Commentary

Variability science in intensive care – how relevant is it?

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Related to *Research* by Seely *et al*., see page 513

Abstract

The article by Seely *et al*. in this issue of *Critical Care* highlights that variability portend prognosis. Numerous parameters interact to modify variability in intensive care. The commentary discusses why variability can nevertheless accurately estimate prognosis and how easily this can be implemented in the critically ill.

Keywords heart rate, intensive care, prognosis, variability

In this issue of *Critical Care*, Seely and Macklem [1] present a clear and concise overview of several methodologies used to characterize variability. Why is this report important? First, not only does it provide an opportunity to appreciate the principles of the analytical techniques, but it also gives clues for interpreting the results. Those who are unfamiliar with this field of investigation, as well as those who participated in the early time domain and spectral analysis studies but who were somewhat overwhelmed by the complexity of the more recent and elaborate multifractal and entropy analyses, will appreciate this broad overview. Second, the relevance and respective contribution of the various techniques are clearly highlighted. This is an important aspect of the overview because such information is scarce in the medical literature.

Most people would be more interested in the height of the coastal waves that challenge their homes in bad weather than in the average sea level. However, as with many other elaborate research techniques, the practitioner may question the clinical relevance of cardiovascular variability, and why should he or she care about it? The clinical relevance may be even more questionable when one takes into consideration that all of these techniques do require some time and effort. No direct, online, fully automated and sophisticated variability parameters are yet available for application in the critically ill. The investigator must always verify the data before computing the variability estimates. Nonstationarities in the signals confound the time and frequency domain analyses. This also applies to power law and entropy techniques. Artifacts, ectopy, or more sustained arrhythmias will markedly affect calculations and must be carefully detected and corrected for. Many of these events are unpredictable, whereas others, such as those induced by various nursing procedures, physiotherapy and catheter flushing, must be postponed during data acquisition if at all possible. This is somewhat less important for the time domain methods, but it is frequently a key element for the more elaborate variability assessment techniques. In some conditions, obtaining stable and artifact-free recordings devoid of large numbers of ectopic beats is a challenge in itself.

So why spend so much time and effort? One important reason is that variability science can be used in prognostic assessment for critically ill patients. There is abundant evidence that variability portends prognosis, longer length of stay in the intensive care unit (ICU) and arrhythmias, as well as subsequent illness severity and organ failure [1]. Preserved variability is frequently a sign of good health. Heart rate variability is maximal when there is full interplay between vagal and sympathetic drive to the sinus node. In severe heart failure vagal activity is absent and sympathetic drive is maximal. As a result, variability decreases. Even low-frequency variability in heart rate – a parameter that traditionally was considered a marker of sympathetic activity in conditions of

ICU = intensive care unit.

less marked sympathoexcitation – disappears in patients with severe heart failure [2]. This does not render this parameter clinically irrelevant because the disappearance of low-frequency oscillations in heart rate has important negative prognostic implications [3]. Thus, the predictive value of altered heart rate oscillations remains valid, even if they are unlikely to provide a reliable surrogate of cardiac sympathetic tone. Changes in heart rate variability are not specific for cardiac failure and are observed in a wide range of common diseases in the ICU; patients who recovered with good outcome after neurosurgery also had greater low-frequency oscillations in their heart rate than those who did not [4].

Many different parameters interact together to modify cardiovascular variability in the ICU. For example, organ dysfunction and β-adrenergic downregulation, but also adrenergic agents, decrease heart rate variability [5], whereas invasive ventilation enhances respiratory oscillations. The list of medications that affect heart rate variability is impressive. Thus, variability studies may not allow one to disentangle the precise physiological mechanisms that are involved in heart rate variability alterations in the ICU. In such conditions, one could even wonder how heart rate variability parameters can provide estimates of prognosis. The explanation may reside in the fact that heart rate variability represents a summary of the impact of several diseases and therapeutic interventions into single prognostic parameters.

Another interesting field of research that employs techniques very close to those presented by Seely and Macklem [1] is analysis of the interactions between different parameters in the critically ill. Under normal conditions the arterial baroreceptors reduce blood pressure changes through compensatory fluctuations in heart rate. This homeostatic mechanism becomes ineffective in several conditions, which carries independent negative prognostic information [4,6]. Many more interactions between systems and organs are still largely unexplored, and their study in the ICU would be worthwhile. For example, heart rate fluctuations are closely related to those in electroencephalographic activity during normal sleep [7]. However, very little is known regarding how heart rate variability relates to electroencephalographic activity in the ICU patient, and whether this has any prognostic implications.

Further large-scale, multicentre studies are needed to delineate the prognostic significance of variability in ICU patients. We may end up with a useful and widely accepted prognostic tool for the clinician.

Competing interests

The author(s) declare that they have no competing interests.

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