Clinical treatment of hospital-acquired pneumonia caused by extensively drug-resistant Acinetobacter baumannii: single-centre retrospective study

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Research Article

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Abstract

**Background:** Extensively drug-resistant *Acinetobacter baumannii* (XDRAB) has strong ability to acquire drug resistance genes, which are then rapidly cloned and transmitted, leading to worldwide spread posing a significant treatment challenge. Currently, limited drugs are available for the treatment of XDRAB infection, and their clinical effects are not clear; therefore, the specific factors that affect the treatment response and patient outcome require further exploration. The aim of this was to clarify effective treatment methods during XDRAB infection and the factors affecting patient prognosis according to a retrospective review of cases at our hospital.

**Methods:** Hospital-acquired XDRAB pneumonia cases clinically diagnosed at Guangzhou First Municipal People's Hospital from January 2016 to December 2017 were selected, and their clinical features, treatment, and prognosis were retrospectively analysed.

**Results:** Forty-eight patients met the diagnostic criteria of hospital-acquired pneumonia caused by XDRAB in the study period, 20 of whom survived and 28 of whom died for an overall mortality rate of 58.3%. There was no significant difference in anti-*A. baumannii* activity according to the type of antibiotic administered or their combinations between the patients that survived and those that died from the infection. The use of antibacterial drugs during infection did not effectively improve the clinical outcome. Advanced age, multiple organ failure, and disease severity (APACHE score) were significantly negatively correlated with bacterial clearance, whereas effective airway management (tracheotomy and sputum suction during infection) had a positive impact on bacterial clearance. In multivariate analysis, age [odds ratio (OR) 1.1, 95% confidence interval (CI) 1.0–1.3] and APACHE score (OR 1.5, 95% CI 1.1–2.0) were independent risk factors affecting prognosis. Tracheotomy during infection (OR 0.0, 95% CI 0.0–0.55) was a protective factor contributing to survival.

**Conclusion:** XDRAB hospital-acquired pneumonia has a high mortality rate. Advanced age and severe disease are independent risk factors that affect patient prognosis. The use and type of antibacterial drugs for treatment do not appear to substantially affect the prognosis during XDRAB infection. Overall, timely and effective airway management is the key to improving the prognosis of patients with hospital-acquired XDRAB infection.

**Background**

*Acinetobacter baumannii* is a type of gram-negative bacillus that does not ferment sugar. *A. baumannii* is considered to be a conditional pathogen, which is widely distributed in nature, hospital environments, and throughout the surface of the human body, with strong ability to acquire drug-resistant genes that are rapidly cloned and transmitted [1]. In recent years, due to the widespread use of broad-spectrum antibacterial drugs, the increase in interventional procedures, along with an increase in immunocompromised hosts and other factors, the proportion of multi-drug resistant strains, and
especially extensively drug-resistant A. *baumannii* (XDRAB), in hospital infections has been increasing annually [2, 3], posing a significant clinical challenge in anti-infective treatment.

XDRAB refers to strains that are resistant to current commonly used antibacterial drugs in clinical settings and are only sensitive to one to two drugs with potential anti-*Acinetobacter* activity [4]. Since the first XDRAB isolate was reported in Taiwan in 1998, these strains have broadly spread worldwide. XDRAB infections are particularly common in critically ill patients and in those with severe underlying diseases, resulting in a high mortality rate [5].

At present, the optimal treatment strategy for XDRAB infection remains controversial, and the drugs that are available for treating XDRAB are also extremely limited [6]. Once XDRAB infection occurs, especially lower respiratory tract infection, the prognosis of patients is often poor. Therefore, it is important to identify the clinical factors that contribute to infection and prognosis among patients with hospital-acquired XDRAB infections.

Toward this end, we performed a retrospective analysis of the clinical features and treatment outcomes of patients clinically diagnosed with XDRAB pneumonia at our hospital from January 2016 to December 2017.

