Journal of Hospital Infection 87 (2014) 159–164

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevierhealth.com/journals/jhin

Validity analysis of a unique infection surveillance system in the intensive care unit by analysis of a data warehouse built through a workflow-integrated software application

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ARTICLE INFO

Article history:
Received 21 October 2013
Accepted 30 March 2014
Available online 28 April 2014

Keywords:
Infection surveillance
Information technology systems
Computer-assisted surveillance
ICU-acquired infection

SUMMARY

Background: An electronic decision support programme was developed within the intensive care unit (ICU) that provides an overview of all infection-related patient data, and allows ICU physicians to add clinical information during patient rounds, resulting in prospective compilation of a database.

Aim: To assess the validity of computer-assisted surveillance (CAS) of ICU-acquired infection performed by analysis of this database.

Methods: CAS was compared with prospective paper-based surveillance (PBS) for ICU-acquired respiratory tract infection (RTI), bloodstream infection (BSI) and urinary tract infection (UTI) over four months at a 36-bed medical and surgical ICU. An independent panel reviewed the data in the case of discrepancy between CAS and PBS.

Findings: PBS identified 89 ICU-acquired infections (13 BSI, 18 UTI, 58 RTI) and CAS identified 90 ICU-acquired infections (14 BSI, 17 UTI, 59 RTI) in 876 ICU admissions. There was agreement between CAS and PBS on 13 BSI (100 %), 14 UTI (77.8 %) and 42 RTI (72.4 %). Overall, there was agreement on 69 infections (77.5%), resulting in a kappa score of 0.74. Discrepancy between PBS and CAS was the result of capture error in 11 and 14 infections, respectively. Interobserver disagreement on probability (13 RTI) and focus (two RTI, one UTI) occurred for 16 episodes. The time required to collect information using CAS is less than 30% of the time required when using PBS.

Conclusion: CAS for ICU-acquired infection by analysis of a database built through daily workflow is a feasible surveillance method and has good agreement with PBS. Discrepancy between CAS and PBS is largely due to interobserver variability.

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http://dx.doi.org/10.1016/j.jhin.2014.03.010

Introduction

Intensive care unit (ICU)-acquired infection is a frequent complication in patients admitted to the ICU,[1,2] and is associated with adverse outcomes.[3,4] Although the incidence of ICU-acquired infection varies according to the patient case-mix, it is, to some extent, a preventable complication. Surveillance of various types of infection has been advocated as a means to measure hospital quality, and serves as an instrument to guide and evaluate the infection control policy.[5] However, conventional surveillance requires time-consuming extraction of data from dispersed information sources by dedicated and trained personnel. The cost and workload associated with conventional surveillance is a major barrier to its continuous implementation; as such, surveillance is generally performed erratically or for limited time periods. In a joint project with the Department of Information Technology of Ghent University, the authors designed and implemented a software application for electronic decision support in infectious diseases at the ICU [Computer-based Surveillance and Alerting of infections, Antimicrobial Resistance and Antibiotic consumption in the ICU (COSARA)]. COSARA has been fully operational since 2010 at the study ICU, where it assists the attending ICU physician in acquiring oversight of various data related to infection diagnosis and treatment. The programme facilitates the compilation of an extensive data warehouse on antibiotic use and infection in the ICU, which can be consulted for various purposes.[6] It was hypothesized that analysis of the COSARA data warehouse would facilitate surveillance of ICU-acquired infection, and the list of infections resulting from conventional prospective paper-based surveillance (PBS) was compared with the list of infections retrieved from COSARA [computer-assisted surveillance (CAS)]. For the purpose of this study, surveillance was restricted to ICU-acquired respiratory tract infection (RTI), urinary tract infection (UTI) and bloodstream infection (BSI).

Methods

The study was conducted at the 14-bed medical ICU (MICU) and the 22-bed surgical ICU (SICU) of Ghent University Hospital (1050 beds). The MICU and SICU are completely computerized, and COSARA software has been available on every personal computer dedicated to patient care since 2010. With COSARA, all infection-related data from the various electronic patient records are integrated and presented to the treating ICU physician by means of a continuously updated clinical dashboard. This includes a graphical display of current and past antibiotic treatments as a timeline, and provides direct links to a real-time copy of the various source records. The graphical interface allows episodes of antibiotic treatment to be labelled according to a predefined list of indications and diagnoses, and linked with microbiological culture results. Labels are made in a two-step approach: a preliminary label is created by completing a short questionnaire that pops up at the time of electronic prescription; and a definitive label can be assigned after review of all relevant data. This can be done during clinical patient rounds, interdisciplinary staff meetings or at any given time. All data are stored in a data warehouse.

The study was approved by the institutional ethics committee. Only patients aged 16 years or more were included. All patients and relatives were informed about the surveillance through a leaflet distributed at ICU admission, which explicitly offered the possibility to opt-out of the study.

Design

The results from CAS were compared with those from PBS over a four-month study period (1st November 2011–29th February 2012). It was estimated that four months of surveillance would allow the inclusion of 100 infections, based upon average observed incidence rates at the study ICU [RTI ($N = 15$/1000 ICU-days), UTI ($N = 5$/1000 ICU-days) and BSI ($N = 5$/1000 ICU-days)] found by previous surveillance in collaboration with the national Scientific Institute of Public Health. An infection was defined as ICU-acquired if it occurred 48 h or more after admission to the ICU. Infections diagnosed at re-admission of a patient who was discharged from the ICU less than 48 h previously were also considered to be ICU-acquired. Only the first infectious episode was included for patients who developed consecutive infections during the same ICU stay. Results of CAS and PBS were compared with a reference set to determine sensitivity and specificity (see below). The time required for data collection using both surveillance systems was recorded per week.

Paper-based surveillance

One of the investigators (GD) screened all ICU patients for the presence of ICU-acquired infection three times per week. GD was blinded to the COSARA graphical display, but had access to all electronic source data and was allowed to contact the treating physician for more information if necessary. The starting point for detection of a potential case of BSI, UTI or RTI was the presence of a pathogenic micro-organism in a blood, urinary or respiratory culture, respectively. In addition, the patient's electronic medical record was screened to detect episodes of clinically suspected RTI treated with antibiotics in the absence of microbiological documentation to ensure completeness of the dataset. PBS used formal checklists that were developed based on Centers for Disease Control and Prevention–National Healthcare Safety Network (CDC–NHSN) criteria,[7] and modified to make them applicable to the ICU patients as described below.

A BSI was defined as the presence of a pathogen (excluding common skin contaminants) in at least one blood culture. The presence of common skin contaminants in at least two blood cultures drawn on separate occasions, together with fever, chills or hypotension, and judged to require antimicrobial treatment by the ICU physician was defined as ICU-acquired BSI.

Urinary cultures were performed quantitatively three times per week on a regular basis as part of the surveillance programme. Symptoms of suprapubic tenderness or dysuria were not considered for UTI as these are difficult to assess in ICU patients.[8] UTI was defined as episodes of sepsis, pyuria (>25 white blood cells/mm^3), a positive urinary culture [growth of a uropathogen $\geq 10^5$ colony-forming units (cfu)/mL], and judged to require antibiotic therapy by the treating physician. All episodes with a positive urinary culture that did not fulfil all of the criteria were considered as asymptomatic bacteriuria and were not retained. Episodes of UTI with the same pathogen growing in urinary and blood cultures were classified as UTI.