Journal of Infection and Public Health (2013) 6, 89—97

http://www.elsevier.com/locate/jiph

Screening for surgical nosocomial infections by crossing databases

Alexis Hautemanière[a,b,*], Arnaud Florentin[a], Paul R. Hunter[c,d], Laurent Bresler[e], Philippe Hartemann[a,c]

[a] *Service Hygiène, Centre Hospitalier Universitaire de Nancy, rue du Morvan, 54511 Vandoeuvre les Nancy Cedex, France*
[b] *EA RHEM 4369 Relations Hôtes Environnements micororganismes, Faculté de Médecine de Nancy, 9 Avenue de la forêt de Haye, B.P. 184, 54505 Vandoeuvre les Nancy Cedex, France*
[c] *Nancy Université SERES — Faculté de Médecine de Nancy — Inserm U 954, 9 Avenue de la forêt de Haye, B.P. 184, 54505 Vandoeuvre les Nancy Cedex, France*
[d] *University of East Anglia School of Medicine, Health Policy and Practice, Norwich NR4 7TJ, United Kingdom*
[e] *Service de chirurgie digestive et endocrine, Centre Hospitalier Universitaire de Nancy, rue du Morvan, 54511 Vandoeuvre les Nancy Cedex, France*

Received 2 September 2010; received in revised form 27 June 2012; accepted 9 August 2012

KEYWORDS
Surgical infection;
Screening;
Risk management;
Procedure;
Nosocomial infection

Summary Surgical site infection (SSI) is a major cause of morbidity and mortality, and they are the third cause of nosocomial infections. It has been shown that surveillance can reduce the rate of these infections because the publication of the results that introduce a interrogation on her surgical pratices. However, surveillance requires considerable medical resources. Our objective is to validate a computer algorithm that uses microbiological results and the results of a C-reactive protein (CRP) assay and granulocyte count to detect SSIs.
Materials and methods: All patients who underwent colorectal surgery between the 1st of January and the 30th of June 2009 were included. Administrative, surgical and microbiological data and the appearance of neutrophilia and CRP after surgery and during hospitalization were collected. The algorithm uses four biological variables: CRP, neutrophils, and the bacterium found on the positive sample. The CRP and neutrophil variables were coded in 0 or 1. CRP was coded as 1 if the sample was below 5 mg/l at the time of the operation and increased to more than 60 mg/l in the 30 days immediately after post-operation. Neutrophils were coded as 1 if the sample was normal at the time of the operation and increased to more than 12,000 cells/mm^3 in the 30 days immediately after post-operation. The ''type of

* Corresponding author at: Département Environnement et Santé Publique — S.E.R.E.S., Faculté de Médecine, 9 Avenue de la forêt de Haye, B.P. 184, 54505 Vandoeuvre les Nancy Cedex, France. Tel.: +33 3 83 68 34 80.
E-mail address: alexis.hautemaniere@medecine.uhp-nancy.fr (A. Hautemanière).

1876-0341/$ — see front matter
http://dx.doi.org/10.1016/j.jiph.2012.08.002

sample'' and ''bacterium'' variables were coded in categories. For the type of sample, we coded 3 if the sampling site was related to the surgical site, 2 if the sampling site was potentially linked to the surgical site, 1 if the sampling site was not directly or indirectly related to the surgical site and 0 if there was no sample. Regarding the bacteria, we coded 3 for bacteria found in over 5% of SSIs, 2 for bacteria found in 2—5% of SSIs, 1 for bacteria found in less than 2% of SSIs and 0 if there were no bacteria. The algorithm calculates a score from 1 to 5.

Results: Our study included 195 operations, out of which it was possible to study 168. Following the operations, we found neutrophilia above 12,000 cells/mm^3 in 41.5% of cases and CRP above 60 mg/l in 64.6% of cases. Thirty-seven operations (22%) were complicated by an SSI. The positive predictive values and the negative predictive values in our algorithm were 74.07% and 87.94%, respectively, and the number of records that remain to be investigated is 27 out of 168.

Conclusions: Linking databases from bacteriology and biology with those containing the hospital records of surgical procedures is a simple method for identifying surgical nosocomial infections.

