Title: CONTRAST ECHOCARDIOGRAPHY - A NEW TECHNIQUE FOR INTRAOPERATIVE QUANTITATION OF MYOCARDIAL PERFUSION

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Transesophageal two-dimensional echocardiography (2DE) is now established as a sensitive tool for detecting myocardial ischemia. Contrast echocardiography (CE) uses conventional 2DE to detect enhanced ultrasound backscatter from sonicated microbubbles (4.5 ± 2.3 microns) which behave as an intravascular indicator. We have previously reported on the safety and feasibility of qualitative assessment of myocardial perfusion in humans during CABG surgery.

The current study was designed to provide a theoretical and empirical foundation for quantification of myocardial perfusion using CE. A combination of quantitative myocardial perfusion imaging with sensitive detection of myocardial ischemia, using the same imaging techniques, will eventually enable us to better understand the etiology and appropriate therapy of intraprocedural ischemia.

Methods: We studied open chest, halothane anesthetized mongrel dogs, 20-30 kg wt., instrumented for continuous recording of cardiac output, EKG, arterial, left atrial, and right atrial pressures, with a catheter in the proximal circumflex coronary artery (CCA) for drug infusion. Regional myocardial blood flow (RMBF) was measured using radioisotopel labeled microspheres. CE was done using a commercially available unit with a 5 megahertz transducer placed on the surface of the heart. Images of the short axis of the left ventricle were recorded on videotape and later analyzed using an offline videodensitometer. 6 cc of sonicated microsphere suspension, used as the echocohant agent, was injected into the left atrium over 20 seconds using a programmable injector. Measurements were made with microspheres and CE under control conditions, infusion of adenosine into the CCA, and global, nonselective hypoxia. After sacrifice, the heart was sectioned for microscopic RMBF determinations from the regions of the CCA and LAD circulation. CE videodensity curves from the LAD and CCA regions were analyzed for peak height (HD) and curve area (AA). Indicator dilution theory suggests that CE for an intravascular indicator should measure regional blood volume (RBV) not necessarily RMBF.

This important limitation of an indicator dilution curve for an intravascular tracer has not been previously recognized in any published studies attempting to quantitate RMBF with CE.

Results: There were no significant hemodynamic changes as a result of CE or ischemic adenosine. AA correlated weakly (p < 0.05, r²=0.53) with RMBF (Fig 1). If values for AA were grouped by intervention, adenosine increased AA significantly less than hypoxia (p < 0.05), although RMBF values were similar (Fig 2).

Discussion: Our result agrees with known effects of adenosine and hypoxia on RBV and RMBF. Hypoxia maximally recruits the myocardial capillary bed and increases RBV and RMBF, while adenosine does not recruit capillaries and therefore increase RBV without changing RMBF to as great an extent as hypoxia. We therefore conclude that CE directly measures RBV. A covariance between RBV and RMBF is unexpected, although they will not vary exactly under all conditions. As RMBF is an indicator of open capillary density, while RBV is not, measurement of RMBF may prove to be very important in the understanding of ischemia. We conclude that CE can provide a quantitative assessment of an important component of myocardial perfusion, RBV, and will enhance our ability to study ischemia in laboratory and clinical settings.

Fig. 1

Fig. 2

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