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Profile of Pathogenic Bacteria Responsible for Urinary Tract Infections (UTIs) in Patients with Subarachnoid Hemorrhage and Their Sensitivity to Antibiotics

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Abstract

Objective: To analyze the profile of pathogenic bacteria responsible for urinary tract infections (UTIs) in patients with subarachnoid hemorrhage and their sensitivity to antibiotics and provide a basis for clinical treatment and prevention of UTIs. **Methods:** Total of 716 subarachnoid hemorrhage patients in The First Affiliated Hospital of Yangtze University from January 2019 to July 2024 were enrolled. There were 33 patients with urinary tract infection. The composition of pathogenic bacteria and drug susceptibility testing were retrospectively investigated and analyzed. **Results:** Urinary tract infection in patients with subarachnoid hemorrhage incidence was 4.61% (33/716), 42 strains of pathogens were isolated and cultured, there are 15 strains of *Escherichia coli* (35.71%), 3 strains of *Pseudomonas aeruginosa* (7.14%), 5 strains of *Klebsiella pneumonia* (11.91%), 2 strains of *Acinetobacter baumannii* (4.76%) and 1 strain of *Enterobacter cloacae* (2.38%), 3 strains of *Proteus mirabilis* (7.14%), 3 strains of *Enterococcus faecalis* (7.14%), 1 strain of *Staphylococcus aureus* (2.38%), 5 strains of *Staphylococcus epidermidis* (11.91%) and 3 strains of *Enterococcus urinalis* (7.14%). There was 1 strain of *Candida albicans* (2.38%). *Escherichia coli* was highly sensitive to imipenem (100%) and aztreonam (86.7%), *Pseudomonas aeruginosa* was highly sensitive to aztreonam (100%), *Klebsiella pneumonia*e was highly sensitive to nitrofurantoin (80%) and imipenem (80%), and *Enterococcus faecalis* and *Staphylococcus epidermidis* were generally sensitive to vancomycin and imipenem (100%). 1 strain of *Candida albicans* was sensitive to fluconazole and amphotericin. **Conclusion:** In the composition of pathogenic bacteria causing urinary tract infection in subarachnoid hemorrhage patients, *Escherichia coli* was the most common strain. It is necessary to strengthen the monitoring to understand its susceptibility, in order to standardize the rational

use of antimicrobial drugs and improve the treatment effect.

Keywords

Subarachnoid Hemorrhage, Urinary Tract Infection, Pathogenic Bacteria, Susceptibility Testing

1. Introduction

Subarachnoid hemorrhage (SAH) accounts for about 5% - 10% of stroke, with high disability rate and mortality rate. 10% of patients were sudden death due to intracranial hypertension, with a mortality rate of 30% within 30 days. The survivors left varying degrees of dysfunction. The patients are prone to urinary tract infection because of its acute onset, serious condition, consciousness, retained catheterization, don't move and staying in bed for a long time during the treatment period and the immune function decreased. And complications such as infection could aggravate its mortality [1]. Therefore, effective control of infection and reduced mortality and complications are also important measures for the treatment of subarachnoid hemorrhage. Among them, urinary tract infection is one of the major infection sites. Bogossian *et al.* reported that the incidence was 15.7% [2]. Targeted treatment is to select sensitive antibiotics according to the results of urine culture and drug sensitivity test, but it will take 2 - 3 days. Before that, clinicians must carry out anti-infection treatment according to experience. If the treatment is unreasonable or incomplete, it will lead to an increase of bacterial drug resistance, especially the generation and rapid spread of multi-drug resistant strains, which will bring difficulties to the treatment of patients. Although the incidence of urinary tract infection in patients with subarachnoid hemorrhage has been reported, the specific bacterial type and antibiotic sensitivity have not been reported. In order to better understand the distribution and drug resistance of pathogens of urinary tract infection in patients with subarachnoid space, provide basis for clinical selection of antimicrobial treatment and guide clinical rational drug use, we analyzed retrospectively the positive bacterial strains and drug sensitivity test of subarachnoid hemorrhage patients with urinary tract infection in our hospital from January 2019 to July 2024.

