Journal of the American College of Cardiology Vol. 53, No. 17, 2009

Published by Elsevier Inc.
ISSN 0735-1097/09/$36.00
doi:10.1016/j.jacc.2009.01.046

# Baseline Q-Wave Surpasses Time From Symptom Onset as a Prognostic Marker in ST-Segment Elevation Myocardial Infarction Patients Treated With Primary Percutaneous Coronary Intervention

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**Objectives** We assessed the incremental value of baseline Q waves over time from symptom onset as a marker of clinical outcome in ST-segment elevation myocardial infarction (STEMI).

**Background** Time from symptom onset is a central focus in STEMI patients. The presence of Q waves on the baseline electrocardiogram (ECG) has been suggested to be of incremental value to time from symptom onset in evaluating clinical outcomes.

**Methods** We evaluated baseline Q waves and ST-segment resolution 30 min after primary percutaneous intervention (PCI) ECGs in 4,530 STEMI patients without prior infarction. Additionally, peak biomarkers; 90-day mortality; and the composite of death, congestive heart failure (CHF), or cardiogenic shock were assessed.

**Results** Fifty-six percent of patients had baseline Q waves: they were older, more frequently male and diabetic, and had a more advanced Killip class. Patients with baseline Q waves had greater mortality and a higher composite rate of death, CHF, and shock versus patients without baseline Q waves at 90 days (5.3% vs. 2.1% and 12.1% vs. 4.8%, respectively, both $p < 0.001$). Complete ST-segment resolution was highest, whereas 90-day mortality and the composite outcome were lowest among those randomized ≤3 h without baseline Q waves. After multivariable adjustment, baseline Q-wave but not time from symptom onset was significantly associated with a 78% relative increase in the hazard of 90-day mortality and a 90% relative increase in the hazard of death, shock, and CHF.

**Conclusions** Baseline Q waves in STEMI patients treated with primary PCI provide an independent prognostic marker of clinical outcome. These data might be useful in designing future clinical trials as well as in evaluating patients for triage and potential transfer for planned primary PCI. (Pexelizumab in Conjunction With Angioplasty in Acute Myocardial Infarction [APEX-AMI]; NCT00091637) (J Am Coll Cardiol 2009;53:1503–9) © 2009 by the American College of Cardiology Foundation

Time from symptom onset has become a central focus in the diagnosis, triage, and management of patients with ST-segment elevation myocardial infarction (STEMI) (1,2). Despite the implied precision of this metric in a variety of prior clinical studies, there are substantial differences between the pathophysiology of human STEMI as compared

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Manuscript received December 4, 2008; revised manuscript received January 23, 2009, accepted January 25, 2009.

**Abbreviations and Acronyms**

CHF = congestive heart failure
ECG = electrocardiogram
MI = myocardial infarction
PCI = percutaneous coronary intervention
STEMI = ST-segment elevation myocardial infarction

with experimental models that underscore the clinical ambiguity in identifying the stage of evolution of STEMI in humans (3). Accordingly, several efforts have been made to evaluate elements of the electrocardiogram (ECG) at the time of presentation of STEMI in hopes of providing additional insight into the stage of evolution of the process. Because the presence of baseline Q waves has been demonstrated to provide incremental value over the interval between symptom onset and presentation in predicting 30-day mortality in STEMI patients receiving streptokinase, it constitutes a potential marker of the stage of infarct development (4,5). We recently provided support for this concept in the ASSENT (Assessment of the Safety and Efficacy of a New Treatment Strategy for Acute Myocardial Infarction) IV-percutaneous coronary intervention (PCI) study, because patients within the facilitated fibrinolytic group presenting more than 3 h after symptom onset with baseline Q waves had worse outcomes (6). Whether a similar relationship exists in the expanding cohort of STEMI patients treated with primary PCI is unknown but important to ascertain, given that the association between time from symptom onset to reperfusion with PCI seems less strongly related to outcome than with fibrinolysis (7,8). Accordingly, we evaluated whether the aforementioned relationship between Q-wave presence and clinical outcomes exists in a large contemporary cohort of PCI-treated STEMI patients enrolled in the APEX-AMI (Assessment of Pexelizumab in Acute Myocardial Infarction) trial.

## Methods

The APEX-AMI trial was a multicenter, randomized, double-blind, placebo-controlled trial of intravenous pexelizumab administered immediately before primary PCI for electrocardiographically high-risk STEMI patients (9). The primary end point of the present study was 90-day mortality and the composite of death, centrally adjudicated congestive heart failure (CHF), or cardiogenic shock at 90 days. Because no significant difference was observed in the primary end point between the treatment and placebo arms, both arms were pooled for the current analysis.

