Pulseless Supracondylar Humerus Fracture With Anterior Interosseous Nerve or Median Nerve Injury—An Absolute Indication for Open Reduction?

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Background: Optimal management for a pulseless supracondylar humerus fracture associated with anterior interosseous nerve (AIN) or median nerve injury is unclear. The purpose of this study was to determine the incidence of pulseless supracondylar humerus fractures associated with AIN or median nerve injury, to assess open versus closed surgical management, to determine factors associated with the need for neurovascular intervention, and to report the outcome.

Methods: A retrospective review was performed at 4 pediatric trauma hospitals on all patients who sustained a Gartland III or IV supracondylar humerus fracture with the combination of absent distal palpable pulses and AIN or median nerve injury between 2000 and 2014. Choice of treatment, details regarding preoperative and postoperative exam findings, follow-up course, and outcome were recorded.

Results: A total of 71 patients met inclusion criteria; 52 patients (73%) underwent closed reduction (CR); 19 patients (27%) underwent open reduction (OR) and early antecubital fossa exploration. The index procedure of CR plus percutaneous pinning was sufficient treatment in 50 (of 52, 96%) patients with only 2 requiring reoperation. One patient developed compartment syndrome approximately 9 hours after CRPP (13.5 h after time of injury) and underwent emergent fasciotomies. Of the 19 patients who underwent OR and early exploration, 6 needed vascular procedures, 5 required detethering of entrapped surrounding fibrous tissues. Forty patients were diagnosed with median nerve palsy versus 31 diagnosed with AIN palsy. There was no significant difference between patients presenting with median nerve versus AIN palsy, with similar rates of need for OR (10/40; 25% vs. 9/31; 29%), rate of compartment syndrome (3/40; 7.5% vs. 3/31; 9.7%), need for reoperation (4/40; 10% vs. 6.5%), and ultimate resolution of nerve palsy (4/36; 20.1% vs. 3/30; 10%). Compartment syndrome developed in 6 (of 71, 8.5%) patients and was associated with poor perfusion status on presentation and delayed time from injury to surgery. In patients with at least 3-month neurological follow-up, 59 (of 61, 97%) patients had complete resolution of nerve palsy.

Conclusions: Although previous authors have suggested a pulseless SCH fx with an associated AIN or median nerve injury should be treated with exploration and OR, 70% (50/71) of the patients in this series were treated with a CR. In this series, both AIN and median nerve palsies among patients presenting with pulseless extremity and Gartland III or IV SCH fracture, offer similar rates of OR, risk of compartment syndrome, and resolution of nerve palsy.

Level of Evidence: Level IV.

Key Words: supracondylar humerus, fracture, pulseless, nerve injury

(*J Pediatr Orthop* 2019;39:e1–e7)

Management of the pediatric pulseless supracondylar humerus fracture continues to be controversial. Vascular compromise can be present in up to 20% of patients with displaced supracondylar humerus fractures.[1–5] Most commonly, the brachial artery is stretched or kinked over the displaced fracture fragments, or in spasm. Because of the close proximity of the median nerve to the brachial artery, injury to one structure is associated with injury to the other. Nerve injuries can occur in 11% to 16% of supracondylar humerus fractures with median and anterior interosseous nerve (AIN) injuries comprising the vast majority of these.[2,6–8] In particular, the combination of a pulseless supracondylar humerus fracture and AIN or median nerve injury may present a specific situation where the neurovascular structures are at increased risk of injury necessitating an open procedure. A retrospective review by Mangat et al.[9] highlighted the risk: all 7 (of 7) patients with a pulseless supracondylar humerus fracture and AIN or median nerve injury were found to have nerve and/or vessel entrapment at the fracture site. On the basis of these findings, the authors

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Funding source: No external funding was secured for this study.
Approved by the Institutional Review Board at Children's Hospital Los Angeles.
The authors declare no conflicts of interest.

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Supplemental Digital Content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website, www.pedorthopaedics.com.

