CONCISE COMMUNICATION

Emergence of Carbapenem-Resistant *Acinetobacter baumannii* in Nursing Homes With High Background Rates of MRSA Colonization

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Carbapenem-resistant *Acinetobacter baumannii* (CRAB) with diverse multilocus sequence typing emerged among our nursing home residents (6.5%) with a high background rate of MRSA (32.2%). Rectal swabs yielded a higher rate of CRAB detection than axillary or nasal swabs. Bed-bound status, use of adult diapers, and nasogastric tube were risk factors for CRAB colonization.

Infect Control Hosp Epidemiol 2016;37:983–986

Transmission of multidrug-resistant organisms (MDROs) has been increasingly reported in nursing homes.[1,2] In Hong Kong, the prevalence of MRSA in nursing homes increased from 2.8% to 21.6% between 2005 and 2011.[3,4] While infection control measures are generally more stringent in acute hospitals than in nursing homes, the latter have become epidemic centers for MDROs. With the emergence of carbapenem-resistant gram negative organisms in our hospitals,[5,6] it is important to determine the prevalence of and risk factors for carbapenem-resistant *Acinetobacter baumannii* (CRAB), carbapenemase-producing Enterobacteriaceae (CPE), and other MDROs in our nursing homes including methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant Enterococci (VRE). These findings are useful in the formulation of infection control policy.

METHODS

This study was conducted from July 1, 2015, to August 31, 2015, to determine the prevalence of MDROs among 28 nursing homes in the Hong Kong West District with a population of 0.53 million. The role of nursing homes was described previously.[4] Trained research nurses collected nasal swabs, axillary swabs, and rectal swabs from consented subjects all on the same day according to a standard protocol. The specimens were tested by the microbiology laboratory for the presence of CRAB, CPE, MRSA, and VRE as previously described.[4–6] The bacterial species were confirmed by matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS; Bruker Daltonics, Bremen, Germany). Susceptibility of the isolates was determined using the Kirby–Bauer disc diffusion method or E test, and the results were interpreted according to the guidelines of the Clinical and Laboratory Standards Institute (CLSI). For molecular typing of CRAB and MRSA, multilocus sequencing typing (MLST) and *spa* typing were performed on isolates of CRAB and MRSA respectively.[6,7] Patient demographic data were retrieved and analyzed. The χ^2 test and Student *t* test were used as appropriate with SPSS version 20 (IBM, Armonk, NY). Factors with $P < .05$ in univariate analysis were chosen for multivariate analysis. A final model was selected using a forward selection procedure. This study was approved by our institutional review board.

RESULTS

During the study period, 1,408 (60.6%) of 2,322 subjects from 28 nursing homes consented to undergo screening. The mean age was 83.8 ± 10.3 years and 854 (60.7%) were female. Of 691 (49.1%) residents who were functionally dependent, 474 of 691 (68.6%) were chair bound and 217 of 691 (31.4%) were bed bound. Of 1,408 residents, 909 (64.6%) were incontinent requiring the use of adult diapers; 62 (4.4%) had sacral sores; 71 (5.0%) had nasogastric tubes; 4 (0.3%) had percutaneous gastrostomy tubes; 4 (0.3%) had Tenckhoff catheters; and 75 (5.3%) had long-term urinary catheters.

Overall, colonization of MDROs was found in 494 of 1,408 residents (35.1%). MRSA colonization in any 1 of the 3 swabs was found in 454 residents (32.2%), while CRAB colonization was found in 92 residents (6.5%). A single resident had CPE with NDM-1–producing *E. coli*. VRE was not detected in any screened specimens. Of the 1,408 residents, 399 (28.3%) were colonized with MRSA only; 37 (2.6%) were colonized with CRAB only; and 55 (3.9%) were co-colonized with MRSA and CRAB. The subsequent analyses on residents focused on CRAB and/or MRSA colonization because the number of residents with CPE was small. The prevalence of CRAB and MRSA colonization among residents through different body sites is summarized in Table 1.

The univariate and multivariate analyses of the epidemiological risk factors for CRAB and MRSA colonization among residents in nursing homes are shown in Tables 2 and 3, respectively. Bed-bound status, incontinence with the use of adult diapers, and presence of a nasogastric tube were the common risk factors for both CRAB and MRSA colonization by multivariate analysis.

