Development and Optimization of a Critical Care Alert and Display (CCAD) System using Retrospective ICU Databases

Brian A. Janz, MD[1.3], Mohammed Saeed[1], Joseph Frassica, MD[2], Gari D. Clifford PhD[1], Roger G Mark, MD, PhD[1.3]

[1]Harvard-MIT, Cambridge, MA, USA

[2]University of Massachusetts Medical Center, Worcester, MA, USA

[3]Beth Israel Deaconess Medical Center, Boston, MA, USA

Introduction

The goal of this research project is to design and optimize a novel critical care alert and display (CCAD) system to assist decision support in the ICU using a massive temporal ICU patient research database [1]. The CCAD system will generate and display abnormal clinical values (Alerts) to the clinician through a user interface designed to allow for the efficient display of data.

Background

Patients admitted to ICUs are generally physiologically labile and require close monitoring, which results in the accumulation of a large amount of physiologic data. This accumulation of data can lead to an overload of information especially for young physicians caring for these patients. It is essential to have the ability to view and display this information in a concise manner to optimize patient care. Being able to review a large amount of chronological information in a short period of time might help the clinician better evaluate the state of a patient in the ICU.

System Design

The CCAD system was designed using the MIMIC II database which is a robust fully de-identified temporal ICU research database recorded from patients in the MICU, SICU, and CCU at Beth Israel Deaconess Medical Center, Boston, MA [1]. The software program was written using C-sharp and compiled in the Microsoft Visual Studio .NET™ environment. The search engine accesses a set of relational databases and sends abnormal values to a Microsoft ACCESS™ database. The graphical user interface imports data from the ACCESS™ database and displays the abnormal values to the clinician. The clinician can then select an abnormal value and display the trend using a variety of different graphical tools.

Results

The search engine and the clinician GUI were both created off-line using the MIMIC II research database [1], which allowed clinicians to assist with the design of the system without altering real-time data or viewing protected health information. Histograms were generated to evaluate the frequency of abnormal values per ICU patient day. 2000 patients were selected from the MIMIC II database. Sixty different common ICU parameters were specified for analysis. For these parameters, there were a total of 56 abnormal values (alerts) generated per patient ICU day. For a 20 bed ICU, that would equate to 1127 total alerts per ICU patient day. When looking specifically at the complete blood count (CBC), 2.9 alerts were generated per ICU patient day. The arterial blood gas (ABG) generated on average 5.8 alerts per ICU patient day. Table 1 provides statistical characterization for CBC laboratory results and associated clinical alerts per ICU patient day.

	# Results	Median +/- Std	# Alerts	Alert Limits	
				High	Low
WBC	3.3	24.5 +/- 17.9	1.0	15	5
Hematocrit	5.2	30.3 +/- 3.6	0.5	40	25
Hemoglobin	3.6	10.1 +/- 1.2	0.16	15	8
Platelets	3.5	197 +/- 112.7	1.2	600	150

Table 2 CBC results and associated alerts in MIMIC II per ICU patient day

Discussion

The de-identified database was helpful with the design and optimization of the CCAD System. This database also helped to increase the efficiency of the design phase by eliminating the need for additional internal review board (IRB) approval and it eliminated the need to use protected health information. The histograms were useful in optimizing the user interface and designing how to display the information to the clinician.

Conclusions

The research database [1] was helpful during the design phase of the software development. The database also allowed for the evaluation of total alerts per patient per day, which assisted with optimizing the graphical user interface.

Acknowledgements

Research supported from National Institute of Biomedical Imaging and Bioengineering Proposal R01 EB001659.

References

1.Saeed, M., et al., *MIMIC II: a massive temporal ICU patient database to support research in intelligent patient monitoring.* Comput Cardiol, 2002. **29**: p. 641-4.