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Original Article

Antibiotic Susceptibility of Bacteria Isolated from Open Fracture Grade III Presenting to Dr. Soetomo General Academic Hospital Surabaya

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ABSTRACT

Background: Open fractures are a typical case in the orthopedics field. Infection in an open fracture can cause osteomyelitis. An antibiotic susceptibility testing of patient specimen bacteria with open fractures aimed to determine suitable antibiotic agents with which to treat the infectious diseases caused by these bacteria.
Methods: This research is a descriptive study to assess antibiotic susceptibility in cases of open fracture grade III in Dr. Soetomo General Academic Hospital, Surabaya. Total sampling was performed on the microbiological culture results of patients diagnosed with open fracture grade III after debridement from October 2018 to September 2019. The identification of the microbes was based on Gram-positive and Gram-negative categories, and the classification was based on susceptibility to antibiotics, whether sensitive, intermediate, and resistant.
Results: The examination of the data from the microbiological culture results of patients with a diagnosis of open fracture grade III after debridement from October 2018 to September 2019 in Dr. Soetomo General Hospital Surabaya resulted in 56 research subjects who met the criteria. Acinetobacter baumannii was the most common bacterial species found in the microbiological examination of patients with open fractures, at 15.84%. Cefazoline and ceftriaxone showed low susceptibility. Levofloxacin showed a relatively good value of susceptibility against both Gram-positive and negative bacterial groups.
Conclusion: The antibiotic susceptibility pattern of bacteria from specimens in open fracture grade III patients in Dr. Soetomo General Academic Hospital Surabaya varies between each species of bacteria isolate.

Keywords: Antibiotics; Open fracture grade III; Susceptibility

INTRODUCTION

Osteomyelitis presents a significant challenge in orthopedic care. It is notoriously difficult to eradicate, often necessitating prolonged and complex treatment regimens. The impact of osteomyelitis extends far beyond the physical realm, significantly affecting patients' functional abilities, quality of life, and financial and psychosocial well-being.[1] A key risk factor for developing osteomyelitis in the context of open fractures is the bacterial load present after initial debridement.[2] The presence of a high number of bacterial colonies can overwhelm the body's natural defenses and lead to persistent infection. Therefore, reducing this bacterial burden is of paramount importance in preventing osteomyelitis. Thorough debridement, along with the timely administration of effective antibiotic therapy, constitute the cornerstones of treatment for open fractures.[3]

To ensure appropriate antibiotic selection and optimize treatment outcomes, hospitals

should maintain an updated antibiogram. This valuable tool provides insights into the local patterns of bacterial susceptibility to various antibiotics, guiding clinicians in making informed decisions and preventing the irrational use of antibiotics.[4] In line with this, the present study aims to determine the bacterial susceptibility patterns in open fracture cases at Dr. Soetomo General Academic Hospital Surabaya. The findings of this study will provide a critical reference for guiding rational and adequate antibiotic therapy in this patient population.

MATERIAL AND METHODS

Study Design

This was a descriptive study examining bacterial susceptibility patterns in grade III open fractures at Dr. Soetomo General Academic Hospital Surabaya.

Data Collection

The total sampling technique was used to collect data on the bacterial isolates collected from the microbiological cultures of patients diagnosed with post-debridement grade III open fractures between October 2018 and September 2019 at Dr. Soetomo General Academic Hospital Surabaya.

Inclusion Criteria

The inclusion criteria were: 1) Patients diagnosed with grade III open fractures of the following bones: humerus, radius, ulna, femur, tibia, fibula, clavicle, scapula, spine, pelvis, carpal, patella, metacarpal, phalanx, talus, calcaneus, tarsal, and metatarsal; 2) Patients who underwent debridement; 3) Patients with specimens that underwent microbiological culturing.

Exclusion Criteria

The exclusion criteria were: 1) Patients diagnosed with grade III open fractures of the skull, ribs, or vertebrae; 2) Patients who underwent debridement surgery at a hospital other than Dr. Soetomo General Academic Hospital Surabaya.

Data Analysis

The microbiological cultures were classified as Gram-positive or Gram-negative bacteria.[5] Antibiotic susceptibility testing was performed to determine the response of the bacteria to antibiotics at concentrations that can inhibit or kill the bacteria. The results were categorized as sensitive, intermediate, or resistant.[6] After classifying the bacteria according to either Gram-positive or Gram-negative categories, the bacteria were further classified based on their susceptibility to antibiotics. This analysis was conducted to generate a profile of bacterial susceptibility in patients with grade III open fractures at Dr. Soetomo General Academic Hospital Surabaya.

