Outbreak of Resistant \textit{Acinetobacter baumannii} – Measures and Proposal for Prevention and Control

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\textit{Acinetobacter baumannii} colonization and infection, frequent in Intensive Care Unit (ICU) patients, is commonly associated with high morbimortality. Several outbreaks due to multidrug-resistant (MDR) \textit{A. baumannii} have been reported but few of them in Brazil. This study aimed to identify risk factors associated with colonization and infection by MDR and carbapenem-resistant \textit{A. baumannii} strains isolated from patients admitted to the adult ICU at HC/UFMG. A case-control study was performed from January 2007 to June 2008. Cases were defined as patients colonized or infected by MDR/carbapenem-resistant \textit{A. baumannii}, and controls were patients without MDR/carbapenem-resistant \textit{A. baumannii} isolation, in a 1:2 proportion. For statistical analysis, due to changes in infection control guidelines, infection criteria and the notification process, this study was divided into two periods. During the first period analyzed, from January to December 2007, colonization or infection by MDR/carbapenem-resistant \textit{A. baumannii} was associated with prior infection, invasive device utilization, prior carbapenem use and clinical severity. In the multivariate analysis, prior infection and mechanical ventilation proved to be statistically significant risk factors. Carbapenem use showed a tendency towards a statistical association. During the second study period, from January to June 2008, variables with a significant association with MDR/carbapenem-resistant \textit{A. baumannii} colonization/infection were catheter utilization, carbapenem and third-generation cephalosporin use, hepatic transplantation, and clinical severity. In the multivariate analysis, only CVC use showed a statistical difference. Carbapenem and third-generation cephalosporin use displayed a tendency to be risk factors. Risk factors must be focused on infection control and prevention measures considering \textit{A. baumannii} dissemination.

Key-Words: \textit{Acinetobacter baumannii}, multidrug resistance, carbapenem, infection control, outbreak.

\textit{Acinetobacter baumannii} is a ubiquitous aerobic Gram-negative bacterium with non-fermentative metabolism found in nature especially in humid locations, which is able to contaminate and persist on various surfaces, disseminating among patients and in diverse settings. It has been described as an important microorganism that frequently colonizes and infects patients in Intensive Care Units (ICU) worldwide. In this environment, \textit{A. baumannii} can display multiple antimicrobial resistance profiles, which are responsible for significant morbimortality [1-3].

\textit{A. baumannii} is an opportunistic pathogen, frequently involved in infection outbreaks, especially in the ICU. It is a common cause of sepsis, pneumonia, and urinary tract infection following hospitalization of seriously ill patients. Usually, the strains are sensitive to carbapenems, fluoroquinolones, sulbactam associations, tigecycline, rifampicin, aminoglycosides, and polimixins. For empiric therapy, carbapenems are frequently the drug of choice, but ampicillin plus sulbactam, ciprofloxacin, aminoglycoside associations, rifampicin, or other drugs have also been used.

Although resistance profile definitions vary in literature, it is considered that resistance to carbapenems is, in itself, sufficient to define an isolate as highly resistant [2,4-8].

According to the Center for Diseases Control and Prevention (CDC), an \textit{A. baumannii} multidrug-resistant (MDR) strain is defined as resistant to one or more classes of antimicrobial agents, including carbapenems [9]. A minimal inhibitory concentration (MIC) of $\geq$16 mg/mL for imipenem or meropenem is necessary to define carbapenem resistance [10]. The expression “MDR/carbapenem-resistant \textit{A. baumannii}” was first used in 1991 during an outbreak at a hospital in New York City [11]. In 1998, in Taiwan, the term pandrug-resistant (PDR) \textit{A. baumannii} was described, related to resistance to all antimicrobial agents available at that time, including carbapenems, all cephalosporins, aztreonam, aminoglycosides and ciprofloxacin [12].

