Four Years of Surveillance Cultures at a Long-Term Acute Care Hospital

L. Silvia Munoz-Price, MD; Alexander Stemer, MD

OBJECTIVE. To characterize the degree of colonization with multidrug-resistant organisms (MDROs) among patients admitted to a long-term acute care hospital.

DESIGN. Ecologic study.

SETTING. A 70-bed long-term acute care hospital (a hospital within a hospital) in the greater Chicago area.

METHODS. As part of an infection control initiative, specimens were collected from all consecutively admitted patients for culture of MDROs within 72 hours of admission. Cultures from July 28, 2005, through November 1, 2008, were analyzed on the basis of the bodily site from which the isolate was recovered and the organisms identified. If MDROs were yielded by culture of specimens that were obtained from 24 hours to 30 days after collection of the patient’s original set of specimens, these MDROs were removed from the analysis. In addition, repeat rectal swab samples were collected for culture at 2 weeks after admission for all consecutive patients admitted from January 1 through March 31, 2007.

RESULTS. A total of 1,739 patients with a total of 5,198 specimens met entry criteria. Of the corresponding 5,198 surveillance cultures, 1,580 (30%) were positive for MDROs. Of the 1,739 patients, 947 (54%) had a culture-positive specimen recovered from any site. Vancomycin-resistant Enterococcus was the organism most commonly isolated in cultures of rectal swab samples (in 38% of such cultures) and wounds (in 18% of such cultures). The rate of rectal carriage of vancomycin-resistant Enterococcus increased from 29% in 2005 to 44% in 2008.
This for-profit LTACH contracts with an off-site private laboratory for all its cultures. Briefly, each specimen (regardless of bodily source) labeled as MROC was inoculated in (1) mannitol salt with oxacillin agar plates to determine the presence of methicillin-resistant Staphylococcus aureus (MRSA), (2) bile esculin azide with vancomycin agar plates to select vancomycin-resistant Enterococcus (VRE), and (3) tryptic soy broth with two 30-μg vancomycin discs and four 10-μg tobramycin discs to isolate gram-negative MDROs, including extended-spectrum β-lactamase (ESBL)–producers. Final identification and susceptibility testing were performed using the MicroScan Walkaway System (Siemens Healthcare Diagnostics). As previously described, starting May 13, 2008, any gram-negative bacillus suspected of Klebsiella–producing–carbapenemase (KPC) production underwent a modified Hodge test; if this test result was positive, a confirmatory polymerase chain reaction assay for KPC followed.

By means of an electronic microbiology database (LabPro Information Manager; Siemens Healthcare Diagnostics), we collected all consecutive specimens labeled as MROC from July 28, 2005, through November 1, 2008. Positive surveillance cultures were those MROC cultures that yielded any MDROs. For the purposes of our study, MDROs included MRSA, VRE, ESBL-producing gram-negative rods, KPC-producing gram-negative rods, imipenem-resistant Pseudomonas aeruginosa, imipenem-resistant Acinetobacter baumannii, imipenem-resistant Enterobacter species, and other imipenem-resistant gram-negative rods. We also documented all imipenem-susceptible but multidrug-resistant (MDR; resistant to 2 or more antimicrobial classes) gram-negative rods.

The term “set of cultures” was used to describe cultures of all specimens collected within 24 hours of each other from a single patient (eg, cultures of specimens from rectal swab samples, nares, and/or wounds). Unique identifiers, assigned by the microbiology laboratory, were used to link individual patients with each set of cultures. The results of cultures of specimens obtained from 24 hours to 30 days after the collection of initial specimens were removed from the analysis; however, results of cultures of specimens from the same patient collected more than 30 days apart were kept in the database. Colonization prevalences were calculated on the basis of the organisms isolated, bodily sites, and year of collection.

Per recommendation of the Infection Control Committee, from January 1 through March 30, 2007, all consecutive patients admitted to the institution underwent collection of rectal swab samples for surveillance culture at 2 weeks after admission; these cultures were performed in addition to cultures of specimens at entry. We present the results of this additional surveillance.

RESULTS

From July 28, 2005, through November 1, 2008 (39 months), a total of 1,905 sets of cultures were performed; 166 sets of cultures were removed from the analysis, because the specimens were collected from 24 hours to 30 days after the collection of the patient’s original set. A total of 5,198 individual cultures of specimens from 1,739 patients were analyzed (mean, 2.9 cultures per patient). Of the 5,198 individual cultures, 1,580 (30%) were positive for MDROs, and 947 (54%) of the total 1,739 patients had a culture-positive specimen recovered from any site.

