Echocardiographic Manifestations of Left Bundle Branch Block

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SUMMARY

Seventeen patients with left bundle branch block were studied using standard echocardiographic techniques employing a strip chart recorder. All 17 patients were found to have specific echocardiographic findings of abnormal septal motion uniquely different from previously described forms found in volume overload states of the right ventricle as well as coronary artery disease. The specific echocardiographic abnormality demonstrated in left bundle branch block is a very dynamic posterior motion of the interventricular septum occurring within 0.04 seconds of the onset of the QRS and preceding the anterior motion of the posterior left ventricular wall during ventricular ejection. This type of septal motion is not seen in the other forms of abnormal septal motion and appears to be specific for left bundle branch block.

Additional Indexing Words:
- Ultrasound
- Coronary artery disease
- Mitral valve
- Right ventricular volume overload

The use of echocardiography to study septal motion has continued to be of vital interest to the echocardiographer and to cardiologists in general since it was found to be of value in the diagnosis of right ventricular volume overload. Since that time other causes of abnormal or paradoxical septal motion have been described, including infarction of the anterior septum due to obstruction of the anterior descending coronary artery, and cardiomyopathy when associated with tricuspid regurgitation. Diamond et al. determined that right bundle branch block did not cause abnormal septal motion. However, several investigators have recognized abnormal septal motion in patients with left bundle branch block. This motion is quite distinct from the usual abnormal septal motion seen in right ventricular volume overload states or in coronary artery disease. This study proposes to elucidate the echocardiographic findings seen in left bundle branch block; it was not designed to determine the exact mechanism for this abnormal septal motion.

King et al. have studied the temporal sequence of myocardial contraction in bundle branch block, correlating their findings with echocardiography and the electrocardiogram. They concluded that in the presence of left bundle branch block there is normal posterior left ventricular wall movement during the 380 msec interval after the onset of the QRS, which was found also to be present in normal patients. They were impressed with abnormal early systolic motion of the interventricular septum which occurred prior to the usual septal motion seen in patients with normal conduction or right bundle branch block; this abnormal motion was only seen in left bundle branch block.

Materials and Methods

There were four groups of patients used in this study. The first group consisted of 17 patients with left bundle branch block diagnosed on routine scalar electrocardiograms. Ten of these patients underwent cardiac catheterization including selective coronary cineangiography to rule out the presence of coronary artery disease; the other seven patients had no clinical evidence of coronary artery disease. The second group of patients consisted of 30 normal subjects. The third group included 25 patients with right ventricular volume overload documented by cardiac catheterization. Group IV was made up of 48 patients who had angiographically proven disease of the left anterior descending coronary artery with a 70% or greater obstruction.

Echocardiograms were obtained on all patients using a commercial echograph connected to either a Honeywell or an Electronics for Medicine strip chart recorder. The echocardiograms were recorded with the transducer in the third or fourth intercostal space along the left sternal border, with the patients either in the supine or left lateral position. The ultrasonic beam was moved by tilting the transducer in an arc sector between the root of the aorta and the left ven-
tricular apex. In so doing, the interventricular septum was recorded from three different areas: near the root of the aorta, at the level of both mitral leaflets, and towards the left ventricular apex past the mitral leaflets. It has been documented that septal motion varies with the direction of the ultrasonic beam. In order to standardize the septal motion for this study, we required that both the interventricular septum and the posterior left ventricular wall had to be recorded together with parts of both mitral valve leaflets. By recording the posterior left ventricular wall and the posterior mitral leaflet we were assured that our ultrasonic beam was not directed too cephalad, and by requiring both mitral leaflets to be present in the recording provided evidence that the ultrasonic beam was not directed too close to the apex.

Results

Figure 1 is an echocardiogram from a normal subject and demonstrates normal septal motion characterized by movement of the left side of the septum and the posterior left ventricular endocardium towards each other during ventricular systole. At the onset of electrical depolarization there is a momentary delay in motion of both septal and posterior ventricular walls, which is followed by apposition of the two echoes.

Figure 2 is an echocardiogram from a patient with an atrial septal defect and a large left to right shunt. It shows the characteristic findings in the group of patients with right ventricular volume overload. In this type of patient, following the onset of electrical depolarization there is an abrupt anterior motion of the septum. During ventricular ejection the septal echo then gradually moves either anteriorly or in many cases horizontally. In addition, there is enlargement of the right ventricular cavity. This type of echocardiogram may also be seen in other volume overload states of the right ventricle, such as anomalous venous return, tricuspid regurgitation or pulmonic insufficiency.

