Treatment of humeral shaft fractures related to associated injuries

A retrospective study of 237 patients

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The results of treatment in 237 patients with humeral shaft fractures in relation to the severity of associated injuries were reviewed. Three groups were defined with the Injury Severity Score: multiply injured (ISS ≥ 18; n 58), moderately injured (4 < ISS < 18; n 52), and singly injured patients (ISS = 4; n 127). Three basic forms of therapy were evaluated: operative stabilization, traction, and bracing. In singly injured patients the best results were obtained by bracing, and no cases of delayed union were observed. In multiply injured patients, the incidence of delayed union was low after operative stabilization. In moderately injured patients who had to remain in bed, traction therapy was warranted. The majority of 21 primary and 19 secondary radial nerve injuries showed good recovery, independent of surgical exploration.

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In patients with an isolated fracture of the humeral shaft, conservative treatment is preferred to an operation for avoiding infection and radial nerve injury (Mast et al. 1975, Sarmiento et al. 1977, Zagorski et al. 1988). Multiply injured patients may require early fracture stabilization to allow optimal nursing, to permit early mobilization of joints, and to prevent pulmonary complications (Blaisdell et al. 1977, Goris et al. 1982, Bone et al. 1989). However, Vichare (1974) found a high incidence of delayed union, nonunion, and radial nerve involvement when internal fixation or bracing was performed in patients with multiple injuries. He therefore advocated traction therapy.

Thus, associated injuries affect the choice of treatment of humeral shaft fractures. For this reason, we performed a retrospective study over 16 years to evaluate the outcome of humeral shaft fracture management.

Patients and methods

All the patients aged 16 years and older who were admitted to our department during the period 1971–1987 with a nonpathologic fracture of the humeral shaft were included. A humeral shaft fracture was defined as a fracture between the greater tuberosity and the supracondylar ridge. Totally, 237 patients (146 males and 91 females) with 239 fractures of the humeral shaft met the conditions of the study. The mean age was 35 (16–84) years (Figure 1). In the younger age group, males predominated with injuries caused primarily by traffic accidents. The age group 56 to 65 years consisted mainly of females with solitary fractures, mostly caused by falls.

To quantify all the injuries of a patient, the ISS (Injury Severity Score) based on the Hospital

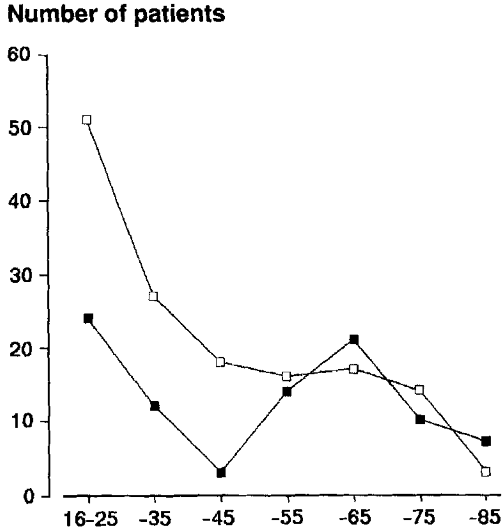

Figure 1. Age and sex (□ = males, ■ = females) distribution of 237 patients with a humeral shaft fracture.

Trauma Index (HTI) was used (Baker et al. 1974, American College of Surgeons 1980). The ISS score varies from 0 to 75 depending on the number of organ systems involved and the severity of each injury. Patients with an ISS ≥ 18 were defined as multiply injured (Group 1), with 4 < ISS < 18 as moderately injured (Group 2), and with an ISS = 4 as singly injured (Group 3). The HTI scores from which the ISS scores were derived are shown in Table 1. Group 1 comprised 58 patients with 60 fractures, and had a median ISS of 35. Group 2 comprised 52 patients with a median ISS of 11. Group 3 comprised 127 patients.

