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Bacterial Isolates and Their Antibiotic Susceptibility Pattern among Patients with Infected Wounds Admited in Orthopaedic and Trauma Ward in Tertiary Care Hospital North-Eastern Tanzania

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Abstract

The hospital environment contributes to wound infections. Effects of such infections include prolonged hospitalization, increased morbidity, potential for antibiotics resistance and mortality due to sepsis. An updated knowledge of antibiotics susceptibility profiles of clinical isolates will assist both in choosing the most appropriate antibiotic treatment for wound infections and help in curbing the escalation of drug resistance. Cross sectional hospital based study, analysis of 125 pus samples collected from January 2018 to December 2020 was conducted. Identification and characterization of isolates were performed on the basis of Gram staining, microscopic characteristics, colony characteristic, and biochemical tests using standard microbiological methods. Antibiotic susceptibilities of bacterial isolates were determined by Kirby Bauer disc diffusion. A total of 125 pus samples were studied, 94 (75%) were from male patients, mean age was 38.5 (SD ± 19) years. Single bacterial isolates were recovered from 120 (96%) samples, 67 (53.6%) shows Multiple Drug Resistance (MDR) pattern, 74 (59.2%) were gram negative, the predominant organism isolated was *Staphylococcus aureus* 46 (36.8%). Gram negative isolates showed high resistance to ampicillin and cephalosporins. Gram

positive isolates showed high resistance to erythromycin. Both gram positive and negative were found to be highly susceptible to gentamicin, amikacin, clindamycin, ciprofloxacin and amoxicillin/clavulanic acid. The study showed that *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* are the major bacteria isolated from pus samples. High proportion (53.6%) of the isolates was MDR. In the light of these findings, a change in antibiotic prescription policy is required at this hospital.

Keywords

Pus, Bacteria, Antibiotic, Tanzania

1. Introduction

Wound infection is a common problem among orthopedic patients. This is due to break of skin barrier by surgery, trauma or burns that facilitate easy entry of pathogens [1] [2] [3]. The infecting organisms are both gram negative and positive bacteria. The consequences of such infections include increased hospital stay, morbidity and mortality as a result of septicemia [4]. Bacterial causing infection increased resistance to commonly used antibiotics, and drug resistance is a public health problem. Drug resistance has been linked to overuse and misuse of antibiotics.

The overuse of antibiotics was estimated to increase by 36% in within 10 years from 2000 to 2010 worldwide. In USA, it is estimated that more than 23,000 deaths per year are due to antibiotics resistance infections [5].

In LMIC, the impact is expected to be higher as compared to developed countries. The burden of infectious disease, poverty, weak governance of health system and low awareness to antibiotics resistance, predisposes LMIC to high adverse effect of antibiotics resistance [6] [7] [8]. In Africa, WHO claims under report by 49% of antibiotics resistance, which lead to difficulties in estimation of actual impact of antibiotics resistance in health system [8].

In Tanzania, Sonda *et al.* shows inappropriate use of third generation cephalosporin, ceftriaxone in up to 40.7% [9]. The antibiotic resistance in low and middle income countries is highly prevalent [9]. This is worrisome due to the fact that only few people will be able to access and afford the limited newer antibiotics [6] [10] [11].

Imperical treatment is sometimes important because in some places there is no facility to perform culture and sensitivity but also culture takes an average of 3 days to have the results. Therefore patients can be given antibiotics imperically in these situations. However, type of antibiotics to be used in imperical treatment depends on local knowledge of the most prevalent organisms and their susceptibility profile. The antimicrobial susceptibility pattern and microbial profile vary greatly from one place to another and therefore imperical treatments vary from place to place.

It is important to identify local antibiotic sensitivity patterns among groups of

patients to target treatment and avoid untargeted empirical and excessive antibiotic use, which promotes antibiotic resistance crisis [12]. An updated knowledge of antibiotics susceptibility profile of clinical isolates will assist both in choosing the most appropriate antibiotic treatment for wound infections and help in curbing the escalation of drug resistance [13].

This study was aimed at identifying the commonly pyogenic bacteria from pus samples from orthopedic patients and determination of their antibiotic susceptibilities to various antibiotics commonly used at KCMC.

