Diagnosis of Atrial Tumors by Ultrasound

By STANLEY B. WOLFE, M.D., RICHARD L. POPP, M.D.,
AND HARVEY FEIGENBAUM, M.D.

SUMMARY
A rapid, harmless, noninvasive technic using ultrasound to diagnose intra-atrial mass lesions is described. The technic permits detection of those tumors which pass through the atrioventricular orifice. Two patients with left atrial myxoma and one with a right atrial myxoma were studied with pulsed, reflected ultrasound, cardiac catheterization, and cineangiography. The diagnosis in each case was confirmed at surgery. The ultrasound technic for detecting atrial tumors was based on recording a mass of echoes immediately behind the echoes originating from the mitral or tricuspid valve leaflets. The mass held the leaflet open during diastole, causing abnormal valve motion. In one case of left atrial myxoma, the tumor plop sound, clinically confused with an opening snap, was shown to occur at a different time in the ultrasound cycle than the true opening snap. This examination is simple enough to be considered as a screening examination for the detection or exclusion of this rare but potentially dangerous abnormality.

Additional Indexing Words:
Atrial myxoma Ultrasound cardiography Echocardiography Mitral stenosis

PRIMAR Y HEART tumors are rare but often curable lesions. The most common type is atrial myxoma, which is pathologically benign. Left atrial myxoma most often produce symptoms and signs that simulate mitral stenosis, but they may also be present with only an apical systolic murmur or even without a murmur.1, 2 Many tumors have first been diagnosed at the time of a closed mitral commissurotomy. Others have been discovered accidently during cardiac catheterization for apparent mitral stenosis. There are, of course, potential hazards in doing cardiac surgery or catheterization, especially septal catheterization, on patients with left atrial tumors. Thus, it is best to have a reasonable idea that a tumor might be present before the procedure is attempted so that the necessary precautions can be taken. Patients with right atrial myxomata may present with findings suggesting isolated tricuspid stenosis, progressive right heart failure of unknown etiology, or constrictive pericarditis.3, 4

Early diagnosis of heart tumors is important so they can be removed prior to serious sequelae such as emboli or sudden unexpected death from atrioventricular valvular obstruction. Angiography is the definitive preoperative study, but it possesses some inconvenience, expense, and hazard for the patient. There also have been reports of false negative angiograms in the presence of a left atrial myxoma when the injection was made in the pulmonary artery.5

Ultrasound cardiography, or echocardiography, has been demonstrated to be of diagnostic aid in left atrial tumors, 6-8 This use of ultrasound, however, has not received popular recognition in this country. The

From the Department of Medicine, Indiana University School of Medicine, and the Krannert Institute of Cardiology, Marion County General Hospital, Indianapolis, Indiana.

Supported in part by the Herman C. Krannert Fund, Grants HE-09815-03, HE-6308, HTS-5363, and HE-5749 from the U. S. Public Health Service and by the Indiana Heart Association.

Paper was presented in part at the meeting of the American Heart Association, Bal Harbour, Florida, November 23, 1968.

Work was done while Drs. Wolfe and Popp were trainees of the National Heart Institute.
purpose of this study is to confirm the validity of ultrasound in detecting atrial tumors.

Methods

This study involved three patients who ultimately proved to have atrial tumors by cineangio-

graphy and subsequent surgery. All three tumors were myxomata. In two cases the tumors were in
the left atrium, while the third tumor was in the right atrium. All three patients had a diagnostic
ultrasound examination prior to cineangiography, as is routinely done on all patients undergoing
cardiac catheterization at this institution. Right and left heart catheterization and selective cineangiography were performed by standard technics. The ultrasound examinations were performed with a commercially available ultrasoundoscope using a ½ inch barium titanate transducer that emits 1-microsecond bursts of 2.25 megahertz ultrasound at a repetition rate of 1000/sec. Between each emission the transducer acts as a receiver to record ultrasound echoes. An echo occurs when the sound waves cross an interface between two media of different acoustical impedance, such as liquid and solid. The examinations were performed with the patient in the supine position utilizing a water-soluble gel as a coupling medium.

