THE UNIVERSITY OF ZAMBIA
SCHOOL OF MEDICINE
DEPARTMENT OF SURGERY

MICROBIOLOGICAL CONTAMINATION PROFILE OF OPEN TIBIA FRACTURES AT THE UNIVERSITY TEACHING HOSPITALS, LUSAKA, ZAMBIA

By

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A dissertation submitted to the University of Zambia in partial fulfilment of the requirements for the award of Master of Medicine in Orthopaedic and Trauma Surgery

The University of Zambia

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DECLARATION

I James Kunda Changwe declare that this dissertation, being presented for Master of Medicine in Orthopaedic and Trauma Surgery, represents my own work and that it has not been previously submitted either wholly or in parts for a degree, diploma or other qualification at this or any other university.

Signed…………………………………………………………………………..

Date……………………………………………………………………………..

APPROVAL

This dissertation of James Kunda Changwe is approved, fulfilling part of the requirements for the award of the degree of Master of Medicine in Orthopaedic and Trauma Surgery by the University of Zambia.

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ABSTRACT

Open tibia fractures are common injuries which are a major cause of morbidity and of great public health concern in Zambia and globally. They are considered contaminated and therefore are at greater risk of soft tissue and bone infection. In an environment of high infection and morbidity rates, this study is of great importance as it investigated factors that influence infection of open tibia fractures and provided a scientific basis for the choice of prophylactic antimicrobial chemotherapy for judicious use in the management of these injuries. This cross-sectional study was conducted in the Accident and Emergency Department of the University Teaching Hospitals (UTHs), Adult Hospital, in Lusaka, Zambia, over a period of nine (9) months. The study received prior ethical approval from ERES Converge IRB. Children and adults meeting the eligibility criteria were recruited. The patient's sociodemographics were noted and recorded in a tailor-made data collection tool. Thereafter, swabs for microbiological evaluation were collected in the emergency theatre prior to surgical debridement. A total of 78 patients with open tibia fractures assessed for the study, of which 52 met the eligibility criteria. All analyses were performed using STATA software, version 13. The study outcome variables were pattern of injuries (GA) presenting to the Hospital, positivity rate of the different injury types and sensitivity pattern to specific antimicrobial agents. The study concluded that mean age was 32(IQR 21 – 43) and sex ratio of males to females was 71.11% to 28.89%. Only 28.7% of patients presenting with open tibia fractures received appropriate treatment prior to referral. In addition, study showed that the majority (80.7%) of patients also presented late (mean 9.375 hours). It was further observed that there was a positive correlation between delayed time of presentation and positivity rate of wound swabs (p =0.04). The vast majority (43.7%) of injuries were of GA IIIA type, with positivity rate of 77%. The most common (45.4%) isolated organism was *Proteus mirabilis.* It was also found that the incidence of MRSA from isolated organisms was 6.06%. Lasly, it found ciprofloxacin to be the most effective drug for prophylaxis in the management of open tibia fractures The study recommended mentorship of personnel in peripheral health facilities in management of open tibia fractures.. Lastly, it recommended for increased awareness, detection and appropriate treatment of MRSA cases.

Keywords: Open tibial fracture, soft tissue, Gustilo-Anderson classification, microbiological profile, sensitivity profile

DEDICATION

To my dear wife Chilombo Musonda Changwe, my beautiful daughters Andrah and Adriannah and my parents Christabel Kunda Malijani and Alfred Malijani for their unconditional love and constant support throughout this process.

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Above all, may glory and honour be to God my creator for his abundant blessings upon me through my academic life.

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LIST OF ACRONYNS

AO/ASIF	Arbeitsgemeinschaft fur Oseosynthesefragen/
.	Association for the study of internal fixation
AAOS	American Academy of Orthopaedic Surgeons
GA	Gustillo-Anderson classification
MRSA	Methicilin-resistant *staphylococcus aureus*
OTF	Open tibia fracture
UTHs	University Teaching Hospitals
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background

Open fractures, also called compound fractures, are high energy complex soft tissue injuries with associated bony involvement, whose management has presented a longstanding challenge to clinicians (Ondari et al, 2016). They are considered contaminated and must be treated as such (Cross and Swiontkowski, 2008).

They also pose a huge socioeconomic burden on developing countries. From a management point of view, they also pose some unique challenges beyond those encountered with similar closed injuries (Enweluzo et al, 2014).

These injuries are a major cause of morbidity and are therefore of great public health concern in Zambia and globally. In the United Kingdom, the annual incidence of open fractures of long bones has been estimated to be 11.5 per100, 000 persons, with 40% occurring in the lower limb (Court-Brown et al, 1998).

At Obafemi Awolowo University Teaching Hospital in Ile-Ife, Nigeria, the incidence of open fractures was 78.7% in male patients and 21.3% in female patients, of which tibia fractures constituted 66.1% (Akinyoola et al, 2006). Local statistics for the University Teaching Hospitals (UTHs), Adult Hospital, revealed 197 cases of OTFs in the four quarters of 2017 (UTH theatre records, 2017).

Goals of open fracture management include the prevention of infection, achievement of bony union, and the restoration of function. Current treatment strategies in the care of open fractures are continuously studied, improved, and adjusted as the literature base expands.

While the negative effect of microbes in fracture healing is accepted as significant, there is still little known about what microbes affect open fractures at UTH, or how we can use the knowledge of these microbes diagnostically to predict outcomes and better inform the treatment of these injuries. There is therefore need to address the deficiencies in the current paradigms of open fracture care.

This study was aimed at providing current information on specific micro-organisms that are present on open tibia fractures, establishing their sensitivity to common antibiotics and provide a framework for decision-making when presented with an open fracture in the acute setting. The ultimate goal was to formulate a protocol for judicious use of antibiotics as prophylaxis for open fractures. In addition, this would also reduce the cost of treatment for the Hospital and patient. The length of hospital stay would also be significantly reduced.

