HealthManagement
Promoting Management and Leadership

Volume 12, Issue 2 / 2010 - Medtech

Antimicrobial Resistance and Antibiotic Use in the ICU:

Utilising Computer Surveillance to Improve Workflow and Outcomes

COSARA (Computerised Surveillance and Alerting of nosocomial infections, Antimicrobial Resistance and Antibiotic consumption in the ICU) is a software application designed and developed for the registration and integration of infection-related data in the ICU patient. The application architecture consists of three different software modules:

1. **A registration module which in real-time requires the ICU-physician at each (electronic) antibiotic prescription;**
2. **A presentation module which provides the ICU-physician with all infection-related data of the individual ICU-patient in a concise and visually attractive way; and**
3. **An information module which incorporates infection-related data at the level of the ICU and can be used for surveillance purposes and to steer infection control measures.**

Background

Nosocomial (i.e. hospital-acquired) infections are common, and are important contributors to unfavorable clinical and economic outcomes. In Belgium, these no socomial infections are estimated to be responsible for a yearly excess mortality, an additional 607,880 hospitalisation days and a total extra society cost of more than 300 million euro. The ICU is clearly the epicentre of the nosocomial infection problem. Furthermore, it is estimated that 20 to 30 percent of these infections are preventable.

Given the importance of infection control in the ICU, one would expect that the medical files and nursing charts of the ICU patient would include a well documented overview of previous and current infections together with the prescribed antibiotic therapy and the associated microbiological data (i.e. cultured bacteria and antibiograms). Unfortunately however, this is not the case, not even in an ICU that utilises advanced computerisation. As such, the intensivist in charge returning to work on Monday, needs to investigate all infectiological details in a way a detective does, in order to be able to answer the following questions:

- Why was this antibiotic regimen chosen?
- Why was it changed after two days?
- What was the focus of this infection?
- Was this a firm diagnosis, or only a suspicion?
- Is there a positive culture?
- What was the severity of the infection?
- What is the resistance pattern of these cultured bacteria?
- Did the patient respond well to the initialised therapy?
- What is the radiological evolution?

Consulting all these different data sources, and trying to integrate this retained information into a comprehensive infection status of an ICU patient is therefore often a very time consuming and frustrating job.

Furthermore, in the absence of a readily available standardised infection overview, high quality infection data are lacking. These data however, are essential to implement an efficient nosocomial infection surveillance system and to perform advanced clinical research regarding infection control.

Solution

An advanced and user-friendly software application (named the COSARA project) was developed by a consortium of the ICU and Information Technology departments from Ghent University in order to alleviate some of these issues. COSARA is an acronym for "Computerised Surveillance and Alerting of nosocomial infections, Antimicrobial Resistance and Antibiotic consumption in the ICU".

The goals of COSARA are to support the intensivist in the daily workflow by automatic integration of all relevant infection related data from different data sources. Besides a continuously available up-to-date view on all parameters regarding the infectious management for every single patient, the application also provides high quality data surveillance data on the ICU level with respect to incidence, severity and focus of infections, antibiotic drug treatments and the micro-organisms involved, including their resistance pattern. These data are stored in a relational database and can be used for clinical research.

Implementation

In the COSARA project, three main software modules were designed: a registration module, a presentation module and an information module (figure 1). These modules are integrated with the existing hospital information systems.

At the moment of a new prescription of antimicrobial therapy, popup screens appear in real-time on the PC monitor asking for a motivation for the start of this new therapy including the probable focus and the severity of infection. These pop-ups appear on the bedside or on the central PC monitor, depending on the workstation where the intensivist is prescribing the drug. There is no possibility to bypass these pop-up screens. As the registration maximally requires 20 seconds and does not require specialised training, the user acceptance is excellent, both by senior ICU-physicians and by fellows in training.
The presentation module is the core of the COSARA software. In one single surveyable graphical view, the intensivist can consult the selected patients' current and past infections during his/her ICU stay, together with the associated antibiotic therapies. After linking of a certain infection with the related microbial data, the graphical view shows the responsible micro-organism and, only one click away, the related antibiogram. The patient's evolution of infectious laboratory parameters (i.e. CRP, WBC count), together with the automatically captured daily SOFA scores, are shown in a graphical way.

Without any delay in loading time, all available chest X-rays are available in another tab, and even the chest X-rays taken before ICU admission are shown.

In contrast to the presentation module, which is focused on the individual patient level, the information module is entirely focused on the ICU unit level. Incidence of specific infections, antibiotic usage, responsible micro-organism and resistance pattern can be analysed together with their evolution over time. Furthermore, it is possible to perform very advanced and refined queries for academic research.

The benefits of COSARA are the potential to decrease the time to therapeutic intervention in case of infection (on the individual patient level), to decrease the intervention time for targeted infection control measures in case of outbreaks (on the ICU level) and to investigate accurately the impact of infection control programmes and antimicrobial exposure on the incidence of nosocomial infection and microbial ecology, taking into account a maximum of potential confounders. Eventually, the implementation of COSARA as a computer- based surveillance and alerting system will likely result in (1) less nosocomical infections, (2) reduced emergence of resistance, (3) better patient survival, and (4) less costs for the society.

Future Expansions

In a future version, COSARA will be extended to generate specific alerts indicating alarming trends in (i) nosocomial infection incidence, (ii) microbial ecology, and (iii) antimicrobial consumption, using expert based thresholds and longitudinal data analysis. Besides the alerts itself, COSARA will automatically provide the associated information in order to make the interpretation of every alert easy and efficient.

Another extension of COSARA will include the integration of a rule base-expert system assisting the intensivist with respect to the optimal choice and duration of antimicrobial therapies. Already in 1998, Evans showed in an article in the New England Journal that a computerised anti-infectives management programme can improve the quality of patient care and reduce costs. However, at that time, important technological barriers were still present, problems that are now solved within the COSARA software.

Conclusion

Advanced computerisation of the ICU has allowed the development of specific software (COSARA) designed to capture and integrate all data related to infection and antibiotic prescription in the ICU patient. These data are returned to the ICU physician as a comprehensive and up-to-date 'infection status' of the individual patient, assisting in daily decisionmaking. In addition, this software builds up a high-quality database, which provides a sound basis for infection surveillance and control policy as well as testing research hypotheses.

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Published on : Sun, 1 Aug 2010