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Research Article

Retrospective Study on the Evaluation, Management, and Pattern of Hand Fractures in Trauma Patients at a Rural Level 1 Trauma Center

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Abstract

Introduction: Hand fractures are responsible for billions in healthcare costs annually. During 2007, hand and finger injuries accounted for $278 million, ranking first as the most expensive injury type. The vulnerability of the hand to injury is significant, especially in a trauma situation, and are often overlooked while life-threatening injuries are being addressed. Identifying a pattern of injury will likely be of benefit to the treatment and outcomes of trauma patients.

Methods: We sought to investigate the patterns of injury, with specific inclusion criteria, and whether this pattern would provide an insight into which injuries occurred most frequently, and lend itself for further investigation in order to identify injuries to the hand quickly and provide timely and appropriate management. The following patient characteristics were collected: age, gender, Injury Severity Score (ISS), Length of Stay (LOS), Mechanism of Injury (MOI), operative vs non-operative management, type and fracture location, delay in diagnosis and patient outcome.

Results: During a four-year period, 4,378 patients received trauma evaluation, of which 2% (80/4,378) experienced 107 fractures of the hand with 39% being phalangeal and 61% metacarpal (21% being the fifth metacarpal). The most common MOI was Motor Vehicle Accident (MVA), 59%. The most common fracture for those involved in an MVA was also the fifth metacarpal, accounting for 22% of those fractures. A delay in diagnosis occurred in 10% (8/80) of these patients, with only one requiring operative repair.

Conclusion: Clinically significant missed injuries are those that if left untreated may cause a significant amount of physical disability, lessen quality of life, and impede one's ability to maintain meaningful employment. In the literature, the percentage of these injuries ranges from approximately 15 to 22%. Our study revealed the rate at our institution to be 10% (8/80). Although our observed percentage of missed hand injuries was consistent with published values, we identified a unique fracture pattern that was statistically significant from that found in the literature, possibly due to the insight gained by isolating metacarpal and phalangeal fractures. Our findings imply that a timely and thorough tertiary evaluation is critical to improving patient outcomes hindered by missed hand fractures sustained during trauma.

Keywords: Trauma; Fracture; Hand; Metacarpal; Phalanx; Rural

Abbreviations : ATLS: Advanced Trauma Life Support; BSA: Body Surface Area; ED: Emergency Department; GCS: Glasgow Coma Scale; GSW: Gunshot Wounds; ISS: Injury Severity Score; LOD: Length of Delay; LOS: Length of Stay; MVA: Motor Vehicle Accident; MOI: Mechanism of Injury; PTD: Post Trauma Day; SBP: Systolic Blood Pressure; TBSA: Total Body Surface Area

Introduction

Patients suffering from trauma to multiple systems have a higher likelihood of having a musculoskeletal injury and if poorly managed, will likely result in increased morbidity [1]. The vulnerability of the hand to injury is significant and can often be overlooked in the setting of life-threatening injuries. In a review of the literature, injuries to the hand/wrist were missed in trauma patients at a rate between 4.1 to 32.9% [2].

Epidemiological studies of fractures of the upper extremity conclude that hand fractures (metacarpals plus phalanges) are the most common fractures of the upper extremity [3,4]. In isolation, metacarpals are the most commonly fractured bone, however when combined, phalangeal fractures outnumber metacarpal. In the hand alone, when the bones are separated into distal phalanx, middle phalanx, proximal phalanx and metacarpals, the metacarpals are the most com-

monly fractured bone. When the phalanges are grouped as one set, they are the largest number fractured when compared against the metacarpals [5].

A study by Meals reported that mechanisms of injury by age group were predictable, with children and young adults being injured in sports activities, middle age patients are likely to be involved in work related injuries, and the older population was injured in falls or Motor Vehicle Accidents (MVA) [6]. The sequela of persistent long term pain, severe impact on hand functionality, atrophy from disuse, depression and anxiety are common following hand injury [7,8].