Introduction

Nosocomial infections (NI) are a major cause of morbidity and mortality. It has been reported that SSIs comprise 14—16% of nosocomial infections [1]. Between 1986 and 1996 in the US, SSI was the most common cause of NI in surgical patients, accounting for approximately 38% of all NIs in this group [2]. In one Italian study, the prevalence of patients with NI in medical, surgical and intensive care areas was 6.6%, 5.0% and 25.8%, respectively. The sites that were most frequently affected were the following: urinary tract (28.4%), surgical site (20.3%), bloodstream (19.3%), and pulmonary and lower respiratory tract (17.6%) [3]. In France, the incidence of SSIs for all categories of operations and patients is 1.54% [4]. The SENIC project in the United States showed that SSI was the principal preventable NI [5—7]. The risk factors for acquiring an SSI can be separated into two categories: factors relating to the patient, and those relating to the surgery or underlying disease [8,9].

Measurement of the rate of NIs in patients who have undergone surgery has shown that the implementation of infection surveillance and the subsequent implementation of intervention programs are effective ways of controlling the risk of post-operative infection (SSI) [10]. A 14% reduction in the rate of SSIs was observed after NI control programs were implemented in participating hospitals [4,7]. SSI surveillance systems have been set up in many countries. Due to the implementation of such surveillance with feedback, health care professionals are discussing and analyzing their practices to reduce the risk of NI. One of the main requirements of this approach is the reproducibility of the measurements, allowing a comparison of the results over time. To make this comparison, the typology of the diseases managed and the general health score of patients who have had surgery must be taken into account in this analysis [8]. In fact, these two parameters (analysis of the results of her practices and make a benchmarking) affect the probability of occurrence of an SSI [7]. The Center for Disease Control and Prevention in Atlanta has identified 3 risk factors for occurrence of an SSI in its surgical NI surveillance program (the length of surgical procedures, the contamination class according to the infectious agent and the medical condition of the patient) [11]. In this program, an NNIS (National Nosocomial Infection Surveillance) risk score has been created. The NNIS score is obtained by combining the three risk factors for SSI: Altemeier's classification of contamination [12], the ASA score (or the ''Physical status score'' was developed by American Society of Anesthesiologists (ASA); the ASA score is used in medicine to express the health status of pre-operative patients, and its use also offers the opportunity to study and determine the factors that may lead to infection after surgery) [13] and the length of the operation. Each of these factors is scored as 0 or 1. The NNIS score is calculated by adding up the scores for these three risk factors (Altemeier's classification, ASA score and length of the operation); it therefore varies from 0 to 3. The NNIS score is used as a variable in adjusting the risk factor for onset of an SSI, so that the results can be given by the type of patient and surgery [14—16]. The collection of data relating to the patient or operation is not limited to the NNIS score. This method of data collection can prove to be extremely time-consuming and tiresome for clinicians. As a result, integrating SSI surveillance

into a hospital's IT system may encourage surgical departments to participate in SSI surveillance.

The diagnosis of SSIs is based on either clinical, biological or microbiological definitions. The biological markers of inflammation that are most used for diagnosing infections include C-reactive protein (CRP) and neutrophils. The presence of CRP is an important biological marker of the acute inflammatory phases. CRP is an early, sensitive and specific marker of the inflammatory reaction [17]. Neutrophils are cells that belong to the line of blood cells involved in non-specific immunity. In the normal state, the neutrophil count comprises 40—70% of the total leukocyte count, i.e., from 1700 to 7000 cells/mm^3.

The objective of our work was to design an algorithm for detecting SSIs based on data from the hospital's IT system, and thus to improve surveillance.

Materials and methods

Population and data source

All the patients who had undergone colorectal surgery carried out in the gastrointestinal and endocrine surgical department at Nancy University Hospital (*CHU de Nancy*), France, between the 1st of January and the 30th June 2009 were included. To achieve reasonable statistical power, the study was carried out in categories of surgery with a high probability of SSI, the expected rate ranging from 11.6% to 26.1% [15]. The surveillance of SSIs was organized in the surgery ward, and the methodology was a clinical follow-up.

