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HEART Score for Major Cardiac Events

The HEART score for major cardiac events predicts the 6-week risk of major adverse cardiac events.

Points & Pearls

- HEART is an acronym of its components: history, electrocardiogram (ECG), age, risk factors, and troponin. Each of these is scored with 0, 1, or 2 points.
- The HEART score helps emergency department (ED) clinicians risk stratify patients with chest pain into low-, moderate-, and high-risk groups.
- It was designed to risk stratify patients with undifferentiated chest pain, not those already diagnosed with acute coronary syndromes (ACS).
- The HEART score helps identify patients with higher risk of having a major adverse cardiac event (MACE) within the following 6 weeks. MACE is defined as all-cause mortality, myocardial infarction, or coronary revascularization.
- The user needs some experience taking a detailed chest pain history and reading ECGs in order to adequately apply these 2 components of the score.
- The HEART score is sometimes compared to the TIMI (Thrombolysis in Myocardial Infarction) and GRACE (Global Registry of Acute Coronary Events) risk scores, which are older ACS scores; however, TIMI and GRACE differ from HEART in that they measure risk of death for patients with ACS.

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Why to Use

The HEART score objectively risk-stratifies patients into low-, moderate-, and high-risk categories. This helps guide management, leading to better resource utilization, shorter hospital and ED stays for low-risk patients, and earlier interventions for moderate- and high-risk patients.

When to Use

The HEART score can be applied to any patient presenting to the ED with chest pain who the physician deems appropriate to evaluate for possible ACS.

Next Steps

- **Scores 0 to 3:** 0.9% to 1.7% risk of adverse cardiac event. In the HEART score study, these patients were discharged (0.99% in the retrospective study, 1.7% in the prospective study).
- **Scores 4 to 6:** 12% to 16.6% risk of adverse cardiac event. In the HEART score study, these patients were admitted to the hospital (11.6% in the retrospective study, 16.6% in the prospective study).
- **Scores ≥ 7 :** 50% to 65% risk of adverse cardiac event. In the HEART score study, these patients were candidates for early-invasive measures (65.2% in the retrospective study, 50.1% in the prospective study).
- A MACE was defined as all-cause mortality, myocardial infarction, or coronary revascularization.

Abbreviations: ACS, acute coronary syndromes; ED, emergency department; HEART, history, electrocardiogram, age, risk factors, and troponin; MACE, major adverse cardiac event.

- HEART outperforms TIMI, safely identifying more low-risk patients.
- HEART is most widely validated for regular-sensitivity troponin, although it has been studied recently using high-sensitivity troponin (Ljung 2019).

Instructions

The HEART score should be used in patients aged ≥ 21 years who present with symptoms suggestive of ACS. Do not use the HEART score if there is new ST-segment elevation ≥ 1 mm, or if there are other new ECG changes, hypotension, life expectancy < 1 year, or if the clinician identifies noncardiac medical, surgical, or psychiatric illness requiring admission.

Critical Actions

Do not use the HEART score if the ECG shows new ST-segment elevation requiring immediate intervention, or with clinically unstable patients.

Evidence Appraisal

The HEART score was originally developed by Backus et al (2008) in a cohort of 122 patients with chest pain in an ED setting. The study included any patients admitted to the ED due to chest pain, irrespective of age, prehospital assumptions, and previous medical treatments. It excluded patients with chest pain and significant ST-segment elevations. End points in this study were acute myocardial infarction, percutaneous coronary intervention, coronary artery bypass graft, and death. HEART scores of 0 to 3 points confer a risk of 2.5% for any end point, and were therefore used to support discharge from the ED. Conversely, HEART scores of 4 to 6 points confer a risk of 20.3% for any end point, implying admission for clinical observation is necessary. HEART scores of ≥ 7 points have a risk of 72.7% for any end point and support early invasive strategies.

In a retrospective multicenter validation study also by Backus et al (2010), 880 patients presenting with chest pain were evaluated. The primary end points studied were the same as in the original study. In this study, 158 patients (17.95%) reached a primary end point. Of the 303 patients with HEART scores of 0 to 3 points, 3 (0.99%) had a MACE. Among 413 patients with HEART scores of 4 to 6 points, 48 cases (11.6%) resulted in a MACE, and among patients with HEART scores of 7 to 10 points, a MACE was identified in 107 of 164 cases (65.2%).

