**Original Research Article**

**ANTIBIOTIC SENSITIVITY OF BACTERIAL BLOODSTREAM INFECTIONS IN THE INTENSIVE CARE UNIT PATIENTS OF UNIVERSITY HOSPITALS IN SANA'A CITY, YEMEN**

**ABSTRACT**

**Aim and Objective:** High rates of morbidity and mortality are attributed to bacterial bloodstream infections (B-BSI) in many hospitals, especially in the intensive care unit. This study investigated the prevalence of antibiotic- and multidrug-resistant bacteria isolated from blood samples of patients in intensive care units of university hospitals in the city of Sana'a, Yemen.

**Subjects and methods**: From January 1 to April 30, 2022, a cross-sectional study was performed on sepsis patients hospitalized in intensive care units in four hospitals in Sana'a, Yemen. Patients suspected of having sepsis underwent blood cultures, then potential bacterial pathogens were isolated and identified by standard laboratory techniques, and microbial susceptibility testing was performed by the disk diffusion method.

**Results:** Eighty seven(60%) of the 145 ICU patients with suspected sepsis had the condition verified by culture, and 92 distinct bacterial isolates had their antibiotic susceptibilities examined. Gram-negative bacteria made up most of the detected microorganisms (57.5%). For all identified bacteria, the average resistance rate to a broad spectrum of antibiotics tested ranged from 22.5% to 98.1%, with cefazoline (98.1%) having the greatest resistance rates, followed by amoxicillin (87.2%) and cefixime (83%). Vancomycin had a resistance rate of 4.8% whereas erythromycin had a resistance rate of 75% for Gram-positive bacteria. For Gram-negative bacteria, the resistance rates to narrow spectrum antibiotics ranged from 2.3% for colistin sulphate to 84.8% for aztreonam. Our isolates' MDR rates for resistance to at least three classes of antibiotics were 52.2% and 8.7%, respectively, for resistance to 10 different classes of broad-spectrum antibiotics and their subclasses.

**Conclusion**: Gram negative organisms show highly resistance to amoxcillin+clavulanic acid, ciprofloxacin, and all generations of cephalosporin’s, whereas erythromycin and penicillin shows highly resistance to gram positive bacteria. This studied also shows the emergence and rates of Multi Drugs Resistance (MDR) organisms and emphasizes the importance of timely clinical and bacteriological monitoring among patients in a critical care situations as in ICU patients.

**Keywords**: Antibiotic resistant, Bacteria, Bloodstream infections (BSIs), ICUs, Multi-drug resistant (MDR), Sepsis

**INTRODUCTION**

One of the leading causes of illness and mortality worldwide continues to be bloodstream infection (BSI). Geographical variables can affect the variety of organisms that have been documented to cause BSI. Clinical staff members in charge of intensive care unit (ICU) patients face some of the most challenging issues when it comes to BSI1,2. Antimicrobial resistance is spreading globally for a variety of causes, the most significant of which being the rise in prescriptions, distribution in poorer nations, and indiscriminate use. A significant concern to global public health continues to be the estimated 700,000–multiple million deaths that take place each year3. Antimicrobial resistance-related mortality may become more common over time, according to predictions made by the World Health Organization (WHO) and United Nations study4,5. Antimicrobial resistance (AMR) is a significant public health risk in the modern era. Antimicrobial resistance bacteria are growing rapidly in a variety of hospital departments around the globe, but the issue is particularly severe and complicated in Yemen8–16. Regarding some specifics of the earlier research in Yemen, these studies mainly concentrated on examining the sensitivity to antibiotics for each bacterial isolate separately8-16, whereas the current study examined resistance to all bacterial isolates and also determined the temporal correlation of the rate of increase in the prevalence of bacterial isolate resistance to the studied antibiotics. Antimicrobial resistance is expected to become one of the major causes of death among hospitalized patients, especially immunocompromised patients such as ICU patients in developing countries including Yemen as well as even in developed countries, if appropriate control and prevention measures are not taken17-19. Antibiotics must be administered and used properly to treat bacterial infections20. Therefore, improper antibiotic prescribing and abuse may contribute to the development of pathogenic bacteria that are resistant to antibiotics, a limitation on available treatments, a lengthening of hospital stays, an increase in treatment expenses, and ultimately a rise in mortality21.

