A New Terminology for Left Ventricular Walls and Location of Myocardial Infarcts That Present Q Wave Based on the Standard of Cardiac Magnetic Resonance Imaging

A Statement for Healthcare Professionals From a Committee Appointed by the International Society for Holter and Noninvasive Electrocardiography

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The ECG is the most frequently used tool for evaluating myocardial infarction (MI). The ECG provides an opportunity to describe location and extent of infarction expressed as pathological Q waves or their equivalents. The terminology used for the left ventricular (LV) walls has varied over time, although the most currently accepted terms by electrocardiographists have been anterior, septal, lateral, and inferior. However, terminology has been complicated by use of posterior to refer to either the basal lateral or the basal inferior wall (see below). On the basis of correlations with the postmortem anatomic gold standard reported, the presence of abnormal Q waves in leads V1 and V2 was related to septal wall MI; in V3 and V4 to anterior wall MI; in V5 and V6, I, and aVL to lateral wall MI (I, aVL high lateral; V4 and V6, low lateral); and in II, III, and aVF to inferior wall MI. The presence of abnormally increased R waves in V1 and V2 as a mirror image of Q waves in posterior leads was considered a posterior wall infarction. Although similar considerations may be applied for ECG location of ST-segment deviation, this report focuses only on ECG localization of the QRS complex abnormalities indicative of established MI as depicted by cardiac magnetic resonance (CMR) imaging.

Although attempts to standardize the terminology applied to the LV walls have been reported, differences persist among the terms used by anatomists, pathologists, electrocardiographists, cardiac imagers, and clinicians. However, the pathologist’s view of infarcted myocardium lacks insights into the in vivo positioning of the LV walls.

CMR imaging with delayed contrast enhancement (CE-CMR) has emerged as a new anatomic gold standard technique that provides precise identification of infarcted myocardium in vivo. It is therefore appropriate to use CMR verification of the accuracy of ECG localization on infarction to form the basis for a consensus among healthcare professionals regarding the terminology of the LV walls identified by the Q-wave or Q-wave-equivalent MI patterns on the standard 12-lead ECG. This consensus document is based on the experience of all the members of the committee and a review of the literature about this topic.

Overview of Terminology of LV Walls: From the Pathology Era to the In Vivo Imaging Era

The LV is cone shaped, and it lies obliquely in the chest, with the base located posteriorly and the apex positioned toward the left, anterior, and inferior. This oblique orientation has caused confusion about how to define the various regions of the LV. Although the limits are imprecise, it can be divided, except at the apex, into 4 walls. Historically, all 4 walls have had varying terminology applied, and the wall that lies on the diaphragm has had the widest variety of different names and therefore requires special consideration.

The LV Wall Positioned on the Diaphragm

Because this wall is more or less opposed to the anterior wall, it has been called posterior for many years (1940s to 1950s). Accordingly, the ECG pattern showing pathological Q waves in leads II, III, and VF (Figure 1A, top) was considered indicative of a posterior MI. Grant and Massie and Walsh mentioned that the infarction of the basal part of this wall is a separate entity and coined the term true posterior MI in coexistence with the term inferior MI, which

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was applied to the involvement of the remaining mid and apical parts of this wall. Later, in 1964 Perloff defined the criteria of the true posterior MI on the basis of the presence of an R/S ratio >1 and an R-wave duration >40 ms in lead V1 (Figure 1, bottom). The term true posterior infarction has remained in use for decades, leading to the use of the term inferoposterior wall to refer to the entire wall that lies on the diaphragm. Thus, MI affecting the mid and inferior part is considered to produce Q waves in leads II, III, and aVF, whereas MI in the basal or posterior part (posterior MI) should result in a tall R wave in lead V1. Recently, the consensus of the American Heart Association (AHA) divided the LV into 4 walls: septal, anterior, lateral, and inferior; in turn, the 4 walls were divided into 17 segments: 6 basal, 6 mid, 4 apical, and 1 segment being the apex (Figure 2). This consensus states that the inferoposterior wall should be called inferior “for consistency” and segment 4 should be named inferobasal instead of posterior. In addition, the report of the Electrophysiological Working Group of the European Society of Cardiology/North American Society of Pacing and Electrophysiology advocates the elimination of the term posterior.