The technic for detecting atrial tumors was based on using the echo from the mitral or tricuspid valve as a landmark and then finding a mass of echoes originating from the tumor posterior to the valve echo. To record the anterior leaflet of the mitral valve, the transducer was placed in the fourth intercostal space along the left sternal border and pointed posteriorly, slightly medially, and superiorly.7 The anterior leaflet of the tricuspid valve was located by pointing the transducer even more medially.7 The echoes were displayed on an oscilloscope and photographically recorded in the time-motion or M mode presentation whereby time was along the abscissa and distance along the ordinate. This presentation permitted recording of the echo motion. Any single moving echo also could be recorded on a multiple channel oscilloscope by using an analogue output attachment. Such a display permitted the simultaneous recording of an electrocardiogram and a phonocardiogram.

Results

To understand how this technic works in diagnosing atrial tumors, a brief review of

Figure 1

Left. Schematic drawing showing the structures the ultrasound beam passes through when the transducer is located over the fourth interspace at the left sternal border and pointed posteriorly, slightly medially, and superiorly. On the right is the corresponding ultrasound recording. In this and all subsequent ultrasound photographs and analogue recordings, the top of the picture corresponds with anterior and the bottom, posterior. Time is on the abscissa and distance along the ordinate. The dots in the photographs are ½ second and 1 cm apart. The following echoes are recorded: CW = stationary chest wall structures; AW = anterior wall of right ventricle; IVS = interventricular septum; AM = anterior mitral valve leaflet; LAW = posterior left atrial wall. The clear space between AW and IVS is the cavity of the right ventricle, between IVS and AM the cavity of the left ventricle, immediately behind AM the mitral valve funnel, and anterior to LAW the left atrial cavity.
mitral valve echocardiography will be necessary. It has been demonstrated that when an ultrasound transducer is placed on the chest and is directed posteriorly and slightly medially from the third or fourth intercostal space at the left sternal border, the ultrasound beam will pass through the anterior chest wall, the anterior wall of the right ventricle, the interventricular septum, the anterior mitral leaflet, and then through the posterior wall of the left atrium (fig. 1), or in some patients through the posterior wall of the left ventricle. The anterior mitral leaflet has a characteristic motion and is usually located between 4 to 8 cm from the transducer. Figure 2 shows a recording from a patient with a normal mitral valve. The phases of the cardiac cycle can be appreciated from the simultaneous electrocardiogram and phonocardiogram. On the ultrasound cardiogram (UCG) systole is from A to D and diastole D to A. Slope D-E is the initial opening of the leaflet at the onset of diastole. Point E is the time when the valve is closed.

Figure 2
Analogue ultrasound recording (UCG) of normal anterior mitral valve leaflet with simultaneous recording of electrocardiogram (ECG) and apex phonocardiogram (PCG). See text for description of UCG motion.

Figure 3
Echograms of mitral valve with simultaneous ECG. Photograph A represents a normal valve. Recording B is from a patient with mitral stenosis. In both pictures the space behind the AM, the mitral valve funnel, is echo-free during diastole.
Ventricular Systole

Figure 4

Selected frames from cineangiogram of a patient with a left atrial tumor. The upper outlined chamber is the left atrium, the lower the left ventricle. The outlined clear space within the left atrium is the tumor which lies only in the left atrium during ventricular systole but passes into the left ventricle during ventricular diastole.

Ventricular Diastole

Figure 5

Mitral valve echograms of patient whose angiograms are illustrated in figure 4. A, Mass of echoes originating from the tumor is seen behind AM during the latter two thirds of diastole. The E-F descent rate is abnormally slow because of the obstruction by the tumor. B, Postoperative recording showing the absence of the tumor echoes and normal valve motion.

first fully opened. The leaflet then tends to float toward a closed position, E-F, and reopens again following atrial contraction, F-A.