Costs to the patient, employer, government, society and the healthcare system can be large and cause a significant burden. In 2011, the average annual aggregate total expenditures of persons with a musculoskeletal disease were estimated at $796.3 billion, with injuries accounting for $176.1 billion [9]. Data from a 2007 population-based study, analyzing the economic impact of injuries seen in the Emergency Department (ED), reported $4.4 billion in total costs due to injuries. Of this total cost, hand and finger injuries accounted for $278 million, ranking first [10]. Production losses due to absence from work associated with hand and wrist injuries (fractures, amputations, and ligamentous/tendon/nerve damage) totaled $411 million (56% of the costs due to hand and wrist injuries) [10].

To improve the quality of trauma care and address a gap in the existing body of literature, our department of trauma investigated the fracture pattern and missed injury rate of the hand in the trauma population. Our aims were to identify, coincident with MOI, the hand fracture patterns in our trauma population, determine the rate of delayed diagnoses and the subsequent impact on patient outcome. This knowledge could be utilized to triage those most at risk for a hand fracture thereby decreasing time to intervention and improving outcome.

Materials and Methods

This is a retrospective study at a single institution, rural community-based level 1 regional resource trauma center in western Pennsylvania, USA. We sought to investigate the patterns of injury and whether this pattern would provide an insight into which injuries occurred most frequently, and lend itself for further investigation in order to identify injuries to the hand quickly and provide timely and appropriate management.

Inclusion criteria:

1. Blunt trauma requiring admission
2. Significant life threatening injury, i.e.
    - Glasgow Coma Score (GCS) ≤ 8
    - any patient with airway compromise, intubated at scene
    - penetrating wound to torso, neck or head
    - any patient with acute paralysis
    - pregnancy of ≥ 5 months with high suspicion of severe injury
    - persistent tachycardia (heart rate > 120)
    - persistent hypotension with Systolic Blood Pressure (SBP) < 100 (two or more episodes); any patient receiving blood to maintain SBP > 100;
    - burn ≥ 30% Total Body Surface Area (TBSA) in adults,
      burn ≥ 10% TBSA in children,
      burn with associated inhalation injury
3. Significant injury of two or more organ systems (polytrauma)
    - specifically, ≥ 2 of the following: soft tissue, head/spine/neurological, musculoskeletal, thorax, abdominal, genitourinary, vascular
    - chest wall deformity
    - decreased breath sounds; persistent respiratory rate > 26 or < 10
    - burn ≥ 20% TBSA burn in adults; ≥ 5% in children
4. Clinical deterioration in the ED, including but not limited to:
    - SBP < 100
    - respiratory decompensation
    - mental status change
5. Any hand fractures (fx), defined as follows:
    - one phalanx fx = proximal, middle &/or distal phalanx fracture of any digit,
    - thumb fx = proximal and distal phalanx fracture of a thumb,
    - index finger fx = proximal, middle and distal phalanx fracture of an index finger, etc.
    - The metacarpals were separated from the digits and defined as:
    - thumb metacarpal, index metacarpal and so on for a total of 10 possible fractures on each hand

Most patients experienced multiple system injuries and all were managed according to Advanced Trauma Life Support (ATLS) guidelines. Consultations to the orthopedic or plastic surgeon were made for the management of any hand injury.

The following patient characteristics were collected: age, gender, Injury Severity Score (ISS), Length of Stay (LOS), MOI, operative vs non-operative management, type and fracture location, delay in Length of Diagnosis (LOD) and patient outcome. The patients were managed by the trauma service throughout their admission. The hand fractures were managed by the orthopedic surgeon or plastic surgeon during the admission and follow-up. Patients were discharged home, transferred to a hospital closer to their residence, personal care homes, rehabilitation center or long term acute care facilities either in Johnstown or closer to the patient's home. We defined missed injury/delay in diagnosis as any

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injury not identified during the primary or secondary survey. Study data was described by summary measures (e.g. mean, percentage) overall and by various pertinent stratifications (i.e. mechanism of injury, fracture pattern, management decision, fracture type, delay in diagnosis). Statistical significance testing between study proportions and those found in the literature was accomplished using the z-test for independent proportions with alpha set at .05.