**Methods**

**Study subjects**

This study was designed as a retrospective case analysis. Cases of hospital-acquired pneumonia caused by XDRAB clinically diagnosed at Guangzhou First Municipal People's Hospital from January 2016 to December 2017 were reviewed. Inclusion criteria were as follows: (1) XDRAB was isolated and cultured from sputum, fibreoptic bronchoscopy drainage fluid, lavage fluid, or venous blood; (2) typical manifestations of bacterial infection (e.g. fever, and increase in white blood cell count, C-reactive protein, and procalcitonin); (3) clinical symptoms and signs consistent with pneumonia; and (4) imaging manifestations of new, continuous, or worsened lung exudation, infiltration, or consolidation [7]. The exclusion criteria were: (1) aged < 18 years; (2) XDRAB was cultured not less than twice; (3) mixed infection; (4) non-pneumonia-related death; and (5) incomplete clinical data in medical records. This study was approved by the Ethics Committee of Guangzhou First Municipal People's Hospital.

**Data collection**

The following data were extracted for patients with a clinical diagnosis consistent with hospital-acquired pneumonia caused by XDRAB: (1) basic information, including age, gender, ward admitted to, underlying diseases, discharge status or death, and mechanical ventilation (method and time); (2) airway care during infection, including fibreoptic bronchoscopy, the number of daily sputum suctions, and the number of times of turning over; (3) disease severity according to the APACHE II score [8]; (4) Clinical Pulmonary Infection Score [9]; (4) use of antibiotics, albumin, and enteral nutrition during infection; (5) symptoms,
signs, white blood cells, C-reactive protein, procalcitonin, chest X-ray examination, and bacterial culture (including sputum, fibre bronchoscopy drainage fluid, bronchoalveolar lavage fluid, venous blood) during treatment; and (6) prognosis classified as a binary variable according to survival or death. The worst value measured within 24 h after entering the intensive care unit (ICU) or beginning treatment was recorded for each index.

**Evaluation of clinical efficacy**

According to the guidelines for clinical research on antimicrobial drugs formulated by the United States Food and Drug Administration in 1997 [10], the criteria for determining clinical efficacy were mainly based on the patient's symptoms, physical signs, and laboratory tests, and were divided into four levels: recovery, significant response, disease progression, and no response. A clinical response was considered as the combination of recovery and significant response. The bacteriological curative effect was evaluated according to the following five levels: pathogenic bacteria clearance, partial clearance, no clearance, substitute, and reinfection.

**Related definitions**

XDRAB was defined according to confirmed resistance of the isolate to the following antibiotics assessed using the KB disc agar diffusion method: gentamicin, amikacin, piperacillin and tazobactam, ampicillin and sulbactam, cefepime, aztreonam, imipenem, meropenem, ciprofloxacin, and levofloxacin. Sensitivity to only polymyxin and/or tigecycline further confirmed the diagnosis [11].

Hospital-acquired pneumonia was defined as new or progressive flaky and patchy infiltrates observed on the chest X-ray film 48 h after admission, with or without the following symptoms: body temperature ≥ 38°C, white blood cell count >10 × 10⁹/L or <4 × 10⁹/L, and presence of purulent airway secretions [12].

**Pathogen isolation and identification**

According to the aetiology and drug sensitivity laboratory standards of Clinical and Laboratory Standards Institute, all strains were identified with the API 20NE identification board (bioMérieux, France). The susceptibility test was carried out using the KB disc agar diffusion method. The resulting judgement criteria were based on the clinical cut-off values of the Clinical Laboratory Standards Institutes 2011 guidelines so that the strains were classified to be sensitive, resistant, or intermediate sensitivity to a given drug [13].

**Statistical analysis**

Attributes data are expressed as frequency (number, percentage) and were compared between groups using the χ² test. Normally distributed data are expressed as mean ± standard deviation, which were compared using Student's t-test, whereas non-normally distributed data were compared with Mann-Whitney U test. The factors affecting prognosis (survival or death) were identified in logistic multiple regression analysis. P < 0.05 was considered to indicate a statistically significant difference or
association with prognosis. All statistical analyses were performed with Statistical Package for the Social Sciences, Version 19.0 (SPSS 19.0).

