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Major article

Risk factors for surgical site infections after neurosurgery: A focus on the postoperative period

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Background: Surgical site infection (SSI) after neurosurgery has potentially devastating consequences.
Methods: A prospective cohort study was conducted over a period of 24 months in a university center. All adult patients undergoing neurosurgical procedures, with exception of open skull fractures, were included. Multivariate logistic regression analysis was used to identify independent risk factors.
Results: We included 949 patients. Among them, 43 were diagnosed with SSI (4.5%). A significant reduction in postneurosurgical SSI from 5.8% in 2009 to 3.0% in 2010 ($P = .04$) was observed. During that period, an active surveillance with regular feedback was established. The most common microorganisms isolated from SSI were *Staphylococcus aureus* (23%), *Enterobacteriaceae* (21%), and *Propionibacterium acnes* (12%). We identified the following independent risk factors for SSI postcranial surgery: intensive care unit (ICU) length of stay $\geq$7 days (odds ratio [OR] = 6.1; 95% confidence interval [CI], 1.7-21.7), duration of drainage $\geq$3 days (OR = 3.3; 95% CI, 1.1-11), and cerebrospinal fluid leakage (OR = 5.6; 95% CI, 1.1-30). For SSIs postspinal surgery, we identified the following: ICU length of stay $\geq$7 days (OR = 7.2; 95% CI, 1.6-32.1), coinfection (OR = 9.9; 95% CI, 2.2-43.4), and duration of drainage $\geq$3 days (OR = 5.7; 95% CI, 1.5-22).
Conclusion: Active surveillance with regular feedback proved effective in reducing SSI rates. The postoperative period is associated with overlooked risk factors for neurosurgical SSI. Infection control measures targeting this period are therefore promising.

Surgical site infections (SSIs) are the most common and serious complications among surgically treated patients, resulting in increased rates of morbidity and mortality, length of stay in hospital, and costs.[1,2] SSIs are now recognized as the most common and most costly health care–associated (HA) infections in the United States.[3] Reported rates of SSI are relatively variable, ranging from 1%-8% in published series after cranial surgery and from 0.5%-18.8% after spine surgery.[4,5] Such wide-ranging results from different reports may be caused by significant variations in operative factors, such as the use of implants or drains, the surgical approach itself, and population heterogeneity.[5] Because of the potentially devastating consequences of infectious complications, studying their specific risk factors remains of major importance for determining accurate preventive strategies, especially because up to 60% of SSIs are estimated to be preventable when using evidence-based guidelines.[6]

Although advances have been made in infection control pre- and perioperative practices, including improved operating room ventilation, sterilization methods, barriers, surgical technique, and availability of antimicrobial prophylaxis, SSIs remain a substantial concern in neurosurgery.[7] Several studies have documented the efficacy of preoperative showers at reducing skin microbial counts, but the evidence of their effect on infection rates is less compelling.[8] Additionally, Young et al showed that errors in individual antibiotic prophylaxis measures were not significantly

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associated with SSI.[9] On the other side, risk factors for SSI in the postoperative period have been scarcely studied.

In this study, we analyze the rates, types, and main risk factors for SSIs after neurosurgical procedures with a focus on the postoperative period.

MATERIALS AND METHODS

We conducted a prospective cohort study of SSI among adult neurosurgical patients at the 694-bed, University Nord Hospital in Marseille (France). All patients undergoing neurosurgical procedure (brain or spine surgery) from January 1, 2009-December 31, 2010, were eligible for inclusion. We excluded patients already diagnosed with an SSI, patients with open skull fracture, and those for whom the follow-up was incomplete. A neurosurgeon and a member of the infection control team systematically reviewed the medical records of each surgical patient. Postsurgical follow-up was performed for all included patients after at least 30 days (or 1 year if an implant was left in place after the procedure). All patients underwent the same skin preparation protocol before surgery. No modifications in infection control measures were observed during the study period. The use of prophylactic antibiotics was performed according to the French Society of Anaesthesia and Intensive Care (Societé Française d'Anesthésie Réanimation) guidelines.[10]

The definitions for SSI used by the Centers for Disease Control and Prevention were used in this study.[11] SSIs were separated into 2 groups (superficial SSIs limited to the suppuration of wounds, disunion of scars, and abscess of the scalp or wall and deep SSIs, such as organ or space SSIs, such as meningitis, ventriculitis, osteomyelitis, or abscess) depending on the site and extent of infection. The Altemeier score used by the American College of Surgeons wound classification schema was divided into 4 classes: clean, clean-contaminated, contaminated, and dirty.[12] The National Nosocomial Infections Surveillance (NNIS) score (composed of the American Society of Anesthesiologists score, Altemeier score, and surgery duration) was applied for all surgeries, on a scale of 0-3 points. Permanent prosthetic implants included cranioplasty kit, synthetic dura, and spinal anterior or posterior osteosynthesis. Transient material included ventriculoperitoneal or external ventricular shunts and subcutaneous drains. Cerebrospinal fluid leakage was recorded on the basis of otorrhea, rhinorrhea, or leakage from the surgical wound.

