Preoperative carriage and postoperative same-species sternal wound infection after cardiac surgery

Jean-Michel Maillet, Gregoire Oghina, Paul Le Besnerais, Stéphane Thierry, Genevieve Bouquet, Patrick Mesnildrey, Nicolas Bonnet, Denis Brodaty

1. Introduction

Sternal wound infection (SWI) after cardiac surgery remains an important problem. Prediction of pathogens involved in such infection could guide antibiotics. From April 1, 2006 to December 31, 2008, retrospectively, we evaluated the diagnostic value of preoperative methicillin-sensible Staphylococcus aureus (MSSA), methicillin-resistant S. aureus (MRSA) or multi-drug resistant Gram-negative bacillus (MDRGNB) carriage to predict same-pathogens involved in postoperative SWI. All patients referred for elective cardiac surgery were screened using multisite (nares, axillae, rectal) sampling at admission to detect MSSA, MRSA, and MDRGNB. Of the 1895 patients addressed, 425 patients (22.4%) were colonized at admission. Preoperative carriers more frequently developed SWI than non-carriers, respectively, 11% vs. 5.5% (P<0.05). Because of the small sample, MDRGNB carriers could not be analyzed. For prediction of MSSA SWI with preoperative MSSA carriage, the area under the receiver operating characteristic (ROC) curve was 0.720 (95% confidence interval (CI), 0.364–0.796) and 0.710 (95% CI, 0.623–0.787) for prediction of MRSA SWI with preoperative MRSA carriage. Preoperative MSSA carriage is frequent but preoperative MRSA or MDRGNB carriage remains infrequent. The ability of preoperative carriage to predict a same-pathogen–postoperative SWI was low and should not be used to guide empirical antibiotic therapy.

Keywords: Sternal wound infection; Preoperative carriage; Methicillin-sensible Staphylococcus aureus; Methicillin resistant Staphylococcus aureus; Multi-drug Gram-negative bacillus; Cardiac surgery

2. Patients and methods

All patients admitted for elective cardiac surgery, between 1 April 2006 and 31 December 2008, were included...
in this retrospective study. Admission screening for MSSA, MRSA and MDRGNB was systematically done for all admitted patients by sampling anterior nares, axillae, perineal regions. Other samples from other sites were taken when clinically indicated (e.g., skin lesions or urine). Specimens were cultured for 48 h at 37 °C on sheep blood agar plate with a cefoxitin disk, Chapman agar (for MSSA and MRSA) and Drigalski agar with a ceftazidine disk (for MDRGNB selection). MDRGNB were defined as resistance to one or more of the extended-spectrum cephalosporins, one of two aminoglycosides (tobramycin, amikacin) and/or ciprofloxacin. *Stenotrophomas maltophilia* was specifically considered a MDRGNB.

All patients with healing problems or suspected wound infection are systematically re-addressed to their surgeon postoperatively.

SWI were classified as SSSI or DSWI according Center for Disease Control definitions [4]. All SWI were screened and classified independently and prospectively by our local Nosocomial Infection Control Committee.

Our local antimicrobial prophylaxis policy recommends Cefamandole (second-generation cephalosporin) 1.5 g intravenously during the hour preceding the surgical incision and repeated injection (750 mg) every 2 h intraoperatively. Vancomycine (15 mg/kg) is recommended when allergy to β-lactamase is known and when MRSA carriage is preoperatively documented. Our local protocol does not recommend modifying the antibiotic regimen for preoperative MDRGNB carriage. Moreover, standard infection-control measures are used for MRSA and MDRGNB carriage in all wards and consist of contact isolation in single rooms and use of dedicated material (gown, gloves). Lastly, no other prophylactic approaches are used in our center, such as mupirocine.

Screening at admission is standard care in our institution for all patients admitted for cardiac surgery. Informed consent was obtained for all patients. Unless stated otherwise, results are expressed as means ± standard deviation (S.D.). Groups were compared with an unpaired Student’s t-test or a Mann-Whitney-test for continuous variables and a χ²-test for categorial variables when appropriate. All tests of significance were two-tailed, with a P≤0.05 being considered significant.

Considering the pathogens involved in postoperative SWI, admission-screening performance was investigated by comparing preoperative carriage and the pathogen responsible for postoperative SWI. Sensitivity (probability for a test to be positive when the pathogen of interest is present), specificity (probability of a test to be negative when the pathogen of interest is absent), positive-predictive value, negative-predictive value, and positive- and negative-likelihood ratios (LR) were determined. The positive LR is calculated as the sensitivity divided by (1–specificity). Negative LR is calculated as (1–sensitivity) divided by the specificity. LR > 1 indicates that the test result is associated with the presence of the disease, whereas an LR < 1 indicates that the result is associated with the absence of the disease [9]. The further LR are from 1, the stronger the evidence for the presence or the absence of the disease. LR = 10 and < 0.1 are considered to provide strong evidence, respectively, to rule in or out diagnoses in most circumstances [5]. The LR also enables the calculation of the post-test probability of disease based on the pretest probability of disease [5]. During the last five years in our institution, respective pretest probabilities of MSSA or MRSA SWI were 2.25% and 0.38%. The receiver operating characteristic (ROC) curves were generated for each pathogen preoperatively identified. Finally, all factors with P≤0.05 in our univariate analyses were entered into a multivariate logistic-regression model to identify independent risk factors associated with SWI. Odds ratios (OR) and their 95% confidence intervals (CI) were calculated. Statistical analyses were performed with Staview® 5.0 (SAS Institute Inc, Cary, NC, USA), and Medcalc® 11.4.4 (Medcalc software bvba, Belgium).