1.2 Statement of the problem

Open tibial fracture are common injuries in the emergency room and 162 cases were reported at the University Teaching Hospital in 2017 (theatre records, 2017). They are considered contaminated at the time of presentation and at great risk of infection (Cross and Swantiotkowski, 2008).The rate of contamination at the time of injury is reported to be as high as 60% (Faishan et al, 2001). This is associated with a higher rate of complications (Hannigan et al, 2015).

1.3 Significance of the study

Open tibial fractures are a common problem (162 cases recorded at UTH in 2017, UTH theatre records) and cause of morbidity (Carver et al 2017). Standard principles for treatment of open tibial fractures include administration of specific antibiotics (Miller and Thompson 2016).

Superficial wound swabs can provide valuable knowledge about common organisms present on open tibial fractures and cause subsequent wound infection (Ojo et al, 2010). Identification of initial open fracture pathogens improves efficiency of antibiotic prophylaxis (Otchwemah et al 2015).The overall cost of treating these types of injuries would significantly reduce for both the health facility and the patient.

1.4 Objectives

1.4.1 Main objective: To explore the microbiological profile of open tibial fractures presenting to University Teaching Hospitals.

1.4.2 Specific objectives:

1.) To establish the sociodemographic characteristics of patients presenting with open tibial fractures to the UTHs.

2.) To assess the quality of pre-hospital care patients presenting with open tibial fractures receive before referral to the UTHs.

3.) To establish the prevalence of various grades (GA) of open tibial fractures presenting to UTHs.

4.) To characterize the micro-organisms contaminating open tibial fractures on presentation at UTHs.

5.) To analyze the antimicrobial sensitivity profile of organisms contaminating open tibial fractures at UTHs.

1.5. Research Question

What is the microbiological profile of organisms contaminating open tibia fractures presenting to the University Teaching Hospitals?

CHAPTER TWO: LITERATURE REVIEW

2.1 Open fracture

Open fractures of the extremities are most often associated with infection and this can add significantly to the resulting morbidity (Isaac et al 2016, Carver et al 2017). On account of their severity, open fractures are often associated with complications that result in increased lengths of hospital stays, multiple operative interventions and even the possibility of amputation (Hannigan et al, 2015). Celland et al, 2016, reported that 72% of fractures presenting to Kilimanjaro Christian Medical Centre were open. Motor traffic accidents (MTAs) were the most common cause (78%), with falls making up 13%.

2.2 Classification

There are a number of classifications in use for open fractures, whose purpose is to allow communication that infers fracture/soft tissue morphology and treatment parameters. These include the Gustillo-Anderson, Tscherne and AO classification systems. However, the most widely used in clinical practice is the Gustillo-Anderson classification (Kim and Leopold 2012). In 1976, Gustillo and Anderson described a system to classify open fractures based on the size of the associated wound, degree of soft tissue injury, contamination and the presence/absence of neurovascular compromise (Gustillo and Anderson, 1976).

Table1: Gustillo-Anderson classification

Type I fracture	Open fracture with clean wound <1 cm long
Type II fracture	Open fracture with laceration >1 cm long without extensive soft tissue damage
Type IIIA fracture	Open fracture with laceration >10 cm long, with adequate soft-tissue coverage, high-energy trauma regardless of size of wound.
Type IIIB fracture	Open fracture with laceration >10 cm long, without adequate soft-tissue coverage, with bone exposure and periosteal stripping.
Type IIIC fracture	Open fracture with neurovascular injury

medal.org (March, 2011)

In a subsequent article, Gustillo et al (1984) refined the classification for GA type III (severe) open fractures. In general, the risk of infection and limb loss correlate with the Gustillo-Anderson type (Hoff et al 2011).

On the other hand, the Oestern and Tscherne classification for open fractures is based on the following parameters (Tscherne et al 1984):

1.) Wound size,
2.) Level of contamination,
3.) Fracture pattern
4.) Presence or absence of amputation

Grade I	• Open fracture with a small puncture wound without skin contusion. • Negligible bacterial contamination. • Low energy fracture pattern.
Grade II	• Open injuries with a small skin and soft tissue contusions. • Moderate contamination. • Variable fracture pattern.
Grade III	• Open fracture with heavy contamination. • Extensive soft tissue damage. • Often, associated arterial or neural injuries.
Grade IV	• Open fracture with incomplete or complete amputation.

orthobullets.com (2017)

The AO classification was developed because of the limitations of the existing classification systems, including moderate inter-observer reliability and the grading of many different injuries into the same subgroup (Ruedi et al 2007). It is a more detailed and precise grading system for fractures with soft tissue damage. This grading system identifies injuries to the different anatomical structures and assigns them to different severity groups.

The skin (integument), muscles and tendons, and the neurovascular system are the targeted anatomical structures. The fracture grading is done with the letter "O" to designate an open fracture category. Each is further subdivided into five (5) severity groups.

All in all, the GA classification remains the most commonly used inspite of its inadequacy/short comings. It remains the most user-friendly classification for any setting.

2.3 Contamination/environment

The environment in which a particular open fracture wound was sustained also determines the type of organisms likely to contaminate the wound (Zhu et al 2017). For instance, wound contamination with dirt, faeces, puncture wound with unsterile injections, missile and farm injuries, must raise concern for *Clostridium tetani* (Bleck, 2005).

2.4 Microbiological profile

One of the factors thought to influence the extent of complications is the exposure and contamination with environmental microorganisms, potentially those that are pathogenic in nature (Zhu et al 2017). In addition, Otchwemah et al (2015), report that pathogens affecting open fractures and their resistance against therapeutic agents change with time and vary in different regions. All open fractures by definition are contaminated and this must be taken into account during the treatment course (Cross and Swiontkowski 2008). According to Faisham et al (2001), sixty percent of open fracture wounds are contaminated at the time of injury.

The Gustilo and Anderson study of 1978 also reported positive initial cultures in 70.3% of the 158 prospectively observed open fractures (Gustilo and Anderson, 1976). In a more recent study, 53% positive bacterial culture was found in type III open fractures at initial surgery (Yusuf et al, 2015).The rates of infection also differ according to the fracture type. They have been reported to be ranging from 0 to 2% for GA type I fractures, 2 to 10% for type II fractures and 10 to 50% for type III fractures (Zalavras et al, 2007).

