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*Original Article*

# Clinical significance of MDRO screening and infection risk factor analysis in the ICU

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**Abstract:** Objective: This study aimed to investigate the clinical significance of multi-drug resistant organism (MDRO) screening and infection risk factor analysis in the intensive care unit (ICU). Method: A total of 210 patients treated in the ICU of our hospital were enrolled as the study subjects, and were divided into the MDRO group (n=100 cases) and the non-MDRO group (n=110) according to the presence or absence of MDRO infection after examination of the pharyngeal swabs. The pathogens of MDRO infection and drug resistance were analyzed. The single-factor as well as multifactor logistic regression analysis of MDRO infections were carried out and the 30-d mortality rate, hospitalization time and treatment costs were compared between the two groups. Results: A total of 158 MDRO strains were detected in 100 patients with MDRO infection, of which G-84 accounted for 53.16% and G+ 74 accounted for 46.84%. The resistance analysis revealed that G-MDRO was sensitive to imipenem and G+ MDRO was sensitive to vancomycin, and no vancomycin-resistant MDROs were found. The logistic regression model and multifactorial analysis showed that mechanical ventilation, arterial and venous intubation, implementation of fiberoptic bronchoscopy, concurrent chronic lung disease and chronic cardiovascular disease were independent risk factors for the development of MDRO infection ($P<0.05$). The length of hospital stay, cost of treatment, and 30-d mortality rate in the MDRO group were significantly higher than those in the non-MDRO group ($P<0.05$). Conclusion: ICU mechanical ventilation, arterial and intravenous intubation, fiberoptic bronchoscopy, concurrent chronic lung disease and chronic cardiovascular disease are the independent risk factors for MDRO infection.

**Keywords:** ICU, MDRO screening, infection risk factor analysis, clinical significance

## Introduction

The Intensive Care Unit (ICU), also known as an intensive therapy unit or intensive treatment unit (ITU) or critical care unit (CCU), is an isolated place that can provide treatment and care for critically ill or unconscious patients, saving their lives and improving their prognosis [1, 2]. Most of the patients in the ICU have chronic underlying diseases with complex conditions, low immune functions, and disordered pathophysiological conditions. In addition, many treatments such as tracheotomy, tracheal intubation, and mechanical ventilation are required in the treatment process. These invasive operations can increase the risk of bacterial infections and induce inflammatory reactions [3, 4]. Data show that the total number of ICU beds basically accounts for about 10% of the total beds in the hospital, but the incidence of infection in the ICU is 5-10 times higher than that in general wards, and the infection rate and mortality rate are significantly higher than those in general wards since the conditions of patients in the ICU are often critical, and the risk of infection by pathogenic bacteria is high [5, 6].

Multi-drug resistant organism (MDRO) infection is a common type of hospital infection. A survey found that the mortality rate of MDRO infection was about 2.17 times higher than that of non-MDRO infections, the length of stay was extended by 15.8 d, and the hospital costs were increased by 16,000 RMB [7]. Another study conducted in 38 central hospitals of 10 provinces in China pointed out that MDRO infection was closely related to the mortality of patients in the ICU, showing a positive correlation [8].

With the continuous improvement of intensive care system in China, the scope of services available in the ICU continues to expand, which also results in a high risk of MDRO infections in the ICU, presenting new challenges to control of MDRO in healthcare settings [9].

The clinical research on MDRO is plentiful, mostly focusing on intervention and treatment options. However, there is a lack of research on the analysis of MDRO infection regarding pathogens and the exploration of infection risk factors in the ICU. The aim of this study was to screen for MDRO infection in the ICU and analyze the relevant risk factors for infection, thereby providing a clinical reference for improving the prognosis of ICU patients.

## Materials and methods

### *Ethics*

This study has been approved by the Ethics Committee of West China Second University Hospital, Sichuan University. All patients and their families agreed to participate in the experiment and signed the informed consent form.

### *General information*

The swabs from 210 patients treated in the ICU of our hospital were collected and patients were divided into the MDRO group (n=100) and non-MDRO group (n=110) according to the presence or absence of MDRO infection.

Inclusion criteria: patients who (1) received treatment in the ICU; (2) with complete medical records; (3) age ≥ 18 years.

Exclusion criteria: patients (1) who were readmitted to the ICU; (2) who were not sampled within 48 h of admission to the ICU; (3) those patients whose swabs were not screened for pathogenic bacteria 1 d after specimen collection; (4) pregnant or lactating women.

