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Original article

Is hospital information system relevant to detect surgical site infection? Findings from a prospective surveillance study in posterior instrumented spinal surgery

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ABSTRACT

Object: Spinal instrumentation has a high rate of surgical site infection (SSI), but results greatly vary depending on surveillance methodology, surgical procedures, or quality of follow-up. Our aim was to study true incidence of SSI in spinal surgery by significant data collection, and to compare it with the results obtained through the hospital information system.
Methods: This work is a single center prospective cohort study that included all patients consecutively operated on for spinal instrumentation by posterior approach over a six-month period regardless the etiology. For all patients, a "high definition" prospective method of surveillance was performed by the infection control (IC) department during at least 12 months after surgery. Results were then compared with findings from automatic surveillance though the hospital information system (HIS).
Results: One hundred and fifty-four patients were included. We found no hardly difference between "high definition" and automatic surveillance through the HIS, even if HIS tended to under-estimate the infection rate: rate of surgical site infection was 2.60% and gross SSI incidence rate via the hospital information system was 1.95%. Smoking and alcohol consumption were significantly related to a SSI.
Conclusion: Our SSI rates to reflect the true incidence of infectious complications in posterior instrumented adult spinal surgery in our hospital and these results were consistent with the lower levels of published infection rate. In-house surveillance by surgeons only is insufficiently sensitive. Further studies with more patients and a longer inclusion time are needed to conclude if SSI case detection through the HIS could be a relevant and effective alternative method.

1. Introduction

Surgical site infection (SSI) is the third most commonly reported health care associated infection in France [1]. The occurrence of SSI increases hospitalization costs and length of stay, and impairs patients' quality of life [2–4]. Hence, reducing the rate of SSIs is an important medico-economic issue. Among means of prevention, aside from identification and control of known risk factors, ongoing surveillance has proven to be an independent factor for long term reduction of SSI rates [5,6]. In France, as in most European countries, SSI surveillance is a mandatory component of the performance indicator for infection control activities. To reduce time and human resource consumption, surveillance often uses semi-automated, laboratory-based algorithms. Now, in spite of efforts to standardize data collection methods and analyses, SSI rates vary greatly depending on definitions used and quality of post-discharge follow-up, leading to discrepancies between results from national surveillance programs and high-quality studies [7]. Moreover, surgical procedures targeted for surveillance do not always reflect the everyday case mix of unselected patients. These limitations apply to spinal surgery, for which only laminectomies and discal hernias are covered by the French SSI surveillance program and published prospective studies yield contrasting results. Thus, SSI incidence rates in spinal surgery vary from 1 to 9% in programmed surgery, reaching 12% in traumatic spine surgery [8–10].

In our hospital, after several years of a surveillance program tailored to comply with national guidelines at a minimum cost

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and yielding very low SSI rates, we sought to obtain more clinically significant data concerning the true incidence of infections in high risk, clean surgery. We conducted a prospective surveillance study of instrumented posterior spinal surgery in unselected adults, and compared our results with those obtained through the hospital information system.

2. Materials and methods

2.1. Setting

Between 800 and 900 spine surgeries were performed by years in our Montpellier spine department. The infection control (IC) department includes 1.6 full-time-equivalent doctors and 7 qualified nurses, in charge, among other missions, of the hospital-wide SSI surveillance program.

2.2. Database collection

Surveyed surgical procedures are identified by their code in the national social security nomenclature (*Classification Commune des Actes Médicaux*). All procedures appearing under one of the defined codes are searched through the *Programme de Médicalisation des Systèmes d'Information* (PMSI), a comprehensive database of all hospital visits used to define remuneration for the procedure by local health authorities. A rolling search from January 1st is automatically updated twice monthly, feeding a database including patient information such as identification, sex and birthdate, American Society of Anesthesiology (ASA) morbidity score, wound class, duration of operation, multiple procedures, anti-infective prophylaxis. All cases are thus classified according to the National Nosocomial Infection System (NNIS) risk index, a non-specific surgical scoring system developed by the Center for Disease Control, which ranges from 0 (low risk clean surgery) to 3 points (high risk or septic surgery) [11] and is defined by three independent and equally weighted variables where one point is scored for each of the following when present: ASA physical status classification > 2, either contaminated or dirty/infected wound classification, and length of operation > T hours (where T is approximate 75th percentile of duration of the specific operation being performed). Any subsequent operative procedure or readmission of the patient appears in the rolling update.