RESULTS

Fifty-six subjects met the inclusion criteria. Based on Table 1, most open fracture sufferers were aged 11-30 years (46.40%). The male gender group had a higher incidence than the female gender, at 39 subjects or 69.7%. The most common open fracture location was in the lower leg region in 22 cases, or 39.29%. Meanwhile, the number of open fracture cases in the forearm and foot regions had a similar value, namely 8 cases or 14.29%.

Table 1. Subject characteristics.

	Total (n=56)	Percentage (%)
Age		
11-30 years	26	46.40
31-50 years	20	35.70
> 50 years	10	17.90
Gender		
Male	39	69.7
Female	17	30.3
Fracture Location		
Forearm	8	14.29
Thigh	18	32.14
Lower leg	22	39.29
Foot	8	14.29

Table 2. Distribution of bacteria based on microbiological examination.

	Total (n=101)	Percentage (%)
Bacteria		
Acinetobacter baumannii	16	15.84
E. coli ESBL	12	11.88
Pseudomonas aeruginosa	10	9.90
Proteus mirabilis	9	8.91
Enterobacter cloacae	7	6.93
Providencia stuartii	6	5.94
MRSA	5	4.95
Staphylococcus aureus	5	4.95
Morganella morganii	3	2.97
Globicatella sanguinis	2	1.98
Enterococcus faecalis	2	1.98
Bacillus cereus	2	1.98
Corynebacterium striatum	2	1.98
Staphylococcus epidermidis	2	1.98
Enterobacter aerogenes	2	1.98
Streptococcus gordonii	2	1.98
Gemella haemolysans	1	0.99
Pantoea agglomerans	1	0.99
Candida Parapsilosis this is fungi, not bacteria	1	0.99
Enterococcus faecalis	1	0.99
Klebsiella pneumoniae ESBL	1	0.99
Staphylococcus schleiferi	1	0.99
E. coli	1	0.99
Aeromonas hydrophila	1	0.99
Providencia rettgeri	1	0.99
Amycolatum striatum	1	0.99
Kluyvera ascorbata	1	0.99
Stenotrophomonas maltophilia	1	0.99
Streptococcus anginosus	1	0.99
Ralstonia pickettii	1	0.99

In Table 2, the distribution of bacteria shows that Acinetobacter baumannii was the most common species of bacteria found in the microbiological examination of open fracture sufferers, at 15.84%. In comparison, E. Coli ESBL is the pathogen with the second largest frequency, at 11.88%. Other pathogens found from isolated cultures can be seen in the table below. An overview of the pattern of bacterial susceptibility to various kinds of antibiotics can be seen in more detail in the table below as well, as shown in Table 3 and 4. The test results show that the susceptibility value varies based on the bacteria species and the kinds of antibiotics used.

DISCUSSION

Open fracture type IIIB is associated with extensive injury or soft tissue loss, accompanied by periosteal stripping and bone exposure, massive contamination, and a severe degree of comminution.[7] In this study, the majority of patients with open fractures were between 11 and 30 years old (46.40%). This finding is consistent with previous studies reporting a mean age of 23 ± 1.5 years and 29.5 years, respectively.[8,9] This age group is more prone to serious injuries due to increased activity levels and risk-taking behaviors.[8,9]

More males sustained open fractures than females (69.7% vs. 30.3%). This is consistent with reports that males are generally more prone to injuries due to their involvement in risky activities at work and during leisure time.[10] The most common location of open fractures was the lower leg (39.29%). This finding aligns with other studies reporting similar incidences of lower leg open fractures (40.62% and 62%, respectively).[8,11] Open fractures of the forearm and foot occurred with a similar frequency (14.29%).

Acinetobacter baumannii was the most common bacteria identified (15.84%), consistent with previous reports.[11] A study by Zhu et al. found Acinetobacter baumannii in 16 out of 201 open fracture cases contaminated with seawater. This study found that Acinetobacter baumannii showed low susceptibility to most antibiotics tested, with only trimethoprim-sulfamethoxazole (13%) and tigecycline (22%) demonstrating some efficacy.[12]

