

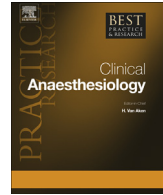


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Monitoring high-risk patients: minimally invasive and non-invasive possibilities



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Over the past decades, there has been considerable progress in the field of less invasive haemodynamic monitoring technologies. Substantial evidence has accumulated, which supports the continuous measurement and optimization of flow-based variables such as stroke volume, that is, cardiac output, in order to prevent occult hypoperfusion and consequently to improve patients' outcome in the perioperative setting. However, there is a striking gap between the developments in haemodynamic monitoring and the increasing evidence to implement defined treatment protocols based on the measured variables, and daily clinical routine. Recent trials have shown that perioperative morbidity and mortality is higher than anticipated. This emphasizes the need for the anaesthesia community to address this issue and promotes the implementation of proven concepts into clinical practice in order to improve patients' outcome, especially in high-risk patients. The advances in minimally invasive and non-invasive monitoring techniques can be seen as a driving force in this respect, as the degree of invasiveness of any monitoring tool determines the

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frequency of its application, especially in the operating room (OR). From this point of view, we are very confident that some of these minimally invasive and non-invasive haemodynamic monitoring technologies will become an inherent part of our monitoring armamentarium in the OR and in the intensive care unit (ICU).

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Introduction

According to the well-proven medical motto 'Primum non nocere', we are urged to manage our patients in line with the highest available evidence with respect to monitoring technologies and treatment protocols. Over the past decades, substantial advancements in the field of less invasive haemodynamic monitoring technologies were achieved, which helped continuously measure and optimize flow-based variables such as stroke volume (SV), that is, cardiac output (CO), in order to prevent occult hypoperfusion and circulatory failure. However, there is a striking gap between the developments in haemodynamic monitoring and the increasing evidence to implement defined treatment protocols and daily clinical routine. Although this topic is relatively unclear, a large body of evidence is available, showing that early goal-directed therapy (GDT) protocols based on minimally invasive monitoring technologies are beneficial in terms of a rational fluid management approach, aimed to preserve and/or to restore euvolaemia.

Recent trials have shown that perioperative morbidity and mortality is higher than anticipated [1]. This emphasizes the need for the anaesthesia community to address this issue and promotes the implementation of proven concepts into clinical practice in order to improve patients' outcome, especially in high-risk patients. The advances in minimally invasive and non-invasive monitoring technologies can be seen as a driving force in this respect, as the degree of invasiveness of any monitoring tool determines the frequency of its application, especially in the operating room (OR). From this point of view, we are very confident that some of these minimally invasive and non-invasive haemodynamic monitoring technologies will become an inherent part of our monitoring armamentarium in the OR and in the intensive care unit (ICU), even in the high-risk patient.

The aim of the present article is to give a brief overview of the commonly used minimally invasive and non-invasive possibilities of haemodynamic monitoring and optimization strategies in high-risk patients. We discuss their value based on the currently available literature with respect to the impact on the perioperative management of the high-risk patient.

Three main issues are addressed:

1. The patient at higher risk and perioperative outcome
2. Discussion of the clinically most relevant minimally invasive and non-invasive haemodynamic monitoring technologies and their clinical impact on the high-risk patient population
3. What is known about minimally invasive- or non-invasive-driven optimization protocols in high-risk patients

Finally, we propose a stepwise haemodynamic monitoring concept based on the previously discussed aspects.

The high-risk patient and perioperative outcome

Over the past several years, there has been an increasing demand for surgical care by patients of any age, from premature infants up to nonagenarians. A recent estimation on the need for surgery worldwide, based on a global population of approximately 6.9 billion people in the year 2010, yielded at least 321 million surgical procedures worldwide [2,3]. Although <15% of inpatient procedures are performed in high-risk patients, such patients account for 80% of deaths [4–6]. The

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