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Predictors of Nonunion in Humerus Shaft Fractures in Adults in Lomé (Togo)

Atchi Walla[1]*, Gamal Ayouba[2], Dadja Essoya Landoh[3], Batarabadja Bakriga[1], Tchaa Towoezim[1], Anani Abalo[1], Assang Michel Dossim[1]

[1]Service de Chirurgie Orthopédique et Traumatologique, CHU Sylvanus Olympio, Lomé, Togo
[2]Service de Chirurgie Générale du Centre Hospitalier de Kpalimé, Kpalimé, Togo
[3]Division de l'Epidémiologie, Ministère de la Santé, Lomé, Togo
Email: *atchi.walla@yahoo.fr

Abstract

Background: To identify predictors of humerus shaft fractures nonunion in adults whatever the type of treatment performed. Patients and Methods: We conducted a retrospective study among patients who had a fracture of the humeral shaft moving towards healing or nonunion. Patients were treated in the orthopedic trauma unit of Sylvanus Olympio Teaching Hospital and two other private clinics in Lomé between January 2008 and June 2012. On the X-ray of each patient, we measured the angulation, the diastasis, and inter fragmentary contact. For each included patient, we looked for: age, sex, medical history, body mass index (BMI), according to the third location of the shaft fracture, the type of fracture according to AO classification and the type of opening according Tscherne classification. Results: During the study period, 184 patients with humeral shaft fracture were identified. Of these 108 were men. The mean age of patients was 37.3 years. The fractures were treated conservatively in 100 patients (54.3%), 78 treated surgically and six (3.3%) have discharged from hospital against medical advice for traditional treatment. The factors that were associated with nonunion of humerus shaft fractures in these patients were: the opening of the fracture (RR = 4.5; 95% CI = [2.9; 7.1]), the presence of immediately radial paralysis (RR = 5.6; 95% CI = [3.7; 8.5]), the existence of other associated lesions or fracture (RR = 1.8; 95% CI = [1.1; 3.1]), energy of the trauma (RR = 2.3; 95% CI = [1.3; 4.4]) and type III classification of Tscherne (RR = 0.3; 95% CI = [0.2; 0.6]). After multivariate analysis, factors that remained significantly associated with the failure of consolidation were: the existence of diastasis > 2 mm (OR = 7.6; 95% CI = [2.2; 25.6]), the Body Mass Index (BMI) > 25 (OR = 1.3; 95% CI = [1.1 - 1.6]) and the existence of other bone lesion (OR = 4.3; 95% CI = [1.4 - 18.9]). Conclusion: BMI greater than 25, the existence of an interfragmentary gap of more than 2 mm and existence of other bone lesions are significant risk factors for nonunion in humerus shaft fractures. The traditional treatment, common singular factor to the African environment, should not be ignored. Control of these predictors is necessary in carrying out the treatment of humerus shaft fractures.

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*Corresponding author.

1. Introduction

The frequency of the humeral fractures is between 5% and 8% of all fractures [1]. According to Mahmoud El-A Rosay, among humerus shaft fractures, treated conservatively, 2% - 10% and around 15% treated surgically, progress to nonunion [2].

Nonunion is a debilitating complication for the patient [3], a challenge for the practitioner [1] and an economic burden to society [4]. Several factors have been cited as risk of nonunion in shaft fractures of the humerus including obesity, osteoporosis, alcoholism, smoking, poor bone quality and scar tissue [5]. Other publications still observed in many of these factors, technical errors [6] [7].

Because of rarity of African studies on this subject, we proposed to identify through our study, factors which, taken separately or combined could explain the occurrence of nonunion in African setting after treatment of humerus shaft fractures.

2. Patients and Methods

We conducted a retrospective study in patients with humeral shaft fractures moving towards healing or nonunion. The sample, consisting of 184 patients with shaft fractures, included the records of patients treated by the same team during the period from January 2008 to June 2012 in the orthopedic trauma unit of Sylvanus Olympio teaching hospital and two others privates clinics of Lomé. On each patient's humerus X-ray, we measured the following: angulation, the diastasis, and inter fragmentary contact after treatment. For each included participant, we looked for the age, sex, medical history, body mass index (BMI), the location of the fracture of the bone concerned, the type of fracture according to AO classification and the type of opening according to Tscherne classification. The study of body mass index was based on a simplified WHO classification and the International Obesity Task Force.

Conservative treatment consisted of the production of a thoracic outlet plaster or dangling plaster after or without reduction of the fracture. The implants used in cases of surgical treatment were plates, Seidel nail, and external fixators types of Hofmann second generation. Ten patients were operated on closed fracture.

