Philips Research is developing a prototype system designed to give timely warning of impending hypotension (abnormally low blood pressure) in Intensive Care Unit (ICU) settings. By using advanced data processing methods to combine vital signs monitoring with other patient data, the system aims to give an early indication of hypotension without adding significantly to the alarm load.

Clinical intervention in Intensive Care Units (ICUs) is often time-critical. ICU patients can deteriorate significantly over a period of minutes to hours to the point where their condition becomes life-threatening. Early detection, diagnosis and treatment of these so-called ‘decompensations’ is therefore critical. One of the most frequent and dangerous decompensations experienced by ICU patients is hypotension (abnormally low blood pressure). Due to the fact that it results in decreased perfusion of the body’s tissues, this condition, if left untreated can result in the rapid failure of vital organs. Some organs like the brain and kidney are very sensitive to these changes in perfusion. Typical causes of rapid onset hypotension in ICUs include cardiogenic shock (acute heart failure) and septic shock. In some ICUs, its incidence can be as high as 25%.

Most existing patient monitoring systems only alert ICU staff once hypotension is already present, typically alarming when the patient’s systolic blood pressure (SBP) or mean arterial pressure (MAP = (2 x systolic pressure + diastolic pressure)/2) falls to a preset threshold. On occasions, this threshold is set as low as 70 mmHg - a level at which significant organ damage can occur if the underlying cause of the hypotension is not rapidly identified and corrected.

Philips Research experimental Hemodynamic Instability Indicator

The research Hemodynamic Instability Indicator prototype software that Philips is developing targets the twin objectives of continuous risk assessment and timely intervention. Using heart rate and blood pressure readings from the normal patient monitoring equipment, together with other patient data and laboratory test results, the system generates a color-coded Hemodynamic Instability Indicator value for each patient. The prototype system displays this value together with the patient’s bed location, on the experimental ICU central nursing station system.

Color coding the indicator value, from green for low risk, to orange for medium risk and red for high risk, is designed to immediately draw attention to patients who are potentially developing hypotension. Clicking on the indicator immediately displays diagnostic information - for example, the patient’s last two or hours of heart rate and blood pressure readings plus relevant data from their lab results and medical history: information valuable to assess the patient well before there is a risk of hypotension-induced organ failure.
**Machine learning**

Based on a patient’s heart rate and blood pressure readings, the experimental software calculates a Vital Signs Instability Index using machine learning algorithms that Philips Research has developed using known outcome data from over 41,000 ICU patients in twenty-five different hospitals. This index is then combined with other information, such as the patient’s lab test results, age and medical history, to present the patient’s overall risk of hypotension in the form of a Hemodynamic Instability Indicator score.

The target for Philips Research was to develop algorithms that could detect hypotension one hour earlier than current patient monitoring systems. Experimental results obtained using known-outcome patient data have already demonstrated that Philips Research’s algorithms achieved a detection specificity of 97% and could do so, on average, around three hours before a patient’s hypotension was actually noticed.

Philips’ experimental Hemodynamic Instability Indicator system will undergo clinical evaluation in hospitals during 2012.

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**The Intensive Care Unit Setting**

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