JACC Vol. 16, No. 2
August 1990:447–50

Editorial Comment

Transesophageal Echocardiography In Children: New Peephole to The Heart*

SAMUEL B. RITTER, MD, FACC
New York, New York

Noninvasive imaging of cardiac structures has altered the practice of cardiology over the past decade. This has been particularly true in the field of pediatric cardiology, where precise anatomic delineation depends so crucially on painstaking segmental two-dimensional echocardiographic imaging. Recent development of an echocardiographic system that simultaneously dispalys cross-sectional morphologic images as well as intracardiac and extracardiac blood flow in real time (Doppler color flow mapping) has revolutionized the field of diagnostic cardiac imaging (1–5). The Doppler color flow information has greatly enhanced both structural as well as functional assessment and evaluation of congenital and acquired cardiac disease, providing a "third plane" for spatial orientation of flow, whereas standard pulsed and continuous wave Doppler recordings have the limitation of single point or single plane sampling. Noninvasive imaging has indeed altered the practice of pediatric cardiology. Delineation of congenital heart disease has become a standard precise diagnostic technique, often supplanting cardiac catheterization for the diagnosis and assessment of congenital heart defects. Transthoracic imaging with color Doppler technology has added much more information to the standard two-dimensional study, often detecting heretofore unseen lesions such as small ventricular septal defects (6).

Recent advances in echocardiography. The adult cardiologist has been somewhat plagued by poor quality images from routine transthoracic echocardiography. These limitations are caused by 1) ultrasonic interference from the chest wall and lung, particularly in patients who are obese, have chronic pulmonary disease or are on ventilatory support, and patients with prosthetic valves, which produce artifact; 2) lack of good color flow sensitivity at increasing depths; and 3) a variety of cardiac lesions not optimally or maximally suitable for diagnostic two-dimensional image assessment (aortic dissection, for example). These limitations have spurred the search for a better ultrasound window to the heart. In the early 1970s, this began with transesphageal M-mode echocardiography (7) and quickly progressed to transesophageal two-dimensional echocardiography by 1977 (8). By the early 1980s, phased array technology paved the way for early flexible endoscopic transesophageal echocardiographic probes (9). A wide variety of reports from Europe, Japan and subsequently the United States began to appear that explored various applications as well as unique clinical indications and findings. These included transesophageal echocardiographic evaluation of cardiac function, especially during surgery (10–16); identification of thrombus or embolism, or both (17–19); dissection of the aorta (20–23); evaluation of atrial and ventricular septa (24–26); assessment of endocarditis (27–28); intraoperative assessment of valve repair (29,30); identification of cardiac tumors (31) and a list of others described in detail in an excellent recent review by Seward et al. (32). The marriage of color flow technology and transesophageal echocardiography was first *reported* (33) *in clinical application in 1986, for the* assessment of valvular regurgitation and intracardiac shunts. Over the past 4 or 5 years, this combination of improved two-dimensional imaging, as well as improved color flow penetration, has proved to be invaluable for the evaluation of both inpatients and outpatients and for preoperative as well as intraoperative and postoperative application (32).

Pediatric echocardiography: cutting it down to size. The pediatric patient is a gold mine of echocardiographic images; the major obstacles to routine transthoracic cross-sectional imaging presented by many adult patients are virtually absent or minimal in the child, especially the infant. Subxiphoid (subcostal) imaging providing a diaphragm-mediated unattenuated window to the hearts of infants or young children has been invaluable in the noninvasive assessment of congenital heart disease (34). Nevertheless, even many pediatric patients are "poor quality imagers"; many are quite ill, tachypneic, on ventilatory support or have undergone previous thoracic surgery, all making for less-than-optimal image quality on transthoracic echocardiography. However, two important groups of pediatric patients are now candidates for excellent cardiac imaging who previously were virtually inaccessible: the intraoperative patient and the postoperative intensive care unit patient. Although epicardial intraoperative echocardiography has been used successfully in the pediatric population (35,36), its use is limited by its small imaging area and window, its intrusion into the sterile surgical field and the fact that it can be performed only during cessation of the surgical procedure. Until recently, transesophageal technology has had one major limitation:

*Editorials published in *Journal of the American College of Cardiology* reflect the views of the authors and do not necessarily represent the views of JACC or the American College of Cardiology.