2.3. "High definition" surveillance

This automatic database is completed by a manual chart review performed by an IC professional (infectious disease specialist). Items reviewed include microbiology reports (regardless of type and results), operative and anesthesiology reports, discharge letter, post-discharge consultation letter. For all procedures, chart reviews are regularly performed until 12 months postoperative. In all cases, the date of latest news is defined as the time when reliable medical information last appears in the patient's file. When no follow-up information is available in the patient's file, the case is classified as suspected SSI and discussed with the surgical team. Cases with one (or more) post-discharge clinical report explicitly stating the absence of complication and no relevant microbiology are classified as uninfected until further notice. Cases are closed after a last chart review 12 months after operation. The SSI surveillance program seeks to cover a full calendar year, so as to limit potential biases due to seasonal variations.

2.4. SSI case automatic detection through the hospital information system (HIS)

Using the same patient database, files were automatically scanned for any of the following diagnostic codes: infectious spondylitis, postoperative infection, nosocomial infection. By definition, only hospital stays generate diagnostic codes, hence information from outpatient consultations does not enter the HIS. Results were then compared with those obtained by "high definition" surveillance method.

Table 1
Surveillance data and risk factors collected from patient files.

Patient characteristics	Surgical procedure	Postoperative care
Age	Duration	Drains
Gender	Number of instrumented levels	Urinary catheter
BMI	Bleeding	Intensive care unit
ASA score	Mini-invasive surgery	
Diabetes mellitus	Emergency	
Smoking[a]	Re-intervention	
Alcohol consumption[b]		
PAI/AC treatment		
Neurological impairment		
Etiology (traumatic, degenerative, tumoral)		

BMI: body mass index; ASA: American Society of Anesthesiology; PAI/AC: platelet aggregation inhibitor/anticoagulant.
[a] > 1 cigarette/day.
[b] > 3 glasses/day.

2.5. Additional data collection

For the purpose of this study, additional information concerning possible risk factors for SSI was retrospectively retrieved from the patients' files. All these data are summarized in Table 1.

2.6. Case definition and diagnosis

SSIs are suspected on the grounds of clinical description (in medical or nursing observations), microbiological results and anti-infective treatments. All suspected cases are discussed by a multidisciplinary panel including surgeons, IC nurses and an IC/infectious disease specialist. SSIs are defined according to national guidelines, derived from the 1992 CDC definitions, and detailed in Box 1. In spinal surgery, the distinction between "deep incisional" and "organ/space" infection being irrelevant, only two categories ("superficial" and "deep") are considered.

2.7. Statistical analysis

Risk factors for SSI were tested using univariate analysis. Imputation of missing data was not performed, due to a very low proportion (< 5%). Because of small numbers and non-normal distribution of variables, non-parametric tests were used: Fisher's exact test was used for categorical variables and Wilcoxon's test for continuous ones. Significance threshold was set for $P < 0.05$. The small number of occurring events precluded a multivariate analysis. Statistical analysis was done using the R software (v.10.13/R Development Core Team).

3. Results

Prospective surveillance of instrumented spinal surgery was implemented from January 1st to July 7th 2012, at which date the hospital information system changed and the automatic extraction of operative procedures became unreliable. During that period, 154 patients underwent 154 *princeps* procedures: 5 cervical (3%), 14 thoracic (9%), 35 thoracolumbar (23%), and 100 lumbar or lumbosacral (65%) posterior instrumentation. Sixteen patients required early revision surgery (15 within 30 days of the *princeps* procedure

Box 1: Definitions used for surgical site infection (SSI) surveillance.

Superficial infection:

- infection occurring within 30 postoperative days, involving skin (or mucosa), and/or soft tissues situated above the fascias or aponeuroses;
- AND at least one of the following:
  - purulent wound drainage,
  - aseptically obtained sample showing microorganisms and white blood cells on direct examination/Gram stain and positive culture,
  - surgeon's decision to re-operate;
- AND presence of one of the following: pain/tenderness, local edema, redness;
- AND positive microbiological culture or culture not performed (a negative culture, in the absence of antibiotic treatment, excludes SSI diagnosis).

NB: minimal inflammation of suture points is not considered as wound infection.

Deep infection:

- infection occurring within 30 postoperative days, or within 12 months for prosthetic implants;
- involving tissues, organs or spaces situated above or below the fascia, or having been open/manipulated during operation;
- AND at least one of the following:
  - purulent drainage through a deeply inserted drain,
  - spontaneous or surgical wound opening and one or more of the following: fever > 38 °C, local pain or tenderness;
- AND positive microbiological culture of an aseptically obtained sample of deep surgical site or organ/space, or cultures not performed (a negative culture, in the absence of antibiotic treatment, excludes SSI diagnosis);
- OR abscess or any other sign of infection noted on surgical re-intervention, pathology, conventional or interventional imagery.

