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Predictors of early wound infection in open lower limb long bone fractures

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Abstract
Aim To determine the predictors of early post-operative wound infection following debridement in lower limb long bone fractures.
Methods 56 patients with open lower limb long bone fracture who consented were studied. Early wound infection was defined as infection occurring not later than 1 month of wound debridement. Using Chi-square and logistic regression analysis, factors such as mechanism of injury, G-A grade of the fracture, method of immediate skeletal stabilization and method of wound closure were correlated with rate of infection.
Results The rate of wound infection in G-A grade I, II, IIIA and IIIB fractures were 1.8%,10.7%, 21.4% and 28.6% respectively. All 14 patients who had immediate skeletal stabilization for G-A IIIA or B with external fixation developed either a post-operative wound infection or pin tract infection.In this study 18(32.1%) patients with tibia and fibular fracture had wound infection compared to 5(8.9%) patients with femoral fracture.
Conclusion Logistic regression shows that the G-A grade of fracture, the anatomic site of fracture i.e. femur or tibia and the immediate method of skeletal stabilization were the main predictors of wound infection in open lower limb long bone fractures.Keywords Predictors of wound infection, G-A grade, immediate method of skeletal stabilization, wound infection.

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I. Introduction

Open long bone fractures are Orthopaedic emergencies associated with high risk of infection and consequent long-term morbidity.[1] The incidence of open fractures is on the increase in our environment due to the increase in motor vehicular accident (MVA) as well as the prevalence of civilian conflicts and the challenge of terrorism. The predictors of wound infection in open fractures have been a subject of research. Open Lower limb fractures are associated with increased rate of infection, [2] with tibia/fibular fractures commonly affected. An incidence of 69.5% of infection wasreported by Ngim and colleagues in Calabar.[3] The high rate of infection in the tibia as suggested by Bryan, [4]can be attributed to restricted soft tissue coverage over tibia and poor osseous supply. Pollak et al, in a prospective study showed that the time of injury to debridement is not a significant independent risk factor for infection rate,[5] and Harley et al also concluded that the strongest predictor for deep seated infection was the grade of the fracture and not the time to debridement.[6]There is great need to determine the predictors of wound infection, as this will go a long way in putting measures that will mitigate this catastrophic complication in open fractures.

II. Materials And Methods

This was a prospectivestudy that was conducted in the Orthopaedic Department of JUTH on patients presenting, with open long bone fractures over a one year period. The aim was to determine the predictors of wound infection in open lower limb long bone fractures.The predictors considered were; Mechanism of fracture-A grade of fracture, method of initial skeletal stabilization, method of wound closure and the anatomic site of the fracture. All patients presenting within 24 hours after sustaining open lower limb long bone fractures at the A/E of JUTH, who are 18 years of age and above and have consented participated in the study.

Following an ethical clearance from the Ethical Committee of the Jos University Teaching Hospital, Research Assistants were trained amongst the Resident Doctors of the department. Training was on patient recruitment and protocol of the study. They participated in patient's recruitment from the A/E.

Consecutive patients who have met the inclusion criteria of the study were recruited and their bio data and fracture data were recorded. Each patient was resuscitated with intravenous fluids at presentation. The fluid therapy was dictated by the state of the circulation. Blood samples were taken for investigations (blood glucose and full blood count) and patients with abnormal parameters such as low haemoglobin arising from haemorrhage were optimized appropriately. Tetanus prophylaxis (0.5ml of tetanus toxoid, 1500IU of anti-tetanus serum) was administered based on the patient's immunization status. Pentazocin was used for pain control.

Debridement was done in the theatre under aseptic conditions and spinal anaesthesia within the shortest possible time following proper resuscitation. Sometimes there were delays due to the nature of concomitant injuries or operating room logistics.

Debridement and irrigation was done with gauze, 5% chlorohexidine solution using a minimum of 3L of normal saline, but up to 6-9 L in severely contaminated wounds. Wounds were closed primarily in G-A I, G-A II and some G-A IIIA fractures. Delayed wound closure was done where primary wound closure was not possible, especially in Some G-A IIIA and most G-A IIIB fractures. Grafts and local flaps were subsequently used for G-A grade III, where soft tissue defects existed. Initial fracture stabilization was done with cast application and where necessary with external fixator or skeletal traction depending on the site of fracture and its Gustilo-Anderson grade. Patients received broad spectrum parenteral antibiotics for five days (ceftriaxone and metronidazole). Fractures were classified based on Gustilo-Anderson system,[7]including grade III A and B.

