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Antibiotic Susceptibility of Bacterial Wound Infection: A Cross Sectional Study

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ABSTRACT

Background: Wound infections are one of the most prevalent hospital acquired illnesses and a significant contributor to morbidity. Antibiotic-resistant bacterial infections worsen the condition in developed, developing, and underdeveloped countries.

Aim: The purpose of this research was to identify the frequency of various bacterial pathogens and their sensitivity to various kinds of antibiotics in various categories of wound infections in randomly selected Basra City hospitals.

Method: Fifty-seven patients with wound infection were involved in this cross sectional study, which was conducted by extracting data from the records of hospital laboratories, where information about bacterial examination of swabs taken by hospital staff from infected wounds and cultured with antibiotic sensitivity test by laboratory staff for treatment purposes.

Results and Conclusions: The median age of patients was 38 years, 59.65% of them were males. The most frequent bacteria encountered was *Klebsiella pneumonia* (24.56%). Single bacterial growth was dominant (86% of cultured bacteria). In antibiotic sensitivity test Gentamycin (7.19%), Ciprofloxacin (5.92%), Amikacin (5.50%), and Tobramycin (5.36%) were the most frequent antibiotics tested, while Cefotaxime, Ceftriaxone, Clarithromycin, and Nalidixic acid were the least used. The highest sensitivity shown by the cultured bacteria was to Tigecycline (92.86%), Lenizoild (90.91%), and Teicoplanin, (80.00%), although they had not been tested widely. While, the antibiotics to which the cultured bacteria did not show any sensitivity were Lomefloxacin (0.00), Ceftriaxone (0.00), and Nalidixic Acid (0.00). Also, the antibiotics to which there had been high resistance were Piperacillin (17.14%) and Minocycline (13.64%).

KEY WORDS: Wound infection, Bacterial culture, Antibiotic sensitivity

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INTRODUCTION

One of the most prevalent hospital acquired illnesses and a significant contributor to morbidity and death are wound infections. It is crucial to have knowledge of the most frequent infection-causing agents and their pattern of antimicrobial sensitivity in order to administer empirical treatment when it is necessary before culture findings are accessible [1].

Antibiotic-resistant bacterial infections worsen the condition in both developed and emerging countries. Microorganisms' sensitivity to antimicrobials changes over time and location. The interaction of numerous variables determines how a wound infection develops. Accidental injuries and shots can end with wound infections, but post-operative wound infections in hospitals are more frequent . Antibiotic sensitivity tests of the isolates can be used to develop an effective infection control plan in light of the variety of the isolated bacteria and their patterns of vulnerability [2].

Wound infection means as the presence of replicating bacteria, virus, parasite and fungi within a wound leading to host tissue injury [3]. As demonstrated by intraoperative culture, wound contamination is connected to a subsequent wound infection [4].

Regardless of the kind of wound, higher colony forming units of bacteria cultured from the wound are predictive of wound infection [5]. strong microbial Wound healing is adversely affected by contamination [1].

There is a complicated interplay of numerous variables determines how quickly a wound infection will spread. Numerous various cell types will flood the area and start an inflammatory reaction if the skin's integrity and protective function are compromised. The typical symptoms of redness, soreness, edema, elevation of temperature, and fever may be present. Pus is typically described as the discharge of a wound infection [3].

Infections from surgical wounds occur frequently, and this is linked to greater illness and medical costs [8]. Despite the new antibiotics that are now readily accessible, multi-drug resistant bacteria continue to develop as a result of extensive prophylactic antibiotic use and secondary bacterial contamination in surgical wounds [9]:

1. Direct contact: passing from a surgeon's or nurse's palms or from surgery instruments
2. Airborne spread - microbes in the nearby air that settle on the incision
3. Self-contamination: when endogenous flora from the patient's epidermis, mucous membranes, or gastrointestinal system physically migrate to the surgical site.

