Treating Percutaneous Pinning of Supracondylar Humerus Fractures Like a Procedure: The Miami Experience

Introduction

Supracondylar humerus fractures are common injuries in pediatric patients. Management of these fractures depends on the amount of fracture displacement. Gartland's classification scheme distinguished three types of supracondylar humerus fractures based on the amount of displacement at the fracture site. Type I fractures have no displacement and are typically managed with immobilization in a long arm cast. Type II fractures have moderate displacement with continuity between the fragments being maintained by an intact posterior cortex of the distal humerus. Type III fractures are the most severe and have complete displacement without contact between the fragments. If a child's fracture is displaced enough to require reduction, the current protocol in most centers is to take the child to the operating room, perform a closed reduction under anesthesia, pin the fracture with Kirschner wires, and immobilize the upper extremity in a long arm splint or cast. Recent literature suggests that unless there is vascular compromise or an open fracture, the surgery can be safely performed on an urgent rather emergent basis.

Like many pediatric centers around the country we have found a growing number of pediatric supracondylar humerus fractures being transferred to our facility from the community over the past few years. Accommodating the increased volume of these cases can sometimes be difficult in an already busy operating room schedule. In an effort to efficiently and effectively manage these patients, we have tried to develop a system that still allows the patients to be treated safely but with as little disruption to the existing operative schedule as possible. Similar to the protocol described by Leet, each patient is initially assessed in the emergency department for signs of neurovascular compromise or open fracture. If the patient's exam reveals an intact neurovascular status, then the patient is admitted with the affected extremity splinted, elevated and iced. Routinely, the child is scheduled for surgery the following morning ahead of the regular elective surgeries. Upon arrival to the operating room, the patient is placed under general anesthesia and fluoroscopy is used to guide a closed reduction of the fracture. With an assistant holding the arm in the reduced position, the surgeon puts on sterile gloves, places sterile towels around the surgical field, preps the elbow locally in the anticipated area of the pin sites, and then pins the fracture with fluoroscopic assistance (Figure one and two). This is similar to the setup used for placing a traction pin at the bedside. No gowns or additional sterile drapes are necessary.   Once the fracture is stabilized with the K-wires, the wires are cut and bent but left out of the skin. Sterile felt padding is placed between the pins and the skin. The elbow is wrapped in sterile cast padding and immobilized in plaster. The patient is discharged to home later the same day if possible.

After using this protocol for several years we decided to review our cases to examine our results using this "semi-sterile" technique. We were specifically interested in determining if we had any increased risk of infection with our limited sterile field method of treatment. In addition, we wanted to evaluate whether perioperative antibiotics in association with percutaneous pinning of supracondylar humerus fractures are really necessary as this subject has not been previously specifically addressed in the literature.

Material and Methods

After obtaining Institutional Review Board approval for the study, all patients taken to the operating room with a supracondylar humerus fracture between 2000 and 2004 were identified using a computerized medical records search. A total of 328 patients were found and the inpatient hospital charts, outpatient clinic charts and emergency department records were reviewed on each patient. Six patients had to be excluded from this study because they were converted to an open reduction which necessitated full prepping and draping. Two other patients had associated injuries requiring full draping in the operating room and were also not included in this review. Sixteen additional patients did not have complete data in their hospital and office charts requiring them to be excluded from this study. Consequently, a total of 304 patients were available for study.

Multiple data points were collected on each patient from the emergency department records including the age of the patient, the side of the fracture, the gender of the patient, the mechanism of injury, the date of injury, the time of injury (if known), the triage time in our emergency department, and whether the patient was transferred to our facility from another emergency department. We also used Gartland's classification scheme to grade each fracture and noted if there were any other associated injuries to the patient. A review of the vascular status and nerve function of the affected upper extremity in the emergency department was performed.

From the operative records we could determine the surgery start time, the surgery finish time, whether perioperative antibiotics were used, the configuration of wires used, and the number of wires used to stabilize the fracture. The inpatient records were reviewed to determine if any postoperative antibiotics were used, to review the patient's post-operative examination and to record the time that the patient was discharged from the hospital. Outpatient clinic charts were reviewed to determine if there were any post-operative neurovascular injuries, to record how many patients required physical therapy after removal of immobilization, to calculate the total follow-up time on each patient, and to document whether any patients developed pin track or deep infections.