From the Department of Pediatric Cardiology, Mount Sinai School of Medicine/Mount Sinai Medical Center, New York, New York.

Address for reprints: Samuel B. Ritter, MD, Department of Pediatric Cardiology, Box 1201, Mount Sinai School of Medicine/Mount Sinai Medical Center, One Gustave L. Levy Place, New York, New York 10029.

0735-1097/90/$3.50

JACC Vol. 16, No. 2
August 1990:447–50

size of the instrument; only 9 to 12 mm diameter probes have been available. These are unsuited for the average young child and certainly the infant. The large probes have also potentially limited the use of transesophageal echocardiography for prolonged postoperative monitoring in the intensive care unit, where a bandaged chest, combined with a mechanically ventilated patient, already limits any "quality" transthoracic imaging.

The advent of a small pediatric-sized transesophageal color flow probe has changed this situation dramatically. This probe is an ultrasound transducer device mounted on a flexible 70 cm gastroscope. The device is 14 × 6.4 × 6.8 mm with a 26 element 5 MHz transducer (Aloka/Corometrics). It is interfaced with an Aloka/Corometrics 870 two-dimensional color flow Doppler echocardiographic unit. An external knob controls up-down orientation (flexion/retroflexion). Initial studies (37) with this prototype probe in 12 infants and children, aged 1 week to 18 years and weighing as little as 3.3 kg, appeared in early 1989. The probe was used intraoperatively and postoperatively in the intensive care unit. Later in 1989, more extensive use of the probe in a group of 26 infants and children (43 studies) was reported (38); of note in that study, 23 of the patients were <1 year of age and 16 were studied within the first 10 days of life. Once again, both intraoperative as well as postoperative studies were performed in a wide variety of congenital heart defects, including transposition of the great vessels, truncus arteriosus, critical pulmonary stenosis, hypoplastic left heart syndrome, atrioventricular (AV) septal defect, and tetralogy of Fallot. In numerous instances transesophageal echocardiography proved to be of additional value in morphologic-anatomic assessment, intraoperative assessment of surgical correction and postoperative hemodynamic evaluation. Several cases of supplanted cardiac catheterizations were pointed out in this report. The most current published experience (39) in pediatric transesophageal echocardiography comprises 83 studies in 65 infants aged 6 h to 18 years (mean 32 months), weighing 2.4 to 30 kg (mean 10.6), with 29 patients <1 year of age and 18 <10 days (weight 2.4 to 4.3 kg).

Utility of transesophageal echocardiography in congenital heart disease. This has been pointed out in a number of other studies as well. Sutherland et al. (40) discussed the importance of intraoperative ultrasound in congenital heart disease, both before and after bypass surgery, to check the preoperative diagnosis, determine or modify the operative approach, or both, check the repair and exclude residual significant intracardiac shunts or valvular insufficiency and assess chamber volume and ventricular function. They pointed out the advantages of the transesophageal approach as well, such as no interference with the surgical field, additional scanning planes, which adds to epicardial imaging availability, not only during surgery, but postoperatively as well. This latter use may be extremely valuable, they point out, when a problem arises after surgery. The specific postoperative use of transesophageal echocardiography in congenital heart disease is discussed by Kasper et al. (41) in a study of 123 patients. They compared transthoracic and transesophageal echocardiography and demonstrated the advantages of the latter approach in a subgroup of children with atrial septal defect who had recurrent left to right shunt detected only by transesophageal echocardiography. In another study, Sutherland (42) specifically points out that in the adolescent and adult patient with congenital heart disease, transesophageal echocardiography can provide "surprising amounts of new information"; notably, abnormalities of both systemic and pulmonary venous drainage, atrial lesions, atrial baffle function, Fontan procedure circulation, AV valve morphology, subaortic obstruction and descending aortic pathology, among others.

