BJA

British Journal of Anaesthesia, 119 (1): 40–9 (2017)

doi: 10.1093/bja/aex095
Cardiovascular

CARDIOVASCULAR

Prolonged concurrent hypotension and low bispectral index ('double low') are associated with mortality, serious complications, and prolonged hospitalization after cardiac surgery

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Abstract

Background: Low bispectral index (BIS) and low mean arterial pressure (MAP) are associated with worse outcomes after surgery. We tested the hypothesis that a combination of these risk factors, a 'double low', is associated with death and major complications after cardiac surgery.
Methods: We used data from 8239 cardiac surgical patients from two US hospitals. The primary outcomes were 30-day mortality and a composite of in-hospital mortality and morbidity. We examined whether patients who had a case-averaged double low, defined as time-weighted average BIS and MAP (calculated over an entire case) below the sample mean but not in the reference group, had increased risk of the primary outcomes compared with patients whose BIS and/or MAP were at or higher than the sample mean. We also examined whether a prolonged cumulative duration of a concurrent double low (simultaneous low MAP and BIS) increased the risk of the primary outcomes.
Results: Case-averaged double low was not associated with increased risk of 30-day mortality {odds ratio [OR] 1.73 [95% confidence interval (CI) 0.94–3.18] *vs* reference; $P=0.01$} or the composite of in-hospital mortality and morbidity [OR 1.47 (95% CI 0.98–2.20); $P=0.01$] after correction for multiple outcomes. A prolonged concurrent double low was associated with 30-day mortality [OR 1.06 (95% CI 1.01–1.11) per 10-min increase; $P=0.001$] and the composite of in-hospital mortality and morbidity [OR 1.04 (95% CI 1.01–1.07), $P=0.004$].
Conclusions: A prolonged concurrent double low, but not a case-averaged double low, was associated with higher morbidity and mortality after cardiac surgery.

Key words: arterial pressure; bispectral index monitor; cardiac surgical procedure; consciousness monitors; patient outcome assessment

Editorial decision: March 17, 2017; **Accepted:** March 20, 2017

Editor's key points

- The implications of low bispectral index and low mean arterial pressure on outcome following cardiac surgery are unclear.
- In a retrospective analysis of data from two US centres, cumulative concurrent 'double low' (low bispectral index and low mean arterial pressure) was associated with increased 30-day mortality and composite in-hospital mortality and morbidity.
- These findings suggest that interventions to reduce the duration of simultaneous hypotension and low bispectral index might improve outcomes after cardiac surgery.

Patients who have cardiac surgery are at high risk for postoperative morbidity and mortality. Intraoperative anaesthetic and haemodynamic conditions might increase the risk for these complications. For example, deep anaesthesia, demonstrated by low bispectral index (BIS; Covidien, Dublin, Ireland) scores, has been associated with increased risk for stroke, myocardial injury, and mortality after cardiac surgery[1] and non-cardiac surgery.[2–5] Low intraoperative blood pressure is also associated with increased postoperative myocardial infarction, stroke, and mortality in cardiac surgical patients.[6–8]

The 'triple low' condition, defined as the combination of deep anaesthesia (low BIS), hypotension [low mean arterial pressure (MAP)], and low minimum alveolar concentration of anaesthetic (MAC), is associated with increased morbidity and mortality after non-cardiac surgery.[9] Two other investigations primarily in non-cardiac surgical patients provide conflicting results.[10 11] A 'double low', defined as a combination of deep anaesthesia (low BIS) and low blood pressure (low MAP), was also associated with an increased risk of adverse outcome after non-cardiac surgery.[9] A recent study in non-cardiac surgical patients investigated whether an alert to the presence of a double low condition would trigger a clinical intervention to reduce double low duration and decrease 90-day mortality,[12] but the alert was ineffective and the double low duration was unchanged. Nonetheless, the implications of the double low during cardiac surgery are unclear. We tested the primary hypothesis that case-averaged double low, defined as case-based time-weighted average BIS and MAP below the sample mean (and not in the reference group), and the cumulative duration of concurrent double low (simultaneous low MAP and BIS) was associated with increased 30-day mortality and a composite of in-hospital death and major complications after cardiac surgery.