The echocardiogram in figure 3 was recorded from a patient who had angiographically proven coronary artery disease with an obstructive lesion of the anterior descending coronary artery proximal to the first septal perforator. In this patient the septal motion is essentially flat during systole with only slight motion away from the posterior left ventricular wall. This is the type of motion seen in 23 of the 48 patients in group IV with coronary artery disease.

Figure 4, an echocardiogram from one of the 17 patients who had left bundle branch block, demonstrates paradoxical motion very similar to that seen in the patient with right ventricular volume overload. During ventricular ejection both the posterior left ventricular endocardium and the left side of the septum move anteriorly. The feature that differentiates septal motion in left bundle branch

Figure 1

An echogram from a normal subject demonstrating the left side of the interventricular septum (LS), the endocardium (EN), the anterior mitral valve leaflet (AM), and the posterior mitral valve leaflet (PM). The line to the right of the echogram indicates the onset of electrical depolarization. The septum and posterior left ventricular wall oppose each other during systole.

Figure 2

An echogram from a patient with an atrial septal defect demonstrating the echocardiographic features of right ventricular volume overload. With the onset of left ventricular wall contraction (arrow), the interventricular septum is moving paradoxically. In addition the right ventricle is enlarged. RV = right ventricle, LV = left ventricle, IVS = interventricular septum, AMV = anterior mitral valve leaflet, PLV = posterior left ventricular wall.

Figure 3

An echogram from a patient with coronary artery disease and occlusion of the left anterior descending coronary artery. The interventricular septum is flat, and with posterior left ventricular wall contraction there is slight paradoxical septal motion. Remnants of the mitral valve are recorded. Reprinted with permission from reference 7.
block from that seen with right ventricular volume overload is that within 0.04 sec following the electrocardiographic QRS, there is a very rapid posterior motion of the left side of the interventricular septum (arrow, fig. 4). Following this posterior septal motion and with the onset of posterior left ventricular contraction, which is presumed to coincide with left ventricular ejection, the septum moves anteriorly. This rapid posterior and then anterior motion of the septum following the onset of the electrical depolarization was observed in all 17 patients with left bundle branch block and was not seen in any other patient in this study. As mentioned earlier, there may be an occasional transient posterior septal motion in patients with a right ventricular volume overload; however, such motion always occurs before the onset of ventricular systole (fig. 2).

The patterns of septal motion differed distinctly in the four groups of patients (fig. 5). In normal subjects, following the onset of electrical depolarization there is a momentary delay followed by opposing motion of the left septum and the posterior left ventricular endocardium. At the end of systole the septum begins to move anteriorly slightly before the left ventricular endocardium moves posteriorly. Usually at the peak of the endocardial anterior motion there is a "notch" in the septal echo. During diastole the two echoes again move in opposite directions. All of the normal subjects showed essentially the same pattern of motion with only minor variations.

Septal motion in the patients with right ventricular volume overload varied to some extent; the diagram in figure 5 shows the most common pattern. With the onset of electrical depolarization, the septal motion is usually flat and slightly paradoxical, i.e. moves anteriorly. Frequently there was a transient posterior and then anterior motion of the septum just prior to electrical depolarization.

There were three types of septal motion in patients with coronary artery disease involving obstruction of the left anterior descending coronary artery. Seventeen of the 48 patients had essentially normal septal motion despite the presence of a significant obstruction in the left anterior descending coronary artery. In four patients the pattern of motion was normal although the amplitude was significantly decreased. In four patients the septal motion was paradoxical with the septum moving anteriorly during ventricular systole. Twenty-three of the 48 patients with left anterior descending coronary artery disease exhibited basically flat septal motion (fig. 5). There may be minor oscillations during ventricular systole in either direction.

The patients with left bundle branch block showed a pattern of septal motion which was distinctively different from the other three groups. The distinguishing feature was a rapid posterior or downward motion of the septum immediately after the onset of electrical depolarization. This motion lasted for approximately 0.04 sec and then the septum moved anteriorly, continuing in this direction throughout ventricular systole. This rapid early posterior and then anterior motion was present to some degree in all 17 patients with left bundle branch block and was not observed in any of the other patients.

Discussion

Since its original description the echocardiographic recording of the interventricular septum has become a very important part of the echocardiographic examination. It was first noted to be useful in obtaining a dimension of the right and left ventricles.1 In the same study it was pointed out that in patients with a
volume overload of the right ventricle the septal motion was abnormal during ventricular ejection. Subsequent studies confirmed this observation and proposed possible mechanisms for the finding. Recent studies using echocardiography to examine patients with coronary artery disease have found abnormal septal motion in patients with obstructive disease involving the left anterior descending coronary artery. This paper describes yet another entity which will produce abnormal septal motion, that is, left bundle branch block.