2. Data and Methods

2.1. General Information

716 hospitalized patients with subarachnoid hemorrhage in the first affiliated hospital of Yangtze University (China) (from January 2019 to July 2024 were selected, and the informed consent was signed by themselves or their families. Inclusion criteria: 1) Patients with subarachnoid hemorrhage confirmed by cranial CT or lumbar puncture; 2) No urinary tract infection before admission; 3) Urinary tract infection has clear diagnosis and classification criteria according to the U.S. Centers for Disease Control and Prevention (CDC). The criteria for symptomatic catheter-

related urinary tract infection: 1) The patient retained the catheter continuously for 2 days at the time of the event; 2) Patients have fever, suprapubic tenderness, costal vertebral angle pain/tenderness, urgent urination, frequent urination or dysuria; 3) There are less than 3 kinds of bacteria in the cultured urine of patients, and the culture amount of one kind of bacteria is at least $\geq 10^5$ colony forming units/ml; 4) Non-catheter-related urinary tract infection meets similar standards, but the patient has a catheter for less than 2 days or don't use a catheter during hospitalization. Patients with severe abnormalities of lung, kidney, liver functions and mental diseases were excluded.

2.2. Methods

2.2.1. Bacterial Culture

The middle urine was taken after catheterization in the morning, place it in a sterile culture bottle, and send it for testing immediately. The collected samples were inoculated in a chocolate plate, place it in a 5% CO_2 and 37˚C incubator box for culturing 48 hours, and isolate and culture bacteria.

2.2.2. Bacterial Identification and Drug Sensitivity Analysis

The isolation, culture and identification of bacteria are carried out strictly in accordance with the operating procedures for clinical testing. The flora identification and drug sensitivity test were carried out by Vitek-2 automatic biological analyzer, microbial detection reagent card and ID32GN identification card produced by French bio merier company.

2.2.3. Observation Indicators

1) Incidence of urinary tract infection and distribution of pathogens; 2) The antibiotics sensitivity and drug resistance of main gram-negative bacteria; 3) The antibiotics sensitivity and drug resistance of main gram-positive bacteria; 4) Antifungal drug sensitivity and drug resistance of fungi.

2.2.4. Statistical Methods

The composition ratio is expressed by rate. Strains are represented by actual numbers. Drug sensitivity and resistance are expressed by rate.

3. Results

3.1. General Information

716 hospitalized patients were selected, aged from 2 to 94 years (mean (59.08 ± 11.39)], including 423 women, aged 27 - 94 years [mean (60.96 ± 10.86)], and 293 men, aged 2 - 87 years (mean (56.38 ± 11.58)], 322 cases were treated surgically, including 33 patients with urinary tract infection, aged 45 - 88 years [mean (63.12 ± 9.27)].

3.2. Incidence of Urinary Tract Infections

716 patients with subarachnoid hemorrhage were selected, there are 33 patients with

urinary tract infection and the infection rate was 4.61%. 33 cases were included in the statistics, without leakage.

3.3. Pathogen Distribution

33 patients with subarachnoid hemorrhage complicated with urinary tract infection, 42 strains of pathogens were isolated and cultured, there are 29 strains of gram-negative bacteria (69.04%), including 15 strains of *Escherichia coli* (35.71%), 3 strains of *Pseudomonas aeruginosa* (7.14%), 5 strains of *Klebsiella pneumonia*e (11.91%), 2 strains of *Acinetobacter baumannii* (4.76%) and 1 strain of *Enterobacter cloacae* (2.38%), 3 strains of *Proteus mirabilis* (7.14%). There were 12 strains of gram-positive bacteria (29.63%), including 3 strains of *Enterococcus faecalis* (7.14%), 1 strain of *Staphylococcus aureus* (2.38%), 5 strains of *Staphylococcus epidermidis* (11.91%) and 3 strains of *Enterococcus urinalis* (7.14%). There was 1 strain of *Candida albicans* (2.38%). See Table 1.

Table 1. Distribution and composition ratio of pathogens in urine culture of SAH patients with urinary tract infection.