Backus et al (2013) externally validated HEART with a prospective multicenter study. The study evaluated 2440 patients presenting with chest pain to 10 EDs in the Netherlands. The primary end point was the occurrence of any MACE within 6 weeks. The performance of HEART was also compared

to TIMI and GRACE. In the low-risk group (HEART scores of 0-3 points), 15 of 870 patients (1.7%) were found to have a MACE. In the group with HEART scores of 4 to 6 points, 183 of 1101 patients (16.6%) were diagnosed with a MACE. A MACE occurred in 50.1% of patients with HEART scores of 7 to 10 points. The C-statistic of the HEART score (0.83) was significantly higher than the C-statistic of the TIMI score (0.75) and the GRACE score (0.70), respectively ($P < .0001$).

Poldervaart et al (2017) studied the HEART score in a stepped-wedge, cluster-randomized trial, with the objective of measuring both outcomes and use of healthcare resources. The 9 Dutch hospitals included in the study were instructed to start usual care when assessing patients with chest pain. Every 6 weeks, one of the hospitals was randomly assigned to use HEART to assess patients with chest pain. A total of 3648 patients were included (1827 receiving usual care and 1821 receiving HEART care). The study found that the 6-week MACE incidence while using HEART was 1.3% lower than with usual care, but there were no statistically significant differences in early discharge, readmissions, recurrent ED visits, outpatient visits, or visits to general practitioners.

Recent studies have compared HEART head-to-head with other clinical decision rules for the ability to safely identify low-risk patients. A study by Poldervaart et al (2017) comparing HEART to TIMI and GRACE showed that HEART outperformed the others when identifying low-risk patients, with only 0.8% incidence of MACE in the low-risk group. In addition, Nieuwets et al (2016) compared HEART with TIMI for identifying low-risk patients without compromising safety, while also evaluating expected cost reductions. The study found that the HEART score identified more patients as low-risk than the TIMI score did, which would have led to potential cost savings of €64,107 (~USD \$76,000) by using the HEART score cutoffs versus cost savings of €14,670 (~USD \$17,000) using the TIMI score cutoffs.

The HEART pathway developed by Mahler et al (2015) combined the HEART score with 0- and 3-hour cardiac troponin tests in a decision aid designed to identify ED patients who are safe for early discharge. The study found that the HEART pathway decreased length of stay by 12 hours, decreased objective cardiac testing by 12%, and increased early discharges by 21%. No MACE was seen within 30 days in patients who were identified for early discharge. Of note, this study (and the original HEART studies) used regular-sensitivity cardiac troponin testing.

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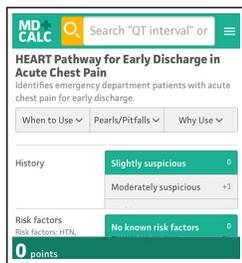
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HEART Pathway for Early Discharge in Acute Chest Pain

The HEART pathway was designed to aid in efficiently evaluating patients with acute chest pain, using the previously validated HEART score.

Points & Pearls

- The HEART pathway identifies patients who are safe for early discharge versus those who need observation, admission, and potentially emergent cardiology assessment.
- While patients with ischemic changes on electrocardiogram (ECG) or elevated troponin may be classified as low-risk using the HEART pathway, the creators recommend against relying on the HEART pathway in such cases.
- New elevations in troponin or ECG changes indicate that further workup is needed, and these patients should not be assumed to be low risk.
- The creators of the HEART pathway recommend against using this clinical decision tool in patients with known coronary artery disease, a disease state that puts patients at significant increased risk of acute coronary syndromes (ACS).
- The HEART pathway was designed for patients presenting to the emergency department (ED) with chest pain, and was not tested in patients with chest pain who are already hospitalized.

Advice

The HEART pathway is an accelerated diagnostic pathway. It is not designed to replace clinical judgment. Any patient with a concerning presentation or clinical progression should receive workup and treatment based on the clinician's discretion, regardless of the risk predicted by the HEART pathway.

Shared decision-making is a crucial part of further management after ACS risk has been determined, especially in patients with moderate risk who are recommended for observation and comprehensive cardiac evaluation. There is notable risk involved with hospitalization as well as risks for false-positive or nondiagnostic testing that would result in invasive procedures such as cardiac catheterization. The patient should be presented with the risks of both missed ACS and hospitalization for further workup.

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Why to Use

Chest pain is one of the most common and potentially life-threatening chief complaints in emergency medicine. Many patients presenting with chest pain undergo unnecessarily extensive and costly evaluations to rule out ACS. The HEART pathway can reduce the number of prolonged and invasive evaluations while maintaining high sensitivity and negative predictive value for ACS.

