Multidrug-Resistant Acinetobacter baumannii: An Emerging Pathogen among Older Adults in Community Hospitals and Nursing Homes

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(See the editorial commentary by de Medina and Carmeli, on pages 1617–1618.)

Background. Drug-resistant Acinetobacter species are problematic in tertiary-care hospitals. We describe the epidemiology, resistance patterns, and outcomes of older adults with Acinetobacter infection in community hospitals.

Methods. We queried the microbiology databases of the Oakwood Healthcare System (4 hospitals with 632, 259, 199, and 168 beds) for clinical Acinetobacter cultures obtained in 2003–2008. Patients aged ≥60 years who were admitted from home or nursing homes were included. We recorded the initial Acinetobacter isolate and susceptibility to 8 antibiotics. Cultures obtained 48 h after hospitalization were categorized as “nosocomial.” Administrative databases provided patients’ origins (home or nursing home) and discharge destinations (home, nursing home, long-term acute-care facility, another hospital, or hospice care or death).

Results. During the 6-year period, 560 community-dwelling (mean age ± standard deviation, 74 ± 8.6 years) and 280 nursing home–dwelling (78 ± 9.1 years) patients had Acinetobacter isolated. During this period, Acinetobacter prevalence increased 25% (P < .001, by trend test). In comparison of 2003 with 2008, Acinetobacter resistance to imipenem and ampicillin/sulbactam increased (from 1.8% to 33.1%; P < .001), as did “panresistance” (ie, resistance to all 8 antibiotics; increase from 0.0% to 13.6%; P < .001). Although resistance was stable in community-acquired isolates (resistance to ~4.2 antibiotics), resistance increased among nursing home–acquired and nosocomial-acquired isolates (from 4.5 to 5.7 and from 5.0 to 6.0 antibiotics, respectively; P < .01). At discharge, only 25% of community-dwelling and 50% of nursing home–dwelling patients returned to their place of origin; the remainder required higher levels of care or died. After adjustment for age, length of stay, and origin, resistance to each additional antibiotic predicted a >20% increased risk for discharge to higher levels of care or death (odds ratio, 1.23; 95% confidence interval, 1.11–1.36).

Conclusions. The prevalence and resistance of Acinetobacter species are increasing in the community. Patients with resistant isolates are selectively discharged to nursing homes and long-term acute-care facilities, introducing resistance to new facilities.

Acinetobacter baumannii is an increasingly common pathogen in health care settings globally [1, 2]. A. baumannii can infect a patient’s respiratory tract, blood, soft tissues, urinary tract, and central nervous system [1, 2]. Infections caused by Acinetobacter species are associated with adverse clinical outcomes, including high rates of morbidity and mortality, prolonged hospital stay, and substantial health care expenses [2, 3]. During the past decade, increasingly resistant strains of Acinetobacter have emerged, necessitating greater use of broad-spectrum antibiotics, such as imipenem and ampicillin-sulbactam [4, 5]. Of particular concern, strains of Acinetobacter are now being encountered that are resistant to all commonly used antibiotics and are susceptible only to colistin, an old, toxic agent.

Although A. baumannii has classically been recognized as a hospital-acquired pathogen [6, 7], community-acquired Acinetobacter infections have been reported in the literature, most occurring in countries with tropical climates [8–12]. A. baumannii is also a pathogen associated with water reservoirs, including showers [13], and has been associated with combat injuries in Iraq [14]. Reports have suggested that the...
community Acinetobacter pathogens are relatively susceptible to antibiotics, and the more resistant subtypes have occurred almost exclusively in hospitals and intensive care units [5, 9, 15].

Although Acinetobacter species are being recognized in the community, Acinetobacter infections in long-term care facilities and in older adults are not well described. We were unable to find any reports that documented the epidemiology or outcomes of Acinetobacter among nursing home residents or older adults in general. Therefore, the prevalence of Acinetobacter strains and the outcomes of Acinetobacter infections in this population are largely unknown.

This study had 2 major objectives. The first was to describe the epidemiology of A. baumannii in older adults cared for at 4 community hospitals in southeast Michigan. In particular, the resistance patterns of Acinetobacter strains present at the time of admission among older adults who were admitted from home and from nursing homes were analyzed and compared. The second objective was to describe the impact of Acinetobacter infection and of the degree of antibiotic resistance on the clinical outcomes of older adults admitted to study hospitals.

