Improving Sepsis Prediction by Advanced Model Development.

M Seisa, MD[1]; I Pessach, MD, PhD[2,3]; A Lipsky, MD, PhD[3]; V Fedosov, MD, PhD[1]; M Dziadzko, MD, PhD[1]; R Siwani, MBBS[1]; BW Pickering, MD[1]; V Herasevich, MD, PhD[1].

1- Multidisciplinary Epidemiology and Translational Research in Intensive Care (METRIC), Department of Anesthesiology and Perioperative Care, Mayo Clinic, Rochester, MN, USA

2- Sheba Medical Center, Tel-Aviv University, Israel

3- Intensix Ltd, Netanya, Israel

Background

Sepsis and septicemia are ranked among the top most costly in-hospital conditions in the US. Conventional management of sepsis, based on early goal-directed therapy, has not significantly decreased mortality in patients with septic shock. A number of efforts are focused on prevention, early prediction and recognition of sepsis both in out-hospital and in hospital settings. This includes quality improvement projects , modeling, development of rule-based surveillance algorithms and alerts. However, the current application of early detection algorithms (sniffers) is limited by a number of factors including: the need for specific environments (ICU, ED or wards) with enhanced continuous monitoring) to provide structured data, low sensitivity and specificity of the sniffers, and implementation barriers. We are aiming to develop a model that can overcome the problem of missing data without negatively influencing the accuracy of the detection algorithm.

Objective

The objective of this study was to test sepsis detection and prediction models compare to gold standard observation in medical ICU.

Methods

Design: We conducted an observational diagnostic performance study using independent derivation and validation cohorts then compared it to the gold standard.

Subjects:. We included all adults (≥ 18 years) patients who admitted to a medical ICU at tertiary academic medical center in Rochester, MN at the period between Aug 5 to Dec 15 2016. We excluded patients who did not provide research authorization.

Gold Standard: The gold standard used in this study for sepsis was clinician confirmation of Mayo Clinic sepsis sniffer and additional manual review by 2 trained reviewers with a third super reviewer for cases of disagreement.

Methods

Prediction model development phases:

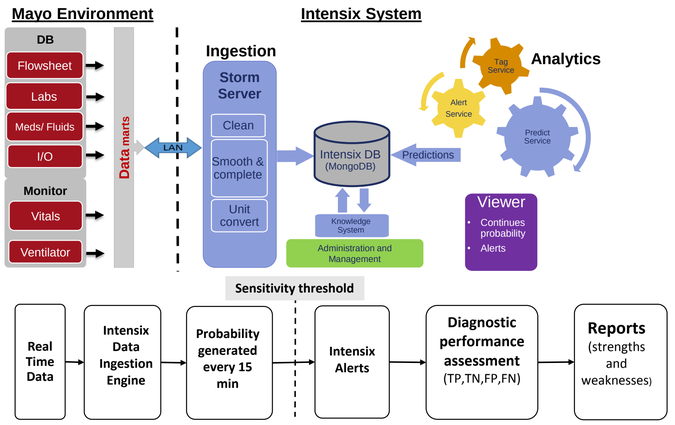
Phase 1: Retrospective primary concepts mapping.

- System integration for real time ingestion to the model for sepsis patients data at the period time from Jan 2010 to Jan 2015.
- Patients with sepsis were identified by a retrospective application of Mayo Clinic sepsis sniffer algorithm and validated using abstraction of ICD9,10 and DRG codes.
- Double validated patients created a true positive cohort. Patients without confirmed sepsis but with positive sepsis alert from sniffer constituted a false positive cohort.
- Records for patients without sepsis were used as a control group and for sensitivity analysis.

Phase 2: Prospective silent system integration and models calibration.

- The bedside monitors at one of Mayo Clinic`s medical ICU were connected to Mango DB “patient monitoring system”, each of which records vital signs and waveform data.
- The data were recorded every 15 minutes.
- Alerts were processed and logged in the system for different sensitivity thresholds (Alert service).
- Review of continues predictor graph vs. clinical condition was done by the viewer (PV).
- System health was monitored internally and reports were generated.

System architecture



Results

During the study 924 patients were under surveillance during study period.

The study cohort comprised of 782 patients who were eligible for study inclusion of whom 43.3% were female, with a median age of 65 years (IQR 77- 53).

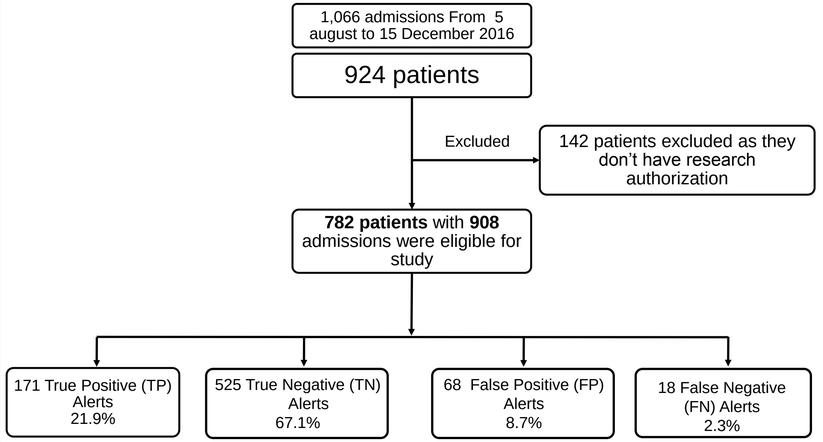
Median ICU length of stay was 35.5 hours (IQR 63.3 - 20.1).

The system shows **Sensitivity** of **90.5%** (CI 85.4 - 94.3%) and **Specificity** of **88.5%** (CI 85.7- 91%).

The **Positive Predictive Value** of system was **71.5%** (CI 66.68 – 76%).

The **Negative Predictive Value** of system was **96.7%** (CI 95 – 97.8%).

Figure



Discussion and Conclusion

We have developed a model for the detection of sepsis in patients admitted to the ICU. The model showed performance comparable to manual review.

We have observed that in our study most septic patients are admitted to ICU with sepsis already developed.

Developed model and system showed high reliability with no down time and ability to proceed flow of data needed for algorithm execution.

Future plans

The nature of machine learning based models is their ability to constantly change and improve as more patient data becomes available. Furthermore, as our model has detected other events, such as massive bleeding, that have signs similar physiological manifestation as sepsis.

Hence, additional studies that will better define the final model and evaluate the algorithm performance in multiple institutions are needed.

References

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Contacts

Vitaly Herasevich, MD, PhD Herasevich.vitaly@mayo.edu

Itai M. Pessach, MD, PhD Itai@intensix.com