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### Continuous non-invasive haemodynamic monitoring

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## INVITED COMMENTARY

## Continuous non-invasive haemodynamic monitoring: a beneficial impact on patient outcome is needed to gain ‘confidence in the technology’

Bernd Saugel and Thomas W.L. Scheeren

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This Invited Commentary accompanies the following original article:

Meidert AS, Nold JS, Hornung R, *et al.* The impact of continuous non-invasive arterial blood pressure monitoring on blood pressure stability during general anaesthesia in orthopaedic patients: A randomised trial. *Eur J Anaesthesiol* 2017; 34:716–722.

Innovative technologies enable arterial blood pressure (BP) and cardiac output (CO) to be measured continuously and non-invasively using pulse contour analysis.<sup>1–4</sup> Therefore, in theory, for advanced haemodynamic management in the perioperative setting, there is no need to insert arterial, central venous or pulmonary artery catheters. In this setting, ‘finger cuff methods’ (vascular unloading technology, volume clamp method) seem to offer promise for continuous haemodynamic monitoring; in a recent editorial, it was even speculated that ‘it is only a matter of time until volume clamp devices replace many if not the majority of arterial catheters for the continuous measurement of blood pressure, arterial respiratory variation, and even non-invasive cardiac output monitoring’.<sup>5</sup>

But before this, innovative finger cuff technologies for continuous non-invasive haemodynamic monitoring still have to jump several hurdles. Numerous validation studies comparing these devices with invasive reference methods are available for both arterial BP and CO. These studies show conflicting results<sup>6–8</sup> and demonstrate that clinical applicability is still limited with regard to signal quality and stability.<sup>9</sup> Taking the cumulative evidence of

these validation studies (these usually include selected critically ill or high-risk surgical patients) into account, the available systems are – as expected – not interchangeable with invasive ‘gold standards’.<sup>6–8</sup> Nevertheless, we still seem to be unsure whether we expect these new finger cuff methods to replace arterial catheters or to replace/complement the oscillometric upper arm cuff (thus, enabling haemodynamic variables to be monitored continuously instead of only intermittently). The latter option seems more promising given the fact that critically ill patients in the ICU and high-risk surgical patients will continue to have arterial and central venous catheters for the foreseeable future.

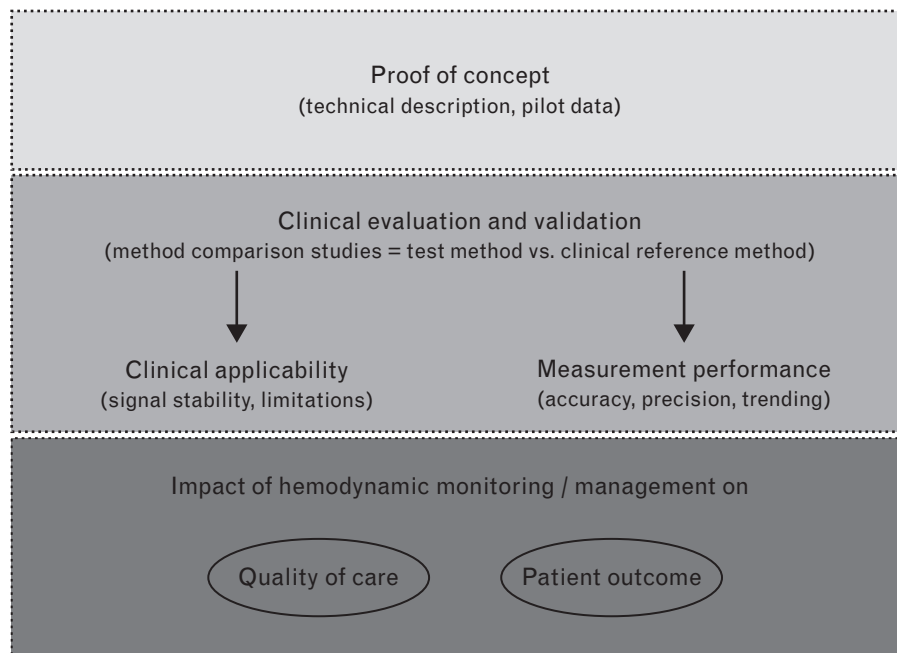
Thus, following evaluation and validation studies illustrating the measurement performance (accuracy, precision and trending ability) and clinical applicability of a new non-invasive method compared with a reference method under study conditions, we may put emphasis on clinical studies evaluating whether haemodynamic management based on continuously and non-invasively assessed variables can actually improve the quality of care or patient outcomes in a certain clinical setting (Fig. 1).