Unlike other scoring systems such as the TIMI risk score or the GRACE risk score, the HEART pathway is designed to predict the likelihood of ACS in the patient presenting to the ED with acute chest pain. TIMI and GRACE risk scores are used to risk stratify patients who have been diagnosed with ACS.

When to Use

The HEART pathway can be used in patients aged ≥ 21 years presenting with symptoms suggestive of ACS. It should not be used in patients with new ST-segment elevation ≥ 1 mm, or if there are other new ECG changes, hypotension, life expectancy < 1 year, or if the clinician identifies noncardiac medical, surgical, or psychiatric illness requiring admission.

Next Steps

- Low-risk patients with a follow-up troponin (at 3 hours) can be considered for safe discharge home with appropriate follow-up.
- High-risk patients require admission, serial cardiac biomarkers, ECG, and cardiology consult.

Abbreviations: ACS, acute coronary syndromes; ECG, electrocardiogram; ED, emergency department; GRACE, Global Registry of Acute Coronary Events; TIMI, Thrombolysis in Myocardial Infarction.

Any patient who presents with chest pain and is subsequently discharged should be informed that, even with a negative workup, there is still a small risk of ACS. Patients should have close follow-up arranged and be given extensive return precautions prior to discharge.

Critical Actions

Clinician judgment should prevail, even if patients are deemed to be at low risk by the HEART pathway. If there is some other cause for concern for an acute cardiac event, workup should be individualized to the patient.

All patients presenting to the ED with chest pain concerning for ACS should receive aspirin unless there is an absolute contraindication, such as known allergy, active bleeding, or if the patient has received a therapeutic aspirin dose prior to arrival.

Evidence Appraisal

The HEART pathway was developed by Mahler et al in 2015 in a randomized controlled single-center trial. The control arm was managed at the discretion of care providers encouraged to follow American College of Cardiology/American Heart Association guidelines for acute chest pain. The use of the HEART pathway in this study was designed to mimic the real world in that it was used as an accelerated diagnostic pathway. Patient care was at the discretion of the clinician and not mandated by the outcome of the HEART pathway.

There were 282 patients studied, with 141 patients in each treatment group. The primary outcome was the rate of objective cardiac testing (stress test, coronary computed tomography angiogram, or invasive coronary angiography) within 30 days of presentation. Secondary outcomes were early discharge rate, index length of stay, cardiac-related recurrent ED visits, and nonindex hospitalization at 30 days.

The rate of objective cardiac testing in the HEART pathway group was 12% less than in the usual care group. The rate of early discharge in the HEART pathway group was 21% higher than in the usual care group. The index length of stay was 12 hours shorter using the HEART pathway. There was no significant difference between the 2 groups for cardiac-related recurrent ED visits or nonindex hospitalization at 30 days. No patients identified for early discharge in either group had a missed major adverse cardiac event (MACE) during the first 30-day follow-up period. The study was not designed to adequately detect differences in MACE between the 2 study groups.

Riley et al in 2017 published a cost analysis of the HEART pathway compared to usual care, using the same data set as the original HEART pathway trial. There were 270 patients studied. Billing data were missing for 12 patients from the original study. Cost metrics considered in each group were index visit cost, total cost at 30 days, cardiac-related healthcare cost at 30 days, cardiac and noncardiac diagnostic testing cost, ED cost, inpatient cost for index visit, and outpatient cost. HEART pathway patients had a significantly lower mean and median cost for both index visit and 30-day follow-up. There was no significant difference between the median and mean costs

of the other metrics. Average savings per patient was \$216 when using the HEART pathway. On a larger scale, this would mean approximately \$2 billion in savings per year for undifferentiated chest pain.

Mahler et al in 2017 also published a secondary analysis looking at high-sensitivity cardiac troponin I (hs-cTnI) and high-sensitivity cardiac troponin T (hs-cTnT). The study compared risk stratification using cardiac troponin I (cTnI) versus hs-cTnI and hs-cTnT in calculating the HEART pathway score. Blood samples were sent for cTnI, hs-cTnI, and hs-cTnT for 133 patients.