Wound infection was defined as presence of positive operative wound discharge culture or clinical evidence of purulence or wound break down requiring operative debridement recorded from 72 hours after first debridement to four [4] weeks after debridement.[7]Gustilo and Anderson stated that "infections were usually evident during the first month after surgery". Spectrum of wound infection included; cellulitis, wound breakdown, stitch abscess and purulent discharge.Where the dressing of the debrided wound became soaked with offensive odour before 72 hours post debridement, a "second look" was indicated.

Statistical analysis

The data obtained was grouped based on G-A grade of open fractures and total injury time to operative debridement. All data generated was entered and analyzed using the statistical package of social science (SPSS) version 23. The characteristics of respondents were described using frequencies, tables and charts.

The predictors of wound infection following operative debridement were evaluated using chi-square test and logistic regression analysis. Power analysis was done to determine the number of patients needed to detect a 5% difference in rate of infection with P-value <0.05 and confidence level of 95% considered as statistically significant.

III. Results

All 56 patients recruited for the study participated with atleast 4 completed weeks of follow-up for wound infection.

The mean age of study participants was 39.5(±14.3) years. Males accounted for 71.4% of patients with a M:F ratio of 2.5:1. The age range was 18-73 years with 46.5% of the patients within the peak age of 18-37 years (table 1). Among the study participants 71.5% of the patients had tibia fracture either in isolation or with co-existing fibular fracture. Left tibia fracture was the most common, occurring in 42.8% of patients. Fifteen patients (26.8%) sustained femoral fractures. Tibia and fibular fractures were seen in 23 (41.1%) patients. The most common mechanism of injury in 87.5% of the patients was MVA while 8.9% had fractures due to gunshot.

Gustilo-Anderson grade IIIA fractures were the most common occurring in 18 (32.1%) patients followed by G-A type IIIB (28.6%). seven (12.5%) patients presented with G-A type I fractures (figure 2). Above knee POP cast was the most common method of initial fracture stabilization in 31(55.4%) patients followed by external fixation in 14(25.0%) patients and skeletal traction (figure 3).

Table 1: Age group distribution of study participants

AGE GROUP(years)	FREQUENCY	PERCENT
18-27	17	30.4
28-37	9	16.1
38-47	13	23.2
48-57	12	21.4
58-67	2	3.6
68-77	3	5.4
TOTAL	56	100

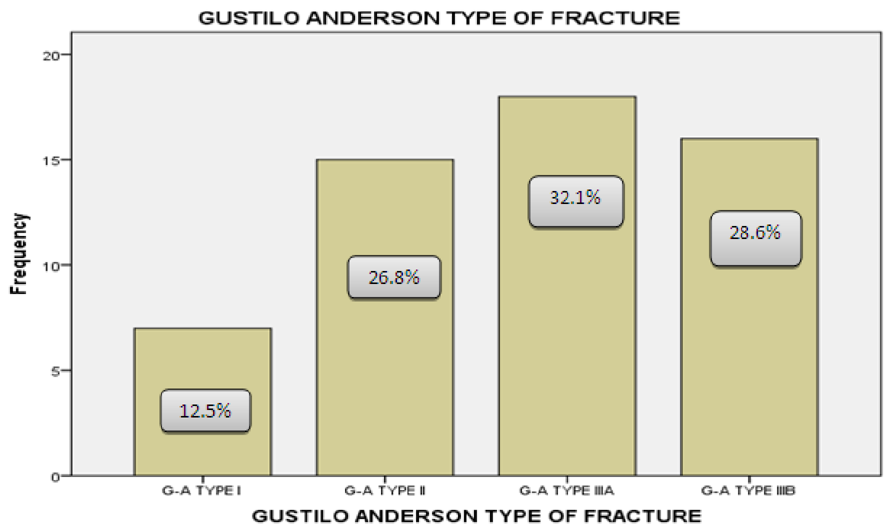

Figure 2: Bar chart showing frequency of Gustilo-Anderson grade of fracture

Table 2: Frequency of post debridement wound infection (N=56)