Healing or nonunion of the fracture was observed on X-ray control six months after treatment.

Data were recorded using Epi Info software version 3.5.1. For continuous variables, means and standard deviation were calculated while for categorical variables we calculated proportions. Our primary outcome of interest was patient who developed nonunion fracture to ART compared to those who had their fracture consolidated. Pearson chi-square test or Fisher's exact test were used when appropriate in bivariate analysis.

In the multivariate logistic regression was performed to identify independent risk factors in the occurrence of nonunion fractures.

All the significant variables in the bivariate analysis with a p-value less than 0.05 and the previously known variables associated with the occurrence of nonunion were included in the multivariate analysis. However, we excluded from the model the variable "onset of paralysis" since there were missing values for a large number of subjects. We then removed from the model in a progressive manner the variables that were not significant with a p-value > 0.3. No interaction was made in the logistic regression between variables included in the model.

Ethical Aspects

This study was authorized and conducted under the direction of the chief of orthopedic trauma unit of Sylvanus Olympio Teaching Hospital. This is a retrospective study consisting in the analysis of patient records; however, the privacy aspects were met: only aggregated data have been presented to ensure confidentiality.

3. Results

Of the 184 patients, 108 were male and 76 were female with a sex ratio (M/F) = 1.4. The mean age of the par-

ticipant was 37.3 years ranging from 17 to 72 years old.

Seventy (70) patients (38.04%) had a medical history of which 16% were alcoholics, 9% were tobacco users, 12% were diabetics, 18% had sickle cell disease.

3.1. Lesional Characteristics

There were 169 (91.8%) cases of public highway accident, 7 cases (3.8%) of work accident, 7 cases (3.8%) of intentional injury and 1 case accident perfirearm.

In 22 patients (11.9%), fractures were opened; 3 patients presented with major lesions of soft tissue. Bone lesions associated with humerus shaft fracture were recorded in 68 patients (36.9%); 5 cases (2.7%) were not documented. These bone lesions are detailed in **Table 1**.

There were 10 cases (5.4%) of immediately radial paralysis.

Treatment was conservative in 100 patients (54.3%) and surgical in 78 patients (42.4%) while 6 patients (3.3%) were discharged from hospital against medical advice for traditional treatment. The DCP plate was used in 89 patients, the Siedel nailin 5 patients and 3 patients with external fixators. Osteosynthesis were performed with autologousbone graft in 6 cases and without graft in86 cases. Radiological characteristics after the reduction are shown in **Table 1**.

3.2. Outcome

There was one (1) case of early postoperative superficial infection whose evolution was controlled. In total, 142 patients (77.2%) consolidated after 6months of evolution and other patients (22.8%) had progressed to nonunion fracture.

The factors that were associated with nonunion of humerus shaft fractures in these patients were: the opening of the fracture (RR = 4.5; 95% CI = [2.9; 7.1]), the presence of radial paralysis immediately (RR = 5.6; 95% CI = [3.7; 8.5]), the existence of other associated lesions or fracture (RR = 1.8; 95% CI = [1.1; 3.1]), energy of the trauma (RR = 2.3; 95% CI = [1.3; 4.4]) and type III classification of Tscherne (RR = 0.3; 95% CI = [0.2; 0.6]). Patients with BMI between 25 and 28, and BMI greater than 28 were more likely to progress to nonunion than those with a BMI below 25 (**Table 2**).

In the multivariate analysis showed in **Table 3**, factors that remained significantly associated with the failure of consolidation were: the existence of diastasis > 2 mm (OR = 7.6; 95% CI = [2.2; 25.6]), the Body Mass Index (BMI) > 25 (OR = 1.3; 95% CI = [1.1 - 1.6]) and the existence of other bone lesion (OR = 4.3; 95% CI = [1.4 - 18.9]).

4. Discussion

In this study, we found that three factors were significantly associated with the failure of consolidation of humerus shaft fractures were: the existence of diastasis > 2 mm, the Body Mass Index (BMI) > 25 and the existence of other bone lesion. In our study, female gender seems with 27.6% against 19.4% for men, tend to progress more to nonunion; however, the difference was not significant. This has been noted by BROADBENT [8] without providing an explanation on the real interference of the sex in the healing process.

Nonunion rate before 30 years old was 24%; this rate decreased to 20.7% after 30 years. In the series of SOFCOT symposiumin 2004, there was a very marked nonunion rate in the age group of 15 - 35 years accounted for 49% of total nonunion [9]. This disparate distribution may mean that the age does not appear to be a factor in the occurrence of nonunional though osteoporosisis mentioned as a risk factor [10]; the difference between the results that can be attached to the sample used in our study. However it might be interesting to investigate the simultaneous influence of age and sex couple as postmenopausal women for example.