Results

Patient characteristics

*Acinetobacter baumannii* was isolated from a total of 547 patients in the 2 years, 143 of which were identified as XDRAB for a detection rate of 26.1%. After excluding records of duplicates (10 cases), non-respiratory infections (25 cases), colonisation [7] (40 cases), XDRAB cultured not less than two times (11 cases), and incomplete clinical data (5 cases), a total of 52 cases of clinically diagnosed XDRAB pneumonia were retained. In addition, cases of mixed infections (3 cases) and non-pneumonia-related death (1 case) were excluded, leaving a total of 48 cases that met the inclusion criteria. The flow chart for patient selection is shown in Figure 1.

The mean age of the included patients was 78 ± 15 years, including 41 men and 7 women. All 48 patients with XDRAB pneumonia were admitted to the ICU, all received invasive mechanical ventilation and deep venous catheterisation, eight patients had a tracheotomy, and six patients had haemodialysis. Most of the patients had multiple underlying diseases, including 32 cases of hypertension, 15 cases of coronary heart disease, 26 cases of chronic cardiac insufficiency, 23 cases of chronic obstructive pulmonary disease, 11 cases of chronic renal insufficiency, 9 cases of malignant tumour, and 9 cases of diabetes. The most common source of the specimen was bronchoscopy drainage fluid (26 cases), followed by sputum (14 cases) and venous blood (8 cases). Of the 48 patients, 20 (42%) survived and 28 died (58%).

Associations of antibacterial use during infection with clinical characteristics

Table 1 shows a comparison of the antibacterial drugs used during XDRAB infection in relation to the prognosis of patients (survival versus death). There was no significant difference between groups with respect to the commonly used antibacterial drugs with potential antibacterial activity against *A. baumannii* or their combinations. All 48 patients exhibited chest imaging progression during the infection period, which most commonly manifested as multiple pulmonary lobar infiltrates and patchy exudation. The time from the first isolation of the pathogen to the improvement of chest X-ray absorption in the survival group was shorter (8.3 ± 4.7 days) than that of the death group (12.4 ± 12.0 days) the difference statistically significant. Thirty-five patients had fever during the infection, 16 of whom were in the survival group with a mean time from first isolation of the pathogen to fever abatement of 10.2 ± 9.8 days, whereas the mean time from first isolation to fever abatement or death for the 19 patients in the death group was 7.2 ± 7.4 days. There were no significant differences in the time of persistent fever between the two groups, although the frequency of patients with persistent fever for ≤3 days and for 4–7 days after infection was higher for the death group, whereas relatively more patients in the survival group had a persistent fever for >7 days (Table 2).
Table 1 Use of antibacterial drugs during infection.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Survival group/bacteria cleared (N = 20), n (%)</th>
<th>Death group/bacteria not cleared (N = 28), n (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monotherapy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefoperazone and sulbactam</td>
<td>6 (30.0)</td>
<td>4 (14.2)</td>
<td>0.282</td>
</tr>
<tr>
<td>Carbapenems</td>
<td>3 (15.0)</td>
<td>8 (28.5)</td>
<td>0.319</td>
</tr>
<tr>
<td>Tigecycline</td>
<td>1 (5.0)</td>
<td>0 (0.0)</td>
<td>0.417</td>
</tr>
<tr>
<td><strong>Two-drug combinations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefoperazone and sulbactam</td>
<td>4 (20.0)</td>
<td>2 (7.1)</td>
<td>0.218</td>
</tr>
<tr>
<td>Carbapenem-based combination</td>
<td>2 (10.0)</td>
<td>4 (14.2)</td>
<td>1.0</td>
</tr>
<tr>
<td>Piperacillin and tazobactam combined with quinolones</td>
<td>3 (15.0)</td>
<td>3 (10.7)</td>
<td>0.683</td>
</tr>
<tr>
<td><strong>Three-drug combinations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefoperazone and sulbactam-based combinations</td>
<td>2 (10.0)</td>
<td>0 (0.0)</td>
<td>0.168</td>
</tr>
<tr>
<td>Doxycycline-based combinations</td>
<td>3 (15.0)</td>
<td>3 (10.7)</td>
<td>0.683</td>
</tr>
</tbody>
</table>