At Nancy University Hospital, we designed a computer program using Microsoft Access® software that enables us to carry out surveillance of surgical procedures. The list of patients for inclusion and the variables used were supplied by the Medical Information Department (MID) after extraction from the hospital information system (*Système d'Information Hospitalier* — SIH). To do this, the operational hygiene team obtained the list of procedure codes (*Classification Commune des Actes Médicaux* — *CCAM*) and their dates of realization. This list was provided by the MID. In the event that there were multiple or repeat interventions within 30 days, only those cases where the abdominal surgery was the main procedure was included, and analysis was restricted to this primary procedure. The complete medical record was investigated by one of the members of the hospital hygiene team.

To standardize the data collection, a file was created of administrative, surgical, and microbiological data, and the appearance of neutrophilia and increased levels of CRP after surgery and during hospitalization. Sixteen variables were considered for surveillance of SSIs. These variables were either taken directly from the SIH or calculated using other variables in the SIH. The variables taken from the SIH were *Administrative data* (surname, first name, date of birth, sex, IPUM (patient's unique identification number in the hospital), date of admission, date of discharge, department carrying out the procedure) and *Surgical data* (date of the operation, time the operation started, time the operation ended, CCAM procedure code).

Definition of SSI

The definition of an SSI used is based on the definition of the Centers for Disease Control and Prevention translated into French [18]. An SSI is an infection that occurs within 30 days after the operation if no implant is left in place or within 1 year after the operation (only deep SSIs) if an implant is left in place and the infection appears to be related to the operation. An implant is understood to mean a non-human-derived implantable foreign body (e.g., a prosthetic heart valve, a non-human vascular graft, a mechanical heart, or a hip prosthesis) that is permanently placed in a patient during surgery.

Design of the algorithm

The hospital also has a database of all microbiological and pathological samples taken from patients. All positive bacteriological samples were extracted into a separate database and cross-referenced with the data on the surgical procedures that were performed during the study period and extracted from the SIH. An algorithm was designed to link three administrative variables (date, operation and sample) with four biological variables: CRP, neutrophils, the type of positive microbiological sample and the bacterium found in the positive sample. The CRP was coded 1 if the sample was below 5 mg/l at the time of the operation and increased to more than 60 mg/l in the 30 days immediately after post-operation, otherwise, it was coded 0. The threshold of 60 mg/l was chosen in accordance with data in the literature [19,20]. The neutrophils were coded 1 if the sample was normal at the time of the operation and increased to more than 12,000 cells/mm^3 in the 30 days immediately after post-operation [20]. The biochemical parameters were regrouped in a 3rd variable: biomarker +. This variable was coded 1 if the neutrophils were $\geq$12,000 and CRP $\geq$ 60 mg/l. The other combinations were coded 0 (Fig. 1).

