

## REVIEW ARTICLE

# Intraoperative hypotension and the risk of postoperative adverse outcomes: a systematic review

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## Abstract

**Background:** Intraoperative hypotension is a common side effect of general anaesthesia and might lead to inadequate organ perfusion. It is unclear to what extent hypotension during noncardiac surgery is associated with unfavourable outcomes.

**Methods:** We conducted a systematic search in PubMed, Embase, Web of Science, and CINAHL, and classified the quality of retrieved articles according to predefined adapted STROBE and CONSORT criteria. Reported strengths of associations from high-quality studies were classified into end-organ specific injury risks, such as acute kidney injury, myocardial injury, and stroke, and overall organ injury risks for various arterial blood pressure thresholds.

**Results:** We present an overview of 42 articles on reported associations between various absolute and relative intraoperative hypotension definitions and their associations with postoperative adverse outcomes after noncardiac surgery. Elevated risks of end-organ injury were reported for prolonged exposure ( $\geq 10$  min) to mean arterial pressures  $< 80$  mm Hg and for shorter durations  $< 70$  mm Hg. Reported risks increase with increased durations for mean arterial pressures  $< 65$ – $60$  mm Hg or for any exposure  $< 55$ – $50$  mm Hg.

**Conclusions:** The reported associations suggest that organ injury might occur when mean arterial pressure decreases  $< 80$  mm Hg for  $\geq 10$  min, and that this risk increases with blood pressures becoming progressively lower. Given the retrospective observational design of the studies reviewed, reflected by large variability in patient characteristics, hypotension definitions and outcomes, solid conclusions on which blood pressures under which circumstances are truly too low cannot be drawn. We provide recommendations for the design of future studies.

**Clinical registration number:** (PROSPERO ID). CRD42013005171.

**Keywords:** acute kidney injury; hypotension; mortality; myocardial ischemia; stroke

**Editor's key points**

- In a systematic review of the association between intraoperative hypotension and adverse postoperative outcomes in noncardiac surgery, 42 relevant studies were identified and analysed.
- Elevated risks of end-organ injury were reported for exposures to mean arterial pressures <80 mm Hg for >10 min, and for shorter durations <70 mm Hg.
- Elevated risks were reported for increased durations for mean arterial pressures <65–60 mm Hg or for any exposure <55–50 mm Hg.
- Future prospective studies are indicated with less variability in patient characteristics and better definitions of hypotension and adverse outcomes.

Intraoperative hypotension is a common side-effect of general anaesthesia that has received much attention in recent years because of its frequent occurrence and presumed adverse consequences. However, no widely accepted definition of intraoperative hypotension is available.<sup>1</sup> Despite this lack of a uniform definition, researchers have addressed the association between intraoperative hypotension and postoperative mortality and organ dysfunction after general anaesthesia. Monk and colleagues<sup>2</sup> were one of the first groups to show a significant association between duration of intraoperative hypotension and mortality. More recent landmark studies have shown associations between hypotension and other adverse outcomes such as acute kidney injury (AKI) and myocardial injury (MI).<sup>3,4</sup>

It remains a topic of debate if, and to what extent, hypotension disrupts organ perfusion resulting in organ damage. Furthermore, such organ damage might depend on the degree and duration of the hypotensive episodes. A summary of what is known about the effects of intraoperative hypotension on postoperative organ dysfunction and mortality is essential for anaesthesiologists to determine the range of blood pressures acceptable during surgery. So far, no systematic search of the literature has been conducted to summarise the available evidence regarding the association between intraoperative hypotension and adverse postoperative outcomes. As hypotension has not clearly been defined, such a summary needs to include an analysis of which blood pressure threshold an association with adverse outcomes becomes clinically relevant.

We studied the relationship between intraoperative hypotension and postoperative adverse outcomes after noncardiac surgery by performing a systematic search of the literature. We classified studies according to quality criteria and report strengths of associations for various blood pressure thresholds and postoperative adverse outcomes.

**Methods****Search strategy and selection of articles**

We conducted a systematic search of literature in PubMed, Embase, Web of Science, and CINAHL on March 8, 2017. Synonyms and medical subject headings for intraoperative hypotension were combined with synonyms and medical subject headings for complication, mortality, AKI, MI,

**Box 1****Search string**

*Determinant:* (((hypotension[title and abstract] OR hypotensive[title and abstract]) AND (intraoperative[title and abstract] OR perioperative[title and abstract] OR intraoperatively[title and abstract] OR perioperatively[title and abstract] OR peroperative[title and abstract] OR peroperatively[title and abstract])))

*Outcome:* (mortal\*[title and abstract] OR death[title and abstract] OR "moribund"[title and abstract] OR die\*[title and abstract] OR fatal[title and abstract]) OR ((kidney[title and abstract] OR renal[title and abstract]) AND (insuff\*[title and abstract] OR failure[title and abstract] OR injury[title and abstract] OR "ATN"[title and abstract]) OR (((heart[title and abstract] OR myocard\*[title and abstract] OR cardial[title and abstract] OR coronary[title and abstract]) AND (ischem\*[title and abstract] OR ischaem\*[title and abstract] OR infarct\*[title and abstract]) OR (acute AND coronary AND syndrome[title and abstract] OR ACS[title and abstract]))) OR (((Brain[title and abstract] OR cerebr\*[title and abstract]) AND (Vascular[title and abstract] OR cerebrovascular[title and abstract]) AND (embol\*[title and abstract] OR accident\*[title and abstract] OR complication\*[title and abstract] OR ischaem\*[title and abstract] OR ischem\*[title and abstract] OR infarct\*[title and abstract] OR incident\*[title and abstract] OR stroke[title and abstract] OR apoplexy[title and abstract] OR stroke\*[title and abstract] OR apoplexy[title and abstract] OR stroke\*[title and abstract] OR (((Delirium[title and abstract] OR Delirious\*[title and abstract]) OR ((admission[title and abstract] OR stay[title and abstract]) AND (day\*[title and abstract] OR duration[title and abstract] OR LOS[title and abstract] OR length[title and abstract]) OR (morbidity[title and abstract] OR complication[title and abstract] OR "adverse event"[title and abstract] OR "adverse events"[title and abstract])))

ischaemic stroke, delirium, and length of hospital stay (LOS) as described in [Box 1](#). The search filters were restricted to presence of the synonyms in titles and abstracts. No other limits were used. The articles obtained by this search were independently screened by two reviewers (E.W. and H.M.T.). In case of inconsistency, consensus was achieved by a third independent reviewer (T.H.K.). The reference lists of all selected and included articles were checked to retrieve relevant publications that were not found by the above described search strategy. The inclusion and exclusion criteria for publication type, study design, hypotension, and studied outcome definitions are described in [Box 2](#).

**Data extraction and quality assessment**

Data on study design, hypotension definitions, studied outcomes, and (adjusted) strengths of association were extracted from all included studies ([Tables 1 and 2](#)).<sup>2–43</sup> Commonly reported baseline characteristics were summarised by calculating weighted means of medians across study groups

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