Most of the time, contaminating bacteria are destroyed by the human immune system and do not survive; however, species that multiply and colonize a lesion can do so [10]. Toxic compounds are secreted by the microorganisms when infectious bacteria invade wound tissues. These elements, also known as virulence factors, enable the microbes to colonize the wound. When bacteria invade a wound, inflammatory cells like neutrophils fight the invaders and produce cytotoxic enzymes, oxygen radicals, and inflammatory substances that further harm the tissue. This defense system is also a factor in the infection wound's non-healing stage [11].

Sterilizing damaged tissue from any microbial invasion is one of the most crucial methods for maintaining the healing process. The ongoing use of systemic and topical antimicrobial agents has created the selective pressure necessary for the rise of types that are resistant to antibiotics, which in turn triggers the ongoing research for new medications [12].

Currently, wound infection resistant to antibiotic treatment is growing more due to the rising costs of finding effective antimicrobial agents and the slowing rate of new medication development [13].

However, variables like wound type, depth, location, and quality, level of tissue perfusion, and antimicrobial effectiveness of the host immune response will affect the quantity and variety of microbes in any wound. Many different microorganisms, including bacteria, fungus, parasites, and viruses, can infiltrate a wound [14].

Staphylococcus aureus (*S. aureus*), which has been linked to wound infection frequently and accounts for 20–40% of cases according to research, and *Pseudomonas aeruginosa* (*P. aeruginosa*) accounts for 5–15% of nosocomial infections, with burns and operations being the primary causes of infection. In particular, immune-compromised patients and those who underwent stomach surgery have been linked to other organisms like enterococci and members of the Enterobacteriaceae family [6]. Due to pervasive bacterial antibiotic resistance, an increased frequency of infections brought on by methicillin-resistant *S. aureus*, and polymicrobic flora, controlling wound infections has become more difficult [15].

Despite their great worth in treating infections and serving as a preventative measure, timeliness of delivery, selection of the antimicrobial agent, and length of administration have all contributed to defining the importance of antibiotics in the prevention of skin diseases [1].

AIM

The purpose of this research was to identify the frequency of various bacterial pathogens and their Susceptibility to various kinds of antibiotics in various categories of wound infections in randomly selected Basra City hospitals.

METHOD

The study was cross sectional and conducted by extracting data from the records of hospital laboratories, where information about bacterial examination of swabs taken from infected wounds of patients consult/admitted to the hospital during the period from April 2022 and January 2023 for treatment purposes. Diabetic foot infections were excluded from this study.

Two hospitals that were selected by simple random sampling from a total of seven hospitals in Basra City Center. One in Basra's south and the other in the city's north. Inside the laboratory, as far as all the records data were taken, no sampling needed to be conducted and no sample size was calculated.

The following variables were all gathered from the records of both hospital laboratories and were used in the research, age, sex, bacterial culture results, antimicrobial sensitivity, and type of method used to determine culture results and bacterial sensitivity.

As a research tool, we used a data collection form, which was structured in accordance with the study's objectives and reviewed by the researchers themselves as well as laboratory work experts.

In order to conduct this study, a formal endorsement was sought from the official authorities through the Basra Directorate of Health (Annex 1).

Official endorsement was taken from the relevant body in the Basra Directorate of Health, The Center of Training and Human Resource Development.

After frequent attending for 2 days/ week, for 3 weeks, to each hospital, data were hand copied from the records.

All the relevant data, which were recorded by the microbiology laboratory staff were considered. Swab samples were routinely collected by the laboratory staff during the year 2022.

The collected data were checked for accuracy and completeness by each of the research team at the end of the working day. Then the collected filled-in forms were cross-checked by the team members, double checking, to be completed/corrected in the next visit to the laboratory. After gathering the data, they were triple checked. The checked data was entered into the SPSS software, version 26, where they were analyzed.

Simple training was carried out before to the team members on filling-in the data collection forms.