WOUND INFECTION	FREQUENCY	PERCENT
INFECTION	35	62.5
NO INFECTION	21	37.5
TOTAL	56	100

Table 3: Relationship between total injury time to debridement and wound infection (N=56)

INJURY TIME TO DEBRIDMENT (HOURS)	WOUND INFECTION		
	PRESENT (%)	ABSENT (%)	
<6 HOURS	3(5.4)	1(1.8)	
6-12 HOURS	8(14.3)	5(8.9)	
13-18 HOURS	8(14.3)	7(12.5)	
19-24 HOURS	16(28.6)	8(14.3)	
TOTAL	35(62.5%)	21(37.5)	100%

Chi square(λ^2) =0.993, P value of 0.803 (no statistically significant relationship)

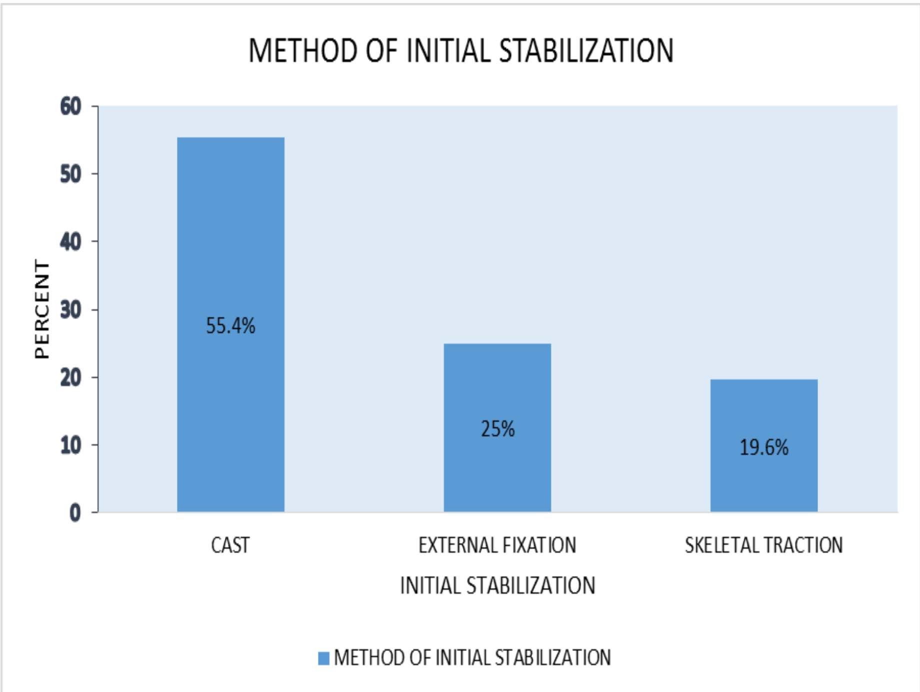

Figure 3: Bar chart showing frequency distribution for methods of fracture stabilization

Wound infection was assessed using clinical signs and laboratory evidence of positive wound swab culture. Thirty five (62.5%) patients had evidence of post-operative wound infection with wound breakdown and purulent discharge being the common signs, 17.9% and 33.9% respectively (table 2). From the study wound infection following debridement was noticed between the 4th to 7thdays in 25 (71.4%) patients.

On further analysis using chi-square, the statistical relationship between total injury time to operative debridement and wound infection was tested. There was no statistically significant relationship between total injury time to debridement and wound infection (P <0.05). The rate of wound infection amongst those who had debridement within a total injury time of <6 hours was 5.4%, and 14.3% in those who had debridement after 6-12 had wound infection. Of the 24 patients who had debridement after a total injury time of 19-24 hours, 16 (28.6%) developed wound infection. (Table 4).

The microbiology of post-operative wound infection showed that 28 (80%) patients had a positive culture. Staphylococcus aureus was cultured in 21(60.0%) patients followed by klebsiella and pseudomonas. Among those who developed wound infection, 71.4% did well on regular wound care in the ward without requiring another formal debridement in the theatre. Twelve (21.4%) with G-A grade IIIA had wound infection while the rate of infection in G-A type IIIB was 28.6%. Rate of infection in G-A grade I and II was 1.8% and 10.7% respectively. A statistically significant difference was found between rate of wound infection and Gustilo-Anderson types of fracture (p< 0.05) with rate of wound infection proportionate to severity of open fracture (table 4).