There is confusion in the current literature regarding the value of obtaining wound cultures in the management of open fractures, with several studies reporting contrasting results. Bumbasirevic et al (2012) recommended taking culture swabs before administering antibiotics as a treatment protocol. This is also supported by a study by Ojo et al (2010), who concluded that in resource-poor settings, superficial wound swabs are effective in predicting subsequent organisms that may cause wound infections. However, others have strongly recommended against such practice (AAOS, 2008).

There is also lack of consensus regarding the bacteria most likely to colonise open fracture wounds. Platzakis et al (1974) in a randomized controlled trial on 310 patients found that after culturing wound infections; staphylococci (specifically coagulase positive staphylococci such as *staphylococcus aureus*) were the most commonly isolated organisms. It was on this basis that they suggested that antibiotic prophylaxis should target gram positive organisms.

However, Agrawal et al in a 2008 study to ascertain the frequency of bacterial flora on open fractures, bedsores and wounds clinically suspected to be infected, found contrasting bacterial species. Of the 111 positive cases out of 209 cultures, 30 cases with open fracture wounds had contamination at the time of initial presentation, with dominance of gram negative organisms (76%).

The various organisms isolated were *Escherichia coli* (9/30), *Pseudomonas* species (9/30), *Staphylococcus aureus* (6/30), *Klebsiella* species (4/30), *Steptococcus* species (1/30) and *Proteus* species (1/30). They, however, did not report if the initial organism caused the subsequent infection in the patient. This was eventually confirmed in a more recent study, whose researchers concluded that in resource-poor settings, superficial wound swabs were effective in predicting organisms that may subsequently cause wound infections (Ojo et al 2010).

In addition, the study by Carsenti-Etesse et al (1999) found coagulase-negative Staphylococci, Bacillus species, Acinetobacter species and Enterobacter species, as the most common bacterial contaminants at initial presentation. However, cultures at the time of infection the most common Gram-positive organisms were methicilin-sensitive and methicilin-resistant *Staphylococcus aureus,* Gram-negative organisms were *Enterobacter* species, *Klebsiella* species, E.coli and *Pseudomonas* species.

The discrepancy in the initial contamination and the subsequent infecting organism was explained by Carsenti-Etesse et al (1999). They concluded from their study that among patients who developed a deep infection, patients who were given prophylaxis against Gram-negative bacteria grew primarily Gram-positive bacteria, whereas patients who were given prophylaxis against Gram-positive organisms grew Gram-negative bacteria from deep infected tissue. Therefore, the current trend in antibiotic prophylaxis protocols may have a role in the development of resistant organisms.

Recent studies also report an increasing incidence of Methicilin-resistant staph aureus (MRSA) in a community setting (Chen et al, 2013). Given the high incidence of MRSA and Gram-negative rods in open fracture infections, future consideration for changing antibiotic prophylaxis to cover MRSA and gram-negative organisms may be effective in reducing rate of infection in open fractures (Chen at al, 2013, Saveli et al, 2011).

2.5 Treatment

Goals of open fracture management include preservation of life, preservation of healthy soft tissues, prevention of infection, skeletal stabilization, achievement of bony union and rehabilitation of the patient (Cross and Swiontkowski, 2008).

The preservation of healthy soft tissues can in part be achieved through appropriate and timely surgical debridement. Historically, the 6-hour rule had been employed as the time limit within which an open fracture should be taken to the operating room for initial debridement (Gustillo and Anderson, 1976). Many factors influence this parameter including how soon patient arrives at health facility, operating room availability, surgeon availability and the patient's physiological status.

In addition, available empirical evidence does not seem to justify strict adherence to the emergent 6-hour rule (Pollak, 2006). In a more recent study, no significant increase in infection rates was observed if debridement is performed beyond six hours from time of injury (Satpathy et al, 2017). All these credible articles provide sufficient evidence to prove that the 6-hour rule should not be cast in stone. The administration of antibiotics is routinely practiced as an adjunct to a comprehensive management protocol that also includes irrigation, surgical debridement and stabilization when indicated, and is thought to reduce the frequency of infections.

Attempts to address the utility of prophylactic antibiotics yielded weak and conflicting results until 1974, when Platzakis et al reported a reduction in open fracture wounds from 13.9% without antibiotic prophylaxis, to 2.3% when patients were treated with cephalothin antibiotics. This study strongly supported the need for prophylactic antibiotic use. In 1998, Luchette et al presented their EAST Practice Management Guidelines at the 11th Annual Scientific Assembly. These guidelines were published in 2000 and offered three (3) level I and two (2) level II recommendations regarding choice of specific antibiotic coverage and duration of therapy.

According to their recommendations, antibiotics should be directed at gram-positive organisms for GA type I and II fractures, with additional gram-negative coverage for type III injuries. Furthermore, in the presence of potential clostridial contamination, penicillin should also be initiated irrespective of GA type.

With regard to duration of antibiotic coverage, the original guidelines stated that antibiotics should be discontinued 24 hours after successful wound closure for type I and II injuries. However, antibiotics should be continued for type III injuries subsequent to the injury and not more than 24 hours subsequent to successful soft tissue coverage of the wound.

Vasenius et al (1998) compared clindamycin versus cloxacillin in the treatment of 240 open fractures. Clindamycin was demonstrated to be effective in type I and II fractures, with reported infection rates of 3.3% and 1.8%, respectively. Unacceptably high infection rates were reported in type III fractures for both clindamycin (29.0%) and cloxacillin (51.8%). This study demonstrated the efficacy of gram-positive antibacterial agents in type I and II fractures, and also confirmed the need for gram-negative coverage for type III injuries.

However, there is no consensus regarding the exact timing and duration of antibiotic prophylaxis (Isaac et al 2016), Dunkel et al (2013) concluded that the infection rate in open fractures is not related to the duration of antibiotic prophylaxis.

Current literature suggests that antibiotic prophylaxis should be started immediately (Miller and Thompson, 2016) and the choice of antibiotics depends on the GA classification of the wound. Type I injuries should be treated with first generation cephalosporins (cefazolin), type II with a cephalosporin and gentamycin, while for type III injuries require a cephalosporin, aminoglycoside and high-dose penicillin.

