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Clinical Investigation

CLINICAL INVESTIGATION

Is applanation tonometry a reliable method for monitoring blood pressure in morbidly obese patients undergoing bariatric surgery?

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Abstract

Background: The aim of this study was to evaluate the validity of non-invasive continuous BP measurement by applanation tonometry in morbidly obese patients undergoing bariatric surgery.

Methods: Arterial blood pressure (AP) was recorded intraoperatively both by applanation tonometry (AT) (T-Line 200pro, Tensys Medical®, USA) and an arterial line (AL) after radial cannulation in obese patients undergoing bariatric surgery. Discrepancies between the two methods were assessed as bias, limits of agreement and percentage error. Mean, systolic, and diastolic arterial pressures were assessed (MAP, SAP, DAP respectively). Trending ability was assessed by concordance based on four-quadrant plotting.

Results: Mean (SD) BMI of the 28 patients was 49.4 (9.7 kg m^{-2}). A total of 201 907 time points were available for analysis. Bias for MAP_{AT} compared with MAP_{AL} was +3.97 mm Hg (SAP_{AT} +3.45 mm Hg; DAP_{AT} +3.66 mm Hg) with limits of agreement for MAP_{AT} of −14.47 and +22.41 mm Hg (SAP_{AT} −22.0 and +28.9 mm Hg; DAP_{AT} −15.7 and +23.1 mm Hg). Percentage error for MAP_{AT} was 23.5% (23.4% for SAP_{AT}; 30.5% for DAP_{AT}). Trending ability for MAP, SAP, and DAP revealed a concordance of 0.74, 0.72, and 0.71, respectively.

Conclusions: Continuous BP assessment by applanation tonometry is feasible in morbidly obese patients undergoing bariatric surgery. However, despite a low mean difference, 95% limits of agreement and trending ability indicate that the technology needs to be improved further, before being recommended for routine use in this group of patients.

Key words: arterial pressure; bariatric surgery; blood pressure monitors; monitoring, intraoperative

Obesity-associated comorbidities, such as coronary vessel disease, heart failure or arterial hypertension which may cause intraoperative haemodynamic instability, can demand increases and changes in routine perioperative monitoring, especially arterial pressure (AP) measurement. However, in practice, establishing a reliable arterial pressure measurement with oscillometric

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Editor's key points

- Applanation tonometry (AT) is a non-invasive method of measuring arterial pressure but its accuracy in obese patients is not established
- In this small study AT was compared with direct intra-arterial pressure measurement in patients undergoing bariatric surgery
- Although mean differences in measured pressure were small, the limits of agreement were wide and concordance moderate
- These data suggest that the accuracy of AT in morbidly obese patients is limited

methods can be challenging or even futile, especially in obese patients with extreme upper arm circumferences. Non-invasive oscillometric upper-arm cuff arterial pressure measurement may be highly inaccurate for obese patients, as blood pressure cuffs may not fit properly as a result of the conical shape of the arm and this can prevent correct measurements.[1 2] In obese patients, arterial cannulation is the most accurate procedure, if conventional oscillometric upper-arm cuff measurement fails, or continuous measurement is desired. However, the placement of arterial catheters can be time consuming and can cause inconvenience and carry risks for patients.[3 4]

Applanation tonometry (AT) is a non-invasive method for continuous arterial pressure monitoring which has been evaluated with promising results in perioperative, intensive care and emergency department settings.[5–11] A disposable sensor, which is connected to a bracelet, is placed above the patient's radial artery. Fully automated, the system detects the maximum radial arterial signal. By flattening the vessel, a continuous arterial pressure signal is obtained. In contrast to oscillometric methods of BP measurement, this allows for continuous measurements because the sensor constantly floats above the artery, detecting the maximum pulse pressure. Processed by an underlying algorithm, this results in a continuous arterial pressure waveform, with numeric display of MAP, SAP and DAP.[2] This method may have the potential to bridge the gap between intermittent oscillometric BP measurement and invasive arterial pressure measurement from an intra-arterial catheter. This might be of particular clinical advantage in obese patients undergoing surgery. However, it is not known whether extreme obesity may damp the arterial signal by increased soft tissue mass at the forearm, which might limit the usability and accuracy of this new technology. We therefore compared arterial BP measurement by AT to the most accurate standard of arterial blood pressure measurement by a radial artery catheter in morbidly obese patients during bariatric surgery.

Methods

This prospective study was approved by the Ethics Committee of the Medical Board of Hamburg (Aerztekammer Hamburg) (PV 3767). All patients gave written informed consent before the onset of the study.

Study design and patients

Patients ≥18 yr undergoing elective bariatric surgery (gastric bypass or gastric sleeve) at a university hospital (University Medical Center Hamburg-Eppendorf, Germany) were invited to participate. Exclusion criteria were previous surgery to one of the forearms or arterial vessels of the arms, upper limb neuropathy or lack of consent.

Anaesthesia and instrumentation

Eligible patients received premedication with midazolam (between 7.5 and 15 mg orally approximately one h before transfer to the operating room). After establishing standard haemodynamic monitoring with a 5-lead ECG and pulse oximetry, cannulation of the left radial artery was performed under local anaesthesia. The AT bracelet device (T-Line 200pro, Tensys Medical®, San Diego, USA) was placed on the right forearm. After calibration of both methods, standardized anaesthesia was induced with remifentanil 0.5 μg kg^{-1} min^{-1} and target-controlled (TCI) infusion of propofol, with a calculated plasma concentration of 4 μg ml^{-1} (using the model according to Marsh[12 13]). Rocuronium 0.6–0.8 mg kg^{-1} (ideal body weight) was administered for muscle relaxation to facilitate orotracheal intubation. Anaesthesia was maintained by continuous target-controlled-infusion of propofol, aiming for a bispectral index between 30 and 50 and continuous administration of remifentanil 0.3–0.5 μg kg^{-1} min^{-1}. Norepinephrine was administered continuously directly from induction of anaesthesia via a second i.v. line at the discretion of the anaesthetist to avoid arterial hypotension and maintain mean arterial pressure >60 mm Hg.

Applanation tonometry method

The AT device used in this study, allows continuous monitoring of arterial pressure in real time, with the visualization of an arterial pressure curve without being invasive and without the need for external calibration: A specific sensor is placed on the patients forearm in the position of a routine radial artery puncture. A sensor bracelet is locked to the sensor and compresses (applanates) the radial artery against the radial bone. During measurement, the sensor lies above the artery and the pressure from the bracelet flattens the vessel. Under ideal conditions this results in a transmural pressure of zero on the radial artery and the maximum pulse pressure can be acquired by the sensor. The mean arterial pressure is determined from the maximum pulse pressure. To determine systolic and diastolic arterial pressure the acquired arterial pressure waveform is scaled with the help of an underlying transfer function. As a result, a continuous arterial pressure waveform, with a numeric display of mean (MAP), systolic (SAP) and diastolic (DAP) pressure is displayed.

Measurements and data collection

The AT device was set up according to the manufacturer's instructions and as described before.[5] Data collection was started after instrumentation and initial calibration while the patient was awake and continued until the termination of capnoperitoneum at the end of surgery. Measurements were interrupted during transfer of the patient to the operating theatre. Recalibration was performed when necessary (e.g. changes of patient position, movement of the limb) or at least once an hour according to the manufacturer's recommendation. AT and AL data were simultaneously transferred to the standard patient monitor (Infinity delta, Draeger©, Luebeck, Germany) and extracted to a computer and recorded every s by an analysing software (eData Data Grabber, Draeger©, Luebeck, Germany).

After completing data collection the data set was visually screened by at least three authors for artifacts or obviously