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EDITORIAL

Blood pressure stability: a road to better outcomes

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Maintaining hemodynamic stability is emphasized as an important goal during anesthesia training. Stable blood pressure exemplified by the "railroad track" blood pressure recordings in anesthesia chart is equated with high quality anesthesia delivery. However, the relationship between blood pressure stability during surgery and the postoperative outcome is unclear. For example, we know that low blood pressure during surgery [1] and in critically ill patients [2] is associated with worse outcomes, thus should be avoided. But the defintion of blood pressure stability is unclear. Patients with stable blood pressure can be identified if they have low blood pressure variability measured by; standard deviation, coefficient of variation, average real variability, or generalized average real variability. Nevertheless, in this issue, Yoon et al. [3] calculated blood pressure stability using performance measurement of MAP (mean arterial pressure) using median performance error (MDPE) and median absolute performance error (MDAPE), and wobble, using preoperative blood pressure as a reference value. MDPE is a measure of bias, in this case how far the intraoperative blood pressure deviated from baseline blood pressure. MDAPE is a measure of accuracy, in this case closeness of the measured intraoperative blood pressure to the baseline. Infact, wobble is a measure of MAP varibaility independant of baseline pressure. The use of performance measurement is interesting, which otherwise is commonly used in pharmacokinetic studies to measure difference in predicted and actual concentration.

Yoon et al. [3] evaluated the relationship between blood pressure stability and postoperative mortality in patients undergoing cardiac surgery requiring CPB (cardiopulmonary bypass). The intraoperative invasive MAP was obtained from the electronic patient medical records every 2.5 min. All MAP data were categorized into pre-CPB, CPB, and post-CPB periods. Among 1203 patient, 28 (2.3%) died at 30 days and 88 (10.6%) died at 1 year. The median [IQR] baseline MAP was similar, 83[77–90] in survivor vs. 85[78–95] mmHg in non-survivors. But the overall intraoperative MAP was higher in survivors compared to non-survivors, suggesting the benefit of tight blood pressure control. Using Cox proportional hazard model, higher MADPE and lower MDPE, during all time periods, was associated with higher mortality. In other words, if the intraoperative blood pressure readings were closer to baseline the mortality was low. However, time dependent variance, wobble, was largely similar in survivor and non-survivors which is consistent with current evidence. Authors concluded that proportional variation in MAP from the preoperative reference value, a measure of blood pressure stability, predicts 30-day mortality.

Measuring deviation of blood pressure from the baseline is different from previously reported methods of blood pressure variability which do not depend on baseline blood pressure. It can be argued that Yoon et al. [3] measured the relationship between tight blood pressure control from baseline and postoperative mortality. Actual measure of blood pressure variability is coefficient of variance. Coefficient of variance, defined as the standard deviation divided by the mean, is a dimensionless number. For example, in cardiac surgery patients Jinadasa et al. [4] used one invasive blood pressure reading every 15 s to measure of blood pressure variability using coefficient of variance. Authors reported a statistically significant association between increasing systolic blood pressure variability and 30-day mortality and renal failure. One other key difference is sampling rate, how often the blood pressure was measured and analyzed. Despite availability of continuous invasive blood pressure Yoon et al. [3] used one reading in 2.5 min, compared to every 15 s, which can affect the measure of blood pressure variability.

Similarly, in cardiac surgery patients Aronson et al. assessed blood pressure variability as the product of magnitude and duration or area under the curve of systolic blood pressure excursions outside defined blood pressure ranges.

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Systolic blood pressure ranges were analyzed from 65 to 135 mm Hg intraoperatively and 75 to 145 mm Hg pre- or postoperatively. Authors concluded that perioperative blood pressure variability is associated with 30-day mortality in cardiac surgical patients [5]. In ambulatory setting, 24-h blood pressure variability adversely affects cardiovascular complication rate in hypertensive patients [6].

However, Hansen et al. followed 8938 subjects for an average 11 years and concluded that blood pressure variability assessed from 24-h ambulatory recordings did not contribute much to risk stratification beyond 24-h blood pressure [7]. They measured baseline standard deviation and average real variability in 24-h ambulatory blood pressure recordings. Similarly, in noncardiac surgery patients Mascha et al. reported only a mild association between intraoperative MAP variability and postoperative mortality [8]. Whereas hypotension below absolute MAP thresholds was strongly associated with postoperative mortality. Mascha et al. modified the average real variability technique to account for different time interval between blood pressure recording and called it generalized average real variability in blood pressure (ARV-MAP). The units for ARV-MAP are mmHg/min, so an ARV-MAP of 1 would mean that the MAP changes on average approximately 1 mmHg, in either direction, between consecutive minutes during the case for a given patient [8].

$$\text{Generalized ARV} = \frac{1}{T}\sum_{k=1}^{N-1}\left|\text{BP}_{k+1} - \text{BP}_{k}\right| \text{ mmHg/min}$$

ARV is the average real variability, BP is the blood pressure, N is the the number BP readings, t is the the time interval between each set of BP readings, BP_k and BP_{k+1}, T is the total time from first to last BP reading. From Mascha et al.

Other common measures of blood pressure variability are respiratory variation in systolic pressure and pulse pressure. Systolic pressure variation and pulse pressure variation are used to assess fluid responsiveness in patient on controlled ventilation [9]. Thus blood pressure stability and variability have very different meaning. We need to standardize statistical methodology, time interval between blood pressure readings, and the clinical setting to truly compare different blood pressure variability studies.

The use of performance measure variables to characterize blood pressure stability is novel but we need to be clear that it actually is proportional variation in MAP from the preoperative reference value. Furthermore, varied impact of performance measurement variables on mortality across different time-periods, pre-CPB, CPB, and post-CPB, makes it difficult to draw robust conclusion. Nonetheless, authors should be congratulated for thinking out of the box to measure blood pressure stability.

Compliance with ethical standards

Conflict of interest Dr Maheshwari is consultant with Edwards Lifesciences and Dynocardia.

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