### *Intervention methods*

*Clinical data:* General data including gender, age, mean weight, mean BMI, education level, and monthly income were compared between the two groups.

*Specimen collection:* Swabs were collected one hour after the patient was admitted to the ICU. A sterile disposable patient suction tubing or a bronchoscopic protected specimen brush was used to collect a sputum sample from the artificial airway or endotracheal tube of the enrolled patient. The sample was placed in an airtight sterile container and sent to the laboratory for bacterial culture, and the pathogenic bacteria in the qualified sputum sample were isolated, cultured and tested for drug susceptibility testing.

### *Bacterial culture and drug susceptibility testing*

The collected samples were placed on a culture plate and incubated at 35°C for 18-24 h. In general, green colonies were observed on chromID MRSA agar plates. A VITEK2 automatic bacteria analyzer was used for bacterial species analysis and drug susceptibility testing, and test results were analyzed using the WHONET software.

### *Outcome measurement*

Main outcomes included MDRO pathogen composition, drug susceptibility results, single-factor and multifactor analysis of MDRO colonization or infection, and efficacy indicators.

### *Statistical methods*

SPSS 20.0 was the statistical tool. Graphpad Prism 8 was used for illustrating data. Continuous variables that conformed to a normal distribution were indicated by mean ± standard deviation and compared by analysis of variance. Data that did not conform to a normal distribution were indicated by the median value and examined by non-parametric test. Count data (%) were compared by *Chi*-square test. Logistic multifactorial regression analysis was applied to screen for risk factors and calculate the OR values as well as 95% confidence intervals of risk factors, with $P<0.05$ indicating significant differences [10].

## Results

### *Comparison of baseline data*

A total of 210 patients were included as the study subjects, including 132 males and 78 females, aged 40-63 years, with the average age of (55.98±3.22) years. The clinical data such as gender, age, and weight of the two groups were not statistically significant (*P*>

**Table 1.** Comparison of baseline data between the two groups ($\chi \pm sd$)/[n (%)]

| Baseline data | | MDRO group (n=100) | Non-MDRO group (n=110) | $t/X^2$ | *P* |
|---|---|---|---|---|---|
| Gender | Male | 60 | 72 | 0.668 | 0.414 |
| | Female | 40 | 38 | | |
| Average age (years) | | 54.49 ± 3.49 | 55.11 ± 3.21 | 1.341 | 0.181 |
| Average weight (kg) | | 64.33 ± 3.21 | 64.29 ± 3.41 | 0.087 | 0.931 |
| Average BMI (kg/m$^2$) | | 23.22 ± 1.22 | 23.19 ± 1.31 | 0.799 | 0.425 |
| Education level | University and above | 12 | 13 | 0.454 | 0.761 |
| | Middle school | 43 | 57 | | |
| | Lower secondary and below | 45 | 50 | | |
| Monthly income | <1000 Yuan | 28 | 40 | 0.789 | 0.211 |
| | 1000-5000 Yuan | 40 | 30 | | |
| | Over 5000 Yuan | 32 | 40 | | |

**Table 2.** Analysis of the composition of MDRO strains

| Pathogen | | Number of strains | Percentage (%) |
|---|---|---|---|
| G-bacteria | *Enterobacter cloacae* | 4 | 2.66 |
| | *Escherichia coli* | 18 | 12.00 |
| | *Klebsiella pneumoniae* | 12 | 8.00 |
| | *Pseudomonas pickettii* | 2 | 1.33 |
| | *Pseudomonas aeruginosa* | 28 | 18.67 |
| | *Stenotrophomonas maltophilia* | 8 | 5.33 |
| | *Enterobacter aerogenes* | 4 | 2.66 |
| | *Acinetobacter baumannii* | 8 | 5.33 |
| Total | | 84 | 53.16 |
| G+ bacteria | MRSA | 30 | 20.00 |
| | MRSE | 20 | 13.33 |
| | *Enterococcus* | 14 | 9.33 |
| | *Streptococcus mitis* | 2 | 1.33 |
| | *Staphylococcus* | 4 | 2.66 |
| | *Group D Streptococcus* | 4 | 2.66 |
| Total | | 74 | 46.84 |
| Total | | 158 | 100.00 |

0.05) and were comparable (**Table 1**) between the two groups.