DOI: 10.1097/BPO.0000000000001238

recommended open reduction (OR) and early antecubital fossa exploration for all pulseless supracondylar humerus fractures associated with AIN or median nerve injury. It is interesting to note that, this is the only study with such strong recommendations for OR, and current practices remain unclear given the paucity of data. The current best practice for these injuries, that is, pulseless supracondylar humerus fracture associated with AIN or median nerve injury, however remains unclear. The aims of this study were (1) to determine the incidence of pulseless supracondylar humerus fractures associated with AIN or median nerve palsy, (2) to assess the rate of surgical exploration of the neurovascular bundle in these cases, (3) to report the long term results of these injuries, and (4) to determine what factors might indicate that OR be performed as index procedure.

METHODS

Following institutional review board approval, a multicenter, retrospective chart review at 4 pediatric trauma centers was performed and identified all patients who underwent operative treatment for a displaced (modified Gartland grade 3 and 4) supracondylar humerus fracture between January 1, 2000 and December 31, 2014. The study specifically included patients with an absent radial pulse (by palpation) and clinical signs of AIN or median nerve injury at presentation. Medical records and radiographs were reviewed to identify demographic information, injury characteristics, associated injuries, procedure(s) performed, and complications. Time of injury, time to surgery, time to return of nerve function, length of follow-up, and outcome were also recorded. Decision to perform OR and to convert from closed to OR was at the discretion of the treating surgeon. "Poor Perfusion Status" was defined as having at least one of the following: cold distal extremity on exam, pale distal extremity on exam, or capillary refill > 2 seconds. Distinction between Gartland III and Gartland IV fractures were determined intraoperatively with Gartland IV fractures classified based on instability in both flexion and extension, according to the guidelines originally outlined by Leitch et al.[10]

Following initial collection, data was analyzed using multivariate and univariate analysis. Student paired t test and χ^2 test were utilized to determine factors to be included in multivariate analysis with $P < 0.20$ as cutoff for inclusion. Factors analyzed included time from injury to surgery, type of preoperative nerve palsy, perfusion data, open versus closed reduction (CR) (and intraoperative findings), time to resolution of nerve palsy, and incidence of compartment syndrome. All statistical analysis was performed using Stata/IC 12.1 for Windows (Stata-Corp, College Station, TX). Analysis of variance (ANOVA) and linear regression were carried out to examine significant relationships between variables. Significance was assumed when $P < 0.05$.

RESULTS

A total 71 patients were operatively treated for supracondylar humerus fractures and had an absent distal radial pulse (by palpation) and presence (clinical signs) of AIN or median nerve injury met inclusion criteria. Average patient age at presentation was 6.9 years (range, 2.7 to 11.6 y). Average follow-up was 8.2 months (0.76 to 73.9 mo). Of the 71 patients, 40 patients (56%) were male and 31 patients (44%) were female. There were 61 Gartland III fractures (86%) and 10 Gartland IV fractures (14%). In total 40 patients (56%) had median nerve injury (6 isolated median nerve injury, 34 multiple nerve injuries). Thirty one patients (44%) had AIN injury (29 isolated AIN injury, 2 multiple nerve injuries) (Table 1).

TABLE 1. Presenting Nerve Palsies

	Total	Open	Closed
Median nerve palsy	40	10	23
Isolated median	6	2	4
Multiple nerve palsy	34	8	26
AIN nerve palsy	13	5	8
Isolated AIN	29	9	20
Multiple nerve palsy	2	0	2

AIN indicates anterior interosseous nerve.

The patients were divided into 2 groups based on treatment type: 52 patients (73%) underwent CR, 19 patients (27%) underwent OR and antecubital fossa exploration. Fracture type, as well as decision to perform open reduction as distinguished by site is outlined in Table 2.

CR

In the CR group, the mean age of the patients was 7.03 years (range, 2.66 to 11.63 y; SD, 1.84). There were 22 AIN and 30 median nerve injuries. The average time from injury to procedure was 9.37 hours (range, 0.82 to 23.95 h; SD, 4.84).

