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Major article

A bundle that includes active surveillance, contact precaution for carriers, and cefazolin-based antimicrobial prophylaxis prevents methicillin-resistant *Staphylococcus aureus* infections in clean orthopedic surgery

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Background: Methicillin-resistant *Staphylococcus aureus* (MRSA) is a frequent cause of orthopedic surgical site infections (SSIs). The aim of this study was to evaluate the effect of a bundle approach in the prevention of orthopedic MRSA SSIs.

Material and Methods: MRSA active surveillance and decolonization were performed preoperatively at our institution from July 2004 until 2007. In January 2008, a bundle approach comprising contact precautions for MRSA-positive patients and cefazolin-based antimicrobial prophylaxis (AMP) stewardship was implemented. Data on the prevalence of MRSA SSIs, antimicrobial use density, duration of AMP, and the use of an alcohol antiseptic agent (L/1,000 patient-days) were evaluated during 2 periods: July 2004-December 2007 (period A) and January 2008-December 2012 (period B).

Results and Discussion: The MRSA SSI rate during period B (0.97%; 19 out of 1,966) was significantly lower than that during period A (2.17%; 29 out of 1,333; $P = .003$). The infection rate correlated negatively with both the cefazolin antimicrobial use density ($r = -0.76$; $P = .0002$) and the use of an alcohol antiseptic agent ($r = -0.68$; $P = .002$).

Conclusions: An infection-prevention bundle consisting of contact precautions for carriers and AMP stewardship in addition to active surveillance was associated with a significant decrease in the incidence of orthopedic MRSA SSIs.

Staphylococcus aureus is among the most common pathogens in orthopedic infections, including bone/joint infections and surgical site infections (SSIs).[1,2] For patients undergoing clean orthopedic surgery, cefazolin (CEZ) is the recommended prophylactic antibiotic.[1] Methicillin-resistant *S aureus* (MRSA) has been increasingly identified as a causative organism in nosocomial infections, including orthopedic SSIs. The incidence of MRSA among orthopedic SSIs has been reported to be 20%-35%.[3,4]

Medical devices are frequently required in orthopedic surgery, including prosthetic joint arthroplasty, internal fixation for bone fracture, and spinal fusion surgery. In patients with chronic infection caused by MRSA, removal of the orthopedic hardware is required, decreasing their ability to carry out daily activities and therefore their quality of life.[5]

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Contact precautions[6] and antimicrobial stewardship[7] are effective in preventing nosocomial MRSA infections. Because nasal MRSA carriage is a risk factor for MRSA SSIs in patients undergoing orthopedic procedures,[8] several bacterial decolonization strategies have been developed. However, MRSA colonization can serve as a reservoir for transmission and lead to nosocomial infections among patients. Therefore, to identify patients requiring decolonization, implement adequate barrier precautions, and successfully control MRSA, active surveillance cultures are important.[9,10] However, there were few reports on the efficacy of such a bundle approach for orthopedic MRSA carriers in orthopedic SSIs. Thus, in this study we followed patients before and after the implementation of a bundle approach consisting of MRSA active surveillance, contact precautions for MRSA-positive patients, and CEZ-based antimicrobial prophylaxis (AMP) stewardship.

METHODS

Prevention strategy for SSI

Kagoshima University Hospital in Japan is a 720-bed tertiary care hospital with a 50-bed orthopedic ward. Since July 2004, preoperative MRSA active surveillance culture from the nasal cavity has been performed in all patients before or at admission to this ward. Those determined to be MRSA-positive are decolonized by the administration of mupirocin thrice daily for 3 days. We do not perform chlorhexidine shower or bath because there have been reports of eardrum perforation and shock symptoms connected with use of chlorhexidine to the vagina, bladder, oral cavity, and nasal cavity and the application of chlorhexidine to mucous membranes is contraindicated in Japan. Contact precautions using gloves and a gown plus single-room isolation or cohorting is performed only for patients with confirmed MRSA infection. Beginning in January 2008, an additional protocol was implemented in which contact precautions were instituted for all patients with MRSA colonization and/or infection.

