BJA

*British Journal of Anaesthesia*, 120(1): 77–83 (2018)

**doi:** 10.1016/j.bja.2017.11.002
Advance Access Publication Date: 23 November 2017
Cardiovascular

# Association between postoperative mean arterial blood pressure and myocardial injury after noncardiac surgery

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Editorial about this article by P. Nagele, BJA 2018:120:4-5, doi: 10.1016/j.bja.2017.11.008.

## Abstract

**Background:** Myocardial injury after noncardiac surgery is common, although the exact pathophysiology is unknown. It is plausible that hypotension after surgery is relevant for the development of myocardial injury. The authors evaluated whether low mean arterial pressures (MAPs) after surgery are related to an increased incidence in postoperative cardiac-troponin elevation.

**Methods:** A prospective cohort of 2211 patients aged ≥60 yr, undergoing major or moderate noncardiac surgery in The Netherlands, was retrospectively analysed for the occurrence of postoperative cardiac-troponin elevation [high-sensitive troponin T (hsTnT) >14 ng $L^{-1}$]. Blood pressures after surgery were recorded and divided into quartiles based on the lowest MAP prior to peak troponin recording. The association between MAP and extent of postoperative cardiac-troponin elevation was analysed.

**Results:** The patients were divided into quartiles based on their lowest MAP in the period preceding the peak hsTnT, ranging from a median of 62 in the lowest quartile to 94 in the highest quartile. Postoperative hsTnT elevation was present in 53.2% of the population. An association between MAP quartile and postoperative peak hsTnT was predominantly observed in the lowest quartile ($P<0.001$): median hsTnT 17.6 (10.3–37.3), 14.9 (9.4–24.6), 13.8 (9.1–22.5), and 14.0 (9.2–22.4). The multivariable logistic-regression analysis showed an increased risk for postoperative cardiac-troponin elevation with decreasing MAP thresholds.

**Conclusions:** Lower postoperative blood pressure is associated with an increased incidence of postoperative cardiac hsTnT elevation, irrespective of pre- and intraoperative variables.

**Keywords:** hypotension; observational study; surgery; troponin

Myocardial injury after noncardiac surgery is common, and is an independent risk factor for 30-day mortality and for 1 yr mortality in patients undergoing noncardiac surgery.[1–3] Although the exact pathophysiology of myocardial injury is unknown, similar pathways probably exist between postoperative myocardial injury and postoperative myocardial infarction.[4] Tachycardia, anaemia, hypoxaemia, and

**Editorial decision**: September 7, 2017; **Accepted:** September 12, 2017

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### Editor's key points

- The role of postoperative hypotension in myocardial injury after noncardiac surgery is unclear.
- A retrospective analysis of a single-centre cohort of 2211 patients found a significant association between low mean arterial pressure and elevation of cardiac troponin.
- Further study is required to determine if postoperative hypotension is a modifiable risk factor for myocardial injury.

hypotension are all common after surgery, and can result in the development of myocardial injury because of a supply-and-demand mismatch.[5] Studies in the previous decade have mainly focused on the role of postoperative heart rate rather than postoperative blood pressure. In contrast, intraoperative hypotension has been studied extensively in patients undergoing surgery. Although various definitions of intraoperative hypotension have been used, it appears to be an important risk factor for myocardial injury, stroke, acute kidney injury, and mortality.[6–12] An important limitation in studying the effects of intraoperative arterial pressure is the confounding effect of surgical stimuli, pain, intravascular volume status, anaesthetics, and use of inotropic or vasopressive agents. In the postoperative phase, many of these limitations are overcome, and postoperative arterial pressure is the result of the combined response to anaesthetic effects, volume status, cardiac depressant effects, and inflammatory response.

As troponin release is most prominent in the early hours and 1st day after surgery, (early) postoperative hypotension could play a crucial role in the development of myocardial injury. The effects of postoperative hypotension on myocardial injury and outcome after noncardiac surgery have not been studied previously. In this study, we investigated the association between postoperative arterial pressures and postoperative cardiac-troponin elevation after noncardiac surgery.