MDR/carbapenem-resistant \textit{A. baumannii} is associated with treatment challenges, emphasizing the importance of preventing and controlling the dissemination of this strain. Outbreaks due to MDR/carbapenem-resistant \textit{A. baumannii} have been reported, mainly in ICUs, and treatment of these strains has been considered a global problem [13-15]. The Meropenem Yearly Susceptibility Test Information Collection (MYSTIC), which includes strains from several sites worldwide, describes \textit{A. baumannii} sensitivity as 76.1% and 74.7% to meropenem and imipenem, respectively. Sensitivity is even lower for Latin American strains [16-17]. According to the Sentry Antimicrobial Surveillance Program, \textit{A. baumannii} resistance was reported at rates of 14%, 68%, 65%, and 48% to imipenem, ceftazidime, ciprofloxacin, and ampicillin plus
sulbactam, respectively [18]. Although some studies describe increasing resistance to carbapenems and other drugs, achieving rates up to 90% [19-20].

In the resistance setting, some other drugs can be used for these infections and polymixin is the first choice [2-5]. Tigecycline, another treatment option, was only licensed by the Food and Drug Administration (FDA) for skin and abdominal infections. Further, there is no standard MIC to define A. baumannii sensitivity to tigecycline, and clinical resistance is also reported [2-5,21-25]. Recently, it was suggested that combination therapy could improve treatment outcome by a synergistic effect [26].

MDR/carbapenem-resistant A. baumannii has been identified in our hospital since 2004 and dissemination in different settings has been recognized. Considering the epidemiological importance of this microorganism, the Hospital Infection Control Committee (HICC) developed this study to determine the risk factors associated with colonization or infection.

Material and Methods

Study Design

This case-control study was performed in an adult ICU at the University Hospital from January 2007 to June 2008. Cases were defined as all patients colonized or infected by MDR/carbapenem-resistant A. baumannii, as of the second day after ICU admission and until 48 hours after discharge from the Unit. Controls were patients admitted to the ICU during the study period from which MDR/carbapenem-resistant A. baumannii was not isolated, matched with a 2:1 proportion (controls:cases ratio).

Data were routinely collected by HICC, according to the Brazilian Ministry of Health [27] and National Healthcare Safety Network (NHSN) recommendations [28].

Microbiological Identification

Swabs and biological samples were cultured. All Acinetobacter strains identified in any biological material were cultivated by standard microbiological methods (Gram staining, colony and cell morphology, and biochemical tests). Susceptibility characterization was established by Clinical and Laboratory Standards Institute (CLSI) recommendations [10].

Variables

Age, gender, device utilization (central venous catheter - CVC; mechanical ventilation - MV; indwelling urinary catheter - IUC), antimicrobial use (carbapenems, fluoroquinolones, and third-generation cephalosporin), surgery in the 30 days prior to ICU admission, transplantation (heart, liver, or kidney), severity score at ICU admission (classified from A to E according to the Average Severity of Illness Score – ASIS) [29] and prior infection (regardless of microorganism or infection site) were studied.

Statistical Analysis

Data were organized and analyzed using the Statistical Package for the Social Sciences (SPSS), version 13.0. Proportion comparison was performed by Pearson’s $\chi^2$ or Fisher’s test and mean comparison with the t test. Statistical significance was reached when $p \leq 0.05$, and in these variables the Odds Ratio (OR) was considered with a 95% confidence interval (95% CI). Univariate and multivariate analysis was performed, using length of stay in the ICU to match case and control groups in order to avoid a bias.

For statistical analysis, the study was divided into two periods (January - December 2007, and January - June 2008), since recommendations of infection control guidelines were altered by NHSN/CDC [28], with modifications in terms of infection criteria and notification process.

Ethical Considerations

This study was approved by the Institutional Research Ethical Committee. Privacy was guaranteed, and patients were identified by their hospital registration number. Only HICC personal involved in data collection and researchers had access to the information of all enrolled patients.