2.6 Implications/outcomes

The study was aimed at informing clinical practice and ultimately reduce the burden of morbidity in terms of early wound infection, acute or chronic osteomyelitis, delayed unions or no-unions, amputations and deaths (Gosslin et al, 2004).

This is because in a resource-poor setting, where pre-hospital care is unavailable and patients frequently present late, superficial wound swabs are effective in predicting subsequent organisms that may cause wound infections (Ojo et al 2010). In a more recent study, Agarwal et al, 2015 advised that all institutions and hospitals should find out the most common infecting pathogen of open fractures in their environment and formulate an antibiotic policy accordingly.

It was also expected to reduce treatment costs for both the patient and the hospital, as well as reducing the duration of hospital stay.

CHAPTER THREE: RESEARCH METHODOLOGY

1. Research Methods

In this part of the dissertation detailed descriptions of methods used in the study are presented. This includes critical aspects such as data collection techniques, study type, sampling methods and procedures, data collection and analysis, ethical considerations.

3.1.1 Study Design

This was a cross sectional study

3.1.2 Study Site

The study was conducted in the Accident and Emergency Department of the Adult Hospital of the University Teaching Hospitals. Patients were recruited from the Casualty section upon presentation.

3.1.3 Target population

All patients presenting with open tibial fractures.

3.1.4 Study population

Patients presenting with open tibial fractures satisfying the inclusion criteria.

3.2 Inclusion Criteria

- Patients with isolated open tibial fractures
- Patients below 18 years with consent signed by a guardian
- Patients aged 18-80 years with signed informed consent

3.3 Exclusion criteria

- Patients with tibial fractures that present > 48 hours after injury
- Non-traumatic open tibia fractures such as pathological fractures
- Patients referred from other medical facilities where they had already received some form of treatment
- Patients who refuse to give consent

3.4 Sample size

The sample size was calculated using Open EPI info with infection rate of 23% as highlighted by Ondari et al (2016) being the endpoint, giving 52 as the final sample size.

3.5 Sampling strategy

The patients were recruited into the study by the principle researcher and two trained assistants by convenient sampling

3.6 Procedure

- Identification of a patient presenting with open tibial fracture in casualty
- Adequate resuscitation of the patient
- Obtain informed consent/assent
- Patient taken to emergency theatre
- Under aseptic technique, including use of face masks, pus swab collected before debridement in theatre
- Data recorded in a questionnaire
- Data later entered into an Excel spreadsheet

3.7 Variables

Outcomes

- Number of different grades of injuries GA) presenting to hospital
- Positivity rates of different injury grades (GA)
- Sensitivity to specific antibiotics

Dependent (outcome) variable: GA type, level of contamination, microbiological culture result and size of the wound at particular day of presentation.

Independent variables: Sex/age of patient

Categorical variables: Sex (Male/Female), GA type,

Continuous variables: Age, time of presentation, GA type

Potential confounders: Inconsistency of availability of specific antibiotics in the laboratory and different personnel processing the swabs. This was reduced by enganging a specific laboratory technician to process all samples.

3.8: Data Management

3.8.1 Data Collection

The data was collected using a tailor made data collection tool (questionnaire).

3.8.2 Data entry

Data collected was then entered into Excel spreadsheet for analysis

3.8.3 Data analysis

The data was analysed using STATA version 13.

The first step was to determine the normality (spread) of the collected data, using Shapiro-Wilk test. If the data is continuous, means and standard deviation will be used.

For data that was not normally distributed, median and interquantile range were used. In addition, Chi-square or Fisher's test (if any number in a cell will be less than 5) was used to determine any associations between categorical variables. The T-test was then used to determine if there are any associations between continuous variables.

Thereafter, the analysed data was presented in form of tables and pie charts.

3.9 Ethical Considerations

- For this study, approval was sought from Research Ethics Committee. Secondly, approval was also sought from University Teaching Adult Hospital Management.
- Thirdly, if a patient had incidental medical problems, they were referred to the appropriate medical personnel and specific information about the patient was shared with them.
- Participation in the study was strictly voluntary and refusal to take part in the study did not affect the patient's management at UTH. Guardians who consented for their

children to participate in the study were at liberty to have their children withdrawn without demand for reasons. Patients were not remunerated.

- All the investigations done were by qualified personnel. Pus swab was a non-invasive procedure. The only anticipated risk to the patient was minimal discomfort. A written consent was obtained from every guardian.

- Although antibiotics are routinely used, there is still a possibility that some patients may have adverse reactions such as anaphylactic shock to some antibiotics. In view of this, every effort was made to ensure that appropriately stocked emergency trolleys are available should such need arise.

- Lastly, the final document does not have any identifiers.

CHAPTER FOUR: RESULTS

4.1 Enrolment

In this study, 78 patients were assessed and only 52 met the inclusion criteria. Twenty six patients could not meet the inclusion criteria as they had received some form of treatment at the time of presentation.

4.2: Characterisation of patients in the study

The quantitative results obtained in this section are aimed at answering the first objective of the study, which was to establish the sociodemographic characteristics of patients presenting with open tibial fractures. Patients enrolled in the study were characterized based on sex, age, injury classification (GA) and time taken to reach the hospital.

4.2.1: Sex distribution of the patients enrolled in the study

The sex ratio was 71% males and 28% females

Table 1: Statistical analysis of sex distribution patients enrolled in the study

Variable	Category	Proportion
Sex	Female Male	14 (28.89%) 34 (71.11%)

4.2.2: Age distribution of the patients enrolled in the study

Table 2: Statistical analysis of age distribution patients enrolled in the study

Variable	Category	Proportion
Age	≤ 14 ≥ 14	4 (9%) 32(IQR 21 – 43) 44 (99%)

4.2.3: Statistical analysis of patient management according to standard management principles (prior to referral)

Table 3: Statistical analysis of initial management prior to referral

Patient management	Number	Proportion
Received antibiotic prophylaxis and wound debridement before referral	21	21 (28.7%)
Did not receive antibiotic prophylaxis and wound debridement before referral	52	52 (71.2%)

The above quantitative results address the second objective of the study, which was to assess the quality of pre-hospital care patients with open tibial fractures received prior to presentation to The UTHs. Of the 78 patients who were assessed for the study, only 21 (28.7%) received appropriate treatment in form of antibiotic prophylaxis and surgical debridement at the referral facility.