METHODS

We queried the Oakwood Healthcare System’s microbiology databases for all clinical A. baumannii cultures obtained from January 2003 through November 2008. The clinical microbiology laboratory serves all 4 of the system’s community hospitals. These hospitals are located in suburban Detroit cities (Dearborn, Wayne, Taylor, and Trenton) and have 632, 259, 199, and 168 beds, respectively. The system includes 3 teaching hospitals, and all 4 hospitals have nonteaching (private) patients.

To avoid multiple entries from a single patient, only the first positive Acinetobacter culture for a given patient was included. The medical record numbers from these study patients were then cross-referenced in the administrative database. The administrative database was queried for patient demographic characteristics, including age, sex, patient origin (home, nursing home, long-term acute care facility, or other hospital), admission date, discharge date, disposition at discharge, and destination at discharge.

Only clinical cultures were analyzed. From the clinical microbiology database, the antibiotic susceptibility profile was extracted. Organisms were tested using conventional overnight identification/sensitivity panels with the Siemens MicroScan WalkAway system. Tested antibiotic classes included ampicillin/sulbactam, aztreonam,cephalosporins (3rd generation and 1st generation), aminoglycosides (gentamicin and tobramycin), quinolones (ciprofloxacin and levofloxacin), carbapenems (imipenem), tetracycline, and trimethoprim/sulfamethoxazole. If an isolate was susceptible to any of the antibiotics in a given class, then the isolate was considered susceptible to that class. Isolates with “intermediate” susceptibility to a particular antibiotic class were considered to be resistant to that class. Of note, throughout the 6-year period, Acinetobacter isolates were highly resistant (≈97%) to aztreonam, and sensitivity testing was discontinued in August 2008. The 22 untested isolates included in this study were therefore classified as resistant to aztreonam.

For this analysis, all patients aged <60 years were excluded, as were those patients presenting from other acute care facilities (hospitals or long-term acute-care facilities). Patients presenting from home or outpatient clinics were classified as “community-dwelling,” and those patients from nursing homes were classified as “nursing home–dwelling.” Acinetobacter isolates that were collected within 2 days after admission were considered to be acquired prior to the hospitalization, or “nonnosocomial”; Acinetobacter isolates acquired after day 2 were considered “nosocomial.” Panresistance was defined as resistance to all 8 antibiotic classes tested.

Continuous variables are expressed as mean ± standard deviation; categorical variables as percentages. Colonization/infection rates are expressed as the percentage of overall hospital admissions of patients aged ≥60 years. Resistance patterns are expressed as the annual percentage of Acinetobacter cultures that were resistant to both imipenem and ampicillin-sulbactam or resistant to all 8 tested antibiotic classes. Differences in means were compared using Student’s \( t \) test. Linear regression analysis was used to analyze trends in antibiotic resistance profiles over time. After adjustment for possible confounders, multiple linear regression was used to investigate the relationship between increasing antibiotic resistance and discharge to a higher level of care (ie, nursing home or long-term acute-care facility) or death. This protocol was approved by the Oakwood Healthcare Systems Institutional Review Board and received no external funding.

RESULTS

Overall trends. During the 6-year period at the study hospitals, 1441 unique patients (including patients of all ages) had A. baumannii recovered from clinical cultures. Of these patients, 455 (32%) were aged <60 years, and 147 (10%) were admitted from other acute care facilities; all these patients were excluded from further analysis. Of the remaining patients aged ≥60 years with Acinetobacter cultures, 560 were admitted from home (“community-dwelling”), and 280 were admitted from >17 nursing homes (“nursing home–dwelling”). Community-dwelling individuals ranged in age from 60 to 95 years (mean age, 74.3 ± 8.6 years), and 52% were male. Nursing home–dwelling individuals ranged in age from 60 to 100 years (mean age, 78.0 ± 9.1 years), and 46% were male. The initial Acinetobacter cultures among older adults were obtained from a va-
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Figure 1. Evolving resistance profile of Acinetobacter baumannii among patients aged ≥60 years in 4 community hospitals. Resistance to imipenem and ampicillin-sulbactam and panresistance (resistance to all 8 antibiotic classes) are expressed as a percentage of the total Acinetobacter cultures from 2003 through 2008. The total number of cultures from unique patients in each year was 113 in 2003, 125 in 2004, 152 in 2005, 143 in 2006, 189 in 2007, and 118 in 2008. Note that all panresistant Acinetobacter cultures were also included in the imipenem and ampicillin-sulbactam resistance category.