In the CR group, the index procedure of CR plus percutaneous pinning was sufficient treatment in 50 (of 52, 96%) patients with the anterior humeral line bisecting the capitellum at final follow-up. No cases in the CR group needed vascular procedure. In total, 28 of 52 were documented as having return of palpable pulses immediately post reduction, 14 of 52 were documented as having absent palpable pulse post reduction, and 10 were unfortunately missing data. Two cases required reoperation: one patient needing revision CR because of fracture displacement which occurred 2 weeks postoperatively secondary to a fall; second case needing fasciotomies because of compartment syndrome, which occurred 9 hours after surgery (13.5 h

TABLE 2. Site Statistics

Site	Total	Open vs. Closed	Gartland III	Gartland IV
Site 1	25	Open	6	4
		Closed	11	4
Site 3	10	Open	3	0
		Closed	5	2
Site 4	1	Open	1	0
		Closed	0	0
Site 5	35	Open	5	0
		Closed	30	0

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TABLE 3. Reasons for Open Reduction

Inadequate closed reduction	7
Concern for nerve entrapment	5
Concern for artery entrapment	9
Open fracture	4
Concern for compartment syndrome	1

after time of injury). This isolated incidence of compartment syndrome occurred in a patient with a type III fracture, median nerve injury, and poor perfusion status on presentation (sluggish capillary refill and cold temperature). A palpable pulse was reported postoperatively with good perfusion noted.

OR and Early Antecubital Fossa Exploration

In the OR group, the mean age of the patients was 6.62 years (range, 4.03 to 10.08 y; SD, 1.84). There were 10 AIN and 9 median nerve injuries. The average time from injury to procedure was 19.94 hours (range, 5.48 to 138.50 h, SD 8.02). Indications for OR and early antecubital fossa exploration were inadequate CR (7), concern for nerve entrapment (5), concern for artery entrapment (9), open fracture (4), and concern for compartment syndrome (1) (Table 3). Intraoperative findings included injury to nerve and/or artery (6), entrapment/tethering of surrounding fibrous tissues (5), open injury (4), clinical signs of compartment syndrome (1). One case had no significant intraoperative findings, that is, no evidence of injury to nerve and/or artery. Intraoperative findings were not recorded in 2 cases.

Of the 19 patients who underwent OR and antecubital fossa exploration, 6 needed vascular procedures: repair of subtotal brachial artery (and median nerve) transection (1), thrombectomy/arteriotomy of brachial artery (2), radial collateral ligation for hemostasis (1), and release of neurovascular bundle from fracture site (2). Five required detethering of the entrapped surrounding fibrous issues (Appendix 1, Supplemental Digital Content 1, http://links.lww.com/BPO/A173). Four underwent irrigation and debridement for the open injuries. One required fasciotomies (in addition to the OR and antecubital fossa exploration) as compartment syndrome was diagnosed as part of the initial presentation. Three did not require any neurovascular intervention. Of the open fractures which underwent irrigation and debridement, all 4 were classified as Gartland III.

Time to Operation

The time from injury to surgery among the CR versus OR groups with all patients included was 9.37 hours for the closed group and 19.94 hours for the open group. This difference was statistically significant. However, the difference between these 2 groups was primarily a result of a single outlier patient, whose time from injury to OR was 138 hours ($P=0.0235$). With this patient excluded, the average time from injury to surgery between the 2 groups was 9.37 (closed group) versus 13.36 (Open group) and was not statistically significant ($P=0.101$).

Need for Vascular Procedure or Detethering

In total, 11 patients (of 71) needed vascular procedure (6) or detethering of entrapped surrounding fibrous tissues (5). All 11 cases requiring vascular procedure or detethering involved patients who underwent OR and antecubital fossa exploration. No patients (of 52) ultimately needed a vascular procedure or detethering in the CR group. One patient was attempted with initial CR, after which the limb became cool, the pins were removed, and was immediately converted to open. Under OR tissue was removed from the fracture site.

Need for vascular repair and/or detethering was not affected by time from injury to surgery [$P=0.19$ (for vascular repair alone) versus 0.51 (vascular repair+detethering)], AIN versus median nerve injury ($P=1.00$ vs. $P=0.52$), or perfusion status ($P=0.28$ vs. $P=1.00$).