There is growing worry around the globe regarding the incidence of antibiotic resistance in blood-borne isolates22. BSI must therefore be regularly monitored. The inappropriate and illogical use of antibiotics has contributed to an increase in the development of antibiotic resistance (AMR) in Yemen, where the burden of infectious disease is among the highest in the world23. The AMR situation in Yemen has also been exacerbated by poor economic conditions, limited infrastructure, a high disease load, and unrestricted over-the-counter sales of cheap antibiotics24,25.  Awareness of hospital-specific baseline microbial resistance protects against irrational use of antibiotics. This may help progress towards preventing the spread of antibiotic resistance and could be termed proper antibiotic stewardship26.

The WHO Global Action Plan on antibiotic Resistance27 states that raising awareness of antibiotic resistance in research and monitoring initiatives around the globe is crucial. Monitoring bacterial resistance is important and has many advantages, such as: 1) providing data on the rate of bacterial resistance, 2) assisting in the selection of appropriate antibiotics and thereby reducing the rate of bacterial resistance, 3) reducing hospitalization rates and treatment costs, and 4) resulting in low mortality rates [20]. Hence, determining the epidemiological profiles and antibiotic resistance of bacteria isolated from ICU sepsis patients admitted to 4 specialized hospitals in Sana'a city in 2022 is the purpose of the current study.

**SUBJECTS AND METHODS**

**Study design and subjects:** ICU patients admitted to Sana'a city's Al Kuwait, Al Gumhory, Al Sabeen, and ALThawra hospitals' ICUs between initial admission and first January 1 through April 30 in 2022 (period allotted for PhD fieldwork in clinical microbiology) were the subjects of this cross-sectional study. Patients with suspected sepsis who were hospitalized for at least 72 hours during the study period were included.

**Diagnosis of sepsis:** Sepsis was suspected based on the presence of clinical indicators or risk factors and was confirmed as sepsis if a blood culture was positive, in accordance with international guidelines. To record the clinical traits of sepsis patients, clinicians employed standardized tools. The guardians of all patients were informed of the study's goals before providing signed consent.

**Ethic approval:** All of the techniques employed in this study were authorized by the research and ethics committee of the Faculty of Medicine and Health Sciences at Sana'a University, Sana'a, Yemen (Approval No. UGR/SU-223).

**Laboratory investigations:**

Laboratory examinations were conducted in accordance with accepted microbiological practices [28]. Blood was added to a BacT/Alert PF plus culture bottle (BIOMERIEUX, France, LOT 4053532) with a minimum of 1 ml (typically 5 ml in adult patients), and the bottle was left to incubate until the BacT/Alert instrument (BACTEC 9050, Becton Dickinson) identified the culture as positive or negative. Then, after being sub-cultured on blood agar, MacConkey agar, and choclate agar, all positive samples were incubated at 37 °C for 24-48 hours. Gram-staining was utilized to differentiate between gram-positive and gram-negative microorganisms. Enough pure culture colonies were used to suspend the bacteria in 3.0 ml of sterile saline in a test tube. Pure bacterial suspension was added to the bacterial specific identification and sensitivity testing kit device in accordance with the instructions in the product information manuals (BIOMERIEUX), and the VITEK II system was then used to analyze the samples for bacterial bio-typing and antibiotic susceptibility (the results of the patterns will be published in a separate article). Gram negative bacteria were identified using a VITEK ® GN ID identification card (lot 2410933203), whereas gram positive bacteria were identified using a VITEK ® GP ID identification card (lot 2420938203). All treatments were carried out for standard therapeutic and diagnostic purposes.