NB: the need for surgical re-intervention must be documented.

and one on day 39), due to screw repositioning, postoperative hematoma, or suspicion of SSI.

Cutaneous preparation was performed with alcoholic povidone-iodine, and antibioprophylaxis with intravenous 1.5 g of cefamandole (third generation cephalosporin) was administered before incision and every four hours during surgery [as recommended by French Anesthesiologist Society (SFAR), and available at http://www.sfar.org/_docs/articles/Antibioprophylaxieversion2010.doc.pdf]. No systematic antibioprophylaxis was administered during postoperative period.

Patients were mostly men (54%), of mean age 50 years. The underlying condition was of degenerative etiology in 60% of cases. Patients' characteristics are summarized in Table 2, also showing results of the univariate analysis of risk factors. Their distribution regarding their preoperative ASA score is shown on Fig. 1, also showing the distribution of surgical procedures according to their NNIS score.

Seven patients were lost to follow-up after less than 10 days: one patient's file was accidentally destroyed, the six others did not return to our hospital after discharge, and had no family doctor to call for news. After excluding these 7 patients, mean and median duration of clinical neurosurgical postoperative follow-up were 316 and 236 days, respectively (extremes: 41 to 776 days).

Table 2
Patients characteristics ($n = 154$) and distribution according to the risk factors.

Characteristics			*P* value
Age: average, median, [extremes]	50, 52 [11–81]		$P = 1$
Gender nb, (%)			$P = 0.12$
Males	83 (54%)		
Females	71 (46%)		
BMI: average, median, [extremes]	26.7, 26 [17–42]		$P = 1$
According to the BMI			
BMI > 30	25 (16%)		
BMI < 30	129 (84%)		
Etiology of affection: nb, (%)			$P = 0.28$
Traumatic	55 (36%)		
Degenerative	92 (59%)		
Tumoral	7 (5%)		
Risk factors	**Yes: nb (%)**	**No: nb, (%)**	***P* value**
Diabetes	11 (7%)	143 (93%)	$P = 1$
Smoking	58 (38%)	66 (62%)	$P = 0.04$
Alcohol consumption	18 (11%)	136 (89%)	$P = 0.002$
PAI/AC treatment	8 (5%)	148 (95%)	$P = 1$
Duration: ≥ 180 min	18 (11%)	136 (89%)	$P = 0.9$
Number of instrumented levels > 3	45 (29%)	109 (71%)	$P = 0.07$
Re-intervention: nb, (%)	16 (11%)	138 (89%)	$P = 0.3$
Bleeding > 500 mL	16 (11%)	138 (89%)	$P = 0.3$
Neurological impairment	20 (13%)	134 (87%)	$P = 0.08$

BMI: body mass index; PAI/AC: platelet aggregation inhibitor/anticoagulant; nb: number; (%): percentage of population; mL: milliliter.

Four patients developed a surgical site infection: 2 deep SSIs and 2 superficial, amounting to a gross incidence rate of 2.60/100 procedures (95% CI: 0.1 to 5.1%). The incidence rate for deep SSIs was 1.30/100 procedures (95% CI: −0.5 to 3.1%). These infections occurred 7, 6, 11 and 9 days after surgical procedure. Their main characteristics are summarized in Table 3.

The hospital information system detected all but one of the SSI cases. The undetected patient had a superficial infection, which was diagnosed after his discharge from our hospital and treated at an

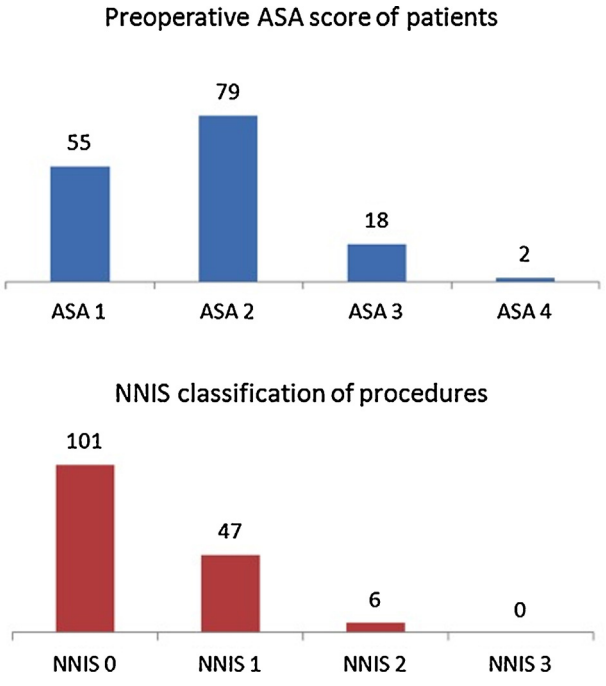

Fig. 1. Distribution of patients and procedures according to preoperative American Society of Anesthesiology (ASA) scores and National Nosocomial Infection System (NNIS) classification, respectively.

