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Research Article

"Open Fractures Infection! Bacteriological Study and Risk Factors" Cohort Study

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Abstract

Introduction: The incidence of infection following an open fracture remains high, especially for open fractures with loss of substance. The purpose of this study is to determine risk factors for hospital infection and to determine germs and their susceptibility to antibiotics.

Patients and Method: This is a monocentric prospective cohort follow-up. Included patients were those over the age of 15 admitted to hospital for an open leg fracture.

Results: A total of 57 patients were included in the study. The average age of patients was 35 years old [16 to 66 years old]. Open fracture type III was observed in 24 patients (42.10%), including 16 patients with type IIIA fracture (28.07%) and 8 patients with type IIIB fracture (10.03%). Of the 57 cases of open leg fractures, 11 patients (19%) had an infection. Two risk factors were identified: Open fracture type III (RR = 13.75, CI [2.66 - 196.15]) and the existence of bone externalization at the time of the accident (RR = 3, 52, IC [1.13 - 21. 69]). Of the 11 cases of infected open fractures, 15 germs were isolated. *Pseudomonas aeruginosa* was isolated 5 times (35.71%), followed by *Staphylococcus aureus* isolated 3 times (20%). Regarding the sensitivity of germs, 4 were multi-resistant bacteria (MRB).

Keywords: *Complication; Infection; Leg; Open Fracture; Staphylococcus*

Introduction

Cutaneous opening complicates 10% of fractures [1]. This exposes the outbreak to contaminations first initial (at the place of accident and during transport) then hospital (during the hospital stay) at the origin of an infection whose management is difficult. Measures are proposed to fight against this infection combining medical and surgical means. Nevertheless, the incidence of infection remains high, especially for open fractures with loss of substance [2]. Especially since studies reported infections by gram-negative and multi-resistant antibiotics [3]. The purpose of this study is to determine the risk factors for infection in hospitals and also to determine the nature of the germs at the origin of the infection and their susceptibility to antibiotics.

Patients and Method

The study was performed in an orthopedic and trauma department. The study period was 6months from April 1st to September 30th, 2015. Patients over the age of 15 admitted to hospital for an open leg fracture throughout the study period were recruited comprehensively. Joint fractures, patients lost sight of, patients discharged against medical advice and amputee patients in the emergency department were excluded. The initial management of patients was carried out in emergency rooms systematically comprising analgesics, antibioprophylaxis (Amoxicillin-Clavulanic acid 2g in IVDL). In the block, a large physiological saline wash was mixed with iodinated povidone injected into the gavage syringe supplemented with a mixture of antiseptic (oxygenated water and iodinated povidone) and end with a saline rinse physiological saline. All the necrotic and devitalized tissues were excised. The wound is immediately sutured for fractures without loss of substance (Gustilo I, II, IIIA). For loss of substance fractures, an "American" type sterile dressing is placed after trimming, flap recovery is performed no later than 5 days after the first procedure. External restraint (plaster splint for Gustilo I fractures and external fixator for Gustilo II and III fractures) was put in place at the end of the procedure. The antibiotic was systematically continued at a curative dose for 10 days. For open fractures type I and II, a definitive compression (plaster or ORIF) was set up from the 15th day of the accident in the absence of infection. In case of infection, an external fixator would be put in place for fractures initially stabilized by plaster. If the contention is already provided by an external fixator, it is maintained until the drying of the wound. Patients were followed throughout the hospital stay. A dressing was performed in the hospital room every 2 days until the discharge of the hospital. Cases considered to be infected were unhealed wounds from the tenth day after hospitalization with continuous secretion (whatever the nature), the removal of which (sterile swab with culture on ordinary medium) made it possible to isolate pathogen (s). The studied parameters were: age, sex, height, weight, medical history (diabetes, hypertension) and toxic (tobacco, alcohol), type of accident (work accident, domestic accident, sports accident, school accident, traffic accident) the interval between the time of the accident and the time of arrival to the emergency (before or after 6 am), the means of transport (private car, city taxi, ambulance not medicalized, medical ambulance, other), the interval between the time of the accident and the time of the first dose of antibiotic (before or after 6h), the existence or not of a bone externalization just after the accident, the type of initial fracture according to Gustilo and Anderson (Type III or others), fracture level. In case of infection, the culture-isolated seed (s) was identified to determine their susceptibility to antibiotics.