It appeared in various studies that obesity (BMI > 28) is a factor which can lead to the failure of consolidation [8] [10] [11]. In our study, obesity was significantly associated with the occurrence of nonunion. Obese patients with advanced toward nonunion, are predominantly female and treated conservatively (hanging humeral plaster or thoracic outlet plaster); fat masses and presence of breasts in these patients, can induce mobilities of fracture site that are harmful to the consolidation process.

The presence or absence of medical history in our study had no significant effect on the occurrence of nonunion; However, in our study sample, known factors of nonunion as, alcoholism, smoking, diabetes [10] [12] [13] have not all been documented because of the retrospective nature of the work.

Table 1. Characteristics of the patients included in the study.

	Cases number	Percentage (%)
Sex		
Male	108	59
Female	76	41
Medical story		
Yes	70	38.04
No	114	61.96
Type of accident		
Work accident	7	3.8
Highway accident	169	91.8
Intentional injury	7	3.8
Perfirearm	1	0.6
Type of fracture		
Open fractures	22	12
Closed fractures	162	88
Interfragmentary gap		
<2 mm	77	41.8
Between 2 and 3 mm	31	16.8
Between 3 and 4 mm	4	2.2
>4 mm	0	0.0
Not documented	72	39.1
Contact area		
At least third circumference	20	10.9
1/3 to 1/2 circumference	15	8.2
>1/2 circumference	51	27.7
No contact	4	2.2
Not documented	94	51.1
Associated bone lesions		
Yes	68	37.9
No	111	62.1
Type of bone associated lesions		
Femur fracture	4	5.9
Tibia fracture	8	11.8
Femur and tibia fractures	7	10.3
Tibia and distal humerus fractures	3	4.4
Tibia and forearm fractures	4	5.9
Distal humeral fracture	6	8.8
Wrist fracture	3	4.4
Ribs fractures	7	10.3
Forearm and ribs fractures	3	4.4
Fracture of hand and foot squelet	23	33.8

Table 2. Factors associated with nonunion.

	Nonunion N (%)	Consolidation N (%)	RR	95% CI	p
Sex					
Female	21 (27.6)	55 (72.4)			**0.19**
Male	21 (19.4)	87 (80.6)	1.4	0.8 - 2.4	
Age					
<30 ans	24 (24.7)	73 (75.3)			
>30 ans	18 (20.7)	69 (79.3)	1.2	0.7 - 2.1	**0.6**
BMI					
<25	16 (14.5)	94 (85.5)	Ref		
[25 - 28]	13 (29.5)	31 (70.5)	2.1	1.1 - 3.9	**0.05**
>28	9 (47.4)	10 (52.6)	3.3	1.7 - 6.3	**0.002**
Medical story					
Yes	14 (20)	56 (80)			**0.59**
No	28 (24.6)	86 (75.4)	1.2	0.7 - 2.2	
Type of fracture					
Open	16 (72.7)	6 (27.3)			**<0.001**
Closed	26 (16.1)	136 (83.9)	4.5	2.9 - 7.1	
Immediately radial paralysis					
Yes	9	1			**<0.001**
No	24	125	5.6	3.7 - 8.5	
Associated bone lesions					
Yes	22	46			**0.04**
No	20	91	1.8	1.1 - 3.1	
Traumaenergy					
Low	15 (31.9)	32 (68.1)	Ref		
Average	15 (13.6)	95 (86.4)	2.3	1.3 - 4.4	**0.007**
Strong	12 (44.4)	15 (56.6)	0.7	0.4 - 1.3	**0.4**
Stroke type					
Single transverse	16 (20.0)	64 (80.0)	Ref		
Long or short oblique	2 (18.2)	9 (81.8)	1.1	0.3 - 4.2	0.6
Comminuted	8 (21.1)	30 (78.9)	0.9	0.5 - 2.1	0.9
With third fragment	16 (29.1)	39 (70.9)	0.7	0.4 - 1.3	**0.3**
Tscherne classification					
Tscherne 1	14 (21.9)	50 (78.1)			
Tscherne 2	15 (15.8)	80 (84.2)	1.4	0.7 - 2.7	0.4
Tscherne 3	13 (65.0)	7 (35.0)	0.3	0.2 - 0.6	**<0.001**