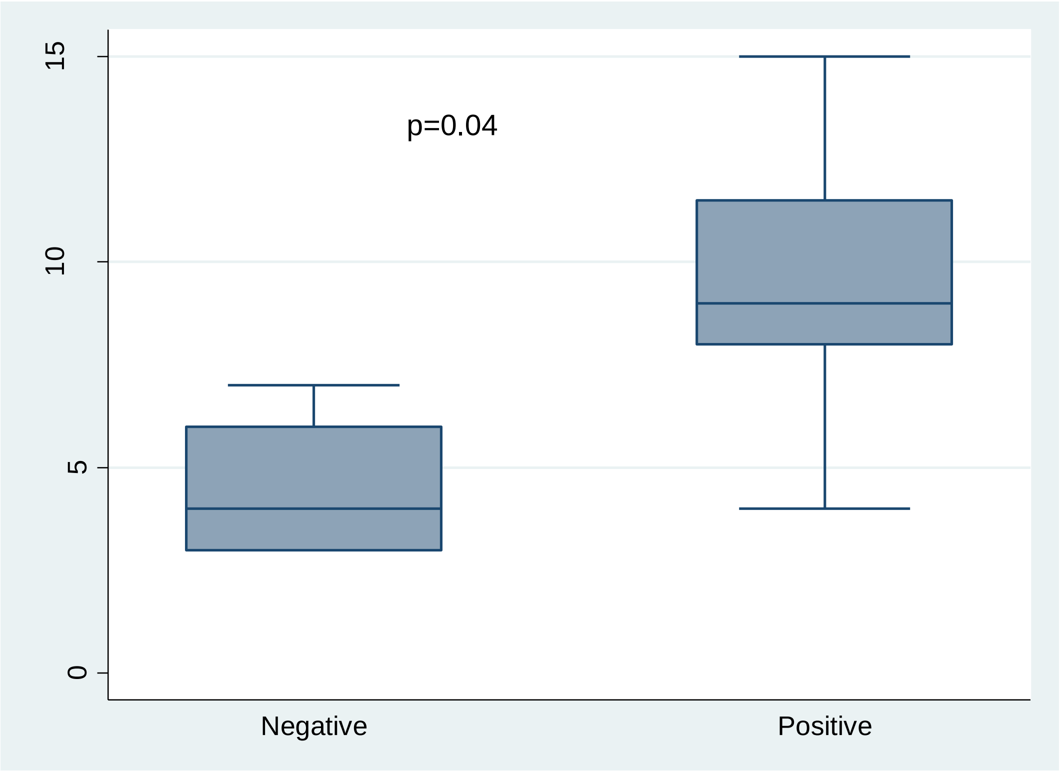
4.2.4: Statistical analysis of time of presentation of enrolled patients

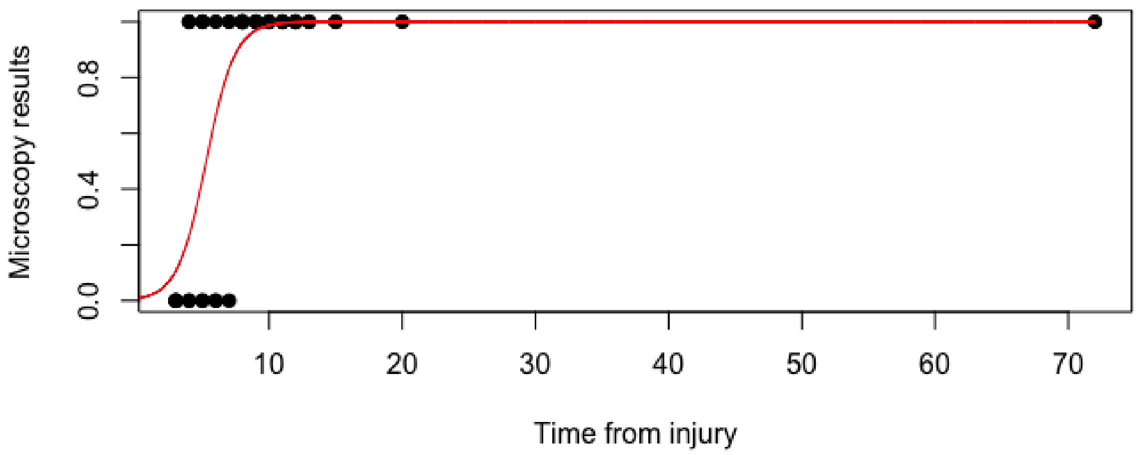
Table 4: Time (hours) from injury to presentation to hospital

	Percentiles	Smallest
1%	4	4
5%	4	4
10%	5	5
25%	8	5
50%	9	Mean 9.375
		Std. Dev 2.882
		Largest
75%	11.5	13
90%	13	13
95%	15	15
99%	15	15

4.2.5: Analysis of time of presentation versus microscopy results

Graph 1: Statistical analysis of time of presentation versus microscopy results





Graph 2: Microscopy results against time from injury

As expected, there was a positive correlation between delay in presentation to hospital and positivity rate (p=0.04).

4.2.6: Injury distribution based of GA classification

In this section, the quantitative results obtained were aimed at answering the third objective of the study, which was to establish the various grades of injuries (GA) presenting to the University Teaching Hospitals (UTHs).

Table 5: Distribution of injury types

GA type	Total (%)
I	5(10.4%)
II	9(18.7%)
IIIA	21(43.7%)
IIIB	12(25%)
IIIC	1(2%)

Pearson Chi2(4) = 29.8543

Pr = 0.000

The combined total of type III injuries was 70.7%, which is in agreement with the 73% reported by Ashford et al, 2004 and the 85% by Odatuwa-Omagbemi, 2019.

