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Fracture type, treatment, and outcome of humeral shaft fractures in polytraumatized patients: a case series

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Since most clinical studies on humeral shaft fractures exclude polytraumatized patients, the epidemiology in this population is largely unknown. The aim of this study was to describe the fracture type, treatment, and outcome of humeral shaft fractures in adult polytraumatized patients. A case series with a single follow-up questionnaire was performed in patients aged 16 years or older with a humeral shaft fracture and an injury severity score of 16 or higher, admitted to a level 1 trauma center between January 1, 2007, and July 31, 2021. Details on injuries, treatment, and clinical outcome were collected from the national trauma registry and medical records. Patients were asked to complete the Disabilities of the Arm, Shoulder, and Hand (DASH), EuroQol-5D (EQ-5D), and Short Form-36 (SF-36). Twenty-nine patients were included. The median age was 41 years and 18 (62%) were male. Most fractures were type A (N=19; 66%). Most patients were treated operatively (N=26; 90%) within three days. Radial nerve palsy at presentation was reported in five (20%) patients. Infection occurred in one (4%) patient and nonunion in six (27%) patients. The patient-reported outcome measures were as follows (median; quartiles): DASH (20.0; P25-P75 5.6-35.2), EQ utility (0.75; P25-P75 0.58-0.88) and visual analog score (0.80; P25-P75 71-95), SF-36 physical (49; P25-P75 43-55) and mental component summary (58; P25-P75 47-61). Humeral shaft fractures in adult polytraumatized patients were most often AO-type A and treated operatively. Radial nerve palsy at presentation and nonunion rates were high. Patients still reported upper extremity disability at approximately five years post trauma.
Level of evidence: Prognosis study Level IV: Case series.

Keywords: Fracture, Humerus, Outcome, Polytrauma, Shaft, Treatment.

INTRODUCTION

Many studies have reported on the fracture type, treatment, and outcome of isolated humeral shaft fracture[1-5]. However, even though it has been described that 49% of patients with a humeral shaft fracture had an injury severity score (ISS) ≥16, most clinical studies on humeral shaft fractures exclude polytraumatized patients[5-9]. In general, patients with an isolated humeral shaft fracture have good or excellent clinical outcomes. Outcomes may become less favorable in polytraumatized patient population[10-13]. However, since most studies exclude polytraumatized patients, the epidemiology and outcome of humeral shaft fractures in polytraumatized populations is largely unknown.

Given the higher level of energy causing the injury, it is possible that humeral shaft fractures in polytraumatized patients are more often comminuted and accompanied by more extensive soft tissue damage. The fracture location and pattern are of interest, since they may influence treatment, risk of complications, and long-term functional recovery[2]. Furthermore, the presence of other (more life-threatening) injuries may have an effect on the (timing of) treatment, complication risk, and (long-term) recovery of the humeral shaft fracture[14]. Clinical and patient-reported outcomes are valuable for evaluating the long-term consequences in terms of disability and health-related quality-of-life.

The relative lack of research directed at understanding the impact of polytrauma on the epidemiology and outcome of a humeral shaft fracture results in the need for an overview of this diverse population

and insight into the long-term consequences. The aim of this study was to describe the fracture type, treatment, and outcome of humeral shaft fractures in adult polytraumatized patients. The hypothesis was that polytraumatized patients would have a variable distribution of fracture types, would be predominantly treated operatively, and have suboptimal outcomes considering complications and functional outcome.

METHODS

Study design

This case series enrolled adult polytraumatized patients (age 16 years or older with an ISS ≥16) at least one year post-trauma with a radiologically confirmed humeral shaft fracture, who were admitted to a level 1 trauma center between January 1, 2007, and July 31, 2021, and provided informed consent. Patients were identified from the national trauma registry (NTR). Radiographic imaging (X-ray or CT-scan) was assessed to determine the eligibility (SHVB and DDH). Patients were excluded if they had 1) insufficient cognitive function to comprehend the study documents; 2) insufficient comprehension of the Dutch language; 3) unknown contact details; or 4) deceased during follow-up. The study was exempted by the local Medical Research Ethics Committee (No. MEC-2018-1231 and No. MEC-2022-0371).