Results

Outbreak Description

From January 2004 to December 2006, in the ICU, the mean colonization/infection rate due to MDR/carbapenem-resistant A. baumannii was 0.5 case/month. After that, however, an increase in cases was identified and lead to a mean incidence of 5.3 cases/month in 2007 and 5.7 cases/month in 2008. This event was defined as an outbreak, since the mean incidence was above the control limit, defined as three standard deviations above the mean incidence (FIGURE 1).

First Period (January - December 2007)

- Fifty-one patients infected or colonized by MDR/carbapenem-resistant A. baumannii were included and paired to 102 control patients, according to defined criteria.
- Univariate analysis: Colonization or infection by MDR/carbapenem-resistant A. baumannii was associated with those patients who had prior infection ($p<0.001$), device utilization such as MV ($p<0.001$), CVC ($p=0.001$), and IUC ($p=0.004$), prior carbapenem use ($p<0.001$), and a severe ASIS score ($p<0.001$) (Table 1).
- Multivariate analysis: prior infection ($p=0.002$) and MV use ($p=0.003$) continued to be significant risk factors. Carbapenem use showed a tendency towards a statistical association ($p=0.07$) (Table 2).

Second Period (January to June 2008)

- Thirty-five cases were notified and 70 control patients were selected for analysis.
- Univariate analysis: variables with a significant association with MDR/carbapenem-resistant A. baumannii colonization or infection were CVC utilization ($p=0.02$), carbapenem and third-generation cephalosporin use ($p=0.019$ and $p=0.039$, respectively), liver transplantation ($p=0.015$), and severe ASIS score ($p=0.041$) (Table 3).
Table 1. Risk factor univariate analysis for MDR/carbapenem-resistant *A. baumannii* in the Intensive Care Unit, Hospital das Clínicas - UFMG, 2007.

<table>
<thead>
<tr>
<th>Variable</th>
<th>MDR/carbapenem-resistant <em>A. baumannii</em></th>
<th>p</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case (51)</td>
<td>Control (102)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>23 (45.1)</td>
<td>53 (52)</td>
<td>0.42</td>
<td>0.8</td>
</tr>
<tr>
<td>F</td>
<td>28 (54.1)</td>
<td>49 (48)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invasive devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MV</td>
<td>44 (86.3)</td>
<td>33 (32.4)</td>
<td>&lt;0.001</td>
<td>6.2</td>
</tr>
<tr>
<td>CVC</td>
<td>41 (80.4)</td>
<td>55 (53.9)</td>
<td>0.001</td>
<td>2.4</td>
</tr>
<tr>
<td>IUC</td>
<td>48 (94.1)</td>
<td>76 (74.5)</td>
<td>0.004</td>
<td>3.7</td>
</tr>
<tr>
<td>ATB utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>14 (27.5)</td>
<td>17 (16.7)</td>
<td>0.12</td>
<td>1.5</td>
</tr>
<tr>
<td>3rd gen. cephalosporin</td>
<td>9 (17.7)</td>
<td>14 (13.7)</td>
<td>0.52</td>
<td>1.2</td>
</tr>
<tr>
<td>Carbapenem</td>
<td>21 (41.2)</td>
<td>10 (9.8)</td>
<td>&lt;0.001</td>
<td>2.8</td>
</tr>
<tr>
<td>Severity (ASIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>3 (5.9)</td>
<td>33 (32.4)</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>10 (9.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>18 (35.3)</td>
<td>34 (33.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>23 (45.1)</td>
<td>21 (20.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>7 (13.7)</td>
<td>4 (3.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transplantation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>0</td>
<td>4 (3.9)</td>
<td>0.15</td>
<td>1.5</td>
</tr>
<tr>
<td>Liver</td>
<td>1 (2.0)</td>
<td>4 (3.9)</td>
<td>0.67</td>
<td>0.6</td>
</tr>
<tr>
<td>Kidney</td>
<td>1 (2.0)</td>
<td>3 (2.9)</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Prior surgery</td>
<td>34 (66.7)</td>
<td>63 (61.8)</td>
<td>0.55</td>
<td>1.2</td>
</tr>
<tr>
<td>Prior infection</td>
<td>36 (70.6)</td>
<td>26 (25.5)</td>
<td>&lt;0.001</td>
<td>3.5</td>
</tr>
</tbody>
</table>

MDR- multidrug resistance; N- number; OR- Odds ratio; CI- confidence interval; M- male; F- female; MV- mechanical ventilation; CVC- central venous catheter; IUC- indwelling urinary catheter; ATB- antibiotic; ASIS- Average Severity of Illness Score.