4.2.7: Statistical analysis of microscopy results

Table 6: Microscopy results

Sex	Microscopy results Negative	Positive	Total
Male	7 (14.5%)	28(58.3%)	35(72.9%)
Female	4(8.3%)	9(18.7%)	13(27%)
Total	11((22.9%)	37(77%)	48

Pearson Chi2 (1) = 0.3960

Pr = 0.529

Positivity rate = 77%

Table 7: Microscopy results vs injury type (GA)

GA type	Microscopy results Negative	Positive	Total (%)
I	5	0	5(10.4%)
II	5	4	9(18.7%)
IIIA	1	20	21(43.7%)
IIIB	0	12	12(25%)
IIIC	0	1	1(2%)
Total	**23%**	**77%**	

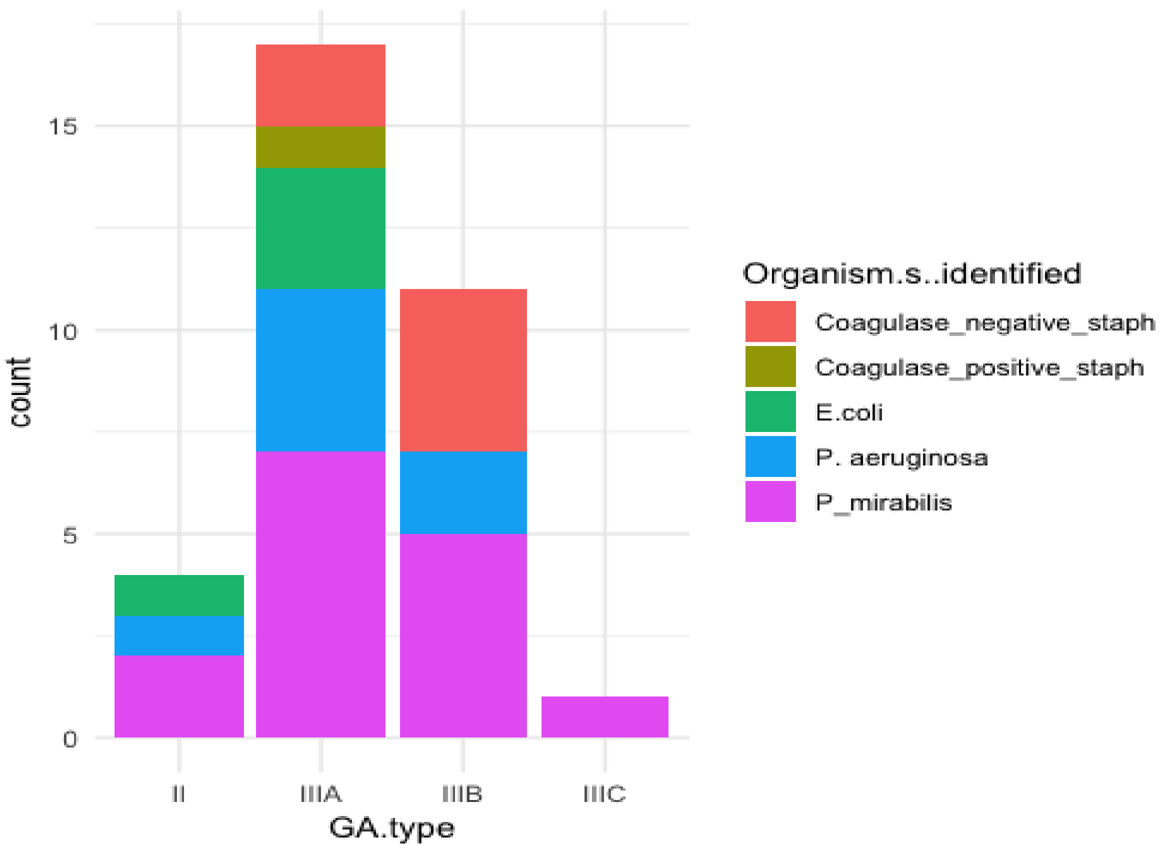
Pearson Chi2(4) = 29.8543

Pr = 0.000

Table 8: Distribution of specific isolated organisms

Organism identified	Positive results	Proportion
Escherichia coli	4	12.1%
Proteus mirabilis	15	45.4%
Pseudomonas aeruginosa	7	21.2%
Coagulase positive staphylococcus	1	3.0%
Coagulase negative staphylococcus	6	18.1%
Total	33	100%

Graph 3: Isolated organisms



4.2.8: Statistical analysis of sensitivity pattern of isolated organisms

4.2.9: Statistical analysis of MRSA incidence

Table 9: Distribution of isolated organisms resistant to cefoxitin

Result	Proportion
Number of positive tests	33
Number resistant to cefoxitin	2
MRSA	**6.06%**

Of the 33 positive cases, Cefoxitin-resistant *Staphylococcus aureus* was isolated from two patients, one male and one female. This represented 6.06% MRSA incidence.

CHAPTER FIVE: DISCUSSION

5.1 Overview of findings

The study explored the sociodemographic characteristics of patients presenting with open tibial fractures and also the organisms present on these injuries, as well as their antimicrobial sensitivity profile. Notably, the study found that an average patient presenting with open tibial fractures is a male aged 32 years old.

It was also discovered that the majority of the patients (71.2%) did not receive appropriate management prior to referral.

Delayed presentation of patients to Hospital was also noted (average 9 hours and 36 seconds), which posed a significant challenge to the management of patients (Odatuwa-Omagbemi, 2019).

The study also revealed a 6.06% incidence of MRSA, which is of serious public health concern (Siddiqui and Koirala, 2019).

5.2 Socio-demographic characteristics of the patients

Foremost, overall the data revealed that open tibial fractures are injuries that are not confined to a specific segment of the population, as shown by age ranging from 14 years to 49 years. This fits in with findings from the Zambia Demographic and Health Survey, 2018, where 84% of the population were aged 15 to 49 years old.