Result

A total of 57 patients were included in the study. The average age of patients was 35 years [16 to 66 years]. Patients aged between 15 and 35 years were 30 (52.63%). The sex ratio (M/F) was 2.56 with 41 men (72%) and 16 women (28%). The body mass index (BMI) was normal [BMI between 18 and 25] for 49 patients (85.96%), one patient (1.75%) was obese [BMI greater than 30], 3 patients were overweight [BMI between 25 and 30] and 4 patients were malnourished [BMI less than 18]. The traffic accident was the main etiology with 47 patients (82.46%). The transport to the hospital consisted of taxis in 37 patients (64.91%), personal cars in 15 patients (26.31%), 3 patients were transported by ambulance, one patient by motorcycle and a patient by a police car. Regarding the toxic habits, 21 patients (36.84%) were both alcoholic and smoking, 7 patients (12.28%) only alcoholic and 10 patients (17.54%) only smokers. For the medical history, 6 patients (10.52%) had hypertension and only 1 patient was diabetic (1.75%). The fracture was observed on the right leg for 30 patients (52.63%) and the left leg for 26 patients (45.61%). One patient had a bilateral fracture but only the right side was open (Figure 1). The type of fracture 42A according to AO (synchronous fracture of the two bones of the leg) was found in 20 patients (35.09%), for 3 patients it was isolated fractures of the tibia (5.26%), and for 4 patients were isolated fractures of the fibula (7.02%) (Table 3). Open fracture type III was observed in 24 patients (42.10%), including 16 patients with type IIIA fracture (28.07%) and 8 patients with type IIIB fracture (10.03%). Type I fracture was observed in 19 patients (33.33%) and type II in 14 patients (24.56%). Bone externalization was reported at the time of the accident in 20 patients (35.09%). Six patients could not answer whether there was bone externalization or not. The average time taken after the accident was 3h 43min [15 minutes to 23h]. Initial management was performed before six hours after the accident for 49 patients (85.96%). For the remaining 8 patients (14.03%) initial management was performed after the sixth hour. Of the 49 patients, 20 patients (40.82%) were managed in the first hour and 21 patients (42.85%) in the second hour (Table 2). The average

time between the accident and the first dose of antibiotic prophylaxis was 13h 14 minutes [1h15 to 28h]. Anti-prophylaxis was administered before the 6th hour for 14 patients (24.56%) and after the 6th hour for 43 patients (75.44%). All patients had initial trimming and emergency external fixation (external fixation for type III and posterior plaster splint for type I and type II). For open type III fractures, 11 patients required a secondary flap, including 5 gastrocnemius flaps and 6 saphenous flaps. The average duration of hospitalization was 17 days [3 - 61 days]. The majority of patients were discharged between the first (32%) and the second week (23%). Of the 57 cases of open leg fractures 11 patients (19%) had an infection. Two risk factors for infection were identified: Type III open fracture (RR = 13.75, CI [2.66 - 196.15]) and the existence of bone exteriorization at the time of the accident (RR = 3.52, IC [1.13 - 21.69]) (Table 1). The delay in treatment after the 6th hour (RR = 0.61, CI [0.06 - 5.09]), the delay in administering the first antibiotic prophylaxis dose greater than 6 hours (RR = 1.47 IC [0.30 - 8.43]), alcoholism (RR = 1.43, CI [0.42 - 5.85]), smoking (RR = 0.44, IC [0.09 - 1, 09]) were not correlated with the occurrence of an infection. Of the 11 cases of infected open fractures, 15 germs were isolated. Concomitant infection with two germs was found in four patients (26.66%). *Pseudomonas aeruginosa* was isolated 5-fold (35.71%), followed by *Staphylococcus aureus* which was isolated 3-fold (20%) (Figure 1). Gram-negative bacilli were exclusively responsible for infections of open fractures type II (1/1) and IIIA (5/5). For type IIIB open fractures, 9 germs were isolated including 4 gram-negative bacilli and 5 gram-positive bacilli (Table 2). Regarding the susceptibility of germs to antibiotics, 4 germs (26%) were multi-resistant bacteria (MRB) (Table 3). These MRBs consisted of two *Pseudomonas aeruginosa*, a methicillin resistant Staphylococcus coagulase negative (SNCoRM) and a hafnia alvei. The remaining eleven germs (60%) were *Pseudomonas* sp (4 germs), *Staphylococcus aureus* (3 germs) and *Acetobacter* sp (2germs). These 9 germs were 100% sensitive to Gentamycin. The four *Pseudomonas* sp were 100% sensitive to ceftazidime, cefpirome and colistin. They were 100% resistant to ceftriaxone, cefpodoxime, ampicillin, amoxiclav and cephalosporins of 1st and 2nd generation. The three *Staphylococcus aureus* were sensitive to several molecules including cephalosporins. They were 100% resistant to Ampicillin and Amoxicillin. Both Acinetobacter's were sensitive to imipenem and gentamycin.

