Title: INTRAOPERATIVE ECHOCARDIOGRAPHY AND COLOR FLOW IMAGING DURING PEDIATRIC CARDIOVASCULAR ANESTHESIA AND SURGERY

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Introduction: The recent development of two-dimensional echocardiography with color flow imaging (CFI) has provided new information on cardiac function and blood flow in normal and pathologic states. The usefulness of intraoperative 2-D Echo with CFI has recently been described in adult patients and has centered on a transesophageal approach for diagnosis[1]. This approach is not useful in infants and children undergoing cardiac surgery due to the limitations of probe size and the restrictive views from the esophagus which do not clearly assess the spectrum of cardiac anomalies in congenital heart disease. In order to overcome these limitations, we devised an epicardial approach for intraoperative echocardiographic analysis with CFI. This study was designed to test the feasibility, safety and usefulness of intraoperative epicardial echocardiogram with CFI (IEE-CFI) in infants and children during anesthesia and surgery.

Methods: As part of a standardized approach to the intraoperative assessment of congenital heart defects 140 pediatric patients undergoing cardiac surgery were studied. Ages ranged from 1 day - 18 years. IEE-CFI was performed at 2 predefined intervals during surgery: 1) pre-bypass 2) after bypass. A 5.0 MHz short focus transducer was used and connected to a Hewlett-Packard echocardiograph (77020 CF) incorporating a color module. For each patient the transducer was washed using sterile technique, passed over the anesthesia screen into the operative field where it was ensheathed in a sterile plastic sleeve prior to direct epicardial use. A phase array transducer, containing 64 elements, was used to provide black and white images recorded from the epicardial surface and displayed on a video screen. The same ultrasound transducer was used simultaneously for CFI.

Results: Mean patient age was 3.6 years; 79/140 (56%) were less than 3 years and the smallest patient was 2.2 kg. The mean time for intraoperative echocardiography was 10.4 minutes per case. In 53% of cases IEE-CFI confirmed known findings, in 39% IEE-CFI assisted anesthetic and operative planning, and in 7% it significantly altered approach. This help included: changed diagnosis (2 patients), changed plan operation (2), guided intraoperative approach (29), influenced operative plan (25), and influenced anesthetic management (7). 18 patients had immediate rerepair of residual defects at the time of their surgery. In 6 of these 18 patients the decision for rerepair was made on clinical assessment and epicardial echocardiographic confirmation. However, in 12 of the 18, this decision was based on echo data alone. In other words, these 12 patients were at risk for leaving the operating room with a suboptimal repair were epicardial echocardiography not used. In 105 of the patients studied the surgical results were judged to be acceptable as assessed by echo. In the remaining 35 patients there were 55 residual defects of concern noted after repair. In patients with residual defects of concern there was twofold higher rate of reoperation (8%) and a sixfold greater rate of mortality (29%) when compared to those patients where no residual defect of concern was present. If a RV contraction abnormality was present, 58% of patients died. There were no side effects from IEE-CFI excepting infrequent self-limiting arrhythmia secondary to epicardial stimulation.

Discussion: This study suggests that IEE-CFI is a safe, sensitive and reliable method to precisely define anatomy and blood flow patterns before and after repair of congenital heart defects. For the anesthesiologist, IEE-CFI provided immediate information about blood flow direction and ventricular function which permitted specific therapeutic interventions and an assessment of therapy. For the cardiologist, IEE-CFI provided new information regarding cardiac structure made possible by this epicardial approach in the anesthetized patient. For the surgeon, IEE-CFI provided a sensitive and reliable method for judging adequacy of repair, i.e. shunt closure, relief of obstruction, redirection of blood flow, valve repair. IEE-CFI was especially helpful in identifying residual defects, assessing valvular regurgitation, quantifying right ventricular pressure, and evaluating pressure gradients across the right and left ventricular outflow tract and pulmonary artery bands. Post-repair residual defects of concern were predictive of outcome and the need for rerepair.

IEE-CFI overcomes the limitations of probe size and selected views of the transesophagel approach and gives better identification of the multiple anatomic defects seen in congenital heart disease. We conclude that IEE-CFI provides reliable assessment of intracardiac blood flow, anatomy and function, demonstrating the importance of this technique in assisting the intraoperative management of patients with congenital heart disease.

Reference:

1. de Bruijn NP, Clements F, Kisslo JA: Intraoperative transesophageal color flow mapping: Initial experience. Anesth Analg 66:386, 1987