Factors affecting bacteria clearance

Bacteria were effectively cleared in 20 of the 48 cases. As shown in Table 2, advanced age, number of organ failures, severity of illness (APACHE II score), and airway care (tracheotomy, sputum suction) significantly affected bacterial clearance.

Table 2 Influence of patient factors on prognosis/bacteriological clearance.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Survival group/bacteria cleared (N = 20)</th>
<th>Death group/bacteria not cleared (N = 28)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean ± SD</td>
<td>65.6±18.4</td>
<td>79.6±9.3</td>
<td>0.001</td>
</tr>
<tr>
<td>ICU stay (days), mean ± SD</td>
<td>29.4±19.2</td>
<td>25.1±21.5</td>
<td>0.488</td>
</tr>
<tr>
<td><strong>Underlying disease, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>12 (60.0)</td>
<td>20 (71.4)</td>
<td>0.537</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4 (10.0)</td>
<td>5 (17.8)</td>
<td>1.0</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>4 (20.0)</td>
<td>11 (39.2)</td>
<td>0.212</td>
</tr>
<tr>
<td>COPD</td>
<td>7 (35.0)</td>
<td>16 (57.1)</td>
<td>0.154</td>
</tr>
<tr>
<td>Malignant tumour</td>
<td>3 (15.0)</td>
<td>6 (21.4)</td>
<td>0.716</td>
</tr>
<tr>
<td>Chronic cardiac insufficiency</td>
<td>8 (40.0)</td>
<td>18 (64.2)</td>
<td>0.143</td>
</tr>
<tr>
<td>Chronic renal insufficiency</td>
<td>3 (15.0)</td>
<td>9 (32.1)</td>
<td>0.311</td>
</tr>
<tr>
<td>Number of organ failures, mean ± SD</td>
<td>1.6 ± 0.7</td>
<td>2.7 ± 0.08</td>
<td>0.000</td>
</tr>
<tr>
<td>APACHE II score, mean ± SD</td>
<td>20.8 ± 4.8</td>
<td>25.9 ± 5.4</td>
<td>0.012</td>
</tr>
<tr>
<td>APACHE II score ≥ 19, n (%)</td>
<td>14 (70.0)</td>
<td>26 (92.8)</td>
<td>0.053</td>
</tr>
<tr>
<td>APACHE II score ≥ 20, n (%)</td>
<td>12 (60.0)</td>
<td>25 (89.2)</td>
<td>0.034</td>
</tr>
<tr>
<td>APACHE II score ≥ 23, n (%)</td>
<td>7 (35.0)</td>
<td>20 (71.4)</td>
<td>0.019</td>
</tr>
<tr>
<td>APACHE II score ≥ 25, n (%)</td>
<td>5 (25.0)</td>
<td>17 (60.7)</td>
<td>0.02</td>
</tr>
<tr>
<td>CPIS, mean ± SD</td>
<td>5.3 ± 1.4</td>
<td>6.3 ± 1.0</td>
<td>0.067</td>
</tr>
<tr>
<td>Albumin (g/L), mean ± SD</td>
<td>28.0 ± 4.4</td>
<td>29.0 ± 4.9</td>
<td>0.480</td>
</tr>
<tr>
<td>Tracheal intubation, n (%)</td>
<td>20 (100.0)</td>
<td>28 (100.0)</td>
<td>1.0</td>
</tr>
<tr>
<td>Mechanical ventilation time (days), mean ± SD</td>
<td>19.7 ± 16.4</td>
<td>19.7 ± 21.3</td>
<td>0.998</td>
</tr>
<tr>
<td>Tracheal intubation time before infection (days), mean ± SD</td>
<td>7.3 ± 7.4</td>
<td>12.0 ± 16.2</td>
<td>0.234</td>
</tr>
<tr>
<td><strong>Airway care during infection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracheotomy, n (%)</td>
<td>7 (35.0)</td>
<td>1 (3.5)</td>
<td>0.006</td>
</tr>
<tr>
<td>Number of times per day of turning over and backslapping, mean ± SD</td>
<td>8.4 ± 2.4</td>
<td>7.3 ± 2.5</td>
<td>0.113</td>
</tr>
<tr>
<td>Number of sputum suctions by bronchoscope, mean ± SD</td>
<td>4.5 ± 2.5</td>
<td>2.6 ± 17.7</td>
<td>0.003</td>
</tr>
<tr>
<td>Number of sputum suctions per day, mean ± SD</td>
<td>9.3 ± 2.5</td>
<td>7.4 ± 2.6</td>
<td>0.013</td>
</tr>
<tr>
<td>Bacteraemia, n (%)</td>
<td>2 (10.0)</td>
<td>6 (21.4)</td>
<td>0.214</td>
</tr>
<tr>
<td>Albumin transfusion, n (%)</td>
<td>12 (60.0)</td>
<td>16 (57.1)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Duration of persistent fever during infection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤3 days</td>
<td>4 (25.0)</td>
<td>8 (50.0)</td>
<td>0.717</td>
</tr>
<tr>
<td>4–7 days</td>
<td>4 (25.0)</td>
<td>6 (31.5)</td>
<td>0.25</td>
</tr>
<tr>
<td>≥7 days</td>
<td>8 (50.0)</td>
<td>5 (26.3)</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Abbreviations: ICU, intensive care unit; COPD: chronic obstructive pulmonary disease; CPIS, Clinical Pulmonary Infection Score.

