Distribution of Bacteria and Drug Resistance in Wounds of Patients with Traumatic Infections

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Abstract: Objective: To analyze the distribution of wound bacteria and drug resistance in patients with traumatic infections. Methods: Clinical laboratory tests were conducted on wound secretions or pus samples from 851 suspected traumatic infection patients (sent to the orthopedic department of the hospital for examination from January 2023 to December 2024). Based on the test results, the distribution and drug resistance of bacteria in traumatic infections were analyzed. Results: (1) A total of 508 strains of non-repetitive pathogens were detected in 851 clinical samples, with a detection rate of 59.69%. Among these, 199 strains (39.17%) were Gram-positive bacteria, with Staphylococcus aureus, Staphylococcus epidermidis, and Enterococcus being the most common species; 299 strains (58.86%) were Gram-negative bacteria, mainly Escherichia coli, Klebsiella pneumoniae, and Proteus mirabilis; 10 strains (1.97%) were fungi. (2) The main antibiotic-resistant bacteria for Staphylococcus aureus and Staphylococcus epidermidis were ampicillin, with resistance rates of 96.23% and 94.11%, respectively. Both species showed high sensitivity to linezolid and vancomycin. The main resistant drugs for Escherichia coli were ampicillin and piperacillin, with resistance rates of 85.87% and 80.43%, respectively. Klebsiella pneumoniae showed no significant resistance, with the main resistant drugs being ciprofloxacin and levofloxacin, with resistance rates of 31.58% and 29.82%, respectively. Both species showed high sensitivity to imipenem, meropenem, and amikacin. Conclusion: In the clinical anti-infective treatment of orthopedic traumatic infection patients, attention should be paid to laboratory testing of pathogen types and drug resistance to ensure the safe and effective implementation of anti-infective treatment.
Keywords: Orthopedics; Nosocomial infection; Traumatic infection; Bacterial distribution; Drug resistance testing

1. Introduction

Wound infections are common complications in orthopedic surgery patients. Factors such as surgical approach, space creation, blood loss during surgery, and wound exposure can lead to infections in some patients during or after surgery due to the invasion of pathogenic microorganisms. This requires attention to treatment[1-2]. Anti-infective treatment is the primary therapeutic measure for wound infection patients, which can actively control the progression of the infection after systemic or local drug administration. However, due to inadequate adherence to antibiotic treatment guidelines in the past, some pathogens exhibit multi-drug resistance or strong resistance, which may result in the failure of certain antibiotic treatments. Therefore, it is essential to focus on the testing and analysis of the pathogen types and drug resistance in related patients to provide a basis for the safe implementation of anti-infective treatments[3-4]. Hence, a study was conducted to analyze the distribution of bacteria and drug resistance in wounds of traumatic infection patients, as detailed below:

2. Materials and Methods

2.1 General Information

A total of 851 patients suspected of traumatic infections, who were referred to the orthopedic department for examination between January 2023 and December 2024, were included in the study. Among them, 579 were male and 272 were female, with ages ranging from 18 to 73 years (mean age: 45.51±5.27 years). All participants were informed, confirmed their participation, and signed consent forms. Inclusion criteria: Patients were those with suspected surgical site infections after orthopedic surgery, meeting the criteria for laboratory bacterial testing. Exclusion criteria: Patients with diagnosed traumatic fractures or multiple injuries; severe contamination of the fracture wound upon admission; severe infectious diseases; severe systemic immune diseases or malignant tumors; history of long-term systemic steroid treatment, radiotherapy, or chemotherapy; incomplete data.

2.2 Methods

(1) Sample Collection: Prior to laboratory testing, the skin in the sample collection area was disinfected. Subsequently, wound secretion samples or drainage fluid samples were collected using sterile techniques. For suspected abscess areas,

multiple puncture sites were used to collect pus samples.

(2) Laboratory Testing: After receiving the test samples, the laboratory inoculated them onto agar plates and Sabouraud's agar medium, and then incubated the culture media in an incubator at 35°C to 37°C for 24 to 48 hours. After incubation, pathogen isolation and cultivation were carried out according to laboratory operational standards. Following pathogen cultivation, bacterial identification and drug sensitivity tests were performed using the BD Phoenix 100 automated microbiological identification and sensitivity testing system.