**Antibiotic sensitivity test:** Utilizing Kirby-Bauer disc diffusion techniques, antibiotic resistance was assessed, and CLSI was used to interpret antibiotic sensitivity data [29]. Typically, Sigma-Aldrich sources are used in NCPHL for antibiotic disks and medium powders. As quality control for a standard DDM test advised in the NCPHL Department of Microbiology, GPB and GNB isolates consisting of Pseudomonas aeruginosa (ATCC 27853), Escherichia coli (ATCC 25922), and Staphylococcus aureus subsp. Aureus ATCC 25923 were employed. The antibiotic disks were used to assess the susceptibility of Gram-positive bacteria and GNB to various antibiotics. The findings of the study were classified as sensitive (S), intermediate (I), or resistant (R).

**RESULTS**

Gram-negative bacteria were more common than Gram-positive bacteria overall, with frequencies of 50 (52.1%) and 42 (43.7%) respectively. *E. coli* had the highest frequency of identified Gram-negative bacteria at 20.8%, followed by *Klebsiella* spp. 11 (11.5%), *Burkholderia cepacia* 6, *H. influenzae* 5, *Acintobacter baumannii* 4, *Pseudomonas aeruginosa* 3, and *Chryseobacterium indologenes* 1. The highest frequency of isolated Gram-positive bacteria was coagulase negative *Staphylococci* 25 (26%) followed by *S. aureus* 9 (9.4%), *S. pneumoniae* 5 (5.2%), *Enterococci* 2 (2.1%) and *S. pyogenes* 1 (1.0%) respectively.

As for susceptibility to penicillin antibiotic classes, the highest rate of resistance was to piperacillin-tazobactam (76.1%) (Table 1). For the beta-lactam classes of cephalosporins, the highest susceptibility rate was to cefuroxime (47.1%), for the first generation the highest resistance rate was to cefazoline (98.1%), and for third generation β-lactam cephalosporins was ceftriaxone (79.2%) (Table 2). Meropenem (63%) and imipenem (34.8%) had the highest sensitivity rates among the various classes of carbapenems. Additionally, monobactams were only tested on Gram negative bacteria, with a resistance rate of 84.8%, while glycopeptides were only tested on Gram positive bacteria, with the highest sensitivity rate to vancomycin (95.2%) (Table 3). The sensitivity rate for colistin sulphate was 90.9% in the susceptibility to poly-peptide classes of antibiotics, which solely tested for gram negative bacteria (Table 4). For the classes of macrolides that were tested only for isolated Gram-positive bacteria, we used two types of this class: the first was azithromycin with a resistance rate of 77.8% and the other was erythromycin with a resistance rate of 75%. The aminoglycoside classes also used two types with a sensitivity rate of 67.4% to amikacin and a resistance rate of 41.8% to gentamicin (not tested for *Streptococcus pyogenes* (Table 5). Table 6 displays the susceptibility to the antibiotic families of tetracyclines, lincosamides, and oxazolidinones. Doxycycline has a sensitivity rate of 75.3% and a resistance rate of 32.5%. Table 7 displays the groups of folate pathway inhibitors and fluoroquinolone susceptibility. Levofloxacin had a 32.6% sensitivity rate while ciprofloxacin had a 66.3% resistance rate for fluoroquinolone classes. The co- trimoxazole sensitivity rate for folate pathway inhibitors was 55.8%. Figure 1 displays the range of antibiotic resistance rates for all identified bacteria, ranging from 22.5% to 98.1%, with cefazoline (98.1%) having the greatest resistance rates, followed by amoxicillin (87.2%) and cefixime (83%). For Gram-positive bacteria, the resistance rates to narrow spectrum antibiotics ranged from 4.8% for vancomycin to 75% for erythromycin. For Gram-negative bacteria, the resistance rates to narrow spectrum antibiotics ranged from 2.3% for colistin sulphate to 84.8% for aztreonam. Table 8 shows the prevalence of MDR among BSI isolates. The MDR that showed resistance to at least three classes of antibiotics for our isolates was 52.2%, and the MDR rate for resistance to 10 different classes of broad-spectrum antibiotics and their subclasses reached a rate equal to 8.7%.