Pathogen	Number of plants	Composition ratio
Gram-negative bacteria		
Escherichia coli	15	35.71%
Pseudomonas aeruginosa	3	7.14%
Klebsiella pneumoniae	5	11.51%
Acinetobacter baumannii	2	4.76%
Enterobacter cloacae	1	2.58%
Proteus mirabilis	3	7.14%
Gram-positive bacteria		
Enterococcus faecalis	3	7.14%
Staphylococcus aureus	1	2.58%
Staphylococcus epidermidis	5	11.51%
Enterococcus urinalis	3	7.14%
Fungi		
Candida albicans	1	2.58%

3.4. Antibiotics Sensitivity and Drug Resistance Rate of the Main Gram-Negative Bacteria

Escherichia coli was highly resistant to ceftazidime (88.7%), levofloxacin (80%) and amikacin (80%), but highly sensitive to imipenem (100%) and aztreonam (86.7%); *Pseudomonas aeruginosa* was highly resistant to levofloxacin (100%), ceftriaxone (100%) and amikacin (67.7%), and aztreonam (100%) was highly sensitive; *Klebsiella pneumonia*e had high resistance to levofloxacin (80%), amikacin (80%)

and cefoperazone (100%), and was most sensitive to nitrofurantoin (80%) and imipenem (80%).

3.5. Antibiotics Sensitivity and Drug Resistance Rate of the Main Gram-Positive Bacteria

Enterococcus faecalis had high resistance to penicillin (100%) and erythromycin (100%), *Staphylococcus epidermidis* had high resistance to penicillin (100%) and erythromycin (80%), and *Enterococcus faecalis* and *Staphylococcus epidermidis* were generally sensitive to vancomycin and imipenem (100%).

1 case of *Candida albicans* was sensitive to fluconazole and amphotericin.

4. Discussion

The incidence of urinary system infection ranks second among hospital acquired infections in China, with a constituent ratio of about 10.9% [3]. Subarachnoid hemorrhage is a very serious stroke with acute onset, rapid progress, high mortality and disability. The proportion of indwelling catheterization is high in patients because there is the high incidence of consciousness and long time in bed; meanwhile, patients with subarachnoid hemorrhage often have low resistance because old age and accompanied by hypertension or diabetes; and perineum can not be kept clean and sanitary. These factors can easily lead to urinary tract infection in patients with subarachnoid hemorrhage. In our data, we also found that the incidence of urinary tract infection in 716 patients with subarachnoid hemorrhage was 4.61%. It is much higher than that of hospitalized patients with other diseases [4]. This conclusion can be also confirmed. Complications such as urinary tract infection aggravate the mortality and prolong the hospital time, thus forming a vicious circle. Therefore, effective control of infection and reduce mortality and complications are also important measures for the treatment of subarachnoid hemorrhage. Targeted treatment is to select sensitive antibiotics according to the results of urine culture and drug sensitivity test, but it will take 2 - 3 days. Before that, clinicians must carry out anti-infection treatment according to experience. If the treatment is unreasonable or incomplete, it will lead to the increase of bacterial drug resistance, especially the generation and rapid spread of multi-drug resistant strains, which will bring difficulties to the treatment of patients. In order to better understand the distribution and drug resistance of pathogens of urinary tract infection in patients with subarachnoid space, provide basis for clinical selection of antimicrobial treatment and guide clinical rational drug use, we analyzed the species, distribution, sensitivity and drug resistance of infectious pathogens of subarachnoid hemorrhage with urinary tract infection in our hospital in the past 5 years, so as to select effective antibiotics and nursing measures.

Among the 42 strains of pathogens, gram-negative bacilli accounted for a large proportion, accounting for about 69.04%. Among them, 15 strains of *Escherichia coli*, accounting for 35.71%; 5 strains of *Klebsiella pneumonia*e, accounting for 11.91%; 53 strains of *Proteus mirabilis*, accounting for 7.14; 1 strain of *Enterobacter*

cloacae, accounting for 2.38%; 3 strains of *Pseudomonas aeruginosa*, accounting for 7.14%, 2 strains of *Acinetobacter baumannii*, accounting for 4.76%. Among gram-positive cocci, 5 strains of *Staphylococcus epidermidis* accounted for 11.91%: followed by 3 strains of *Enterococcus faecalis*, accounting for 7.14%. Secondly, fungal urinary tract infection has increased in recent years. This data showed that there were 1strains of *Candida albicans*. At present, the incidence of Candida infection has increased rapidly. Hospital acquired Candida has become one of the common pathogens of urinary tract infection [5].