Table 3. Antibiotic Susceptibility to Gram-positive Bacteria

	MRSA	Staphylococcus aureus	Globicatella sanguinis	Enterococcus faecalis	Bacillus cereus	Corynebacterium striatum	Gemella haemolysans	Streptococcus gordonii	Staphylococcus schleiferi	Amycolatum striatum	Streptococcus angionosus	Staphylococcus epidermidis
	The number of bacteria tested(percentage)											
Amikacin	-	5(100)	0	0	-	0	-	-	1(100)	1(100)	-	-
Gentamicin	0	4(80)	0	0	2(100)	-	0	-	1(100)	1(100)	0	1(100)
Aztreonam	-	-	-	-	-	-	-	-	-	-	-	-
Amoxicillin-Clavulanic Acid	0	4(80)	2(100)	2(100)	-	0	-	-	0	-	-	1(100)
Ampicillin	0	0	-	1(50)	0	-	-	0	0	-	1(100)	0
Ampicillin-sulbactam	-	-	-	-	0	-	-	-	-	-	-	-
Piperacillin	-	-	-	-	-	-	-	-	-	-	-	-
Tazobactam	-	-	-	2(100)	2(100)	0	-	-	-	1(100)	1(100)	1(100)
Oxacillin	0	4(80)	-	0	0	-	-	-	0	0	-	1(100)
Cefazolin	-	-	-	-	-	-	-	-	-	-	-	-
Ceftazidime	-	-	-	-	-	-	-	-	-	-	-	-
Cefotaxime	0	-	-	0	-	0	0	0	-	-	0	-
Ceftriaxone	-	-	-	0	-	0	0	2(100)	-	-	1(100)	-
Cefepime	-	-	-	-	-	-	-	-	-	-	-	-
Trimethoprim-Sulfamethoxazole	2(40)	5(100)	0	0	0	0	0	0	1(100)	0	1(100)	1(100)
Tetracyclin	1(20)	0	-	-	-	-	-	-	0	-	0	1(100)
Tigecycline	-	-	-	-	-	-	-	2(100)	-	-	-	1(100)
Chloramphenicol	2(40)	60	0	2(100)	1(50)	1(50)	0	2(100)	-	1(100)	0	1(100)
Erythromycin	2(40)	4(80)	1(50)	0	1(50)	0	0	2(100)	0	0	0	1(100)
Clindamycine	3(60)	4(80)	0	0	0	0	0	2(100)	0	0	0	0
Quinopristin-dalfopristin	5(100)	5(100)	-	0	-	-	-	-	-	-	-	-

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	MRSA	Staphylococcus aureus	Globicatella sanguinis	Enterococcus faecalis	Bacillus cereus	Corynebacterium striatum	Gemella haemolysans	Streptococcus gordonii	Staphylococcus schleiferi	Amycolatum striatum	Streptococcus angionosus	Staphylococcus epidermidis
	The number of bacteria tested(percentage)											
Ciprofloxacin	0	4(80)	-	-	-	-	-	-	100	-	-	1(100)
Levofloxacin	0	75	1(50)	2(100)	2(100)	0	-	2(100)	-	0	1(100)	1(100)
Moxifloxacin	2(40)	75	-	-	-	-	-	2(100)	-	-	-	1(100)
Fosfomycin	5(100)	4(80)	-	2(100)	2(100)	1(50)	-	-	-	0	0	1(100)
Nalidixic Acid	-	-	-	-	-	-	-	-	-	-	-	-
Imipenem	-	-	-	-	-	-	-	-	-	-	-	-
Meropenem	-	-	-	-	-	-	-	-	-	-	-	-
Vancomycin	5(100)	5(100)	1(50)	2(100)	0	2(100)	1(100)	2(100)	0	-	1(100)	1(100)
Linezolid	5(100)	5(100)	1(50)	2(100)	2(100)	2(100)	1(100)	2(100)	0	-	1(100)	1(100)
Fosfomycin	0	5(100)	0	0	-	-	-	-	-	1(100)	-	1(100)

Table 4. Antibiotic Susceptibility to Gram-negative Bacteria

	Acinetobacter baumanni	E.Coli ESBL	Pseudomonas aeurigenosa	Proteus mirabilis	Enterobacter cloaca	Providencia stuartii	Morganella morgagnii	Enterobacter aerogenes	Pantoea agglomerans	Kleibsella pneumonia	E.Coli	Providencia rettgeri	Amycolatum striatum	Kluyvera ascorbata	Stenotrophomonas maltophilia	Ralstonia pickettii
	The number of bacteria tested(percentage)															
Amikacin	0	9(100)	6(60)	9(100)	7(100)	4(67)	3(100)	2(100)	0	0	1(100)	1(100)	1(100)	1(100)	0	1(100)
Gentamicin	0	-	6(60)	5(55)	2(29)	0	2(67)	50	0	1(100)	-	0	1(100)	1(100)	0	0

