TRANSESOPHAGEAL ECHOCARDIOGRAPHY

AND CARDIAC OPERATIONS

Essay
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BY

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Wael Reda Hussein

بسم الله الرحمن الرحيم

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قالوا سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم

سورة البقرة - الآية ٣٢

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INTRODUCTION

Introduction

During the past few years, transesophageal echocardiography (TEE) has rapidly developed into one of the most valuable monitoring and diagnostic tools for cardiac anesthesia and surgery. The recent recognition of TEE by the American College of Cardiology as a clinically accepted procedure for the diagnosis of heart disease, as well as for patients undergoing cardiac surgery, reflects a change of the image of TEE from a procedure of exclusivity to one of use in daily practice ***(Seward, 1992)***.

Anesthesiologists are expected to use TEE intraoperatively for monitoring regional and global left ventricular (LV) functions and its determinants. This is a demanding task requiring intensive training in the imaging of the left ventricle from the esophageal and gastric windows and competency in the on line evaluation of the left ventricular wall motion.

Despite the understandable interest of cardiac anesthesiologists in left ventricular function, they must also be familiar with other cardiac structures and their function. It is irresponsible to use TEE solely to monitor left ventricular short axis view, ignoring other structures with the possibility of overlooking essential information.

Anesthesiologists applying TEE in cardiac surgery should therefore also acquire the knowledge necessary to perform a standard TEE examination. This training should be done in close cooperation with experienced consultation and help in event of unsuspected or confusing findings.

Thus, TEE is not only useful for left ventricular function monitoring but it provides relevant data to anesthetists, surgeons, and it is helpful for intraoperative decision making ***(Foster and Schiller, 1992)***.

CHAPTER (1)
HISTORY

History

Side and Gosling, in *1971*, first reported use of the esophagus to record thoracic aortic flow in humans using continuous wave Doppler.

Experimental studies using this approach to assess the blood flow dynamics and wall motion of the thoracic aorta in dogs followed in 1975 ***(Daigle et al., 1975)***.

In ***1976***, ***Frazin et al.*** Described a method for obtaining M (motion) mode recordings of the heart from the esophagus using a single element transducer. The transducer was connected to the ultrasound machine by thins (3 mm), flexible, shielded coaxial cable and the ability of the operator to control the transducer and direct the ultrasonic beam was severely limited.

In ***1977***, ***Hisanaga et al.*** Introduced the first two dimensional echo device for recording images from the esophagus. Their instrument consisted of a high speed rotating ultrasound scanner fixed to the tip of a rigid gastroscope-like shaft. The rotating transducer was enclosed in an inflatable oil bag to separate the moving elements from the surrounding tissues and to maintain contact with esophageal wall.

Further clinical motivation for the development of esophageal echocardiography was provided by ***Matsumoto et al.*** who, in ***1981***, used the technique to monitor left ventricular performance during cardiothoracic surgery. They demonstrated that the esophagus offered a stable location for continuous cardiac examination that did not interfere with the surgical procedure and could be performed before the chest was opened and after it was closed.

In ***1982***, ***Schluter et al.*** Incorporated a transducer into the tip of a flexible gastroscope, permitting greater flexibility and patient comfort and this probe design has become the standard for image acquisition.

During the next decade, pulsed, continuous wave and color flow Doppler were added to the basic two-dimensional imaging format, and the initial monoplane design was largely replaced by biplane imaging probes ***(Harui and Souquet, 1985)***.

Improved probe design and flexibility, together with the enhanced access and image resolution provided by TEE have lead to expanded clinical application. At present, between 2.5 - 5% or more of all echocardiograms are being performed from the esophagus in major institutions ***(Seward et al., 1990).***

CHAPTER (2)

UNDERLYING PRINCIPLES AND TECHNIQUES

Underlying Principles and Techniques

Echocardiography is based on fundamental ultrasonic principles. Ultrasound is defined as sound above the upper threshold of human hearing (20,000 Hz). The ultrasound waves (1 MHz to 5 MHz) are created by striking an appropriate piezoelectric crystal which is pressure electric crystals. These materials have the property of mechanical expansion when stimulated by an electrical potential. With removal of the applied voltage, the crystal returns to its previous shape. The energy of this mechanical process is then propagated as an ultrasound waves through the surrounding medium ***(Abel et al., 1987).***