In this sense, the study published by Meidert *et al.*<sup>10</sup> in this issue of the journal provides important insights on how finger cuff methods might improve the quality of care during induction of general anaesthesia. The authors randomised 160 orthopaedic surgical patients with a history of chronic hypertension to either the study group (continuous non-invasive arterial BP monitoring during induction of anaesthesia in addition to intermittent oscillometric arterial BP monitoring) or to the control group (intermittent oscillometric arterial BP monitoring only) and analysed the arterial BP values in the first 60 min after induction of anaesthesia. The authors noted that at

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Fig. 1



Steps when studying innovative haemodynamic monitoring technologies. After initial proof of concept studies, innovative haemodynamic monitoring technologies are validated and evaluated in clinical method comparison studies to assess the clinical applicability and the measurement performance. Finally, the impact of haemodynamic management, based on the variables assessed with the haemodynamic monitoring technology, on quality of care or patient outcome is studied.

12 and 15 min after anaesthesia induction, the mean arterial BP was significantly higher in the study group than in the control group (with markedly fewer mean arterial BP readings <55 mmHg); thus, the authors conclude that continuous arterial BP monitoring contributes to arterial BP stability during induction of general anaesthesia. Taking the association of even short phases of 'intraoperative hypotension' with postoperative organ dysfunction into account,<sup>11,12</sup> the authors' findings can provide at least indirect evidence that continuous arterial BP surveillance may improve the quality of care (and perhaps patient outcomes) as compared with intermittent arterial BP measurements.

In line with the findings of Meidert *et al.*, in a previous small randomised controlled trial, the duration of hypotension in patients undergoing surgery in a beach chair position was significantly less using continuous rather than intermittent non-invasive arterial BP monitoring.<sup>13</sup>

In addition, it has been shown that continuous non-invasive arterial BP monitoring with finger cuff technologies enables arterial BP changes to be detected earlier than with intermittent oscillometric arterial BP monitoring in emergency department patients,<sup>14</sup> in patients undergoing gastrointestinal endoscopy,<sup>15</sup> and in patients undergoing Caesarean section with spinal anaesthesia.<sup>16</sup>

In general, when compared with arterial catheter-derived arterial BP measurements, the accuracy and precision of oscillometric upper arm cuff arterial BP measurements has been demonstrated repeatedly to be poor.<sup>17</sup> Nevertheless, oscillometry is used with great confidence as a 'clinical gold standard' in the vast majority of surgical patients. Thus, one might surmise that intermittent oscillometric arterial BP monitoring is used routinely more because of the users' deep-rooted 'confidence in the technology' rather than because of objective validation data.

So, what has to be done to gain more knowledge on the actual clinical value of continuous haemodynamic monitoring with finger cuff technologies in perioperative care? Despite the undisputed need for solid validation studies,<sup>9,18</sup> more clinical studies aimed at showing beneficial impact on quality of care or patient outcomes are needed. Such studies are key for the implementation of continuous non-invasive monitoring with finger cuff technologies both for routine perioperative haemodynamic management and for allowing anaesthesiologists to gain the 'confidence in the technology' that is needed to use continuous finger cuff technologies instead of traditional intermittent upper arm cuff oscillometry. As most anaesthesiologists will at first be reluctant to use new technologies such as the volume clamp method using finger cuffs, ultimately, only evidence for improved patient care

will convince them to incorporate it into their clinical practice.

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