The electrocardiographic diagnosis of ischemic heart disease is made more difficult in the setting of confounding patterns, including left bundle branch block (LBBB). The electrocardiographic detection of abnormalities arising from acute ischemic cardiac disease in this setting is possible in certain cases, contrary to popular medical opinion. Several strategies are available to assist in the correct interpretation of the electrocardiogram (ECG) with LBBB and potential acute ischemia, including: (1) a knowledge of the anticipated ST segment–T wave morphologies of LBBB and, consequently, the ability to recognize ischemic changes; (2) the performance of serial ECGs demonstrating dynamic change; and (3) a comparison to previous ECGs. The first strategy, an awareness of the anticipated ST segment morphologies of LBBB, is the most important and not dependent on additional diagnostic testing or past medical records. (Am J Emerg Med 1998;16:697-700. Copyright © 1998 by W.B. Saunders Company)

The 12-lead electrocardiogram (ECG) is a powerful clinical tool used in the evaluation of the chest pain patient. The ECG assists the physician in the selection of the proper therapy, in particular the application of therapy aimed at acute revascularization in patients with acute coronary ischemic events. Certain electrocardiographic patterns may hinder this evaluation; ventricular paced rhythms, left ventricular hypertrophy, and left bundle branch block (LBBB) are the most frequently encountered entities. LBBB may mask acute ischemic change due to myocardial ischemia or myocardial infarction (MI), thereby hindering this evaluation and invalidating the ECG. The electrocardiographic abnormalities associated with ischemic heart disease may be concealed by the altered patterns of ventricular conduction encountered in patients with LBBB.

The ability of the physician to correctly interpret the ECG in such complicated patients directly and immediately affects patient management. A detailed knowledge of the anticipated ST segment–T wave changes resulting from the abnormal ventricular conduction of the LBBB is mandatory. Such an understanding of the ECG in LBBB consequently allows the clinician to recognize the morphologies of acute MI and initiate proper management in a timely fashion.

CASE PRESENTATIONS

Case 1

A 76-year-old man with a history of MI, angina, hypertension, and diabetes mellitus presented to the emergency department (ED) with dyspnea and left shoulder pain. An ECG (Figure 1) showed normal sinus rhythm with an LBBB with ST segment–T wave changes worrisome for acute MI. The patient was taken to the catheterization laboratory where a proximal left anterior descending artery occlusion with thrombus was found. Angioplasty was unsuccessful, and an intracoronary thrombolytic agent was then administered. The ventriculogram showed anterolateral hypokinesis. Cardiac enzyme levels were elevated, confirming the diagnosis of acute MI.

Case 2

A 65-year-old man with a history of MI and hypertension presented to the ED with chest pain of approximately 1 hour’s duration, associated with diaphoresis and nausea. An ECG (Figure 2) showed normal sinus rhythm with LBBB morphology. The patient was treated for acute cardiac ischemia with continued chest discomfort while serial ECGs were performed. After approximately 45 minutes, the ECG (Figure 3) showed changes suggesting acute MI. The patient was taken to the catheterization laboratory where an angioplasty was successfully performed on a proximal circumflex artery lesion with thrombus. Lateral hypokinesis was also noted on ventriculography. The patient had an uneventful recovery from the MI, which was confirmed by elevated cardiac enzyme levels.

DISCUSSION

When a patient presents to the ED with a complaint of chest pain, it is imperative that an accurate and rapid diagnosis of acute MI is made. Numerous studies have clearly demonstrated that the rapid restoration of adequate perfusion in the infarct-related coronary artery preserves myocardium, limits post-MI ventricular dysfunction, and minimizes mortality. In certain situations, however, the diagnosis of acute MI is not clear. The history may be atypical; the ECG may be either nondiagnostic or confounding. In such extreme cases, the actual diagnosis of acute MI may be missed. Missed acute MI in the ED occurs in approximately 2% to 5% of all MI cases. Missed MI is the leading cause of malpractice loss in the ED setting. Further, patients with a missed acute infarction often have a worsened outcome when compared to patients with an initially correct diagnosis.