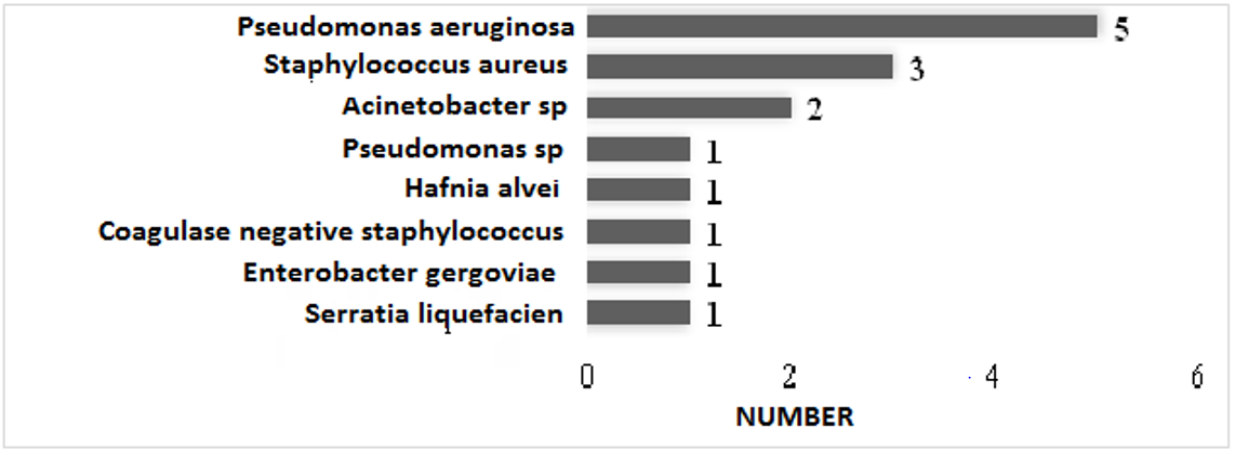

Figure 1: *Distribution according to the type of germ.*

Risk factors		Infected N°(%)	Uninfected N°(%)	Effective	RR	IC
Delay of care	> 6h	1 (1.75)	7 (12.28)	57	0.61	[0.06 - 5.09]
	< 6h	10 (17.54)	39 (68.42)			
Alcohol	Yes	6 (10.52)	20 (35.08)	57	1.43	[0.42 - 5.85]
	No	5 (8.77)	26 (45.61)			
Tobacco	Yes	5 (8.77)	24 (42.10)	57	0.44	[0.09 - 1.09]
	No	11 (19.3)	46 (80.70)			
ATB delay	> 6h	9 (15.78)	34 (59.64)	57	1.47	[0.30 - 8.43]
	< 6h	2 (3.50)	12 (21.05)			
Very soiled (+++/++++)	Yes	1(1.75)	3 (5.26)	57	1.46	[0.15 - 17.95]
	No	7 (12.28)	34(59.65)			
	Not determined	12 (21.05)				
Gustilo III	Yes	10 (17.54)	14 (24.56)	57	13.75	[2.66 - 196.15]
	No	1 (1.75)	32 (56.14)			
Wearing pants	Yes	6 (10.53)	33 (57.89)	57	0.46	[0.05 - 2.42]
	No	2 (3.51)	4 (7.02)			
	Not determined	12 (21.05)				
Externalization of the bone	Yes	8 (14.03)	14 (24.56)	57	3.52	[1.13 - 21.69]
	No	3 (5.26)	26 (45.61)			
	Not determined	6 (10.53)				

