British Journal of Anaesthesia **111** (5): 743–9 (2013)
Advance Access publication 24 June 2013 · doi:10.1093/bja/aet212

BJA

Assessment of changes in left ventricular systolic function with oesophageal Doppler

X. Monnet[1,2]*, J.-M. Robert[1,2], M. Jozwiak[1,2], C. Richard[1,2] and J.-L. Teboul[1,2]

[1] Hôpitaux universitaires Paris-Sud, Hôpital de Bicêtre, service de réanimation médicale, 78, rue du Général Leclerc, Le Kremlin-Bicêtre F-94270, France
[2] Université Paris-Sud, Faculté de médecine Paris-Sud, EA4533, 63, rue Gabriel Péri, Le Kremlin-Bicêtre F-94270, France

* Corresponding author: Service de réanimation médicale, Centre Hospitalier Universitaire de Bicêtre, 78, rue du Général Leclerc, Le Kremlin-Bicêtre F-94270, France. E-mail: xavier.monnet@bct.aphp.fr

Editor's key points

- Oesophageal Doppler is becoming more widely used in major surgery to guide fluid therapy.
- It is unclear whether the indices derived from the oesophageal Doppler signal are affected by changes in left ventricular (LV) systolic function.
- Continuous monitoring of LV systolic function may help guide fluid and inotropic therapy during and after surgery.
- This study found that mean acceleration and peak velocity of the aortic flow signal are markers of LV systolic performance.

Background. We tested the ability of mean acceleration (Acc) and peak velocity (V_{peak}) of the aortic velocity signal measured by oesophageal Doppler to reflect left ventricular (LV) systolic performance.

Methods. We included critically ill patients in whom a fluid challenge (n=25) or the introduction of dobutamine, 5 μg kg^{-1} min^{-1} (n=25), was planned by the attending physician. Before and after therapeutic interventions, we measured Acc and V_{peak} (CardioQ device) and LV ejection fraction (LVEF) using echocardiography.

Results. For all pairs of measurements, the absolute values of Acc and V_{peak} correlated with LVEF (r=0.36 and 0.57, respectively). The correlation was significantly higher for V_{peak} than for Acc. Volume expansion did not significantly change LVEF and Acc, but significantly increased V_{peak} by 7 (8)%. Dobutamine increased LVEF by 30 (15)%, Acc by 33 (25)%, and V_{peak} by 20 (10)%. Considering the pooled effects of volume expansion and dobutamine, changes in Acc and V_{peak} and those of LVEF were correlated (r=0.53 and 0.67, respectively). When excluding changes <18% (i.e. the least significant change for LVEF), the concordance rate was 96% for Acc and 100% for V_{peak}.

Conclusions. V_{peak} and, to a lesser extent, Acc measured by oesophageal Doppler behaved as markers of LV systolic performance as they were almost insensitive to fluid administration and changed to a much larger extent with dobutamine. These indices could be used to estimate LV systolic performance and to assess the effects of inotropic therapy.

Keywords: cardiac output; cardiac output, shock; measurement, equipment; monitors, dobutamine, measurement techniques

Accepted for publication: 11 April 2013

Oesophageal Doppler was developed years ago as a minimally invasive technique allowing haemodynamic monitoring.[1] It has gained increasing popularity, in particular because studies have shown its use in high-risk surgical patients leads to improved outcomes.[2–9] By measuring blood flow in the descending thoracic aorta, oesophageal Doppler provides reliable estimation of cardiac output.[10]

Beyond aortic blood flow, oesophageal Doppler devices also measure the mean acceleration (Acc) and peak velocity (V_{peak}) of aortic flow from the Doppler signal. By analogy with the measurements performed at the aortic root level, which are recognized as indices of left ventricular (LV) systolic performance,[11] Acc and V_{peak} measured by oesophageal Doppler in the descending thoracic aorta have been suggested to be related to LV contractility.[1] Nevertheless, these previous investigations were conducted in a small number of patients[1] or in healthy subjects.[12] Moreover, Acc and V_{peak} were not compared with the gold standard for the assessment of the LV systolic function at the bedside [i.e. the LV ejection fraction (LVEF) measured by echocardiography].

In the present study, we aimed to confirm that Acc and V_{peak} are indicators of LV systolic function by comparing these indices to echocardiographic LVEF. We also tested whether Acc and V_{peak} behave as indicators of LV systolic function; that is, whether they remain unchanged after volume expansion yet increased by dobutamine administration.