3. Results

A total of 1895 patients were referred for elective cardiac surgery between April 2006 and December 2008: 1319 males (69.6%) and 577 females (30.4%), with a mean age of 66.3±12.1 years and a mean EuroSCORE of 5.2±4.5 points [6]. A coronary artery bypass graft and/or valve replacement was performed among 1037 patients (54.7%), an isolated valve replacement for 720 patients (38%) and miscellaneous for 138 patients (7.3%). On admission, 425 patients (22.4%) had a positive preoperative carriage: 389 (20.5%) for MSSA, 26 (1.4%) for MRSA and 10 (0.5%) for MDRGNB (Fig. 1). Colonization sites differed significantly among pathogens (Table 1), with nasal carriage of MSSA (93%), as opposed to rectal colonization for MDRGNB (90%).

One hundred and twenty-eight patients (6.8%) developed a SWI [24 DSWI (1.3%) and 104 SSWI (5.5%)], respectively, in mean 14±10 and 24±19 days postoperatively. Pathogens are detailed in Table 2. Notably, preoperative carriers more frequently developed SWI than non-carriers, respectively, 11% (47 patients) vs. 5.5% (81 patients) (P<0.05). Forty-seven (36.7%) of the 128 patients who developed a postoperative SWI were colonized preoperatively: 43 with MSSA and four with MRSA (Fig. 1). Twenty-seven MSSA carriers developed a same-species MSSA SWI. Three MRSA carriers developed a same-species MRSA SWI. For the 17 remaining MSSA (16 patients) or MRSA (one patient) carriers, eight SWI were caused by antibiotic-susceptible Gram negative bacilli, four to MDRGNB and five to Gram-positive cocci. None of the 10 preoperative MDRGNB carriers developed a SWI. For the 20 remaining SWI among the 50 involving MSSA or MRSA, no preoperative carriage was detected at admission. Seven SWI involved MDRGNB without preoperative detection at admission. Lastly, among the seven MRSA SWI, four had not been detected as MRSA carriers at admission.

The rate of SWI was influenced by the presence or the absence of pathogens identified preoperatively: 11.5% MRSA SWI for MRSA carriage vs. 0.2% MRSA SWI for MRSA-free patients (P<0.05); 6.9% of MSSA SWI for MSSA carriage vs. 1.1% MSSA SWI MSSA-free (P<0.05) and 0% of MDRGNB SWI for MDRGNB carriage vs. 0.5% for free MDRGNB patients (ns). The operating characteristics for preoperative carriage to predict a subsequent same-species SWI are shown in Table 3. Based on respective pretest SWI probabilities of 2.25%
Table 2. Distribution of the 151 pathogens involved in the 128 sternal wound infections

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>n</th>
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<tbody>
<tr>
<td>Gram-positive cocci</td>
<td>84</td>
</tr>
<tr>
<td>MSSA</td>
<td>43</td>
</tr>
<tr>
<td>MRSA</td>
<td>7</td>
</tr>
<tr>
<td>MSNCS</td>
<td>8</td>
</tr>
<tr>
<td>MRNCS</td>
<td>13</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>13</td>
</tr>
<tr>
<td>Gram-negative bacilli</td>
<td>60</td>
</tr>
<tr>
<td>Sensitive</td>
<td>52</td>
</tr>
<tr>
<td>Resistant</td>
<td>8</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
</tr>
</tbody>
</table>

Values are numbers. MRCNS, methicillin-resistant coagulase negative Staphylococcus; MRSA, methicillin-resistant Staphylococcus aureus; MSCNS, methicillin-sensitive coagulase negative Staphylococcus; MSSA, methicillin-sensitive Staphylococcus aureus.

Fig. 1. Distribution of pathogens involved in the 128 sternal wound infections and preoperative carriage. MDRGNB, multidrug-resistant Gram negative bacilli; MRSA, methicillin-resistant Staphylococcus aureus; MSSA, methicillin-sensitive Staphylococcus aureus; SWI, sternal wound infections.

4. Discussion

The result of this study indicated that preoperative carriage at admission seems to be too fair to predict a same pathogen involved in subsequent SWI after an elective cardiac surgery.