Methods

Patient population and data collection

We included patients who had cardiac surgery at the Cleveland Clinic main campus in Cleveland, OH, USA between January 1, 2008 and October 18, 2013 and patients who had cardiac surgery at Mount Sinai Hospital, New York, NY, USA between January 1, 2008 and June 1, 2012. The study design, primary and secondary outcomes, and statistical analysis were defined *a priori*.

We included patients who had coronary artery bypass grafting, valve (aortic, mitral, and/or tricuspid) repair or replacement, combined coronary artery bypass graft and valve procedures, ascending aortic surgery, or left ventricular myomectomy with or without additional minor concomitant procedures (Maze procedure, closure of patent foramen ovale, etc.). We excluded patients who had heart or lung transplantation, ventricular assist device implantation, institution of extracorporeal membrane oxygenation, ventricular aneurysm repair, procedures requiring hypothermic circulatory arrest, or off-pump procedures. We also excluded patients who did not have BIS and/or MAP monitoring for at least 30 non-contiguous minutes during pre-cardiopulmonary bypass (CPB) (from the time of surgical incision to the start of initial CPB) and post-CPB (from the end of the final CPB to the end of surgery). Data from the Cleveland Clinic were obtained from the Cardiothoracic Anaesthesia Patient Registry using methods that have been reported previously.[13] The requirement for written informed consent was waived by the institutional review board. The study protocol was reviewed and approved by both the Cleveland Clinic and Mount Sinai Institutional Review Boards.

At Cleveland Clinic, all data were collected daily, concurrent with patient care, on pre-printed forms, by experienced and specifically trained research personnel. Data were entered in an electronic database directly through tablet computers. Intraoperative data were obtained from the local Anaesthesia Information Management System (AIMS) [Anaesthesia Record Keeping System (ARKS), Cleveland Clinic, Cleveland, OH, USA], in which MAP was recorded at 1-min intervals for patients with an intra-arterial line and BIS was recorded at 1-min intervals. Data were queried using SAS SQL and saved as SAS datasets (SAS Institute, Cary, NC, USA). Mortality data were derived from the US Social Security Death Index (SSDI).

Patient data from Mount Sinai were obtained from the Department of Anesthesiology Data Warehouse. Intraoperative data, including BIS and MAP at 15-sec intervals, were captured using the electronic record keeping system (CompuRecord, Philips, Andover, MA, USA). Vital signs in the Mount Sinai warehouse were kept in 15-sec increments. The median value for each minute for valid values of BIS and MAP was used. Validity was recorded by the local AIMS. MAPs <20 mm Hg and >200 mm Hg and BIS of zero were automatically invalidated. Postoperative outcomes were retrieved from data collected by the Icahn School of Medicine at the Mount Sinai Department of Cardiovascular Surgery according to guidelines set by the New York State Department of Health (NYSDOH, State Cardiac Advisory Committee). The NYSDOH data registry represents a mandatory, verified, peer-reviewed data collection system that includes all cardiac surgery procedures in New York State. Medical chart review was performed to obtain additional information when necessary. Follow-up survival information to 30 days was obtained from the SSDI or by phone call to the patient's referring cardiologist. Mortality data beyond 30 days were derived from the SSDI alone. Data were extracted from the perioperative data warehouse and local cardiac outcomes database using SQL queries.

Demographic, preoperative, and intraoperative variables from Cleveland Clinic sources were merged with variables with similar definitions from the Icahn School of Medicine at Mount Sinai. All patient identifiers were removed prior to statistical analysis. Patients with incomplete or unavailable data were excluded from the analysis.

Anaesthesia and surgery

Patients received standard anaesthesia care and monitoring, including arterial catheters for blood pressure monitoring and