Recent Techniques in Echocardiography: Two-Dimensional Echocardiography

KIRAN B. SAGAR, M.D.

Assistant Professor of Medicine, Division of Cardiology, and Director of Echocardiography, Medical College of Virginia, Health Sciences Division of Virginia Commonwealth University, Richmond, Virginia

Conventional M-mode echocardiography is a widely used noninvasive diagnostic technique. It allows bedside assessment of cardiac chamber dimensions, valve motion and left ventricular function. The limitations of this technique are that it (1) provides only a one-dimensional (icepick) view of the heart, (2) displays cardiac structures in an unfamiliar form that bears no resemblance to cardiac anatomy, and (3) does not provide information regarding spatial orientation of cardiac structures.

These limitations led to the development of two-dimensional (2-D) real-time echocardiography in the last decade. The 2-D echo allows simultaneous visualization of cardiac structures in real time through multiple planes.

There are two types of commonly used 2-D echocardiography:

1. **Mechanical sector scanner.** A single crystal transducer is mounted on a motor and oscillates in an arc of 30°. It is less expensive than the phased array scanner and can be interphased with the existent M-mode echocardiograph. The disadvantages are noisiness, vibrations which the patient feels on the chest, and a narrow angle image. Newer, wide-angle mechanical sector scanners will overcome the last problem.

2. **Phased array wide-angle sector scanner.** This technique requires multiple elements in the transducer and there is a series of delays in the firing of the individual elements so that the ultrasonic wave front is at an angle to the transducer. By controlling the time sequence, the beam is electronically swept through a wide-angle sector.

The patient is examined lying supine or in the left lateral position with head slightly elevated. The echo information is recorded on a video cassette which can be stored and replayed later. The figures shown here are still frames of the cine.

The cardiac imaging is done in the following multiple views:

1. **Parasternal long axis.** The ultrasonic beam is parallel to the long axis of the left ventricle. Figure 1 is the anatomic section of the heart obtained in a presumed long axis plane of the left ventricle. Figure 2 shows the same structures seen with the 2-D echo. This view allows evaluation of pathology of the aortic root, aortic valve, mitral valve, and left ventricle.

2. **Parasternal short axis.** This view is obtained by rotating the transducer through 90° and provides tomographic sections of the heart from the apex of the left ventricle to the aortic root. Figures 3 and 4 show the anatomical and 2-D echo sections at the level of the papillary muscles; Figure 5 shows the 2-D echo sections at the level of the mitral valve. At this level the mitral valve area can be estimated by measuring the valve orifice with a planimeter during diastole. Figures 6 and 7 show anatomic sections and a still frame of a tomographic section of the sector scan at the level of the aortic valve.
3. **Apical four-chamber view.** This view is obtained by positioning the transducer over the point of maximal cardiac impulse with the patient in the left lateral position. The ventricles are at the top and the atria at the bottom. Figures 8 and 9 are the diagrammatic and 2-D echo sections of this view.

4. **Suprasternal view.** The transducer is in the suprasternal notch and the ultrasonic beam im-
Fig 4—Ultrasonic tomographic section of left ventricle at the level of papillary muscles (PM). Papillary muscles are seen at approximately 3 and 8 o’clock positions. RV = right ventricle, LV = left ventricle, VS = ventricular septum, PW = posterior left ventricular wall, LA = left atrium, AV = aortic valve.

Fig 5—Still frame of sector scan of short axis tomographic section of left ventricle at the level of mitral valve. In this figure, right ventricle is anterior and to the left. Left ventricle appears circular and is to the right. Anterior and posterior mitral leaflets have a fish mouth appearance during diastole. RV = right ventricle, LV = left ventricle, VS = ventricular septum, PW = posterior left ventricular wall, LA = left atrium, AV = aortic valve.

Fig 6—Anatomic section of heart obtained along presumed ultrasonic tomographic section at level of aortic valve.
Fig 7—Still frame of a tomographic section at level of aortic valve. Aorta appears circular. Three leaflets of aortic valve during diastole form a Y (R = right, L = left, N = non-coronary). Left atrial cavity is directly posterior to aortic root and left atrial appendage (LAA) is towards right of figure. Right atrium (RA) and tricuspid valve (TV) are on left of figure. Right ventricular outflow (RVO) tract, pulmonic valve (PV), and main pulmonary artery (MPA) are on top of figure. Atrial septum (AS) is also seen.

Fig 8—Left. Demonstration of placement of the transducer over apex and plane of tomogram. The image is displayed as if one were looking from below in the position of left hip, showing right and left atria (RA and LA) and right and left ventricles (RV and LV). Right. Section of the normal heart shown as it appears on the picture at left cardiac apex at top. RA = right atrium, LA = left atrium, RV = right ventricle, LV = left ventricle.

ages the ascending aorta. This view is useful for the diagnosis of coarctation of the aorta.5

**Contrast Echocardiography**

Contrast echocardiography is of value in detecting right-to-left shunt and tricuspid regurgitation. The usual contrast medium is a mixture of 5 ml of normal saline and 2 ml of air which are shaken together in a syringe to form microcavities then injected into a peripheral vein. An important precaution is to avoid injecting visible air bubbles. Two ml of green dye produce similar results. Figure 10 shows opacification of the right atrium, right ventricle, and pulmonary artery, following an injection of normal saline in a tomographic section at the level of the aortic valve.

**Clinical Application of 2-D Echocardiography**

The 2-D echo is still in the developmental phase and further investigations are required to establish its accuracy, sensitivity, and specificity. However, it has already made a significant contribution in the assessment of the severity of
mitral and aortic stenosis, regional and global abnormalities of the left ventricular wall motion, and congenital heart diseases.

**Mitral Stenosis**

Quantitative assessment of the mitral valve area with 2-D echo shows excellent correlation with the mitral valve area obtained by cardiac catheterization ($r = 0.95$)\(^6\) and at operation ($r = 0.92$).\(^7\)

**Aortic Stenosis**

Two-dimensional echocardiography not only localizes the level of aortic obstruction, that is, valvular, subvalvular or supravalvular\(^9\) but also allows noninvasive separation of significant from insignificant aortic stenosis. In our laboratory, patients with an aortic valve diameter of $<1.3$ cm (obtained in the long axis) and concentric left ventricular hypertrophy had a mean aortic gradient of $>50$ mm Hg at cardiac catheterization.\(^10\)

**Left Ventricular Wall Motion**

Regional and global left ventricular wall motion abnormalities can be studied noninvasively. The 2-D echo provides an ultrasonic angiogram of the left ventricle and thus left ventricular volumes and ejection fraction can be estimated. At the present time we still need validation of the accuracies and inaccuracies of the technique.

**Coronary Artery Disease**

There are reports of detection of left main coronary artery lesions with 2-D echo-
Further investigations are needed to define sensitivity and specificity of this technique.

**Congenital Heart Disease**

Two-dimensional echocardiography should prove helpful in delineating cardiac anatomy in critically ill infants who are at a high risk for cardiac catheterization as well as aid in the diagnosis of lesions such as atrial septal defects, ventricular septal defects, A-V canal defects, and transposition of great vessels.

In conclusion, the development of 2-D wide-angle echocardiography is a hallmark in the use of ultrasound as a diagnostic tool. It allows simultaneous visualization of cardiac structures in real time through multiple planes without known risk to the patient.

Figures 1, 2, 3, 4, 5, 6, 7, and 10 are reproduced by permission from Mayo Clinic Proceedings (53:271-303, 1978).

Figures 8 and 9 are reproduced from Circulation (57:503-511, 1978) by permission of the American Heart Association, Inc.

**REFERENCES**