Fractures

In 188 cases, the initial radiographs were available for assessing fracture type and location; and in 185 cases, clinical follow-up data were available. In 168 of these cases, both radiographs and follow-up data were available for establishing the relation between fracture and complications (Table 2). The type of fracture was classified by means of the fracture quotient Q, which was defined as the length of the fracture divided by the width of the shaft at the fracture site:—transverse: Q = 1.0–1.1; short-oblique: Q = 1.2–1.3; oblique: Q = 1.4–1.7; longitudinal: Q ≥ 1.8. The degree of comminution was graded as none: no fragments; moderate: one or two fragments; severe: more than two fragments. Ten fractures were open. Half the fractures were transverse or short-oblique, were mostly caused by traffic accidents, and were often situated in the middle segment of the humeral shaft; in a minority of these cases, the fractures were severely comminuted. Oblique fractures were mostly caused by falls. In contrast to the transverse and short-oblique fractures, these fractures were uniformly distributed over all three segments of the humeral shaft and had a relatively high incidence of severe comminution. Fracture characteristics in patients with (Group 1) and without multiple injuries (Groups 2 and 3) differed mainly in fracture type and comminution. In multiply injured patients, the fractures of the humeral shaft were mostly transverse with no comminution, whereas patients without multiple injuries more frequently showed long-oblique fractures with severe comminution.

Treatment

Three forms of therapy were applied: operative treatment (open or closed reduction with internal or external fixation), traction (extension wire, hanging cast), and bracing (Sarmiento brace, U-shaped plaster of Paris cast). Traction was the most frequently used treatment in all three groups (Table 3). The primary operation was mainly performed in multiply injured patients because of the patients' associated injuries. In Group 2, surgery was performed mainly because of radial nerve involvement or brachial artery injury. Traction was used in two thirds of Group 3 patients. The fracture was considered healed when no further fixation was necessary. Union after more than 90 days was

Table 1. Associated injuries in 239 humeral shaft fractures

	Hospital trauma index (HTI)					
Organ system	0	1	2	3	4	5
Respiratory	189	7	3	21	14	5
Cardiovascular	152	40	19	17	7	4
Neurologic	175	4	35	5	12	8
Abdomen	203	7	4	17	5	3
Skeleton	0	0	161	48	22	8
Skin	153	69	16	1	0	0

Table 2. Location and type of humeral shaft fracture. The number of patients with delayed union is shown in parentheses

	Type of fracture				
	Transverse	Short-oblique	Oblique	Long-oblique	Total
Upper	10 (1)	5 (0)	6 (1)	22 (4)	43 (6)
Middle	44 (12)	20 (4)	10 (1)	20 (4)	94 (21)
Lower	8 (1)	3 (0)	1 (0)	19 (4)	31 (5)
Total	62 (14)	28 (4)	17 (2)	61 (12)	168 (32)

Table 3. Initial treatment in relation to Injury Severity Score (ISS). The number of patients with delayed union is shown in parentheses

	Injury group			
Therapy	1	2	3	Total
Traction	24 (5)	25 (7)	66 (14)	115 (26)
Brace	3 (2)	3 (0)	27 (0)	33 (2)
Operation	19 (2)	10 (2)	8 (1)	37 (5)
Total	46 (9)	38 (9)	101 (15)	185 (33)
Incomplete follow-up	14	14	26	54

Table 4. Radial nerve damage in the three Injury Severity Score (ISS) groups

	Injury group			
	1	2	3	Total
Primary palsy	10	6	5	21
Secondary palsy	6	6	7	19
Total	16/46	12/38	12/101	40/185

Table 5. Radial nerve damage and location of fracture

	Type of fracture				
Fracture location	Trans-verse	Short-oblique	Oblique	Long-oblique	Total
Upper	0	0	0	1	1/43
Middle	6	6	0	0	12/94
Lower	1	1	0	3	5/31
Total	7/62	7/28	0/17	4/61	18/168

Table 6. Recovery of radial nerve motor function in 35 humeral shaft fractures. Functional level according to Sunderland (1968)

	Functional level		
Months posttrauma	M0–M3	M4	M5
0–4	24	0	11
5–8	18	2	15
9–12	12	4	19
13–16	9	6	20
17–20	6	7	22
21–24	4	9	22

considered delayed. Primary radial nerve injury was diagnosed when loss of function was observed immediately after the accident, and secondary injury when it was observed after a period without signs of damage. Radial nerve motor function was graded from M0 (no movement) to M5 (normal power) according to Sunderland (1968).

Fisher's exact test and the chi-square test were used.