*The composition of MDRO strains*

A total of 158 strains of bacteria were revealed, of which there were 84 G-type strains, accounting for 53.16%, including 4 strains of *Enterobacter cuniculi* (*E. cuniculi*) (2.66%), 18 *strains of Escherichia coli (E. coli)* (12.00%), 12 strains of *Klebsiella pneumoniae* (*K. pneumoniae*) (8.00%), 2 strains of *Pseudomonas pickettii* (*P. pickettii*) (1.33%), 28 strains of *Pseudomonas aeruginosa* (*P. aeruginosa*) (18.67%), 8 strains of *Stenotrophomonas maltophilia* (*S. maltophilia*) (5.33%), 4 strains of *Enterobacter aerogenes* (*E. aerogenes*) (2.66%), 8 strains of *Acinetobacter baumannii* (*A. baumannii*) (5.33%); 74 G+ type strains, accounting for 46.84%, specifically 30 strains of methicillin-resistant *Staphylococcus aureus* (*S. aureus*) (20.00%), 20 strains of methicillin-resistant *Staphylococcus epidermidis* (*S. epidermidis*) (13.33%), 14 strains (9.33%) of *Enterococcus, 2 strains* (1.33%) of *Streptococcus mitis* (*S. mitis*), and 4 strains (2.66%) of other *Staphylococcus* (**Table 2**).

*Analysis of drug resistance to MDRO infection*

The results showed that *E. coli* in G- was 100.00% resistant to cefazolin, *K. pneumoniae* was 100.00% resistant to ampicillin, cefazolin and gentamicin, and *P. pickettii* was 100.00% resistant to ceftazidime, amikacin, ampicillin, cefazolin, ciprofloxacin, bactrim, and gentamicin. The resistance of *P. aeruginosa* to ampicillin, cefazolin and ciprofloxacin was 100.00%, the resistance of *S. maltophilia* to imipenem, ampicillin, cefazolin and gentamicin was 100.00%, the resistance of *E. aeruginosa* to antibiotics except imipenem was 100.00%, and the resistance of *A. baumannii* to antibiotics except amikacin and imipenem was 100.00%. Drug resistance was also more severe in G+ bacteria, with *S. aureus* resistant to imipenem, tazocin, ampicillin, benzathine penicillin, erythromy-

**Table 3.** Analysis of drug resistance of G-MDRO strains

| Pathogen | n | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|---|
| *Enterobacter cloacae* | 4 | 0 | 0 | 0 | 0 | - | 2 | 0 | 0 | 2 |
| *Escherichia coli* | 18 | 6 | 10 | 0 | 0 | 6 | 18 | 12 | 6 | 12 |
| *Klebsiella pneumoniae* | 12 | 6 | 8 | 0 | 0 | 12 | 12 | 8 | 6 | 12 |
| *Pseudomonas dermatitidis* | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 |
| *Pseudomonas aeruginosa* | 28 | 0 | 0 | 0 | 0 | 28 | 28 | 28 | 0 | 20 |
| *Stenotrophomonas maltophilia* | 8 | 4 | 4 | 0 | 8 | 8 | 8 | 4 | 4 | 8 |
| *Enterobacter aerogenes* | 4 | 4 | 4 | 4 | 0 | 4 | 4 | 4 | 4 | 4 |
| *Acinetobacter baumannii* | 8 | 8 | 8 | 0 | 0 | 8 | 8 | 8 | 8 | 8 |

Note: A: Sulperazon, B: Ceftazidime, C: Amikacin, D: Imipenem, E: Ampicillin, F: Cefazolin, G: Ciprofloxacin, H: Bactrim, I: Gentamicin.

**Table 4.** Analysis of drug resistance in G+MDRO pathogens

| Pathogen | n | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* | 30 | 0 | 0 | 30 | 30 | 24 | 30 | 30 | 30 | 30 |
| *Staphylococcus epidermidis* | 20 | 0 | 0 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| *Enterococcus* | 14 | 0 | 0 | 10 | 10 | 12 | 14 | 14 | 14 | 14 |
| *Streptococcus mitis* | 2 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| *Staphylococcus* | 4 | 0 | 0 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| *Group D Streptococcus* | 4 | 0 | 0 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

Note: A: vancomycin, B: ticloplanin, C: imipenem, D: Tazocin, E: cotrimoxazole, F: ampicillin, G: benzylpenicillin, H: erythromycin, I: penicillin.

cin and penicillin, and *S. epidermidis* resistant to imipenem, tazocin, bactrim, ampicillin, benzathine penicillin, erythromycin and penicillin (**Tables 3** and **4**).