Continued

Fracture sit					
Upper 1/3	12 (20.0)	48 (81.4)			
Midle 1/3	25 (24.0)	79 (76.0)	0.8	0.5 - 1.5	0.7
Less 1/3 Inférieur	5 (25.0)	15 (75.0)	0.8	0.3 - 1.9	**0.8**
Type of treatment					
Conservative	29 (34.5)	55 (65.5)			**<0.001**
Surgical	13 (13.0)	87 (87.0)	2.7	1.5 - 4.8	
Lack of immobilization (traditional treatment)					
Yes	6 (100)	0 (0)			**<0.001**
No	36 (20.2)	142 (79.8)	4.9	3.7 - 6.6	
Interfragmentary gap					
>2 mm	17 (48.6)	18 (51.4)			**<0.001**
<2 mm	8 (10.4)	69 (89.6)	4.7	2.2 - 9.8	

Table 3. Multivariate analysis of possible factors of nonunion.

	Odds ratio	95% CI	Coefficient	p-value
Interfragmentary gap > 2 mm	7.6	2.2 - 25.6	2	0.0011[*]
BMI	1.3	1.1 - 1.6	−0.3	0.0376[*]
Bone associated lesions	5.3	1.4 - 18.9	1.7	0.011[*]
Conservative treatment	2.4	0.6 - 10.2	0.9	0.2349
Energy of trauma	0.5	0.0 - 90.9	−0.6	0.8071

4.1. Lesional Factors

The opening of the fracture with the spoliation of consolidation factors and the involvement of a high-energy trauma that generates soft tissue lesions are factors identified by several authors as being able significantly determine the evolution of a fracture to the failure of consolidation [14] [15].

The radial paralysis at the outset was a factor significantly associated with nonunion in study. The role of the nervous system in bone metabolism has been demonstrated by HURRELL [16] which found that the growth and bone remodeling were affected through osteoblasts in connection with the nerve fibers; studies of FRYMOYER [17] and MADSEN [18] reported that the resection of the sciatic nerve induced a mechanically insufficient callus after fracture in rats. CHERRUAU discovered that nerve damage can affect bone metabolism due to the release of neuropeptides [19]; also, TOGARI [20] reveals the possible involvement of the nerve dysfunction, which may inhibit bone formation and accelerated bone resorption by reducing releases of neuromodulators factors [21]. It is therefore apparent that the radial palsy outset could play a role in the evolution of the humerus fracture to nonunion; however, larger series will allow better study this factor.

The type of stroke and the seat of the fracture were not significantly associated with nonunion factors in our study as in the work of MARTINEZ [22]; results published on this subject vary widely. While DECOMAS [23], RING [24], and VOLGAS have criminalized short oblique fracture line, others like BABA [25] found that the open comminuted fracture in the middle third was directly associated with nonunion.

Others found instead that the transverse feature was predictive factor of nonunion [8] [10]. These different results may want to indicate that the anatomical type of fracture in itself does not interfere directly in the occurrence of nonunion but its association with the gap inter fragmentary than 3 mm and the interposition of soft tissues could determine nonunion [7] [26]. However, the height of the gap selected for our study was 2 mm.

4.2. Therapeutic Factors

The orthopedic treatment and diastasis greater than 3mmare recognized aspotential factors for developing nonunion [7] [9]; its occurrence if surgical treatment is related to technical errors during osteosynthesis [7] [27].

In sufficientor in adequate immobilization can lead to nonunion [8] [10]. This data was found in our study with positive association of traditional treatment and nonunion; in our sample, all patients who have opted for the traditional treatment for lack of financial means, returnedtous for nonunion; this factor remains a feature of developing countries like ours with very low incomes, do not allow everyone access to conventional care; these poor patients then turn to the healer in which the asset is illusory and broken homes subjected to unwanted massages are mobileas demonstrated OGUNLADE [26].

Smoking, work accident and standard interfragmentary than 3 mm were, in analyzing the series of SOFCOT, statistically significant factors in multivariate analysis [9].

This difference may be related to this type of retrospective study that was not allowing an exhaustive study of the factors that negatively influence bone healing; in addition, this ample size was limited in Lomé. An extensive prospective study taking in account the rest of the country would be more objective.

5. Conclusion

BMI greater than 25 and the existence of interfragmentary gap of more than 2 mm and bone lesions are significant risk factors for nonunion in the multivariate analysis. In the bivariate analysis, the traditional treatment remains a singular risk factor, specific to developing countries such as ours. It should not be ignored. Control of these predictors is necessary in carrying out the treatment of humerus shaft fractures to prevent nonunion.

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