In summary, a clear discrepancy currently exists between cardiac imaging consensus, which has suppressed the word posterior, and the context of echocardiography and electrocardiography, in which the term posterior is still in use. However, several considerations indicate that the terms posterior wall and posterior MI should be abandoned because this wall is neither posterior when one considers the heart in situ nor posterior in relation to the human torso.

Depolarization of Basal Areas and Q-Wave Generation
Isolated perfused human hearts have shown that a great part of the inferior-basal segment depolarizes 40 to 50 ms after the beginning of ventricular activation. Therefore, MI affecting this region should not alter the first part of the QRS complex and consequently should not result in tall R waves in leads V1 and V2.

Left-Ventricular Shape
CMR has documented that the basal segment of the inferior wall often follows a straight alignment with respect to the other segments of this wall. This occurs in more than two thirds of the cases. However, in some cases the basal segment of the wall bends upward. Only in rare cases with asthenic body build is the heart in a more vertical position with the entire inferior wall being more posterior. Therefore, the true posterior position of the basal part of this wall claimed by the traditional ECG literature is not usually present.

Anatomic Position of the Heart
It is commonly accepted that the heart is located in the thorax strictly in a posteroanterior position (Figure 3D), “standing” on its apex and with the atria above the ventricles (the so-called Valentian shape, which resembles St Valentine’s Day greeting cards). This view coincides with the way that anatomists and pathologists have considered the organ since the time of Leonardo da Vinci’s anatomical drawings (Figure 3A). This view is also in concordance with the bull’s eye

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Figure 1. Top, Original drawings in Goldberger’s book in 1953 showing the location of an anterior and a posterior infarct. Bottom, Drawings of anterior and true posterior infarcts with the QRS morphology according to Perloff.

Figure 2. LV walls divided into 17 segments according to AHA consensus. Left, Segments at basal, mid, and apical levels and the apex (segment 17). Right, Bull’s eye image (polar map).
graphic representation reported in nuclear medicine studies\textsuperscript{25} (Figure 3B) and with the transverse image obtained by CMR\textsuperscript{26} (Figure 3C). The real position of the heart within the thorax in vivo is evident from CMR (Figure 4). The 4 cardiac walls are clearly seen in the horizontal plane only when the inferior wall bends upward (Figure 4A). The sagittal view (Figure 4B) follows an oblique right-to-left line (C and D of Figure 4A) and not a strictly posteroanterior direction (Figure 3D). This is the case even in very thin individuals with a vertical heart position. Therefore, infarction of the basal and mid segments (4 and 10) of the inferior wall will generate increased R waves in leads V\textsubscript{3} and V\textsubscript{4} instead of in leads V\textsubscript{1} and V\textsubscript{2} because the “infarction vector” faces V\textsubscript{3} and V\textsubscript{4} (Figure 5B). Infarction located in the lateral wall (C) involving more than the basal segment (segments 5 and 11) may generate increased R waves in leads V\textsubscript{1} and V\textsubscript{2} because the infarction vector will face these leads (Figure 5C). This is in agreement with different articles showing on an anatomic,\textsuperscript{27} nuclear,\textsuperscript{28} and CMR basis\textsuperscript{29,30} that the RS pattern in V\textsubscript{1} is accounted for by lateral and not inferobasal MI (classically posterior MI).

Recommendations

1. Historically, the terms true and strictly posterior MI have been applied when the basal part of the LV wall that lies on the diaphragm was involved. However, although in echocardiography the term posterior is still used in reference to other segments of the LV, it is the consensus of this report to recommend that the term posterior be abandoned and that the term inferior be applied to the entire LV wall that lies on the diaphragm.

2. This decision regarding change in terminology achieves agreement with the consensus of experts in cardiac imaging appointed by the AHA\textsuperscript{21} and thereby provides great advantages for clinical practice. However, a global agreement, especially with an echocardiographic statement, is necessary.

Location of MI With Q Wave in the Era of Cardiac Imaging Techniques

The concept of Q-wave versus non-Q-wave MI is currently questioned. However, CE-CMR has demonstrated that MI with Q wave may or may not be transmural but is usually larger than MI without Q wave, and has demonstrated that it is possible to assess the likelihood of an infarct producing a typical ECG pattern.\textsuperscript{29–32}

The LV is generally divided into 2 approximately equal halves: the anteroseptal perfused by the left anterior descending (LAD) coronary artery and its branches, and the infero-
lateral perfused by either the right or circumflex coronary arteries. Figure 6 shows the correspondence between the 17 segments of the LV and their supplying coronary arteries. Variation in coronary anatomy among individuals affects the relationship between coronary arteries and myocardial segments.