2. Materials and Methods

2.1. Study Design and Settings

Cross sectional hospital based study was done at Kilimanjaro Christian medical centre (KCMC). KCMC is Institution of the Good Samaritan Foundation of Tanzania located in Moshi Municipality, North-eastern Tanzania. The hospital has 650 bed capacities and is the second largest consultant zonal referral hospital in the country serving patients from northern and central regions of Tanzania. It is the teaching hospital for the Kilimanjaro Christian Medical University College, which offers undergraduate and post-graduate training. It has a well equipped Clinical laboratory for patient care with a back-up advanced biotechnology laboratory. The study involved all pus culture and sensitivity results for samples collected form orthopedic and trauma patients sent to KCMC clinical laboratory from January 2018 to December 2020.

2.2. Sample Size

Total of 125 subjects were included into the study, sampled from January 2018 to December 2020. The power of the study was calculated by using a formula of single proportion. Wound infection prevalence of 7% taken from study done in Kenya by Dinda [14] $n = \frac{z^2 p(1-p)}{d^2}$ (minimum sample size 100).

2.3. Sampling Technique

Non probability, convenient sampling technique was used.

2.4. Dependent Variable

Gram positive and Gram Negative Bacterial pathogens isolated.

2.5. Independent Variable

Age, sex, occupation, history of cigarette smoking, Hemoglobin level, comorbidities, education level, source/site of pus sample and antibiotics susceptibility pattern of gram negative and positive bacteria isolates.

2.6. Study Procedures

All orthopedic and trauma patients registered in microbiology laboratory for

culture and sensitivity during the study period were included in the study. And all who's their sample shows no growth was excluded from the study. Only those with growth their particulars were taken and used to trace their files from medical record and into Electronic Health Management System (EHMS) where social demographic and clinical characteristics data were found. Their laboratory results for culture and sensitivity were traced from laboratory dataset system. All data were recorded into data extraction sheet.

2.7. Standard Operating Procedures for Pus Swab Collection and Quality Control

At KCMC Orthopedic department, Pus samples were collected by sterile syringe aspiration and/or by sterile swabs in accordance with standard protocols and ethical guidelines. Pus samples were kept in Cary-Blair transport medium until processed for Gram staining and culturing. The samples were then aseptically inoculated on blood agar (with 5% sheep blood) and Mac-Conkey agar plates (Oxoid, UK), incubated aerobically at 35˚C - 37˚C for 24 - 48 hours. Identification and characterization of isolates were performed on the basis of Gram staining, microscopic characteristics, colony characteristic, and biochemical tests using standard microbiological methods. For quality control, the plates with culture media were inoculated at 37˚C for 24 hours to check for sterility. The ability to support growth of the common bacteria were determined by inoculating the media with a typical stock culture of *Staphylococcus aureus* ATCC25923, Escherichia *coli* ATCC 25922 and *Klebsiella pneumoniae* ATCC 12883. Isolated bacteria were tested for susceptibility using antibiotics discs containing amikacin (30 µg), amoxicillin/clavulanic acid (30 µg), ampicillin (10 µg), ceftriaxone (30 µg), cefotaxime (30 µg), cefuroxime (30 µg), ciprofloxacin (1 µg), clindamycin (2 µg), trimethoprim/sulfamethoxazole (25 µg), erythromycin (15 µg), gentamicin (10 µg), imipenem (10 µg), meropenem (10 µg), piperacillin/tazobactam (100/10 µg), tetracycline (30 µg), and vancomycin (30 µg), cefoxtin (30 µg), ceftazdime (30 µg), chloramphenicol (30 µg), penicillin (10 µg), piperacillin (100 µg) and Tobramycin (10 µg) which are constant supplied by local supplier.

2.8. Antibiotics Susceptibility Testing

Antibiotic susceptibilities of bacterial isolates were determined according to the method recommended by Clinical and Laboratory Standards Institute (CLSI) of 2017. Briefly, inocula were prepared for each bacterial isolate by adjusting the turbidity to 0.5 McFarland standard and spread on Muller-Hinton agar plates. Antibiotic disc was placed on the agar plates and incubated overnight at 37˚C for 24 hours. The zones of inhibition were measured and the isolates were classified as sensitive, intermediate, and resistant according to CLSI tables and guidelines.

For this study intermediate resistance was regarded as resistance and Multi-drug-resistance (MDR) was defined as resistance to at least one antibiotic in three or more antibiotics category [15] [16].

2.9. Data Management and Analysis

Patients' social-demographic and clinical characteristics particulars were recorded into the data extraction sheet by a researcher or researcher assistance. Filled data extraction sheet were collected daily and cross checked before entered into data analysis system.