Results

The overall incidence of delayed union was 18 percent (Table 3). In the patients treated with traction, the incidence of delayed union did not differ between the three ISS groups. Bracing was not associated with delayed union in singly or moderately injured patients. However, traction in singly injured patients was associated with a greater number of cases of delayed union than bracing ($P <$ 0. 01). Two of three multiply injured patients treated with braces developed delayed union. Traction in multiply injured patients was not associated with a greater number of cases of delayed union than operative methods.

Radial nerve involvement

There were 21 primary and 19 secondary radial nerve injuries (17 percent). In 35 of these 40 radial nerve palsies, outcome data were available. In Group 1 the incidence of primary radial nerve involvement was higher as compared with Groups 2 and 3 ($P < 0.005$, Table 4). Transverse and short-oblique fractures in the midshaft and long-oblique fractures in the distal part of the humerus were more often associated with primary radial nerve injuries ($P < 0.05$, Table 5). One of these injured radial nerves did not regain function.

We had 19 cases of secondary radial nerve paralysis, 11 of which were caused by fracture manipulation or patient factors, such as restlessness. Nine radial nerves regained function, whereas two did not. Four radial nerve palsies were related to excessive callus formation. One radial nerve was explored and three were managed conservatively. All of them resolved with a good result. In the 57 humeral shaft fractures surgically explored without prior radial nerve damage, four radial nerves were damaged: two were injured during exploration, one was grasped in a clamp, and one was wound over an external fixation pin; except for this last case, all of them regained full function.

In 23 cases, the radial nerve was explored, and in 2 cases a neurotmesis was sutured: 1 of these regained complete function. Both fractures were transverse and located in the midshaft. In general, the prognosis of radial nerve injury with or without exploration was good (Table 6).

Discussion

The choice of treatment for a humeral shaft fracture is related to the patient's associated injuries. For the multiply injured patient, operative stabilization of the fracture is advocated, whereas in patients with an isolated fracture of the humeral shaft, a purely conservative treatment is preferred (Holm 1970, Mast et al. 1975, Bell et al. 1985, Brumback et al. 1986). However, every method is related to some disadvantages. Operative fracture stabilization carries the risk of radial nerve injury and infection, whereas traction is related to a higher risk of delayed union.

Vichare (1974) found delayed union in one fifth and unacceptable fracture displacement in two fifths of the multiply injured patients when treated with gutter splints and plaster U slabs. However Peeters et al. (1987) reported excellent results with bracing in multiply injured patients.

Others have investigated operative methods in multiply injured patients. Brumback et al. (1986) used Rush rods in 63 patients with a mean ISS of 24. They reported nonunion in 4 patients, infection in 1 patient, and no radial nerve involvement in any patient. However, protruding devices caused problems in a third of the cases. Plating techniques were used by van der Griend et al. (1986) in treating 36 multiply injured patients; they reported no infections and 1 case of secondary radial nerve involvement; further, only 1 patient needed later surgical intervention to obtain union. Similar findings were reported by Bell et al. (1985). In our multiply injured patients, the high incidence of delayed union does not support the opinion of Vichare (1974) that traction is the best option for treating these patients. Secondary radial nerve palsies and unacceptable fracture displacement were seen with traction. Unacceptable fracture displacement, infection, and iatrogenic radial nerve involvement did not occur when operative methods were used in multiply injured patients. Two of 3 multiply injured patients treated with bracing had delayed union, also indicating that treatment modalities using gravity to obtain alignment should not be used in such patients (Vichare 1974, Bell et al. 1985, van der Griend et al. 1986).

In isolated fractures of the humeral shaft, conservative treatment is associated with excellent results considering the risk of radial nerve damage and infection associated with operative methods (Christensen 1967, Holm 1970, Mast et al. 1975). Over the past six decades, different forms of conservative treatment have been popular. In 1933, Caldwell popularized the hanging cast, which resulted in a decreased incidence of delayed union (Holm 1970). Other conservative treatment modalities became widely used later on, such as bracing and olecranon wire traction. Sarmiento et al. (1977) and Zagorski et al. (1988) reported good results with functional brace treatment. However, an important deficiency of these studies is that, although the results were good, it is not always clear whether the patients were singly injured or not. In Group 3, conservative treatment alone resulted in an average consolidation period of 8 weeks. Bracing led to a lower incidence of delayed union than traction (0 and 14 patients, $P < 0.05$). Like Sarmiento, we believe that bracing is the therapy of choice in ambulatory patients, for it leads to rapid healing with few complications. Bracing can be preceded by a short period of traction (1 week), which facilitates subsidence of the fracture hematoma and prevents malrotation errors.