The ultrasound wave is partially reflected at the boundary of different acoustic impedance, a property that is primarily determined by the slight difference in density between different tissues. This technique is termed pulsed-reflected ultrasound. The transmission of pulsed reflected ultrasound through the heart, with detection of returning echoes detailing the position and movement of cardiac acoustic interfaces, is termed echocardiography ***(Abel et al., 1987).***

There is two different imaging systems, one is called motion (M) mode which is aimed in one direction and therefore depicts only one dimension of the target structure in an image that does not resemble cardiac structure, and the other is called 2-dimensional mode in which ultrasound beam sweeps in an arc to give a panoramic view of the heart that results in cross sectional images that are anatomically recognizable ***(Clements et al., 1991).***

Doppler echocardiography provides an alternative method for imaging blood flow by applying Doppler frequency shift analysis to echoes reflected by the moving red blood cells.

The Doppler principle states that the frequency of ultrasound reflected by a moving target (red blood cells) is different from the frequency of the emitted ultrasound. The shift in frequency is proportional to the speed of the moving target (red blood cells) *(Clements et al., 1991)*.

Color-coded Doppler flow imaging (color Doppler) simultaneously presents real-time images of intracardiac flow and structures in two dimensions. Continuous color maps of flow superimposed on monochromatic cross sectional echocardiograms. Color Doppler greatly improves the evaluation of valvular function and intracardiac shunts ***(Clements et al., 1991)***.

Instrumentation

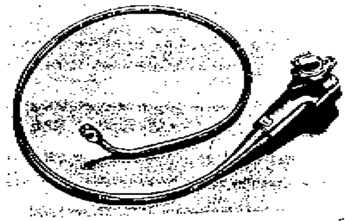
Transesophageal studies are performed using the same basic echocardiographic instruments used for routine transthoracic studies with two-dimensional imaging and pulsed, continuous wave and color Doppler capabilities.

The transesophageal probe is a modification of a standard gastroscope, with the optics removed and one or more transducers inserted in its tip. A cable for establishing electrical connection between the echograph and transducer extends from the base of the probe ***(Schluter et al., 1982)***.

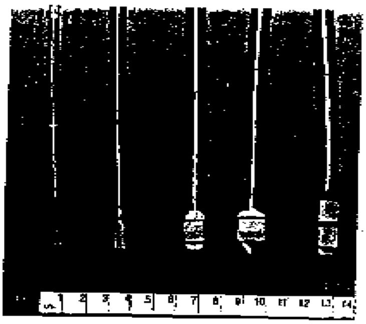
The original transducer constructed by ***Schluter et al.*** contained a single array of 32 elements, which operated a 35 MHz, was focused at 10 cm, and was aligned perpendicular to the long axis of the probe. The transducer was embedded in soft plastic material with carefully rounded edges to avoid damage of the esophagus and was fitted to the distal end of a standard flexible gastroscope. The outer diameter of the gastroscope was roughly 9 mm with a length of 100 cm. The only rigid part of the apparatus was the transducer at the tip which, in the earlier models, was 35 mm long, 15 mm wide and 16 mm thick ***(Schluter et al., 1982)*** (Figure 1).

As the technique has evolved, transducers with greater variety in design, frequency, focusing, and size have been developed. Transducers

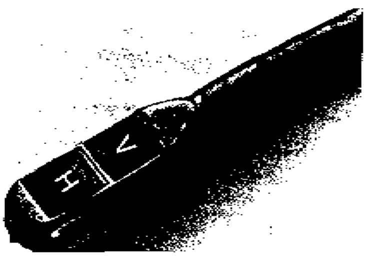
Figure (1) :



(A) Transducer for esophageal echocardiographic imaging. The probe consists of a flexible gastroscope with the optics removed and a transducer placed at the tip of the probe.



(B) The different sizes of transducers that are commercially available for use.



(C) Close-up of a transesophageal echocardiographic biplane endoscope tip with two different transducer elements. H = Horizontal plane; V = Vertical plane.

(Khandheria, 1992)