Results

The average age of the 304 patients in our study was 5.4 years. There were 162 males (53%) and 142 females (47%). The right upper extremity was fractured in 144 patients (47%) and the left upper extremity was fractured in 160 patients (53%). 176 of these patients (58%) were transferred to our facility from an outside emergency department. The mechanism of injury was a fall at the playground in 73 patients (24%), a fall from bed in 40 patients (13%), a fall in the home in 32 patients (11%), a fall off of a bicycle in 27 patients (9%), a fall in school in 15 patients (5%), a fall on the trampoline in 12 patients (4%), a fall while playing ball sports in 7 patients (2%), a fall off of a car in 5 patients (2%), a fall out of a tree in 4 patients (1%), a fall while skating in 3 patients (1%), a fall in a bounce house in 3 patients (1%), a fracture during karate in 2 patients (<1%), a fall off of a jet ski in one patient (<1%), and 80 miscellaneous injuries in the remaining patients (26%). There were 125 (41%) type II supracondylar fractures and 179 (59%) type III supracondylar fractures according to Gartland’s classification system. There were 299 extension type supracondylar fractures (98%) and 5 flexion type supracondylar fractures (2%). Three fractures (1%) were classified as Type I open fractures according to the grading system of Gustilo and Anderson. There were 23 patients (8%) that had a total of 27 additional fractures: 11 ipsilateral distal radius fractures (4%), 6 T-type supracondylar fractures (2%), 3 ipsilateral distal radius and ulna fractures (1%), one ipsilateral ulna fracture (<1%), one ipsilateral femur fracture(<1%), and one ipsilateral 2nd and 3rd metacarpal fracture (<1%). Five patients (2%) were found to have pre-operative neurapraxias (4 radial nerve and one median nerve). One patient (<1%) had vascular compromise at the time of presentation which resolved with reduction of the fracture in the emergency department.

The average duration from time of injury to surgery was 19.9 hours and the average duration from triage time in the emergency department to surgery was 12.9 hours. Forty-nine patients (16%) were taken to the operating less than eight hours from triage in the emergency department and 255 patients (84%) were taken to the operating more than eight hours from triage in the emergency department. Cross pinning technique was used on 263 patients (87%) and lateral entry pin technique was used on 41 patients (13%). Two wires were used in 268 patients (88%), three wires were used in 34 patients (11%), and four wires were used in two patients (1%). The average surgery start time was 08:47 AM and the average duration of surgery was 22 minutes (range from 5 to 65 minutes). Two hundred and twenty four of the 304 patients (74%) were able to be taken to the operating room as the first case of the day. At the treating physician's discretion, 97 patients (32%) received a single intravenous dose of peri-operative antibiotics and 207 patients (68%) did not receive any antibiotics. There were 20 patients (7%) with 21 total documented post-operative neurapraxias: 5 radial nerve, 6 ulnar nerve, and 10 median nerve (anterior interosseous). All nerve injuries (pre-operative and post-operative) spontaneously resolved within six months and all six ulnar nerve injuries occurred in patients with cross pinning technique. Three of post-operative neurapraxias occurred in the 49 patients treated in less than eight hours from presentation to the emergency department (6.1%) and 17 patients with post-operative neurapraxias were in the group of 255 treated more than eight hours from presentation to the emergency department (6.6%). The average time from surgery to discharge was 19.7 hours. One hundred twelve patients (37%) were discharged home on the same day as the surgery at an average of 499 minutes (8 hours and 19 minutes) after surgery completion. Of these 112 patients, 55 (49%) had type II supracondylar fractures and 57 (51%) had type III supracondylar fractures. The average total hospital admission duration from triage to discharge was 32.7 hours. No patient received any post-operative antibiotics and no patients were discharged home on antibiotic therapy.

The average number of days of follow-up per patient after surgery was 79.9 days (11.4 weeks). The pins were removed from the patient at an average of 30.3 days post-operatively (range 20 to 46 days). Detailed measurements of elbow range of motion were not recorded for all patients in this study and therefore could not be included in the post-operative results but 41 patients (13%) were prescribed post-operative physical therapy to assist with regaining elbow range of motion. There were no pin track infections requiring treatment in this group of 304 patients. No patient developed a compartment syndrome or a Volkmann's ischemic contracture post-operatively.

Discussion

Pediatric supracondylar humerus fractures are very common injuries that all orthopedic surgeons will probably encounter at some point in the emergency department. The management of these fractures is generally agreed upon depending on the amount of fracture displacement. Type I fractures and some Type II fractures usually require no more than three or four weeks of immobilization in a long arm cast. Fractures with enough displacement to require a closed reduction (many Type II fractures and all Type III fractures) are taken to the operating room for attempted percutaneous pinning. Recent evidence in the orthopedic literature suggests that delayed rather emergent treatment for these fractures may be safe and effective. In this series, the patients were taken to the operating room an average of 13 hours after being triaged in the emergency department and an average of 20 hours from the time of injury. Only 49 (16%) of our 304 patients were treated with closed reduction and percutaneous pinning less than eight hours from presentation to the emergency department. 20 of the 49 patients (41%) had Type II fractures and 29 patients (59%) had Type III fractures. In the group treated more than eight hours after presentation 105 had Type II fractures (41%) and 150 had Type III fractures (59%) giving an identical distribution of fracture types between the two groups. In this series, there was no difference between the groups with regards to post-operative nerve injury, compartment syndrome, or infection. (Table 1) This data serves to further strengthen the argument that displaced supracondylar fractures without significant soft tissue or vascular injury may be safely managed on an urgent rather than emergent basis.