The following data were recorded age, comorbid conditions, length of preoperative stay, reason for the surgery, type of operative procedure, previous surgery at the same site, SSI classification, causative microorganisms, permanent prosthetic implant or transient material used, emergency or scheduled surgery, NNIS score, length of drainage, cerebrospinal fluid leakage, postoperative length of stay in the intensive care unit (ICU), coinfections (postoperative infections documented at another site) and coinfection causative microorganisms.

PASW Statistics 17.0 (SPSS, Inc., Hong-Kong, China) was used for the statistical analysis. Mean ± SD or median with minimum and maximum was used to describe continuous variables. Percentage and number of events were used for quantitative variables. Student *t* test or Mann-Whitney *U* test was used to perform 2-group comparisons for quantitative variables. The χ^2 test was used to perform 2-group comparisons for qualitative variables, or the Fisher exact test was used when the expected count was <5. A multivariate analysis using logistic regression was performed to identify independent risk factors for SSI. Variables clinically relevant and associated ($P < .10$) with SSI in univariate analysis were used in the model. A significance threshold of .05 was adopted for all statistical analyses.

RESULTS

A total of 949 neurosurgical patients were prospectively included during a 24-month period. Their age ranged from 18-90 years (mean ± SD, 55.9 ± 18 years); 533 (56.5%) of them were men. The procedures were divided into cranial surgery (n = 526; 55.4%) and spinal surgery (n = 423; 44.6%). The general combined SSI rate was 4.5% (43 SSIs), corresponding primarily to deep or organ-space SSI (n = 37; 86%). It was divided into 25 SSIs (4.7%) for cranial surgery and 18 SSIs (4.2%) for spinal surgery. The general rate decreased from 5.8% in 2009 to 3.0% in 2010 ($P = .04$). During the study period, quarterly feedback of SSI incidence was shared with the surgical team.

The predominantly isolated organisms in patients with SSI were *Staphylococcus aureus* (23%), *Enterobacteriaceae* (21%), and *Propionibacterium acnes* (12%) (Table 1). After brain surgery, *S aureus* (24%) were most frequently isolated, whereas *Enterobacteriaceae* (33%) was most frequently isolated after spinal surgery. Coinfections during the postoperative period corresponded to HA bloodstream infections (n = 6; 14%), HA urinary tract infections (UTIs) (n = 5; 11.6%), and HA pneumonia (n = 2; 4.6%). In 6 cases of SSI (14%), the same microorganism was isolated from coinfection sites (2 UTIs caused by *Klebsiella pneumonia*, 1 UTI caused by *Escherichia coli*, 2 catheter-related infections caused by *S aureus*, 1 ventilator-associated pneumonia caused by *Pseudomonas aeruginosa*).

Risk factors independently associated with SSI after cranial surgery were a NNIS score ≥2 (odds ratio [OR] = 9.6; 95% confidence interval [CI], 3.7-23.9), previous surgery at the same site (OR = 6.8; 95% CI, 1.6-29.4), postoperative ICU length of stay ≥7 days (OR = 6.1; 95% CI, 1.7-21.7), duration of drainage ≥3 days (OR = 3.3; 95% CI, 1.1-11), and cerebrospinal fluid leakage (OR = 5.6; 95% CI, 1.1-30) (Table 2). Risk factors independently associated with SSI after spinal surgery were a NNIS score ≥2 (OR = 8.5; 95% CI, 2.2-32.5), postoperative ICU length of stay ≥7 days (OR = 7.2; 95% CI, 1.6-32.1), postoperative coinfection (OR = 9.9; 95% CI, 2.2-43.4), and duration of drainage ≥3 days (OR = 5.7; 95% CI, 1.5-22) (Table 3).

DISCUSSION

In this study we observed a significant decrease of the SSI incidence rate during a 2-year surveillance period. Implementation of an active surveillance with quarterly feedback to the surgical staff may have contributed to it.[13] As noted by Heipel et al, active surveillance by an infection control practitioner together with neurosurgeons may enhance significantly the sensitivity for detecting SSI.[14] Moreover, in a French national-based surveillance program, the SSI rate decrease was associated with survey implementation and regular feedback.[15] The percentage decrease, however, was lower after the first 3 years, probably because of difficulties in maintaining the resources needed to constantly monitor all surgical patients.[15] In addition, it has recently been shown that each episode of wound infection after a spine procedure contributed to a mean increase in the cost of care by $4,067 compared with a noncomplicated case.[16] These findings highlight the need for permanent significant infection control resources to limit the global burden of SSI.

Our multivariate analysis led us to identify independent risk factors for neurosurgical SSI during the postoperative period, especially an ICU length of stay ≥7 days. Previous studies have already identified the ICU length of stay as an independent risk factor for neurosurgical SSI in general.[17,18] This could be in part explained by the fact that ICU patients are more vulnerable to skin colonization and HA infections and that manipulation of different devices represents a risk for cross-transmission in the