A pilot study was conducted to evaluate the feasibility of the research proposal, as well as to determine the amount of money, materials, labor, and time needed to carry it out

For the purpose of statistical analysis, SPSS software, version 26 was used. Qualitative data were expressed in frequencies and percentages, while quantitative data were expressed in mean± standard deviation. To investigate the association between qualitative data, Fisher's Exact Test was used. To investigate the difference between/among groups of quantitative data, student t-test and ANOVA tests were used.

RESULTS

Records contained 57 patients' data (33 in Al-Sadr Teaching Hospital and 24 in Al-Fayhaa Teaching Hospital). Swabs from those were taken during the period from April 2022 and January 2023, examined routinely by the laboratory staff, and documented in the registries. Males were more than females and the median age of them was 38 years, with a minimum age of 2 years and maximum age of 75 years (Table 1).

Table (1): Demographic characteristics of the patients

Variable	Frequency	Percent
Hospital:		
Al-Sadr Teaching Hospital	33	57.89
Al-Fayhaa Teaching Hospital	24	42.11
Sex:		
Male	34	59.65
Female	23	40.35
	Mean± SD	**Median (Min.- Max.)**
Age:	36.05±18.03	38 (2-75)
Total	57	(10.00%)

Table (2) shows that about 86% of culture growth was single, with 13 bacterial species could be recognized. The most frequent bacteria encountered was *Klebsiella pneumoniae*. About 82.5% of culture and sensitivity results were diagnosed via using the Vitec approach.

Table (2): Type of growth and culture results of swabs taken from the patients

Variable	Frequency	Percent
Growth:		
Single	49	85.96
Mixed	8	14.04

Culture result:		
Klebsiella pneumoniae	14	24.56
Staphylococcus aureus	10	17.54
Escherichia coli	9	15.79
Pseudomonas aeruginosa	7	12.28
Proteus mirabilis	5	8.77
Acinetobacter baumannii	4	7.02
Staphylococcus haemolyticus	2	3.51
Sphingomonas saucimobilis	1	1.75
Klebsiella oxytoca	1	1.75
Proteus penneri	1	1.75
Morganella morganii	1	1.75
Streptococcus pyogens	1	1.75
Staphylococcus epidermidis	1	1.75
Type of method:		
Vitec	47	82.46
Manual	10	17.54
Total	57	(10.00)

No any significant statistical difference could be found in the distribution of bacterial species grown when compared according to the method of identification used (Vitec or manual) (Table 3).

Table (3): Types of bacteria grown distributed according to method of identification

Bacterial genus	Type of method		Total	P-value*
	Vitec	Manual		
Klebsiella	14	1	15	0.823
	29.8%	10.0%	26.3%	
Pseudomonas	6	1	7	
	12.8%	10.0%	12.3%	
Proteus	4	2	6	
	8.5%	20.0%	10.5%	
Escherichia	7	2	9	
	14.9%	20.0%	15.8%	
Acinetobacter	3	1	4	
	6.4%	10.0%	7.0%	
Sphingomonas	1	0	1	
	2.1%	0.0%	1.8%	
Staphylococcus	10	3	13	
	21.3%	30.0%	22.8%	
Morganella	1	0	1	
	2.1%	0.0%	1.8%	
Streptococcus	1	0	1	
	2.1%	0.0%	1.8%	
Total	47	10	57	
	100.0%	100.0%	100.0%	

* Fisher's Exact Test

It can be seen in Table (4) that Gentamycin (7.19%), Ciprofloxacin (5.92%), Amikacin (5.50%), and Tobramycin (5.36%) were the most frequent antibiotics, out of 51 antibiotics, used to investigate the sensitivity of the bacteria cultured. On the other hand, Cefotaxime, Ceftriaxone, Clarithromycin, and Nalidixic acid were the least used. The highest sensitivity shown by the cultured bacteria was to Tigecycline (92.86%), Lenizoild (90.91%), and Teicoplanin, (80.00%), although they had not been tested widely. While, the antibiotics to which the cultured bacteria did not show any sensitivity were Lomefloxacin (0.00), Ceftriaxone (0.00), and Nalidixic Acid (0.00). Also, the antibiotics to which there had been high resistance were Piperacillin (17.14%) and Minocycline (13.64%).

