HOW SHOULD THE STROKE VOLUME VARIATION BE CALCULATED, INSIGHTS FROM A MATHEMATICAL MODEL

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Background and Goal of Study

The universal formula of PPV is:

$$PPV = \frac{PP_{\max} - PP_{\min}}{(PP_{\max} + PP_{\min})/2}$$

However, there are different aspects in calculating and using the formula of SVV.

- SVV can be calculated as the mean of the SVVs of each individual respiratory cycle (RC) (I-approach) or as the mean of the pooled Stroke Volumes (SV) of all RCs (P-approach). (Figure 1)
- The number of RCs can vary¹.
- Also the heart rate/mechanical ventilation rate ratio (HR/MVR) is known to influence the predictive value of SVV.²

This simulation study investigates the impact of these different calculation methods on the accuracy of the calculated SVV, and this across a wide range of HR/MVR.

Materials and Methods:

- A mathematical model was build based on the assumption that venous inflow follows a sinusoidal curve. Variation was arbitrarily set at 20%. (Figure 2)
- This curve was then partitioned into equal segments. The length of the segments depended on the HR/MVR ratio.
- SVs were simulated by the integral of the curve over the individual segments.
- Each calculation was repeated 100 times, using a different phase lag between the beginning of the RC and the beginning of the first SV.

For each HR/MVR ratio between 1 and 8, the medians of the calculated SVVs were compared according to the number of included RC's (1 to 5) and to the I- and P-approach.

Figure 1: Schematic representation of methods to determine PPV

Figure 2: Schematic representation of the mathematical model

Results and discussion:

- With only one RC, there is a systematic underestimation of the SVV, which is most pronounced at lower HR/MVR ratios. Tolerating a 10% error margin, a minimum HR/MVR of 5.6 is needed for a reliable calculation of SVV. (Figure 3)
- With the P-approach, including more RCs results in an upward shift of the curve and a leftward shift of the 10% error threshold. (Figure 4)
- When using the I-approach, these effects were absent. (Figure 4)

Conclusions:

- The P-approach gives a more accurate estimation of the SVV, with an optimal number of 4 RCs.
- Further simulations, using different set variations, and implementation of the concept in clinical studies are needed to confirm these effects and apply the principles in clinical practice.

References:

¹ Michard Anesthesiology 2005 ² De Backer Anesthesiology 2009

Figure 3: Calculating SVV with only 1 RC

Figure 4: Calculating SVV with 1-5 RCs using the P-approach (curve on the left) and the I-approach (curve on the right)