AIN Versus Median Nerve Palsy

On initial presentation, 40 patients (56%) had median nerve injury (6 isolated median nerve injury, 34 multiple nerve injuries); 31 patients (44%) had AIN injury (29 isolated AIN injury, 2 multiple nerve injuries). There was no significant difference between patients with AIN versus median nerve palsy in terms of time from injury to surgery (mean: AIN, 10.3; median, 13.6; $P=0.446$), perfusion status (AIN 25/29 well perfused; median, 32/40 well perfused; $P=0.502$), type of fracture (AIN 26/31 Gartland III; median 35/40 Gartland III; $P=0.663$), or open versus CR (AIN 9 open, 22 closed; median 10 open, 30 closed; $P=0.703$). Following operative treatment, there was no significant difference between AIN versus median nerve palsies in regards to return of pulses (AIN 19/26 with return of pulse, median 18/31 with return of pulse; $P=0.237$), perfusion status post reduction (AIN 27/28 well perfused; median 35/35 well perfused; $P=0.260$), development of compartment syndrome (AIN 3/31, median 3/40; $P=0.744$), or resolution of nerve palsy (AIN 27/30 resolved by final follow-up, median 4/36 resolved by final follow-up, 5 lost to follow-up; $P=0.884$).

Similar distinctions were found between patients with multiple versus isolated single nerve palsies (Table 4).

Perfusion Status

On initial presentation, there was no significant difference in perfusion parameters between median versus AIN nerve palsy or between open versus CR groups.

TABLE 4. Single Versus Multiple Nerve Palsy

Nerve Palsy	Rate of Open Reduction	Rate of Reoperation	Rate of Compartment Syndrome	Rate of Nerve Palsy Resolution
Single nerve palsy	31.4% (11/35) $P=0.381$	8.6% (3/35) $P=1.0$	11.4% (4/35) $P=0.374$	8.8% (3/34) $P=0.628$
Multiple nerve palsy	22.2% (8/36) $P=0.381$	8.3% (3/36) $P=1.0$	5.6% (2/36) $P=0.374$	12.5% (4/32) $P=0.628$

Values should be expressed as "percent of patients".

On presentation, 12 patients were classified as poorly perfused, 57 as well perfused, and 2 lacked sufficient data. Of the 12 patients classified as "poorly perfused" on presentation, 2 of 12 had pale hands on clinical exam, 6 of 12 had cool hands on clinical exam, and 10 of 12 had capillary refill > 2 seconds. Of the poorly perfused patients, 2 were treated with OR, and 10 with CR with no significant difference between groups ($P = 0.337$).

Among the 52 patients treated with CR, 28 had documented return of palpable pulses postoperatively, 14 were documented as having no palpable pulses, and 10 lacked data. Of the 24 patients without documented of return of pulses, 19 had dopplerable pulses or good perfusion, and 5 lacked data. Among the 19 treated with OR, 9 had return of pulses, 6 did not have return of pulses, and 4 lacked data. Of the 10 without documented return of pulses, 3 had documented dopplerable pulses, and 9 were documented as being well perfused. The lone patient with poor perfusions parameters postoperatively was diagnosed and treated for compartment syndrome within 2 hours of initial surgery.

Risk of Compartment Syndrome

Six (of 71) patients with displaced pulseless supracondylar humerus fractures associated with AIN or median nerve injuries developed compartment syndrome—one in the CR group; 5 in the OR group (Appendix 1, Supplemental Digital Content 1, http://links.lww.com/BPO/A173). Case 1 involved a patient who underwent CR and percutaneous pinning for a poorly perfused pulseless supracondylar humerus fracture with median nerve palsy and developed compartment syndrome 9 hours after index surgery. Diagnosis of compartment syndrome in these patients were made clinically. Following initial CR, patient was documented to have palpable pulse and a warm, well-perfused hand, and was placed in a long arm cast. Pulses were absent before reoperation, though were noted to have returned following fasciotomies, vascular exploration, and removal and replacement of percutaneous pins. Of the 5 cases of compartment syndrome in the OR group, 1 case (case 2) of compartment syndrome was diagnosed as part of the initial presentation. In this case (case 2), perfusion status was reported to be good on presentation. Diagnosis was delayed because of the patient presenting over 5 days post injury (time from injury to diagnosis = 138.5 h), and therefore overall time from injury to treatment was also delayed (time from injury to treatment = 138.5+1.1 = 139.6 h). The remaining 4 cases of compartment syndrome occurred in the postoperative period after initial operative treatment. Compartment syndrome developed about 0.8 hours after index surgery (range, 0.65 to 19.86 h). There was no significant association between AIN versus median nerve palsy and compartment syndrome with 3 of 6 patients presenting with median nerve palsy, and 3 of 6 with AIN nerve palsy ($P = 0.534$).