Table (4): The antibiotics used in the sensitivity testing of the bacterial growth

Antibiotic	Sensitive	Intermediate	Resistant	Total
	No. (%)	No. (%)	No. (%)	No. (%)
Gentamicin	27(52.94)	22(43.14)	2(3.92)	51(7.19)
Ciprofloxacin	20(47.62)	22(52.38)	0(0.00)	42(5.92)
Amikacin	25(64.10)	13(33.33)	1(2.56)	39(5.50)
Tobramycin	18(47.37)	20(52.63)	0(0.00)	38(5.36)
Piperacillin	14(40.00)	15(42.86)	6(17.14)	35(4.94)
Trimethoprim/sulfamethoxazole	13(40.63)	19(59.38)	0(0.00)	32(4.51)
Meropenem	21(67.74)	10(32.26)	0(0.00)	31(4.37)
Ceftazidime	12(40.00)	16(53.33)	2(6.67)	30(4.23)
Imipenem	12(42.86)	15(53.57)	1(3.57)	28(3.95)
Ticarcillin/clavulanic acid	5(17.86)	23(82.14)	0(0.00)	28(3.95)
Cefepime	11(42.31)	15(57.69)	0(0.00)	26(3.67)
Levofloxacin	12(50.00)	12(50.00)	0(0.00)	24(3.39)
Ticarcillin	2(8.33)	22(91.67)	0(0.00)	24(3.39)
Tirapazamine	14(58.33)	10(41.67)	0(0.00)	24(3.39)
Minocycline	7(31.82)	12(54.55)	3(13.64)	22(3.10)
Aztreonam	9(47.37)	10(52.63)	0(0.00)	19(2.68)
Tetracycline	9(47.37)	10(52.63)	0(0.00)	19(2.68)
Ofloxacin	2(12.50)	13(81.25)	1(6.25)	16(2.26)
Rifampicin	9(64.29)	5(35.71)	0(0.00)	14(1.97)
Tigecycline	13(92.86)	1(7.14)	0(0.00)	14(1.97)
Moxifloxacin	7(53.85)	5(38.46)	1(7.69)	13(1.83)
Azithromycin	5(41.67)	7(58.33)	0(0.00)	12(1.69)
Erythromycin	6(50.00)	6(50.00)	0(0.00)	12(1.69)
Lenizoild	10(90.91)	1(9.09)	0(0.00)	11(1.55)
Clindamycin	5(50.00)	5(50.00)	0(0.00)	10(1.41)
Benzylpencilin	1(11.11)	8(88.89)	0(0.00)	9(1.27)
Cefoxitin	3(33.33)	6(66.67)	0(0.00)	9(1.27)
Nitrofurantoin	9(10.00)	0(0.00)	0(0.00)	9(1.27)
Cefalotin	1(12.50)	7(87.50)	0(0.00)	8(1.13)
Colistin	4(50.00)	4(50.00)	0(0.00)	8(1.13)
Fusidic acid	5(62.50)	3(37.50)	0(0.00)	8(1.13)
Trimethoprim	4(57.14)	3(42.86)	0(0.00)	7(0.99)
Penicillin-G	1(16.67)	5(83.33)	0(0.00)	6(0.85)
Vancomycin	1(16.67)	5(83.33)	0(0.00)	6(0.85)
Azidothymidine	3(60.00)	2(40.00)	0(0.00)	5(0.71)
Doxycycline	2(40.00)	3(60.00)	0(0.00)	5(0.71)
Piperacillin/Tazobactam	3(60.00)	2(40.00)	0(0.00)	5(0.71)
Teicoplanin	4(80.00)	1(20.00)	0(0.00)	5(0.71)
Norfloxacin	1(25.00)	3(75.00)	0(0.00)	4(0.56)
Cefixime	1(33.33)	2(66.67)	0(0.00)	3(0.42)
Linezonomycin	3(10.00)	0(0.00)	0(0.00)	3(0.42)
Tedizolid	2(66.67)	1(33.33)	0(0.00)	3(0.42)
Augmentin	1(50.00)	1(50.00)	0(0.00)	2(0.28)
Ampicillin	1(50.00)	1(50.00)	0(0.00)	2(0.28)
Chloramphenicol	2(10.00)	0(0.00)	0(0.00)	2(0.28)
Lomefloxacin	0(0.00)	2(10.00)	0(0.00)	2(0.28)