Data collection

The following patient characteristics and details of admission and additional traumatic injuries were extracted from the NTR: age, sex, hospital length of stay (HLOS), admission to the intensive care unit (ICU), and ICU length of stay (ICU LOS). Details on additional traumatic injuries were extracted and described using the nine separate Abbreviated Injury Scale (AIS) regions. Upper extremity injuries were described using the AIS type of injury. Upper extremity fractures were described based on fracture location. The AIS coding used for patients admitted before January 1, 2015, was the AIS 1990 (update 1998).15 The AIS 2005 (update 2008) was used for patients admitted after January 1, 2015[16].

Details on the humeral shaft fracture were collected from the patient's medical records, i.e., AO/OTA classification, presence of radial nerve palsy at presentation, primary treatment strategy (nonoperative treatment, i.e., functional bracing, or operative treatment, i.e., intramedullary nailing (IMN), plate osteosynthesis, or an external fixator), and time to operative treatment[17]. Furthermore, data were collected on infection at the humeral shaft fracture site occurring within 30 days after hospital presentation requiring surgical intervention and nonunion (defined as a failure to heal at six months post fracture with no progress towards healing seen on the most recent radiographic imaging). Radiographic imaging (X-ray or CT-scan) was reviewed for determining the fracture type and identify nonunion (SHVB and DDH).

Eligible patients were invited by regular mail to complete three validated patient-reported outcome measures (PROMs; the Disabilities of the Arm, Shoulder, and Hand (DASH), EuroQol-5D (EQ-5D-5L), and Short Form-36 version 2 (SF-36-v2)[18-24].

The DASH is a 30-item (scored 1-5) instrument with an overall score ranging from zero (no disability) to 100 (severe disability), reflecting disability and pain of the upper extremity[18-20]. The EQ-5D-5L is a 5-item instrument for measuring health-related quality-of-life, consisting of a utility score (EQ-US) and a visual analog scale (EQ-VAS), both ranging from zero (death) to 100 (perfect health)[21-23]. The SF-36 is a 36-item instrument for measuring health-related quality-of-life, representing eight health domains that are combined into a Physical Component Summary (PCS) and a Mental Component Summary (MCS) score[24]. Normalized scores range from zero to 100 points for each domain, with higher scores indicating better quality-of-life. Scores were converted to a norm-based score and compared with United States general population (1998) norms, in which each scale was scored to have the same average (50) and standard deviation (SD; 10)[25].

Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 28 (IBM corp, Armonk, NY, USA). The Shapiro-Wilk test was used to test normality of continuous data. Continuous data, which were all non-parametric, are reported as a median with percentiles (P25-P75). Categorical data are reported as number with percentages (N; %).

RESULTS

Baseline patient and injury characteristics

Sixty-one polytraumatized patients had a confirmed humeral shaft fracture based on radiographic imaging (Figure 1). Of these, 38 were eligible and were invited to complete the questionnaires. Twenty-nine of these completed the questionnaire, resulting in a response rate of 76%. The median age at trauma was 41 (P_{25}-P_{75} 26-51) years and 18 (62%) patients were male (Table

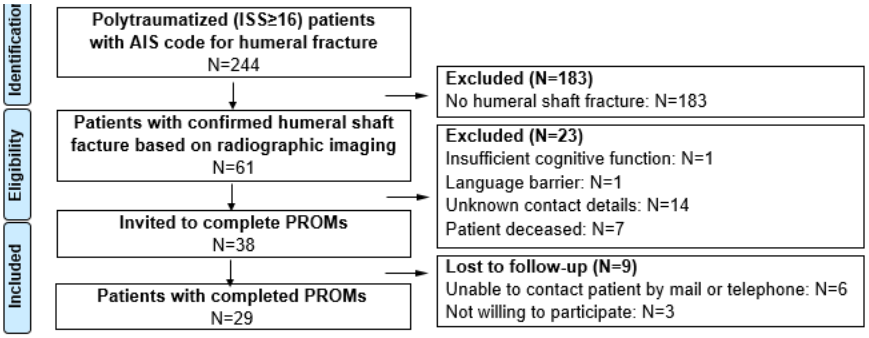

Fig. 1 — Flow chart of the study.
AIS, Abbreviated Injury Score; ISS, Injury Severity Score; PROMs, Patient-Reported Outcome Measures.