Results by Site Cultured

A total of 1,629 cultures of rectal swab samples were performed over the study period; 807 (50%) were positive for any MDRO, 38% grew VRE, and 9% grew ESBL-producing gram-negative rods (Table). Among the 807 positive cultures of rectal swab samples, 560 (69%) had only 1 MDRO, 185 (23%) had 2 MDROs, and 62 (8%) had 3 or more MDROs. Thirty-three percent of 1,518 wound cultures were positive. Among patients who underwent collection of wound specimens for culture, the mean number of wounds tested was 1.5 (range, 1–8). The most frequent organism isolated was VRE (18%), followed by MRSA (7%) and imipenem-resistant A. baumannii (7%). Sixty-five percent of all culture-positive wounds had only 1 MDRO, 28% had 2 MDROs, and 7% had 3 or more different MDROs per culture.

With regard to the 521 cultures of nasal specimens, only 79 (15%) were positive for MDROs. The most common organisms isolated were MRSA (in 6% of such cultures) and VRE (in 4% of such cultures). Interestingly, gram-negative MDROs were identified in 7% of all nasal cultures.

There were 328 specimens from percutaneous gastrostomy tube entry sites cultured, and only 68 (21%) were positive for MDROs. The most common organism isolated was VRE (in 8% of such cultures), followed by ESBL-producing gram-negative rods (in 4% of such cultures). Most specimens from central vascular catheter entry sites (94%) were culture-negative.

Only 49 tracheal aspirates were cultured on admission, and 36 (73%) were negative. Other sources of specimens were urine (n = 25) and skin (n = 3); however, the sum of all these sources was negligible and therefore not analyzed. Rectal swab samples and wound specimens were the most frequent sources of VRE and all MDR gram-negative rods (including imipenem-resistant A. baumannii and imipenem-resistant P. aeruginosa) (Table).

Concordance between Sites Cultured

Only 923 sets of cultures included cultures of both rectal swab samples and wound specimens; 580 (63%) of these sets had MDROs isolated from any site (eg, rectum, nares, or percutaneous gastrostomy tube entry sites). Among the corresponding 580 colonized patients, 496 (86%) had culture-positive rectal swab samples, but only 361 (62%) had culture-positive wound samples.

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### Table. Multidrug-Resistant (MDR) Organisms Yielded by Culture of Isolates

<table>
<thead>
<tr>
<th>Organism</th>
<th>Rectal swab sample</th>
<th>Nares</th>
<th>Wound</th>
<th>CVC insertion site</th>
<th>PEG entry site</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>99 (6.1)</td>
<td>33 (6.3)</td>
<td>112 (7.4)</td>
<td>6 (0.6)</td>
<td>10 (3.0)</td>
</tr>
<tr>
<td>Vancomycin-resistant Enterococcus</td>
<td>615 (37.8)</td>
<td>20 (3.8)</td>
<td>275 (18.1)</td>
<td>19 (2.1)</td>
<td>26 (7.9)</td>
</tr>
<tr>
<td>ESBL-producing gram-negative rods</td>
<td>146 (9.0)</td>
<td>8 (1.5)</td>
<td>85 (5.6)</td>
<td>9 (1.0)</td>
<td>13 (4.0)</td>
</tr>
<tr>
<td>KPC-producing gram-negative rods</td>
<td>3 (0.2)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Imipenem-resistant Pseudomonas aeruginosa</td>
<td>46 (2.8)</td>
<td>4 (0.8)</td>
<td>33 (2.2)</td>
<td>5 (0.5)</td>
<td>6 (1.8)</td>
</tr>
<tr>
<td>Imipenem-resistant Acinetobacter baumannii</td>
<td>97 (6.0)</td>
<td>19 (3.6)</td>
<td>104 (6.9)</td>
<td>10 (1.1)</td>
<td>16 (4.9)</td>
</tr>
<tr>
<td>Imipenem-susceptible MDR A. baumannii</td>
<td>13 (0.8)</td>
<td>2 (0.4)</td>
<td>21 (1.4)</td>
<td>6 (0.6)</td>
<td>4 (1.2)</td>
</tr>
<tr>
<td>Other imipenem-susceptible MDR gram-negative rods</td>
<td>66 (4.1)</td>
<td>4 (0.8)</td>
<td>34 (2.2)</td>
<td>4 (0.4)</td>
<td>6 (1.8)</td>
</tr>
<tr>
<td>Imipenem-susceptible MDR P. aeruginosa</td>
<td>11 (0.7)</td>
<td>0 (0)</td>
<td>6 (0.4)</td>
<td>2 (0.2)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Imipenem-resistant Enterobacter spp.</td>
<td>2 (0.1)</td>
<td>0 (0)</td>
<td>2 (0.1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Other imipenem-resistant gram-negative rods</td>
<td>2 (0.1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>No MDR organisms isolated</td>
<td>822 (50.5)</td>
<td>442 (84.8)</td>
<td>1,014 (66.8)</td>
<td>874 (94.4)</td>
<td>260 (79.3)</td>
</tr>
<tr>
<td>Total no. of cultures</td>
<td>1,629 (100)</td>
<td>521 (100)</td>
<td>1,518 (100)</td>
<td>926 (100)</td>
<td>328 (100)</td>
</tr>
</tbody>
</table>