A total of 5,745 patients were enrolled in the trial according to the following specific entry criteria described previously (10): briefly, patients were ≥18 years of age, with symptom onset <6 h, and had an ECG indicative of acute STEMI that fulfilled any of the following 3 criteria: ≥2-mm ST-segment elevation in 2 anterior or lateral leads; ≥2-mm ST-segment elevation in 2 inferior leads coupled with ST-segment depression in 2 contiguous anterior leads for a total ST-segment deviation of ≥8 mm; or new left bundle branch block with at least 1-mm concordant ST-segment elevation.

**ECG analysis.** All baseline and 30-min post-PCI ECGs were evaluated centrally at the ECG core laboratories (Canadian VIGOUR Centre, Edmonton, Canada and Duke Clinical Research Institute, Durham, North Carolina) without knowledge of treatment assignment and outcomes.

The Q-wave or Q-wave equivalent was determined at baseline ECG with the Selvester QRS screening criteria (11): a Q-wave of ≥30 ms in aVF (inferior); ≥40 ms in I and aVL (lateral), or ≥40 ms in ≥2 of $V_4$, $V_5$, or $V_6$ (apical); or any Q-wave in $V_2$ (anterior). As well, Q-wave equivalents were defined as an R-wave of ≥40 ms in $V_1$ (posterior) or an R-wave ≤0.1 mV and <10 ms in $V_2$ (anterior).

To assess the degree of ST-segment resolution after PCI, we used Schröder's method (12), in which the degree of ST-segment resolution at 30 min after PCI was calculated relative to the baseline ST-segment elevation (or deviation if present): complete resolution at ≥70%, partial resolution at 30% to 70%, and no resolution at <30%. The degree of ST-segment deviation was determined at the J-point with magnified calipers. For anterior infarction, the total ST-segment deviation was the sum of ST-segment elevation in leads I, aVL, and $V_1$ to $V_6$ added to the sum of ST-segment depression in leads II, III, and aVF. For inferior infarction, total ST-segment deviation was the sum of ST-segment elevation in leads II, III, aVF, $V_5$, and $V_6$ added to the sum of ST-segment depression in leads $V_1$ to $V_4$. There was excellent interobserver agreement (96%) on the basis of both assessments of ST-segment deviation and Q waves.

Additionally, biomarkers of myocardial necrosis (i.e., peak samples of creatine kinase [U/l], creatine kinase myocardial band [μg/l], troponin-I [μg/l], or troponin-T [μg/l]) were obtained. Peak samples of these biomarkers were collected and processed according to local protocols. Samples for at least 1 biomarker for myocardial necrosis were available for all in the current study population.

**Statistical analysis.** Descriptive statistics were reported as percentages for categorical variables with comparisons between patient groups made with the chi-square test, medians with 25th and 75th percentiles, and the nonparametric Mann-Whitney *U* test for continuous variables. Time from symptom onset to PCI was considered as a dichotomous variable with 3 h as the cut point (to correspond to current American College of Cardiology/American Heart Association guidelines; ≤3 h vs. >3 h). The analysis of time to PCI treated as a continuous variable is also presented in the accompanying online appendix.

Associations between baseline Q-wave and the time to the (first) event (i.e., death or death/CHF/shock) were examined with Kaplan-Meier survival estimates (i.e., unadjusted survival analyses) with pairwise comparisons based on the log-rank test. Further stratification of Q-wave according to myocardial infarction (MI) location was also examined.

