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EARLY PREDICTION OF CLINICALLY SIGNIFICANT DETERIORATION OF CRITICALLY ILL PATIENTS

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RATIONALE

Critically ill patients are susceptible to life-threatening events such as sepsis, shock and respiratory failure that result in morbidity, mortality and prolongation of Intensive Care Unit (ICU) stay. A "tool" that will alert the physician that such events are in progress could lead to rapid initiation of appropriate care. The aim of the present study was to develop prediction models for early detection of significant deterioration events. For this purpose, we harnessed the power of machine learning algorithms combined with processing and analysis of large quantities of data, automatically acquired in real-time from the electronic medical record (EMR).

FIGURE 1: SYSTEM ARCHITECTURE

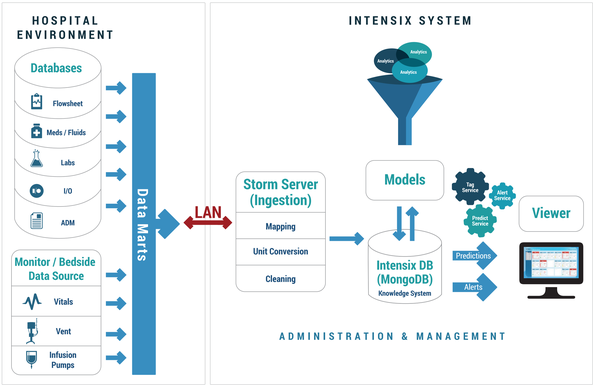

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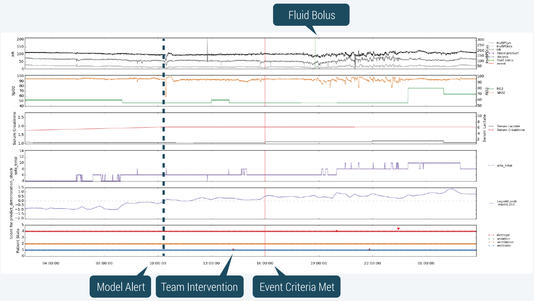
FIGURE 2: CLINICAL RESEARCH INTERFACE

41YO MALE, SPINE FRACTURE, DAY 6 OF ICU STAY



METHODS

All entries including, but not limited to, vital signs, laboratory results, medication orders and procedures were retrospectively obtained from the EMRs of 8220 adult patient admitted to a 16-bed medical surgical ICU in the Tel Aviv Medical Center, a tertiary academic medical center, from 01/2007 to 12/2014. Using the Intensix Ltd. system, a multivariable model for the prediction of clinically significant deterioration was developed. The model was then validated using a separate data set of 1026 stays from 01/2015 to 12/2015. The validated model was further used for a prospective observational study on 72 patients admitted from 05/2016 to 08/2016. The system architecture is depicted in Figure 1. Clinically significant events were defined as deterioration (e.g., hypotension, rise in serum lactate, low PaO2/FiO2 ratio) requiring significant clinical intervention by the team (e.g., initiation of mechanical ventilation, inotropic support).

A representative stay as displayed on the clinician's user interface used for the study is presented in Figure 2.

RESULTS

In the retrospective cohort, 2199 stays had clinically significant events that were automatically tagged by the system and validated by clinicians. A multivariate model to predict events 3-6 hours prior to the event was developed with an AUC of 0.91. The model was then validated on a separate retrospective cohort that included 285 clinically significant events yielding an AUC of 0.86. Prospective observation of 72 patients resulted in early detection of 20 significant events that were later validated by the clinical team. Clinical characteristics of the patients with events are detailed in Table 1. The predictive performance of the models are depicted in Tables 2 and 3.

TABLE 1: STUDY POPULATION CHARACTERISTICS

	Retrospective Cohort 8220 stays N (% of positive stays)	Validation Cohort 1026 stays N (% of positive stays)	Prospective Cohort 72 stays N (% of positive stays)
Age / % Male	57 / 47.3%	58 / 46.8 %	60 / 58.1%
Average LOS / % Mortality	5 / 11.4 %	5.1 / 9.8 %	7 / 1.4%
Total Number of Stays with Significant Deterioration Event	2199 (100%)	285 (100%)	20 (100%)
Need for Inotropic or Vasopressor Support	2066 (94%)	254 (89%)	18 (90%)
Mechanical Ventilation	2084 (95%)	271 (95%)	19 (95%)
Elevated Serum Lactate Levels (>2 mmol/L)	1870 (85%)	235 (82%)	17 (85%)
Need for Antibiotics	2003 (91%)	254 (89%)	20 (100%)
Acute Kidney Injury	1741 (79%)	214 (75%)	13 (65%)
Acute Respiratory Distress Syndrome	2061 (94%)	266 (93%)	15 (75%)

TABLE 2: RETROSPECTIVE PREDICTIVE PERFORMANCE OF THE MODEL

	Sensitivity	Specificity	AUC
Retrospective cohort 8220 stays	0.80 0.90	0.95 0.90	
Validation cohort 1026 stays	0.80 0.90	0.94 0.89	0.86

TABLE 3: PROSPECTIVE PREDICTIVE PERFORMANCE OF THE MODEL

n=72	Predicted True	Predicted False	
Actual True	TP = 18	FN = 2	
Actual False	FP = 2	TP = 50	
Sensitivity = 0.9	Specificity = 0.96	PPV = 0.90	NPV = 0.96

CONCLUSIONS

An early prediction model for significant deterioration of ICU patients was developed using machine learning and advanced data processing of large quantities of clinical data with a relatively high accuracy and reliability. When prospectively applying this technology the system predicted clinically significant events in real-time. Further prospective open studies are needed to validate this model and its utility in improving outcomes.

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