**Note.** MDR means resistant to 2 or more drug classes. CVC, central vascular catheter (includes only triple line catheters and peripherally inserted intravenous catheters); ESBL, extended-spectrum β-lactamase; KPC, Klebsiella-producing carbapenemase; MRSA, methicillin-resistant Staphylococcus aureus; PEG, percutaneous gastrostomy tube.

### Results by Year of Collection

The percentage of cultures of rectal swab samples found positive for VRE increased from 29% in 2005 to 44% in 2008 (Figure 1). Similarly, the percentage of patients carrying ESBL-producing gram-negative rods increased from 8% to 17% throughout the years. To the contrary, imipenem-resistant Acinetobacter rectal colonization stayed constant at approximately 5%.

VRE carriage detected via wound cultures increased from 14% in 2005 to 22% in 2008 (Figure 2). A high prevalence of ESBL-producing gram-negative rods (33%) among wound cultures was observed during 2007, which was followed by 5% in 2008. Imipenem-resistant Acinetobacter wound colonization decreased from 10% in 2005 to 7% in 2008.

### Rectal Swab Cultures at 2 Weeks

During the first 3 months of 2007, a total of 86 patients underwent another collection of rectal swab samples at 2 weeks after admission: 39 of these patients had culture-negative rectal swab samples on admission, of whom 15 (38%) had culture-positive rectal swab samples at 2 weeks. Among the 47 patients with culture-positive rectal swab samples on admission, 17 (36%) had acquired a new MDRO on repeat collection.

### Readmissions to the Hospital

A total of 60 patients underwent a second collection of specimens for culture more than 30 days after collection of their first set (and thus were counted as new patients for the purposes of this study). Forty-one patients had second collections performed within 6 months (mean, 74.3 days; range, 31–173 days), and 20 had second collections performed after 6 months of their first collection (mean, 364 days; range, 188–614 days). One patient had additional collections during both periods.

These 60 patients had a prevalence of MDRO colonization on initial set of cultures of 35%. The 41 patients with second collections within 6 months had a prevalence of MDRO colonization of 52%, and the 20 patients with second collections after 6 months had a prevalence of MDRO colonization of 32%.

### Discussion

In this study, we describe the colonization rates among 1,739 patients on admission to an LTACH; more than half of these patients were found to be colonized with MDROs. VRE was the most common organism identified, followed by MDR gram-negative rods, including imipenem-resistant P. aeruginosa and imipenem-resistant A. baumannii. As expected, a subanalysis of patients who had cultures of both rectal swab samples and wounds showed culture of rectal swab samples with the highest yield of MDROs (86% of these patients had culture-positive rectal swab samples, but only 62% had culture-positive wound samples).

The prevalence of MRSA carriage at either nares or other sites remained less than 10%. Furthermore, colonization with either VRE or resistant gram-negative rods was found among all sites cultured, including the nares; this finding suggests that at the time of discharge from acute care hospitals, there is an extensive bioburden of MDROs on patients’ skin. Moreover, although gram-negative MDROs were identified in nasal
Colonization prevalences among cultures of rectal swab samples from July 28, 2005, through November 1, 2008. The percentage was calculated as the no. of culture-positive rectal swab samples/total no. of rectal swab samples during the specific year x 100. Light gray, Vancomycin-resistant Enterococcus; dark gray, extended-spectrum β-lactamase (ESBL)–producing gram-negative rods; black, imipenem-resistant Acinetobacter.

cultures, culturing only nasal specimens would have misled the institution by giving a false low level of colonization.