I). The median ISS was 29 (P_{25}-P_{75} 22-43). Nineteen (66%) type A, seven (24%) type B, and three (10%) type C fractures were identified. Type A3 (N=9; 31%) and A2 (N=7; 24%) fractures were the most common fracture types. Five (20%) of the 25 patients in whom radial nerve function was assessed, had radial nerve palsy at presentation. Radial nerve function was undocumented in one patient, unevaluable due to tetraplegia in one patient, and unknown due to transfers to other hospitals in two patients.

Treatment and complications

The median HLOS was 14 (P_{25}-P_{7} 9-47) days (Table I). Twenty (69%) patients were admitted to the ICU for a median of five (P_{25}-P_{75} 2-15) days. Three (10%) patients were treated nonoperatively. Twenty-six (90%) patients were treated operatively. The median time to surgery was 3 (P_{25}-P_{75} 1-6) days (N=24). The time to surgery in two patients was unknown due to transfers to other hospitals. The type of operative treatment consisted of IMN in 12 (48%) patients, plate osteosynthesis in 10 (40%) patients, and an external fixator in three (12%) patients. One patient had two humeral shaft fractures and was treated on one side with an IMN and on the other side with plate osteosynthesis, and was therefore not included in the abovementioned calculations. The rationale for the choice of operative treatment was unfortunately seldom documented.

Data on infection and nonunion was unavailable in three and seven patients, respectively, due to transfer to other hospitals (N=4) and lack of radiographic imaging (N=3). One patient (4%), initially treated with an external fixator, developed a fracture site infection. This resolved following surgical debridement, placement of gentamicin-impregnated beads, and an extended course of antibiotics. Six of the 22 patients with available radiographic imaging (27%) had a nonunion, of whom four were treated with plate osteosynthesis and two with an external fixator.

Traumatic injury details

The 29 included patients had a total of 82 upper extremity injuries (Table II). Sixty-five (79%) of these were fractures, the next most prominent injuries were superficial soft tissue injuries (N=6; 7%), muscle/tendon/ligament injuries (N=4; 5%), and vascular injuries (N=4; 5%). Fourteen (48%) patients had two or more upper extremity fractures. The most common fracture location was the humerus (N=30; 46%), followed by the (meta)carpus (N=8; 12%), ulna (N=8; 12%), and radius (N=7; 11%).

Additional injuries were most often located to the thorax (N=23; 79%), head (N=19; 66%), and lower extremities (N=16; 55%; Table III). Severe injuries occurred most often to the thorax (N=22; 76%), head (N=16; 55%), and upper extremities (N=11; 38%).

Patient-reported outcome measures

Patient-reported outcome measures were completed between August 13, 2018, and November 18, 2022. The median time from trauma to the completion of the follow-up questionnaires was 55 (P_{25}-P_{75} 37-85) months. The median DASH score was 20.0 (P_{25}-P_{75} 5.6-35.2). The EQ-US and EQ-VAS were 0.75 (P_{25}-P_{75} 0.58-0.88) and 80 (P_{25}-P_{75} 71-95), respectively. The proportion of patients with a certain level of problems in each of the domains of the EQ-5D-5L survey is shown in Figure 2. Few patients reported extreme problems or inability to do one of the activities; however, more than half of the patients reported extreme to mild problems with walking, daily activities, or pain. The median SF-36 PCS and SF-36 MCS scores were 49 (P_{25}-P_{75} 43-55) and 58 (P_{25}-P_{75} 47-61), respectively (Figure 3). Scores were lowest for the domains physical functioning (45; P_{25}-P_{75} 33-54), role limitations due to physical health (43; P_{25}-P_{75} 36-55), and general health perceptions (49; P_{25}-P_{75} 39-58).

Table I. — Baseline patient characteristics, injury, and treatment details.