**Table 1** Selected Baseline Characteristics According to Q-Wave and Time From Symptom Onset to PCI

| | All Patients | | | Time From Symptom Onset to PCI ≤3 h | | | Time From Symptom Onset to PCI >3 h | | |
|---|---|---|---|---|---|---|---|---|---|
| | No Q-Wave | Q-Wave | p Value | No Q-Wave | Q-Wave | p Value | No Q-Wave | Q-Wave | p Value |
| n | 2,016 | 2,514 | | 890 | 940 | | 1,126 | 1,574 | |
| Age, yrs | 60 (51, 70) | 61 (53, 71) | <0.001 | 58 (50, 68) | 60 (52, 69) | 0.005 | 62 (53, 71) | 62 (53, 72) | 0.036 |
| Female, % | 26.4 | 21.0 | <0.001 | 21.5 | 17.4 | 0.030 | 30.4 | 23.2 | <0.001 |
| Diabetes mellitus, % | 12.4 | 15.7 | 0.001 | 9.9 | 13.9 | 0.008 | 14.3 | 16.8 | 0.082 |
| Hypertension, % | 45.8 | 46.9 | 0.455 | 40.3 | 41.7 | 0.553 | 50.1 | 50.0 | 0.964 |
| Heart rate, beats/min | 72 (62, 84) | 76 (66, 88) | <0.001 | 72 (61, 83) | 75 (65, 85) | <0.001 | 72 (62, 84) | 78 (67, 89) | <0.001 |
| Systolic blood pressure, mm Hg | 131 (116, 150) | 135 (119, 150) | 0.077 | 130 (115, 148) | 130 (116, 148) | 0.746 | 134 (117, 152) | 136 (120, 151) | 0.129 |
| Killip >1, % | 7.9 | 11.0 | 0.001 | 6.5 | 10.2 | 0.004 | 9.1 | 11.4 | 0.047 |
| Inferior MI, % | 57.1 | 29.3 | <0.001 | 56.7 | 27.8 | <0.001 | 57.4 | 30.1 | <0.001 |
| Creatinine clearance, ml/min | 85.3 (66.1, 108.7) | 82.7 (64.4, 107.9) | 0.096 | 89.8 (69.5, 111.3) | 86.5 (68.7, 108.3) | 0.120 | 81.8 (64.2, 105.7) | 80.8 (61.9, 107.5) | 0.508 |
| Baseline ST-segment deviation, mm | 13 (9, 18) | 14.5 (10.0, 20.5) | <0.001 | 13 (9.5, 18.5) | 15 (10.0, 21.5) | <0.001 | 13 (9, 17.5) | 14 (9.5, 20) | <0.001 |
| Symptom onset to baseline ECG, h | 1.65 (1, 2.64) | 1.95 (1.18, 3.12) | <0.001 | 1.03 (0.68, 1.43) | 1.08 (0.73, 1.52) | 0.019 | 2.47 (1.80, 3.41) | 2.78 (1.97, 3.73) | <0.001 |
| Symptom onset to PCI, h | 3.13 (2.37, 4.13) | 3.30 (2.53, 4.33) | <0.001 | 2.32 (1.95, 2.67) | 2.42 (2.00, 2.72) | 0.014 | 4.07 (3.48, 4.78) | 4.12 (3.48, 4.95) | 0.103 |

Median (25th, 75th percentile) presented for continuous variables.
ECG = electrocardiogram; MI = myocardial infarction; PCI = percutaneous coronary intervention.

**Table 2** Selected Pre- and Post-PCI Indicators and Peak Biomarkers According to Q-Wave and Time From Symptom Onset to PCI

| | All Patients | | | Time From Symptom Onset to PCI ≤3 h | | | Time From Symptom Onset to PCI >3 h | | |
|---|---|---|---|---|---|---|---|---|---|
| | No Q-Wave | Q-Wave | p Value | No Q-Wave | Q-Wave | p Value | No Q-Wave | Q-Wave | p Value |
| n | 2,016 | 2,514 | | 890 | 940 | | 1,126 | 1,574 | |
| Pre-PCI TIMI flow grade, % | | | <0.001 | | | 0.176 | | | <0.001 |
| 0/1 | 72.2 | 77.6 | | 74.6 | 77.3 | | 70.3 | 77.7 | |
| 2 | 15.3 | 13.4 | | 13.6 | 12.9 | | 16.7 | 13.7 | |
| 3 | 12.5 | 9.1 | | 11.8 | 9.8 | | 13.1 | 8.6 | |
| Post-PCI TIMI flow grade, % | | | <0.001 | | | 0.010 | | | 0.021 |
| 0/1 | 2.3 | 2.1 | | 2.3 | 2.0 | | 2.2 | 2.2 | |
| 2 | 4.9 | 8.1 | | 3.7 | 6.4 | | 5.9 | 9.1 | |
| 3 | 92.8 | 89.8 | | 93.9 | 91.7 | | 91.9 | 88.7 | |
| ΣST-segment deviation resolution, % | | | <0.001 | | | <0.001 | | | <0.001 |
| <30 | 11.1 | 17.3 | | 11.1 | 16.1 | | 11.2 | 17.9 | |
| 30–<70 | 27.2 | 39.7 | | 24.9 | 38.1 | | 29.0 | 40.6 | |
| ≥70 | 61.7 | 43.1 | | 64.0 | 45.7 | | 59.8 | 41.5 | |
| Peak CK, U/l | 1,504 (708, 2,901) | 2,270 (1,108, 3,865) | <0.001 | 1,435 (677, 2,788) | 2,133 (1,018, 3,771) | <0.001 | 1,570 (746, 2,990) | 2,366 (1,159, 3,942) | <0.001 |
| Peak CKMB, μg/l | 137 (59.7, 269) | 172 (75, 301) | <0.001 | 133 (54, 266) | 174 (77, 311) | <0.001 | 139 (63, 272) | 171 (73, 300) | 0.001 |
| Peak TnT, μg/l [n] | 3.9 (1.6, 7.0) [544] | 5.6 (2.7, 10.9) [649] | <0.001 | 3.1 (1.4, 6.5) [281] | 4.9 (2.2, 9.8) [277] | <0.001 | 4.6 (2.0, 7.3) [263] | 6.1 (2.9, 11.7) [372] | <0.001 |
| Peak TnI, μg/l [n] | 46.9 (16.5, 95.6) [1,055] | 77.0 (32.3, 132.3) [1,354] | <0.001 | 41.4 (15.8, 95.8) [426] | 81.5 (28.4, 145.1) [469] | <0.001 | 49.7 (17.6, 95.6) [629] | 75.6 (35.0, 128.2) [885] | <0.001 |