Surveillance cultures on admission to LTACHs not only identify the extent of multidrug resistance pressure to these institutions but also represent the degree of colonization at the end of acute care hospitalizations; therefore, it is only reasonable to conclude that the degree of colonization—and type of organisms—on admission would differ among LTACHs in different geographical areas, just as it occurs among acute care hospitals. A previous surveillance study performed during hospital stay at a Maryland LTACH showed a predominance of MRSA colonization (28%) and only a 3% imipenem-resistant A. baumannii colonization.9 The LTACH depicted in our study receives patients discharged from Chicago’s tertiary care hospitals and community hospitals from Northwest Indiana. This large geographic area has experienced during the past few years multifacility outbreaks of infection with both OXA-40–producing A. baumannii10 and KPC–producing enterics.8 It is interesting to note the high degree of VRE colonization among patients admitted to this LTACH; most likely, this means that VRE is highly endemic in regional acute care hospitals, but we lack the data to confirm this hypothesis.

This study has several limitations, starting with its retrospective nature. Also, nursing personnel had less-than-optimal compliance with collection of specimens for surveillance culture from all bodily sources. Moreover, we lacked dates of admission to the institution, and therefore we assumed collection of specimens was performed within 72 hours of admission (per hospital policy) rather than several days after admission. The latter would give us information on the degree of colonization during hospital stay (representing acquisition within the LTACH) rather than on admission (representing colonization acquired during acute care hospital stays). There were 166 sets of cultures performed on specimens collected from patients within a month of their original sets. Given that we do not have admission dates, we could not determine if these were readmissions or simply overzealous surveillance; therefore, we decided to remove these 166 sets. All MDROs were processed by a private microbiology laboratory rather than a research or academic laboratory; however, results of this private laboratory have been previously validated.3 In addition, despite the high rate (25%) of mechanical ventilator usage, only 49 patients underwent cultures of tracheal secretions; we suspect this was because of an inappropriate labeling of specimens (“tracheal secretions” rather than “MROC”), as only specimens labeled MROC were collected for this study.

The high degree of colonization with MDROs on admission to LTACHs is important, given that it directly affects regional acute care hospitals. Our 3 main epidemiological questions were as follows: (1) Do patients transferred from acute care hospitals to nearby LTACHs negatively affect LTACH patients’ flora because of horizontal transmission of MDROs? (2) Are readmissions of LTACH patients—with long hospital stays, use of mechanical ventilators, and long periods of intravenous antibiotics—to acute care hospitals the cause of further spread of antimicrobial resistance in acute care institutions? (3) Are LTACHs magnifying centers of MDRO carriage because of
their patient’s acuity and relatively long hospital stay (25 days)? The combination of all 3 scenarios is most likely. We can now say that as many as 50% of patients admitted to LTACHs are already colonized with MDROs. Also, on the basis of our small study performed during 2007, we can also state that patients acquire MDROs during their stays at LTACHs. In addition, a previous study done in the greater Chicago area showed horizontal transmission of KPC-producing gram-negative rods at an LTACH. Furthermore, Stephens et al. have also documented the transmission of MDR A. baumannii from an LTACH to an acute care hospital in the Ohio area. The existence of “resistance loops” among acute care hospitals, LTACHs, and nursing homes has been previously postulated; these “resistance loops” might perpetuate and magnify the number of MDRO carriers by facilitating horizontal transmission among referring and accepting institutions.

On the basis of our data, we recommend screening all patients admitted to LTACHs with cultures of rectal swab samples only, looking for VRE, MRSA, and imipenem-resistant gram-negative rods. The cost of all cultures presented in this study was covered by the institution, and we did not do a cost-benefit analysis of this intervention. It would have been interesting to determine if there was a change in the rate of horizontal transmission of MDROs after universal surveillance was instituted in 2005. Unfortunately, that data is not available. Given that the number of LTACHs is increasing, further research on the epidemiology of MDROs across LTACHs is urgently needed.

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Potential conflicts of interest. Both authors report no conflicts of interest relevant to this article.

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REFERENCES