Figure 3A shows a photographic recording of normal anterior mitral leaflet motion. The motion of the anterior leaflet during diastole is shaped like a capital M. The E-F descent rate
in normals usually falls between 70 and 150 mm/sec. Figure 3B is a recording from a patient with mitral stenosis. Here the tendency for the leaflet to close during mid-diastole is lost because of a pressure gradient holding the valve open throughout diastole, so the valve motion looses its capital M shape. In mitral stenosis the E-F descent rate is usually less than 25 mm/sec. In both pictures the space immediately behind the anterior mitral leaflet (AM) during diastole is echo-free.

The tricuspid valve echo is more difficult to obtain than is the echo from the mitral valve. It is easier to record the tricuspid valve echo in patients with enlarged right ventricles, as in those with an atrial septal defect. The pattern of motion of the anterior tricuspid valve leaflet is similar to the mitral valve, but the tricuspid echo usually lies closer to the transducer and is always anterior to the interventricular septal echo.

Figure 4 shows selected frames from the cineangiogram of the first patient with a left atrial tumor. The injection was made into the pulmonary artery with filming of the left atrium and left ventricle in the right anterior oblique position. The upper outlined chamber is the left atrium, the lower the left ventricle. The large atrial tumor remained completely within the left atrium during ventricular systole. During ventricular diastole the tumor passed through the mitral valve orifice. Figure 5A shows the echogram from this patient. The principal finding was a mass of echoes posterior to the anterior leaflet of the mitral valve appearing during the latter two thirds of diastole. These echoes originated from the tumor as it passed through the mitral orifice during diastole. The diastolic slope or E-F descent was also abnormally slow because the tumor created an obstruction at the orifice and prevented rapid emptying of the left atrium. Figure 5B shows the postoperative recording. The mass of echoes behind the mitral valve was now absent. The valve motion returned to normal since there was no longer any obstruction to flow through the mitral valve.

This patient, like many with atrial tumors, had an early diastolic sound which was due to tumor motion but at the bedside frequently was confused with an opening snap. Simultaneous recording of the anterior mitral leaflet echo with a phonocardiogram recorded at the apex permitted proper identification of the sound. Figure 6A is a recording from this patient, whereas figure 6B is from a patient with surgically proven mitral stenosis. In both patients the E-F descent of the mitral valve

---

**Figure 6**

Simultaneous oscillograph recordings of ECG, apex PCG, and UCG recording of anterior mitral leaflet at 100 mm/sec. A, Patient with left atrial tumor. B, Patient with mitral stenosis. $S_1 =$ first heart sound; $S_2 =$ second heart sound; $A_o =$ aortic component of $S_2$; T.E.S. = tumor ejection sound; TP = tumor plop; O.S. = opening snap; D.M. = diastolic murmur.

*Circulation, Volume XXXIX, May 1969*
Echograms from second case with a left atrial tumor. A, The preoperative tracing shows a mass of echoes from the tumor behind the AM during the latter two thirds of diastole and an abnormal E-F descent rate. B, The patient has a normal valve echogram following surgery.

Echo was abnormally slow because of delayed emptying of the left atrium and a persistent left atrioventricular diastolic pressure gradient. In figure 6A the obstruction was due to a tumor and in figure 6B a stenotic valve. Echoes from the tumor were not recorded in A because the analogue gate can record only one echo, and the mitral valve was selected. In figure 6B the opening snap occurred at point E of the ultrasound tracing, at the time when the anterior mitral leaflet came to an abrupt halt at the end of its initial opening in diastole. In figure 6A the early diastolic low-frequency sound (TP), which was caused by tumor motion and probably its sudden cessation of motion, occurred after point E of the ultrasound recording. A "dropout" occurred in the ultrasound tracing at the time of the tumor plop because the mitral valve was deflected out of the analogue gate when the tumor initially passed through the mitral valve.