Table 4: Relationship between G-A grade of fracture and wound infection (N=56)

GUSTILO-ANDERSON GRADE OF FRACTURE	WOUND INFECTION		
	PRESENT (%)	ABSENT (%)	
G-A I	1(1.8)	6(10.7)	
G-A II	6(10.7)	9(16.1)	
G-A IIIA	12(21.4)	6(10.7)	
G-A IIIB	16(28.6)	0(0.0)	
TOTAL	35(62.5%)	21(37.5%)	100%

Chi square (λ^2)= 21.634, P Value of 0.00 (Statistically significant relationship)

Eighteen (32.1%) patients with tibia and fibular fracture had wound infection as against 5 (8.9%) patients with femoral fractures. There was a statistically significant relationship (P<0.05) between the site of lower limb fracture and wound infection with probability of infection being higher in open tibia and fibular than femoral fractures (table 5, 6).

The method of initial fracture stabilization in 17 (30.4%) patients who had wound infection was by above knee POP cast. All the 14 patients who had stabilization with external fixators developed wound infection after debridement. There was a statistically significant relationship between method of stabilization and rate of wound infection after debridement with infection more likely when external fixators were used (table 7, 8).

Table 5: Relationship between site of lower limb fracture and wound infection (N=6)

SITE OF LOWER LIMB FRACTURE (BONE AFFECTED)	WOUND INFECTION		
	PRESENT (%)	ABSENT (%)	
ISOLATED FEMUR	5(8.9)	9(16.1)	
ISOLATED TIBIA	9(16.1)	7(12.5)	
ISOLATED FIBULAR	2(3.6)	0(0.0)	
FEMUR AND TIBIA	1(1.8)	0(0.0)	
TIBIA AND FIBULAR	18(32.1)	5(8.1)	
TOTAL	35(62.5)	21(37.5)	100%

Chi square (λ^2) of 8.169, P value =0.043 (Statistically significant relationship)

Table 6: Incidence of wound infection by site of fracture (binary logistics) N=56

SITE OF LOWER LIMB FRACTURE (BONE AFFECTED)	WOUND INFECTION			
	PRESENT (%)	ABSENT (%)	OR	95% CI
ISOLATED FEMUR	5(14.3)	9(42.9)		
ISOLATED TIBIA	9(25.7)	7(33.3)	6.480	1.879-22.352
ISOLATED FIBULAR	2(5.7)	0(0.0)	2.80	0.865-9.059
FEMUR AND TIBIA	1(2.9)	0(0.0)		
TIBIA AND FIBULAR	18(51.4)	5(23.8)		
TOTAL	35(100)	21(100)		

Table 7: Relationship between method of stabilization and wound infection (N=56)

METHOD OF FRACTURE STABILIZATION	WOUND INFECTION		
	PRESENT (%)	ABSENT (%)	
CAST	17(30.04)	14(25.0)	
EXTERNAL FIXATION	14(25.0)	0(0.0)	
SKELETAL TRACTION	4(7.1)	7(12.5)	
TOTAL	35(62.5)	21 (37.5)	100%

Chi square (λ^2) of 12.382, P value of 0.002 (Statistically significant relationship)

Table 8: Predictors of wound infection by method of initial fracture stabilization (Logistic regression)

METHOD OF FRACTURE STABILIZATION	WOUND INFECTION			
	PRESENT (%)	ABSENT (%)	OR	95% CI
CAST	17(48.6)	14(66.7)		
EXTERNAL FIXATION	14(40.0)	0(0.0)	0.47	0.143-1.546
SKELETAL TRACTION	4(11.4)	7(33.3)		
TOTAL	35(100)	21 (100)		

OR= Odd ratio, CI =Confidence interval

Logistic regression analysis showed that the site of fracture and the choice of method of stabilization are other determinants of wound infection in this study.

IV. Discussion

This study was designed to determine the predictors of post-operative wound infection in open lower limb fractures. The rate of wound infection was also evaluated in relation to Gustilo-Anderson grade IIIA and B open fractures and the site of lower limb fracture. The study however showed that the factors that determine wound infection in open fractures are; the G-A grade of fracture, site of long bone fracture and choice of method of stabilization.