Table 1: *Study of Risk Factors for Open Fracture Infection.*

	Gustilo Classification			
	Type II	Type IIIA	Type IIIB	Total (%)
Gram positive	-	-	4	4 (26.66)
Gram negative	1	5	5	11 (73.33)

Table 2: *Distribution of germs according to the Gustilo Classification.*

Germ type	Antibiotic	Duration	Drying
PARC	Gentamycin Ciprofloxacin	5 days 35 days (5+30)	19 days
PARC	Gentamycin Ciprofloxacin	5 days 58 days (5+53)	50 days
SNCo RM	Gentamycin Ofloxacin	5 days 50 days (5+45)	42 days
ERC (Hafnia alvei)	Amikacin	46 days	40 days

Table 3: *Type and Duration of Antibiotic Therapy and Drying Time for Each MRB.*

PARC: Pseudomonas aeruginosa intermediate or resistant to ceftazidime

SNCo RM: Staphylococcus negative coagulase resistant to Methicillin

ERC: Enterobacter resistant to 3rd generation cephalosporins

Discussion

Infection is the main secondary complication of an open fracture. Its proportion varies from one hospital to another. In sub-Saharan Africa, such as Nigeria [1] and Chad [2], the infection rate is 51% and 44%, respectively. A study in Japan reported an infection rate of 6.1% [3]. For our series, the infection rate was 19%, which was close to the proportion reported in several studies [4,5].

The management of open fractures is not standardized despite the few universally approved concepts. Gustilo., *et al.* [6] showed that the implementation of preventive measures (debridement and antibiotic prophylaxis) made it possible to reduce the risk of infection. This was also observed by István K., *et al.* [7] over a period of 15 years, they noted a clear decrease in the infection rate by improving the initial management of open fractures.

From the opening of the fracture site, it is subject to bacterial contamination, germs that consist essentially of community germs. This contamination occurs at the accident site and during transport. This "initial contamination" is effectively treated through the application of medical and surgical prevention measures. A study conducted in India by Reddy L., *et al.* [8] showed that initial contamination of the fracture site, taking into account the various preventive measures, could not predict the possibility of an infection. This leads us to consider the risk of "secondary contamination" essentially hospitable open fractures. Indeed, for our study, of the 15 isolated organisms, eleven (73%) were gram-negative bacilli and four (26%) were multi-resistant bacteria. They were germs a priori hospitable. Once arrived at the hospital, an open fracture must follow a sterilized circuit which each step of management must be performed in a condition of drastic sterility including block, in the room and especially during each dressing. However, the realization of an early recovery flap of open fractures with loss of substance remains the best solution to barrier to possible hospital contamination. Regarding the debridement time, the delay of 6 hours can only be arbitrary from an experimental study whose recommendation goes back several decades and by which its own author explains the scope and the limit. In fact, a study by Harley., *et al.* [9] stated that debridement performed after 6 hours was not a risk factor for hospital infection. This does not mean that the management of open fractures is not an emergency. It is obvious that the risk of an infection is all the greater as the time of debridement is delayed. A study in Japan by Yokoyama K., *et al.* [2] found that early surgical debridement and early focus coverage was a protective factor against infection ($p < 0.05$). This time factor is all the more evident in hospitals where patients are treated late. A study carried out in Nigeria by Ikem IC., *et al.* [1] also observed a relationship between debridement time and the occurrence of an infection ($p = 0.008$). As with any emergency, the management of an open fracture needs a temporal reference and objective, as well as keeping this 6 hours delay without stubbornness or fanaticism, taking into account the local possibilities with regard to the availability of staff and inputs.