The second patient with a left atrial myxoma had a cineangiogram and echogram that were almost identical with the first patient's. The preoperative ultrasound tracing (fig. 7A) again showed a mass of echoes immediately behind the anterior mitral leaflet during the latter two thirds of diastole. The E-F descent rate was also abnormally slow. In the postoperative tracing (fig. 7B), the tumor echoes were absent and the valve motion was normal.

A frame of the cineangiogram and the echogram of the third patient is shown in figure 8. This patient had a large right atrial myxoma. The cineangiogram was made by injecting contrast material into the superior vena cava and filming in the right anterior oblique position. The tumor arose in the right atrium and passed through the tricuspid valve into the right ventricle during ventricular diastole. During ventricular systole it was incompletely ejected back into the right atrium. The tricuspid valve echogram (fig. 8B) was considered only suggestive of a tumor since the landmark, the anterior tricuspid valve leaflet, was incompletely recorded. With the transducer directed toward the tricuspid valve a clearly defined valve could
not be recorded, but instead one noted a mass of echoes which appeared during the latter two thirds of diastole and which presumably arose from the tumor.

Discussion

The ultrasound diagnosis of atrial tumors is based on the fact that whenever the ultrasound beam records the motion of either the anterior leaflet of the mitral or tricuspid valve, the space immediately behind the valve is always the mitral or tricuspid valve funnel. Any structure present in the funnel will interrupt the ultrasound beam and produce echoes. The mitral and tricuspid valve echograms are obtained in exactly the same manner as the routine ultrasound study for valve motion. A mitral valve echogram is not difficult to obtain on almost any patient. The tricuspid valve examination is more difficult but can usually be performed successfully by an experienced examiner. Both studies are quite reproducible.

The technic depends on the tumor passing through the valve orifice sometime during the cardiac cycle. Small tumors or tumors that are not pedunculated may not do this, and thus the echogram would be interpreted as negative. The exact frequency that left atrial tumors pass into the left ventricle is not known, but a fairly high incidence can be assumed from indirect evidence in the literature. In the largest collected series of 45 patients with left atrial myxomata, 91% had pulmonary hypertension or mitral valve murmurs, or both, thought to be due to obstruction by the tumor. Tricuspid obstruction also appears to be common in the reported cases of right atrial myxomata. The only other patient with a right atrial myxoma at this institution studied with angiography exhibited marked obstruction of the tricuspid orifice.
small echoes were observed both anterior and posterior to the valve. However, there was no localized mass of echoes as seen with the atrial tumors. The echogram was interpreted as showing only mitral stenosis. Subsequent cardiac catheterization and cineangiography confirmed the absence of a left atrial tumor and the presence of mitral stenosis.

Because of the simplicity, safety, and theoretical advantages of diagnostic ultrasound, an increasing number of techniques are being developed which utilize this intriguing diagnostic tool. The detection of atrial tumors represents another contribution to this relatively new field.

References


Figure 9

*Mitrval valve echogram showing only mitral stenosis. The gain was increased, resulting in the appearance of multiple diffuse echoes, however, no localized mass of echoes could be reproduced.*

This patient was seen before the availability of ultrasound.

Thus, it would appear that a positive echogram should be obtained in a high percentage of patients with atrial myxomata. Being able to detect those tumors which pass through the atrioventricular orifice is especially valuable because it is this obstructive aspect of the tumor which produces the hemodynamic alteration and sudden death. The echogram, of course, is nonspecific and indicates only that a mass is present. Other types of tumors or thrombi would produce a similar mass of echoes if they interrupted the ultrasound beam.

One word of caution in performing this examination. Almost every structure in the heart, including the blood, can produce echoes if the gain control on the ultrasonoscope is high enough. Figure 9 shows the echogram from a patient suspected of having a left atrial tumor. The gain was increased and multiple
Diagnosis of Atrial Tumors by Ultrasound
STANLEY B. WOLFE, RICHARD L. POPP and HARVEY FEIGENBAUM

Circulation. 1969;39:615-622
doi: 10.1161/01.CIR.39.5.615

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1969 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/39/5/615

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org/subscriptions/