The risk of compartment syndrome was increased in patients with poor perfusion status on presentation ($P = 0.03$). Delay in treatment also increased the risk of compartment syndrome ($P = 0.003$). The risk of compartment syndrome did not differ between the AIN and median nerve injury groups ($P = 1.00$).

Neurological Recovery

In patients with at least 3-month neurological follow-up data, 59 (of 61) patients had complete resolution of their nerve palsy or palsies, as determined by return of light touch and motor function. Five patients of the original study population (of 71) did not have neurological follow-up data recorded so were excluded from this subanalysis. An additional 5 patients had <3-month follow-up so were excluded from this subanalysis. There was no significant difference in neurological recovery between treatment groups (43/44 in CR, 16/17 in OR; $P = 0.478$). Distribution of initial nerve injury (AIN or median nerve) ($P = 0.50$) and time from injury to surgery ($P = 0.75$) also did not affect neurological recovery. Two patients underwent repair of the median nerve. One patient demonstrated resolution of his median nerve palsy between 3 and 6 months. The second patient who underwent median nerve repair was lost to follow-up at 3.7 months without full resolution of his nerve palsy.

Outcome

All (71/71) fractures healed within 4 weeks of surgery, regardless of the treatment (closed vs. OR). There were no significant differences in fracture/radiographic alignment at final follow-up between treatment groups: no significant difference in the Baumann angle (mean: 71.0 degrees OR, 71.6 degrees CR; $P = 0.775$); no cases of cubitus varus (by clinical assessment) in either group; anterior humeral line intersected with capitellum in 16 of 17 OR and 45 of 48 CR ($P = 1.0$). In patients with at least 2-month (ROM) follow-up data, joint stiffness (with loss of motion > 20 degrees in flexion or extension) was seen in 1 of 18 patients in OR and 4 of 39 patients in CR ($P = 0.560$).

DISCUSSION

Best practice for a pulseless supracondylar humerus fracture associated with AIN or median nerve injury has remained the subject of debate. The increased risk of these injuries was highlighted in a retrospective series comparing CR versus early open exploration for the perfused but pulseless supracondylar humerus fracture.[9] In a subpopulation of 7 patients with a pulseless supracondylar humerus fracture associated with AIN or median nerve palsy, all 7 patients were found to have tethering or entrapment of the brachial artery and/or nerve at the fracture site. On the basis of these findings, recommendations were for OR and early exploration for all displaced pulseless supracondylar humerus fractures associated with AIN or median nerve injury.

In the current series, we were able to collect nearly 10 times as many patients with a displaced pulseless supracondylar humerus fracture associated with AIN or median nerve injury, and our findings suggest that OR and early exploration may not always be necessary. An index procedure of CR plus percutaneous pinning was sufficient treatment in 50 (of 52, 96%) patients with a pulses supracondylar humerus fracture associated with AIN or median nerve palsy. No patients needed vascular repair. All fractures in the CR group healed within 4 weeks of surgery with satisfactory alignment in both the coronal (52/52 no cubitus varus) and sagittal (45/48) planes. Neurological recovery was noted in 43 of 44 patients by 3 months (and was comparable with OR group). One patient did develop compartment syndrome approximately 9 hours after surgery and required urgent decompressive fasciotomies. Of note, this patient presented preoperatively with clinical signs of poor perfusion (delayed capillary refill and cool temperature). Poor perfusion on presentation has been reported to be a risk factor for compartment syndrome in the pulseless supracondylar humerus fracture population[11] and seems to be a risk factor in this specific population (pulseless supracondylar humerus fracture associated with AIN or median nerve injury) as well.