Results

During the study period, the trauma department evaluated 4,378 patients that met trauma evaluation criteria of which 2% (80/4,378) also had one of the defined hand fractures. The mean age was 54, (range 14 to 92) with the following distribution: 5% < 18 years of age, 30% 18-45 years of age, 34% 46-64 years of age, and 31% ≥ 65 years of age. Sixty percent of the patients were male.

A variety of MOI were seen, including MVA, fall, occupational, animal bites, Gunshot Wounds (GSW), and bicycle accident. MVA was the most common MOI (59%), followed by falls at 28% (Table 1).

ISS was evaluated for each patient and ranged from 1 to 45, with a mean of 10.4. A review of the number of systems injured was performed. Twenty-five percent had a 1 organ system trauma, reflecting isolated hand trauma from the various mechanisms of injury. The majority (46%) of hand fractures occurred with a 2-system trauma, with 26% being 3-system and 2.5% being 4-system. The number of systems correlated loosely with ISS score as 24% of our study population had an ISS > 15.

The cumulative number of hand fractures was 107, with 14 patients having multiple fractures (41 fractures) and 66 patients with isolated fractures. Of the 107, 39% were phalangeal and 61% metacarpal (Table 1). Overall, the little metacarpal was the most commonly fractured bone (21%), followed by the thumb metacarpal (16%). When categorized by mechanism of injury followed by type of bone, the most common fracture for those involved in an MVA was the little metacarpal (22%) followed by the thumb metacarpal (19%), Table 1. Falls were the second most common MOI; here again, the little metacarpal was the most common fracture (30%).

Plastic or orthopedic surgeons managed the patients 84% of the time as 10 patients had no record and 3 patients were transferred. Non-operative management (i.e. splint, buddy tape, etc.) was the choice in 50% of the fractures and operative in 33% (Table 2). Open reduction with internal fixation was reported in 21% (22/107) fractures with closed reduction used in 12% (13/107). Plates and screws were the management in 14% (15/107) fractures, percutaneous pinning was used in 16% (17/107) fractures, external fixation was used in 1 patient, and 2% (2/107) fractures were repaired by closed reduction without metalwork in the operating room.

Of the 107 hand fractures, non-intra-articular fractures (79%) were more common than intra-articular (21%) and non-displaced fractures (55%) were more common than displaced (45%), Table 3. Open fractures were found in 18%, none of the open fractures had a delay in diagnosis, Table 4. Of the 80 patients in our study sample, 90% (72/80) were diagnosed with hand fractures through radiological imaging during initial resuscitation with 10% (8/80) having a missed injury/delay in diagnosis (Table 4). A delay in diagnosis of one day was found in 63% of patients. All 8 patients had at least a 2 organ system injury and 7 of the eight had a three or greater system injury. ISS ranged from 2-45, with 75% having had an ISS ≤ 15 and 13% an ISS ≥ 25. Of the patients with a delay in diagnosis/missed injury, 13% were treated operatively, 63% received splints, and 25% were missing records.

When looking at hand fractures alone, the phalanges (grouped together) accounted for 56% and 43% metacarpals, respectively [4]. Phalanges accounted for 64% and the metacarpals 36% of all hand fractures [5]. With further individual categorization of the bones, the little metacarpal was the most commonly fractured bone [10].

When comparing bone groups, not only did our MOI pattern differ but also our fracture pattern statistically significantly differed from the literature[5] (z-test of independent proportions: metacarpals, P < .0005; phalangeal, P < .0005).

Table 1. Mechanisms of Injury and Fracture Patterns.

