The effect of sample duration on the robustness of pulse-pressure variation during ongoing surgery

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I. Introduction & aim

Intraoperative hemodynamic optimization using goal-directed volume expansion reduces postoperative morbidity and hospital stay. To guide volume expansion and predict fluid responsiveness, pulse pressure variation (PPV), derived from the arterial blood pressure (ABP), has been proposed [1]. Clinical practice has adopted PPV algorithms with extended pulse-pressure sample durations spanning multiple ventilation cycles [2,3]. The validity of these PPV algorithms to predict fluid responsiveness under stable hemodynamic conditions is well established. However, little is known about their performance in the face of rapid-changing blood pressure, which often occurs during ongoing surgery. In this paper, we study the effect of the sample duration on the robustness of the PPV algorithm during ongoing surgery.

II. Methods

Invasive ABP signal was continuously recorded at the radial artery with a catheter (Philips Heartstart MRx monitor). A total of 91.2-hour data from 29 patients undergoing major abdominal surgery was used for the analysis. We identified a common pattern in the PPV values that concerning the robustness of PPV algorithm. This pattern is a short-term elevation of the PPV values: a 10-40 second increase in median PPV values larger than 2 percentage points compared to the PPV values in preceding 40 seconds and following 40 seconds. This temporal deviation originates from the PPV calculation formula. When the pulse pressure gradually changes over a time span of several ventilation cycles, the difference between the pulse pressure extrema is artificially amplified, leading to temporarily elevated PPV values. Thus, this no longer reflects true volume status and may confuse clinicians. To investigate how this pattern affects PPV calculation, we computed the occurrence rate of this event as indicators inversely related to the performance. We considered three algorithms that all shared the structure of the original definition: the formula to calculate raw PPV, three-point mean filter to post-process raw PPV. The tested algorithms only differed in sample duration: one ventilation cycle, eight seconds, and ten seconds.

III. Results

The occurrence rates of short-term elevations for the PPV algorithms are 1.9, 2.4, and 2.6 times per hour, for sample durations of 1 ventilation cycle, 8 seconds, and 10 seconds, respectively.

IV. Compliance with ethical requirements

A. Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

B. Statement of Human and Animal Rights

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. The study protocol was reviewed and approved by the regional medical ethics committee (METC Brabant, The Netherlands, NL48421.028.14-P1409).

V. Conclusions

Extended sample durations increase the occurrence rate of temporal elevations of the PPV during ongoing surgery. This happens when the pulse pressure gradually changes over a time span of several ventilation cycles. Such short-term elevations that may complicate clinical decision making on fluid loading in the operating room.

Conflict of Interest

W.H. Peeters, R. Bezemer, X. Long, I. Paulussen, and R.M. Aarts are employed by Philips, and G.J. Noordergraaf

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