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**Project:** Early warning of the deteriorating patient

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**Introduction:**
Heart rate variability (HRV) refers to changes in the intervals between heartbeats. This results from interactions between the nerves that automatically speed up the heart (sympathetic nerves) or slow it down (parasympathetic nerves).

The interplay between the opposing sympathetic and parasympathetic nervous systems produces beat-to-beat variability. When a person is at rest, the sympathetic and parasympathetic systems are relatively balanced and thus HRV is high. When a person is deteriorating, their stress response results in higher levels of sympathetic nervous system activity. This causes the two competing systems to become imbalanced, with the sympathetic nervous system dominating, which reduces HRV. Therefore, HRV monitoring gives a non-invasive insight into the balance of these two nervous systems.

Our research aims to assess the potential for HRV monitoring to indicate levels of patient stress, which could alert clinicians to patients who are either failing to recover, or worse, are deteriorating.

This type of analysis is already used in obstetrics through the continuous monitoring of a foetal heart rate (cardiotocography). When it appears that the variability of the baby's heart rate is becoming reduced, this indicates to the clinician that the baby may be distressed, prompting further investigations. Continuous monitoring of HRV is not in routine clinical use in adults.

**Aim:**
The aim of our preliminary research was to characterise HRV trends in high risk post-surgical patients and to assess the feasibility of HRV monitoring as an indicator of patients failing to recover or deteriorating.

**Method:**
Eligible study participants were those undergoing surgery at Christchurch Hospital admitted to the Surgical Progressive Care Unit (SPCU) following surgery. The SPCU receives sicker and more complex patients who require more intensive monitoring following their surgery.

On arrival in the SPCU after their surgery, each patient was fitted with a Garmin Premium Heart Rate Monitor that was linked with wires to two ECG dots placed on the patients' chest. The heart rate monitor picked up the electrical heart signals and sent the beat-to-beat (R-R) intervals to a laptop computer at the bedside, which were continuously recorded.

De-identified copies of the CDHB Adult Observation Chart, during the times each patient had the monitor attached, were reviewed. The patient's nurse was also asked to record any events which might affect the patient's heart rate, such as nursing cares, moving from bed to a chair, doctor visits, nausea and vomiting, physiotherapy, among others.

Using a programme developed in Python software, the standard deviations of the R-R intervals from each patient, during their stay in the SPCU, were assessed to indicate their level of HRV. The HRV was graphed over time and correlated with clinical progress.

**Results:**
Twelve patients consented to participate in the study. However, the heart rate monitor was sometimes unreliable so useful data was captured from only six patients totalling 285 hours.

In general, across the six patients with good data, we found that for each patient there was considerable transient variation in HRV. It appeared that HRV changes rapidly with ordinary changes in the patient's environment, such as moving around or changing posture from lying in bed to sitting. Because of this, it was difficult to distinguish these ordinary changes from possible sinister physiological changes that might occur if the patient were to deteriorate.

What seems to be more useful is the overall trend in the patient's HRV. The clinical condition of five out of the six patients, which did not considerably improve over the time we monitored them, was reflected by their persistent low HRV. In contrast, the HRV rapidly increased in the patient whose clinical condition improved such that he could be discharged from the SPCU the following day. While this result needs to be replicated in a larger group of patients, it suggests HRV monitoring could be used to quantify a patient's recovery from surgery. The benefit of this would be to indicate when a patient is not recovering as expected, which may give early warning before a patient deteriorates further.

Over the course of the study, one of the participants developed atrial fibrillation, which produces a very irregular heart rate. This resulted in a four-fold increase in their HRV. In terms of detecting clinical deterioration, this is an aberration that will need to be taken into account. However, because of the magnitude of change in variability, this monitoring could aid in the diagnosis of atrial fibrillation or other disturbances of heart rate. This potentially valuable use of HRV monitoring at the bedside should be further researched.

**Conclusion:**
Significant deterioration in a patient's condition is a very serious but fortunately rare event. This was not seen in the small number of patients who participated on our study and therefore we were unable to ascertain the impact of clinically significant changes in condition on HRV.

From the limited selection of patients that were studied, we found many normal events can greatly influence HRV, thus it may not be specific enough to draw attention to a clinically significant change in condition. However, HRV monitoring might be used as another diagnostic tool for atrial fibrillation or other tachyarrhythmia's.

Most importantly our results indicate monitored trends in HRV have the potential to show a patient is recovering normally from surgery. If patients fail to recover their normal HRV this might mean they are at risk of further deterioration.