Over the past few years there has been an observed increase in the amount of pediatric supracondylar humerus fractures being transferred to our facility from community emergency departments. Although this is probably occurring across the country at all major pediatric orthopedic centers, Kasser has been the first to document that this observation is a reality. He noted a fourfold increase in the number of Type II or Type III fractures being managed at Children's Hospital, Boston, over an eight year period with no increase in the incidence of the injury. While the exact reason for this apparent reluctance to treat these injuries in the community had not been clearly defined, the fact remains that we are faced with the task of trying to incorporate these injuries into the operating room schedule on an almost daily basis. In an ideal world, the hospital would have an operating room dedicated to trauma patients that would be available each morning to accommodate these cases. Unfortunately, our institution, like many others, does not have an operating room set aside just for trauma patients. Consequently, we have found the best way to handle these cases is to try to start them ahead of the elective schedule. We were successful in arranging the patient's surgery before the day's scheduled cases 74% of the time with an overall average start time for all supracondylar pinnings of 08:47 AM. Perhaps the best possible solution for a hospital without a dedicated trauma room would be to have the anesthesia department start the case(s) 30 minutes ahead of the regular schedule so that the normal schedule does not get significantly delayed.

One of the known possible complications from percutaneous pinning of a supracondylar humerus fracture is infection. Superficial pin track infections are reported to occur in the literature with rates ranging from 0% to 7% depending on the series. The recommended management for these infections includes oral antibiotics, release of the skin around the pin, and pin removal, if possible. More serious deep infections, such as septic arthritis and osteomyelitis, can occur and are mentioned anecdotally throughout the literature. The infections require more aggressive treatment with intravenous antibiotics and surgical drainage if necessary. A review of the published literature dealing with closed, percutaneous pinning of supracondylar fractures in children reveals an overall infection rate of 2.34% (45/1922). (Table 2) Significant infections requiring more than just oral antibiotics for treatment were found to occur with a rate of 0.47% (9/1922). (Table 2) Beaty and Kasser feel the low infection rate (their estimate was <1% of cases) is due to the fact that the pins are in place for only three to four weeks. In our series of 304 patients, the average duration of time before pin removal was 30.3 days which supports their concept.

Prevention of infection, however, involves more than just removing the pins in a timely fashion. Reynolds and Mirzayan reported that they did not have a problem with pin tract infection in their series because the procedure of percutaneous pinning was "performed under sterile technique." The explanation of their technique is similar to many of the other descriptions of the surgical technique for performing a percutaneous pinning of a supracondylar humerus fracture in the literature and textbooks. Most depict a full sterile prepping and draping of the patient with the surgeon wearing a surgical gown and gloves. While these sterile precautions are recommended and remain the standard of care, they are not as failsafe as Reynolds and Mirzayan would have us believe. The infection rate of 2% calculated from the literature includes many studies that specifically documented full sterile technique was used intra-operatively. Consequently, there must be more factors at play than just the quality of the operative sterile field.

In an effort to streamline our management of these injuries in the operating room, we have modified the full prepping and draping technique to a "limited" sterile field similar to what may be used when placing a traction pin at the bedside. After obtaining a reduction of the fracture with the patient in a supine position, an assistant holds the patient's arm and maintains the reduction during the procedure. Sterile towels are placed around the patients affected extremity. The surgeon uses sterile gloves and performs a betadine preparation of the elbow in the anticipated area of pin placement. The pins are placed percutaneously using fluoroscopic guidance with a cordless drill. The assistant rotates the arm between lateral and antero-posterior views to assist the surgeon, as necessary. Once the fixation is complete, the pins are bent to 90 degrees and cut short but left outside the skin. Sterile felt padding is placed between the pins and the skin and sterile cast padding is applied over the arm. Standard immobilization in plaster splints is then performed. No surgical gowns or drapes are used. Staheli illustrates a similar limited prepping and draping technique but places the patient in the prone position. We have not found there to be any increased risk of infection with this method (0% in 304 patients). In addition, the simplified set up helps to decrease the cost of materials charged to the patient and decreases the time necessary in the operating room both in terms of actual surgical time (average duration of each case = 22 minutes) and the time it takes for the staff to set up and turn over the room.