Median (25th, 75th percentile) presented for continuous variables.
CK = creatine kinase; CKMB = creatine kinase myocardial band; TIMI = Thrombolysis In Myocardial Infarction; TnI = troponin-I; TnT = troponin-T; other abbreviations as in Table 1.

The relationship between time from symptom onset to PCI (i.e., first balloon inflation) and these outcomes was also examined. These associations were then adjusted for patient characteristics via Cox proportional-hazards regression. Unadjusted and adjusted hazard ratios and corresponding 95% confidence intervals are reported. Interactions between baseline Q-wave and MI location (inferior vs. noninferior infarction) and baseline Q-wave and time from symptom onset to PCI were also tested. The relative contributions of baseline Q-wave and time to PCI were calculated as the percent of Σchi-square for each outcome model. The preceding analyses were conducted in patients with Q waves in the distribution of their qualifying ST-segment elevation, and patients with prior MI were excluded to remove any potential confounding of Q-wave ascertainment during the acute index event. All tests were 2-sided with a 5% level of significance. All analyses were performed with the use of SAS statistical software (version 9.1.3, SAS Institute, Cary, North Carolina).

## Results

Of the 5,745 patients enrolled in the APEX-AMI trial, 4,530 patients were considered in the current analysis; 559 patients were excluded, because they had missing (n = 12) or noninterpretable ECGs (n = 206) or did not undergo primary PCI (n = 341). Six hundred fifty-six patients were also excluded because of a prior history of MI and/or Q waves outside of the acute MI territory.

In Table 1, selected clinical baseline characteristics are provided along with key time points in the interval between symptom onset and treatment. Among all patients (left panel), approximately 56% had a Q-wave on their baseline ECG. Such patients were slightly older, more frequently male and diabetic, and had a more advanced Killip class. They were less likely to have inferior MIs and had a greater extent of cumulative ST-segment deviation on the baseline ECG. Symptom onset duration to baseline ECG and to PCI was approximately 18 and 10 min longer, respectively,

