

Association between preoperative pulse pressure and perioperative myocardial injury: an international observational cohort study of patients undergoing non-cardiac surgery

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Abstract

Background. The management of elevated blood pressure before non-cardiac surgery remains controversial. Pulse pressure is a stronger predictor of cardiovascular morbidity in the general population than systolic blood pressure alone. We hypothesized that preoperative pulse pressure was associated with perioperative myocardial injury.

Methods. This is a secondary analysis of the Vascular Events in Non-cardiac Surgery Patients Cohort Evaluation (VISION) international cohort study. Participants were aged ≥ 45 yr and undergoing non-cardiac surgery at 12 hospitals in eight countries. The primary outcome was myocardial injury, defined using serum troponin concentration, within 30 days after surgery. The sample was stratified into quintiles by preoperative pulse pressure. Multivariable logistic regression analysis explored associations between pulse pressure and myocardial injury. We accounted for potential confounding by systolic blood pressure and other co-morbidities known to be associated with postoperative cardiovascular complications.

Results. One thousand one hundred and ninety-one of 15 057 (7.9%) patients sustained myocardial injury, which was more frequent amongst patients in the highest two preoperative pulse pressure quintiles {63–75 mm Hg, risk ratio (RR) 1.14 [95% confidence interval (CI): 1.01–1.28], $P=0.03$; >75 mm Hg, RR 1.15 [95% CI: 1.03–1.29], $P=0.02$ }. After adjustment for systolic blood pressure, preoperative pulse pressure remained the dominant predictor of myocardial injury (63–75 mm Hg, RR 1.20 [95% CI: 1.05–1.37], $P<0.01$; >75 mm Hg, RR 1.25 [95% CI: 1.06–1.48], $P<0.01$). Systolic blood pressure >160 mm Hg was not associated with myocardial injury in the absence of pulse pressure >62 mm Hg (RR 0.67 [95% CI: 0.30–1.44], $P=0.31$).

Conclusions. Preoperative pulse pressure >62 mm Hg was associated with myocardial injury, independent of systolic blood pressure. Elevated pulse pressure may be a useful clinical sign to guide strategies to reduce perioperative myocardial injury.

Key words: blood pressure; high; cohort studies; hypertension; pulse pressure; surgery

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Editor's key points

- Elevated pulse pressure, most often an indicator of poor arterial vascular compliance, is independently associated with cardiovascular disease in the general community.
- This study identified that elevated pulse pressure, but not systolic blood pressure, was independently associated with myocardial injury.
- Elevated preoperative pulse pressure is a more important risk indicator for the development of myocardial injury compared with systolic blood pressure.

One in 10 patients sustain asymptomatic myocardial injury after major non-cardiac surgery, which is strongly associated with mortality.¹⁻⁴ In the general population, elevated pulse pressure (the difference between systolic and diastolic blood pressure) predicts myocardial infarction and congestive cardiac failure, independent of high systolic and diastolic blood pressures (including 'white coat' hypertension). However, the risk of perioperative cardiovascular complications associated with elevated preoperative arterial pressure or pulse pressure is unclear.⁵⁻⁷

Patients presenting for surgery with high blood pressure pose a daily challenge for perioperative practitioners. Internationally, the prevalence of poorly controlled blood pressure in patients with hypertension is high, and a significant proportion of the general population have undiagnosed hypertension.⁸ Surgical procedures are frequently cancelled because of high preoperative systolic blood pressure on the day of surgery.⁹⁻¹¹ This reflects widespread uncertainty about whether or not isolated elevated blood pressure readings increase the risk of perioperative cardiovascular complications. Clinical guidelines suggest that surgery can be undertaken safely if the preoperative blood pressure is below 160/110 mm Hg.^{9, 12} However, this guidance, which varies internationally,¹³ is derived from a very limited evidence base constructed from small studies using subjective clinical outcome measures, rather than prognostic biomarkers for morbidity (e.g. high-sensitivity troponin) and mortality.^{5, 14}

Elevated pulse pressure is associated with an excess risk of multiple adverse cardiovascular outcomes in the general population, independently of hypertension.¹⁵⁻¹⁸ Pulse pressure reflects left ventricular stroke volume, cardiac contractility, and arterial wall compliance, which are key factors that influence cardiovascular performance in the perioperative setting.^{19, 20} Preoperative pulse pressure may therefore refine risk assessment for perioperative cardiovascular complications in patients undergoing non-cardiac surgery. We hypothesized that pulse pressure is associated with an increased risk of myocardial injury within 30 days of non-cardiac surgery, independent of preoperative systolic arterial pressure.

Methods

We undertook a planned secondary analysis of the Vascular Events in Non-cardiac Surgery Patients Cohort Evaluation (VISION) study. The methods of this prospective international observational cohort study have been previously described in detail elsewhere.^{2, 21} The study was approved by institutional review boards or ethics committees at each site, and was registered with ClinicalTrials.gov (NCT00512109). It was conducted in accordance with the principles of the Declaration of Helsinki

and institutional guidelines. Participants were approached for written informed consent before surgery. When this was not possible, for example before emergency surgery, written consent was sought within 24h after surgery. Eight sites used a deferred consent process for patients with no next of kin and who were unable to provide consent before surgery.

Participants

Participants were aged 45yr or older and underwent non-cardiac surgery using general or regional anaesthesia, and with at least an expected overnight hospital stay. Participants were excluded if they refused consent or if they had previously enrolled in the study.

Data collection

Researchers collected a detailed and standardized data set from patients and their medical records, before and during the 30 days after surgery; the full details have been published previously.² A past history of hypertension was defined by a previous physician diagnosis. Full definitions of the variables included in this analysis are documented in the Supplementary material. Clinical staff measured arterial blood pressure (in millimetres of mercury) as part of routine patient care according to local practice. Specific details of the equipment used to measure blood pressure are not available. Preoperative arterial blood pressure was defined as the systolic and diastolic arterial pressure measurements before and closest to the induction of anaesthesia. Preoperative arterial pulse pressure was defined as the arithmetic difference between preoperative systolic and diastolic arterial pressures.

Blood samples were obtained between 6 and 12h after the end of surgery and on postoperative days 1, 2, and 3. If participants developed an ischaemic symptom during the 30 days after surgery, investigators were encouraged to obtain additional blood samples.¹ The serum troponin T (TnT) concentration was measured using a Roche (Basel, Switzerland) fourth-generation assay (ElecsysTM). If TnT was increased above 0.04 ng ml⁻¹, the standard laboratory threshold at the start of the study, an ECG was performed.

Outcome measure

Myocardial injury, defined as any TnT measurement ≥ 0.03 ng ml⁻¹ judged attributable to an ischaemic aetiology, within 30 days of surgery was the primary outcome measure. This definition is used by the European Society of Anaesthesia and European Society of Intensive Care Medicine (ESA-ESICM) taskforce for perioperative clinical outcomes.²² For each TnT measurement ≥ 0.03 ng ml⁻¹, one of 15 independent adjudicators reviewed the clinical information, including the medical record, ECGs, and echocardiograms, and decided if there was evidence of a non-ischaemic cause of the TnT elevation (e.g. pulmonary embolus, sepsis, renal failure). Participants with TnT ≤ 0.04 ng ml⁻¹ did not undergo ECGs and were not assessed for clinical symptoms to rule out myocardial ischaemia.

Statistical analysis

We planned the statistical analysis before taking custody of the data. We used SPSS version 22 (IBM, New York, NY, USA) and STATA version 14 (StataCorp LP, College Station, TX, USA) to analyse the data. We ordered the sample according to integer values of preoperative pulse pressure and divided it into five

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