The pattern of motion exhibited by the echoes from the interventricular septum varies with the direction of the ultrasonic beam. It was noted in the original study that the septum near the left ventricular outflow tract will usually move anteriorly or paradoxically during ventricular systole. The exact explanation for this motion is not perfectly clear; however, the septum is continuous with the anterior wall of the aorta, which normally moves anteriorly during ventricular systole. More recently it has been noted that when the ultrasonic beam moves towards the cardiac apex, the normal posterior motion of the interventricular septum during systole is exaggerated. Thus in any given patient there may be an entire spectrum of septal motion depending upon the direction of the ultrasonic beam. Probably the best way of standardizing the direction of the ultrasonic beam is by looking at the mitral valve echoes. The "standard" ultrasonic examination of the interventricular septum is through the body of the left ventricle. This type of examination usually has parts of both mitral leaflets in the recording as well as the septum and posterior left ventricular wall. One must be careful about not relying entirely upon having both mitral valve leaflets because occasionally, such as with prolapsed mitral valves, one can record both mitral leaflets, but the ultrasonic beam may traverse the left atrial wall and not the left ventricle.

Having noted abnormal septal motion in patients with left bundle branch block, the primary purpose of this paper was to see whether or not this motion could be distinguished from other types of abnormal septal motion. Patients with left bundle branch block, right ventricular volume overload, or even coronary artery disease all exhibit flat or paradoxical septal motion during ventricular ejection. However, in the presence of left bundle branch block, the distinguishing feature seems to be a specific pattern of motion at the very onset of electrical depolarization. Within 0.04 seconds of the onset of the QRS there is a rapid downward or posterior motion of the interventricular septum. This downward motion lasts for approximately another 0.04 seconds or until the onset of ventricular ejection, at which time there is a rapid upward or anterior motion which lasts throughout ventricular ejection. The end result of this motion is the inscription of a posteriorly directed "beaking" of the septal echoes immediately after the onset of the electrical depolarization.

The abnormal septal motion found in these patients with left bundle branch block is interesting from several points of view. First of all, the pattern of the early systolic motion seems to be specific for this abnormality since it was not found in any of our other patients with abnormal septal motion. Thus paradoxical septal motion due to left bundle branch block probably can be distinguished from patients with right ventricular volume overload and from patients with coronary artery disease. This finding also supports the concept that the pattern of electrical depolarization will influence the mechanical aspects of ventricular systole. In left bundle branch block the interventricular septum has been found to depolarize from right to left rather than the usual left to right depolarization that is found in both normal patients and those with right bundle branch block. Whether this is in fact the mechanism of abnormal septal motion as seen echocardiographically in left bundle branch block remains to be proven. It is felt that it is beyond the scope of this paper to speculate to any great length on the true etiology of this abnormal septal motion. It is more our purpose to report what we have found echocardiographically and to stress that not all forms of abnormal septal motion are either right ventricular volume overload or coronary artery disease. The fact that the interventricular septum depolarizes from the opposite direction with left bundle branch block is a very likely explanation for the peculiar early systolic motion seen in the interventricular septum.

The velocity with which the interventricular septum moves is also quite intriguing. The early systolic motion seen in the patients with left bundle branch block approaches velocities similar to valvular structures. Similar rapid motion is rarely found in the posterior left ventricular free wall. The differences could possibly result from the restricting effect of the pericardium around the cardiac free wall. The fact that the septum is not impeded by the pericardium might explain its ability to move as rapidly as seen on the echocardiogram. To our knowledge this very rapid and somewhat abnormal septal motion has not been detected by angiography. It is possible that the motion is too rapid and too subtle to be picked up by an angiogram and points out one of the many advantages of echocardiography in detecting small and rapid cardiac motion.
We have examined two patients with the diagnosis of left bundle branch block and coronary artery disease. In these two patients the septum moved like that seen with coronary artery disease and the rapid early systolic motion was not observed. It is quite possible that the characteristic motion of left bundle branch block was not recorded because of decreased viability of the septum due to ischemia or fibrosis. These patients are the only two with electrocardiographic evidence of left bundle branch block who did not show this characteristic motion. They were not included in the study because the diagnosis of coronary artery disease was based solely on clinical findings without angiographic confirmation. Obviously a more thorough study is necessary to determine the pattern of septal motion in patients with left bundle branch block and coronary artery disease. If the abnormal septal motion exhibited in patients with left bundle branch block requires a healthy, dynamically moving septum, it is quite probable that an ischemic or fibrotic septum may not move in the usual manner.

References
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*Circulation.* 1974;49:876-880
doi: 10.1161/01.CIR.49.5.876
*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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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:
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