Characteristic			Total population (N=29)	
			N*	
Patient characteristics				
Age at trauma (years)			29	41 (26-51)
Male			29	18 (62%)
Injury Severity Score			29	29 (22-43)
Injury characteristics				
Fracture type		A1	29	3 (10%)
		A2		7 (24%)
		A3		9 (31%)
		B1		3 (10%)
		B2		4 (14%)
		B3		0 (0%)
		C1		1 (3%)
		C2		1 (3%)
		C3		1 (3%)
Radial nerve palsy at presentation			25	5 (20%)
Treatment details				
HLOS (days)			29	14 (9-47)
ICU admission			29	20 (69%)
ICU LOS (days)			20	5 (2-15)
Index treatment	Nonoperative		29	3 (10%)
		Operative		26 (90%)
Nonoperative treatment	Functional brace		3	3 (100%)
Operative treatment	Intramedullary nailing		25	12 (48%)
		Plate osteosynthesis		10 (40%)
		External fixator		3 (12%)
Time to operative treatment			24	3 (1-6)
Complications				
Infection			25	1 (4%)
Nonunion			22	6 (27%)
Survey at follow-up				
Upper extremity treatment since hospital discharge			27	3 (11%)
		Infection (near plate)	3	1 (33%)
		Cartilage repair		1 (33%)
		Surgery for muscle spasms		1 (33%)

Data are presented as median (P25-P75) of n (%).
N* represents the number of patients for whom data were available.
ICU, Intensive Care Unit; ICU LOS, ICU length of stay; HLOS, Hospital length of stay.

DISCUSSION

This study provides a detailed description of adult polytraumatized patients with a humeral shaft fracture admitted to a level 1 trauma center during a 15-year period. Humeral shaft fractures in adult polytraumatized patients were most often AO-type A (66%) and treated operatively (90%). Rates of radial nerve palsy at presentation (20%) and nonunion were high (27%). Approximately five years post trauma, disregarding the EQ-US, patient reported levels of quality-of-life comparable to the population norms and standardized combined scores. However, the DASH score indicated that patients still experience upper-extremity disability in the long term.

Type A2 and A3 fractures comprised more than half of the humeral shaft fractures (24 and 31%, respectively) in contrast to populations with an isolated humeral shaft fractures in which type A1 fractures were most common (19 and 28%)[2,5]. This is possibly due to the high energy trauma mechanism causing direct trauma to the arm instead of transmitted rotational or axial loading forces caused by a fall. More complex fractures (type C) could have been expected, considering the high energy trauma mechanism, but were seldom reported and comparable with a population with an isolated humeral shaft fracture (9 versus 10%)[2].

Table II. — Type of upper extremity injuries and location of upper extremity fractures.

Type of injury	N injuries	N patients	N patients with 1 up to 10 injuries					
	(N=82)	(N=29)	1	2	3	4	5	10
Soft tissue	6 (7%)	5 (17%)	4	1				
Muscle/tendon/ligaments	4 (5%)	3 (10%)	2	1				
Nerves	1 (1%)	1 (3%)	1					
Vascular	4 (5%)	3 (10%)	2	1				
Joints	2 (2%)	2 (7%)	2					
Fracture	65 (79%)	29 (100%)	15	5	4	2	2	1
Type of fracture	N fractures	N patients	N patients with 1 up to 3 fractures					
	(N=65)	(N=29)	1	2	3			
Clavicle	5 (8%)	5 (17%)	5					
Scapula	6 (9%)	6 (21%)	6					
Humerus	30 (46%)	29 (100%)	28	1				
Radius	7 (11%)	6 (21%)	5	1				
Ulna	8 (12%)	6 (21%)	5		1			
Hand	0 (0%)	0 (0%)						
Carpus/metacarpus	8 (12%)	6 (21%)	4	2				
Finger	1 (2%)	1 (3%)	1					
Data are shown as n (%). AIS, Abbreviated injury scale.								

Table III. — Overview of the location and severity of injuries for the nine anatomical regions.

