Brief report

Occurrence of nosocomial methicillin-resistant *Staphylococcus aureus* as a marker for transmission in a surgical intensive care unit in China

Yong Chen MSc [a], Wei Zhao PhD [a], Hui Liu MD [b], Qing Song MD [b], Yan Wang MSc [a], Jingya Zhao BMed [a], Dongyu Zheng MSc [a], Xuelin Han MSc [a], Xiaohua Hu BMed [a], Hajo Grundmann PhD [c], Li Han PhD [a,*]

[a] Center for Hospital Infection Control, Chinese PLA Institute for Disease Control and Prevention, Academy of Military Medical Sciences, Beijing, China
[b] Department of Surgical Intensive Care Unit, Chinese PLA General Hospital, Beijing, China
[c] Department of Medical Microbiology, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

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In 2008, an intensive care unit (ICU) in a large Chinese hospital was moved from a 6-bed old ward to a 20-bed new ward. After the move, the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in patients and environmental sites decreased significantly, but the number of ICU-acquired cases per imported MRSA case increased from 1.4 to 4.1. This study suggests that the nurse cohorting level and hand hygiene compliance are strong predicators of MRSA transmission in ICUs.

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With the booming economic development in the big cities of China, such as Beijing and Shanghai, many large hospitals have been expanding rapidly, with enlargement of ward capacities and more advanced facilities. To date, the effect of these changes on nosocomial infection transmission has not been evaluated, however. An ongoing surveillance of methicillin-resistant *Staphylococcus aureus* (MRSA) was conducted in a surgical ICU of a large Beijing hospital between April 2008 and July 2009. During this period, the ICU was moved from an old 6-bed crowded ward to a new 20-bed state-of-the-art ward. This study evaluated the occurrence of nosocomial MRSA as a marker for MRSA transmission, along with the consequences of ward expansion on nosocomial infection control in the ICU.

METHODS

All patients admitted to the ICU were screened for MRSA carriage within 48 hours of admission, with swab samples obtained from the anterior nares, forehead, groin, and axillae. The patients were screened every other day thereafter for the duration of their ICU stay. Clinical specimens from sputum, urine, blood, pus, and drainage were collected when infection was suspected. Swab samples from surfaces close to the patients and common sites throughout the ICU were collected every 4 days for MRSA detection. Health care workers (HCWs) were also screened for MRSA transient carriage, as described previously.[1] Bacterial strains were isolated from screening swabs and clinical specimens on 5% sheep blood agar plates at 37°C. MRSA was identified by the CHROMagar Staph aureus assay (CHROMagar, Paris, France) and the disk-diffusion method with cefoxitin.

Data on cohorting levels and hand hygiene compliance were obtained through direct observation of staff–patient contact patterns and HCW hand hygiene practices, as described previously.[2] Daily follow-up data for patients and specific variables of treatment were obtained from the ICU audit. Patients who had a swab culture and/or a clinical specimen positive for MRSA within 48 hours after ICU admission were considered MRSA-positive on admission. ICU acquisition was determined for the patient who was negative for MRSA on admission but had at least one sample positive for MRSA 48h after ICU admission.

Data were recorded with EpiData 3.1 (The EpiData Association, Odense, Denmark) and analyzed using SAS version 9.1 (SAS Institute, Cary, NC). The sampling density was calculated by dividing the total number of samples by the number of patient-days. All *P* values were 2-sided, and a *P* value < .05 was considered statistically significant. This observational study was approved by the Institutional Ethic Committee of Chinese PLA General Hospital.

RESULTS

After the ICU relocation on July 15, 2008, the number of medical staff members in the ICU increased from 25 to 40; however, the nurse:patient ratio decreased from 2.0 to 1.2, and the nurse cohorting level decreased from 0.62 to 0.47. In addition, the rate of HCW hand hygiene compliance after patient contact decreased from 31.3% (130 of 415) to 18.2% (37 of 203).

A total of 518 patients had an ICU stay of at least 2 days, 64 of whom (12.4%) had been admitted in the old ward. There were no significant differences in patient age, sex distribution, or length of ICU stay between the 2 wards; however, the patients admitted in the old ward had higher Acute Physiology and Chronic Health Evaluation II (APACHE II) scores ($P < .001$). Antibiotics (third-generation cephalosporins, glycopeptides, and carbapenems) were used more frequently in the old ward.

In the old ward, out of 1,098 samples collected from the anterior nares, forehead, axillae, and groin, 115 (10.5%) were identified as MRSA-positive. In contrast, in the new ward, only 195 of 10,261 samples (1.9%) obtained from the same 4 sites were MRSA-positive (Table 1). A significant decrease in MRSA prevalence was detected in samples collected from 9 environmental sites and all the samples in total after the ward relocation (Table 1).