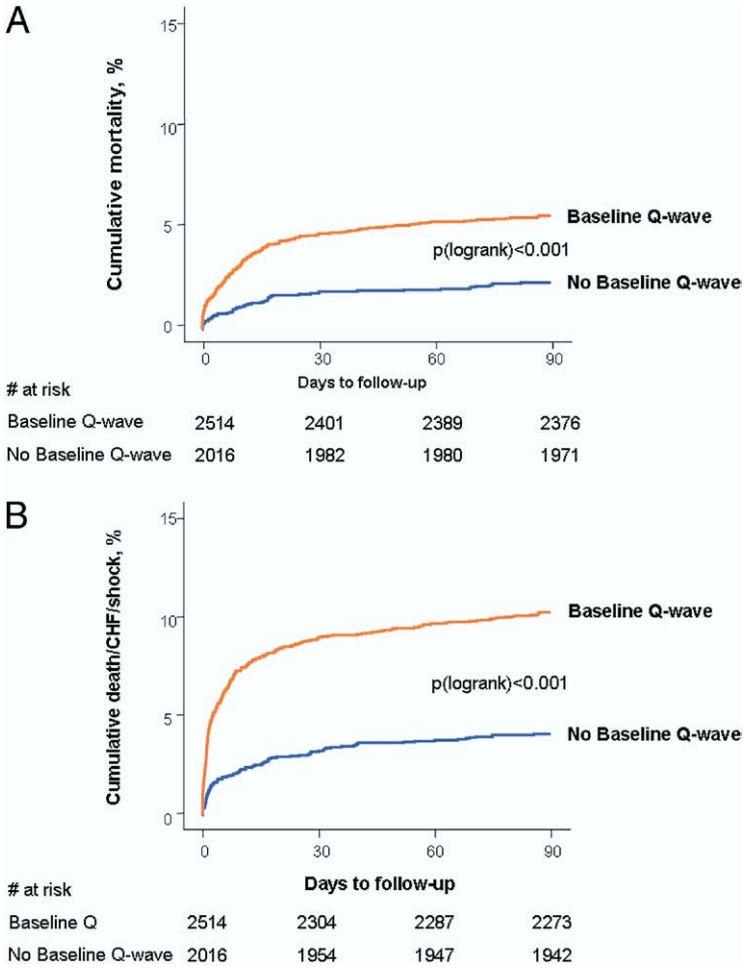


**Figure 1** Kaplan-Meier Curve by Baseline Q-Wave

Kaplan-Meier curve for 90-day **(A)** mortality by baseline Q-wave and **(B)** death/congestive heart failure (CHF)/shock by baseline Q-wave.

in patients with Q waves. When patients were further stratified by the conventional 3-h time frame from symptom onset to PCI (Table 1, middle and right panel), the aforementioned distinguishing features seen for all patients were also evident.

In Table 2, with a similar format, culprit coronary artery flow before and after PCI, ST-segment resolution 30 min after PCI, and peak biomarkers are shown. Patients presenting with Q waves more often had impaired culprit coronary vessel flow before PCI, less frequently achieved complete reperfusion as indicated by lesser Thrombolysis In Myocardial Infarction flow grade 3 after PCI, and less ΣST-segment resolution in the 30-min after PCI ECG. Patients with Q waves at baseline also exhibited higher peak biomarkers than those without baseline Q waves. When patients were subdivided according to the 3-h time window from symptom onset, these distinguishing features between Q-wave and non–Q-wave at baseline were consistent with the overall group findings.

In Figure 1, cumulative 90-day outcomes (i.e., mortality [Fig. 1A] and composite of death, CHF, and cardiogenic shock [Fig. 1B]) according to baseline Q-wave are shown. A clear separation is evident, with patients without a Q-wave on the baseline ECG experiencing fewer 90-day outcomes than those with Q waves (mortality, 2.1% vs. 5.3%, $p < 0.001$; death/CHF/shock, 4.8% vs. 12.1%, $p < 0.001$). Similarly, patients who underwent PCI within 3 h had better 90-day outcomes than those undergoing PCI later, as evident by their mortality (3.1% vs. 4.5%, $p = 0.018$) and the composite measure of death/CHF/shock (6.7% vs. 10.3%, $p < 0.001$), respectively. When the relationship between baseline Q-wave and outcomes was examined according to MI location, patients with noninferior MI and a Q-wave at baseline consistently had the highest event rates

