Echocardiography, the pulsed reflected ultrasound method of cardiac examination, was introduced by Edler and Hertz in 1954. Subsequent to this original report, many studies have demonstrated the usefulness of this technic and have shown that ultrasound is an energy form which is remarkably well suited for the study of the cardiovascular system. The principles involved in diagnostic ultrasound are well known. It is a noninvasive technic and there is no evidence of either immediate or late harmful effects from the ultrasound energy required for visualization of intracardiac structures. Therefore, repetitive studies may be done or continual monitoring undertaken without hazard. Since ultrasound does detect minor tissue differences, soft-tissue structures can be outlined in a manner not possible with conventional radiologic examination. This alone would be of some value in cardiac diagnosis, but it is the ability to record movement with extreme precision which has made the echocardiogram so valuable. Recent reviews illustrate the extent to which echocardiography has been developed as a method of physiologic study and clinical diagnosis. The list of applications of this technic has become quite long. These include the recording of abnormalities of anatomy and motion which may be found in patients with valve disease, a cardiomyopathy, pericardial disease, or congenital cardiac disease. Ultrasound has proved reliable for the diagnosis of intracardiac tumors and has been used in conjunction with cardiac catheterization and phonocardiography to extend our understanding of the mechanism of the production of heart sounds and murmurs. A most important development in the last few years has been the introduction of technics to estimate the dimension of the ventricles, atria, and aorta. The ultrasonic measurement of the distance between the interventricular septum and one area of the posterior left ventricular wall has been used with reasonable accuracy to estimate left ventricular systolic and diastolic volumes. With these measurements, it has been possible to estimate stroke volume and ejection fraction. One aspect of left ventricular function has thus been assessed by the reflected ultrasound method of study. While the expanded application of echocardiography has been most impressive in the past few years, it is apparent that we are still in a phase of rapid development of this technic. With rapid evolution problems are inevitable. Diagnostic ultrasound is no exception. There are problems in instrumentation and problems in

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technic. Some of the difficulties have been resolved, others remain, and others will likely appear in the future. It is appropriate to consider some of the difficulties which have been encountered.

There is a lack of uniform standardization of the ultrasound instruments in common use. Controls vary, and not all instruments have the same circuitry. For example, the image presented by an instrument with a Fast Time Constant (FTC) circuit differs from that recorded from an instrument without an FTC. The FTC circuit has the advantage of preserving the pattern of motion of a structure surrounded by other echoes which might otherwise overload the instrument. This is of value in defining motion of the septum and endocardium of the left ventricle, but the FTC does remove some information from the record. Therefore, an instrument without an FTC circuit is better suited to record anatomic detail such as the thickness of the mitral leaflet. Lack of uniformity of ultrasound equipment has apparently been responsible for some of the differences in ultrasound pictures obtained in different laboratories.

Some instruments have a time-compensated gain control (depth compensation) and others do not. This control, which permits independent adjustment of near and far gain is needed for optimal recording of the interventricular septum and endocardium. When an instrument without the capability for independent near and far gain control is used, the gain setting required to record the posterior endocardial echo may be so high that near echoes are increased to a level which overloads the image and prevents clear resolution of the septum.

Echocardiograms have been obtained with a variety of recording technics. Polaroid film may be used to photograph the image from the face of the oscilloscope, an analog gate, and write-out can be utilized to record the motion of a dominant echo, or the entire intensity-modulated echo pattern may be displayed upon the continually moving paper of a strip recorder. The Polaroid film method has a distinct disadvantage in limiting the number of cardiac cycles which can be photographed and restricting the ability to record the echogram as the heart is scanned with the ultrasonic beam. The analog gate system is designed to permit a single-line recording from a chosen echo. However, many records which have been published show a discontinuity of the pattern, as the echo spike under observation moves out of the gate and an adjacent echo signal moves into the gate. A direct display of the entire echo pattern on a strip recorder obviates most of the problems presented by the other methods. With this equipment, the ultrasound pattern is seen and recorded while the beam is directed into various areas of the heart, and proper adjustments in gain control are made. There is some indication of a trend toward standardization of commercial instruments, and the availability of commercial strip recorders should obviate previous problems encountered with the Polaroid film and analog gate methods.

Confidence in the proper identification of the origin of echoes has been a concern in the past and continues to be a problem for the individual who is beginning to learn echocardiography. However, the identification of echoes is more assured since Edler proved that the distinctive mitral echo truly originated from the anterior mitral leaflet, and the intracardiac injection of dye was found useful as an ultrasonic contrast agent which allowed other intracardiac structures to be identified and their echo pattern become recognizable. Knowing the distinctive mitral valve echo pattern, and the characteristic appearance of other echoes which have been defined by the dye injection technic, proper orientation and identification of echoes can usually be accomplished without great difficulty. The mitral valve is a superb landmark, and orientation is best achieved by first locating the echo from the anterior mitral leaflet. Then, angulation of the ultrasound transducer allows the heart to be scanned to identify the interventricular septum, the posterior left ventricular wall, the left atrial wall, and the aortic and pulmonic valve areas. However, it will always remain

Circulation, Volume XLVI, November 1972
true that no single position of transducer placement can be considered “ideal” for every patient. In some individuals, the mitral valve is best identified from the fifth interspace, while in others the third, fourth, or sixth interspace may prove to be the best “acoustic window” for intracardiac visualization.

If the transducer is properly directed to record the echo desired, appropriate gain setting of the ultrasound instrument is necessary to reduce the likelihood of false-positive or false-negative results. We have seen a patient with a left atrial myxoma which prolapsed into the mitral sleeve but was not detected by echocardiography. The sensitivity of the instrument was adjusted to such a low gain that insufficient ultrasound energy was available to penetrate the anterior mitral leaflet. The mitral pattern was thought to suggest mitral stenosis. A repeat study, using a proper gain setting, demonstrated the dense mass of multiple echoes typical for a left atrial myxoma. Pericardial effusion can usually be diagnosed readily by the ultrasound technic. However, an excessively high gain setting can produce echoes from the pericardial fluid and result in a false-negative study. There is thus an “operator factor.” Experience is required to become proficient in transducer placement, beam direction, and control setting.

With the instruments now available, and with the increasing experience of echocardiographers, some of the problems which have been presented in the past are becoming less important. New equipment will become available and will likely include the pulsed Doppler instruments which should open entirely new areas for investigation. However, what may reasonably be done with the technics now available?

More patients should be studied, and the results from various laboratories should be compared. At a time when the volume of medical literature seems overwhelming, it may seem inappropriate to suggest that more reports are needed. However, many of the papers describing the echo method of cardiac diagnosis have included relatively few patients, or the reports have not been duplicated in other laboratories. In this situation, a report which adds nothing new but confirms the work of previous investigations is of value. We need more information regarding false-positive, false-negative, and inconclusive echographic studies. A larger volume of patients with congenital disease should be evaluated so that we can determine the confidence which can be placed upon the echographic diagnosis of an anatomic malformation. Further studies of valve movement, ventricular size, and atrial size would likely increase the value of the ultrasound method for the assessment of individuals with valvular heart disease. Further information regarding the reliability of the ultrasonic determination of left ventricular function would be valuable. Should the formula which was applied to a small heart be applied to a large dilated heart? What errors can be introduced by ventricular dyskinesia? Obviously these are only a few areas where attention should be directed. Echocardiography is unquestionably established as a valid procedure which is remarkably reliable for the assessment of many conditions. Its value in clinical cardiology will increase as further studies are reported. At the same time, these studies should enable us to define more precisely the limitations of the technics now employed.

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References