Table 4. Antibiotic Susceptibility to Gram-negative Bacteria

	Acinetobacter baumanni	E.Coli ESBL	Pseudomonas aeurigenosa	Proteus mirabilis	Enterobacter cloaca	Providencia stuartii	Morganella morgagnii	Enterobacter aerogenes	Pantoea agglomerans	Kleibsella pneumonia	E.Coli	Providencia rettgeri	Amycolatum striatum	Kluyvera ascorbata	Stenotrophomonas maltophilia	Ralstonia pickettii
	The number of bacteria tested(percentage)															
Aztreonam	0	3(33)	3(30)	8(88)	1(14)	0	2(67)	50	0	-	1(100)	0	-	0	0	0
Amoxicillin/ Clavulanic Acid	0	-	0	5(55)	0	0	0	0	0	-	0	0	-	0	0	0
Ampicillin	0	0	0	1(11)	0	0	0	0	0	1(100)	0	0	-	0	0	0
Ampicil-lin-sulbactam	0	2(22)	0	5(55)	0	1(17)	0	0	0	-	0	0	-	0	0	0
Piperacillin	0	0	8(80)	5(55)	1(14)	0	-	2(100)	0	-	0	0	-	0	0	0
Tazobactam	0	8	8(80)	7(77)	3(43)	5(83)	3(100)	2(100)	0	-	1(100)	0	1(100)	0	0	1(100)
Oxacillin	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-
Cefazolin	0	0	0	6(67)	0	0	0	0	0	-	0	0	-	0	0	0
Ceftazidime	0	8(88)	8(80)	9(100)	1(14)	0	3(100)	1(50)	0	-	1(100)	0	-	0	0	0
Cefotaxime	0	-	1(10)	5(55)	1(14)	0	1(33)	1(50)	0	-	1(100)	0	-	0	0	0
Ceftriaxone	0	-	2(20)	7(77)	1(14)	0	1(33)	1(50)	0	-	1(100)	0	-	0	0	1(100)
Cefepime	0	0	4(40)	7(77)	4(57)	0	1(33)	2(100)	0	-	1(100)	0	-	1(100)	-	0
Trimetho-prim/Sulfa-methoxazole	2(13)	-	0	1(11)	3(43)	0	1(33)	1(50)	0	0	1(100)	1(100)	0	1(100)	1(100)	0
Tetracyclin	0	0	0	0	5(71)	0	0	2(100)	0	-	0	0	-	1(100)	0	-
Tigecycline	4(25)	0	0	4(44)	4(57)	6(100)	0	-	0	-	1(100)	0	-	-	1(100)	-
Chloram-phenicol	0	0	0	1(11)	2(29)	0	0	1(50)	0	-	-	0	1(100)	1(100)	0	0

Table 4. Antibiotic Susceptibility to Gram-negative Bacteria

	Acinetobacter baumanni	E.Coli ESBL	Pseudomonas aeurigenosa	Proteus mirabilis	Enterobacter cloaca	Providencia stuartii	Morganella morgagnii	Enterobacter aerogenes	Pantoea agglomerans	Kleibsella pneumonia	E.Coli	Providencia rettgeri	Amycolatum striatum	Kluyvera ascorbata	Stenotrophomonas maltophilia	Ralstonia pickettii
	The number of bacteria tested(percentage)															
Erythromycin	-	-	-	-	-	-	-	-	-	0	1(100)	-	0	-	-	-
Clindamycin	-	9(100)	-	-	-	-	-	-	-	0	-	-	0	-	-	-
Quinopristin-dalfopristin	-	-	10(100)	-	-	-	-	-	-	1(100)	-	-	-	-	-	-
Ciprofloxacin	0	0	3(30)	4(44)	1(14)	5(83)	2(67)	2(100)	0	-	1(100)	0	-	1(100)	-	0
Levofloxacin	0	2(22)	6(60)	4(44)	4(57)	3(50)	1(33)	1(50)	0	1(100)	1(100)	0	0	1(100)	0	0
Moxifloxacin	-	-	-	3(33)	2(29)	2(33)	1(33)	2(100)	0	-	1(100)	0	-	1(100)	-	-
Fosfomycin	0	3(33)	3(30)	5(55)	4(57)	0	0	0	-	-	1(100)	0	0	1(100)	0	0
Nalidixic Acid	-	5(55)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imipenem	0	5(55)	6(60)	-	6(86)	-	-	0	0	-	1(100)	0	-	1(100)	0	0
Meropenem	0	-	7(70)	9(100)	7(100)	5(83)	3(100)	2(100)	0	-	1(100)	0	-	1(100)	0	1(100)
Vancomycin	-	-	10(100)	-	-	-	-	-	-	1(100)	-	-	-	-	-	-
Linezolid	-	-	10(100)	-	-	-	-	-	-	-	-	-	-	-	-	-
Fosfomycin	0	27	0	100	100	-	-	-	-	0	-	-	1(100)	-	-	-