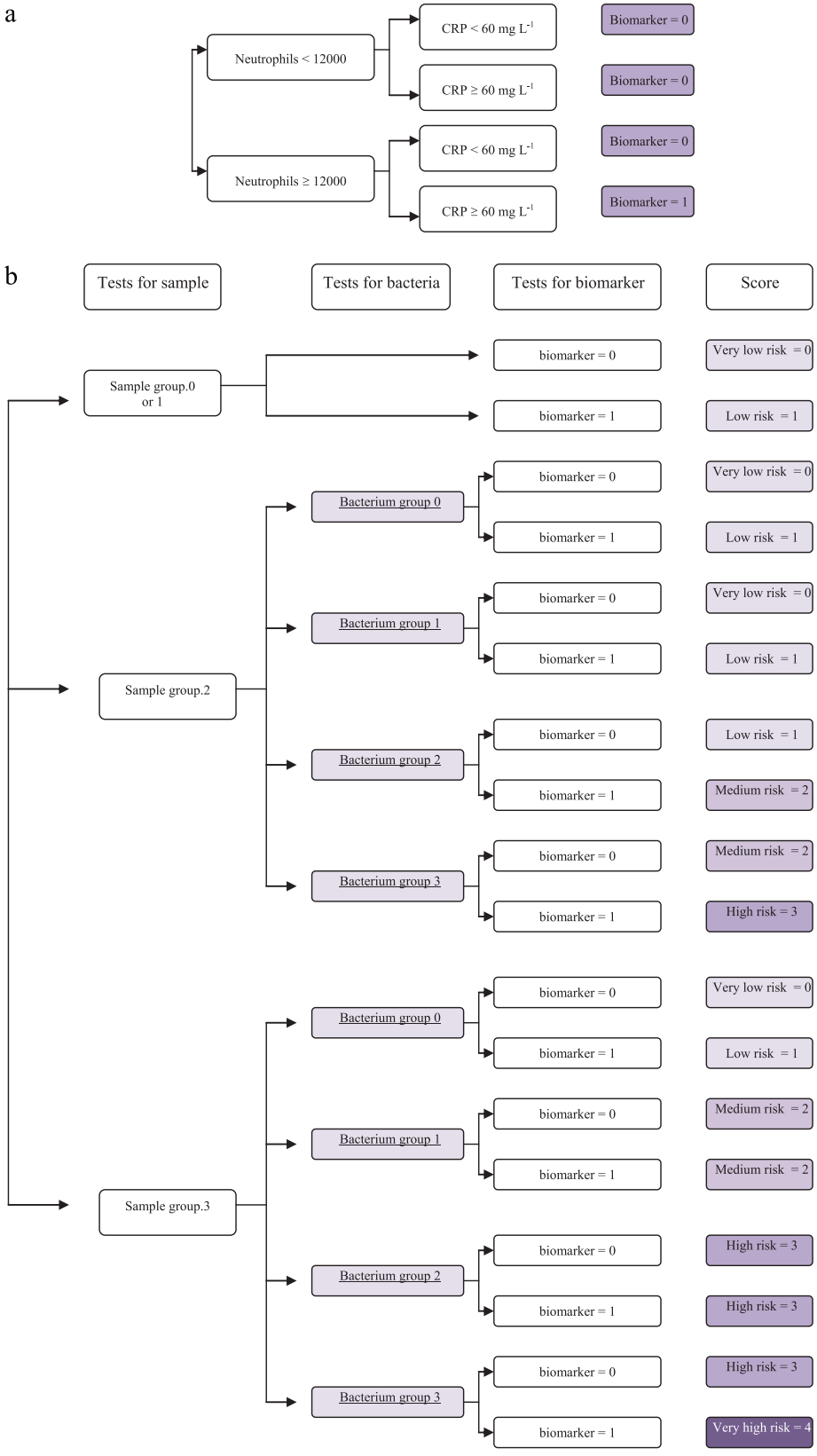

Figure 1 Decision tree according to positive parameters from the IT system. (a) Decision tree to aggregate the biomarker. (b) Decision tree to aggregate all parameters.

Table 1 Prevalence of microorganisms of SSIs in study INCISO 2008.

Type of bacterium	Percentage (%)	IT code
Gram-positive cocci		
Staphylococcus aureus	29.1	3
Coagulase-negative staphylococci	7.1	3
Enterococcus faecalis	5.8	3
E. faecium	0.4	1
Other enterococci	3.3	2
Streptococcus agalactiae (B)	1.6	1
Hemolytic streptococci (C, G)	0.4	1
Other streptococci	4.1	1
Gram-negative bacilli (GNB)		
Enterobacteria	37.3	
Escherichia coli	17.4	3
Enterobacter cloacae	4.6	2
Proteus mirabilis	3.7	2
Klebsiella pneumoniae	2.9	2
Morganella sp.	2.5	2
Citrobacter koseri	1.7	1
K. oxytoca	1.2	1
Other *Proteus*	0.8	1
Serratia sp.	0.8	1
E. aerogenes	0.4	1
Other *Enterobacter*	0.4	1
C. freundii	0.4	1
Providencia	0.4	1
Non-enterobacteria GNB	5.8	
Pseudomonas aeruginosa	5.4	1
Other *Pseudomonas*	0.4	1
Anaerobic	3.7	
Bacteroïdes fragilis	1.7	1
Other *Bacteroïdes*	0.8	1
Clostridium sp.	0.8	1
Prevotella sp.	0.4	1
Yeasts		
Candida albicans	0.4	1
Others		
Corynebacterium sp.	0.4	1

Based on expert opinion, the ''type of sample'' and ''bacterium'' variables were coded into categories. The type of sample was coded 3 if the sampling site was directly related to the surgical site (for example, an abdominal sample in colorectal surgery), 2 if the sampling site was potentially linked to the surgical site (for example, peripheral blood cultures), 1 if the sampling site was not directly or indirectly related to the surgical site and 0 if there was no sample. The bacteria detected were coded based on how commonly they were implicated as causes of SSI: 3 for bacteria found in over 5% of SSIs (e.g., *Staphylococcus aureus*), 2 for bacteria found in 2—5% of SSIs (e.g., *Enterococcus* sp. group), 1 for bacteria found in less than 2% of SSIs and 0 if there were no bacteria reported (cf. Table 1) [21].