Another component used to help prevent infections while performing percutaneous pinning of supracondylar humerus fractures is antibiotics. Most articles dealing with supracondylar fractures do not mention whether antibiotics are used routinely either at the time of surgery or post-operatively. However, a poll of the audience at a recent Instructional Course Lecture demonstrated an overwhelming majority of surgeons do give perioperative intravenous antibiotics. While there has not been a study specifically designed to investigate the role of antibiotics in the management of patients with supracondylar fractures treated by percutaneous pinning, de las Heras et al recommend using “preoperative and postoperative antibiotic treatment with cefazolin that can be extended with an oral antibiotic (cloxacillin) for 5 more days." In our series, no patients with closed fractures received any post-operative antibiotic therapy. Examination of the operative records revealed that 32% of the patients received a single dose of peri-operative intravenous antibiotic (cefazolin unless allergy required an alternative) and 68% of the patients did not receive any antibiotics at all. This suggests that the use of antibiotics may not be necessary in the management of supracondylar humerus fractures.

The appropriate amount of time for post-operative observation in the hospital after percutaneous pinning of supracondylar humerus fractures has not been clearly defined. The literature varies in its recommendations from discharging home less than 24 hours from admission to an average hospital stay for patients of 2.9 days. Kasser noted that as the management of these injuries has shifted to pediatric orthopedic specialists that the average hospital stay has decreased from 2.2 days to 1.4 days. Most authors recommend observation of the patient overnight so that any neurovascular compromise can be recognized and managed expeditiously. The exact threshold of time elapsed from surgery for the surgeon to feel comfortable that a compartment syndrome will not occur varies from patient to patient and from surgeon to surgeon. Because compartment syndromes, fortunately, happen so infrequently after percutaneous pinning of supracondylar humerus fractures it is hard to draw any firm conclusions from the information in the literature. In this series, we were rather aggressive in discharging the patients home after surgery compared to most studies. Generally, after having had the surgery done in the morning, the patients were examined post-operatively by the surgeon later that same afternoon or evening. If the child's neurovascular exam was normal and the surgeon felt comfortable, then the child was discharged to home. 37% of the patients (112/304) were discharged home the same day at an average of eight hours and 19 minutes after surgery. These 112 patients were evenly distributed between type II fractures (55) and type III fractures (57) and no patient was found to have a compartment syndrome or Volkmann's ischemic contracture throughout the post-operative course. Our average time from surgery to discharge for all 304 patients was 19.7 hours and there were no instances of compartment syndrome in any patient. The overall average time of complete hospital admission from triage to discharge was 32 .7 hours which is consistent with Kasser's data. Perhaps a future prospective study will be necessary to elucidate exactly how long a child needs to be observed post-operatively to be safe. Certainly, if it turns out that each child does not need to routinely remain admitted overnight after percutaneous pinning of a supracondylar humerus fracture, then there will be a cost savings to the patient and better utilization of available bed space for the hospital.

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Table 1. Treatment Group Results

	Early Treatment Group (<8 hours)	Delayed Treatment Group (>8 hours)
Total Patients	**49**	**255**
Type II fractures	**20 (41%)**	**105 (41%)**
Type III fractures	**29 (59%)**	**150 (59%)**
Nerve injuries	**3 (6.1%)**	**17 (6.6%)**
Compartment Syndromes	**0 (0%)**	**0 (0%)**
Pin Track Infections	**0 (0%)**	**0 (0%)**

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Table 2 Reported Rates of Infection after Percutaneous Pinning of a Supracondylar Humerus Fracture

Author, Reference	Year	Total Number All Infections	Number of Significant Infections*
Boyd and Aronson	1992	2/71	2/71
Cheng et al.	1995	2/82	0/82
Cramer et al.	1992	1/15	0/15
De las Heras et al.	2005	3/77	2/77
Flynn et al.	1974	0/72	0/72
Foead et al.	2004	3/66	0/66
Fowles and Kassab	1974	9/119	3/119
Gosens and Bongers	2003	1/189	0/189
Gupta et al.	2004	1/150	0/150
Kallio et al.	1992	2/80	0/80
Leet et al.	2002	1/158	0/158
Mehlman et al.	2001	5/198	0/198
Mehlman et al.	1996	3/115	0/115
Mostafavi and Spero	2000	2/42	1/42
O'Hara et al.	2000	2/31	0/31
Pirone et al.	1988	2/96	0/96
Ponce et al.	2004	4/104	1/104
Prietto	1979	0/20	0/20
Reynolds and Mirzayan	2000	0/46	0/46
Shannon et al.	2004	1/20	0/20
Skaggs et al.	2004	1/124	0/124
Topping et al.	1995	0/47	0/47
Total		**45/1922 = 2.34%**	**9/1922 = 0.47%**

*** = Treatment required more than just oral antibiotics**