SPSS version 23 was used for statistical analysis. Data cleaning were done, by checking for outliers and missing values. Descriptive statistics were summarized using the frequency and percentage for categorical variables, mean and standard deviation for continuous variables. Cross-tabulation was done to estimate proportions of bacteria susceptibility.

3. Results

3.1. Social-Demographic and Clinical Characteristics of Study Population

A total of 148 samples were collected in the study period, 23 (15.5%) shows no growth. From 125 samples that shows growth, 94 (75.2%) were from male patients. Mean age was 38.5 years (SD ± 19 years), age range from 2 to 98 years and 90 (72.6%) of the patient were aged 19 to 60 years. Those with no formal and primary education were 26 (51%), 84 (80.8%) had no employment, 14 (13.3%) had life time history of smoking, and 22 (19.4%) had comorbidities.

Mean Hemoglobin (Hb) was 10.8 g/dl (SD ± 2.7 g/dl), and 93 (77%) had Hb < 12.5 g/dl. Of the 125 samples collected, 98 (86.7%) were collected by pus swab and 15 (13.3%) by a sterile syringe aspiration. And 27 (23.7%) were from surgical site infected wounds, 49 (43%) from infected open traumatic wound and 38 (33.3%) from non-traumatic infected wound/abscess/pyogenic arthritis.

Single bacterial isolates were recovered from 120 (96%) samples and 90 (72%) showed resistance to more than two drugs and 67 (53.6%) showed resistance to more than three drugs. A total of 13 gram negative isolates (*Escherichia coli*, *Citrobacter* species, *Proteus* species, *Enterobacter* species and *Acinetobacter* species) were tested for ESBL and all were found to be ESBL producer (Table 1).

3.2. Distribution of Bacteria Isolates

Gram negative was predominant isolate accounting for 74 (59.2%). Of all the isolates *Staphylococcus aureus* has high prevalence of 46 (36.8%) follow by *Pseudomonas aeruginosa* 17 (13.6%), *Escherichia coli* 13 (10.4%) and *Citrobacter* species 12 (9.6%). Among the gram negative isolate *Pseudomonas aeruginosa* was the predominant isolate 17 (13.6%) (Table 2).

3.3. Resistivity Pattern of the Gram Positive Bacteria Isolates

Out of 46 isolated *Staphylococcus aureus*, 20 (43%) were resistant to erythromycin, 16 (35%) were resistant to clindamycin, 16 (35%) were resistant to vancomycin, 12 (26%) were resistant to Trimethoprim/sulfamethoxazole, 8 (17%) to ciprofloxacin and 7 (15%) to gentamicin. And among the 5 Coagulase negative

Table 1. Social-demographic and clinical characteristic of the participants (N = 125).

Variable	N	%
Age (n = 124)		
<19	14	11.30
19 - 60	90	72.60
>60	20	16.10
Mean (±SD)	38.5 (±19.0)	
Sex (n = 125)		
Male	94	75.20
Female	31	24.80
Education level (n = 51)		
No formal and primary education	26	51.00
Secondary and higher education	25	49.00
Occupation (n = 104)		
Employed	20	19.20
Not employed	84	80.80
History of smoking (n = 105)		
Yes	14	13.30
No	91	86.70
Comorbidity (n = 112)		
Yes	22	19.40
No	89	79.60
Hemoglobin level (n = 121)		
Non anemia > 12.5 g/dl	28	23
Anemic ≤ 12.5 g/dl	93	77
Mean (±)	10.8 (±2.7)	
Types of sample (n = 113)		
Sterile syringe aspirate	15	13.30
Pus swab	98	86.70
Source of pus sample (n = 114)		
Surgical wound	27	23.70
Open traumatic wound	49	43.00
Non traumatic wounds	38	33.30
Multiple isolate		
Yes	5	4.00
No	120	96.00
ESBL (n = 13)		
Producer	13	100.00
Non producer	0	0.00
MDR		
Yes	67	53.60
No	58	46.40

Table 2. Distribution of bacterial pathogens isolated from pus samples (N = 125).

Pathogen	N	%
Gram positive	**51**	**40.8**
Staphylococcus aureus	46	36.8
Coagulase negative *staphylococcus*	5	4.0
Gram negative	**74**	**59.2**
Escherichia coli	13	10.4
Klebsiella species	1	0.8
Pseudomonas aeruginosa	17	13.6
Citrobacter species	12	9.6
Acinetobacter species	9	7.2
Coliforms	3	2.4
Proteus species	11	8.8
Non fermenting gram negative bacillus	5	4.0
Enterobacter species	3	2.4

staphylococcus isolated, 2 (40%) were resistant to clindamycin, ciprofloxacin and erythromycin (Table 3).