The mean total injury time to debridement in this study was 16.2(±6.1) hours. Bryan et al, reported a mean time to debridement of approximately 13 hours, [4] while Huu[8]and Natalie[9] reported 10.6 hours and 8 hours respectively. The higher total injury time to debridement in this study was due to the delays in A/E, with 53.6% of patients having a time delay of 6-12 hours despite a relatively early presentation. The delays in A/E were due to reasons such as lack of urgency in wheeling patient for radiologic investigations, theatre unavailability, patient's physiological instability and co-existing injuries. The exact effect of some of these factors may be beyond the scope of this study.

Krishna et al[10], reported a 25.9% rate of infection. Pollak et al[5], reported a 27% infection rate while Spencer J[11] after a prospective study found a 20.9% rate of infection.The overall incidence of wound infection in this study was 62.5%, with staphylococcus aureus accounting in this study is almost twice that reported in the literature, and this difference may have resulted from the gunshot fractures which are high energy injuries included in this study. Another reason may be due to the 100% infection rate recorded where external fixators were used. The implication of this is that future studies should be standardized with a larger sample size, same mechanism of injury and method of stabilization to achieve appropriate statistical associations.

Gustilo-Anderson grade IIIA fractures occurred most common, occurring in 32.1% of patients followed by G-A IIIB with an incidence of 28.6%. The results are similar to those reported in several studies.[3,9]This study showed that open lower limb long bone fractures following MVA are more likely to be G-A grade III.

The rate of wound infection in G-A IIIA and IIIB was 21.4% and 28.6% respectively and a statistically significant difference was found between rate of infection and G-A grade of fracture at P<0.05. Gustilo and Anderson[7] reported that, infection ranges from 1% for G-A type I to 30% for type IIIC. Krishner et al, **Error! Bookmark not defined.**[0]following a retrospective study showed an infection rate of 28% for G-A IIIB open fractures. The findings in this study are similar to that reported in other studies, [7,12]with statistically significant association between wound infection and severity of G-A type of fracture.

Among participants studied 71.5% of the patients had tibia fracture either in isolation or co-existing with fibular fracture, indicating that the most common anatomical fracture site is the tibia and fibular. This finding is similar to that reported by Ngim and colleagues[3] at University of Calabar Teaching Hospital, who showed a 69.5% preponderance of tibia and fibular fracture. No particular explanation could be adduced to the increased involvement of the left leg.

In this study 18(32.1%) patients with tibia and fibular fracture had wound infection compared to 5(8.9%) patients with femoral fractures. Studies by Bryan[4] and Gupta et al[13]have corroborated the findings in this study with a statistically significant difference between rate of infection and anatomic site of open fracture. The infection rates ranging from 2%-47% in open tibia shaft fractures.[4,13] The high infection rate in open tibia fractures is attributed to restricted soft tissue coverage and poor osseous supply.

Above knee POP cast was used for stabilization in 55.4% of patients followed by external fixation (25.0%) and skeletal traction. These methods of initial stabilization are similar to those reported by Ikem et al[14]and Ngim and colleagues.[3]

The method of initial skeletal stabilization, the type of wound closure and who performed the debridement all appear to be confounding variables in this study. For instance, there was a statistically significant relationship between method of stabilization and rate of wound infection with a proportionate increase in infection when external fixators are used. This may be explained by the choice of external fixation for the more severe G-A IIIA and IIIB fracture. It is also worthy of note that, these fractures by themselves regardless of method of stabilization have a higher rate of infection.[7]Future studies will require absolute standardization with minimization of confounding variables.

V. Conclusion

The rate of wound infection in Gustilo and Anderson grade IIIA and IIIB fractures is 21.4% and 28.6% respectively and a statistically significant difference exist between wound infection and severity of fracture (p value 0.000).The rate of wound infection in tibia/fibular fractures and femoral fractures is 32.1% and 8.9% respectively, with a statistically significant difference between site of fracture and wound infection (P value 0.067).The use of external fixator was associated with an increase in rate of wound infection. The main predictors of wound infection following debridement are the, G-A grade, anatomic site of fracture and method of skeletal stabilization.

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Compliance with ethical standards
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