**DISCUSSION**

The average proportion of resistance to broad-spectrum antibiotics evaluated for all identified bacteria in the current study ranged from 22.5% to 98.1%, with cefazoline having the greatest resistance rate at 98.1%, followed by amoxicillin at 87.2% and cefixime at 83%. This typically high incidence of resistance can be explained by the fact that antimicrobial usage in both humans and other animals, as well as the occurrence of resistant strains between the two, are primarily responsible for the rise in drug resistance. The emission of inadequately treated effluents from the pharmaceutical industry, particularly in nations where bulk medicines are produced, has also been linked to an increase in resistance. Antibiotics boost the rate at which the remaining resistant bacteria proliferate by increasing the selective pressure on bacterial populations, which causes the susceptible germs to perish. The advantage of resistant bacteria over weak microorganisms can exist even at relatively low levels of antibiotic use. Alternative therapies are becoming necessary as instances of antibiotic resistance increase. New antibiotic therapies have been demanded, but it is getting harder to produce new medications30,31. In 4 tertiary hospitals in Sana'a, Yemen, the current study examined the prevalence of antibiotic resistance among the primary pathogenic bacteria isolated from ICU patients' blood. One of the top concerns of clinicians worldwide is the occurrence and spread of these agents, which are certain to be capable of causing serious infections in ICU patients, particularly in immunocompromised patients, the elderly, neonates, and children25,32,33. Because different patterns of antimicrobial resistance exist in different places, it is not permitted to administer multiple classes of antibiotics to neonates and children. It is also challenging to choose and prescribe the right antibiotics to treat various infections in immunocompromised, elderly, neonatal, and pediatric patients. Additionally, understanding the patterns of antibiotic resistance might assist physicians and policy officials in addressing the issues with resistance in their respective nations34.

Patients and healthcare professionals would use antibiotic resistance inappropriately as a result of the absence of public surveillance initiatives in developing nations like Yemen and many industrialized nations35–38. Investigation of antimicrobial resistance trends is therefore crucial and significant, particularly in underdeveloped nations like Yemen where there are no formal recommendations for the use of antibiotics. On the other hand, it is vital to look at the patterns of GPB and GNB antibiotic resistance in Sana'a city hospitals' intensive care units (ICUs) in 2022. This research could serve as a valuable model for policymakers and physicians implementing experimental treatments to ICU sepsis patients. The findings of the current study revealed that linezolid had a rate of resistance of 21.4% (Table 8), making it ineffective against *Enterococcus* spp. and *S. aureus*. This rate differed from those previously reported by Al-Shami *et al*.24 (0.4%), Al-Huraibi *et al.*39 (0.0%), and Al-Safani *et al.*25 (<1%) in Yemen. The resistance to linezolid was also higher than that reported by Azimi *et al*. in Iran40, Dharmapalan *et al*. in India41, He *et al*. in China42, Li Tian *et al*. in China43, and Al-Naqshbandi and others in Iraq44, where it was less than 2%. However, the results of other investigations were consistent with the current study, and it has been reported that linezolid resistance is widespread and may reach 20% or more45,46.

As of right now, 4.8% of Gram-positive bacteria were resistant to a restricted range of antibiotics, including vancomycin (Table 8). In contrast to the rates of vancomycin resistance reported by Al-Huraibi *et al.*39 for *S. aureus* (0.0%) and total GPB by Al-Shami *et al*.24, which was 7.8%, the resistance rate observed in the current study was greater at 18.0%. Many nations, including the USA, have implemented successful VRSA risk reduction strategies, and certain guidelines have been produced to prevent infections brought on by these pathogenic bacteria, according to a number of published research and reports47. As a result, we recommend comparable policies and initiatives created for patients in Sana'a, Yemen. The current study also demonstrated that, in contrast to ciprofloxacin (66.3% resistant rate), a restricted spectrum of antibiotics targeting Gram-negative bacteria, such as colistin, exhibited a 2.3% resistance rate (Table 8). These findings contrasted from those published by Azimi *et al.*, who found that colistin has a higher rate of resistance than ciprofloxacin40, but were similar to those of Mahmoudi *et al.* from Iran21 and Dharmapalan *et al*. from India4.