The prophylactic antimicrobial agents used and the duration of antimicrobial prophylaxis before January 2008 were selected by the surgeons and included 1 g CEZ, 1 g cefotiam (CTM), 2 g piperacillin, and 1 g flomoxef (FMOX). Antimicrobial agents were administered just after the surgical incision was made and additional doses were provided every 12 hours thereafter. The protocol implemented in January 2008 was based on a prophylactic antimicrobial manual for orthopedic surgery prepared by our hospital's infection control team. The manual recommends the use of 1 g CEZ before a surgical incision is made, with additional doses every 3 hours intraoperatively and every 8 hours after surgery. The dose of CEZ was not changed based on patient weight. In patients undergoing clean surgery, AMP is discontinued within 48 hours. For MRSA carriers undergoing implant-related surgery, 1 g vancomycin (VCM) is to be administered 2 hours before a surgical incision is made. However, VCM is used optionally rather than routinely. Clindamycin (600 mg every 8 hours) or VCM is administered to patients allergic to β-lactams. A summary of the choice of prophylactic antimicrobial agents and the duration of antimicrobial prophylaxis was given back to the orthopedic surgeons every 3 months.

Study design

This was a retrospective before–after study that evaluated the influence of contact precautions for carriers and CEZ-based AMP stewardship in the prevention of orthopedic MRSA SSIs. The infection rates before and after implementation of the January 2008 protocol were evaluated. Thus, 2 consecutive periods were compared: July 2004-December 2007 (period A) and January 2008-December 2012 (period B).

Table 1
Characteristics of the patients during study periods A and B*

Characteristic	Period A (n = 1,333)	Period B (n = 1,966)	*P* value
Age, y	50.9 ± 20.9	50.8 ± 22.0	.50
Operation time, min	181 ± 131	185 ± 237	.34
Male sex	662 (49.7)	906 (46.1)	.043
Surgical procedure			
Amputation	11 (0.83)	5 (0.25)	.037
Spinal fusion surgery	123 (9.23)	343 (17.5)	<.001
Open reduction of fracture	66 (4.95)	93 (4.73)	.77
Total hip arthroplasty	88 (6.60)	284 (14.5)	<.001
Total knee arthroplasty	22 (1.65)	45 (2.29)	.2
Laminectomy and laminoplasty	326 (24.5)	305 (15.5)	<.001
Malignant tumor surgery	47 (3.5)	148 (7.5)	<.001
Benign tumor surgery	253 (19.0)	395 (20.1)	.22
Miscellaneous†	397 (29.8)	348 (17.7)	<.001
Antimicrobial prophylaxis			
CEZ‡	684 (51.3)	1781 (90.6)	<.001
FMOX	364 (27.3)	53 (2.7)	<.001
PIPC	211 (15.8)	66 (3.4)	<.001
CTM	41 (3.1)	13 (0.7)	<.001
VCM	12 (0.9)	36 (1.8)	.013
Others	21 (1.6)	17 (0.9)	.033

Note. Values are presented as n (%) or mean ± standard deviation.
CEZ, cefazolin; *CTM*, cefotiam; *FMOX*, flomoxef; *PIPC*, piperacillin; *VCM*, vancomycin.
*Period A covered July 2004 through December 2007, whereas period B covered January 2008 through December 2012.
†Includes malignant and benign musculoskeletal tumor surgery, peripheral neuron surgery, arthroplasty except prosthetic joint surgery, and arthroscopy.
‡The number of surgeries using antimicrobial prophylaxis of CEZ excluded those using VCM in addition to CEZ.

The 3,299 patients (1,333 in period A and 1,966 in period B) retrospectively reviewed in this study underwent orthopedic clean surgical treatment at our department between July 2004 and December 2012. Data on antimicrobial use density (AUD), use of an alcohol-based hand hygiene solution (L/1,000 patient-days) on the orthopedic ward, and the incidence of MRSA-positive patients were collected and then analyzed every 6 months during the 2 periods. The incidence of nosocomial MRSA SSIs was compared and correlations between the incidence of these infections and the other variables were analyzed. Infection was diagnosed based on the criteria proposed by the US Centers for Disease Control and Prevention.[11] A nosocomial infection was diagnosed if MRSA was isolated >72 hours after admission. The incidence was calculated per 100 patients undergoing surgery. Additionally, the association between prolonged (>48 hours) AMP use and nosocomial MRSA SSI was determined. The compliance with hand hygiene of medical staff before and after patient contact was evaluated by direct observation performed every 6 months from 2009 to 2012.

Statistical analysis

Statistical analyses consisted of the χ^2 test, Fisher exact test, or Pearson correlation coefficient performed using IBM SPSS version 22.0 (IBM-SPSS Inc, Armonk, NY) and Epi-info (Centers for Disease Control and Prevention, Atlanta, GA). A *P* value <.05 was considered to indicate statistical significance.

RESULTS

The characteristics of the patients treated during each period are shown in Table 1. The prevalence of device-related surgeries, including spinal fusion surgery, total hip arthroplasty, and malignant tumor surgery, were significantly higher during period B than