When the patient is moderately injured, the decision that has to be made as regards treatment might be more complicated. Bracing can be used if the patient does not have to remain in bed. In case of a mild thoracic, abdominal, or head injury, conservative therapy is recommended. If mobilization can be expected within 2 weeks, skeletal traction may precede bracing. If mobilization is not expected within a few weeks, initial operative fixation should be considered.

If the moderately injured patient has extensive skeletal injuries, we recommend primary open reduction and osteosynthesis, because operative stabilization of the humeral shaft facilitates the early movement of joints and prevents pulmonary complications.

Radial nerve paralysis

Several authors suggest a relation between the likelihood of radial nerve damage to the type of fracture and the fracture location. Holstein and Lewis (1963) stated that the radial nerve is more susceptible when associated with long-oblique fractures in the distal third of the humerus. They argued that the force of injury moves the proximal fragment distally, displacing the intermuscular septum through which the radial nerve runs from the posterior to the anterior compartment. At the same time, the apex of the distal fragment moves proximally and radially, thus lacerating the radial nerve between the bone fragments. Mast et al. (1975) reported a higher incidence of radial nerve injury in the midshaft, and concluded that radial nerve damage was basically caused by the close anatomic relation to the middle part of the shaft.

Böstman et al. (1985, 1986) reviewed 59 patients with radial nerve paralysis. They concluded that a paralysis in the midshaft is the result of a direct impact to the nerve, and leads in most cases to a contusion, whereas in the distal third, an indirect mechanism with traction applied to the nerve would lead to laceration or entrapment of the radial nerve. Our results are comparable to those of Böstman et al. (1985, 1986). The fractures associated with radial nerve involvement differed in type when situated in the middle or distal segment of the shaft. In the middle segment, transverse fractures were more frequent, whereas in the distal segment, long-oblique fractures were more frequent. However, the number of cases was too small to draw definite conclusions concerning the prognosis related to the location and type of fracture.

Does the presence of a radial nerve paralysis justify operative fracture treatment, and thus exploration of the radial nerve? In the 1950s and 1960s, exploration of the radial nerve was advocated (Holstein and Lewis 1963, Packer et al. 1972); however, in the 1970s, satisfactory radial nerve recoveries were reported with a wait-and-see policy (Pollock et al. 1981). Especially in primary radial nerve paralysis, this policy is advocated (Mast et al. 1975, Pollock et al. 1981). Our observations confirm this opinion. In treating secondary nerve paralysis, opinions differ. Most authors advise early exploration because entrapment after manipulation is frequently found (Klenerman 1966, Packer et al. 1972, Müller et al. 1979).

Delayed union

Is a certain type of fracture an indication for operative stabilization? Mast et al. (1975) found a relationship between the location of the fracture and the occurrence of delayed union. He found that fractures situated between the upper and middle part of the shaft were more susceptible to delayed union. He found no explanation for this. Others reported a higher incidence of delayed union when a fracture was situated between the middle and distal parts of the humeral shaft (Klenerman 1966). This was explained as an injury to the nutrient artery of the shaft, and consequently resulted in a higher risk of delayed union or nonunion. We found that no fracture location or fracture type was specifically prone to delayed union (Table 2). Remarkably, long-oblique fractures had the same overall incidence of delayed union as transverse fractures. Müller et al. (1970) recommended operative treatment for all transverse fractures of the shaft because others had found that transverse fractures when located in the midshaft were more prone to undergo delayed union (Epps 1975). We believe that except for transverse midshaft fractures the location and the type of the fracture are of minor importance in the decision whether or not to treat a patient with a humeral shaft fracture conservatively or operatively.

On the whole, we found that in multiply injured patients with a humeral shaft fracture, operative intervention is the treatment of choice for avoiding general pathophysiologic complications. In moderately injured patients, the initial choice of treatment depends on the mobility of the patient. If the patient can be mobilized within a reasonable period of time, initial traction followed by bracing is preferable. In singly injured, mobile patients, bracing is the best option.

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