BJA

British Journal of Anaesthesia, ■ (■): 1–10 (2018)

doi: 10.1016/j.bja.2018.01.033
Advance Access Publication Date: xxx
Clinical Investigation

CLINICAL INVESTIGATION

Different methods of modelling intraoperative hypotension and their association with postoperative complications in patients undergoing non-cardiac surgery

L. M. Vernooij[1,2,*], W. A. van Klei[1], M. Machina[3], W. Pasma[4], W. S. Beattie[3] and L. M. Peelen[1,2]

[1]Department of Anesthesiology, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands, [2]Department of Epidemiology, Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands, [3]Department of Anesthesia and Pain Management, University Health Network, Toronto, ON, Canada and [4]Department of Intensive Care Medicine, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands

*Corresponding author. E-mail: l.m.vernooij@umcutrecht.nl.

Abstract

Background: Associations between intraoperative hypotension (IOH) and postoperative complications have been reported. We examined whether using different methods to model IOH affected the association with postoperative myocardial injury (POMI) and acute kidney injury (AKI).

Methods: This two-centre cohort study included 10 432 patients aged ≥50 yr undergoing non-cardiac surgery. Twelve different methods to statistically model IOH [representing presence, depth, duration, and area under the threshold (AUT)] were applied to examine the association with POMI and AKI using logistic regression analysis. To define IOH, eight predefined thresholds were chosen.

Results: The incidences of POMI and AKI were 14.9% and 14.8%, respectively. Different methods to model IOH yielded effect estimates differing in size and statistical significance. Methods with the highest odds were absolute maximum decrease in blood pressure (BP) and mean episode AUT, odds ratio (OR) 1.43 [99% confidence interval (CI): 1.15–1.77] and OR 1.69 (99% CI: 0.99–2.88), respectively, for the absolute mean arterial pressure 50 mm Hg threshold. After standardisation, the highest standardised ORs were obtained for depth-related methods, OR 1.12 (99% CI: 1.05–1.20) for absolute and relative maximum decrease in BP. No single method always yielded the highest effect estimate in every setting. However, methods with the highest effect estimates remained consistent across different BP types, thresholds, outcomes, and centres.

Editorial decision: February 7, 2018; **Accepted:** February 7, 2018

Conclusions: In studies on IOH, both the threshold to define hypotension and the method chosen to model IOH affects the association of IOH with outcome. This makes different studies on IOH less comparable and hampers clinical application of reported results.

Keywords: intraoperative period; hypotension; statistical models; troponin; acute kidney injury

Editor's key points

- Hypotension is variably defined in most perioperative studies.
- This study found that less stringent definitions were associated with a lower incidence of complications.
- Both relative and absolute changes in blood pressure (BP) thresholds correlated with complications.
- No single, best BP threshold or definition of hypotension could be identified.

Intraoperative hypotension (IOH) commonly occurs in patients undergoing non-cardiac surgery and has been a topic of growing research interest in recent years.[1–3] Serious postoperative complications have been associated with IOH, including acute kidney injury (AKI),[4–6] myocardial injury,[5–7] stroke,[8] delirium,[9] and mortality.[10–12]

However, IOH has proved difficult to define. In a systematic review, 140 different definitions of IOH in terms of what threshold to use were found in 130 different scientific articles.[13] Depending on the applied definition, the incidence of IOH varied between 5% and 99%. Accordingly, the interpretation of reported associations based on IOH is complex.

Next to defining IOH, no standardised methodology currently exists on how to express the severity of hypotension in statistical models. Commonly used methods to reflect clinical important IOH involve presence of hypotension, number of hypotensive episodes,[7,14] duration,[4,5,8] decrease below blood pressure (BP) threshold,[14] or a combination of the latter (expressed as area under the threshold).[7] Comparison of research papers reporting the same association between IOH and an outcome could be complicated if the method to reflect the severity of IOH varies between the publications. We hypothesise that different methods to model IOH will affect the association found between IOH and clinically important postoperative outcomes.

In this two-centre cohort study, we examined whether the method used to express the severity of IOH affects the association with postoperative outcomes. To check consistency of our findings, we conducted the comparison between methods to model IOH using different thresholds to define IOH, in two different hospitals, and on two postoperative outcomes: postoperative myocardial injury (POMI) and postoperative AKI.

Methods

Study design and population

This was a retrospective two-centre observational cohort study including patients undergoing non-cardiac surgery at the University Medical Center Utrecht (UMCU), Utrecht, The Netherlands, between January 1, 2010 and December 31, 2012 or at the University Health Network Toronto (UHNT), Toronto, Canada between January 2, 2010 and December 31, 2014. In both hospitals, the local ethics committees approved the study protocol and waived the need for informed consent (UMC Utrecht Medical Research Ethics Committee, protocol number 12–425; University Health Network Research Ethics Board, protocol number 06-0193-AE, respectively).

Eligible patients were aged ≥50 yr, underwent intermediate or high risk non-cardiac surgery under general or spinal anaesthesia with a postoperative hospital stay of ≥24 h. Reoperations within 30 days or within the same hospital admission were excluded from the analysis; if patients underwent surgery during another hospital admission at least 30 days after the first surgery, then this procedure was considered a novel case. Patients were excluded if intraoperative BP measurements were not available or if the anaesthesia duration was <20 min. In the UMCU, only patients aged ≥60 yr were included as outcomes were not routinely measured in younger patients.

Data collection

All preoperative and postoperative data were collected previously from electronic medical and administrative records for another study from which the results have been reported elsewhere.[7] Intraoperative BP measurements were extracted from the anaesthesia information management system after designing the current study. Invasive BP measurements were recorded per minute, whereas non-invasive BP measurements were stored every 3–5 min. When both invasive and non-invasive BP measurements were available, the combination of both measurements was used to analyse IOH.

Thresholds for IOH

As there is not a single threshold to define hypotension, we chose eight different thresholds; four absolute thresholds [i.e. mean arterial pressure (MAP) <50 mm Hg, MAP <60 mm Hg, systolic blood pressure (SBP) <70 mm Hg, SBP <90 mm Hg] and four relative thresholds (i.e. 20% and 40% below baseline BP for both MAP and SBP). Relative thresholds were calculated with respect to baseline BP, which was obtained for each patient by averaging all valid available BP measurements in the operating room before induction of anaesthesia. An algorithm to calculate time of induction has been previously described for the UMCU cohort.[13] In the UHNT cohort, time of induction was defined as the first end-tidal carbon dioxide reading. Patients were excluded from the analyses regarding relative thresholds if no baseline BP could be calculated as a result of unavailability of pre-induction BP measurements.

Methods to model intraoperative hypotension

We selected 12 different methods to model IOH. Selection was based on a systematic literature search on methods that were