2.3 Observational Indicators

The bacterial distribution and drug resistance in traumatic infections were analyzed based on the test results.

2.4 Statistical Methods

The pathogen culture results and drug sensitivity test results were entered into Excel software. Data analysis of bacterial source, composition, species, distribution, and drug sensitivity results was then performed using WGONET 5.6 software.

3. Results

3.1 Distribution and Composition of Major Pathogenic Bacteria in Traumatic Infections

A total of 508 non-repetitive pathogenic bacteria were detected from 851 clinical samples after laboratory cultivation and testing, with an overall detection rate of 59.69%. This included 199 Gram-positive bacteria (39.17%), with Staphylococcus aureus, Staphylococcus epidermidis, and Enterococcus species being the most commonly detected; 299 Gram-negative bacteria (58.86%), with Escherichia coli, Klebsiella pneumoniae, and Proteus mirabilis being the main types detected; and 10 fungi (1.97%). Detailed distribution is shown in Table 1.

Table 1. Distribution and Composition of Major Pathogenic Bacteria in Traumatic Infections (n, %)

Bacterial Type		n	Proportion (%)
Gram-positive Bacteria (199 strains)	Staphylococcus aureus	106	53.27
	Staphylococcus epidermidis	51	25.63
	Enterococcus species	19	9.55
	Streptococcus species	11	5.53
	Other Staphylococcus species	8	4.00
	Bacillus cereus	4	2.00
Gram-negative Bacteria (299 strains)	Escherichia coli	92	30.77
	Klebsiella pneumoniae	57	19.06
	Proteus mirabilis	42	14.05
	Pseudomonas aeruginosa	27	9.03
	Enterobacter cloacae	21	7.02
	Proteus vulgaris	15	5.02
	Serratia marcescens	14	4.68
	Acinetobacter baumannii	9	3.01
	Enterobacter aerogenes	8	2.68
	Stenotrophomonas maltophilia	5	1.67
	Klebsiella oxytoca	4	1.34
	Other Enterobacteriaceae	3	1.00
	Other Pseudomonas species	2	0.60
Fungi (10 strains)	Candida species	7	70.00
	Molds	3	30.00

3.2 Antibiotic Resistance Analysis of Pathogenic Bacteria in Traumatic Infections

Based on the analysis of the antibiotic susceptibility test results, the resistance of major Gram-positive bacteria is as follows: Staphylococcus aureus showed significant resistance to ampicillin, with a resistance rate of 96.23%, followed by penicillin (94.34%), erythromycin (69.81%), and clindamycin (63.21%). Staphylococcus epidermidis showed major resistance to ampicillin, with a resistance rate of 94.11%, followed by penicillin (92.16%), erythromycin (76.47%), and trimethoprim-sulfamethoxazole (68.63%). Both species exhibited high sensitivity to linezolid and vancomycin.

The resistance of major Gram-negative bacteria is as follows: Escherichia coli showed major resistance to ampicillin, with a resistance rate of 85.87%, followed by piperacillin (80.43%), ciprofloxacin (68.48%), and levofloxacin (66.30%). Klebsiella pneumoniae exhibited no significant resistance, with the main resistance to ciprofloxacin and levofloxacin, with resistance rates of 31.58% and 29.82%, respectively. Both species showed high sensitivity to imipenem, meropenem, and amikacin. Detailed results can be found in Tables 2 and 3.

Table 2. Antibiotic Resistance Analysis of Major Gram-positive Bacteria in Traumatic Infections (n, %)

Drug Type	Staphylococcus aureus (106 strains)			Staphylococcus epidermidis (51 strains)		
	Sensitive strains	Intermediate strains	Resistant strains	Sensitive strains	Intermediate strains	Resistant strains
Ampicillin	2	2	102 (96.23)	2	1	48 (94.11)
Penicillin	6	0	100 (94.34)	4	0	47 (92.16)
Erythromycin	29	3	74 (69.81)	9	3	39 (76.47)
Amoxicillin/Clavulanic Acid	94	0	12 (11.32)	18	0	33 (64.71)
Gentamicin	86	1	19 (17.92)	32	3	16 (31.37)
Rifampin	104	0	2 (1.89)	49	0	2 (3.92)
Oxacillin	93	0	13 (12.06)	18	0	33 (64.71)
Ciprofloxacin	81	8	17 (16.04)	18	5	28 (54.90)
Clindamycin	39	0	67 (63.21)	26	0	25 (49.02)
Trimethoprim-Sulfamethoxazole	78	0	28 (26.42)	16	0	35 (68.63)
Tetracycline	89	2	15 (14.15)	39	2	10 (19.61)
Linezolid	106	0	0	51	0	0
Vancomycin	106	0	0	51	0	0