Finally, the algorithm was used to calculate a score from 0 to 4, which reflects the risk of having acquired a nosocomial SSI (very high, high, medium, low, and very low risk). The decision tree is shown in Fig. 1b.

All of our statistical analyses were carried out in Epi Info version 6.04 (CDC Atlanta) at a significance threshold of 5%. This study was performed after presentation to the Information Medical College, which accepted this methodology.

Results

Our study included 195 consecutive surgical procedures that occurred during the study period,

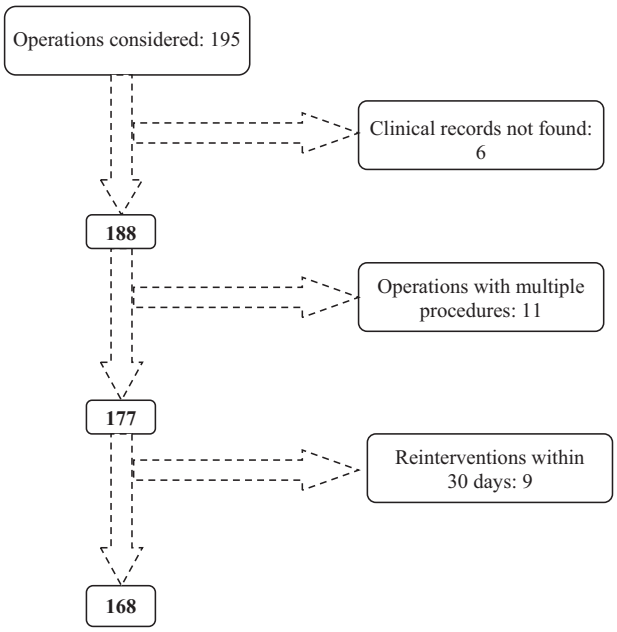

Figure 2 Flow chart.

involving 167 patients. Of these operations, the clinical records of 9 operations could not be found. After excluding cases as described above and omitting operations where the clinical record was unavailable, we studied 168 operations. The flow chart in Fig. 2 summarizes these various stages.

Description of the population

The average age was 61.8 years (1.98) for men and 57.4 (1.91) for women. The sex ratio (F/H) was 1.025. Twenty-nine (17.3%) operations were performed with laparotomy, and 18 (10.7%) were emergency procedures. The operations were carried out on an average of 64.2 h (7.6) after admission to the hospital, with a median of 23.6 h. The average length of the post-operative stay was 16 days (1.1).

In the period following the operations, we found neutrophilia (over 12,000 cells/mm^3) in 41.5% of cases and a CRP above 60 mg/l in 64.6% of cases. Of the 168 operations we studied and after analyzing the medical record of all the patients, 37 (22%) were complicated by an SSI. The average time until onset of an SSI was 10.7 days (1.1). The location of the 37 SSIs was distributed as follows: 20 (54.1%)

Table 2 Single predictor variable analysis diagnosed through review of patient records.

Variables	Number of operations	Number of SSIs	*p*	Odds-ratio (CI 95%)
Samples score			<0.001	
0	108	12	Ref	Reference
1	31	5	0.455	1.5 (0.5; 4.8)
2	4	2	0.047	8 (1; 62.1)
3	25	18	<0.001	20.6 (7.1; 59.3)
Bacteria score			<0.001	
0	108	12	Ref	Reference
1	4	0	0.999	0 (0; ∞)
2	7	4	0.004	10.7 (2.1; 53.5)
3	49	21	<0.001	6 (2.6; 13.7)
CRP score			0.001	
0 (CRP < 60 mg/l)	63	4		Reference
1 (CRP > 60 mg/l)	105	33		6.8 (2.3; 20.2)
Neutrophils score			<0.001	
0 (<12,000 cells/mm^3)	105	12		Reference
1 ($\geq$12,000 cells/mm^3)	63	25		5.1 (2.3; 11.2)
Neutrophils or CRP score			0.001	
0 (CRP and neutrophils −)	57	3		Reference
1 (CRP or neutrophils +)	111	34		7.95 (2.3; 27.2)
Total score			<0.001	
0 (very low risk)	139	17	Ref	Reference
1 (low risk)	21	0	0.999	0 (0; ∞)
2 (medium risk)	5	1	1	1^E10 (0; ∞)
3 (high risk)	21	4	0.003	28.7 (3; 272)
4 (very high risk)		15	<0.001	17.9 (6.1; 52.5)

Table 3 Sensitivity, specificity according to the semi-quantitative probability score of SSI.

