Can We Still Rely on the ECG for Detecting Past Myocardial Injury?*

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The electrocardiogram (ECG) remains a cornerstone in the management of cardiovascular disease, but its value has been challenged in some conditions by newer diagnostic and imaging modalities. This is particularly true in diagnosing prior myocardial injury, for which the “Q-wave” first described by Harold Pardee in 1930 (1) is increasingly challenged by the direct visualization of scar using delayed enhancement (DE)—magnetic resonance imaging (MRI) (2). Numerous studies have established the accuracy of DE-MRI to quantify post-infarct ventricular scar (3), identify regression of scar with therapy, quantitate scar burden to predict outcomes such as arrhythmic death (4,5), and image edema to identify myocardium at risk and potential reversible injury (6,7).

In the current era, then, how useful are Q waves on the ECG? Many studies actually defend the Q-wave, citing its specificity for post-infarct scar (8), ability to localize the site of injury (9), and identify large infarcts (2,10), among other attributes. Notably, however, the optimal definition for a Q-wave continues to be revisited and, because these pathologies may differ in their ECG manifestations, various Q-wave definitions have emerged for various purposes.

The present study. The study by Delewi et al. (11) in this issue of *JACC* compared the utility of Q waves diagnosed by various definitions, hypothesizing that “classic” (stricter) criteria for Q-wave myocardial infarction (MI) would better quantify infarct size than newer criteria and that Q-wave regression would reflect infarct regression on DE-MRI and improved left ventricular ejection fraction (LVEF). In this multicenter trial, the authors studied 184 patients following ST-segment elevation MI treated with percutaneous coronary intervention (PCI). ECG Q waves were assessed using classic criteria (≥0.04 s duration with amplitude ≥25% of its corresponding R-wave), the 1999 Thrombolysis In Myocardial Infarction criteria, and the 2000 and 2007 consensus criteria at time of PCI and follow-up at 24 months. Cardiac function and (reverse) remodeling were defined by cardiac magnetic resonance (CMR) and DE-MRI at initial presentation, then at follow-up.

Classic Q waves correlated best with infarct size, indicating larger MI. Q-wave myocardial infarction (QWMI) patients had significantly lower LVEF compared with patients without Q waves (37 ± 8% vs. 45 ± 8%, p < 0.001). Interestingly, Q-wave regression was noted in 40% of QWMI patients, all within 4 months, and correlated with significantly improved LVEF over 2 years. Patients with persistent Q waves had greater prevalence of microvascular obstruction (MVO) than patients whose Q waves regressed.

The work by Delewi et al. (11) strongly supports the use of classic Q-wave criteria in identifying...
infarct size, and lower and sustained reductions in LVEF, but also raises several interesting questions. A first question is the extent to which this study reflects the general population. Study subjects (age 56 ± 9 years, post-MI LVEF 37 ± 8%) experienced no cardiac deaths in 2 years of follow-up, which is substantially lower than even the 30-day mortality rates of 3% to 5% in some prior studies (12), although with a similar prevalence of MVO (13,14). It is thus essential to verify these findings in a sicker population.

Second, the pathophysiological significance of Q-wave regression is unclear (15). Although Q waves regressed in only 40% of QWMI patients, all groups experienced infarct regression over 4 months. Moreover, Q-wave regression in the first 4 months was associated with improved LVEF over a 24-month period. This mismatch between Q waves and contractile function is unexplained, and may reflect scar characteristics not revealed by the Q-wave, such as the extent of interspersed viable myocardium. It is unclear whether 4-month Q-wave regression was associated with further scar regression, because DE-MRI was not performed at 24 months. Mismatch may also reflect the impact of angiotensin-receptor antagonists and beta-blockers on residual viable myocardium. Although precise data on pharmacologic therapy are not provided, future studies should define their impact on Q-wave and scar regression. It is also not specified whether patients with greater reverse remodeling may have had MI in locations that may contribute less to LVEF, although a recent study showed that Q-wave regression may occur in all MI territories and is associated with smaller infarct size at 1 year (14). Third, the natural history of Q-wave regression may also be influenced by prior scar. Although patients with a history of prior MI were excluded, this ascertainment was not clearly defined. A recent study reported that 17% of patients studied for the epidemiology of aging had MRI-detected MI that was previously unrecognized by clinical criteria (16). Finally, the study found Q-wave regression to correlate with lesser MVO that associates with greater functional recovery (14,17). Although it is unclear whether relative functional improvement differed in patients with and without MVO, these data indirectly support thrombectomy during PCI to reduce no-reflow and MVO (18). However, it is not clear from the study whether such patients can be identified a priori.

**Future directions: improving the venerable Q-wave.** In order to improve the ability of the Q-wave to identify myocardial scar, it is necessary to re-examine its pathological basis. Although Q waves are considered to represent depolarizing current from opposing myocardial walls though “a window” of infarcted tissue (19), studies at autopsy and DE-MRI now show that scar is rarely homogeneous and often exhibits strands of interspersed viable tissue (20). The signal-averaged ECG was initially developed to indicate heterogeneous conduction through heterogeneous scar yet, though predictive for arrhythmic events in patients with reduced LVEF post-MI (21), its accuracy for determining scar burden is undefined (22).

Das et al. (23) have recently described the index of fragmented QRS (fQRS), defined as the presence of R’ or notching in the nadir of the S-wave (QRS < 120 ms) in 2 contiguous leads corresponding to a major coronary artery territory, which may represent conduction through islands of viable tissue within scar. Recent studies show that the fQRS adds to the predictive value of Q waves for myocardial scar (23), although the Q-wave has higher specificity and positive predictive value for scar and prior MI than fQRS (24). More recent work demonstrates the ability of fQRS to predict arrhythmic and total mortality in patients with widened QRS and nonischemic cardiomyopathy. This is a potentially exciting area for future work.

In summary, Delewi et al. (11) should be congratulated on this elegant multicenter study that compared the value of competing Q-wave criteria against longitudinal imaging and outcome in patients after acute MI. Remarkably, the authors’ work reaffirms that, even in 2013, the ECG Q-wave defined by classic criteria accurately identifies post-infarct scar and can track its regression over time. Pardee would be proud.

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REFERENCES


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