3.4. Resistivity Pattern of the Gram Negative Bacteria Isolates

All *Enterobacter* species isolated were resistant to cefotaxime and ciprofloxacin, and all *Coliforms* were resistant to amoxicillin/clavulanic acid. *Pseudomonas aeruginosa*, shows high resistant to cephalosporin, 6 (35%) were resistant to cefotaxime, 5 (29%) were resistant to ceftazdime and 5 (29%) were resistant to ceftriaxone. Among the 13 isolates of the *Escherichia coli*, 8 (62%) were resistant to ciprofloxacin, 6 (46%) were resistant to ampicillin, 5 (38%) were resistant to cefotaxime and 5 (38%) were resistant to gentamicin. Among the 12 *Citrobacter* species isolated, 8 (67%) were resistant to ampicillin, 7 (58%) were resistant to gentamicin, 6 (50%) were resistant to cefotaxime and 4 (33%) were resistant to ceftriaxone. And among the 11 isolates of *Proteus* species, 6 (55%) were resistant to ampicillin and 4 (36%) were resistant to gentamicin, ceftriaxone and Trimethoprim/sulfamethoxazole. Out of 9 *Acinetobacter* species isolates, 7 (78%) were resistant to gentamicin, 5 (56%) were resistant to ceftriaxone, 5 (56%) were resistant to Amoxicillin/clavulanic acid and 5 (56%) were resistant to ampicillin (Table 4).

3.5. Sensitivity Pattern of the Gram Positive Bacteria Isolates

Out of 46 *Staphylococcus aureus* isolated, 26 (57%) were sensitive to gentamicin, 23 (50%) were sensitive to clindamycin, 16 (35%) were sensitive to vancomycin, 14 (30%) were sensitive to ciprofloxacin, 13 (28%) were sensitive to erythromycin and 10 (22%) were sensitive to Amoxicillin/clavulanic acid. And among the 5 Coagulase negative staphylococcus isolated, 3 (60%) were sensitive to clindamycin, gentamicin and vancomycin (Table 5).

Table 3. Resistivity pattern of the gram positive bacteria isolates.

Resistivity	SA n = 46	CNS n = 5
Amoxicillin/clavulanic acid	1 (2)	
Ampicillin	2 (4)	
Cefotaxime	1 (2)	
Ceftriaxone	3 (7)	
Chloramphenicol	1 (2)	
Ciprofloxacin	8 (17)	2 (40)
Clindamycin	16 (35)	2 (40)
Trimethoprim/sulfamethoxazole	12 (26)	1 (20)
Erythromycin	20 (43)	2 (40)
Gentamicin	7 (15)	1 (20)
Meropenem	1 (2)	
Penicillin	4 (9)	
Piperacillin	4 (9)	
Tetracycline	9 (20)	
Vancomycin	16 (35)	1 (20)

NB: SA—*Staphylococcus aureus*, CNS—Coagulase Negative Staphylococcus.

Table 4. Resistivity pattern of the gram negative bacteria isolates.

Resistivity	PA n = 17	CF n = 3	CTB n = 12	EC n = 13	KB n = 1	AC n = 9	PT n = 11	NFNB n = 5	ET n = 3
Amikacin	1 (6)					1 (11)	3 (27)	2 (40)	
Amoxicillin/clavulanic acid	2 (12)	3 (100)	1 (8)	4 (31)	1 (100)	5 (56)	3 (27)	2 (40)	
Ampicillin			8 (67)	6 (46)		5 (56)	6 (55)	1 (20)	
Cefotaxime	6 (35)	2 (67)	6 (50)	5 (38)	1 (100)	2 (22)	3 (27)	2 (40)	3 (100)
Ceftazdime	5 (29)		2 (17)	2 (15)		2 (22)	1 (9)		2 (67)
Ceftriaxone	5 (29)		4 (33)	3 (23)		5 (56)	4 (36)	2 (40)	1 (33)
Cefuroxime				1 (8)					
Ciprofloxacin	3 (18)	1 (33)	3 (25)	8 (62)	1 (100)	1 (11)	2 (18)	2 (40)	3 (100)
Clindamycin						1 (11)			
Trimethoprim/sulfamethoxazole	2 (12)		2 (17)	4 (31)		2 (22)	4 (36)	2 (40)	
Erythromycin				1 (8)					
Gentamicin	2 (12)	1 (33)	7 (58)	5 (38)	1 (100)	7 (78)	4 (36)	1 (20)	
Imipenem	1 (6)								
Meropenem	2 (12)		3 (25)	2 (15)		3 (33)			1 (33)
Piperacillin	3 (18)						1 (9)		
Piperacillin/Tazobactum	2 (12)								
Tetracycline								1 (20)	

NB: PA—*Pseudomonas aeruginosa*, CF—*Coliforms*, CTB—*Citrobacter* species, EC—*Escherichia coli*, KB—*Klebsiella* species, AC—*Acinetobacter* species, PT—*Proteus* species, NFNB—non fermenting gram negative bacillus, ET—*Enterobacter* species.

