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A Model Proposal for the Rational Prescription of Antimicrobials in Intensive Care Medicine

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Abstract and objective

Inadequate prescription of antimicrobials has been associated with increased toxicity and selection of resistant strains that adversely affect patient's health, especially for the infections treated in the Intensive Care Units. The AB+K clinical decision support system gathers information from electronic patient records, laboratorial reports, radiological findings, bed-side monitoring devices, antimicrobials and pathogenic agents resistances databases aiming at the choice of a rational antibiotherapy, based on the current condition of the patient and available drugs.

Keywords:

pneumonia, anti-infective agents,
computer-assisted drug therapy, intensive care units

Introduction

Inadequate prescription of antimicrobials has been associated with increased toxicity and selection of resistant strains that adversely affect patient's health and increases the costs of care. This problem is especially relevant for the community and nosocomial infections treated in the Intensive Care Units (ICU) due to the severity and complexity of their patients.

The AntiBiotherapy+Knowledge (AB+K) project aims at the design, development and validation of a solicited decision support system for friendly clinical guidance on the use of antimicrobials in Intensive Care Medicine. The applied decision rules are expected to reflect the expert knowledge on the area but also to validate and, if possible, infer novel knowledge.

Through the combination of several information technologies, clinical expertise and pharmacological concepts, the AB+K system is expected to improve the prescription of antimicrobials in Intensive Care Medicine. The clinical decision support system combines information collected from an Electronic Patient Record (EPR), laboratorial reports, radiological findings, bed-side monitoring devices, an antimicrobials database and a regularly updated model of pathogenic agents resistances in order to help the intensivist in the choice of a rational antibiotherapy, based on the current condition of the patient, the available drugs, and of the resistance profile of the pathogenic agent(s).

This research project may contribute to improve clinical performance concerning the prescription of antimicrobials and to the study of the community and hospital epidemiology of infectious diseases. All this is likely to improve the clinical management of ICU and patient's outcome.

Methods

General architecture

The AB+K decision support module feeds from three main sources: the Intensive.CARE electronic patient record, the Antibio-therapy Knowledge Base and the Medical Guidelines Module.

AB+K is intended to be fully integrated with the EPR. Specific screens are added to the EPR's graphical user interface, allowing the health professional to introduce the patient related values for the decision related variables. Nevertheless, in order to minimize data input by AB+K users, interfaces for other Information Systems (IS) are implemented to enable automatic collection of relevant data. The main sources are administrative applications (such as the Hospital Admition System (HAS)), other EPRs, bed-side monitoring, and laboratory departmental systems, supplying respectively demographic data, clinical data, vital signs reports and laboratory results. All patient related data is stored in a proper database schema.

A different database schema holds the antibiotherapy related data. This database schema is regularly updated with the list of available drugs, their pharmaceutical characteristics, recommendation, possible alternatives, side effects and interactions. Likewise, a regular update is performed on the documented resistances to antibiotics developed by the known pathogenic agents.

Decision rules, expressing the clinical guidelines, are used to infer relations among the variables and suggest a therapy the health professional. The ability to explain thoroughly every expressed suggestion is required to the decision module; hence decision trees are to be shown in

user interfaces. The health professional is asked to validate or refute the suggestions, thus contributing to the evolution of the expert knowledge.

Auxiliary departmental systems

Most Portuguese hospitals use a common Hospital Admission System (HAD). A set of Web Services have been developed to integrate the AB+K system with the HAD, through the EPR. The Clinical Pathology data is also incorporated, via a database level interface that enables the transfer of data between AB+K and the Clinical Pathology Departmental System.

Automatic acquisition of vital signs

The automatic acquisition of vital signs improves the quality and speed of data collection, while enabling the assembly of large electronic archives. Most Vital Signs Monitoring Centrals feature network interfaces that broadcast data in the Health Level 7 (HL7) standard. To take advantage of such a powerful tool, the AB+K framework is provided with a HL7 communication handler. For the time being, received data conveys the patient identification, a timestamp and five physiological parameters: arterial tension (PNIs and PNId), temperature (T), arterial oxygen saturation (SPO_2), cardiac frequency (FC) and respiratory frequency (R).

The AB+K decision module

Arguably, the implementation of internationally accepted medical guidelines is the best way to emulate medical reasoning. The patient current status is usually described in a number of variables (age, sex, symptoms, diagnosis, etc.) that may derive medical guidelines, medical papers on related topics or from the expert own experience. For the time being, AB+K implements the American Thoracic Society guidelines for the management of adults with community-acquired pneumonia, regarding the diagnosis, assessment of severity, therapy and prevention.

Due to the actual scarceness of data, no advanced decision models, like Bayesian networks, Decision Trees or Neural Networks can be yet applied. For any given patient, the decision variables instances are handled as Datalog facts and guidelines are expressed as Datalog rules, evaluated by a Prolog meta-interpreter. The reaches conclusions and respective explinations are sent to the Intensive.CARE interface through a specialized Java-Prolog interface.

The decision process is divided in two phases. Decision variables associated with patient's symptoms, epidemiologic conditions, physical examination, laboratory and radiology findings are handled first, trying to fit the case at hand into one of four distinct etiologies. The health professional is then asked to sanction the reached conclusion, if necessary by navigating the returned decision tree. In case of disapproval, the health professional may override the system suggestion and manually select the correct etiology.

Phase two proceeds from this point on. Specific rules are applied to discover the best possible prescription taking under consideration the list of available drugs, the documented resistances and the patient medical history. Again, the final suggestion, as well as the decision trees, is sent to the interface and the health professional is asked to sanction them.

Expected results

Speed

AB+K is expected to spend no more than 60 seconds in answer computing and delivery, because that is the amount time we consider the health professionals are willing to wait in the intensive care context.

Presentation

Therapeutic suggestions will be presented in an intuitive manner, illustrating the AB+K rationale. This is expected to improve the acceptability of the system, as well as the detection of inappropriate suggestions. Arguably, it will also improve the knowledge of the implemented guidelines by the health professionals using the system.

Integration in daily activities

Whenever possible, the EPR's data forms will be automatically populated with already known values for decision variables, in order to improve usability. These values may originate from the EPR, lab results or other patient data sources. Special attention will be given to the transformation of existing data on current information systems into the input variables used by the clinical decision support system.

Conclusion

Despite the importance of decision support systems for rational antimicrobials prescription in Intensive Care Medicine, many difficulties arise in their practical implementation.

First of all, information is highly scattered through-out many different data sources, possibly with many different data support structures and data access policies. The isolation of some information systems, the non-adoption of communication standards between the already existing data exchanging systems and several other issues of bureaucratic nature constitute great obstacles for the implementation of specialized interfaces to help integrate data.

Another major faced difficulty is the absence of a standard medical ontology that relates several different concepts and denominations hardens the task of expressing medical knowledge. Moreover, medical guidelines are most often subjective, providing great degree of freedom for the interpretation of the rules.