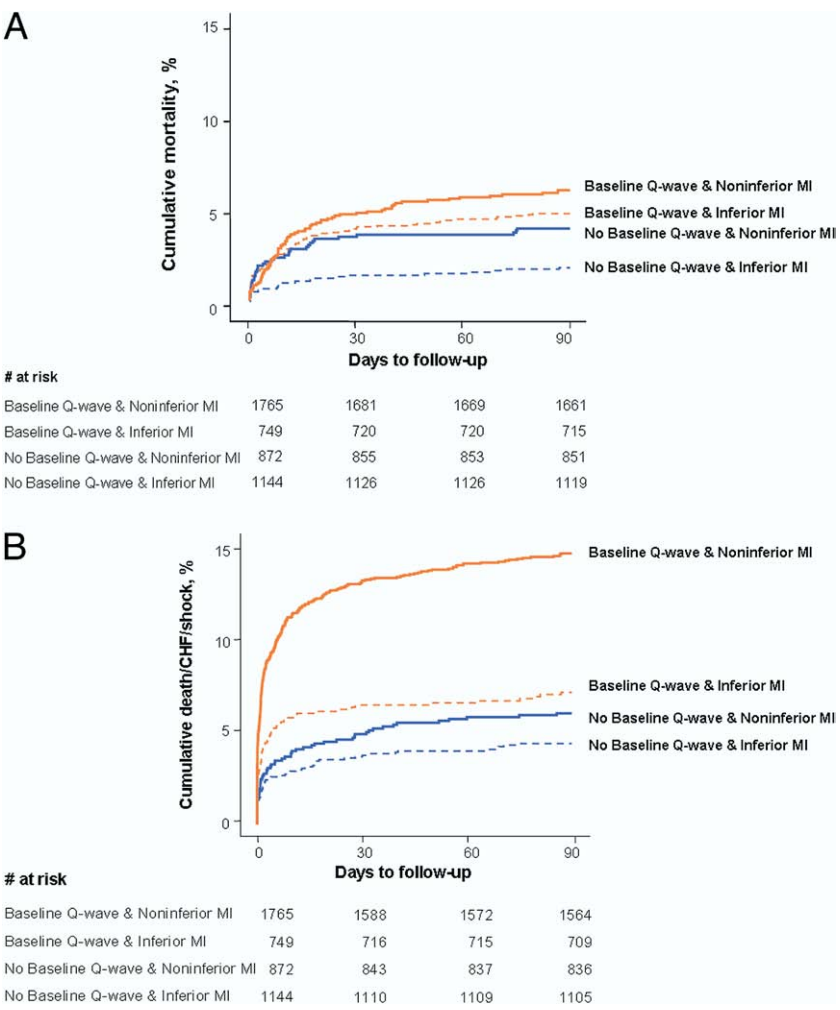


**Figure 2** Kaplan-Meier Curves by Baseline Q-Wave and MI Location

Kaplan-Meier curves for 90-day **(A)** mortality by baseline Q-wave and myocardial infarction (MI) location and **(B)** death/congestive heart failure (CHF)/shock by baseline Q-wave and MI location.

(Fig. 2). Within noninferior MIs, a clear differentiation in mortality existed between Q-wave and no Q-wave (Fig. 2A) (5.8% vs. 2.3%, $p < 0.001$), whereas this relationship was somewhat attenuated in inferior MIs (4.2% vs. 1.9%, $p = 0.004$). Similar patterns were observed for the composite outcome (Fig. 2B) (noninferior MI: 14.1% vs. 5.4%, $p < 0.001$; inferior MI: 7.2% vs. 4.4%, $p = 0.008$).

After multivariable adjustment, baseline Q-wave but not time from symptom onset to PCI was significantly associated with a 78% (relative) increase in the hazard of 90-day mortality (Fig. 3). Baseline Q-wave was also related to a 90% (relative) increase in hazard of 90-day death/CHF/shock (Fig. 3). Time to PCI was significantly associated with the composite outcome (Fig. 3), unlike the relationship with mortality. Of note, baseline Q-wave had a greater contribution to the prediction of the composite than time from symptom onset to PCI (8.8% vs. 3.2%, respectively). Interactions of Q-wave with MI location or time to PCI were not statistically significant. Even when time to PCI was examined in a continuous fashion, baseline Q-wave was significantly associated with an increased hazard of both death and the composite end point and continued to provide a greater prognostic contribution relative to time to PCI. Further details on this analysis are contained in the Online Appendix.

## Discussion

Our data, acquired in over 4,500 STEMI patients treated with primary PCI, provide novel and compelling evidence about the importance of a Q-wave on the baseline ECG as an independent prognostic marker of clinical outcome. Patients presenting within 6 h of symptom onset who exhibit Q waves on their baseline ECG seem to have a distinct clinical profile that portends more advanced disease (i.e., older men with diabetes, a more advanced Killip class, more frequent noninferior MI, greater baseline ST-segment deviation, and delayed presentation). The strong relationship between lesser ST-segment resolution after PCI (previously demonstrated as a key prognostic factor in this population) (13) and Q-wave presence indicates less successful myocardial reperfusion with PCI and is further supported by the greater peak biomarkers for myocardial necrosis. Hence, such patients would be expected to have less salvageable myocardium and worse clinical outcomes, as we demonstrated. The reasons for the greater likelihood of ST-segment resolution among patients without baseline Q waves are unclear but could relate to their shorter overall ischemic times, lesser tissue jeopardy as indicated by the extent of ST-segment deviation, and better pre-PCI culprit coronary flow.