Closer scrutiny of the socioeconomic data also revealed that the vast majority of patients were aged 21 to 43 years, with an average patient presenting with an open tibial fracture being a male adult 32 years old. This finding coincided perfectly with Abraham and Wamisho, 2009, who reported mean age of 31.55 years. It also agrees with a recent study by Odatuwa-Omagbemi 2019, who reported an average age of 36.4±12.2, but lower than the recorded 45.5 by Kombate et al, 2017. However, the last study was carried out in an adult population only.

It was also found that the vast majority of the patients were males (71.11%), with women making up 28.8% of the cases. Interestingly, this finding varies significantly from 2010 Zambia Census of Population and Housing Report, which asserts that males were 49.2% of the overall Zambian population and females 50.8%. This finding however, coincided very well with Abraham and Wamisho, 2009, who found 82.7% of the patients to be male.

In addition, other similar trauma-related studies offer clear explanations for such a discrepancy. Both Ibeanusi in 2007 and more recently Odatuwa-Omagbemi, 2017, reported that males are generally more prone to injuries as a result of exposure to risky activities at work (being largely the bread winners) and at leisure.

5.3 Patient care prior to referral

Secondly, it was clearly evident that there is glaring lack of knowledge/expertise in peripheral hospitals about correct management of these injuries. A vast majority of patients (71.2%) did not receive antibiotic prophylaxis and surgical debridement inspite of presenting within six (6) hours to the health facilities.

In addition, only 28.7% of patients were commenced on antibiotic prophylaxis as per protocol. As concluded by Ondari et al, 2016, infection rate was significantly associated with time lapsed before administration of antibiotics (p=0.004).

This is of great concern because some of patients sustained severe injuries with significant soft tissue defects (type IIIB and type IIIC). Statistically significant increase in rate of deep infection has been reported in type III injuries with such soft tissue defects (Hull et al, 2010).

5.4 Time of presentation of patients

From this study, the average time of presentation of the patients to hospital was 9 hours and 37 seconds. This lag time agrees with Ashfold et at, 2004, who reported a mean presentation time of 9 hours and 45 minutes. In a more recent study, Hull et al, 2014, reported a mean delay of 10.6 hours.

Some of the reasons for delay include lack of transport, incorrect assessment/diagnosis (Odatuwa-Omagbemi, 2019). In addition, six (6) of the patients had multiple injuries, whose management was deemed to be more important to the survival of the patient. Another possible reason could be low health insurance coverage (Odatuwa-Omagbemi, 2019).

This delay in presentation to hospital coupled with the failure to administer prophylactic antibiotics in 71.2% of the cases was detrimental to the overall prognosis of the cases, as studies have shown an exponential increase in infection rate associated with such delays (Pollack et al, 2010).

In addition, Hull et al, 2014, reported a linear increase of 3% infection rate per hour of delay of surgical debridement.

Our patients thus have to grapple with two major negative prognostic factors; lack of timely administration of appropriate antibiotics and delays in presentation to a definitive surgical debridement center.

5.5 Time of presentation versus microscopy results

As expected, there was a positive correlation between delay in presentation to hospital and increases in positivity rate of the injuries (p=0.01). However, the 2010 Lower Extremity Assessment Project (LEAP) dispelled such a correlation, as it found that from the time from injury to operative debridement was NOT a significant predictor of infection risk.

To the contrary, more recent studies paint a picture that supports the findings from this study. Pollack et al, later that same year 2010, reported that the time between the occurrence of the injury and admission to the definitive trauma treatment center was an independent predictor of the likelihood of contamination and subsequent infection. The picture became clearer as in 2014, when Hull et al also concluded that time delay was an independent predictor of likelihood of infection. Zuluaga et al, 2002, had earlier concluded that the dynamics of bacterial populations on soft tissue wounds and bones differ over time. In addition, they reported that patients brought to hospital after six (6) hours showed maximum growth of bacterial isolates.

5.6 Injury distribution based on GA classification

It was very clear from the results obtained that the majority of open tibial fractures seen at the University Teaching Hospitals (UTH) were Gustillo-Anderson type IIIA. A more recent study by Weder et al, 2019, found 49.3% were type I injuries, 27.5% type II and 23.2% type III.

The explanation for this marked difference is the late presentation of our patients to the health facility (UTH), which lead to a higher GA grading. As can be seen from above results, the mean (average) time of presentation of the patients to hospital was 9.3 hour. This coupled with time for resuscitation and delays in taking patients to theatre lead to a higher reclassification of the injuries.

Secondly, this high incidence of type III injuries is in agreement with Yusuf et al, 2015, who reported 53% incidence of type III injuries. In addition, Odatuwa-Omagbemi, 2019, concluded that type III injuries tend to be more common in tertiary hospital-based studies in third world countries compared to more economically-advanced countries.

5.7 Microscopy results

The study established a positivity rate of 77%, supported by similar studies such as Yusuf et al, 2015, who reported 53%. Agarwal et al, 2015, reported 51.42% positivity rate. The higher incidence in this study could be explained by delays in referral plus the failure to administer prophylactic antibiotics in 71.2% of the cases (Table 3).

As expected, type III injuries had the highest combined positivity rate (70.7%), which is in agreement with Zalavras et al, 2007, who reported 50% positivity rate for type III injuries.

In terms of specific isolated organisms, the study found the majority (45.4%) were *Proteus mirabilis, Pseudomonas aeruginosa 21.2%, Coagulase negative staphylococcus 18.1%, Escherichia coli 12.1% and Coagulase positive staphylococcus 3.0%.* Compared to an earlier study, Agrawal et al (2008) isolated *Escherichia coli 30%, Pseudomonas aeruginosa 30%, Staphylococcus aureus 20%, Klebsiella 13.3%, Streptococcus 3.3% and Proteus 3.3%.*

In 2015, Agarwal et al isolated Coagulase-negative *Staphylococcus aureus* was the most common bacteria isolated in 66.66% of cases, with gram-negative bacterial isolated in 33.3% of cases.