Sulfamethoxazole/trimethoprim, ceftazidime, ampicillin, ceftorexime, cefazoline, cefadroxil, cefuroxime, cefixime, and cefotaxime are all ineffective antibiotics against GPB or GNB, according to the study's overall findings. It is important to note that these antibiotics are frequently used to treat various illnesses, particularly sepsis and septicemia, in Sana'a's hospitals. It is generally known that the misuse or overuse of antibiotics as well as bystander selection lead to the daily rise in antibiotic resistance, which is the cause of this48. So the following role must be followed in our situation: use antibiotics with caution if major pathogenic microorganisms have a resistance rate of > 40%. Drug sensitivity test findings must be utilized to choose which antibiotics to employ when major pathogenic bacteria have a resistance rate of > 50%. If the major pathogenic bacteria are more than 75% resistant to antibiotics, then antibiotic use must be discontinued. It is necessary to look into and assess feedback on bacterial resistance in order to decide if clinical usage of the medication can continue49. Consistent with the high antibiotic resistance among bacteria, in an attempt to stop the unwanted consequence of sepsis and septicemia, as well as with the purpose of reduce the mortality rate because of these infections, accurate recognition and employ of efficient antibiotics for effective treatment is critical50-53. Thus, awareness of antibiotic resistance patterns among common pathogens, holding work-shops to correct prescribing for empirical therapy, and changes in antimicrobial use are necessary and highly recommended.

In the current study MDR rate was 52.2% (Table 8), this is higher than that reported elsewhere in which infections by multidrug resistant bacteria (MDR) occur frequently in patients admitted to intensive care unit (ICU) with incidence up to 40% in and are usually associated to high mortality49. ICU patients are in critical condition, and are often accompanied with multiple organ dysfunction and severe immune dysfunction. Ventilator and invasive operation may result in damage to physiological barriers of patients, and risk of infection in ICU patients is higher compared with patients in other departments54. ICU patients use antibiotics at a higher frequency, higher dose and longer duration, and infection with multiple drug-resistant bacteria (multidrug-resistant organisms; MDROs) is severe compared with patients in other departments. Although bacteria have their own mechanisms for drug resistance, improper use of antibiotics, particularly abuse of third-generation cephalosporins, is the main cause of the high frequency of multidrug-resistant bacteria infection in ICUs55–57. According to studies, a significant cause of death for ICU patients is nosocomial infection. Improve the treatment effectiveness and prognosis of ICU patients by adopting clear, evidence-based prevention and control measures to drastically lower the incidence of nosocomial infection. To combat nosocomial infections and lower the risk of antibiotic resistance, lobbying efforts should be made.

**LIMITATIONS OF THE STUDY**

The limitations of the study were as follows. First, because the data came from one geographical location (Sana’a city), we were not able to accurately determine the types of isolates and their sensitivity pattern to antibiotics for Yemen. Molecular research should also be conducted on these isolates to confirm the bacterial resistant genes.

**CONCLUSIONS**

The prevalence and antibiotic resistance of bacteria isolated from ICUs are briefly reviewed in this study's conclusion. In contrast to Erythromycin and Penicillin, which are extremely resistant to gram positive bacteria*, E. coli* was the most often isolated gram negative organism. It also exhibits strong resistance to amoxcillin+clavulanic acid, Ciprofloxacin, and all generations of cephalosporins. This study highlights the significance of timely clinical and bacteriological monitoring among patients in critical care conditions, such as in ICU patients, and also demonstrates the appearance and rates of Multi Drug Resistant (MDR) pathogens. Antibiotics should also be administered with caution. ICUs and other critical care facilities should therefore establish antibiotic policies.

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**CONFLICT OF INTEREST**

This work does not include any conflicts of interest.

**AUTHOR CONTRIBUTIONS**

Eshtiaq A. Al-Yousafi, the study's first author, conducted the fieldwork as part of his PhD studies at Sana'a University's Faculty of Medicine and Health Sciences' Department of Medical Microbiology. Additional authors contributed to the data analysis, the writing, reviewing, and final approval of the work.

