Methicillin-resistant *Staphylococcus aureus* transmission in a low-prevalence healthcare setting

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**Abstract**

**Background:** The aim of this study was to assess the nosocomial transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) and the predictive role of colonization pressure (CP) in a low-prevalence healthcare setting.

**Methods:** A retrospective analysis of MRSA infection rates from 2004 to 2009 at the Saudi Aramco Dhahran Health Center, Saudi Arabia, was performed. MRSA patient-days, susceptible patient-days, nosocomial incidence and CP were calculated for each month from January 2008 to December 2009.

**Results:** During the study period, 878 cases of MRSA colonization/infection were identified. Of these cases, 777 (88.4%) and 101 (11.5%) were community-acquired MRSA (CA-MRSA) and healthcare-associated MRSA (HA-MRSA) cases, respectively. A decrease in the number of HA-MRSA cases and an increase in the number of CA-MRSA cases were observed during the study period. The incidence of nosocomial infection per 1000 susceptible patient-days was 1.17 in 2008 and 0.7 in 2009. The monthly colonization pressure ranged from 0.1 to 1.62 throughout the 2-year period. Nosocomial transmission was observed in 13 months of the 24-month study period. No association between the CP of the preceding month and the incidence of nosocomial transmission in the subsequent month was observed.

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Introduction

Methicillin-resistant Staphylococcus aureus (MRSA) infection has become endemic in many hospitals worldwide. These infections are associated with increased mortality, morbidity and health care costs [1]. Colonized or infected patients are the reservoir of infection, and patient-to-patient transmission is facilitated by health care personnel, fomites and environmental contamination [2,3]. Several preventative protocols, including surveillance measures, hand hygiene, and decolonization using chlorhexidine body washes and nasal mupirocin, have been adopted with varying degrees of success [2,4,5]. Recent studies analyzed colonization pressure (CP) as an independent predictor of nosocomial acquisition of MRSA [6–8]. However, these studies were performed in settings with high prevalence rates of MRSA. Currently, there are no reports on CP as an indicator of nosocomial transmission of MRSA in a low-prevalence setting. In this paper, we present data on the trends in MRSA infection and transmission in a secondary care hospital in Saudi Arabia and on the utility of CP as a predictor of nosocomial transmission of MRSA.

Materials and methods

Setting

This study was performed at the Saudi Aramco Dhahran Health Center, Saudi Arabia. This 405-bed health care facility is comprised of inpatient wards, critical care units and outpatient clinics. It provides primary and secondary care to a catchment population of 360,000. A retrospective analysis of MRSA colonization/infection in inpatients was performed over a six-year period (2004–2009).

MRSA infection control policy

After a patient was admitted, MRSA screening was performed within 48 h. Screening swabs of the anterior nares, wounds and sites that were previously positive for MRSA (in known MRSA-positive patients) were obtained. Isolation and contact precaution measures for suspected MRSA patients ("at risk") were implemented upon admission and remained in place until screening results were available. At-risk patients were defined as those patients who were transferred from other health care facilities, had a history of hospitalization within the past year, and were receiving home or institutional care. A policy of "once MRSA always MRSA" was adopted for patients who were known to be positive for MRSA infection, and appropriate control measures were initiated upon subsequent admissions. Standard infection control protocols were adopted for all MRSA-colonized or -infected patients. MRSA-infected patients were placed in a single, private room or with other MRSA-positive patients. Contact precautions, including the donning of gloves/gowns and hand hygiene using alcohol-based hand rubs/soap and water, were adopted by all staff who were caring for any MRSA-infected patients.

MRSA identification

MRSA culture was performed by utilizing conventional screening culture methods that used Mueller Hinton agar (MHA) with 4% NaCl and oxacillin. Confirmation of the MRSA phenotype was performed using MHA with a cefoxitin disc and using the Vitek2 (WSVT2-ROS.02) automated system (bioMerieux, Marcy l’Etoile, France). Molecular detection of MRSA from nasal swab samples was performed using GeneXpert® (Cepheid, Sunnyvale, CA, USA).