Pathological Q waves have been defined by the classic criteria and by those criteria (termed Selvester criteria) documented by computer application. Infarcts identified by both of these criteria have now been studied with the use of CMR as a gold standard. Recently, Q-wave MI patterns have been defined with the use of the classic criteria, which match better with infarcted area and the correlation of these classic ECG criteria with their corresponding infarction areas detected by CMR has been reported to be high (86% overall concordance). Preliminary studies of the Selvester criteria of the infarcts in the anteroseptal half of the LV have also documented a high correlation with CMR-assessed infarcts.

The consensus group has decided to classify the different infarct locations by using the name of the wall or the name of the more affected segment of the wall. The 6 most commonly occurring patterns of abnormal Q waves and Q-wave equivalents are presented in Figure 7. All of these ECG patterns present specificity >90%. The sensitivity is >80%, except for the patterns of mid-anterior and lateral MI, which present a lower sensitivity (66%). The characteristics of these patterns are as follows:

**Septal Myocardial Infarction**
The ECG shows Q waves in leads V1 and V2. The CMR reveals involvement of the septal wall and often a small part of the adjacent anterior wall. The infarct is caused either by occlusion of septal branches or LAD distal to origins of the diagonal branches.

**Mid-Anterior Myocardial Infarction**
Characteristically, this infarction presents abnormal Q waves in leads aVL and sometimes I but not in leads V5 and V6. A Q wave in leads V2 and V3 may be present. CMR shows that the infarction encompasses especially the mid-low segments (7 and 13) of the anterior wall. The infarct is usually caused by occlusion of the first diagonal branch of the LAD.

**Apical-Anterior Myocardial Infarction**
Compared with septal infarction, the abnormal Q waves extend into the more leftward precordial leads: typically V3 and V4 and sometimes V5 and V6. There are no abnormal Q waves in leads aVL and I. The CMR documents MI in the LV apex, often with extension into both the anterior and septal walls but not into the lateral wall. The infarct is caused usually by mid-LAD occlusion.

**Extensive Anterior Myocardial Infarction**
The extensive anterior infarction is essentially a combination of types a, b, and c. Consequently, the ECG shows abnormal Q waves in the precordial leads and leads aVL and sometimes I. The CMR documents that the infarct extensively involves the anterior, septal, and mid-low lateral walls. The infarct is caused by occlusion of the LAD proximal to both the initial septal and diagonal branches.

**Lateral Myocardial Infarction**
These infarcts may produce the Q-wave equivalents of abnormally prominent R waves in leads V1 and V2. There may
also be abnormal Q waves in leads I, aVL, and/or V4, V5, and V6. The CMR documents infarction in the lateral walls. The infarct is caused by occlusion of a nondominant left circumflex coronary artery (LCX) or of its marginal branch.

**Inferior Infarction**

These infarcts produce Q waves in leads II, III, and VF but without increased R waves in leads V1 and V2. The CMR shows involvement of the inferior wall, very often including the basal segment. It should be noted that there may be involvement of the inferior part of the septal wall because the posterior descending artery has “perforating” branches that supply part of the inferior portion of the septum. The infarct is caused by occlusion of the dominant coronary artery that supplies the posterior descending branch. This is the right coronary artery (RCA) in ∼90% and the LCX in ∼10% of humans. When the RCA or LCX is very dominant and the occlusion is proximal, the infarction encompasses both the inferior and the lateral wall, and then the ECG pattern is the association of criteria of inferior and lateral MI (inferolateral MI).

**Recommendations**

1. Because these 6 ECG patterns matched well with the CE-CMR necrotic areas, although some of them present limited sensitivity, they offer a better global concordance than the classic Q-wave ECG pattern location.

2. The concordance between the ECG patterns and the location of MI by CMR shows that abnormally increased R waves, the Q-wave equivalent, in leads V1 and V2 indicate a lateral MI and that abnormal Q waves in leads aVL and I without a Q wave in lead V6 indicate a mid-anterior MI. Therefore, the terms posterior and high lateral MI are incorrect when applied to these patterns and should be changed to lateral wall MI and mid-anterior wall MI, respectively.

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