Despite the advanced means of management of open fractures, the decay of the soft tissues and the violence of the trauma were consistently identified as a risk factor for infection. A study by Miguel., *et al.* [10] in Brazil showed that among 20 cases of open fracture infection 16 were Gustilo-Anderson type III fractures ($p = 0.008$). In Malaysia, Nazri., *et al.* [11] conducted a study of 79 open fractures and also found a correlation between Gustilo-Anderson fracture severity and the occurrence of an infection. For our series, skin-muscle delamination (Gustilo III) and bone externalization during trauma were risk factors for infection. After the trauma, the tissues (skin, muscle, periosteum) suffered a distress by the disruption of their vascularization which will lead to tissue hypoxia. These suffering tissues do not defend themselves against bacterial attacks and would be a favorable bed for infections. Therefore, careful trimming should be done by removing all tissues of doubtful vitality. By removing these tissues, the operator certainly decreases the risk of infection by initial contamination but widens the loss of substance and exposes the outbreak to hospital contamination. The ideal would be realized immediately after trimming a recovery of the home by a flap. Studies [12,13] have shown that the realization of an immediate recovery flap reduced the risk of infection by hospital germs, decreased the number of procedures and accelerated bone healing. A study by Gopal., *et al.* [14] noted that immediate coverage of loss of substance fractures prevented nosocomial infections, including *Pseudomonas* sp infections. Whatever the realization of an immediate flap is virtually impossible in most Traumatology centers. The alternative will initially be a dressing with a vacuum assisted closure (VAC). A study by Hou Z., *et al.* [15] showed that performing this type of dressing while waiting for a flap significantly reduced the risk of infection and amputation.

Antibiotic plays an important role against infection during open fractures [16]. Its initiation before 3 hours at a prophylactic dose would significantly reduce the risk of infection [17]. When the type of antibiotic used, it was changing over time. Initially, the use of penicillin and streptomycin or first generation cephalosporin was recommended to target primarily Gram positive [18]. After Gram-negative infection of open, dilapidated fractures, Gustilo., *et al.* [19] recommended the use of second-generation cephalosporin for type I open fractures and the addition of aminoglycoside for type II and type III. Contemporary studies reported a high proportion of infection due to negative Gram [20,21]. For our series, there is a clear predominance of Gram negative infection. This predominance was observed for type I, type II and type III open fractures. Thus, whatever the type of fracture, it would be desirable to carry out antibiotic prophylaxis which covers both Gram negative and Gram positive. Despite the massive presence of MRB in our series (40%), it would be unwise to target these germs with antibiotics using the risk of causing pan-resistant germs. Since it is a nosocomial infection, the contamination by these germs should be avoided by the usual preventive measures by insisting on the respect of a sterile circuit during the hospitalization and especially during the dressing (surgical washing of the hands, wearing mask and use of disposable set, confine the patient in a single room previously disinfected...). For our series, the management of MRB infections was discussed on a case-by-case basis with infectious disease specialist.

Conclusion

The degree of cutaneous opening, including soft tissue openings, remains the major risk factor for open fracture infection in hospital settings. There are an alarming proportion of gram-negative bacilli and multi-drug resistant germs. These germs are essentially hospital germs responsible for nosocomial infection whose treatment is difficult and expensive. Since it is often difficult to achieve an emergency recovery flap, all preventive measures against "hospital contamination" of open fractures with loss of substance must be taken throughout the treatment.

Conflict of Interest

No conflict of interest.

Authors' Contribution

Ralahy Malinirina Fanjalalaina: Protocol writing, article writing, submission and article review.

Andrianimaro Florelia Martinetti - Anesthesiologist - CHU Tambohobe- Fianarantsoa.

Widade: Recruitment and follow-up of patients, data collection.

Mamy Ben Joseph: Bibliography.

Razafimahandry Henri Jean Claude: Correction before submission.

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