

Title: INTRAOPERATIVE MONITORING WITH TWO-DIMENSIONAL TRANSESOPHAGEAL ECHOCARDIOGRAPHY

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**Introduction.** Complex and invasive forms of monitoring play an increasing role in the care of patients with serious cardiac disease. Significant morbidity and (rarely) mortality can result from the monitoring itself. We would welcome equally informative monitoring devices that were noninvasive and hence without risk.

Precordial echocardiography is a commonplace noninvasive aid to the preoperative assessment of patients with a variety of cardiac disorders (1). Precordial inaccessibility and instability of the position of the echo probe are two inherent problems that prevent the intraoperative application of this technique. We report that continuous, high quality two-dimensional (2-D) echocardiograms can be simply and safely obtained from a transesophageal approach. Certain applications of this technology hold special promise.

**Methods.** With the approval of the committee on human experimentation, we studied 75 adult patients undergoing a variety of surgical procedures. Immediately after endotracheal intubation, a gastro-scope tipped with a special 3.5 MHz phased array transducer was introduced into the esophagus. The positional controls of the gastroscope allowed the transducer to show multiple and reproducible views of the heart. We selected and maintained a cross-sectional view of the left ventricle (LV) below the tips of the leaflets of the mitral valve. The echocardiograms were recorded on videotape and evaluated by a commercially available computer program (Diagnostics Light Pen).

**Results.** In all but one of 75 patients, high resolution 2-D echocardiograms were obtained. Continuous monitoring was performed for up to 12 hours. No complications occurred in any patient. We have identified the occurrence of four potentially life threatening problems with the help of 2-D transesophageal echocardiography (TEE). We will briefly illustrate each with a short case summary.

**Acute Hypovolemia.** A 67 year old female required resection of an abdominal aortic aneurysm. Compounding medical problems included hypertension and ischemic heart disease. During one hour of retroperitoneal dissection, the following hemodynamic changes occurred: mean arterial pressure (MAP in mm Hg) 122 to 100, pulmonary capillary wedge pressure (PCWP in mm Hg) 23 to 13, and cardiac output (CO in ml/min) 3700 to 2700. Simultaneous echocardiographic measurements revealed: end diastolic area (EDA in  $\text{cm}^2$ ) 5.9 to 1.9 (normal range 6-14), end systolic area (ESA in  $\text{cm}^2$ ) 2.1 to 0.3 (normal range 3-8), and ejection fraction (EF in % calculated as (EDA-ESA)/EDA x 100) 68 to 86 (normal range >50). Despite the apparently normal PCWP, inadequate LV filling was diagnosed and additional fluid was given.

**Acute LV Failure.** A 70 year old male required resection of an abdominal aortic aneurysm. Coronary

artery disease but not congestive failure was suspected. Immediately prior to supraceliac aortic cross-clamping, hemodynamic and echocardiographic parameters were: MAP 87, PCWP 12, CO 3.2, EDA 11.5, ESA 5.0, and EF 57%. Immediately following cross-clamping, marked dilatation of the LV occurred, sluggish contraction was noted, and these parameters were recorded: MAP 132, PCWP 35, CO 2.7, EDA 14.5, ESA 8.4, and EF 42. Acute LV failure was diagnosed and a vasodilator given.

**Intravascular Air.** A 65 year old male required aortic valve replacement for severe aortic stenosis. At the conclusion of the repair and rewarming, the heart was defibrillated. A gradually decreasing number of air bubbles were noted by TEE streaming through the LV for the next 27 min despite previous surgical maneuvers aimed at removing air.  $\text{N}_2\text{O}$  was withheld for the entire post bypass period.

**Intraoperative Myocardial Ischemia.** A 52 year old female required mitral valve replacement for mitral stenosis. Prior to bypass, parameters recorded were: MAP 70, no PCWP or CO, EDA 11.2, ESA 4.9, and EF 56. After a surgically difficult valve replacement, TEE demonstrated complete absence of anterior and severe reduction in lateral wall motion. Termination of bypass required multiple inotropes and a vasodilator. Parameters recorded were: MAP 45, no PCWP or CO, EDA 10.2, ESA 7.1, and EF 33. An anterior lateral myocardial infarction was documented by subsequent EKGs and enzymes.

**Discussion.** TEE has two major advantages over the precordial approach. The proximity of the transducer to the LV results in clearer images, and the stability of the probe affords a constant monitoring position. Assessment of changes in LV volume, contraction, and even regional wall motion is now possible intraoperatively. The simultaneous measurement of LV diastolic filling volume and pressure may allow estimation of diastolic compliance changes and perhaps aid in the early detection of LV ischemia. Future studies are required to establish if TEE is more sensitive to intravascular air detection than any of our current clinical monitors - a likely possibility. TEE identified life threatening events in these patients in a noninvasive fashion. Although other measurements might have led to the same identification, those measurements often are invasive and impose an element of risk not present with the TEE. It also should be noted that when TEE and LV pressure measurements are used concomitantly, a more complete picture of cardiac function is available. We believe the addition (or sometimes the substitution) of TEE may lead to a more rapid and accurate assessment of life-threatening events.

#### Reference.

1. Popp RL, Rubenson DS, Tucker CR, et al: Echocardiography: M-Mode and two-dimensional methods. *Ann Int Med* 93:844-856, 1980