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Automated detection of nosocomial infections: evaluation of different strategies in an intensive care unit 2000–2006

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SUMMARY

The aim of this study was to evaluate seven different strategies for the automated detection of nosocomial infections (NIs) in an intensive care unit (ICU) by using different hospital information systems: microbiology database, antibiotic prescriptions, medico-administrative database, and textual hospital discharge summaries. The study involved 1499 patients admitted to an ICU of the University Hospital of Lyon (France) between 2000 and 2006. The data were extracted from the microbiology laboratory information system, the clinical information system on the ward and the medico-administrative database. Different algorithms and strategies were developed, using these data sources individually or in combination. The performances of each strategy were assessed by comparing the results with the ward data collected as a national standardised surveillance protocol, adapted from the National Nosocomial Infections Surveillance system as the gold standard. From 1499 patients, 282 NIs were reported. The strategy with the best sensitivity for detecting these infections using an automated method was the combination of antibiotic prescription or microbiology, with a sensitivity of 99.3% [95% confidence interval (CI): 98.2–100] and a specificity of 56.8% (95% CI: 54.0–59.6). Automated methods of NI detection represent an alternative to traditional monitoring methods. Further study involving more ICUs should be performed before national recommendations can be established.

Introduction

Nosocomial infections (NIs) are a major concern in hospitals, especially in intensive care units (ICUs). NI rates vary widely according to the type of ICU and the population studied. In France, the last national prevalence survey conducted in 2006 estimated the prevalence of NIs in ICUs to be 22.4%.[1]

Standardised methods of NI surveillance in ICUs have been used in France since 1995. These methods are adapted from the National Nosocomial Infections Surveillance (NNIS) system and are consistent with HELICS (Hospitals in Europe Link for Infection Control through Surveillance) European definitions.[2,3] They are based on the manual collection of clinical data from medical records, clinical laboratories, and antibiotic prescriptions by infection control or ICU professionals. This approach is both costly and time-consuming and focuses infection control resources on counting rather than preventing infections. In addition, applying Centers for Disease Control and Prevention (CDC) and HELICS case definitions requires considerable clinical judgement and can be difficult to apply.[4] Also, case-finding may lack sensitivity, and inter-institutional variability in surveillance techniques further complicates inter-hospital comparisons.[5]

The automated or electronic surveillance of infectious disease is the process of obtaining information from interrelated electronic

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databases for identifying infection distribution within a particular setting.[6] With the increasing use and availability of electronic patient data within healthcare institutions including data from clinical care (e.g. microbiology results, antibiotic prescriptions), data from administration and data from clinical information systems in ICUs (including prescriptions, laboratory reports, automatic monitoring of ventilators), the potential for implementing automated surveillance of NIs has increased in recent years. Alternative approaches to NI surveillance have therefore been proposed.[7] In this study we assess seven different strategies for detecting NIs in an intensive care unit using a combination of different data sources extracted from the hospital information systems (microbiological database, antibiotic prescriptions, discharge diagnosis codes and textual hospital discharge summaries). The sensitivity, specificity, positive and negative predictive values of these different strategies were estimated by comparison with a reference method based on a national standardised surveillance method.

Methods

Setting

One of the nine adult ICUs of the University Hospital of Lyon (France) participated in this study. This ICU is located in one of the hospitals (Lyon Sud Hospital) that comprise the University Hospital and has 14 beds, including two beds for post-surgery intensive care. All patients were adults admitted for medical or surgical problems.

Reference method

The reference method was based on a national standardised surveillance method, REA-RAISIN (Réanimation – Réseau Alerte Investigation Surveillance des Infections Nosocomiales). Definitions of NI used in this protocol were based on the HELICS definitions.[3] Data collection was carried out either in real time (daily collection) or at the time of hospital discharge by ICU physicians.