In the old ward, 9 of 64 patients (14.1%) were MRSA-positive on admission, and 13 of 55 MRSA-negative patients (23.6%) acquired MRSA after a 48-hour ICU stay. In the new ward, 8 of 454 patients (1.8%) were MRSA-positive on admission, and 33 of 446 MRSA-negative patients (7.4%) acquired MRSA in the ICU. Both MRSA prevalence on admission and MRSA acquisition rate in the ICU were significantly lower in the new ward ($P < .001$). Accordingly, the MRSA acquisition rate in the ICU per 1,000 patient-days at risk decreased significantly after relocation, from 40.9 to 8.7 ($P < .001$). However, the number of new cases per imported MRSA case was almost 3-fold higher in the new ward compared with the old ward (4.1 vs 1.4) (Table 2). This indicates increased MRSA transmission in the new ward, despite the overall improvement of the ward environment.

DISCUSSION

In this study, the old ICU ward was crowded and dirty. Conditions were greatly improved in the new ward, including more and larger rooms with new ventilators and monitors, greater distances between patient beds, and increased frequency of environmental disinfection. These obvious improvements resulted in lower MRAS rates in the ward environment, a dramatic decrease in MRSA prevalence, and a significant decrease in ICU MRSA acquisition per 1,000 patient-days at risk. The dramatically decreased MRSA prevalence in the new ward may be related to various factors, including a greater number of less ill surgical patients at decreased risk for acquiring MRSA owing to the increased capacity of the new ward,[3] as well as reduced MRSA colonization pressure related to the decreased MRSA prevalence on admission, along with the improved ward environment.[4] The number of new cases per imported case was much higher in the new ward, however, indicating more efficient transmission of MRSA. What were the reasons for this discrepancy?

To answer this question, we analyzed 2 important indicators of nosocomial infection control, nurse cohorting level and hand hygience compliance. Nurse cohorting level is known to be an important predictor of MRSA transmission in ICUs.[1,2,5] After the ward relocation, the number of nurses per patient decreased, and the nurses' workload increased accordingly. Hand hygiene compliance is considered the most essential measure to prevent MRSA transmission.[6] Unfortunately, HCW hand hygiene compliance after patient contact was significantly lower in the new ward than in the old ward. There may be several reasons for this; for example, the

Table 1
Detection of MRSA in various sampling sites of patients, HCWs, and the environment in the old and new ICUs

Sampling site	Old ICU		New ICU		P value
	Samples, n	MRSA-positive, n (%)	Samples, n	MRSA positive, n (%)	
Patients					
Anterior nares	273	47 (17.2)	2,555	85 (3.3)	<.001
Forehead	275	32 (11.6)	2,568	56 (2.2)	<.001
Axillae	275	16 (5.8)	2,570	22 (0.9)	<.001
Groin	275	20 (7.3)	2,568	32 (1.3)	<.001
Total	1,098	115 (10.5)	10,261	195 (1.9)	<.001
Sampling density	1.96 (1,098/560)		1.82 (10,261/5,636)		.17
HCWs					
Hands	284	23 (8.1)	379	9 (2.4)	<.001
Anterior nares	86	1 (1.2)	139	1 (0.7)	.999
Total	370	24 (6.6)	518	10 (1.9)	<.001
Environment					
Bed sheets	249	13 (5.2)	1,290	23 (1.8)	.001
Over-bed tables	229	9 (3.9)	1,290	11 (0.9)	<.001
Surface of nursing documents	229	9 (3.9)	1,290	10 (0.8)	<.001
Bedrails	275	10 (3.6)	1,290	17 (1.3)	.017
Equipment buttons	274	8 (2.9)	1,290	14 (1.1)	.041
Nurses' desk	229	15 (6.6)	1,290	11 (0.9)	<.001
Dispensing station	163	4 (2.5)	756	4 (0.5)	.037
Water taps	132	2 (1.5)	983	1 (0.1)	.039
Air	273	14 (5.1)	1,332	7 (0.5)	<.001
Total	2,053	83 (4.0)	10,811	98 (0.9)	<.001

Sampling density refers to the number of samples per patient-day.

Table 2
Comparison of MRSA prevalence, acquisition, and transmission in the old and new ICUs

Variable	Old ICU (n = 64)	New ICU (n = 454)	P value
Positive on admission, n (%)	9 (14.1)	8 (1.8)	<.001
ICU acquisition, n (%)	13 (23.6)	33 (7.4)	<.001
Patient-days at risk, n	318	3,782	—
ICU acquisition per 1,000 patient-days at risk	40.9	8.7	<.001
Number of new cases per imported case	1.4	4.1	—

HCWs may have felt less exposed to pathogens in the new ICUs owing to the significant environmental improvements and thus less inclined to protect themselves by disinfecting their hands after patient contact.

Taken together, our findings suggest that the higher MRSA transmission rate in the new ICU may be linked to the low nurse cohorting level and poor hand hygiene compliance, while the relatively high nurse cohorting level and hand hygiene compliance rate in the old ward might have compensated for overcrowding and environmental contamination and ultimately reduced MRSA transmission. In this study, nurse cohorting level and HCW hand hygiene compliance were stronger predictors of MRSA transmission in this ICU compared with the overall environmental improvement and antibiotic use.

References

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