Molecular characterization of CRAB and MRSA was performed in 25 and 30 non-duplicated patient isolates from 6 nursing homes and showed a high prevalence of CRAB or MRSA respectively. A predominant *spa* type of MRSA t1081 was identified in 19 of 30 MRSA isolates (63.3%), in

TABLE 1. Prevalence of Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) and Methicillin-Resistant *Staphylococcus aureus* (MRSA) Colonization Among Residents in Nursing Homes by Sampling of Different Body Sites

Body Site	Prevalence of CRAB Colonization, No. (%) (N = 1,408)	Prevalence of MRSA Colonization, No. (%) (N = 1,408)
Nasal swab	14 (1.0)[a]	265 (18.8)[b]
Axillary swab	34 (2.4)[a]	129 (9.2)[b]
Rectal swab	64 (4.5)[a]	259 (18.4)[b]
Combination of any 2 sites		
Nasal and/or axillary swabs	46 (3.3)	336 (23.9)
Rectal and/or axillary swabs	83 (5.9)	315 (22.4)
Rectal and/or nasal swabs	73 (5.2)	418 (29.7)
Any one site	92 (6.5)	454 (32.2)

[a]The prevalence of CRAB colonization was statistically significant by sampling of different body sites ($P < .001$).
[b]The prevalence of MRSA colonization was statistically significant by sampling of different body sites ($P < .001$).

keeping with the predominant MRSA clone of ST45/spa t1081 in our locality.[7] The MLST patterns of CRAB were diverse, including 8 of 25 clones of ST575 (32.0%), and 7 newly reported MLST patterns in 7 patients with gastrointestinal colonization of CRAB.

DISCUSSION

In this study, we have demonstrated the emergence of CRAB colonization and a high prevalence of MRSA among nursing homes residents in Hong Kong. The prevalence of CRAB colonization was 6.5%, almost 3 times higher than in hospitalized patients identified through active surveillance culture in a previous study.[8] The rate of CRAB was highest among rectal swab cultures, which coincides with our previous finding that residents in nursing homes have the most significant risk factor for gastrointestinal colonization of CRAB among hospitalized patients.[8] In our study, the burden of antimicrobial-resistant *A. baumannii* was comparatively less

TABLE 2. Epidemiological Characteristics of Residents With or Without Colonization by Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Carbapenem-Resistant *Acinetobacter baumannii* (CRAB)

	(A) Patients Without Colonization by any MDROs, No. (%) (N = 914)[a]	(B) Patients With Colonization by CRAB, No. (%) (N = 92)	*P* Value (A) vs (B)	(C) Patients With Colonization by MRSA, No. (%) (N = 454)	*P* Value (A) vs (C)
Age (mean years ± SD)	83.6 ± 10.2	81.8 ± 11.2	.107	84.5 ± 10.0	.111
Male sex	358 (39.2)	56 (60.9)	<.001	170 (37.4)	.827
Dependency: chair-bound	277 (30.3)	42 (45.7)	.003	177 (39.0)	.001
Dependency: bed-bound	86 (9.4)	34 (37.0)	<.001	119 (26.2)	<.001
Incontinence with adult diapers	509 (55.7)	84 (91.3)	<.001	363 (80.0)	<.001
Presence of sacral sore	25 (2.7)	12 (13.0)	<.001	31 (6.8)	.001
Presence of indwelling device					
Nasogastric tube	18 (2.0)	14 (15.2)	<.001	48 (10.6)	<.001
Percutaneous gastrostomy tube	1 (0.1)	1 (1.1)	.127	3 (0.7)	.161
Urinary catheter	30 (3.3)	7 (7.6)	.036	42 (9.3)	<.001
Underlying diseases					
Chronic cerebral conditions	119 (13.0)	33 (35.9)	<.001	114 (25.1)	<.001
Chronic cardiac conditions	161 (17.6)	30 (32.6)	<.001	139 (30.6)	<.001
Chronic pulmonary conditions	46 (5.0)	6 (6.5)	.539	28 (6.2)	.382
Chronic renal failure	26 (2.8)	6 (6.5)	.055	25 (5.5)	.014
Liver cirrhosis	13 (1.4)	1 (1.1)	.794	4 (0.9)	.395
Diabetes mellitus	74 (8.1)	15 (16.3)	.008	52 (11.5)	.043
Malignancies	27 (3.0)	7 (7.6)	.019	22 (4.8)	.076
Use of antibiotic in preceding 6 months					
Beta-lactam/beta-lactamase inhibitors	33 (3.6)	15 (16.3)	<.001	50 (11.0)	<.001
Cephalosporins	10 (1.1)	2 (2.2)	.363	11 (2.4)	.060
Carbapenems	12 (1.3)	4 (4.3)	.027	17 (3.7)	.003
Fluoroquinolones	29 (3.2)	10 (10.9)	<.001	29 (6.4)	.005
History of hospitalization in the past 6 months	282 (30.9)	52 (56.5)	<.001	220 (48.5)	<.001

[a]MDROs include methicillin-resistant *Staphylococcus aureus*, carbapenem-resistant *Acinetobacter baumannii* and carbapenemase-producing Enterobacteriaceae.