Summary by					Fracture Pattern (counts)									
Mechanism of Injury (MOI)					Phalangeal					Metacarpal				
Mechanism	Subtotals by MOI				thumb	index	middle	ring	little	thumb	index	middle	ring	little
	Patients		Fractures											
MVA	59%	47	60%	64	7	4	3	3	5	12	4	6	6	14
Fall	28%	22	21%	23	3	1	1	2	4	2	0	1	2	7
Occupational	8%	6	11%	12	2	1	1	2	0	2	0	1	2	1
Animal Bite	3%	2	5%	5	1	0	1	0	0	0	1	0	1	1
GSW	3%	2	2%	2	0	0	0	0	0	1	0	0	1	0
Bicycle	1%	1	1%	1	0	0	1	0	0	0	0	0	0	0
Total Counts:		80		107	42 (39%)					65 (61%)				
					13	6	7	7	9	17	5	8	12	23
					31%	14%	17%	17%	21%	26%	8%	12%	18%	35%
Percent of Overall Fractures (107) →					12%	6%	7%	7%	8%	16%	5%	7%	11%	21%
MVA = Motor Vehicle Accident; GSW = Gunshot Wound														

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Table 2. Management decisions.

Percentage (count)	Fractures (n = 107)	Patients (n = 80)
Non-Operative	50% (53)	51% (41)
Operative	33% (35)	33% (26)
No record	12% (13)	13% (10)
Transferred	6% (6)	4% (3)

Table 3. Fracture types*.

Percentage (count)	Fractures (n = 107)	Patients (n = 80)
Non-displaced	55% (59)	46% (37)
Displaced/Comminuted	45% (48)	54% (43)
Non-Intra-articular	79% (85)	76% (61)
Intra-articular	21% (22)	24% (19)
Open	18% (19)	16% (13)
Amputation or partial	4% (4)	3% (2)

* Not mutually exclusive, Partial amputation- Distal phalanx, not involving metacarpal.

Table 4. Characteristics of patients with delay in diagnosis.

Age (years)	Gender	Fracture Location	Fracture Type	Mechanism	LOD, PTD	ISS	# of systems injured	Management	Outcome
15	M	Ring MC, Little MC	Non-displaced Displaced/Comminuted Intra-articular	MVA	1	9	3	Splint Splint	Regained full function
54	M	Little MC	Displaced/Comminuted Non-intra-articular	MVA	1	9	3	Splint*	Lost to follow-up
62	M	Little MC	Intra-articular	MVA	1	9	3	**	**
43	F	Thumb PX	Non-displaced Non-intra-articular	MVA	1	12	3	Splint	Lost to follow-up
73	M	Little MC	Non-displaced	MVA	1	45	4	Splint	Deceased 3 months later
80	F	Little PX	Non-displaced Non-intra-articular	Fall	2	2	2	Splint	Lost to follow-up
58	M	Little PX	Displaced/Comminuted Intra-articular	MVA	3	9	3	CR PC pin	Regained full function
65	M	Little MC	Displaced/Comminuted Non-intra-articular	MVA	11	17	4	**	Regained full function

M = Male; F = Female; MC = Metacarpal; PX = Phalanx; MVA = Motor Vehicle Accident; LOD = Length of Delay; PTD = Post Trauma Day; PTD 0 = Day of Admission; ISS = Injury Severity Score; CR = Closed Reduction; PC = Percutaneous; * = Transferred; ** = No record of treatment/repair; # = All fractures closed unless otherwise specified

Discussion

From the National Hospital Ambulatory Medical Care Survey of 1998, of all emergency room visits for hand and forearm fractures, falls were the most common mechanism at 47% (MVA ranked fourth at 7%), with the metacarpals accounting for only 18% of all hand and forearm fractures [4]. When looking at hand fractures alone, the phalanges (grouped together) accounted for 56% and 43% metacarpals, respectively [4]. In another study, phalanges accounted for 64% and the metacarpals 36% of all hand fractures [5]. With further individual categorization of the bones, the little metacarpal was the most commonly fractured bone [10].