Body region	Any injury (AIS≥1)	Severe injury (AIS≥3)
	(N=29)	(N=29)
Head	19 (66 %)	16 (55%)
Face	9 (31%)	2 (7%)
Neck	0 (0%)	0 (0%)
Thorax	23 (79%)	22 (76%)
Abdomen	13 (45%)	5 (17%)
Spine	13 (45%)	8 (28%)
Upper extremity	29 (100%)	11 (38%)
Lower extremity	16 (55%)	10 (34%)
External	3 (10%)	0 (0%)
Data are shown as n (%). AIS, Abbreviated injury scale.		

The polytraumatized population was younger and more often male than a population with an isolated humeral shaft fracture[2,5,7]. These patients have possible larger physiological reserves, resulting in better outcomes[26]. However, this study found that the presence of multiple traumatic injuries is associated with a longer HLOS and higher rate of ICU admission than a population with an isolated humeral shaft fracture (14 versus 2 days, 69 versus 0%, respectively)[5]. It is unclear if the longer HLOS was attributable to the impaired arm function restricting self-care or to other injuries prolonging the need for monitoring and rehabilitation.

A high proportion of this polytraumatized population was treated operatively (90%), with a median time to surgery of 3 days. This is in accordance with studies emphasizing the relevance of initial and timely surgical treatment[27-30]. Upper extremity function is necessary for personal hygiene, use of crutches, and daily activities, especially when additional injuries of the (ipsilateral) upper extremity are present[14]. (Relative) stability provided by operative treatment can be considered desirable as this can shorten bedridden immobilization, improve independence, and enable patients to start rehabilitation at an earlier time-point.

Radial nerve palsy at presentation was more often seen than described in a population with an isolated humeral shaft fracture (20 versus 4 and 6%), as expected with high energy trauma and contusion of the soft tissues[5,7,31]. The nonunion rate in the current study was higher than reported in a population with an isolated humeral shaft fracture (27 versus 16%)[5]. The higher nonunion rate might be explained with the Diamond concept, which describes that fracture healing is regulated by the nature and extent of the trauma, the stability of fracture fixation, and

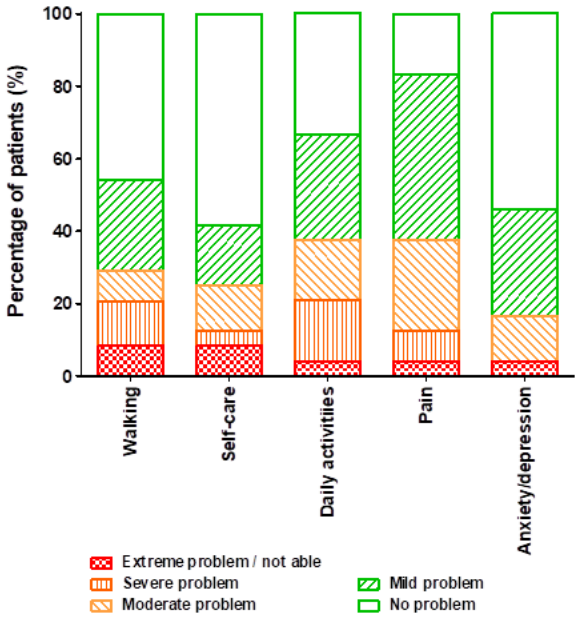

Fig. 2 — Level of problems in the domains of the EQ-5D-5L survey reported by polytraumatized patients with a humeral shaft fracture.

