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Comparison of preoperative and intraoperative assessment of aortic stenosis severity by echocardiography

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Abstract

Background. General anaesthesia and surgically induced changes in cardiac loading conditions may alter flow across the aortic valve. This study examined how echocardiographic assessment of the severity of aortic stenosis (AS) changes during surgery.

Methods. Patients who underwent aortic valve replacement for any severity of AS between July 2007 and June 2015 were identified. Peak velocities, mean gradients, and dimensionless indices (DI) measured with preoperative transthoracic echocardiography (TTE) were compared with those measured with intraoperative transoesophageal echocardiography (TOE). Additionally, agreement of preoperative and intraoperative grading of AS based on these measurements was assessed.

Results. Data from 319 patients were analysed. On average, intraoperative TOE peak velocity and mean gradient were lower by 0.59 m s^{-1} and 12.5 mm Hg, respectively ($P<0.0001$), compared with preoperative TTE measurements, whereas the difference in mean DI was minimal at 0.008. Preoperative and intraoperative grades of AS severity (mild, moderate, and severe) by peak velocity, mean gradient, and DI agreed in 53.3, 53.7, and 83.3% of patients, respectively. The TOE grade of AS severity by peak velocity and mean gradient was at least one lower than the TTE grade in 45.1 and 42.7% of patients, respectively. Significantly fewer patients had their severity of AS reclassified based on DI ($P<0.0001$).

Conclusions. Intraoperative TOE peak velocities and mean gradients are often significantly lower than preoperative TTE measurements, leading to underestimation of AS severity in nearly half of our study patients. The DI is a more reliable measurement of AS severity in the intraoperative setting.

Key words: anaesthesia, general; aortic valve stenosis; echocardiography, transoesophageal

Accurate assessment of the severity of aortic stenosis (AS) is fundamental in perioperative echocardiography.[1] Both American and European guidelines provide detailed recommendations for assessment of AS.[2]

Peak aortic jet velocity, pressure gradient, and valve area are some of the multiple criteria used to evaluate the severity of AS.[3] Peak velocity is well validated, a strong predictor of clinical outcomes, and very straightforward to measure with continuous-wave Doppler.[2] Peak and mean pressure gradients are derived from velocity measurements across the aortic valve, using the simplified Bernoulli equation.[2] Patients with severe AS typically have a peak velocity >4.0 m s^{-1}, a mean

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Editor's key points

- Pre- and intraoperative echocardiography are increasingly used to inform perioperative decision-making.
- However, intraoperative transoesophageal measurements may be affected by anaesthesia and surgery, so may differ from preoperative transthoracic echocardiography data.
- In patients with aortic stenosis, intraoperative measurements of valve velocities and gradients with transoesophageal echocardiography are often lower compared to preoperative measurements with transthoracic echocardiography.
- This could lead to underestimation of the severity of aortic stenosis in the intraoperative setting.
- In contrast, measurements of the dimensionless index were more concordant.

gradient >40 mm Hg, and an aortic valve area <1.0 cm^2.[2–4] Discordance between grading of AS based on these measurements is well described.[4]

However, these guidelines are based on previous data obtained mostly in awake, spontaneously breathing patients with transthoracic echocardiography (TTE). It is unclear how these measurements are impacted by general anaesthesia, positive pressure ventilation, surgery, and use of transoesophageal echocardiography (TOE).

Although both peak velocity and mean gradient are robust and reproducible measurements,[5] they are also flow and angle dependent.[2] Changes in cardiac loading conditions as a result of general anaesthesia, positive pressure ventilation, and surgery may alter blood flow across the aortic valve, leading to changes in these flow-dependent measurements. In this setting, the application of conventional echocardiographic measures validated in awake, spontaneously breathing patients may create errors in estimation of AS severity and adversely influence medical or surgical decision-making.

