Title: CAN DOPPLER ULTRASOUND, TARGETED BY TWO DIMENSIONAL TRANSESOPHAGEAL ECHOCARDIOGRAPHY, BE USED TO MEASURE CARDIC OUTPUT?

Authors: JE Ellis, M.D., A Runyon-Hass, Ph.D., M.D., JL Lichtor, M.D., MF Keamy, M.D., MF Roizen, M.D.

Affiliation: Department of Anesthesia and Critical Care, University of Chicago, Chicago, Illinois 60637.

INTRODUCTION: Instruments which utilize doppler ultrasound to measure cardiac output (CO) non-invasively have recently been introduced into clinical practice. These monitors use esophageal doppler probes to measure blood flow in the descending aorta. While good correlation has been reported between CO measured by this technique and by thermodilution (1), there are theoretical objections to this doppler technique. These include the inability to measure aortic root diameter or the contributions of myocardial and cerebral blood flows to cardiac output.

We undertook to measure CO by pulsed-doppler interrogation of trans-mitral valve flow, using two-dimensional transesophageal echocardiography (2DTEE) to "target" the doppler sampling site. We compared these results with the measurement of CO by standard thermodilution technique.

METHODS: This study was approved by our Clinical Investigations Committee. Ten patients in whom pulmonary artery catheters were placed for perioperative management were included in the study. After induction, a transesophageal echocardiographic (TEE) probe (Diasonics, Milpitas CA) was introduced and connected to a Diasonics 6400 ultrasonogram with pulsed-doppler capability. A characteristic long axis, four-chamber view of the left ventricle was obtained. We attempted to obtain the view which maximized the view of mitral valve leaflet excursion, and minimized the observed portion of the aortic valve.

Simultaneous measurement of doppler CO (DCO) and thermodilution CO (TDCO) were made at 40 separate intervals in the ten patients. One investigator determined TDCO in triplicate, while another measured the mitral valve annulus diameter (D) in triplicate, and positioned the doppler cursor in the left ventricular inflow to obtain the best possible visual signal, with discernible "e" and "a" waves (see figure 1). Patients with doppler evidence of mitral regurgitation were excluded from the study. The doppler flow pattern was manually gated and the diastolic time measured recorded. Fast-Fourier analysis of the diastolic trans-mitral flow provided a mean flow velocity integral (MVI). These results, and the heart rate (HR) were noted, but DCO was not computed in the operating room, to prevent that knowledge from influencing following measurements of the doppler signal or the mitral annular diameter.

DCO was later calculated. We assumed the mitral annulus was circular, with a cross-sectional area (CSA) that remained constant throughout the cardiac cycle. CSA was therefore calculated to be equal to $\pi(D/2)^2$. DCO was computed as:

DCO = (CSA)x(diastolic time)x(MVI)x(HR)

DCO and TDCO were compared by linear regression analysis.

RESULTS: Linear regression analysis of TDCO and DCO revealed DCO = 0.708 (TDCO) + 2.537 (see figure 2). The correlation coefficient was r = 0.71 for the 40 determinations.

DISCUSSION: Experimental studies comparing doppler measurement of trans-mitral valve flow with roller-pump flow rates (2), and clinical studies comparing trans-thoracic pulsed-doppler echocardiography with thermodilution cardiac output measurement (3) have demonstrated excellent results (r = 0.97 and r = 0.96, respectively).

A variety of factors may explain our inability to duplicate such results. It is not always possible, due the limited range of motion allowed by the esophagus, to obtain a true long-axis view; this affects the accuracy of the doppler velocity signal measured. More importantly, resultant errors in the measurement of mitral annular diameter are magnified, as this value is squared in determining DCO. Our method assumes that the mitral annulus is a circle which remains constant in size during diastole; this is an over-simplification.

Despite these limitations, when 2DTEE monitoring is already in place, targeted pulsed-doppler can be used to continuously trend CO intraoperatively. DCO measurement allows the use of central veins for volume infusion and reduces the risks, including carotid puncture, pulmonary artery rupture, and endocarditis, associated with pulmonary artery catherization (4). 2DTEE-targetted DCO is a marginally acceptable substitute for TDCO.

REFERENCES:

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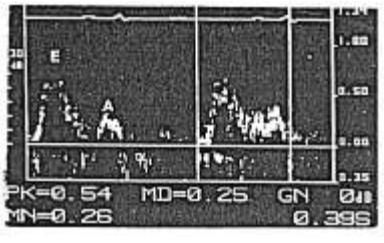
FIGURE 1: DOPPLER MEASUREMENT OF TRANSMITRAL FLOW



e = early passive filling; a = atrial filling

FIGURE 2: LINEAR REGRESSION OF TDCO AND DCO