Outcome related to fracture healing and alignment is excellent with no cases of delayed union or cubitus varus (by clinical assessment). Sagittal alignment is also restored well with the anterior humeral line intersecting the capitellum in 61 (of 65, 93.8%) cases. Functional recovery also appears to be excellent with reports of stiffness limited to 5 (of 57, 8.8%) cases. Both CR and OR treatments can be successful (from this standpoint) with no difference in clinical or radiographic alignment, joint stiffness between treatment groups.

The risk of compartment syndrome in this population is real with 6 (of 71, 8.5%) patients developing compartment syndrome. This lies in comparison to previously reported values, namely; the risk of compartment syndrome in a pulseless supracondylar humerus fracture population was reported to be 6.0% in a series of 33 patients,[11] whereas, the rate of compartment syndrome associated with supracondylar humerus fractures has been reported to be 0.1% to 0.3%.[12] As poor perfusion status was strongly associated with the risk of compartment syndrome with 50% of compartment syndrome patients classified as "poorly perfused" preoperatively. Consequently, in patients with any of (1) delayed capillary refill, (2) cool hand on examination, or (3) pale hand on examination, we recommend urgent CR in the operating room. Further, if any of these symptoms persist following CR, we recommend a low threshold to proceed to OR and exploration.

Early surgical exploration and/or vascular reconstruction seem to play an important role in this population of pulseless supracondylar humerus fracture and AIN or median nerve injury. Eleven (of 71, 15.4%) patients required either a vascular procedure (6) or detethering of the brachial artery (and/or nerve) and/or entrapped surrounding fibrous tissues (5). The role of early surgical exploration and/or vascular reconstruction however continues to be debated for pulseless supracondylar humerus fractures. Some have advocated immediate surgical exploration and/or vascular reconstruction for all pulseless supracondylar humerus fractures because of concern for long-term cold intolerance, exercise-induced ischemia, brachial artery thrombus with potential for propagation, late compartment syndrome, limb-length discrepancy, and limb contracture and loss.[9,12–14] Poor perfusion at presentation has been reported as a risk factor for need of vascular repair in pulseless supracondylar humerus fractures.[11] Success (ie, long-term patency) following brachial artery reconstruction in the setting of a pulseless supracondylar humerus fracture however has been mixed with significant rates of thrombosis of the repaired artery postoperatively.[13,14] Within our study, of the 6 patients who underwent direct vascular repair or detethering of entrapped vascular tissue, all maintained pulses postoperatively. Also, conservative management in the form of CR, percutaneous pinning, and frequent neurovascular monitoring has been shown to be an effective approach in particular for the pulseless supracondylar humerus fracture that is well-perfused and pink.[11,15,16] In this study, we were not able to identify any preoperative factors that could predict the need for vascular procedure and/or detethering. The need for vascular procedure and/or detethering was not associated with preoperative perfusion status ($P=1.00$), time from injury to surgery ($P=0.51$), or whether initial nerve injury was to the AIN versus median nerve ($P=0.52$). In this study, no patients (of 52) who underwent CR as the index procedure ultimately needed vascular procedure or detethering. The difference in this rate between closed versus open was likely because of 2 factors. One, once vascular intervention was deemed necessary, the case was by definition converted to open. Second, clinical judgment by the treating surgeon likely identified a preponderance of the most severe cases, there greatly increasing the chances of OR and vascular intervention.