MRSA definition and calculation of colonization pressure

Hospital-acquired MRSA (HA-MRSA) was defined as the detection of MRSA infection in a patient who had been hospitalized for more than 48 h without any indication of MRSA infection or colonization upon admission to the hospital. Patients with MRSA colonization or infection upon admission and a history of hospitalization within the past 30 days were
also considered to have HA-MRSA. All other infected patients were classified as being infected with community-acquired MRSA (CA-MRSA) [9]. MRSA patient-days, susceptible patient-days, nosocomial incidence and CP were calculated for each month from January 2008 to December 2009 as previously described [8]. The calculation of MRSA patient-days included MRSA-positive patients who were previously known and newly identified, nosocomial cases as previously described. The number of susceptible patient-days was calculated as the total number of patient-days minus the number of MRSA patient-days [8]. CP was calculated as the number of MRSA patient-days \times 100/ the total number of patient-days. Nosocomial incidence was calculated as the number of new, nosocomial cases \times 1000/ the number of susceptible patient-days [8]. The presence or absence of MRSA transmission in the month immediately following each month for which CP was calculated was also determined. CP was used to predict the nosocomial acquisition of MRSA infection and colonization. Statistical analysis was performed using Graphpad Prism software (La Jolla, CA, USA).

Results

A total of 878 cases of MRSA colonization/infection were identified. Of these cases, 777 (88.4%) and 101 (11.5%) were CA-MRSA and HA-MRSA cases, respectively. A decrease in the number of HA-MRSA cases and an increase in the number of CA-MRSA cases was observed during the study period (Fig. 1). In 2008, 10 cases of HA-MRSA were identified, and the number of cases reported decreased to six in 2009. The majority of HA-MRSA isolates were detected in patients with bacteremia or with surgical wound infections (Fig. 2).

The total numbers of patient-days were 103,086 and 104,410 in 2008 and 2009, respectively. The number of MRSA patient-days was 954 in 2008 and 906 in 2009. The incidence of nosocomial infection per 1,000 susceptible patient-days was 1.17 in 2008 and 0.7 in 2009. The monthly colonization pressure ranged from 0.1 to 1.62% during the two-year study period. The monthly distribution of nosocomial MRSA acquisition and the colonization pressure are shown in Fig. 3. Nosocomial transmission was observed in 13 months of the 24-month study period. However, no association between the CP in the preceding month and the nosocomial incidence in the subsequent month was observed. In the last six months of 2009, a sustained level of nosocomial transmission was observed despite a steady decline in the monthly colonization pressure. During the two-year study period, there was no outbreak of MRSA infection at the facility.
Globally, MRSA continues to be a major cause of nosocomial infection. In this study, we evaluated the occurrence of HA-MRSA in our institution and found that there was a decrease in the number of observed cases from 2005 to 2009. An increase in the number of CA-MRSA cases during the study period suggests that CA-MRSA is an emerging, significant cause of infection in the healthcare setting. In the literature, the distribution of MRSA infection is significantly variable by geographical location. Even within the same country, variations in the incidence of MRSA infection have been observed between different health care facilities/units. Surveillance data demonstrated a north:south dichotomy of MRSA incidence in Europe; specifically, a larger prevalence of MRSA was observed to occur in southern European countries compared with northern European countries [10]. While a decreasing trend in the number of HA-MRSA infections was reported in 2008, the incidence of MRSA is still >25% in one-third of the European countries. In the United States, up to 46% of the staphylococci isolates from non-intensive care units and over 50% of those from ICUs were determined to be MRSA isolates [11,12]. In Saudi Arabia, a MRSA infection rate of 38% was reported previously in a tertiary care center in Jeddah, and a range of MRSA infection rates from 12 to 49% was demonstrated in several hospitals in Riyadh [13,14]. At our institution, the MRSA control policy includes screening patients within 48 h of admission, providing of single room to infected patients or rooming MRSA-colonized or infected patients together and strictly enforcing contact precautions. In addition, a policy of "once MRSA always MRSA" is implemented for patients who have been infected, which enables staff to immediately institute appropriate preventative measures upon subsequent admissions. The implementation of these policies can explain the decrease in the number of nosocomially transmitted MRSA cases during the study period even when there was an increase in the numbers of patients being admitted with CA-MRSA. While the implementation of these policies can be challenging in some settings, these findings indicate that adherence to this preventative regimen is associated with a reduction in the occurrence of HA-MRSA.