Changes in antibiotic resistance over time From 2003 to 2007, the number of Acinetobacter isolates from clinical cultures increased from 189 to 329. During the first 10 months of 2008, another 214 cultures were isolated. This translates to a 25% increase in Acinetobacter rates among older adults admitted from 2003 through 2008 (P < .001, by trend test). Isolates that were resistant to both imipenem and ampicillin-sulbactam were uncommon through 2006 but sharply increased in frequency during 2007 (from 1.7% to 33.1%; P < .001, by trend test) (Figure 1). In addition, panresistant Acinetobacter strains emerged during the study (Figure 1). In 2003 and 2004, 0 cases of panresistant Acinetobacter infection were noted. In contrast, 40 cases of panresistant Acinetobacter infection were seen in 2007, and another 16 were seen in the first 10 months of 2008. The panresistant isolates were dispersed among all 4 community hospitals.

Comparison of antibiotic resistance in community, nursing home, and hospital-acquired Acinetobacter isolates. During the 6-year study period, 142 (25%) of the 560 community-dwelling patients and 153 (55%) of the 280 nursing home-dwelling patients had Acinetobacter cultures recovered within the first 2 days of their hospital stay (nonnosocomial). As noted in Figure 2, community-dwelling patients with nonnosocomial Acinetobacter isolates tended to have a fairly stable resistance pattern during the study period, with resistance to a mean of 4.3 ± 2.0 and 4.2 ± 2.2 antibiotic classes in 2003 and 2008, respectively (P > .20). Nonnosocomial Acinetobacter isolates from nursing home–dwelling patients had a resistance pattern similar to that from community-dwelling patients in 2003; however, resistance among isolates from nursing home–dwelling patients increased by the end of the study period, with resistance to a mean of 4.5 ± 0.86 antibiotic classes in 2003 and 5.7 ± 1.9 classes in 2008 (P < .01). Nosocomial strains of Acinetobacter had the highest rates of baseline antibiotic resistance (resistance to a mean of 5.0 ± 0.91 antibiotic classes in

Figure 2. Acinetobacter baumannii (ACB) resistance to the 8 tested antibiotic classes among patients admitted to 4 community hospitals during a 6-year period. Antibiotic resistance was stable in community-dwelling patients who had Acinetobacter species recovered from cultures within the first 2 days of hospitalization (“nonnosocomial”) (solid black line), but resistance increased among patients who had Acinetobacter species recovered from cultures after the first 2 days of hospitalization (“nosocomial”) (dashed line). The resistance pattern of nursing home patients with nonnosocomial Acinetobacter strains closely paralleled the pattern noted for the group with nosocomial strains (gray line). The total number of cultures for each year was 113 in 2003, 125 in 2004, 152 in 2005, 143 in 2006, 189 in 2007, and 118 in 2008.
and discharge disposition. Antibiotic resistance of Acinetobacter ( ) and nursing home–dwelling ( ) patients. No-outcome was evident in both community-dwelling patients 1). This relationship between antibiotic resistance and adverse pice care had the greatest degree of antibiotic resistance (Table whereas those from patients who died or were referred to hospice or died (31%). Similar to the community-dwelling individuals, nursing home–dwelling individuals with Acinetobacter infection frequently required high levels of care after discharge or died; only 50% of the 280 nursing home–dwelling patients returned to the nursing home (n = 133) or were sent home (n = 10). Another 20% were transferred to other hospitals or long-term acute-care facilities (n = 58), and 30% were referred to hospice care or died (n = 82).