Table 2. Risk factor multivariate analysis for MDR/carbapenem-resistant *A. baumannii* in the Intensive Care Unit, Hospital das Clínicas - UFMG, 2007.

<table>
<thead>
<tr>
<th>Variable</th>
<th>p</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior infection</td>
<td>0.002</td>
<td>4.190</td>
<td>1.69 - 10.41</td>
</tr>
<tr>
<td>MV</td>
<td>0.003</td>
<td>6.045</td>
<td>1.86 - 19.69</td>
</tr>
<tr>
<td>CVC</td>
<td>0.78</td>
<td>.842</td>
<td>0.26 - 2.77</td>
</tr>
<tr>
<td>IUC</td>
<td>0.88</td>
<td>1.133</td>
<td>0.22 - 5.85</td>
</tr>
<tr>
<td>Carbapenem</td>
<td>0.07</td>
<td>2.660</td>
<td>0.92 – 7.66</td>
</tr>
<tr>
<td>Severity (ASIS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.67</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.99</td>
<td></td>
<td></td>
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<tr>
<td>E</td>
<td>0.99</td>
<td></td>
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</tr>
</tbody>
</table>

OR- Odds ratio; CI- confidence interval; MV- mechanical ventilation; CVC- central venous catheter; IUC- indwelling urinary catheter.

- Multivariate analysis: CVC use persisted with a statistical difference as a risk factor associated with MDR/carbapenem-resistant *A. baumannii* colonization/infection (p=0.04). Carbapenem and third-generation cephalosporin use showed a tendency towards this association (p=0.07 and p=0.09, respectively) (Table 4).

**Discussion**

*A. baumannii* has emerged as an important nosocomial pathogen and outbreaks due to multiple-resistant strains have been difficult to control, especially in the ICU setting.

Although more consistent studies of *Acinetobacter* MDR risk factors are available in medical literature, only a few of
Table 3. Risk factors for MDR/carbapenem-resistant *A. baumannii* in the Intensive Care Unit, Hospital das Clínicas - UFMG, 2008.

<table>
<thead>
<tr>
<th>Variable</th>
<th>MDR/carbapenem-resistant <em>A. baumannii</em></th>
<th>p</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case (35)</td>
<td>Control (70)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
<td></td>
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</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>19 (54.3)</td>
<td>29 (41.4)</td>
<td>0.21</td>
<td>0.71</td>
</tr>
<tr>
<td>F</td>
<td>16 (45.7)</td>
<td>41 (58.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invasive devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MV</td>
<td>27 (77.1)</td>
<td>46 (65.7)</td>
<td>0.23</td>
<td>1.5</td>
</tr>
<tr>
<td>CVC</td>
<td>30 (85.7)</td>
<td>45 (64.3)</td>
<td>0.02</td>
<td>2.4</td>
</tr>
<tr>
<td>IUC</td>
<td>34 (97.1)</td>
<td>61 (87.1)</td>
<td>0.16</td>
<td>3.6</td>
</tr>
<tr>
<td>ATB utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>10 (28.6)</td>
<td>17 (24.3)</td>
<td>0.64</td>
<td>1.16</td>
</tr>
<tr>
<td>3rd gen. cephalosporin</td>
<td>13 (37.1)</td>
<td>13 (18.6)</td>
<td>0.015</td>
<td>1.79</td>
</tr>
<tr>
<td>Carbapenem</td>
<td>17 (48.6)</td>
<td>18 (25.7)</td>
<td>0.019</td>
<td>1.89</td>
</tr>
<tr>
<td>Severity (ASIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>14 (40)</td>
<td>30 (42.9)</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>1 (2.9)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>11 (15.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>6 (17.1)</td>
<td>13 (18.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>14 (40)</td>
<td>16 (22.9)</td>
<td></td>
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<tr>
<td>Transplantation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>1 (2.86)</td>
<td>7 (10)</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td>Liver</td>
<td>10 (28.6)</td>
<td>7 (10)</td>
<td>0.015</td>
<td>2.07</td>
</tr>
<tr>
<td>Kidney</td>
<td>2 (5.7)</td>
<td>3 (4.3)</td>
<td>1.00</td>
<td>1.2</td>
</tr>
<tr>
<td>Prior surgery</td>
<td>19 (54.3)</td>
<td>37 (52.9)</td>
<td>0.89</td>
<td>1.04</td>
</tr>
<tr>
<td>Prior infection</td>
<td>18 (51.4)</td>
<td>27 (38.6)</td>
<td>0.21</td>
<td>1.4</td>
</tr>
</tbody>
</table>