Table 3. Antibiotic Resistance Analysis of Major Gram-negative Bacteria in Traumatic Infections (n, %)

Drug Type	Escherichia coli (92 strains)			Klebsiella pneumoniae (57 strains))		
	Sensitive strains	Intermediate strains	Resistant strains	Sensitive strains	Intermediate strains	Resistant strains
Ampicillin	12	1	79 (85.87)			Natural resistance
Trimethoprim-Sulfamethoxazole	40	0	52 (56.52)	47	0	10 (17.54)
Piperacillin	9	9	74 (80.43)	39	5	13 (33.33)
Amoxicillin/Clavulanic Acid	78	3	11 (11.96)	51	2	4 (7.01)
Levofloxacin	8	23	61 (66.30)	32	8	17 (29.82)
Ciprofloxacin	6	23	63 (68.48)	30	9	18 (31.58)
Aztreonam	55	8	29 (31.52)	49	1	7 (12.28)
Ceftazidime	68	7	17 (18.48)	50	1	6 (10.53)
Cefotaxime	43	5	44 (47.83)	44	5	8 (14.04)
Amikacin	80	9	3 (3.26)	50	6	1 (1.75)
Meropenem	90	0	2 (2.17)	56	0	1 (1.75)
Imipenem	89	0	3 (3.26)	53	3	1 (1.75)

4. Discussion

Surgery, as a primary treatment for some bone fracture patients, can effectively treat bone fractures after performing fracture reduction, internal fixation, or artificial bone replacement. It plays a significant role in maintaining the function of the fractured limb and reducing the risk of disability [5]. However, previous studies on postoperative recovery in orthopedic patients have indicated that traumatic infections are the main postoperative complications, primarily caused by secondary hospital-acquired infections due to incision exposure, invasive procedures, and other factors during and after surgery. These infections can affect the quality of postoperative recovery and, in severe cases, lead to life-threatening septicemia if the infection is not controlled in time. Therefore, attention should be given to the clinical treatment of traumatic infections.

In the treatment of traumatic infections in orthopedic surgery patients, different types of pathogenic bacteria may be present, which leads to reduced effectiveness of targeted antimicrobial treatments for either Gram-positive or Gram-negative bacteria. Some pathogens may also exhibit multidrug resistance, further decreasing the effectiveness of antimicrobial treatment. It is necessary to conduct reasonable clinical antimicrobial therapy [6].

The results of the study indicate that 508 non-repetitive strains of pathogens were detected from 851 clinical samples, with a total detection rate of 59.69%. Among these, 199 strains were Gram-positive bacteria (39.17%) and 299 strains were Gram-negative bacteria (58.86%). From the analysis of these results, the Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae , and Staphylococcus epidermidis were found to be common hospital-acquired pathogens in orthopedic infections. There is also a risk of mixed infections. The most common infection sites were the incisions around the upper and lower limbs, including the ankle and knee joints. In actual treatment, due to the mixed infection by pathogens, it is essential to actively perform laboratory tests based on the type, distribution, and drug resistance of the infectious pathogens, in order to provide targeted antimicrobial therapy based on the test results [7]. Postoperatively, the healing status of surgical incisions and changes in the surrounding skin should be considered to identify infection risks early. After collecting samples for laboratory testing, the infection situation and type can be determined, and doctors can carry out targeted antimicrobial treatments, optimizing the prognosis of the surgical treatment [8].

In summary, clinical antimicrobial treatment for orthopedic trauma infection patients should focus on laboratory tests for pathogen types and drug resistance to ensure the safe implementation of antimicrobial therapy.

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