**Prognostic factors**
XDRAB was cleared in all cases in the survival group and in no cases in the death group. As shown in Table 3, age and APACHE score emerged as independent risk factors affecting prognosis in multiple logistic regression; tracheotomy during infection was a significant protective factor. There was no effect of various combinations of drugs with anti-Acinetobacter activity on survival.

<table>
<thead>
<tr>
<th>Prognostic factor</th>
<th>Odds ratio (95% confidence interval)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.1 (1.0–1.3)</td>
<td>0.004</td>
</tr>
<tr>
<td>APACHE II score</td>
<td>1.5 (1.1–2.0)</td>
<td>0.005</td>
</tr>
<tr>
<td>Tracheotomy during infection</td>
<td>0.0 (0.0–0.55)</td>
<td>0.026</td>
</tr>
</tbody>
</table>

**Discussion**

*A. baumannii has become an important pathogen of nosocomial infections, which can easily cause epidemics, especially in the ICU, and XDRAB has received particular attention in this regard [14]. A. baumannii was previously considered to be a low-virulence opportunistic pathogen with no impact on the prognosis of hospitalized patients [15]; however, recent studies have shown that *A. baumannii*, especially multidrug-resistant strains, are commonly isolated in critically ill patients, and are associated with a high mortality rate ranging from 52% to 66% [16]. The mortality rate from XDRAB pneumonia in this study was 58.3%, which is similar to that reported by Boral et al. [17], confirming the high mortality rate of this pathogen. Therefore, it is particularly important to deepen the exploration of strategies for the treatment of XDRAB infection.