*Single-factor analysis for MDRO infection in the ICU units*

It was found that ICU patients with a history of surgery, an indwelling urinary catheter, on mechanical ventilation, with arterial and vein catheterization, fiberoptic bronchoscopy, concomitant chronic lung disease and chronic cardiovascular disease were more likely to develop MDRO colonization and infection (**Table 5**). Further analysis of the above single-factor risk factors in logistic regression revealed that history of mechanical ventilation, arterial venous catheterization, receiving fiberoptic bronchoscopy, with concomitant chronic lung disease and cardiovascular disease were all independent risk factors ($P<0.05$) for the development of MDRO-infected pneumonia (**Table 6**).

*Differences in general indicators between the two groups*

The length of hospitalization, treatment costs and 30-d mortality rate of patients in MDRO group were significantly higher than those in non-MDRO group, showing significant a difference ($P<0.05$) (**Figure 1**).

## Discussion

The process by which pathogens such as bacteria, viruses, fungi, or parasites invade the body and cause a local or systemic inflammatory response is known as infection [11]. Infection is a pathological change often seen in clinical practice and is is a main cause of death in patients with trauma [12]. Since the clinical application of penicillin in the 1940s, penicillin has greatly reduced the incidence of infection and effectively improved the survival rate of injured and sick patients. Studies have found that antibiotic misuse has resulted in antibiotic-resistant bacteria while reducing the mortality rate [13, 14]. In particular, the emergence of MDRO has made nosocomial infections a public health challenge for healthcare institutions worldwide, with data showing that there are about 2 million patients with nosocomial infections in the United States each year, of which 60,000-90,000 die from nosocomial infections, and the rate of nosocomial infections in China has reached 6%-8% [15]. MDRO infections not only prolong the course of patient treatment, but also increase the mortality rate, which has a significant negative impact on the progress of healthcare industries [16].

ICUs cater to patients with severe or life-threatening illnesses, reflecting the degree of clinical skill and expertise. Clinical practice has found that patients in the ICU tend to be more susceptible to pathogenic bacteria infection due to the severity of the disease, organ dysfunction and tissue damage [17]. The occurrence of infection may prolong the treatment course and reduce the ICU bed turnover rate, or directly threaten the life and safety of patients and even lead to adverse outcomes, thus active intervention is clinically recommended to improve the prognosis of patients [18]. Screening and analysis of pathogenic bacteria is an

**Table 5.** Risk Factors for MDRO-related Infectious Pneumonia

| Risk factor | | MDRO group (n=100) | Non-MDRO group (n=110) | $X^2$ | *P* |
|---|---|---|---|---|---|
| Gender | Male | 60 | 72 | 0.668 | 0.414 |
| | Female | 40 | 38 | | |
| Surgical history | Yes | 65 | 32 | 27.175 | <0.001 |
| | No | 35 | 78 | | |
| Indwelling catheter | Yes | 60 | 40 | 11.732 | 0.001 |
| | No | 40 | 70 | | |
| Mechanical ventilation | Yes | 67 | 50 | 9.855 | 0.002 |
| | No | 33 | 60 | | |
| Arterial and venous catheterization | Yes | 68 | 40 | 20.988 | <0.001 |
| | No | 32 | 70 | | |
| Fibroscopy | Yes | 71 | 50 | 13.998 | <0.001 |
| | No | 29 | 60 | | |
| Gastroscopy | Yes | 80 | 43 | 36.127 | <0.001 |
| | No | 20 | 67 | | |
| Chronic lung disease | Yes | 67 | 23 | 45.438 | <0.001 |
| | No | 33 | 87 | | |
| Cardiovascular disease | Yes | 66 | 30 | 31.657 | <0.001 |
| | No | 34 | 80 | | |
| Diabetes | Yes | 60 | 40 | 9.266 | 0.002 |
| | No | 40 | 70 | | |