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**Table 1**: The susceptibility of bacterial isolates to penicillin’s classes antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Amoxicillin-Clavulanate** | **Penicillin and β- lactamase** **inhibitor** | 41 | **44.6** | 2 | **2.2** | 49 | **52.7** | 92 |
| **Piperacillin- Tazobactam** | 11 | **11.9** | 11 | **11.9** | 70 | **76.1** | 92 |
| **Amoxicillin** | **Penicillin/amino-penicillin** | 5 | **12.8** | 0 | **0** | 34 | **87.2** | 39\* |
| **Ampicillin** | 9 | **25.6** | 1 | **2.6** | 29 | **74.3** | 39\* |

\*=Excepted *P. aeruginosa*, *Staphylococci, S. pneumoniae, S. pyogens, B.cepacia* and *A. baumannii*.

**Table 2:** The susceptibility of bacterial isolates to cephalosporins β-lactam classes antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Cefazoline** | **1st generation** | 0 | **0** | 1 | **1.9** | 52 | **98.1** | 53\* |
| **Cefadroxil** | 15 | **28.3** | 0 | **0** | 38 | **71.7** | 53\* |
| **Cephradin** | 20 | **37.7** | 5 | **9.4** | 28 | **52.8** | 53\* |
| **Cefoxitin** | **2nd generation** | 30 | **34.5** | 0 | **0** | 57 | **65.5** | 87\*\*\* |
| **Cefuroxime** | 25 | **47.1** | 4 | **7.5** | 24 | **45.3** | 53\* |
| **Cefotaxime** | **3rd generation** | 18 | **34** | 2 | **3.8** | 33 | **62.2** | 53\* |
| **Ceftriaxone** | 10 | **18.9** | 1 | **1.9** | 42 | **79.2** | 53\* |
| **Ceftazidime** | 20 | **22.2** | 2 | **3.6** | 34 | **60.7** | 56\*\* |
| **Cefoperazone** | 25 | **35.7** | 4 | **7.5** | 24 | **45.3** | 53\* |
| **Cefixime** | 8 | **15.1** | 1 | **1.9** | 44 | **83** | 53\* |
| **Cefepime** | **4th generation** | 16 | **28.6** | 0 | **0** | 40 | **71.4** | 56\*\* |

\*=Excepted *Enterococci, P. aeruginosa* and *Staphylococcus spp*.,\*\*=Excepted *Enterococci* and *Staphylococcus spp*., \*\*\* =Excepted *Enterococci* and *P. aeruginosa*.

**Table 3:** The susceptibility of bacterial isolates to carbapenems, glycopeptides and monobactamsclasses antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Imipenem** | **Carbapenems** | 52 | **56.5** | 8 | **8.7** | 32 | **34.8** | 92 |
| **Meropenem** | 58 | **63** | 6 | **6.5** | 28 | **30.4** | 92 |
| **Vancomycin** | **Glycopeptides** | 40 | **95.2** | 0 | **0** | 2 | **4.8** | 42\* |
| **Aztreonam** | **Monobactams** | 14 | **15.2** | 0 | **0** | 36 | **84.8** | 50\*\* |

\*=Tested only for Gram positive bacteria, \*\*=Tested only for Gram negative bacteria

**Table 4:** The susceptibility of bacterial isolates to polymyxins classes antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Colistin Sulphate** | **Polymyxins** | 40 | **90.9** | 3 | **6.8** | 1 | **2.3** | 44\* |
| **Polymyxins B** | 36 | **81.8** | 1 | **2.3** | 3 | **6.8** | 44\* |

\*= Excepted *Burkhoderia cepacia*

**Table 5:** The susceptibility of bacterial isolates to macrolides and aminoglycosidesclasses antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Azithromycin** | **Macrolides** | 9 | **20** | 1 | **2.2** | 35 | **77.8** | 45\* |
| **Erythromycin** | 8 | **20** | 2 | **5** | 30 | **75** | 40\*\* |
| **Amikacin** | **Aminoglycosides** | 62 | **67.4** | 1 | **1.1** | 29 | **31.5** | 92 |
| **Gentamicin** | 50 | **54.9** | 3 | **3.3** | 38 | **41.8** | 91\*\*\* |