The present study. In this issue of the Journal, Stümper et al. (43) report on a group of 25 children aged 1 year to 14.8 years (mean 6.1) and weighing 6.5 to 52 kg (mean 22.4) undergoing cardiac catheterization or intracardiac surgery, or both. The purpose of their study was to assess the potential role of transesophageal echocardiography in initial diagnosis, perioperative management and postoperative follow-up of children with a variety of congenital heart lesions. There was universal success in obtaining images and no complications were encountered. Assessment of venous connections, atrial septal lesions, AV valves and left ventricular outflow tract morphology was enhanced. In 60% of the patients additional information was provided by transesophageal echocardiographic imaging; in addition, this method provided useful information on ventricular function and volume status during weaning from cardiopulmonary bypass. The authors concluded that pediatric transesophageal echocardiography performed under general anesthesia is a safe and valuable technique that gives additional information regarding intracardiac morphologic assessment of congenital heart disease as well as valuable perioperative and postoperative monitoring information.

These conclusions are certainly warranted by the data presented. They also sustain the conclusions set forth in the studies already mentioned. All of these studies point to an inevitable conclusion: "the role of transesophageal echocardiography in children with congenital heart disease . . . is likely to rapidly increase in the near future" (43).

Implications and recommendations. With this prediction in mind, one must pause and reflect: does "ability-to-do" mandate its doing? Does the availability of technology dictate obligatory employment of that technology? Does feasibility necessarily become synonymous with performance? If the answer is in the affirmative (as it appears to be in the case of pediatric transesophageal echocardiography), then who, when, how and where?

Recommendations on uniformity of view orientation have been recently published (44) by the American Society of Echocardiography to standardize transesophageal echocardiographic imaging. Recommendations in that report also are directed at the "how" of transesophageal echocardiographic studies in both awake and sedated patients ("when" and "where"). General suggestions regarding the "who" (potential users) and basic training suggestions are also outlined. Further recommendations as to the "who" (patient, indications) come from the studies already reviewed, and are eloquently summarized in the review article by Seward et al. (32). The "who" (echocardiographer) is also specifically addressed (both cardiologist as well as anesthesiologist) and training guidelines or suggestions are outlined, including suggested minimal prerequisites. That an experienced echocardiographer who is fully conversant with morphologic and hemodynamic conditions of complex congenital cardiac malformations should perform and interpret the transesophageal echocardiographic study has been echoed (no pun intended) by others as well (Sutherland [42]). This clearly places the pediatric cardiologist in the seat of responsibility, whether or not he or she performs these studies with the assistance of the gastroenterologist or anesthesiologist, as an inpatient or outpatient procedure or intraoperatively or postoperatively.

Further advances have already begun, including even smaller probes capable of being used in small premature infants, as reported by Sahn et al. (45). Development of pediatric-sized biplane transesophageal echocardiographic probes similar to the ones used in larger patients will be extremely important and will offer additional and better information regarding structure and blood flow (46).

Although we are apparently at the dawning of the age of the esophagus (Dr. James Huhta, personal communication), one must recall in metaphoric comparison the age-old question as to why does one ascend the mountain?; because it is there! In contradistinction, one should not *de*scend the esophagus simply because it is there. It must provide additional information at an acceptable risk/benefit ratio.

As a complementary and additive procedure to conventional two-dimensional Doppler and color flow imaging, transesophageal echocardiography in infants and children with congenital heart disease will have an expanded role. The pediatric cardiologist must be prepared to accept this new responsbility: *that* may be the more difficult pill to swallow.

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