Prediction of stable clinical conditions after elective coronary bypass surgery.

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Objectives

In cardiac surgery, optimal use of intensive care unit (ICU) and operating room (OR) capacity requires the prediction of future availability of ICU beds. Minimal conditions required to start the weaning from mechanical ventilation in these patients are: hemodynamic and respiratory stability, absence of bleeding and normothermia. This preliminary study is a test of 5 advanced data analysis and trend analysis tools, combined with a Gaussian Processes Classifier, to examine the influence of the trends of standard measured clinical variables in the first 4 hours after ICU admission, on the timeframe in which the minimal clinical conditions to start weaning of the mechanical ventilation are reached.

Methods

For 103 patients, measurements of 14 physiological variables obtained from a Patient Data Management System (Metavision®, iMD-Soft®) were used as inputs for developing the mathematical models in this study. Most variables (Heart rate, Systolic, Diastolic and Mean Arterial Blood Pressure, Systolic, Diastolic and Mean Pulmonary Artery Pressure, PEEP, FiO₂, Blood and Peripheral Temperature) were stored every minute from the patient monitor or respirator. Blood loss was recorded manually by the nurses, approximately once every hour. Blood gas analysis was performed at least once every 4 hours (PO₂, Lactate).

Four-hour time intervals of these measurements were used to build several time-series models (Multivariate Autoregressive (MAR), Multiple Inputs/ Multiple Outputs (ARX), Cepstral Coefficients computed directly from the time-series (CEP) and from the ARX parameters (CEPARX), Signal Average). The actual prediction was done by using the parameters of these models as inputs for a Machine Learning algorithm (Gaussian Process Classifier). Including parameters of different types of time-series models as a representation of the time-varying signals, we incorporate knowledge of the dynamical behaviour of the patients. We believe that this will lead to better predictive performances.

The Gaussian Processes Classifier assigned for each patient a probability of belonging to each of the following classes: the patient will meet the clinical criteria within the first 8 hours after admission, between 8 and 16 hours, between 16 and 24 hours and after 24 hours. These predictions were made from the analysis of data from the first 4 hours of ICU stay.

Results

Table 1: Results of the Gaussian Process Classifier

	Before 8h	8h – 16h	16h – 24h	After 24h
Signal Average	0.814	0.565	0.619	0.671
MAR	0.637	0.586	0.545	0.671
ARX	0.601	0.566	0.667	0.620
CEP	0.662	0.724	0.617	0.658
CEPARX	0.729	0.635	0.847	0.700

Each table entry in Table 1 corresponds to the aROC of the corresponding Gaussian Process Classifier through leave-one-out cross-validation.

Conclusions

In general, it is clear that from analyzing the trend and variability of the selected parameters, it is hard to make predictions with good discrimination. For each prediction interval there was at least one model with an aROC above 0.7.

When examining the results in detail, one can see that the further ahead the patient meets the minimal conditions to start weaning of the mechanical ventilation, different inputs will become more predictive for the task, e.g. the CEPARX-input classifier has the best performance for the 16-24h and the > 24 h intervals, whereas the Signal Average-input results in a high performance for the first 8-hour interval.

Future research will try to improve these results by integrating different combinations of model parameters or all model parameters at once, in the Gaussian Process Classifier.