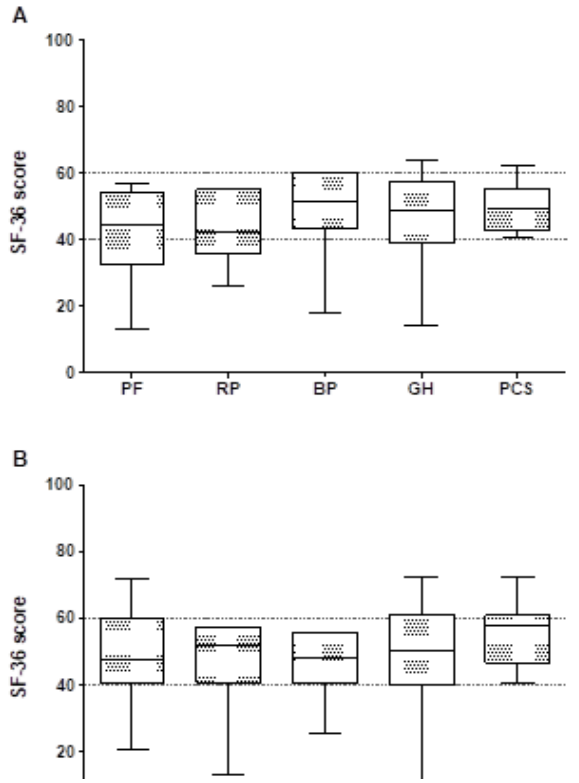

Fig. 3 — SF-36 scores for the domains of the SF-36 survey reported by polytraumatized patients with a humeral shaft fracture.

biological bone healing processes[32]. This suggests that the fracture environment is less favorable in a polytraumatized patient than in a patient with an isolated fracture, due to more extensive injuries to the surrounding (neurovascular) structures.

Patient-reported outcome measures can provide insight into the magnitude of the impact of the trauma on function and quality of life. The DASH score indicates more disability of the upper extremity in this polytraumatized population than in patients with an isolated humeral shaft fracture (20.0 versus 3.3)[5]. This is of importance, as upper-extremity disability can result in work absence and prolonged home care, increasing not only the individual but also the societal burden[11,13]. Furthermore, it should be noted that the level of disability might be underestimated as, due to the lack of objective measurement of function (strength and range of motion), no distinction can be made between adaptation to disability and actual disability. However, as many patients in this cohort had other concomitant upper extremity injuries, the DASH score cannot be attributed solely to the humeral shaft fracture. The EQ-US were lower than the population norm (0.75 versus 0.89).22 The EQ-VAS, SF-36 PCS, and SF-36 MCS were comparable to the population norms and standardized combined scores (EQ-VAS 80 versus 81; PCS 49 versus 50; MCS 58 versus 50)[22,23]. This suggests that even though physical limitations are present, they do not greatly impact the patient's perception of their general health-related quality-of-life at approximately five years post-trauma. However, it is challenging to determine the extent to which the humeral shaft fracture, its associated treatment or complications, and the presence of other injuries contribute to these health-related quality of life scores.

The most prominent drawbacks of this study are the retrospective and single center design, and single follow-up measurement at a random time-point, giving little insight into the course of recovery of the humeral shaft fracture. Finally, the population studied is relatively small, limiting the ability to draw definitive conclusions about these injuries in this population. Furthermore, the population only reflects the polytraumatized patients who have given their consent, implicating that some are missing, e.g. because they deceased shortly after trauma (N=7), had unknown contact details, or were unable to reach (N=20). Furthermore, the lack of detailed information on the nature and laterality of injuries, inherent to the ISS and AIS scoring systems, complicates the interpretation of the results. Future research involving larger cohorts should aim to incorporate more granular injury documentation to better understand the influence of additional injuries on treatment decision, recovery, and functional outcomes.

CONCLUSIONS

Humeral shaft fractures in adult polytraumatized patients were most often AO-type A (66%) and treated operatively (90%). High rates of radial nerve palsy at presentation (20%) and nonunion (27%) were found. Approximately five years post trauma, patients reported levels of quality-of-life comparable to the population norms and standardized combined scores, but still experienced upper extremity disability.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that they have no conflict of interest.

Ethical approval: The study was exempted by the Erasmus MC local medical research ethics committee (No. MEC-2018-1231 and No. MEC-2022-0371).

Data sharing: No additional data are available. Data can be made available upon reasonable request to the corresponding author.

Contributorship statement: SHVB, DDH, MLZ, EMMVL, and MHJV designed the study and study documents. SHVB, MLZ, and DDH performed patient inclusion and data collection. Statistical analysis was performed by EMMVL. SHVB drafted the manuscript. DDH, MLZ, EMMVL, and MHJV interpreted the results and critically revised the manuscript. All authors read and approved the final manuscript. All authors had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

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