	Positive if ≥4)	Positive if ≥3	Positive if ≥2	Positive if ≥1
Sensitivity	40.5%	51.3%	54.0%	54.0%
Specificity	95.4%	94.7%	94.7%	93.1%
PPV	71.4%	73.1%	74.1%	69.0%
NPV	85.0%	87.3%	87.9%	87.8%
Number of records to be investigated by the hospital hygiene team or clinicians if this score is used	21	26	27	29

superficial SSIs and 17 (45.9%) deep SSIs. The real and total incidence of SSIs was 22% (37/168).

Single predictor variable analysis

Age and the length of stay in the hospital before the operation were not significantly associated with the onset of an SSI. In contrast, the length of post-operative hospitalization was higher following onset of an SSI ($p < 0.001$). Age, sex, NNIS score, emergency surgery, surgery with coelioscopy and the length of the operation were not significant at 5%. The significant results are shown in Table 2.

Analysis of sensitivity — specificity

The characteristics of our weighting tree are shown in Table 3, summarizing the probability scores of an SSI. The sensitivity of the algorithm was modest at a little over 50% for most determined risk groups, although the sensitivity fell in the very high-risk group to 40%. The specificity was high (>90%) in all risk groups, with a modest increase with risk group from 93.1% in the low risk group to 95.4% in the high-risk group. In choosing a score equal to or higher than 2, we obtained a specificity equal to 94.7%, a positive predictive value equal to 74.1% and a negative predictive value equal to 88%. With these parameters, the number of medical records that must be investigated and validated with the surgeon was limited to 27 out of 168 (16%). Thus, the task of performing the surveillance is more acceptable for the surgeon.

In conclusion, the best compromise is found for a threshold value greater than or equal to 2.

Discussion

This study has shown that SSI surveillance together with a computer program based on the crossing of existing data can simplify the surveillance of nosocomial SSIs. In fact, the positive and negative predictive values are high. Furthermore, there are few records to be investigated because only 16% of the records need to be checked for the presence of an SSI. In addition, by using this method of collection, exhaustive information on all operations meeting the established surveillance criteria could be obtained. This system also cuts down on input errors and missing data. It has the advantage of not being dependent on the willingness of departments and surgeons to take part in the survey.

Our study has demonstrated a high rate of SSIs at 22%, but this is compatible with the data in the literature [15] for colorectal surgery. However, for the period 1992—1998, the National Nosocomial Infections Surveillance system has reported that the SSI rate was 8.10% for this type of operation with regard to overall surveillance [22].

With regard to the bacterial samples, it is interesting to note that we only recorded positive samples in our system. For the time being, we have chosen not to use the part of the definition of SSIs that states that it is not an SSI if the bacteriological culture taken during a puncture or a reintervention is negative, even though a sign of infection is present (pain, sensitivity, redness, heat). This culture could be negative because of the antibiotic treatment, which would mask an infection. We have elected to incorporate two inflammation markers available in our IT system into our weighting algorithm. In clinical practice, these two markers are often associated with the presence of an infection. The threshold at which the CRP levels may lead to a suspected SSI is, according to the literature, variable and is expressed by an increase ranging from 19 to 80 times the normal value [23]. The value used in this study corresponds with these data perfectly. For this reason, incorporation of information on the prescription of antibiotics could be potentially important. However, using this technique, we can satisfy the French definition of SSIs perfectly, as the definitions of SSIs were modified in May 2007 by the French National Technical Committee for Combating NI and Healthcare-associated Infections (*Comité Technique National de Lutte contre les IN et les Infections Liées aux Soins* — CTINILS). SSIs whose only diagnostic criterion is the surgeon's opinion are

excluded from surveillance under these new definitions. The USA has recently updated the definitions of NIs [24]. In contrast to the French definitions, in this update, the surgeon's opinion is one of the diagnostic criteria for an SSI. In our study, there were few infections that were undetected because of an algorithm error. This point reinforces the relevance and robustness of our system.