Table 3
Characteristics of the infections cases ($n = 4$).

Patient age (years)	SSI type	Germ	Duration of surgery (minutes)	ASA score	Etiology of affection	Delay (days) between surgery and infection
38	Deep	*Klebsiella pneumoniae*	220	3	Traumatic	17
48	Deep	MRSA	90	1	Degenerative	6
58	Superficial	CNS	120	2	Traumatic	11
26	Superficial	Not found	120	2	Traumatic	9

SSI: surgical site infection; ASA: American Society of Anesthesiology; MRSA: methicillin-resistant *Staphylococcus aureus*; CNS: coagulase negative Staphylococcus.

outpatient clinic in his hometown. The infection was acknowledged in his medical report (postoperative follow-up visit), but neither documented nor coded in our institution, for lack of readmission. Gross SSI incidence rate via the HIS detection system would have been 1.95% (95% CI: −0.2 to 4.1%), slightly lower but not statistically different from the results yielded by "high definition" surveillance.

4. Discussion

In this prospective cohort study, using a "high definition" method of surveillance in an unselected adult population undergoing posterior instrumented spinal surgery, we found a 2.6% gross incidence rate of SSI, with a 1.3% incidence rate for deep SSIs. These findings are consistent with the lower levels of published incidence rates [9,12], although methodological differences preclude comparisons: most published series are retrospective [13], or procedure-specific, or designed to compare surgical techniques [14,15]. In one of the only recent prospective studies looking into risk factors and incidence rates of SSI in adult spinal surgery, Lonjon et al. found an infection rate of 3.55% after a minimum of 3 months' follow-up. Their multicentric study population included only trauma patients, whereas ours represented an unselected mix of elective and trauma surgery. Although trauma is usually reported as a major risk factor for SSI, our data failed to confirm this, probably because of the small numbers involved. In our study, both active smoking and active alcohol consumption were significant risk factors for SSI, but a BMI > 30 was not. Several large-scale, population-based retrospective studies looking into multiple pre- and perioperative variables have yielded contrasting results: obesity, smoking, diabetes mellitus can be associated or not with a higher rate of infection [12,13,16]. Revision surgery, blood loss, number of fused levels and prolonged preoperative hospital stay are more consistently found as risk factors for SSI in spinal surgery. Because our study was based on the existing SSI surveillance system of our hospital, surgery-specific data was not extensively collected.

All the suspected SSI cases were discussed by a multidisciplinary panel, and diagnoses were determined according to internationally accepted definitions. Post-discharge follow-up was maintained for at least 12 months, every patient chart being reviewed by an infection control professional at least three times. Primary care physicians were contacted for news of the patients who had not returned for their post-discharge visit. This "high definition" surveillance provides us with reliable SSI incidence rates, but is extremely time consuming and cannot be durably maintained in a resource-strained context. We therefore sought to compare it to a "high output" method, based on the HIS, and were positively surprised to find there was hardly any difference in the gross results. Many studies have compared surveillance methods, ranging from passive (declarative) surveillance by surgeons to exclusive use of administrative code data, via active surveillance by IC professionals [17,18]. The influence of surveillance methods on incidence rates has long been acknowledged [19]: the importance of post-discharge surveillance increases as mean length of stay shortens, especially in detecting benign superficial SSIs that are managed by primary care physicians; in-house surveillance by surgeons only is insufficiently sensitive, although in can be an option for low risk procedures or hospitals lacking an IC team [20]; when compared to reference methods, active surveillance by IC professionals seems to yield the most accurate results, but is not adapted to rapid alert and timely response to clinical cases of SSI [21]. French national guidelines recommend automatically extracting data from electronic patient files when possible, but the need for active data retrieval and multidisciplinary case ascertainment remains [22].

5. Conclusion

We consider our current surveillance method to meet recommended high-quality standards [7], and our SSI rates to reflect the true incidence of infectious complications in posterior instrumented adult spinal surgery in our hospital. Considering the low incidence rate, our study population was too small to analyze patient-related or procedure-specific risk factors, but reflects the "true-life" case mix of unselected elective and trauma spine surgery in a tertiary care French hospital. The comparison with results obtained through automatic code data collection must be tested over several years before allowing a switch from "high definition" to "high output" SSI surveillance.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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