\*=Tested for *H. influenzae* and Gram-positive bacteriaexcept *Enterococci., \**\*=Tested for Gram-positive bacteriaexcept *Enterococci.*\*\*\*=Excepted *Streptococcus pyogenes.*

**Table 6:** The susceptibility of bacterial isolates to tetracyclines, lincosamides and oxazolidinones classes antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Tigecycline** | **Tetracyclines** | 60 | **67.4** | 5 | **5.6** | 24 | **27** | 89\* |
| **Doxycycline** | 67 | **75.3** | 2 | **2.2** | 20 | **22.5** | 89\* |
| **Clindamycin** | **Lincosamides** | 25 | **62.5** | 2 | **5** | 13 | **32.5** | 40\*\* |
| **Linezolid** | **Oxazolidinones** | 32 | **76.2** | 1 | **2.4** | 9 | **21.4** | 42\*\*\* |

\*= Excepted *P. aeruginosa,*\*\*=Tested only for Gram-positive bacteria except *Enterococci,* \*\*\*=Tested only for Gram positive bacteria

**Table 7:** The susceptibility of bacterial isolates to fluoroquinolones classes and folate pathway inhibitors antibiotics.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antibiotics name** | **Classes** | **Sensitive** | | **Moderate** | | **Resistant** | | **Total** |
| **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** |
| **Ciprofloxacin** | **Fluoroquinolones** | 26 | **28.3** | 5 | **5.4** | 61 | **66.3** | 92 |
| **Norfloxacin** | 29 | **31.5** | 8 | **8.7** | 55 | **59.8** | 92 |
| **Levofloxacin** | 30 | **32.6** | 9 | **9.8** | 53 | **57.6** | 92 |
| **Moxifloxacin** | 27 | **30.3** | 15 | **16.8** | 47 | **52.8** | 89\* |
| **Co-Trimoxazole** | **Folate pathway inhibitors** | 48 | **55.8** | 3 | **3.5** | 35 | **40.7** | 86\*\* |

\*= Excepted *P. aeruginosa*.

\*\*= Excepted *P. aeruginosa*, *S. pyogenes* and *Enterococci*.

**Table 8:** Prevalence of MDR degree among BSI isolates (n = 92)

|  |  |  |
| --- | --- | --- |
| Broad spectrum Antimicrobial class used to define MDR | Degree | **No (%)** |
| Tetracycline (Tetercycline)  Imipenem (carbapenems)  Sulfonamides (Cotrimoxazole)  Gentamicin (Aminoglycoside)  Levofloxacin (fluoroquinolone  Cefoxitin (Cephalosporin)  Ciprofloxacin (Quinolone)  Piperacillin-Tazobactam (combination penicillin)  Azithromycin (macrolide)  Amoxicillin (Amino-penicillin) | R 0 | 12 (13) |
| R 1 | 25 (27.2) |
| R 2 | **7 (7.6)** |
| R 3 | 5 (5.4) |
| R 4 | 1 (1.1) |
| R 5 | 15 (16.3) |
| R 6 | 7 (7.6) |
| R 7 | 1 (1.1) |
| R 8 | 9 (9.8) |
| R 9 | 2 (2.2) |
| R 10 | 8 (8.7) |
| Resistant to at least three antibiotic class | MDR | 48 (52.2) |

R0: Sensitive against all selected antibiotic class; R1: Resistant to at least one antibiotic class; R2: Resistant to two antibiotic class; R3: Resistant to three antibiotic class; R4: Resistant to four antibiotic class; R5: Resistant to five antibiotic class; R6: Resistant to six antibiotic class; R7: Resistant to all seven antibiotic class; etc. MDR: Resistant to at least three antibiotic class.

**Figure 1:** Antibiotics resistant rate for isolated bacteria from septicemia ICUs patients.