When comparing bone groups, not only did our MOI pattern differ but also our fracture pattern statistically significantly differed from the literature [5], (z-test of independent proportions: metacarpals, $P < .0005$; phalangeal, $P < .0005$). These observed differences might possibly be due to multiple system injuries and lower sample size, which itself may have resulted from our chosen population (trauma patients) and hospital classification (rural, level 1 trauma). Our results do imply an association between MVA and metacarpal fractures in the trauma population differing from that found in other populations, such as patients that were assaulted, who would not qualify to meet our criteria, Table 1.

The trauma patients who experienced a delay in diagnosis

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did not produce a pattern of injury nor could we identify any correlation between LOD, ISS, or operative treatment. None of the open fracture and amputations were for reasons that this was an obvious injury to the digit, making this clinical diagnosis. The more difficult to diagnose, non-displaced fractures with minimal edema; however, 4 of our patients had comminuted, displaced and were still missed, not producing a pattern. One would believe, a more obvious type of fracture, however open displaced fractures were still missed. Contrary to what we expected, the patient with the highest ISS (45) did not have the longest LOD (1 day); nor did this patient require operative intervention as the injury was a non-displaced little metacarpal fracture. Three months after his trauma, this patient succumbed to his traumatic injuries while at a long term acute care facility. The lowest ISS (2) was in the oldest patient (80 years) with a LOD of 2 days, who was treated with a splint and lost to follow-up. The longest LOD (11 days) was in a patient with an ISS of 17 and 4-system trauma, unfortunately records of the treatment method(s) were not revealing, but on follow-up the patient had no complaints and regained full function. The only patient who required surgery had a 3 day LOD, an ISS of 9, and fully recovered from his hand fracture. These results were not suitable for any correlation analyses (i.e. between LOD and severity of hand fracture(s) or outcomes). However, our results do imply an association between hand fracture location and MOI (little metacarpal and MVA).

When a patient experiences severe trauma with involvement of numerous systems, one expects that non-life-threatening injuries would be diagnosed later, once the patient is stabilized and life-threatening injuries are treated. The trauma population is frequently susceptible to under triaging, reported as 6.3% in one study, due to more life-threatening injuries (ISS>15), garnering the majority of attention [11,12]. Our results support the need for a tertiary survey to be completed within 12-48 hours post admission. In addition, patients that are in ICU and transferred to step down floor, can receive anther full physical exam. Patient that are intubated and as soon as they become extubated undergo immediate Tertiary survey. In addition, another specialist, not part of the trauma service, i.e. Orthopedic or Neurosurgeon would be able to complete full exam. However, based on time and total patient numbers on any given trauma service, this exam may be limited and therefore delay in identification can still occur.

Although we are confident in applying our study outcomes to the evaluation of our trauma patients, we recognize the need for future studies to duplicate and expand our work, being sure to include those trauma patients with injuries to multiple body systems. Even though we examined patients with missed injuries resulting in a delay in diagnoses, we were not able to identify the causes that led to the delay. There was no reported decline in hand function reported from delay, however one could possibly develop malunion after two weeks. Finally, the sample size limits reasonable generalization to all trauma populations.

Conclusion

The majority of hand injuries sustained in a trauma are non-life-threatening in an acute setting, raising the question, "what is the clinical significance of these hand injuries?" All hand fractures have the potential of being clinically significant injuries and strongly encourage the trauma team to maintain vigilance during every trauma evaluation, particularly the tertiary surveys (within 12-48 hours post admission).

Although our observed percentage of missed hand injuries was consistent with published values, we identified a unique fracture pattern that was statistically significant from that found in the literature, possibly due to the insight gained by isolating metacarpal and phalangeal fractures. Our findings imply that a timely and thorough tertiary evaluation is critical to improving patient outcomes hindered by missed hand fractures sustained during trauma.

Conflict of Interest

The authors have no conflict of interest to declare.

Informed Consent

Verbal and written informed consent were obtained from the patient in the presence of witness.

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