Four anatomical sites of NI were studied: pneumonia, central venous catheter-associated infections (CVC-AIs), urinary tract infections (UTIs) and bloodstream infections (BSIs). Each infection was studied individually and was combined with at least one of the other anatomical sites.

Results from the standardised surveillance method were used as the gold standard in our study for evaluating different strategies of NI detection using different hospital databases. The number of patients monitored (ICU stay $\geq$48 h after admission) in this ICU between 2000 and 2006 was 1,860. Patients with NI symptoms beginning within the first 48 h after admission were excluded ($N = 32$) as were patients for whom no link with a database could be made ($N = 329$). The final number of patients in the evaluation database was $N = 1499$. CVC-AI assessment was carried out on only 806 of these patients because 397 patients (26.5%) did not have a CVC during their ICU stay and for 35 patients the information on the presence or absence of a CVC-AI was unknown (2.3%). For 245 patients (16.3%) the CVC was not removed when they were discharged from the ICU and for 16 patients (1.0%) the microbiology results were unknown.

Databases used for the automated detection of nosocomial infections

For the 1499 patients included in the study, four databases were built retrospectively: microbiology database, drug prescriptions database, medico-administrative database and textual hospital discharge summaries.

Microbiological data were extracted from the laboratory information system of the Lyon Sud Hospital (Molis®, Vision4health, Laufenberg & Co., Freienbach, Switzerland) microbiology laboratory which gathered administrative patient data and the results of microbiological investigations.

Antibiotic prescription data were extracted from the clinical information system of the ICU which contains all drug prescriptions (Clinisoft® GE Healthcare, Chalfont St-Giles, UK).

Medico-administrative data were available from the French medico-administrative database (PMSI), the French equivalent of diagnosis-related groups (DRGs) where discharge diagnoses are coded according to the International Classification of Diseases (tenth revision).

Electronic textual hospital discharge summaries (HDSs), written at the end of the stay by the ICU physician, were used for a subgroup of the patients included in this evaluation study. A subgroup of patients enrolled in 2005 and 2006 were assessed. All patients with NI infection during this period were included ($N = 80$) and 80 non-NI patients were selected at random. For the 80 NI patients, 60 HDSs were extracted from the hospital information system and for the 80 non-NI patients, 68 HDSs were extracted. These summaries were analysed by a hospital epidemiologist and data extracted manually from the textual documents to create a single database.

Computer algorithms to detect nosocomial infections

Different algorithms were developed to detect NI automatically, based on the type of hospital database and anatomical site (Table I).

Strategies based on the use of a single hospital database

We studied four strategies based on the use of a single hospital database: microbiological algorithm (MAC), drug prescriptions algorithm (ATB), medico-administrative algorithm (PMSI), electronic hospital discharge summaries (HDS).

- Microbiological algorithm (MAC) strategy: the selection of sampling type and pathogens was based on the local thesauri used in the microbiology laboratory information system.
- Drug prescriptions algorithm (ATB) strategy: antibiotic prescriptions were selected using the ATC code (Anatomical Therapeutic Classification) for a systemic antibiotic (J01).
- Medico-administrative algorithm (PMSI) strategy: the ICD-10 codes selected for NI detection in the medico-administrative database were those defined in a French report by the Southwest regional coordinating centre for nosocomial infection prevention. The detection of central venous catheter-associated infections (CVC-AIs) could not be assessed with the PMSI strategy because no corresponding code was available in the ICD-10.
- Electronic hospital discharge summaries (HDS) strategy: the detection of nosocomial infection in hospital discharge summaries was based on manual data extraction by a medical epidemiologist. It is therefore not a computer algorithm but the use of textual data extracted from electronic hospital discharge summaries was evaluated in this study in the context of a current research project (ALADIN-DTH Project) to detect nosocomial infection automatically in textual documents through natural language processing.[8] This evaluation of the textual data enabled us to assess the performance of the data available in these documents, independently of the technical performances of the semantic detection tools in development.