When confronted with a clinical history of chest pain, the physician must rapidly decide if the patient is experiencing an MI and, additionally, if that patient is a candidate for urgent revascularization (either through thrombolysis or
percutaneous transluminal coronary angioplasty). The ECG assists in this selection of proper therapy in many cases of transmural infarction. The presence of LBBB on the ECG may confound its use in this ED situation. The electrocardiographic diagnosis of ischemic heart disease is certainly made more difficult in the setting of LBBB. The ECG, however, is not invalidated. Common medical opinion holds that the electrocardiographic diagnosis of acute MI is impossible in the presence of LBBB, whereas others believe that the diagnosis is often possible if not straightforward and “disarmingly easy.”4,5 Careful interpretation of the ECG with LBBB pattern may yield evidence of acute ischemia or infarction in certain individuals.4,5

LBBB alters both the early and the late phases of depolarization and produces secondary ST segment–T wave changes.4 In the patient with LBBB, depolarization proceeds abnormally from right to left, producing a broad, predominantly negative QS or rS complex in lead V1 and a late intrinsicoid deflection in V6 with a positive R wave. The QRS complex is widened, greater than 0.12 seconds. QS complexes can be noted in the right precordial leads as well as leads III and aVF. The diagnosis of acute ischemic syndromes relies heavily on the changes in ST segment; this segment is abnormal in LBBB. The anticipated or expected ST segment–T wave configurations are discordant, directed opposite from the terminal portion of the QRS complex; this relationship is called QRS complex–ST segment/T wave axes discordance—or the rule of appropriate discordance. As such, leads with either QS or rS complexes may have markedly elevated ST segments, mimicking acute MI. Leads with a large monophasic R wave demonstrate ST segment depression. The T wave, especially in the right mid precordial leads, has a convex upward shape or a tall, vaulting appearance, similar to the hyperacute T wave of early MI. The T waves in leads with the monophasic R wave are frequently inverted. Loss of this normal discordant relationship in patients with LBBB may imply an acute process, such as acute MI. The ECG in patients with LBBB must be inspected to look for a loss of this QRS complex–ST segment/T wave axes discordance.5

The correct diagnosis of acute MI in the presence of LBBB is made more crucial because these patients are at higher risk for adverse outcomes and also may benefit greatly from timely revascularization.6,8 Patients with LBBB often have atherosclerotic disease involving the proximal left anterior descending artery and thus have a large segment of myocardium at risk.7 LBBB serves as a marker for lower ejection fraction, higher incidence of cardiogenic shock, and death.8,9 In one large trial of thrombolytic agents, patients presenting with LBBB and enzymatically confirmed acute MI had a 25% reduction in mortality compared with a 21% reduction in the non-LBBB acute MI group at 1-month follow-up.1

These factors have led to several studies and suggested electrocardiographic criteria for the diagnosis of acute MI in the presence of LBBB. Early studies, reviewed by Wackers,10 reported several criteria and utilized localization of infarcts by thallium-201 scintigraphy. The conclusion of these studies was that serial electrocardiographic changes and ST segment elevation were the most sensitive criteria for the electrocardiographic diagnosis of acute MI (67% and 54%, respectively). Several other criteria focusing on changes in the QRS complexes proved to be less sensitive, and furthermore these changes are usually the sign of necrosis and not acute infarction.10
Sgarbossa et al\textsuperscript{11} recently made a refinement and significant advancement in the diagnosis of acute MI in the presence of LBBB. The authors analyzed the ECGs of patients in the GUSTO-I trial. Of 26,003 patients, 131 (0.5\%) had LBBB. In the analysis of criteria that reliably diagnosed an acute MI a clinical decision rule was developed. Only ST segment deviation was found to be useful; changes of the T waves were not found to be helpful in the electrocardiographic diagnosis. The electrocardiographic criteria suggesting a diagnosis of acute MI, ranked with a scoring system based on the probability of such a diagnosis, include (1) ST segment elevation greater than 1 mm which was concordant with the QRS complex (score of 5); (2) ST segment depression greater than 1 mm in leads V\textsubscript{1}, V\textsubscript{2}, or V\textsubscript{3} (score of 3); and (3) ST segment elevation greater than 5 mm which is discordant with the QRS complex (score of 2) (Figure 4). A total score of 3 or more suggests that the patient is likely experiencing an acute infarction based on the electrocardiographic criteria. With a score less than 3, the electrocardiographic diagnosis is less assured, requiring additional evaluation.