MDR- multidrug resistance; N- number; OR- Odds ratio; CI- confidence interval; M- male; F- female; MV- mechanical ventilation; CVC- central venous catheter; IUC- indwelling urinary catheter; ATB- antibiotic; ASIS- Average Severity of Illness Score.

Table 4. Risk factor multivariate analysis for MDR/carbapenem-resistant *A. baumannii* in the Intensive Care Unit, Hospital das Clínicas - UFMG, 2008.

<table>
<thead>
<tr>
<th></th>
<th>p</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVC</td>
<td>0.04</td>
<td>3.61</td>
<td>1.03 - 12.57</td>
</tr>
<tr>
<td>Carbapenem</td>
<td>0.07</td>
<td>2.57</td>
<td>0.92 – 7.18</td>
</tr>
<tr>
<td>3rd gen. Cephalosporin</td>
<td>0.09</td>
<td>2.38</td>
<td>0.85 – 6.64</td>
</tr>
<tr>
<td>Severity (ASIS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.97</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OR- Odds ratio; CI- confidence interval; CVC- central venous catheter; ASIS- Average Severity of Illness Score.

them have been published in Brazil, despite the increasing isolation of MDR *Acinetobacter* strains. The first study was published in 1999 by Levin et al., and focused on clinical approach [30]. Even 10 years later, there are still uncertainties as to adequate prevention, control, and treatment of resistant *Acinetobacter* strains in epidemic and endemic situations.

MDR *A. baumannii* strains have been regularly isolated in Latin American hospital institutions [31]. Recently, *Pseudomonas* and *Acinetobacter* have been presented in Europe and the United States as responsible for nosocomial outbreaks, mainly in ICUs, with different infection sites and high resistance rates [32-34]. Since *A. baumannii* survives for prolonged periods under a wide range of environmental conditions, this microorganism is difficult to control [35]. It is possible that the acquisition of genetic elements, and among these, plasmids containing resistance genes such as metallo-beta-lactamase, could be related to the emergence of resistant strains. Although diverse resistance mechanisms as...
Figure 1. MDR/carbapenem-resistant *A. baumannii* cases of colonization/infection, in the Intensive Care Unit, Hospital das Clínicas - UFMG, 2007-2008.

Some articles have described an association between high carbapenem consumption rates, measured by the defined daily dose (DDD) and *A. baumannii* resistance. Carbapenems have long been regarded as the agents of choice, but resistance rates have risen [33]. Several studies have demonstrated that antimicrobial use can select resistant strains and elevated drug consumption is related to higher resistance rates. Marra et al. reported a carbapenem DDD (1000 patients/days) of 244.4 for a medical-surgical private hospital with an 88.5% *A. baumannii* resistance rate [43]. Another Brazilian study presented a 155.1 DDD index rate for carbapenem use, higher than expected [44]. At our institution, the carbapenem DDD index rate in the ICU was over the 90th percentile, according to the National Nosocomial Infections Surveillance (NNIS) system [45].