Finally, one important limitation of our system is that it can only detect suspected SSIs when the patient is in the hospital or re-admitted to the hospital. It has been shown that a large number of SSIs occur at home [25]. However, out of the patients who are discharged, those presenting with signs of infection are traditionally re-admitted to the hospital. The only cases that would not be detected by our system are those in which the purulent discharge has dried up spontaneously or those from which a sample has not been taken.

We constructed our weighted algorithm according to a clinical relevance approach. In terms of the results of each test, a semi-quantitative ''probability'' onset of an SSI was determined.

An interesting additional observation is that signs of SSI, such as purulent discharge, are often not noted in the medical notes but only referred to in the notes of the dressing nurses. Similarly, we also noted that when the presence of an accumulation of pus is recorded in the medical notes, from the descriptions given, it seems to be regularly regarded as a ''straightforward consequence'' of the operation. It should be remembered that SSIs, as with all NIs, must be mentioned to patients, and the fact that they have been informed must be noted in the medical records. When records are investigated, we found that SSIs were diagnosed by a doctor in the infection prevention team if the surgeon had not made or contradicted the diagnosis. This diagnosis was made by a thorough analysis of the medical record, particularly the reasons for a reintervention, antibiotic treatment or imaging to reveal an abscess. SSIs diagnosed solely on the basis of discharge, although there are quite a few, have proven to be the most difficult to confirm. As a result, there has been a considerable underestimation of the SSI rate.

In conclusion, our weighted algorithm show the difficulty of detecting SSIs. In fact, at best, our algorithm has a sensitivity of approximately 50%, i.e., one SSI was two is not detected. Nevertheless, the specificity was very good, as it was always above 90%.

The plausible explication is the different indication of swab by each surgeon when clinical symptoms were observed. In fact, as we have seen, the probability scores of 3 and 4 are most strongly associated with the occurrence of an SSI. These two scores are closely linked to samples and to the types of bacteria rather than to the presence of high levels of CRP or neutrophilia. Therefore, practice relating to bacteriological sampling has a great impact on the sensitivity of our test. In fact, we have noted than in gastric surgery, bacteriological samples were primarily taken during repeat operations due to infection or loosening of stitches. Samples of purulent discharge from the scar or drains were only taken rarely, as was the case with samples of accumulated pus and abscesses. More SSIs could be detected if samples were systematically taken when purulent discharge occurs and/or if samples were collected more systematically during reinterventions. However, antibiotic treatment is often introduced, rendering the samples artificially negative (false-negative).

Through the use of our procedure of computerized surveillance of SSIs, the exhaustivity is improved. This represents a solid foundation on which to build targeted or overall surveillance.

To improve the sensitivity of our procedure, the policy on bacteriological sampling in our hospital needs to be standardized. More systematic screening of purulent discharge or intra-operative sampling during a reintervention would certainly improve the screening of SSIs by our system. However, the cost/benefit ratio for our hospital would need to be assessed. Only SSIs that are diagnosed by the surgeon or through imaging methods would need to be registered ''manually''.

Conclusions

Our study has demonstrated the feasibility of an IT system for detecting SSIs to improve surveillance. The gain in terms of exhaustivity is real. In addition, this methodology relieves surgeons of the heavy workload involved in performing this surveillance and will therefore increase clinicians' interest in this issue. Through the development of IT systems, relevant results can be accessed quickly and repeatedly, thus helping the practice to proceed.

Funding: This research was supported by the University of Medicine of Nancy.

Competing interests: None declared.

Ethical approval: Not required.

References

[1] Smyth ET, Emmerson AM. Surgical site infection surveillance. Journal of Hospital Infection 2000;45(July (3)):173—84.