Our observations concur with ones we have previously demonstrated on patients with baseline Q waves presenting more than 3 h from symptom onset undergoing facilitated PCI with fibrinolytic therapy in ASSENT 4-PCI (6). Such patients had significantly higher mortality than those without baseline Q waves. The finding of greater ST-segment resolution in patients without early Q-wave development is also consistent with earlier work from our laboratory and that of others (5,14). Whereas it has been argued that baseline Q waves are "a poor predictor of symptom duration," our data support prior observations from fibrinolytic treated patients contending that they are

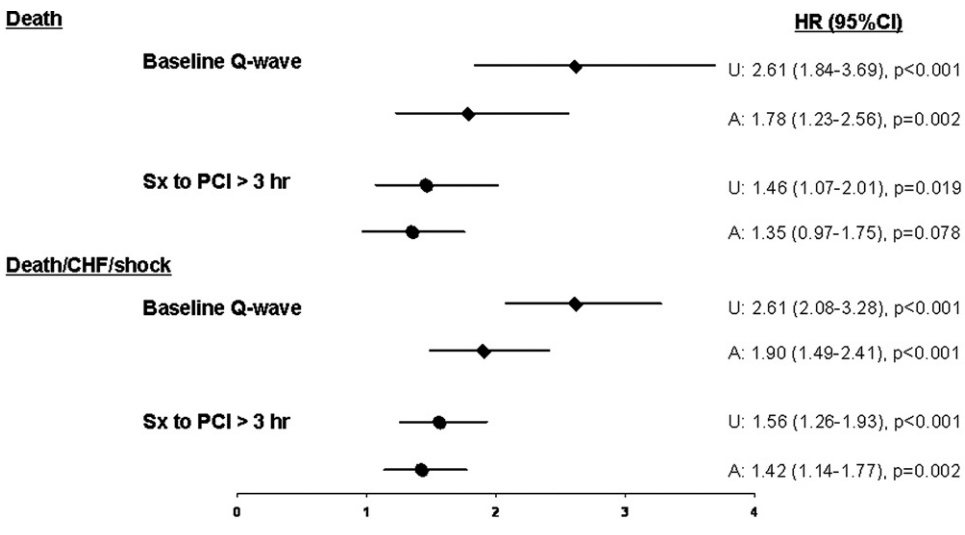


**Figure 3** Associations Between Baseline Q-wave and Time From Symptom Onset to PCI and 90-Day Clinical Outcomes

A = adjusted (death: age, systolic blood pressure, heart rate, Killip Class, myocardial infarction location, serum creatinine, baseline ΣST-segment deviation; death/congestive heart failure (CHF)/shock: age, sex, hypertension, systolic blood pressure, heart rate, Killip Class, myocardial infarction location, serum creatinine, baseline ΣST-segment deviation); CI = confidence interval; HR = hazard ratio; Sx = symptom onset; U = unadjusted.

independent from time from symptom onset and likely represent a more accurate reflection of the wave front of myocardial necrosis (15).

**Study limitations.** The trial and ECG entry criteria, although broad, are not necessarily generalizable to all patients with STEMI. Our study population received timely mechanical reperfusion and high adherence to evidence-based medical therapy as previously reported (9). Whereas it could be argued that the 3-h time point we chose to classify time from symptom onset is arbitrary, we did so because it is a conventional one used in contemporary guidelines (1) of STEMI therapy to influence therapeutic choices: our results were not materially altered when time from symptom onset to PCI was examined as a continuous variable (Online Appendix). Importantly, although there was a tendency for a shorter time from symptom onset to be associated with reduced 90-day mortality, time did prove to be a statistically significant independent covariate predicting the 90-day composite outcome. Minimizing the time from symptom onset to reperfusion should remain a major treatment goal regardless of the presence or absence of Q waves on the baseline ECG.

## Conclusions

We have shown that the baseline ECG in STEMI provides critically important insight into the outcomes after mechanical reperfusion that is independent of time from symptom onset. Because baseline Q waves seem to provide a window into the stage of evolution of infarction, it might be useful to incorporate them into the design and evaluation of future clinical trials aimed at salvaging ischemic myocardium: in particular, specific reporting of baseline Q waves and enriching cohort samples according to this metric might be worthwhile. Moreover, the use of baseline Q waves might prove to be of assistance to frontline clinicians evaluating STEMI patients (similar to those enrolled in the APEX-AMI trial) for triage and potential transfer to a tertiary center for planned PCI as well as the substantial proportion of patients in whom the history of symptom onset is unclear or unavailable. This deserves to be explored prospectively. Curtailing the interval between the onset of STEMI and the symptoms that herald its occurrence and the achievement of prompt reperfusion remains a high priority.