The main causes of subarachnoid hemorrhage complicated with urinary tract infection are the following two points. One is neurogenic bladder, the second is the change of the drainage mode of urinary retention. The main reason is indwelling catheterization. The indwelling catheterization may destroy the barrier and defense effect of the urethra and bladder mucosa on bacteria, leading to some bacteria can adhere to the urinary tract and combine to the glycoprotein receptors on the surface of the urinary tract epithelial cells, resulting in urinary tract infection [6]. *Escherichia coli* that the most common pathogen of urinary tract infection, produces extended spectrum β-Lactase (ESBL) that can decompose not only penicillin antibiotics but also cephalosporins and monoamide antibiotics [7], therefore, it is very easy to develop drug resistance. *Pseudomonas aeruginosa* infection is a common iatrogenic infection, and its drug resistance is gradually increasing, and it is one of the refractory urinary tract infections. The main cause of *Pseudomonas aeruginosa* infection may be the concomitant infection of catheter after long-term indwelling catheter or cystostomy *Staphylococcus epidermidis* is the main form of Staphylococcus infection, because staphylococcus mainly forms a hierarchical functional biofilm through the adhesion, aggregation and proliferation of urinary catheters, which encapsulates the bacteria, so that the bacteria can not only escape the immune damage of the host, but also resist the effects of a variety of antibiotics.

According to the results of drug sensitivity analysis: among gram-negative bacilli, *Escherichia coli* was most sensitive to imipenem and aztreonam; however, it is less sensitive to ceftazidime, levofloxacin and amikacin; *Klebsiella pneumonia*e was most sensitive to imipenem, and nitrofurantoin; *Pseudomonas aeruginosa* was more sensitive to imipenem and aztreonam. Among gram-positive bacteria, most of them have poor sensitivity to antibiotics and are prone to drug resistance. *Enterococcus faecalis* had high resistance to penicillin (100%) and erythromycin (100%), *Staphylococcus epidermidis* had high resistance to penicillin (100%) and erythromycin (80%), and *Enterococcus faecalis* and *Staphylococcus epidermidis* were generally sensitive to vancomycin and imipenem (100%).

5. Conclusions

In conclusion, the incidence of secondary urinary tract infection in subarachnoid hemorrhage patients is high, and it is increasing with the extension of hospitalization time, invasive operation, decline of body resistance and self-care ability, which is worthy of clinicians' great attention [1]. The isolated strains of urinary culture

from patients with urinary tract infection are mainly gram-negative bacteria, especially *Escherichia coli*, which is still the main pathogenic bacteria, while gram-positive cocci and fungal infection are not uncommon, and the sensitivity rate of strains to antibiotics gradually decreases due to the unreasonable application of antibiotics, drug-resistant strains gradually increase, and the dilemma of repeated multi-drug-resistant bacterial infection appears. Therefore, for patients with subarachnoid hemorrhage with urinary tract infection, samples should be collected in time, bacterial culture and drug sensitivity test should be carried out, and effective antibiotics should be selected to improve the treatment effect, prevent and control the occurrence of secondary urinary tract infection, but before the results come out, possible effective drugs can be selected according to the local and hospital bacterial spectrum and antibiotic sensitivity. For the hospital, before the results of the drug sensitivity test are available, whether it is gram-negative or gram-positive bacteria, imipenem or aztreonam can be chosen first.

Of course, this study had limitations. First, it was a single-center study, and the results may not reflect the patient care practices at other hospitals. Second, the data collection was a secondary analysis of a database not collected specifically for the purpose of this study; therefore, the conclusion also has certain limitations. At the same time, this study did not explore specific risk factors for infection and effective preventive measures, which will be further improved in the next prospective study.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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