Neurological recovery can be expected in the majority of patients with this combination of injuries—59 (of 61, 96.7%) patients with at least 3-month neurological follow-up had complete resolution of their nerve palsy. Both patients without documented resolution of nerve palsy had median nerve palsy. One patient required primary repair of the median nerve (and brachial artery) because of transection and did not have median neurological recovery at when he was lost to follow-up at 3.7 months. The second patient (pulseless+median nerve injury) who underwent CR, experienced resolution of his AIN nerve symptoms, though experienced persistent median nerve sensory symptoms, until he was lost to follow-up at 5.8 months. These outcomes reflect the published literature, which found persistent neurological sequelae resolving at an average of 2 to 3 months post injury with many spontaneously resolving up to 10 months after injury.[8,17,18] The likelihood of neurological recovery did not correlate to treatment group (CR vs. OR), time from injury to surgery/treatment, type of nerve injury (AIN vs. median nerve vs. multiple). Of note, 10 patients from the original study population were excluded from this analysis, as 5 did not have neurological follow-up date recorded and 5 had <3-month follow-up.

Study Limitations

Given the inherent differences in clinical and radiographic presentation between patients that determine those treated open versus closed, direct statistical comparisons between the two groups are difficult. Treatment, in particular decision for OR, was determined by the preference of the treating surgeon, and not on a predetermined algorithm as in prospective studies. Further, duties to the patient make true randomization between open and CR among patients with pulseless supracondylar fracture and AIN or median nerve palsy difficult. Patients randomized to the CR group would almost certainly be transferred to the open group with exploration if pulselessness and nerve palsy did not return promptly following CR. Consequently, true comparison of the long term outcomes between groups may not be possible. Although we believe previous treatment recommendations made a true randomized trial inappropriate, future consideration should be given to evaluation of randomized treatment of these patients. Unfortunately, given the retrospective nature of our study, data on dopplerable pulses were incomplete. Of the 71 patients included in the study, 46 of 71 (65%) had recorded doppler exams on presentation with 31 of 46 (67%) documented as having dopplerable pulses at presentation. The use of "palpable pulse" was utilized because of both its traditional use as a metric, as well as its ubiquity within the study.[4,9] Patients without dopplerable pulses on exam were not significantly more likely to have undergone OR ($P=0.457$) or develop compartment syndrome ($P=0.166$).

In analysis of rates of compartment syndrome, we hope to include in future study the degree at which arms were casted postoperatively. Discussion exists between the best method of casting patients post reduction between 45 and 90 degrees. Differences among these 2 techniques in the rate of both postop complications, and the long-term radiographic outcomes warrants investigation in the future. Further, as diagnosis of compartment syndrome was made clinically, compartment pressures were not available for analysis. Although delay in time from injury to surgery was associated with increased risks of compartment syndrome, the relatively few cases overall preclude making any statistically significant claims as to the cutoff time for dramatically increased risk to the patient.

In addition, pain levels in both the immediate postoperative period and at final follow-up were not recorded in this study. Evaluation of patient outcomes, particularly among the pediatric population, warrants consideration of patient satisfaction and pain levels and as such should be included in future studies. Patients without sufficient postoperative follow-up had to be excluded from the study. Finally, given that reexploration data was not included within the study, we were not able to provide a recommendation on time to reexploration for unresolved nerve symptoms.

Although it is of the opinion of the authors that those with persistent nerve palsies were unlikely to discharge their own care, their absence remains a limitation of the study. Even though the upper limit of unresolved nerve palsies could approach 10%, this would require the assumption that all patients who discharged their own care within 3 months had unresolved symptoms, which these authors found unlikely.

In conclusion, this study helps to define best practice for the pulseless supracondylar humerus fracture associated with AIN or median nerve injury and finds that OR and early exploration was performed in 27% of patients and may not be obligatory—contrary to previous studies. CR and percutaneous pinning can be a safe and effective treatment with favorable outcomes related to fracture healing, alignment, and functional recovery and without increased risk of compartment syndrome, delayed neurological recovery, or need for vascular procedure. There was a risk of compartment syndrome (6/71, 8.5%) and need for vascular procedure (11/71, 15.4%) in this population. Among patients with absent palpable pulse and median or AIN nerve palsy, the risk of compartment syndrome may be increased in those who present with clinical signs of poor perfusion and prolonged time to treatment/surgery. Poor perfusion at presentation, as defined by cold distal extremity on exam, pale distal extremity on exam, or capillary refill >2 seconds, may help to identify patients at risk and who may benefit from OR and early exploration.

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