Association between Acinetobacter infection and admission source. Regardless of whether patients were admitted from home or nursing homes, Acinetobacter infection was associated with high rates of adverse outcomes, including discharge to extended care facilities, hospice referral, and death. Of all the patients in the study who were previously community dwelling (n = 560), only 25% were discharged back to home. The remainder were discharged to nursing homes (14%), discharged to long-term acute-care facilities (27%), transferred to other hospitals (2%), or were referred to hospice care or died (31%). Similar to the community-dwelling individuals, nursing home–dwelling individuals with Acinetobacter infection frequently required high levels of care after discharge or died; only 50% of the 280 nursing home–dwelling patients returned to the nursing home (n = 133) or were sent home (n = 10). Another 20% were transferred to other hospitals or long-term acute-care facilities (n = 58), and 30% were referred to hospice care or died (n = 82).

Relationship between degree of antibiotic resistance of Acinetobacter and discharge disposition. Increasing degrees of antibiotic resistance of Acinetobacter strains were associated with discharge to extended care facilities or death. A direct relationship was identified between increasing antibiotic resistance and adverse outcome; Acinetobacter strains isolated from patients discharged to home had the least antibiotic resistance, whereas those from patients who died or were referred to hospice care had the greatest degree of antibiotic resistance (Table 1). This relationship between antibiotic resistance and adverse outcome was evident in both community-dwelling patients (P < .001) and nursing home–dwelling (P = .024) patients. Notably, community-dwelling patients with panresistant Acinetobacter had particularly poor outcomes: one-half (n = 23) died, one-third (n = 16) were discharged to nursing homes or long-term acute-care facilities, and only 6 of the 45 patients were discharged back to home.

Table 1. Acinetobacter baumannii Resistance Profiles and Disposition at Discharge

<table>
<thead>
<tr>
<th>Measure</th>
<th>Discharged to home</th>
<th>Discharged to nursing home</th>
<th>Discharged to LTAC or other hospital</th>
<th>Referred to hospice care or died</th>
<th>( P^a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients admitted from the community (homes)</td>
<td>149</td>
<td>77</td>
<td>159</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Acinetobacter resistance, mean no. of antibiotic classes ± SD</td>
<td>4.3 ± 1.9</td>
<td>5.0 ± 1.4</td>
<td>5.2 ± 1.6</td>
<td>5.3 ± 1.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No. of patients admitted from nursing homes</td>
<td>7</td>
<td>133</td>
<td>58</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Acinetobacter resistance, mean no. of antibiotic classes ± SD</td>
<td>5.1 ± 0.9</td>
<td>4.9 ± 1.3</td>
<td>5.5 ± 1.2</td>
<td>5.3 ± 1.6</td>
<td>.024</td>
</tr>
</tbody>
</table>

NOTE. LTAC, long-term acute-care facility; SD, standard deviation.

\( a \) P value by trend test.

2003) and became increasingly antibiotic-resistant during the study period (resistance to a mean of 6.0 ± 1.7 classes in 2008; \( P < .01 \)).

Another notable trend was the shift toward increasingly resistant strains of Acinetobacter among patients who were discharged to nursing homes during the study period (Figure 3). Patients with Acinetobacter infection who were discharged to nursing homes had increasingly resistant isolates during the study period: resistance to a mean of 4.6 ± 0.98 antibiotic classes in 2003–2006 and resistance to a mean of 5.6 ± 1.7 classes in 2007–2008 (\( P < .001 \)). In 2003–2006, no patients admitted to nursing homes had panresistant Acinetobacter strains. Strikingly, in 2007–2008, 10 (13%) of the patients with Acinetobacter infection who were discharged to nursing homes had isolates that were resistant to all tested antibiotic classes.

To further explore the relationship between antibiotic resistance and outcomes, a multivariate analysis was performed that included the entire study group. Each additional antibiotic class
to which *Acinetobacter* was resistant increased the likelihood of requiring a higher intensity of care at discharge, compared with the intensity of care required prior to admission (odds ratio [OR], 1.47; 95% confidence interval [CI], 1.43–1.19). For example, increasing antibiotic resistance among strains from community-dwelling individuals was associated with an increased likelihood to be discharged to a nursing home, long-term acute-care facility, or another hospital or to die, and among strains from nursing home–dwelling patients, increasing antibiotic resistance was associated with an increased likelihood to be discharged to a long-term acute-care facility or another hospital or to die. In regression analysis, an independent relationship was identified between the *Acinetobacter* resistance profile and an increased likelihood that patients would require a higher intensity of care at discharge. After adjustment for age (OR, 1.03; *P* < .01), length of stay (OR, 1.05; *P* < .001), and community-dwelling status (OR, 2.22; *P* < .001), resistance to each additional antibiotic class remained independently associated with requiring a higher intensity of care at discharge, compared with the intensity of care required prior to admission (OR, 1.23; 95% CI, 1.11–1.36).