In addition to control measures, indicators of nosocomial MRSA infections have been suggested for use as predictors of possible outbreaks. CP has been proposed as an indicator of nosocomial transmission of antibiotic-resistant bacteria, such as MRSA, vancomycin-resistant enterococci (VRE) and Clostridium difficile infection [7,15,16]. The use of this indicator is predicated on the idea that CP increases both the possibility of contact between health care workers and infected patients and environmental contamination in the health-care setting, thus resulting in a higher transmission potential. It can be hypothesized that when the CP is high, the reservoir of infection is large. Therefore, even minor lapses in infection control protocols are likely to result in nosocomial transmission and the potential for MRSA outbreaks. However, the CP levels for which this hypothesis holds true are unclear. Previous work that assessed CP as a predictor of nosocomial MRSA transmission was carried out in an intensive care unit and a general medical unit [7,8]. In these studies, the prevalence of nosocomial MRSA infection and the CP were much higher compared with the rates that we found in this study. Using multivariate regression analysis, Merrer et al. [7] demonstrated that CP was strongly and independently associated with MRSA acquisition in the ICU. Similarly, Bonten et al. [16] demonstrated that colonization pressure was the main variable that affected the acquisition of VRE. Recently, it was suggested that C. difficile-associated disease pressure (which is a modified form of CP) could be an independent risk factor for C. difficile-associated diseases [15]. However, in settings of sporadic C. difficile infections, CP was not associated with the acquisition of C. difficile in approximately one-third of the patients [17]. In contrast to the previously reported data that were gathered from a high CP setting [8], we did not observe any correlation between the CP levels and nosocomial incidence of MRSA infection. This result suggests that in settings of low MRSA prevalence, CP may not be a reliable predictor of MRSA transmission and nosocomial infection. However, our findings indicate that nosocomial transmission of MRSA does occur in cases of low CP. This is most likely because the transmission of MRSA between patients, particularly transmission via health care personnel and environmental contamination, is likely to occur whenever there are lapses in the implementation of infection control policies. Although the impact of such lapses is likely to be magnified when the CP level is high, thus leading to outbreaks, other factors, such as staffing levels, have been demonstrated to be important [7,18]. Following the institution’s MRSA control policy, MRSA screening was carried out within 48 h after a patient was admitted, the "once MRSA always MRSA" policy was adopted for patients who were known or had been known to be MRSA-positive and all MRSA patients were placed in single rooms or...
were roomed with other MRSA-infected individuals during the study period. While we did not measure the rate of compliance with other infection control procedures, such as hand hygiene and contact precautions, we speculate that compliance was high, as evidenced by the steady decline in MRSA rates that was observed during the study period. However, the observed, ongoing nosocomial MRSA transmission in combination with the declining CP rates in the last few months of 2009 is suggestive of lapses in compliance. We suggest that, in low MRSA prevalence and low CP settings, particular attention should be paid to ensuring strict adherence to infection control policies. Some potential limitations of this study are that it was a single-center study and clonality investigations were not performed. Multi-center studies in settings with a low MRSA prevalence are needed to confirm the role of CP as a predictor of nosocomial MRSA transmission.

In conclusion, we have demonstrated a low MRSA prevalence and a decrease in the rate of nosocomial MRSA transmission in a secondary care facility in Saudi Arabia. Further studies are needed to define the utility of CP as a predictor of nosocomial MRSA transmission and incidence in settings with a low prevalence of MRSA infection.

**Conflict of interest statement**

The authors declare that they have no personal or financial relationships that may constitute a conflict of interest.

**Authors contributions**

HK: Conception and design of the study, data acquisition and data interpretation; AS: Design of the study, data analysis, data interpretation and preparation of the manuscript; AA: Conception and design of the study, data acquisition and data interpretation; VK: Design of the study and data interpretation; All authors contributed to the writing of the manuscript, provided critical revisions of important intellectual content, and read and approved the final manuscript.

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