The first challenge is the selection of an appropriate antibacterial drug for the treatment of XDRAB infection, which requires an extensive evaluation of the role of various drugs with potential anti-Acinetobacter activity on the treatment outcome. Commonly used antibacterial drugs that are currently recommended for the treatment of *A. baumannii* infections include sulbactam and a compound preparation of sulbactam-containing β-lactam antibiotics, carbapenem antibiotics, polymyxin antibiotics, tigecycline, tetracycline, aminoglycoside, and quinolone [16, 18]. In cases of XDRAB infection, a two-drug or even a three-drug combination is often used. Although some studies have shown potential benefits of combined regimens, these results are mostly based on animal experiments, in vitro studies, and uncontrolled clinical studies with a small number of cases, and the conclusions are inconsistent [19]. The possibly effective two-drug combination regimens are (1) sulbactam or a compound preparation containing sulbactam as the basis in combination with one of carbapenems, minocycline (or doxycycline), polymyxin, or aminoglycoside antibiotics [20-22]; and (2) tigecycline as the basis combined with a compound preparation containing sulbactam, aminoglycoside antibiotics, or quinolone [23-26]. The three-drug combination regimens include a compound preparation containing sulbactam (or sulbactam) combined with doxycycline and carbapenem antibiotics [20].
All of the recommended drugs with anti-Acinetobacter activity had been used on the patients included in this study with confirmed XDRAB infection, except for polymyxin antibiotics. This is because polymyxin has a limited effect due to its low blood concentration in the lung and cerebrospinal fluid. Kim et al. [27] reported that the clinical response rate of patients with XDRAB pneumonia who received polymyxin or tigecycline as the basis treatment was 48% and 47%, respectively, with no significant difference. Yilmaz et al. [28] reported that the clinical and microbial treatment response rates for the single use of polymyxin, polymyxin combined with sulbactam, and polymyxin combined with carbapenem in the treatment of multidrug-resistant or XDRAB pneumonia were 63.6%, 55%, and 60%, respectively, with no significant differences. In a meta-analysis, Jung et al. [19] found no significant difference in the clinical and microbial treatment response rates of polymyxin or tigecycline alone, or in combination with carbapenem and sulbactam. Liu et al. [29] also reported no significant difference in the prognosis of patients with multidrug-resistant A. baumannii pneumonia who were treated with or without tigecycline. Consistently, in the present study, there was no significant difference in the use of various antibacterial drug combinations (including monotherapy, two-drug combinations, and three-drug combinations) during infection between the survival group and the death group.

Although the recommended anti-A. baumannii antibacterial drug combinations were used at our hospital, following these guidelines did not significantly improve the prognosis or bacterial clearance rate. There are several potential reasons to explain these observations. First, A. baumannii is a low-virulence pathogen. Therefore, even if extensive drug resistance appears, the toxicity would not necessarily be enhanced. Second, antimicrobial drugs cannot effectively clear XDRAB, and therefore other adjuvant treatments are required. Third, the prognosis may be mainly affected by factors other than treatment, such as the underlying condition.

Jung et al. [19] found that advanced age, multiple organ failure, and a severe disease condition had a negative effect on bacterial clearance; effective airway management (e.g. tracheostomy, sputum suction) was conducive to bacterial clearance; and the use of antibacterial drugs had no obvious effect on prognosis, which are all consistent with the present findings. Multivariate logistic analysis showed that age and APACHE II score were independent risk factors affecting prognosis, and that tracheotomy is a protective factor.