Table 5. Sensitivity pattern of the gram positive bacteria isolates.

Sensitivity	SA n = 46	CNS n = 5
Amikacin	4 (9)	
Amoxicillin/clavulanic acid	10 (22)	
Ampicillin	2 (4)	
Cefotaxime		1 (20)
Cefoxtin	1 (2)	
Ceftriaxone	4 (9)	
Chloramphenicol	7 (15)	2 (40)
Ciprofloxacin	14 (30)	2 (40)
Clindamycin	23 (50)	3 (60)
Trimethoprim/sulfamethoxazole	9 (20)	2 (40)
Erythromycin	13 (28)	1 (20)
Gentamicin	26 (57)	3 (60)
Imipenem	6 (13)	
Meropenem	1 (2)	
Tetracycline	5 (11)	2 (40)
Vancomycin	16 (35)	3 (60)

NB: SA—*Staphylococcus aureus*, CNS—Coagulase Negative Staphylococcus.

3.6. Sensitivity Pattern of the Gram Negative Bacteria Isolates

All *Enterobacter* species and *Coliforms* isolates were sensitive to amikacin. Among the 17 *Pseudomonas aeruginosa* isolated, 14 (82%) were sensitive to gentamicin, 12 (71%) were sensitive to amikacin and 8 (47%) were sensitive to ciprofloxacin. Out of 13 *Escherichia coli* isolated, 7 (54%) were sensitive to gentamicin, 7 (54%) were sensitive to amoxicillin/clavulanic acid and 6 (46%) were sensitive to amikacin. Out of 12 *Citrobacter* species isolated, 9 (75%) were sensitive to amikacin, 7 (58%) were sensitive to amoxicillin/clavulanic acid and 6 (50%) were sensitive to ciprofloxacin. Among the 11 *Proteus* species isolated, 6 (55%) were sensitive to gentamicin and 5 (45%) were sensitive to amikacin and amoxicillin/clavulanic acid. And among the 9 *Acinetobacter* species isolated 8 (89%) were sensitive to amikacin (Table 6).

4. Discussion

This study demonstrated the predominance of gram negative isolates to be more than half of isolates 74 (59.2%) which is consistent with the other studies from Tanzania and India [13] [17] [18] [19]. However, the predominant organism isolated was *Staphylococcus aureus* 46 (36.8%). Several studies reported *Staphylococcus aureus* as the most common isolate associated with wound infection as the index study [20] [21] [22] [23] [24]. The high prevalence of *Staphylococcus*

Table 6. Sensitivity pattern of the gram negative bacteria isolates.

Sensitivity	PA n = 17	CF n = 3	CTB n = 12	EC n = 13	KB n = 1	AC n = 9	NFNB n = 5	PT n = 11	ET n = 3
Amikacin	12 (71)	3 (100)	9 (75)	6 (46)	1 (100)	8 (89)	2 (40)	5 (45)	3 (100)
Amoxicillin/clavulanic acid			7 (58)	7 (54)		1 (11)	1 (20)	5 (45)	2 (67)
Ampicillin	1 (6)								
Cefotaxime	2 (12)			1 (8)					
Ceftazdime	2 (12)			1 (8)			1 (20)		
Ceftriaxone				1 (8)				4 (36)	
Chloramphenicol			2 (17)						
Ciprofloxacin	8 (47)	2 (67)	6 (50)	3 (23)		3 (33)		2 (18)	
Clindamycin				1 (8)					
Trimethoprim/sulfamethoxazole			2 (17)	2 (15)		3 (33)		1 (9)	
Gentamicin+	14 (82)	2 (67)	2 (17)	7 (54)			1 (20)	6 (55)	1 (33)
Imipenem	3 (18)		2 (17)	2 (15)			2 (40)	1 (9)	
Meropenem	4 (24)		1 (8)	2 (15)		2 (22)	1 (20)	3 (27)	
Piperacillin	4 (24)			1 (8)			1 (20)	4 (36)	2 (67)
Piperacillin/Tazobactum	1 (6)								
Tetracycline			1 (8)						
Vancomycin				1 (8)					

NB: PA—*Pseudomonas aeruginosa*, CF—*Coliforms*, CTB—*Citrobacter* species, EC—*Escherichia coli*, KB—*Klebsiella* species, AC—*Acinetobacter* species NFNB—non fermenting gram negative bacillus, PT—*Proteus* species, ET—*Enterobacter* species.

aureus can be partly explained by presence of it on the skin surface as a normal flora.