## Methods

### Study design

This was a retrospective study, selected from an ongoing prospective registry of patients undergoing noncardiac surgery at the Erasmus Medical Centre, Rotterdam, The Netherlands. Consecutive patients aged ≥60 yr who are scheduled for intermediate- or high-risk noncardiac surgery are under postoperative surveillance for postoperative cardiac-troponin elevation during the first 3 postoperative days through (high-sensitive) troponin T (hsTnT) measurements. All patients, regardless of the type of anaesthesia or setting (elective of emergency), are included in this registry. For this observational study, we included all patients between the start of the surveillance protocol in July 2012 through July 2014. The institutional approval for this study was obtained. This study was not subject to the Dutch Medical Research Involving Human Subjects Act. Therefore, the ethics committee of the Erasmus Medical Centre waived the requirement for a written informed consent. This study complies with the Declaration of Helsinki on research ethics.[13] The primary outcome was occurrence of postoperative cardiac-troponin elevation (hsTnT above the 99th percentile: 14 ng $L^{-1}$). The secondary outcomes included myocardial infarction (based on the third universal definition[14]) and 30-day mortality.

### Data collection

Data were extracted from the electronic-hospital patient information system. Baseline data included age, sex, type of surgery, and past medical-history variables, including hypertension, diabetes mellitus, coronary heart disease (history of angina pectoris, previous myocardial infarction, percutaneous coronary intervention, or coronary artery bypass grafting), chronic heart failure, previous cerebrovascular disease (cerebrovascular accident or transient ischaemic attack), chronic obstructive pulmonary disease, renal failure (preoperative creatinine concentration above 177 μmol $L^{-1}$), and peripheral arterial disease. Additionally, the preoperative use of beta blockers, statins, angiotensin-converting-enzyme (ACE) inhibitors, angiotensin receptor blockers, diuretics, calcium-channel blockers, nitrates, aspirin, and oral anticoagulants was retrieved from the electronic medical files. Survival status was completed in all patients by means of the institution's medical records, or was ascertained by inquiry from the civil registries.

### Haemodynamic data and troponin measurements

Arterial blood pressures and heart rates measured on the ward on the day of surgery or the evening before surgery were used as baseline preoperative haemodynamic data. Intraoperative arterial pressures and heart rates were extracted from the anaesthesia information monitoring system, and were cleaned using an algorithm previously described.[15] Blood loss was noted at the end of the operation, as reported by the anaesthesiologist. The most recent haemoglobin concentration before surgery and the lowest haemoglobin concentration within 30 days after surgery were noted, irrespective of the peak hsTnT concentration. After surgery, all patients were admitted to the post-anaesthesia care unit, or were transferred immediately to a high-dependency ward/intensive care unit (ICU), depending on the patients' health status and the perioperative course of the surgery. All blood pressures, recorded on the ward and in the high-dependency ward/ICU up to 3 days after discharge from the post-anaesthesia care unit, were retrieved from the hospital information system. As per hospital protocol, non-invasive blood pressure is measured at least once every 8 h on the ward, or is recorded at 5 min intervals for patients with invasive blood-pressure monitoring. Heart rate was recorded simultaneously with all blood pressures. Measurements of hsTnT were routinely obtained in the morning during the first 3 postoperative days, unless discharged earlier, or whenever clinically indicated by the treating physician using the Cobas e602 Troponin T hs STAT assay (Roche Diagnostics, Mannheim, Germany). For each patient, the highest value of all routine hsTnT measurements in the 3 postoperative days was used in the analysis. An hsTnT <14 ng $L^{-1}$ is considered normal and the 99th percentile. We defined hsTnT of 14–50 ng $L^{-1}$ as low elevation, hsTnT of 50–150 ng $L^{-1}$ as moderate elevation, and hsTnT >150 ng $L^{-1}$ as high elevation.[16]

### Statistical analysis

The patients were divided into quartiles based on their lowest mean arterial pressure (MAP) prior to peak hsTnT.

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