Type II | 1 (10.0) | 3 (13.6) |
| Type III | 9 (90.0) | 19 (86.4) |
| Doppler flow before fixation | | |
| Weak signal | 1 (10.0) | 0 |
| Good signal | 9 (90.0) | 22 (100.0) |
| Doppler flow after fixation | | |
| Weak signal | 0 | 0 |
| Good signal | 10 (100.0) | 22 (100.0) |
| Pulse oximetry waves before fixation | | |
| Weak signal | 1 (10.0) | 0 |

| | | |
|---|---|---|
| Good signal | 9 (90.0) | 22 (100.0) |
| Pulse oximetry waves after fixation | | |
| Weak signal | 1 (10.0) | 0 |
| Good signal | 9 (90.0) | 22 (100.0) |
| Need intervention | | |
| Yes | 1 (10.0) | 0 |
| No | 9 (90.0) | 22 (100.0) |

**Table 2:** Follow-up of patients discharged with absent peripheral pulsations

| | 1st week | 2nd weeks | 4th weeks | 3 months |
|---|---|---|---|---|
| Peripheral Pulsations (*N*=7) | | | | |
| Absent | 7 (100) | 7 (100) | 4 (57) | 0 |
| Intact | 0 | 0 | 3 (43) | 7 (100) |

## DISCUSSION

The most frequent upper extremity fractures in children under the age of ten are supracondylar fractures[1]. When a hand is white, cold, and pulseless after reduction and fixation from a supracondylar humeral fracture, there is no debate about the necessity of immediately exploring the brachial artery[14].

Regarding the appropriate way to treat the PPH following a successful closed reduction and fixation, surgeons disagree. Certain researchers have advocated for immediate vascular exploration in children who appear with a persistently missing peripheral pulse despite a warm and well-perfused hand, while others are less enthusiastic about monitoring kids with PPH following orthopedic fixation[6].

The objective of this research was to assess vascular and functional results of conservative management after a supracondylar humeral fracture and to identify factors associated with safe, conservative management to assess a suitable therapeutic technique in kids with a supracondylar humeral fracture. Hand-held Doppler and pulse oximeter were used for assessment and prediction of the necessity of brachial artery exploration in kids with PPH.

In a study conducted by Blakey and colleagues, 26 kids who had sustained PPH were observed on average 3 months following the reduction and fixation of supracondylar humeral fractures. Of these, only four had received urgent brachial artery exploration during their first hospital stay. Out of the 26 kids, 23 had a confirmed ischemia contracture affecting their hand and forearm. To conservative stretching, two responded. In the remaining twenty-one children, the brachial artery was explored. In every patient, pulsatile flow resumed following vascular decompression[6]. In concordance, a study also concluded that brachial artery exploration is a must, and exploration done for their study population of PPH revealed brachial artery entrapment[15].

In a series of 128 children, with 17 presented with PPH, 14 patients restored the pulse after reduction and fixation, leaving three patients with a persistently absent pulse, all explored immediately. It was discovered that they had a serious vascular injury that needed to be repaired[16].

On the other hand, recent studies suggest conservative management of PPH, especially for Gartland type I fractures and nondisplaced type II fractures[9]. In a research involving 22 patients who were admitted with PPH, five individuals suffering from persistent PPH were monitored for 48 h, and 17 patients experienced a return of pulses following reduction and fixation. At the time of the final review, every patient had typical ranges of motion, neurovascular status, and functional ability. Additionally, no patient had experienced vascular compromise or compartment syndrome[17]. This result is comparable to other research that showed most patients to have normal radial pulses after 1-4 days following reduction and fixation. Consequently, certain scholars came to the conclusion that, in the absence of other symptoms of ischemia, the lack of the pulse alone does not warrant rapid vascular exploration[8,18,19].

At the conclusion of the follow-up period, all participants had well-perfused hands with intact wrist pulses, according to a different study that investigated warm, pulseless hands following blunt trauma to the brachial artery. Accordingly, patients with warm, pulseless hands with blunt brachial artery damage might be safely treated conservatively, saving surgical investigation for those patients whose pulses did not return after 2 days[20].

In our current study, our results advocate watchful waiting rather than exploring the brachial artery, as all

of the 32 children had restored peripheral pulsations. They had well-perfused hands with no complications at the end of the follow-up period, apart from patients lost during follow-up and one patient who required vascular exploration. This suggests that regular brachial artery exploration is not always necessary for children with a well-perfused hand but no radial pulse. Anatomical reduction of the fracture is necessary, nevertheless. Treatment should be conservative unless new evidence of vascular impairment emerges. Consequently, the brachial artery must be explored in the event of a disruption in blood circulation.

Several researchers have confirmed the diagnosis of brachial artery damage using diagnostic instruments like catheter-based angiography, hand-held Doppler, and pulse oximeter in addition to duplex ultrasonography[15].

Numerous investigations have determined that because of the time it takes, the possibility of artery injury during catheter insertion, and the possibility of an allergic reaction to contrast material, angiography is an unnecessary and, in some cases, hazardous investigation in the therapy of supracondylar fractures[21,22].

In the present study, we believe that a good waveform on pulse oximetry or the presence of Doppler signal correlates well with adequate perfusion and could be used as good predictors of successful conservative management of PPH.

Segmental pressure monitoring, color flow duplex imaging, and magnetic resonance angiography in combination are correlated favorably with typical angiography, according to Sabharwal *et al*.'s[23] earlier research.

It's critical to understand the limitations of imaging methods. According to several writers, these methods lack the operator dependence and specificity of angiography and Duplex scanning, which can both fail to detect brachial artery occlusions if utilized alone[14,24].

## CONCLUSION

PPH after supracondylar humeral fracture can be managed conservatively safely with close observation for additional signs of ischemia to develop where surgical exploration becomes mandatory. Hand-held Doppler signals and pulse oximetry waveforms are good objective and readily available tools for vascular assessment of hand perfusion and can accept or disagree with the surgical exploration decision.

### *Limitations*

We admit that our study has limitations, including limited sample size, a shortage of imaging to verify that patients with recovered radial pulses have not been injured, and the recommendation for a longer follow-up time to identify functional issues and discrepancies in limb growth

## CONFLICT OF INTEREST

There are no conflicts of interest.

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