In this series, the use of invasive devices was also associated with MDR/carbapenem-resistant *A. baumannii*. During 2007, MV, CVC, and IUC use displayed a statistical association (p<0.001, p=0.001, and p=0.004, respectively). In 2008, however, only CVC continued to be associated with the colonization/infection by MDR/carbapenem-resistant *A. baumannii* (p=0.022), even in a multivariate analysis (p=0.04). Several authors have correlated invasive devices and MDR/carbapenem-resistant *A. baumannii* colonization, reinforcing the need for surveillance and control measures for these devices [13-15,40], mainly MV, as its habitat is a humid environment [1,3,4,46]. Moreover, patients who require invasive devices usually present with a more severe illness, demanding frequent medical interventions and have longer hospital stays, favoring colonization. As severity was analyzed, a statistical difference was also observed. Greater severity, according to the ASIS score, was identified in patients colonized/infected by MDR/carbapenem-resistant *A. baumannii* in the two periods of study (p<0.001 and p=0.041, respectively).

Although the outcome and mortality of *Acinetobacter baumannii* infections cannot be totally established, severity and multiple resistance could affect mortality rates. In the present study, 21 (30%) of 70 patients colonized/infected by *A. baumannii* MDR/resistant to carbapenem died during the study period. Nevertheless, the presence of the microorganism was not a predictor for mortality. Although death showed no statistical association with the isolation of *A. baumannii*, the small number of cases precluded an adequate analysis. We point out that patients classified as Severity grade E by the ASIS score were not included.

However, several other studies have shown the association between mortality and colonization. In a case-control study that included 104 patients with MDR *A. baumannii* isolates and 104 controls, matched as per length of stay, an association with mortality was observed (p=0.014), especially in the presence of infection (p<0.001) in a multivariate analysis. Colonization/infection by *A. baumannii* was a predictive factor of the need for MV, and the use of this device was associated with mortality (p=0.003) [47]. An assessment of six case-control studies concluded that there is an association between
infections by *Acinetobacter baumannii* and mortality in hospitalized patients, regardless of the resistance profile, especially under inadequate antimicrobial therapy [48]. Another study carried out by Playford et al. described that patients with infections caused by carbapenem-resistant *A. baumannii* displayed a 20% higher rate of hospital mortality, with a 3.9 OR (95% CI 1.4 to 10.7) when compared to those merely colonized [49]. Sunenshine et al., in a case-control study paired according to severity, described a higher mortality in patients infected by MDR *A. baumannii* when compared to controls (p<0.01) [50].

Infection Control measures, such as culture surveillance, contact precautions, cohorts, source identification, and environmental control, are effective in preventing microorganism dissemination [1,3,4,51,52]. These actions were recommended and monitored systematically by the HICC during the reported outbreak. An assistance team was directly informed on the outbreak data, microbiological results, and control recommendations. The participation and adherence of healthcare workers to preventive measures was extremely important in achieving control of the outbreak. However, infection control recommendations must be followed incessantly [53]. A booklet with all pertinent information was distributed to all professionals in order to sustain recommendations and to offer better patient assistance. In addition, the HICC antimicrobial audit and protocols for antimicrobial treatment definition, an A-I evidence level recommendation, are vital in order to avoid the emergence of microorganism resistance [36,37,54]. Another important suggestion is to avoid carbapenem use and indicate polymyxin as an alternative treatment, whenever possible, during a MDR/carbapenem-resistant *A. baumannii* outbreak [4].

The use of invasive devices (mainly MV and CVC), prior infections, use of antimicrobial agents (mostly carbapenem), and severity of clinical conditions can be associated with colonization or infection by MDR/carbapenem-resistant *A. baumannii*. These risk factors must be the focus of infection control actions, and the identification of colonized patients is extremely important to prevent microorganism dissemination.

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