In contrast to the above-mentioned measurements, a dimensionless index (DI), the ratio of the left ventricular outflow tract to the aortic valve velocity,[6–8] is a relatively flow- and angle-independent measure of AS severity. An increase in flow velocity between the left ventricular outflow tract and the aortic valve by a factor of more than four corresponds to a DI of <0.25 and severe AS.[7 8]

The aim of this study was to compare preoperative TTE and intraoperative TOE assessment of AS severity by measurement of peak velocities, mean gradients, and DIs in patients who were undergoing aortic valve replacement.

Methods

Approval for this project was obtained from the Human Research and Ethics Committee St Vincent's Hospital, Melbourne as a low-risk, quality-assurance project. The study period for this single-centre, retrospective observational study was from July 1, 2007 to June 31, 2015.

Since July 1, 2007, the institutional electronic database, Synapse Cardiovascular Prosolv (Fujifilm Medical Systems, Indianapolis, Indiana USA) has stored echocardiographic images, measurements, and reports of preoperative TTE and intraoperative TOE studies performed on all adult patients who underwent cardiac surgery.

Patient selection

Inclusion criteria were patients who underwent isolated or concomitant aortic valve replacement (AVR) or transcatheter implantation of an aortic valve for any severity of AS, who had their aortic valves evaluated by spectral Doppler analysis in both preoperative TTE and intraoperative TOE studies, and whose echocardiographic studies were performed <3 months apart.

Patients who had AVR for lone aortic regurgitation, AVR of prosthetic aortic valves, and those with known left ventricular outflow tract obstruction were excluded from the study.

Data collection

All intraoperative TOE studies were performed and reported by experienced cardiac anaesthetists with expertise and qualifications in perioperative TOE.

Before pericardiotomy and institution of cardiopulmonary bypass, continuous-wave Doppler was applied across the aortic valve in a deep transgastric view, according to well-established intraoperative TOE guidelines.[9]

Preoperative TTE studies were performed by experienced echocardiographers in the cardiology department and reported by consultant cardiologists. A suprasternal or an apical view was used to interrogate the aortic valve.

In keeping with the institutional policy, velocity and gradient measurements were reported only if the angle of alignment between continuous-wave Doppler and aortic flow was ≤15°, leading to underestimation of ≤5% for peak velocity.[2]

Preoperative and intraoperative echocardiographic measurements, including peak velocities and mean gradients, were extracted from the electronic database. The DI was obtained by the ratio of left ventricular outflow tract velocity–time integral to aortic valve velocity–time integral. Comparisons were made between preoperative TTE and intraoperative TOE measurements.

Data regarding qualitative estimations of left ventricular ejection fractions (LVEF; normal, >50%; mild dysfunction, 41–50%; moderate dysfunction, 30–40%; severe dysfunction, <30%) and qualitative assessments of coexisting aortic and mitral regurgitation (AR and MR; none, trivial, mild, mild to moderate, moderate, moderate to severe, severe) were also extracted.

Data analysis and statistics

Bland–Altman analysis was used to compare the preoperative TTE and intraoperative TOE measurements of peak velocities, mean gradients, and DIs. Student's paired *t*-tests were also used to compare these measurements. Student's unpaired *t*-tests were used to compare these measurements between patients whose preoperative TTE was <1 month and those whose preoperative TTE was between 1 and 3 months before the intraoperative TOE.

The peak velocities, mean gradients, and DIs were also recoded to grades of AS severity (mild, moderate, and severe) according to recent American Heart Association/American College of Cardiology guidelines.[2 3] Linearly weighted (1, 0.5, 0) κ coefficients, their 95% confidence intervals (CIs), and Wilcoxon signed-rank tests were used to compare the preoperative TTE and intraoperative TOE grades of AS. Fisher's exact test was used to compare the percentage agreement of the three recoded measurements. Wilcoxon signed-rank tests were used to compare grades of LVEF, AR, and MR between preoperative TTE and intraoperative TOE studies.

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