**Acknowledgments**

The authors are pleased to acknowledge the collaboration of Dr. Galen Wagner and his ECG core laboratory from Duke University; Yinggan Zheng, MA, MEd, for his analytical assistance; and the editorial assistance of Heather Good and Durenda Tremblay.

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## REFERENCES

1. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1999 Guidelines for the Management of Patients With Acute Myocardial Infarction). J Am Coll Cardiol 2004;44:671–9.
2. Nallamothu BK, Bradley EH, Krumholz H. Time to treatment in primary percutaneous coronary intervention. N Engl J Med 2007;357:1631–8.
3. Jennings RB, Reimer KA. Factors involved in salvaging ischemic myocardium: effect of reperfusion of arterial blood. Circulation 1983;68:I25–36.
4. Andrews J, French JK, Manda SOM, White HD. New Q waves on the presenting electrocardiogram independently predict increased cardiac mortality following a first ST-elevation myocardial infarction. Eur Heart J 2000;21:647–53.
5. Wong CK, Gao W, Raffel OC, et al. Initial Q waves accompanying ST-segment elevation at presentation of acute myocardial infarction and 30-day mortality in patients given streptokinase therapy: an analysis from HERO-2. Lancet 2006;367:2061–7.
6. McDonald M, Fu Y, Zeymer U, et al. Adverse outcomes in fibrinolytic-based facilitated percutaneous coronary intervention: insights from the ASSENT-4 PCI electrocardiographic substudy. Eur Heart J 2008;29:871–9.
7. Zijlstra F, Patel A, Jones M, et al. Clinical characteristics and outcome of patients with early (<2h), intermediate (2–4h) and late (>4h) presentation treated by primary coronary angioplasty or thrombolytic therapy for acute myocardial infarction. Eur Heart J 2002;23:550–7.
8. Nallamothu BK, Antman EM, Bates ER. Primary percutaneous coronary intervention versus fibrinolytic therapy in acute myocardial infarction: does the choice of fibrinolytic agent impact on the importance of time-to-treatment? Am J Cardiol 2004;94:772–4.
9. APEX-AMI Investigators. Pexelizumab for acute ST-elevation myocardial infarction in patients undergoing primary percutaneous coronary intervention: a randomized controlled trial. JAMA 2007;297:43–51.
10. Armstrong PW, Adams PX, Al-Khalidi HR, et al. Assessment of pexelizumab in acute myocardial infarction (APEX-AMI): a multicenter, randomized, double-blind parallel-group placebo-controlled study of pexelizumab in patients with acute myocardial infarction undergoing primary percutaneous coronary intervention. Am Heart J 2005;149:402–7.
11. Anderson WD, Wagner NB, Lee KL, et al. Evaluation of a QRS scoring system for estimating myocardial size. VI: Identification of screening criteria for non-acute myocardial infarcts. Am J Cardiol 1988;61:729–33.
12. Schroder R, Wegscheider K, Schroder K, Dissmann R, Meyer-Salellek W. Extent of early ST segment elevation resolution: a strong predictor of outcome in patients with acute myocardial infarction and a sensitive measure to compare thrombolytic regimens. A substudy of the International Joint Efficacy Comparison of Thrombolytics (INJECT) trial. J Am Coll Cardiol 1995;26:1657–64.
13. Buller CE, Fu Y, Mahaffey KW, et al. ST-segment recovery and outcome after primary percutaneous coronary intervention for ST-elevation myocardial infarction: insights from the Assessment of Pexelizumab in Acute Myocardial Infarction (APEX-AMI) trial. Circulation 2008;118:1335–46.
14. Lockwood E, Fu Y, Wong B, et al. Does 24-hour ST segment resolution post-fibrinolysis add prognostic value to a Q-wave? An ASSENT 2 electrocardiographic substudy. Am Heart J 2003;146:640–5.
15. Raitt MH, Maynard C, Wagner GS, Cerqueira MD, Selvester RH, Weaver WD. Appearance of abnormal Q waves early in the course of acute myocardial infarction: implications for efficacy of thrombolytic therapy. J Am Coll Cardiol 1995;25:1084–8.

**Key Words:** infarction ■ prognosis ■ Q-wave.

**APPENDIX**

**For a supplemental Methods section, please see the online version of this article.**