Patients with advanced age, multiple organ failure, and severe disease conditions are mostly bedridden, and may even be in a coma and confined to bed for a long time. This situation is typically accompanied by a decreased cough reflex, resulting in poor sputum-discharging and clearance ability of the respiratory tract [30]. Therefore, it is necessary to strengthen airway management, especially the body position and mechanical-assisted sputum discharge. For patients with thick sputum and weakness in expectoration, tracheotomy should be performed as soon as possible. It is currently believed that long-term tracheal intubation is more likely to cause airway damage, infection, and patient discomfort, and requires more doses of sedatives. Therefore, for patients who require long-term mechanical ventilation, tracheotomy should be performed as soon as possible to replace tracheal intubation [31-32], as tracheotomy results in a more stable artificial airway. This also allows patients to eat by mouth, and tracheotomy is further
conducive to the removal of pulmonary secretions, which can improve the overall prognosis [33-35].
Kimura [36] reported that mechanical ventilation with tracheotomy could effectively prolong the median survival of patients with lateral sclerosis. However, the optimal timing of tracheotomy remains controversial [35]. The National Association for Medical Direction of Respiratory Care recommends that patients who have been under tracheal intubation for more than 3 weeks should receive tracheotomy as a substitute [37]. At present, early tracheotomy is preferred. Timely tracheotomy can reduce the complications of long-term tracheal intubation (e.g. larynx injury, airway injury, bacterial growth) and reduce the rate of pulmonary infection, making the infection easier to be controlled, which is closely related to shorter hospital stays, lower treatment costs, and lower mortality [38-40].

Regarding the prognosis of drug-resistant *A. baumannii* infections, it has been reported that the virulence of the drug-resistant bacterium itself does not increase, and therefore neither would the mortality rate, and that it is instead the severity of the underlying disease that will ultimately affect the prognosis [1], in line with our results. At present, the APACHE II score is the most widely used and authoritative critical illness condition evaluation system in clinical ICU wards, which can provide an objective and scientific basis for the rational use of medical resources and prognostic judgements [7]. However, the APACHE II scale is mainly designed for ICU inpatients and is not specific to pneumonia, and few studies have directly assessed its prognostic value in patients with pneumonia. This study shows that an APACHE II score ≥20 can indicate a poor prognosis in patients with XDRAB hospital-acquired pneumonia, similar to the findings of Liu et al. [29].

This study also has some limitations, which should be mentioned. This was a retrospective study, we were lacking data on polymyxin treatment, and this was a single-centre study with a relatively small sample size. Therefore, further in-depth research using prospective multi-centre studies with a large sample size are needed.

**Conclusions**

XDRAB hospital-acquired pneumonia has a high mortality rate. Advanced age and a severe disease condition are independent risk factors for a poor prognosis. Although antibacterial drugs do not have a clear effect on improving prognosis during infection, XDRAB pneumonia is curable. In particular, effective airway management (tracheotomy, sputum suction) is the key to clearing XDRAB, thereby improving the prognosis of patients.

**Abbreviations**

AB:Acinetobacter baumannii; XDR:Extensively drug resistant; MDR:Multidrug resistant; APACHE II:Acute Physiology and chronic Health Evaluation II; CPIS:Clinical pulmonary infection score; ICU:Intensive care unit; COPD: Chronic obstructive pulmonary disease; CLSI:Clinical and Laboratory Standards Institute; FDA:Food and Drug Administration; CRP:C-reactive protein; PCT:Procalcitonin; WBC: leukocyte
Declarations

Ethics approval and consent to participate

This study was approved by Ethics Review Committee, Guangzhou First Municipal People's Hospital and conducted in accordance with the provisions of the Declaration of Helsinki. Approval No.K-2021-015-01. The data used in our study was anonymized before its use. All the data were obtained from the medical records. All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

All patients and legally authorized representative/next of kin of deceased patients provided informed consent for this study.

Consent for publication

Not applicable.

Availability of data and materials

Our present study was a retrospective observational study. All the data were obtained from medical records of patients. The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request, but the identifying/confidential patient data would not be shared.

Competing interests

The authors have declared that no competing interests exist.

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Authors’ contributions

CQF designed the study and drafted the manuscript. LMX managed data and its quality. ZWZ contributed substantially to its revision. JHL, YJL performed the statistical analysis. SQW, ZXZ participated in the data interpretation. All authors read the manuscript carefully and approved the final version.

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References


**Figures**

![Flow chart of selection of patients with extremely drug-resistant Acinetabacter baumanii (XDRAB) infection for this study.](image)

**Figure 1**

Flow chart of selection of patients with extremely drug-resistant Acinetabacter baumanii (XDRAB) infection for this study.