TABLE 3. Risk Factors in Residents With Colonization by Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) and Methicillin-Resistant *Staphylococcus aureus* (MRSA) Using Multiple Logistic Regression[a]

	Colonization by CRAB		Colonization by MRSA	
Characteristic	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value
Dependency: bed-bound	2.70 (1.52–4.79)	.001	2.50 (1.66–3.77)	<.001
Incontinence with adult diapers	5.01 (2.30–10.92)	<.001	1.78 (1.26–2.52)	.001
Presence of nasogastric tube	2.98 (1.25–7.09)	.014	2.64 (1.45–4.77)	.001
Presence of chronic cerebral conditions	NS	NS	1.55 (1.13–2.11)	.006
Use of beta-lactam/beta-lactamase inhibitors in preceding 6 months	NS	NS	2.34 (1.44–3.82)	.001

NOTE. CI, confident interval.

[a]All epidemiological characteristics listed were used as independent variables. Final model was selected using a forward selection procedure. For the analysis of CRAB colonization, the Hosmer-Lemeshow goodness-of-fit statistic was 4.17, and $P = .841$. For the analysis of MRSA colonization, the Hosmer-Lemeshow goodness-of-fit statistic was 3.23, and $P = .780$.

than that in the United States, where 15% of high-risk nursing home residents have been reported to be colonized with multidrug-resistant *A. baumannii* (MRAB) using active surveillance culture.[2] Functional disability was an important risk factor for MRAB colonization,[2] and we further demonstrated that physical dependency such as bed-bound status, incontinence requiring adult diapers, and nasogastric tube feeding were significant risk factors for CRAB colonization in our multivariate analysis. Unlike MRSA, for which a predominant *spa* type prevailed, CRAB isolated from nursing home residents had diverse MLST patterns. This finding contrasts with the observation of clonal dissemination of *A. baumannii* in hospitals,[6] suggesting that a successful clone of *A. baumannii* has not yet been established in these nursing homes.

In this study, the prevalence of MRSA colonization among elderly residents in nursing homes was 32%, which was 10 times higher than the prevalence reported in Hong Kong 10 years ago.[3] The predominant *spa* type of MRSA was t1081, which was also the most commonly identified *spa* type among the hospital isolates.[7] Notably, the rate of gastrointestinal colonization of MRSA was as high as nasal colonization among our residents. Widespread environmental contamination had been shown previously in patients with MRSA colonization of the gastrointestinal tract.[9] This factor may explain why MRSA in nursing homes could not be brought under control.

With the emergence of CRAB and increasing prevalence of MRSA colonization in our nursing homes, it is important to enhance infection control interventions. Active surveillance culture may facilitate early recognition of residents colonized with MDROs. In our analysis, collection of nasal swabs and rectal swabs, even without axillary swabs, detected 80% and 92% of CRAB and MRSA, respectively. Hand hygiene by healthcare workers (HCWs) in nursing homes should be enforced. In particular, supervisors of nursing homes should directly observe and ensure the implementation of hand hygiene practices by HCWs during and after adult diaper changes and feeding via nasogastric tubes because these were significant risk factors for CRAB and MRSA colonization in our study. Additionally, directly observed hand hygiene before meals and oral medication administration by conscious residents should be promoted to prevent ingestion of MDROs into the gastrointestinal tract.[6,10]

We are aware of several limitations in this study. First, we did not screen patients who were demented or mentally incapacitated and had not undergone interval screening. Both of these factors may have led to the underestimation of MDRO prevalence. Second, we did not assess the degree of environmental contamination, and gastrointestinal colonization of MRSA was associated with significant environmental contamination.[9] Third, we selected CRAB and MRSA strains from nursing homes with high incidence, which may have led to the overrepresentation of "epidemic clones." However, our findings highlight the rapid emergence of CRAB in nursing homes, which deserves the attention of infection control professionals.

ACKNOWLEDGMENTS

Financial support: This study was partially supported by the Health and Medical Research Fund (HMRF), Food and Health Bureau, Hong Kong SAR Government (grant no. HKM-15-M12).

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

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Received December 10, 2015; accepted March 11, 2016; electronically published April 25, 2016

 0899-823X/2016/3708-0017. DOI: 10.1017/ice.2016.84

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