Previous studies have showed that preoperative MSSA carriage ranged from 20 to 55%, as seen in current study [7]. In contrast, MRSA colonization was low (<2%), <5.1% reported by Harbarth et al. [8]. MDRGNB carriage, at <1%, seems to be a marginal problem. In current study, we performed multisite sampling that permits to increase the diagnostic value of carriage [9].
Table 3. Ability of preoperative carriage to predict same-pathogen postoperative sternal wound infection

<table>
<thead>
<tr>
<th>Carriage</th>
<th>Sensitivity, % (95% CI)</th>
<th>Specificity, % (95% CI)</th>
<th>PPV, % (95% CI)</th>
<th>NPV, % (95% CI)</th>
<th>PLR (95% CI)</th>
<th>NLR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSSA carriers</td>
<td>63 (47–77)</td>
<td>81 (71–88)</td>
<td>63 (47–77)</td>
<td>81 (71–89)</td>
<td>3.3 (2.0–5.5)</td>
<td>0.5 (0.3–0.7)</td>
</tr>
<tr>
<td>MRSA carriers</td>
<td>43 (12–80)</td>
<td>99 (95–99)</td>
<td>75 (22–99)</td>
<td>97 (91–99)</td>
<td>52 (6–437)</td>
<td>0.6 (0.3–1.1)</td>
</tr>
</tbody>
</table>

CI, confidence interval; MRSA, methicillin resistant Staphylococcus aureus; MSSA, methicillin sensitive Staphylococcus aureus; NLR, negative likelihood-ratio; NPV, negative predictive-value; PLR, positive likelihood-ratio; PPV, positive-predictive value.

The ability of preoperative carriage to predict the pathogen involved in postoperative SWI was low for MSSA and MRSA, even if the positive LR for MRSA was superior to that of MSSA. However, among the seven MRSA SWI, four patients had been MRSA-free preoperatively. Habarth et al. found that 57% of MRSA-infected patients were MRSA-free at admission [8]. No conclusion could be drawn concerning MDRGNB carriage because of small sample size.

Many factors could explain this poor predictive value, in particular, of MSSA carriage. First, the patient’s current ecology is much more variable than in others studies, with only 33.6% of SWI caused by MSSA. Second, SWI was diagnosed, in mean, three weeks after surgery. Indeed, during this period, the patient’s ecology could have been modified by the antimicrobial prophylaxis or a stay in an intensive care unit (ICU). Third, intermittent S. aureus carriage is very common [10]; Konvalinka et al. in a randomized trial testing the impact on SWI of preoperative mupirocin treatment of S. aureus carriers, showed that the bacterium was eliminated in 46.5% of the patients given a placebo [11]. Fourth, despite the multiplication of preoperative samples, we may have missed some patients with MSSA, MRSA or MDRGNB carriage [12]. Lastly, an exogenous source of contamination might have been higher in this study even though very few SWI were caused by specific nosocomial pathogens.

The colonization site changed with pathogens: MSSA was predominantly detected in the nose as opposed to MDRGNB in the perineum or MRSA. Colonization site may indeed explain why MDRGNB carriers did not developed same-pathogen postoperative SWI because of physical distance between carriage and surgical site. All these elements highlight the complexity of the physiopathology of SWI after cardiac surgery and the difficulties to contain the rate of SWI.

Experts and policy makers have repeatedly called for universal screening at admission specifically to detect MRSA carriage with the ultimate objective reining in the MRSA infection rate or its dissemination. In current study, among the seven MRSA SWI, four had been MRSA-free preoperatively. Habarth et al. also found that 57% of MRSA-infected patients were MRSA-free at admission and failed to show that a universal, rapid, MRSA-screening strategy achieved lower nosocomial MRSA-infection rates in a surgical department with endemic MRSA prevalence but relatively low MRSA-infection rates [8]. This issue remains highly controversial [9]. MDRGNB carriage seems to be a marginal problem for the moment and should not influence or modify the type of antimicrobial prophylaxis.
This study has several limitations. First, it is retrospective and we might have missed some SWI, even though all the patients with abnormal healing processes are systematically re addressed to our surgeons. Second, the MDRGNB sample was very small and we tried not to over interpret our findings concerning them. Third, no DNA fingerprinting or other specific methods were used to confirm that the preoperative carriage strains involved and those responsible for SWI were identical. We carefully used the term same pathogen. However, studies using fingerprint methods or pulse field-gel electrophoresis showed that the same MSSA was involved >80% of the postoperative infections [13, 14]. Fourth, microbiological screening at admission did not attempt to identify all possible pathogens present at the different sites sampled and was limited to MSSA, MRSA and MDRGNB.

Before elective cardiac surgery, >20% of the patients are MSSA, MRSA or MDRGNB carriers based on multisite sampling. Diagnostic value of carriage, whatever pathogens, at admission was too low to predict a same-species SWI and should not be used to guide empirical antibiotic.

References