Cefotaxime	1(100.00)	0(0.00)	0(0.00)	1(0.14)
Ceftriaxone	0(0.00)	1(100.00)	0(0.00)	1(0.14)
Clarithromycin	1(10.00)	0(0.00)	0(0.00)	1(0.14)
Nalidixic Acid	0(0.00)	1(10.00)	0(0.00)	1(0.14)
Total	342(46.91)	370(50.75)	17(2.33)	729

In Table (5), it can be noted that there was no any significant statistical difference in the mean age of patients whom their wounds/burns showed single growth and those whom showed mixed growth.

Table (5): The mean age of patients categorized according to the type of growth, whether single or mixed

	Growth	**N**	**Mean**	**SD**	**P-value***
Age	Single	49	37.20	18.80	0.236
	Mixed	8	29.00)	10.50)	

* Independent T-Test

To explore if there is any association between age of the patients and the type of bacteria encountered from the infected wound/burn, Oneway ANOVA test was used and no any statistically significant difference in the mean age of patients grouped according to the bacterial growth (Table 6).

Table (6): The mean age of patients distributed according to the type of bacteria grown

Bacteria	**N**	**Mean**	**SD**	**P-value***
Klebsiella	15	40.47	20.11	0.121
Pseudomonas	7	46.00	14.25	
Proteus	6	27.83	12.81	
Escherichia	9	37.78	15.99	
Acinetobacter	4	39.00	8.87	
Sphingomonas	1	60.00	------.	
Staphylococcus	13	27.31	18.69	
Morganella	1	43.00	------.	
Streptococcus	1	5.00	------.	
Total	57	36.05	18.03	

* ANOVA Test

There was a significant statistical association between sex of the patient and the type of growth, whether single or mixed. While none of the swabs taken from the female patients showed mixed growth, about one quarter of the males' swabs showed the mixed growth (Table 7).

Table (7): The sex of patients categorized according to the type of growth, whether single or mixed

Growth	**Sex**		**Total**	**P-value***
	Male	**Female**		
Single	26	23	49	0.016
	76.5%	100.0%	86.0%	
Mixed	8	0	8	
	23.5%	0.0%	14.0%	
Total	34	23	57	
	100.0%	100.0%	100.0%	

* Fisher's Exact Test

No any significant statistical association was note between the type of bacteria grown and sex (Table 8).

Table (8): Types of bacteria grown distributed according to sex

Bacterial species	Sex		Total	P-value*
	Male	Female		
Klebsiella	9	6	15	0.169
	26.5%	26.1%	26.3%	
Pseudomonas	4	3	7	
	11.8%	13.0%	12.3%	
Proteus	6	0	6	
	17.6%	0.0%	10.5%	
Escherichia	6	3	9	
	17.6%	13.0%	15.8%	
Acinetobacter	3	1	4	
	8.8%	4.3%	7.0%	
Sphingomonas	1	0	1	
	2.9%	0.0%	1.8%	
Staphylococcus	5	8	13	
	14.7%	34.8%	22.8%	
Morganella	0	1	1	
	0.0%	4.3%	1.8%	
Streptococcus	0	1	1	
	0.0%	4.3%	1.8%	
Total	34	23	57	
	100.0%	100.0%	100.0%	

* Fisher's Exact Test

DISCUSSION

Limitations of the study:

The current study was designed to be conducted at the hospital laboratories, when the swab sample needed to be taken from the outpatient and inpatient clinics at the hospitals and examined by the researchers themselves. All official agreements and research requirements were provided according to this plan. However, this research protocol could not be carried out because of the lack of time in the presence of very few patients who attend the hospitals because of infected wounds and the lack of infected burn swabs, as the hospital laboratories examine blood sample to diagnose infection. That is why the study was conducted on extracted data from hospital laboratory records. So, this research suffers from the same two constraints of record-based studies, namely incompleteness and inaccuracy.