**DISCUSSION**

This study analyzed the epidemiology of *A. baumannii* among community-dwelling and nursing home–dwelling geriatric patients who were admitted to a community hospital system. Notable findings were (1) the overall prevalence of *Acinetobacter*, including multidrug-resistant *Acinetobacter* strains, increased during the study period; (2) increasing antibiotic resistance was associated with substantial morbidity and mortality; (3) increasingly resistant *Acinetobacter* strains were being introduced into nursing homes from hospitals and were also introduced into hospitals from nursing homes.

Transfer of *Acinetobacter* strains between hospitals has been well described [16]. However, *Acinetobacter* species are no longer strictly hospital pathogens. Four previous reports have shown that long-term acute-care facilities may serve as reservoirs for *Acinetobacter* species [17–20], but no published studies have detailed multidrug-resistant *Acinetobacter* strains in nursing homes or among community-dwelling elderly persons. This article demonstrates that *A. baumannii* is widespread in southeastern Michigan, including large and small hospitals, long-term acute-care facilities, nursing homes, and the community. Furthermore, transfer of multidrug-resistant strains among health care facilities is bidirectional—patients were admitted from >17 different nursing homes with pre-existing *Acinetobacter* infection; other patients were discharged to >28 different nursing homes after acquiring *Acinetobacter* infection in the hospital. The increase in multidrug resistance among *Acinetobacter* strains compounds the seriousness of the clinical problems associated with this pathogen in our region. Multidisciplinary, collaborative efforts are needed to control the spread of multidrug-resistant *Acinetobacter* strains.

The association between increased degrees of antimicrobial resistance and adverse outcome is noteworthy. The impact of increasing antibiotic resistance on adverse outcome was similar among community-dwelling and nursing-home dwelling elderly persons. Similar associations have been noted with other pathogens [21–25]. This association might relate to the limited number of treatment options available for treatment of multidrug-resistant strains. It is also possible that multidrug resistance might be a marker for an increased severity of illness and more frequent contact with health care. Additional analysis is needed to focus on the impact of multidrug resistance in cases of invasive *Acinetobacter* infection and to control for factors that might confound the impact of antimicrobial resistance on clinical outcome.

The increase in prevalence of *Acinetobacter* strains in nursing homes and the degree of antibiotic resistance among these strains is extremely concerning. As the current study demonstrates, the degree of antibiotic resistance among “hospital-acquired” *Acinetobacter* cultures increased during the study period in parallel with the degree of resistance among *Acinetobacter* isolates from nursing home–dwelling patients. The epidemiology of *Acinetobacter* infection among older adults in this study indicates the existence of a hospital–nursing home “coupling.” This coupling supports a continuous circuit that nurtures the dissemination of multidrug-resistant *Acinetobacter* strains among both types of health care facility. Consequently, coordinated regional efforts are needed to control the spread of this pathogen. Long-term care facilities, despite their vulnerable populations, generally have few resources for infection surveillance and prevention.

This study had several limitations. Infection was not differentiated from colonization. Causation between multidrug resistance and poor outcomes cannot be established or inferred from this study; additional analysis and data collection would be required to control for confounding effects on the association between multidrug resistance and outcome. Despite these limitations, substantial morbidity and mortality was associated with recovery of multidrug-resistant *Acinetobacter* strains in clinical cultures in both community-dwelling and nursing home–dwelling elderly persons, which supports an association between antimicrobial resistance and poor outcome.

This article is the first to report the epidemic of multidrug-resistant *A. baumannii* among older adults residing in the community, in nursing homes, and in hospitals. The prevalence of *Acinetobacter* strains and the degree of antimicrobial resistance continue to grow. The outcomes among patients who developed infection with these organisms were strikingly adverse. The complex nature of *A. baumannii* as a pathogen, the growing geriatric population, and the diversity of settings in which
multidrug-resistant *Acinetobacter* strains have emerged presents a huge challenge to health care facilities, public health, and older adults in general.

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**References**