There are clear consensus explanations for such discrepancies in results of isolated organisms. Otchwemah et al (2015), reported that pathogens affecting open fractures and their resistance against therapeutic agents change with time and vary in different regions. In 2017, Zhu et al added that the environment in which the injury occurs is an important predictor of organisms likely to be present on open fractures.

5.8 Microscopy results versus injury (GA) type

The rates of infection also differed according to the fracture type. The study reveal that the vast majority of positive cases (70.7%) were type III injuries. This compares favourably with Zalavras et al, who reported 50% for type III injuries

5.9 Sensitivity pattern of isolated organisms

The study found both gram positive and gram negative organisms. In addition, the majority of the organisms were sensitive to ciprofloxacin and resistant to cloxacillin.

5.10 MRSA incidence of isolated organisms

The study also found the incidence of MRSA on open tibial fractures to be 6.06%. This was higher than the 2.5% Chen et al (2013) found. However, this agrees with several reports of increasing incidence of MRSA (Calfee, 2012 and Ray et al, 2012). This would suggest that current prophylactic management regimens may not be effective (Chen et al, 2012) and future consideration for change of regimens would therefore be warranted.

This incidence is also of great public health concern as Cheng et al, 2013, reported that there is increasing incidence of MRSA in a community setting. This calls for greater awareness both in communities and health workers. Community-acquired MRSA is associated with significant morbidity, mortality, increased length of hospital stay and cost burden (Siddiqui and Koirala, 2019).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Firstly, the study found that the vast majority of the patients presenting with open tibia fractures were males with average age of 32 years.

Secondly, the study clearly demonstrated that management of most open tibial fractures in our first level hospitals remains a challenge, as clear clinical guidelines were not being followed in 71.2% of the cases. This shows a glaring lack of knowledge/experience of management principles and thus deserves intervention from both the Ministry of Health and Zambia Orthopaedic and Trauma Society (ZOTA).

The study also revealed a 6.06% incidence of MRSA, which is of serious public health concern.

Appropriate and timely management of severe open tibial diaphyseal injuries is clearly a major challenge in our health facilities. The results of this study clearly highlight the need for a co-ordinated, multidisciplinary approach to the management of these common injuries. In addition, broader improvement are needed in terms of human resource expertise, supportive facilities and referral systems.

6.2 Recommendations

Based on the findings, this study therefore recommends the following:

1. Mentorship/Technical Support of peripheral health facilities of management of open tibial fractures. on principles
2. A future study on outcomes of open tibial fracture of all types, taking into account the delay in presentation (mean time nine hour).
3. Increased awareness, detection and treatment of MRSA

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Appendix I

MICROBIOLOGICAL CONTAMINATION PROFILE OF OPEN TIBIAL FRACTURES AT THE UNIVERSITY TEACHING HOSPITALS

Patient information sheet

Code No --------------

Introduction

I, James Changwe, Master of Medicine (M.Med) in Orthopaedic Surgery student in the School of Medicine at The University of Zambia, hereby request your participation in the above mentioned research study. This study is part of the requirement for me to become a doctor who does operations. I kindly request you to carefully read this document and ask me anything you do not understand. I would like you to understand the purpose of the study and what is expected of you. Kindly remember that participation in this study is absolutely voluntary. If you agree to take part in this study, you will be asked to sign consent form in the presence of a witness.

Aim of the study

The purpose of the study is to explore the profile of organisms on open tibial fractures presenting to the University Teaching Hospitals.

Procedure of the study

If you agree to participate in this study, information will be obtained from you and entered into a data collection chart. The patient (your child) will be examined to ascertain the site of the wound(s) associated with the fracture(s), size and level of contamination. A swab (a cotton wool mounted on a stick for collecting specimens from wounds) specimen will be collected from the wound(s) on your first presentation to hospital. There will be two (2) research assistants who will be trained on collection of swabs and measurement of wound size using a graduated 1 cm paper.

Possible risks and discomfort

Participation in this study will not expose your child to any risk as the swabs used are sterile. However, minor reaction might be seen and further during collection of the swab, your child might experience slight pain as the swab is being taken from the fracture wound itself. Kindly note that as part of routine management of all fractures, adequate medication to relieve pain will be given to your child.

Benefits

There are no monetary benefits attached to your child's participation in this study. However, your child will benefit from frequent reviews whilst in the hospital and you will be reminded for follow up reviews in the outpatient clinic. Moreover, your participation will be of help to the institution to manage open tibia fractures better.

Confidentiality

All the information collected is strictly confidential. Data that will be collected, analysed and reported on will not include your name and therefore cannot be traced to you and the data collected is strictly for the purposes of academia and clinical benefit

Refusal and withdrawal

You are free to refuse participation in this study at any time as it is your right and this will have no negative impact on the quality of health care your child will receive. Even upon giving consent, you are still at liberty to withdraw your child from the study.

Who to contact?

For any concerns and clarifications, please contact Dr. James Changwe or The University of Zambia Biomedical Research Ethics Committee on the following respective addresses:

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Appendix II

MICROBIOLOGICAL CONTAMINATION PROFILE OF OPEN TIBIAL FRACTURES AT THE UNIVERSITY TEACHING HOSPITALS

Consent form

Signature:

I …………………………………………….. have read the content of this form. All my questions have been answered; I have been informed that I ask questions at any time during the course of the study and I can skip any questions I feel may be too personal. I am also free to withdraw from the study at any stage. I, therefore agree to participate in this study.

Signature or thumb print of participant……………………………………………

Signature or thumb print of witness………………………………..

Date of signed consent……………………………………..

Participant agrees/Participant does NOT agree

DATA COLLECTION SHEET

AGE/SEX………………DOB…………… school going child: Yes/No Grade:………

File # …………………………….. Firm……………… Date……………… Time…………

Time from injury to hospital……………………… Allocation number…………………

Level of contamination: Mild Moderate Severe ☐

GA classification: Type I Type II Type IIIA Type IIIB Type IIIC

Lab Number……………………….

Microscopy result: Positive ☐ Negative ☐ Culture results………………….

Sensitivity………………………..

Size of wound in cm ……………………….

Status of patient: Admitted ☐ Discharged ☐

Ward/clinic reviewed……………………………