RESULTS DISCUSSION

Patients' sex distribution agrees other studies like Al-Habsi THA *et al* [16] which showed positive wound swabs obtained from (67.5%) males and 52 (32.5%) females. Age distribution was also similar to Al-Habsi's [16], who reported that the age of wound infection patients was between 0-90 years with a median age of 46 years. It, therefore, can be stated that wound infection can occur in patients of any age and both sexes. Swabs from the infected wounds of those patients resulted in about 85.96% of the cultured samples grew single microorganism. This was close to the finding of Roopashree S *et al*. [17], who documented 83.50% of cultured sample showed single culture.

The finding that *Klebsiella pneumoniae* was the most frequent microorganism in this study differed from the findings of other studies, which showed that the most frequent bacteria grown was *Staphylococcus aureus*. [1, 18]. Those studies ranged the percentage of the cultured *Klebsiella pneumoniae* between 0-15% of the samples. These variations could be due to environmental differences, such as a difference in the source of infection, community- or hospital-acquired or a difference in the bacterial prevalence in the general environment. To make sure that the variation was not due to differences in the method used, manual or Vitec, statistical testing was applied and there was no any significant difference between the results of the two methods (p-value= 0.823).

Regarding sensitivity testing, the grown bacteria showed low sensitivity to the top tested antibiotics. However, the antibiotic effectiveness might be augmented when the intermediate sensitivity is considered.

The non-significant statistical differences in the type of bacteria cultured according to age differs with Lari, A.R. et al in Iran [19], who mentioned that the prevalence of several bacterial species in wounds varied greatly depending on the patient's age, especially gram-negative bacteria which were more likely to cause infections in elderly individuals.

Considering the patient's sex, specific wound infections may affect one gender more frequently than the other, maybe due to anatomical and or physiological variations. However, the type of bacteria grown in this study was not associated to sex of the patient. This finding was consistent with other studies like Al-Habsi THA *et al*. in Oman who stated that "the number of infected wounds associated with females was almost the same as males"[16, 19].

The significant finding which needs to be considered carefully is that the wounds of male patients' association with mixed infection rather than females. This finding disagrees with Vicar EK *et al* who stated that they could not document any significant difference in the existence of single or mixed growth infections among males and females (9).

CONCLUSIONS

1. It has been observed that wound infections have the potential to develop in individuals of any age and in both sexes.
2. It seems that single bacterial growth is dominant, when swabs cultured for the sake of diagnosing wound infection.
3. What is different in this study is that *Klebsiella pneumoniae* was found to be the most frequent bacteria associated with wound infection.
4. No difference in culture and sensitivity findings whatever the method of culture used (VITEC or manual)
5. The bacterial sensitivity test revealed that Tigecyclene, Lenizolid, Teicoplanin, demonstrated the highest degree of effectiveness (sensitivity) against the cultured bacteria, whereas Ceftriaxone and Lemofloxacin exhibited relatively lower degrees of sensitivity. Also Piperacillin and Minocycline demonstrated the highest level of resistance among the antibiotics tested. On the other hand, Tobramycin demonstrated the most antibiotic of intermediate potency.

RECOMMENDATIONS

1. The primary emphasis for both physicians and clinical laboratories during the process of requesting, conducting, and analyzing sensitivity tests, as well as prescribing treatment, should consider *Klebsiella pneumoniae* as the most frequent causative agent of wound infections.
2. It is imperative for physicians, laboratory technicians, and pharmacists to prioritize the use of the most effective antibiotics against *Klebsiella pneumoniae*, including Tigecycline, Lenizolid, and Teicoplanin.

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