The genus Acinetobacter comprises non-lactose-fermenting, catalase-positive, non-motile, non-fastidious, oxidase-negative, aerobic, Gram-negative coccobacilli. Acinetobacter baumannii is clinically significant due to its involvement in nosocomial infections and intrinsic resistance to a wide range of antimicrobials. It has a high propensity to develop resistance due to its ability to survive desiccation, remaining viable on inanimate objects for months.[13,14] Acinetobacter baumannii can accumulate multiple antibiotic resistance genes, leading to multidrug-resistant or extensively drug-resistant strains.[15-17]

First-line antibiotics for Acinetobacter baumannii infections include broad-spectrum cephalosporins (ceftazidime or cefepime), beta-lactam/beta-lactamase inhibitor combinations, or carbapenems.[17] Carbapenems are highly bactericidal against susceptible strains but susceptibility patterns can vary. For Acinetobacter baumannii resistant to these agents, tetracyclines (minocycline and tigecycline) or polymyxins (polymyxin B and colistin) may be considered.[17,18]

The second most common bacteria was extended-spectrum β-lactamase (ESBL)-producing E. coli (11.88%). This finding is similar to a study by Abraham and Wamisho, which reported 10.5% of isolates as E. coli.[19] ESBLs are plasmid-mediated enzymes that hydrolyze and inactivate beta-lactam antibiotics, including third-generation cephalosporins, penicillins, and aztreonam.[20] In this study, several antibiotics, including ampicillin, amoxicillin-clavulanic acid, amoxicillin, and trimethoprim-sulfamethoxazole, showed 100% susceptibility against E. coli ESBL. Amikacin and clindamycin also demonstrated 100% susceptibility.

Pseudomonas aeruginosa was the third most common bacteria (9.90%). It is a Gram-negative bacillus ubiquitous in the environment and an opportunistic pathogen in humans, causing various infections, including urinary tract infections, burn infections, respiratory infections, and septicemia.[21,20] It is a primary cause of ventilator-associated pneumonia in intensive care units.[22] Nosocomial infections caused by Pseudomonas aeruginosa are a significant concern due to its intrinsic and acquired resistance to many antibiotics.[23]

Treatment options for Pseudomonas aeruginosa infections include aminoglycosides, third- and fourth-generation cephalosporins, fluoroquinolones, monobactams, extended-spectrum penicillins, and polymyxin B/colistin.[24] For systemic infections with shock or sepsis, combination therapy with two intravenous antimicrobials, including an aminoglycoside, is recommended.[25]

Acinetobacter baumannii, ESBL-producing E. coli, and Pseudomonas aeruginosa are nosocomial pathogens often found in intensive care units.[26] At Dr. Soetomo General Academic Hospital Surabaya, all patients with open fractures undergoing emergency surgery are admitted to the intensive care unit for postoperative observation. This practice may contribute to the prevalence of these bacteria in this study.

Other studies have reported different findings, with Pseudomonas aeruginosa and Staphylococcus capitis being the most common bacteria.[12,27] A prospective study by Gustilo et al. found that 78.7% of open fractures were contaminated with bacteria, with the infection rate correlating with fracture type.[28]

Based on the average antibiotic susceptibility of the top five most common Gram-positive bacteria, the most effective antibiotics were linezolid, vancomycin, levofloxacin, chloramphenicol, and erythromycin. For Gram-negative bacteria, the most effective antibiotics were meropenem, amikacin, tazobactam, tigecycline, and levofloxacin.

This study found low susceptibility to cefazolin in grade III open fractures, contrasting with a study by Patanwala et al. that showed cefazolin monotherapy to be as effective as ce-

fazolin with aminoglycosides.[29] Susceptibility to ceftriaxone varied depending on the bacterial species (22% for Pseudomonas aeruginosa and 100% for E. coli). This differs from research by Abraham and Wamisho, which showed excellent susceptibility to ceftriaxone in various grades of open fracture.[19]

The prevalence of multidrug-resistant nosocomial bacteria in this study highlights the importance of infection control measures. These measures include hand hygiene protocols, routine cultures from healthcare personnel and the environment, the identification of environmental sources of transmission, the closure of hospital units/wards for sterilization, the disinfection of medical equipment, the use of individual medical equipment, and minimizing the time spent in the intensive care unit after emergency surgery for open fractures.

CONCLUSION

The rational use of antibiotics is supported by the selection of antibiotics based on culture and antibiotic susceptibility tests. The prevention of nosocomial infection is the main pillar in preventing grade III open fracture complications.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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