[2] Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. American Journal of Infection Control 1999;27(2):97—132, quiz 133—4, discussion 96.
[3] Pellizzer G, Mantoan P, Timillero L, Allegranzi B, Fedeli U, Schievano E, et al. Prevalence and risk factors for nosocomial infections in hospitals of the Veneto region, north-eastern Italy. Infection 2008;36(March (2)):112—9 [Epub 2008 March 10].
[4] Astagneau P, L'Hériteau F, Daniel F, Parneix P, Venier AG, Malavaud S, et al. Reducing surgical site infection incidence through a network: results from the French ISO-RAISIN surveillance system. Journal of Hospital Infection 2009;72(June (2)):127—34.
[5] Special issue: the SENIC Project. American Journal of Epidemiology 1980;111(May (5)):465—653.
[6] Hughes JM. Nosocomial infection surveillance in the United States: historical perspective. Infection Control 1987;8(November (11)):450—3.
[7] Smyth ET, Emmerson AM. Surgical site infection surveillance. Journal of Hospital Infection 2000;45(July (3)):173—84.
[8] Haridas M, Malangoni MA. Predictive factors for surgical site infection in general surgery. Surgery 2008;144(October (4)):496—501, discussion 501—3.
[9] Humphreys H. Preventing surgical site infection. Where now? Journal of Hospital Infection 2009.
[10] Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. American Journal of Epidemiology 1985;121:182—205.
[11] National Nosocomial Infection Surveillance (NNIS) (2004) System report. Date summary from January 1992 through June 2004, issued October. American Journal of Infection Control 2004;32:470—85.
[12] Altemeier WA, et al. Definitions and classifications of surgical infections. In: Manual on control of infection in surgical patients. Philadelphia: Lippincott JB; 1984. p. 19—30.
[13] American Society of Anesthesiologists. Classification system; 2009. Available from: http://www.asahq.org/clinical/physicalstatus.htm
[14] Emori TG, Culver DH, Horan TC, Jarvis WR, White JW, Olson DR, et al. National Nosocomial Infections Surveillance system (NNIS): description of surveillance methods. American Journal of Infection Control 1991;19(1):19—35.
[15] Moro ML, Morsillo F, Tangenti M, Mongardi M, Pirazzini MC, Ragni P. ICN Regional Group Rates of surgical-site infection: an international comparison. Infection Control and Hospital Epidemiology 2005;26(May (5)):442—8.
[16] Haridas M, Malangoni MA. Predictive factors for surgical site infection in general surgery. Surgery 2008;144(October (4)):496—501, discussion 501—3.
[17] Baruti Gafurri Z, Pacarizi H, Zhubi B, Begolli L, Topciu V. The importance of determining procalcitonin and C reactive protein in different stages of sepsis. Bosnian Journal of Basic Medical Sciences 2010;10(February (1)):60—4.
[18] Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. American Journal of Infection Control 1999;27:97—132.
[19] Codine P, Barbotte E, Denis-Laroque F, Lansac H, Dupetit T, Pradies F, et al. C-reactive protein, leukocyte count and D-dimer monitoring after orthopedic surgery: early diagnosis of infectious or thromboembolic complications. Part one: C-reactive protein and leukocyte count as an aid in diagnosing postoperative infection. Annales de Réadaptation et de Médecine Physique 2005;48(8):590—7.
[20] Sarbinowski R, Arvidsson S, Tylman M, Oresland T, Bengtsson A. Plasma concentration of procalcitonin and systemic inflammatory response syndrome after colorectal surgery. Acta Anaesthesiologica Scandinavica 2005;49(2):191—6.
[21] Hidron AI, Edwards JR, Patel J, Horan TC, Sievert DM, Pollock DA, et al. National Healthcare Safety Network Team; Participating National Healthcare Safety Network Facilities. NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006—2007. Infection Control and Hospital Epidemiology 2008;29(11):996—1011.
[22] Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS. Surgical site infection (SSI) rates in the United States, 1992—1998: the National Nosocomial Infections Surveillance System basic SSI risk index. Clinical Infectious Diseases 2001;33(September (Suppl. 2)):S69—77.
[23] Jebali MA, Hausfater P, Abbes Z, Aouni Z, Riou B, Ferjani M. Assessment of the accuracy of procalcitonin to diagnose postoperative infection after cardiac surgery. Anesthesiology 2007;107(2):232—8.
[24] Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. American Journal of Infection Control 2008;36:309—32.
[25] Ferraz EM, Ferraz AA, Coelho HS, Pereira Viana VP, Sobral SM, Vasconcelos MD, et al. Postdischarge surveillance for nosocomial wound infection: does judicious monitoring find cases? American Journal of Infection Control 1995;23(October (5)):290—4.