Methods

Patients

This study was conducted in a 15-bed medical intensive care unit of a university hospital. It was approved by the Institutional Review Board of our institution (Comité pour la protection des personnes Ile-de-France VII). A deferred informed consent

was obtained from the patient's surrogate as soon as possible. As he/she recovered consciousness, a deferred informed consent was confirmed from the patient. If the patient or his/her next of kin refused to consent, the patient's data were not entered into the analyses. All patients had a diagnosis of septic shock and were receiving norepinephrine. Patients were included in the study if they met all of the following criteria:

(1) The presence of acute circulatory failure defined by (i) systolic arterial pressure $\leq$90 mm Hg (or decrease in systolic arterial pressure of $>$50 mm Hg in known hypertensive patients) or need for norepinephrine administration, (ii) urinary flow $\leq$0.5 ml kg^{-1} min^{-1} for $>$2 h, (iii) tachycardia $\geq$100 bpm, or (iv) presence of skin mottling.
(2) Need for fluid expansion or dobutamine administration, as decided by the attending physician. For fluid administration, volume expansion was administered either as a fluid challenge or because of positivity of fluid responsiveness tests (pulse pressure[13] and stroke volume variations, respiratory variations of the descending aortic blood flow,[14] passive leg raising,[15] or end-expiratory occlusion tests).[16 17] These tests were not assessed during echocardiography. Infusion of dobutamine was used if LV contractile impairment was thought to account for the haemodynamic failure.
(3) Monitoring by a transpulmonary thermodilution device (PiCCO2, Pulsion Medical System, Munich, Germany).

Patients were excluded if echogenicity was not sufficient for a proper assessment of the LVEF by transthoracic echocardiography or if they had a contraindication for the use of oesophageal Doppler monitoring (i.e. known or suspected oesophageal ulcer, malformation, varicose, or tumour).

Measurements

Immediately after inclusion, an oesophageal Doppler device (CardioQ, Deltex Medical, Chichester, UK) was set up. For this purpose, a 90 cm Doppler probe was inserted through the mouth or nose and advanced into the oesophagus to the mid-thoracic level. The probe position was then adjusted to obtain the highest Doppler velocity signal from the descending aorta. The probe position was re-adjusted during the course of the study if the aortic blood velocity signal deteriorated. Three investigators (J.-M.R., M.J., and X.M.) trained in this technique performed all measurements. The time required to obtain an optimal signal was 5 (1) min. We recorded the values of cardiac index, Acc, V_{peak}, and flow time corrected for heart rate that were automatically measured by the oesophageal Doppler device. The flow time is the aortic ejection time. It is related to preload and afterload.[18 19]

Transpulmonary thermodilution was used for assessing the effects of therapeutic interventions on cardiac index as such effects might be underestimated by the CardioQ device when arterial pressure changes to a significant extent.[20] Echocardiography was performed by the transthoracic apical four- and two-chamber apical views (EnVisor Philips version B.0, Philips Medical System, Andover, MA, USA). The LVEF was obtained using the biplane or monoplane Simpson method. The echographic examinations were performed by a cardiologist (X.M.).

Study design

Before all therapeutic interventions, we performed a first set of haemodynamic measurements, including heart rate, systemic arterial pressure, cardiac index measured by oesophageal Doppler and by the transpulmonary thermodilution, flow time corrected for heart rate, Acc, V_{peak}, and LVEF.

After this first set of haemodynamic measurements, volume expansion was done using 500 ml of saline $>$10 min, or dobutamine infusion was commenced at 5 μg kg^{-1} min^{-1}, according to the decision of the clinician in charge of the patient. All other treatments were kept unchanged during the study period.

A second set of haemodynamic measurements was done after the therapeutic intervention (i.e. at the end of fluid administration for patients who received it and 15 min after stabilization of cardiac index in patients in whom dobutamine was used). This set included heart rate, systemic arterial pressure, cardiac index measured by oesophageal Doppler and by the transpulmonary thermodilution, flow time corrected for heart rate, Acc, V_{peak}, and LVEF. Investigators were not blinded to the therapeutic interventions. Echocardiographic measurements were performed after oesophageal Doppler measurements in all instances.

Statistical analysis

The normality of data distribution was tested with the Anderson–Darling test. Variables were summarized as frequencies and percentages for categorical variables, means, and standard deviations (SDs) for continuous normally distributed variables or medians, mean [95% confidence interval (CI)] for sensitivities and specificities, and inter-quartile ranges otherwise. Data were compared using χ^2, Fisher exact, two-tailed Student's or Mann–Whitney *U*-tests, as appropriate. Correlation between variables was tested by the Spearman's coefficient of rank correlation and correlation coefficients were compared using the Fisher transformation.[21] The reproducibility of LVEF (inter- and intra-observer) was evaluated by calculating the coefficient of variation (i.e. the ratio of the SD to the mean).

For assessing the ability of Acc and V_{peak} to track changes in LVEF, we constructed a four-quadrant plot.[22] This allowed calculating the percentage of total data points for which the direction changes of Acc and of V_{max} (increase or decrease) were concordant with LVEF. As the least significant change of LVEF is 18%,[23] we applied an 18% exclusion zone to this four-quadrant analysis.[22] Multivariable regressions were performed by entering Acc and V_{peak} to estimate LVEF absolute values and relative changes. We performed a receiver operating characteristic (ROC) curve analysis in order to test the ability of Acc and V_{peak} to detect an LVEF of $<$35%. Areas under ROC curves were compared by the Hanley–McNeil test. Statistical significance was defined by a *P*-value of $<$0.05.