The two cases illustrate these criteria. As can be seen in the ECG of Case 1 (Figure 1), discordant ST segment elevation greater than 5 mV is noted in leads V\textsubscript{2} through V\textsubscript{6}, while in leads V\textsubscript{1} through V\textsubscript{3} concordant ST segment elevation greater than 1 mV is encountered. In this case, an extensive, acute anterolateral MI was correctly diagnosed on the basis of this ECG; this ECG received a total score of 16—3 points each for the excessive, discordant ST segment elevation in leads V\textsubscript{2}, V\textsubscript{3}, and V\textsubscript{4} and 5 points each for concordant ST segment elevation in leads V\textsubscript{2} and V\textsubscript{6}. In Case 2 (Figure 3), once again an acute lateral MI can be diagnosed on the basis of concordant ST elevation in leads I, aVL, V\textsubscript{5}, and V\textsubscript{6}. The scoring in this ECG is 20—5 points each for concordant ST segment elevation in leads I, aVL, V\textsubscript{5}, and V\textsubscript{6}. These findings are worrisome for acute infarction based upon the Sgarbossa et al criteria as well as the dynamic change observed in the serial ECGs performed in the ED.

In the United States, 1.5 million people will present with acute MIs on an annual basis.\textsuperscript{12} Based upon the results from GUSTO-I, approximately 7,500 patients with acute infarction will present with an LBBB pattern on their ECG. Based on an understanding of the electrophysiological consequences of this conduction disturbances and the guidelines set forth by Sgarbossa et al,\textsuperscript{11} the electrocardiographic suspicion, if not actual diagnosis, is therefore possible in a significant minority of these patients; such a diagnostic approach provides the physician with the information necessary to offer the patient early revascularization therapy. Furthermore, serial ECGs and a comparison to prior ECGs, if available, are invaluable. Thus, the large number of patients that are currently not receiving acute revascularization therapy based upon the nondiagnostic ECGs may be reduced by this strategy.

**CONCLUSION**

The electrocardiographic diagnosis of acute MI in the setting of certain confounding ECG patterns, including LBBB, is difficult, although possible, in certain cases. The ability of the physician to correctly interpret the electrocardiographic findings in such complicated patients directly and immediately affects management. Several strategies are available to the physician to assist in the correct interpretation of these electrocardiographic patterns, including a knowledge of the anticipated ST segment/T wave changes resulting from LBBB and the subsequent recognition of unexpected or pathologic waveforms. Additional tools incorporating this knowledge of the ECG in patients with LBBB involve the performance of serial ECGs, ST segment trend monitoring, and a comparison to previous ECGs. Using a knowledge of the anticipated electrocardiographic changes of LBBB supported by the criteria proposed by Sgarbossa et al,\textsuperscript{12} the physician’s approach in the early phase of care can then move from a “nondiagnostic” ECG with a “rule-out” MI admission diagnosis to a “rule-in” approach, thereby offering more appropriate, potentially more aggressive treatment in timely fashion, including early cardiology consultation with urgent cardiac catheterization. The physician must realize, however, that these ST segment changes are only suggestions of acute MI in patients with complicated ECGs; by themselves, they are not diagnostic of acute MI. Therapeutic decisions must be made with this caveat in mind.

**REFERENCES**

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