Among the gram negative isolates, *Pseudomonas aeruginosa* 17 (13.6%) and *Escherichia coli* 13 (10.4%) were the predominant isolates, this consistent with the study from India, and Nigeria [13] [25]. Contrary to a study done in Tanzania that shows predominance of *Proteus* species among the gram negative isolates [18]. Some other studies shows predominance of *Escherichia coli* among the gram negative isolates [26] [27] [28]. High prevalence of gram negative especially *Escherichia coli* can be partially explained by poor hospital and patient hygiene. This study demonstrates few multiple isolates from the sample 5 (4%), in support of the study done in India [22], but contrary to the study done in Ethiopia [21], this can be explained by either some of the patient might have use antibiotics prior to sample or few contaminations due to sterility during pus sampling.

In regarding to susceptibility pattern, Of the 125 samples studied, 67 (53.6%) showed MDR pattern, and almost all isolate show increased resistivity and decreased sensitivity to tested antibiotics. Similar findings was observed by other researchers from Tanzania and Uganda [26] [29], contrary to study done in

Ethiopia which showed few MDR [23]. This can be explained by the over use of empirical antibiotics before laboratory investigation.

Only 13 gram negative isolates were tested for ESBL and it was found that all were ESBL producer, many studies reported increase in prevalence of ESBL producing gram negative isolates [10] [30] [31], this can be explained by the fact that ceftriaxone is the most misuse antibiotic in this hospital [9].

The index study revealed that most gram negative isolates have high resistance to ampicillin and cephalosporin including the most common used drug at KCMC, ceftriaxone. Similar results were reported in previous studies from Tanzania, India, Napel and ECDC 2014 [13] [17] [18] [22]. While gram positive shows high resistance to erythromycin clindamycin, vancomycin and Amoxicillin/clavulanic acid, this is contrary to the study done in India which shows increased sensitivity to vancomycin but increased resistivity of *Staphylococcus aureus* to erythromycin and Trimethoprim/sulfamethoxazole as the index study [22].

Both gram positive and negative shows high susceptibility to gentamicin, amikacin, clindamycin, ciprofloxacin and Amoxicillin/clavulanic acid, similar to study done in Tanzania and Nigeria [17] [21]. This can be partially explained by the fact that these drugs are expensive and mostly prescribed by a physician, hence community misuse are unlikely.

The findings in this study could be influence by small sample size and Missing of some patient's information. Some patient might have use antibiotics prior, this might have resulted in few isolates per culture. Isolated bacteria were not subjected to all types of antibiotics and not all antibiotics were included in the study, this might have underestimated the susceptibility pattern. Also nature of study design, single centered study and uneven number of antibiotics to bacteria might have resulted in limited information.

5. Conclusions

The study showed that *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* are the most common bacteria isolated from pus samples in orthopedic patients at KCMC. The bacteria isolated showed high resistance to ampicillin and most cephalosporin including ceftriaxone while gentamicin, clindamycin, ciprofloxacin, amikacin and Amoxicillin/clavulanic acid were effective against most of the isolates.

Periodic surveillance of bacteria profile and their susceptibility pattern is recommended to increase the target chance for empirical antibiotics.

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Author's Contributions

LKM and PGH, conception and designed this study, designed data collection

tool and Interpretation of data.

LKM was involved in data collection, analysis and drafting the manuscript.

AJP and RJT supervised the project and reviewed the draft.

All authors read and approved the final manuscript for publication.

Ethical Approval

Ethical clearance certificate with clearance number PG-07/2020 was obtained from Kilimanjaro Christian Medical University College (KCMUCo) ethical review committee for permission to conduct this study. All patients' information was handled with confidentiality and patient file numbers were used instead of their names. All methods were carried out in accordance with standard guideline and regulations. And informed consent was obtained from all patients and for those under 18 years from parents and/or legal guardian.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Conflicts of Interest

Authors declare no competing interests.

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