**Table 6.** Multifactorial logistic analysis of risk factors for MDRO infectious pneumonia

| Risk factor | β | SE | Wald | P | OR | 95% CI |
|---|---|---|---|---|---|---|
| History of mechanical ventilation | 0.881 | 0.231 | 6.891 | 0.01 | 0.782 | 0.671-0.981 |
| Arterial and venous catheterization | 0.912 | 0.199 | 21.229 | <0.01 | 2.334 | 1.287-3.229 |
| Fibroscopy | 0.189 | 0.024 | 1092.821 | <0.01 | 1.298 | 1.221-1.321 |
| Chronic lung disease | 0.189 | 0.015 | 8.981 | <0.01 | 2.981 | 1.879-2.938 |
| Cardiovascular disease | 0.198 | 0.032 | 9.981 | <0.001 | 4.391 | 1.982-3.019 |

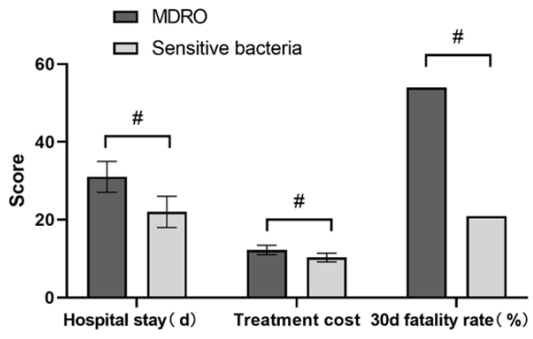


**Figure 1.** Differences in general indicators between patients in MDRO and non-MDRO groups. The length of hospital stay, treatment costs, and 30-d mortality rates of patients in MDRO group were significantly higher than those of patients in non-MDRO group (*P*<0.05). #*P*<0.05.

important premise for the development of treatment options. This study enrolled 210 patients in the ICU as research subjects, and the results showed that there were 84 G-type strains (53.16%), 74 G+ strains (46.84%), suggesting a higher percentage of G-infection. A study conducted on 80 ICU patients with MDRO infection showed that the proportion of G-infection was 56.25%, which was significantly higher than G+ [19], which is consistent with the results of this study. The screening tests found that MDRO were all highly resistant to drugs, with *E. aerogenes* resistant to sulforaphane, ceftazidime, amikacin, ampicillin, cefazolin, ciprofloxacin, cotrimoxazole, bactrim, and gentamicin, and *S. aureus* being resistant to imipenem, tazocin, bactrim, ampicillin, benzyl-

penicillin, erythromycin, and penicillin. A study conducted on 227 MDRO strains found that representative strains of G- types were less resistant to furotoxin, rifampin, linezolid and vancomycin [20], and it was also noted that G- bacteria were more resistant to ceftriaxone, levofloxacin and gentamicin but less resistant to piracetam, and G+ were more resistant to penicillin and erythromycin but less resistant to rifampin [21].

An analysis of risk factors for MDRO infection in the ICU was also carried out. The results showed that ICU patients with a history of surgery, indwelling urinary catheters, mechanical ventilation, arterial venous catheterization, fiberoptic bronchoscopy, concomitant chronic lung disease, and chronic cardiovascular disease were more likely to develop MDRO infection and colonization, and further logistic regression analysis revealed that a history of mechanical ventilation, arterial venous catheterization, fiberoptic bronchoscopy, concomitant chronic lung disease and cardiovascular disease were all independent risk factors for MDRO-related pneumonia. A survey study conducted on ICU patients found that the odds of MDRO infection were approximately 3.2 times higher in patients who underwent tracheotomy than in those who did not [22]. Another retrospective analysis found that the rate of MDRO infection in 329 patients with tracheotomy operations was 20.97%, while the rate in 439 patients without tracheotomy was 5.01%, showing a significant difference [23]. We speculated that mechanical ventilation, arterial and venous catheterization, and fiberoptic bronchoscopy are actually invasive operations. On the one hand, bacteria are more likely to enter the body via the wound, and on the other hand, repeated puncture is also prone to increase the risk of wound infection as well as bacterial colonization [24]. Chronic lung disease and cardiovascular disease can have an impact on an individual's immune system, resulting in a weakened barrier capacity, so the risk of bacterial colonization is also significantly increased [25]. Finally, MDRO infection significantly increases the cost of treatment in ICU patients, suggesting that early screening for MDRO is vital for later treatment.

In summary, vancomycin or imipramine may have a better clinical effect in patients with above risk factors. The limitation of this study was that the types of primary diseases of the enrolled patients were not investigated, which leads to the possibility that the prognosis of patients with MDRO infection might be influenced by the severity of their primary diseases, which is proposed to be improved in the next study.

## Disclosure of conflict of interest

None.

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