Electrocardiographic Signs of Remote Myocardial Infarction

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Twelve-lead electrocardiogram is an integral part of the evaluation of an acute and a remote myocardial infarction (MI). Electrocardiographic signs of an acute ST-elevation MI are more precise than those of an acute non–ST-elevation MI. Recognition of a remote MI is more difficult because once the repolarization abnormalities (ST-segment and T-wave changes) stabilize after an acute MI resolves, then the Q wave remains as the only universally recognized sign of MI. In addition, there is no specific sign of a non–Q-wave MI or a non–ST-elevation MI, or in fact of an ST-elevation MI that did not result in Q waves. The fragmented QRS (fQRS) is another recently described sign of a remote MI. It is defined by the presence of an additional R wave (R′) or notching in the nadir of the S wave, or the presence of >1 R′ (fragmentation) in 2 contiguous leads corresponding to a major coronary artery territory. The specificity of fQRS is inferior to that of a Q wave for an MI scar (89% vs 99%). However, fQRS has a superior sensitivity and a negative predictive value compared with a Q wave. In addition, there is an incremental gain in the sensitivity up to 91.4% when these 2 signs (fQRS and Q wave) are combined. The repolarization abnormalities of MI may also persist indefinitely as a sign of a remote MI in few patients. These abnormalities include persistent ST elevation, ST depression, nonspecific ST-T wave changes, and T-wave inversion.

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0033-0620/$ - see front matter

doi:10.1016/j.pcad.2007.05.003

The 12-lead electrocardiogram (ECG) is an integral part of the evaluation of coronary artery disease (CAD). It remains the initial test in identifying an acute myocardial infarction (MI) and a remote MI.[1,2] The ECG records depolarization of the normal ventricular myocardium as the QRS wave and repolarization as the ST segment and T wave. Ventricular depolarization is an organized conduction of the electrical impulse via specialized conduction tissues and the myocardium causing cardiac contraction. It is followed by myocardial repolarization, which is the process of recovery of the sarcolemmal potentials resulting in myocardial relaxation.[3] This normal pattern of organized cardiac depolarization and repolarization is altered in various physiological and pathological conditions. Myocardial infarction is one of such conditions that result in myocardial necrosis, which subsequently heals by fibrosis. This pathological process modifies cardiac electrophysiological properties that alter the depolarization and repolarization pattern, which can be identified on a 12-lead ECG. However, there are only a few well-established ECG criteria for acute and remote MI; and most of these carry a wide range of sensitivity and specificity.[1] The ECG signs of an acute ST-elevation MI (STMI) are more precise, whereas the ECG signs of an acute non–ST-elevation MI (NSTMI) may be minimal and often nondiagnostic.[4] Therefore, ischemic symptoms or the elevation of cardiac biomarkers is needed to diagnose an acute MI.[1] Noninvasive cardiac imaging is sometimes required, especially if the ECG is nondiagnostic or if the biomarker elevation is borderline. In addition, it is prudent to recognize that approximately one fourth of all MIs are clinically unrecognized.[5] This incidence may even be higher when non–Q-wave or NSTMIs are taken into consideration because typical symptoms of MI may not be present in many patients.[6]

Furthermore, mortality after an unrecognized MI is similar or even higher than that after a recognized acute MI.[7] Recognition of a remote MI is more difficult because once the repolarization abnormalities (ST-segment and T-wave changes) resolve or stabilize, then only the abnormal Q waves remain as a universally recognized sign of a remote MI. However, its utility is limited in identifying only a remote Q-wave MI and therefore does not detect any remote non–Q-wave MI. Moreover, Q waves may regress or disappear over time.[8] In addition, there is no specific sign for a non–Q-wave MI or an NSTMI, or in fact of an STMI that did not result in Q waves. Therefore, in health screening examinations or epidemiological studies, diagnosis of a prior MI may be missed. We recently described that fragmented QRS (fQRS) is a marker of MI scar, which is another marker for all types (STMI and NSTMI) of MI.

Therefore, accurate ECG diagnosis of acute and remote MI is imperative. The purpose of this review is to briefly define the ECG signs of acute MI and elaborate upon the various ECG signs of a remote MI.

Acute Myocardial Ischemia and Acute MI

Acute myocardial ischemia occurs in the early phase of coronary artery occlusion or spasm; and if the coronary artery involved is not rapidly recanalized or revascularized, then myocardial necrosis occurs, resulting in acute MI. Initially, the T waves may become tall and peaked (hyperacute T wave).[9] This is often accompanied by ST-segment changes. An acute MI is classified accordingly as STMI or NSTMI. The *STMI* is defined by ST-segment elevation in 2 or more contiguous leads. The J point should be elevated $\geq$2 mm in leads V_1 through V_3 and $\geq$1 mm in leads I, II, III, aVL, aVF, V_4, V_5, and V_6.[1] In addition, ST-segment depression, with a maximal deviation in leads V_1 through V_3, without ST-segment elevation in other leads should be considered as indicative of posterior MI or ischemia, or both. In the present era of revascularization and aggressive management of CAD, the incidence of Q-wave MI has declined from 66.6% to 37.5%.[10,11] Concomitantly, it has resulted in a reciprocal increase in the incidence of non–Q-wave or NSTMI. The ECG signs of NSTMI are varied and include ST-segment depression, nonspecific ST-segment and T-wave (ST-T) changes, T-wave inversion, or nonsignificant ECG abnormalities. The development of new or presumed new left bundle-branch block in the setting of typical chest pain may pose a diagnostic dilemma. Various epidemiological studies have shown, however, that MI can be diagnosed with a high specificity by carefully analyzing ST-segment elevation or depression in an acute stage.[12,13] Subsequently, depolarization abnormalities in terms of new Q waves and/or fQRS develop within hours and persist indefinitely,[14,15] whereas the ST-T wave changes can resolve after days or weeks or can persist indefinitely.

Q Wave

Pathological Q waves are the major depolarization abnormalities encountered in conjunction with repolarization abnormalities (ST-T wave changes) in patients with acute MI. Pathological *Q waves* are defined as the appearance of Q waves in at least 2 contiguous inferior, lateral, or anterior leads. These represent MI of respective myocardial walls, whereas tall R waves in lead V_1 and/or lead V_2 are analogous to the negative Q waves, which represent a posterior wall MI.[1] A universal definition of a pathological Q wave is not available. The most common criteria for a pathological Q wave are derived from various epidemiological studies, including the most used Minnesota code.[2,16] Recently, the joint consensus meeting of the European Society of Cardiology and the American College of Cardiology published the ECG signs of MI in 2000.[1] This new definition of MI is geared toward homogeneity in the definition of a Q wave for defining a remote MI. It defines *Q wave* as any QR wave in leads V_1 through V_3. The Q wave should be >30 milliseconds in duration and $\geq$0.1 mV deep in leads V_4, V_5, V_6, I, aVL, II, and aVF and should be present in at least 2 contiguous leads.[1] However, Jensen et al showed that the sensitivity, specificity, and positive and negative predictive values were 71%, 60%, 64%, and 67% for the new criteria vs 33%, 97%, 93%, and 59% with the previous criteria for pathological Q wave. Therefore, they concluded that the new Q-wave criteria may be