All of the troponin assays had poor sensitivity for predicting MACE when used separately from the HEART score. There was no difference in the predicted risk of MACE between the use of serial cTnI and 3-hour hs-cTnI in the HEART pathway. Using hs-cTnT in the HEART pathway led to 1 patient with an NSTEMI (non-ST-segment elevation myocardial infarction) being misclassified as low risk. The study found the HEART pathway using serial cTnI or 3-hour hs-cTnI to have sensitivity and negative predictive value of 100% for 30-day MACE. Although hs-cTnT use in the HEART pathway caused an NSTEMI to be misclassified as low risk, the reduction in sensitivity was not statistically significant, given the small study population. The authors recommend further appropriately powered studies to determine small differences in the accuracy of the high-sensitivity troponin assays.

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GRACE ACS Risk and Mortality Calculator

The GRACE risk score estimates in-hospital and 6-month mortality for patients with acute coronary syndromes.

Points & Pearls

- The GRACE (Global Registry of Acute Coronary Events) risk score is a prospectively studied scoring system used to risk stratify patients with diagnosed acute coronary syndromes (ACS) in order to estimate in-hospital and 6-month to 3-year mortality. As with the TIMI (Thrombolysis in Myocardial Infarction) risk score, the GRACE risk score was not designed to assess whether a patient's anginal symptoms are due to ACS.
- The GRACE risk score was recently improved to GRACE 2.0. The GRACE risk score uses 8 variables from the history, physical examination, electrocardiogram (ECG), and laboratory testing. GRACE 2.0 allows for substitutions of Killip class for diuretic usage, and serum creatinine for history of renal dysfunction.
- The GRACE risk score is well studied and well supported; it has been validated in > 20,000 patients in multiple databases.
- The NICE (National Institute for Health and Care Excellence in the United Kingdom) guidelines recommend the use of the GRACE risk score for risk stratification of patients with ACS.

Evidence Appraisal

GRACE is a large international database from 94 hospitals in 14 countries, which gives it excellent external validity *a priori*. The original GRACE risk score study conducted by Fox et al (2006) looked at the cumulative 6-month risk of death, and death or myocardial infarction, in patients who had suspected ACS that was not secondary to trauma, surgery, or other significant comorbidity (n = 43,810; 21,688 in derivation set, 22,122 in validation set).

Patients included in the study presented with signs or symptoms of acute cardiac ischemia and also had ECG findings consistent with ACS, cardiac biomarker serial increases consistent with ACS, or documented coronary artery disease. The in-hos-

Why to Use

Many guidelines recommend more aggressive medical management, or even early-invasive management, for patients with a high mortality risk. Knowing a patient's risk may help with management and with discussions about the goals of care with patients and their families. A patient with some nonspecific features in the workup (eg, history, ECG, troponin) can be more objectively risk-stratified for chest pain by quantifying the risk; this can potentially lead to shorter hospital stays, fewer inappropriate interventions, and more appropriate interventions.

When to Use

The GRACE risk score can be used in patients with known STEMI or UA/NSTEMI to determine mortality risk.

Next Steps

The GRACE Research Group provides information about risk levels based on the GRACE risk score at: http://www.outcomes-umassmed.org/GRACE/grace_risk_table.aspx.

Abbreviations: ECG, electrocardiogram; GRACE, Global Registry of Acute Coronary Events; NSTEMI, non-ST-segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina.

pital mortality status was available in 98.1% of the 11,389 ACS patients studied. Twenty-two percent of the in-hospital deaths occurred within 24 hours of admission, which suggests that this registry contains a very sick cohort of patients.

In 2014, Fox et al updated the GRACE risk score to GRACE 2.0. This new version of the GRACE risk score for 1-year outcomes was derived in the more recent data set of 32,037 patients from the GRACE registry who were enrolled between January 2002 and December 2007. Of note, GRACE 2.0 evaluated variables for nonlinear mortality associations,

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providing a more accurate estimate of outcome. GRACE 2.0 also includes mortality estimates up to 3 years after the ACS event via several other data sets with longer follow-up windows.

Use the Calculator Now

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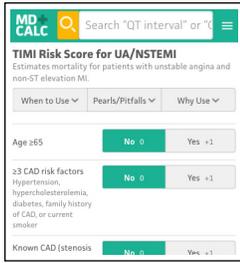
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TIMI Risk Score for UA/NSTEMI

The TIMI risk score for UA/NSTEMI estimates mortality in patients with unstable angina and non-ST-segment elevation myocardial infarction.

Points & Pearls

- The TIMI (Thrombolysis in Myocardial Infarction) risk score for UA/NSTEMI (unstable angina/non-ST-segment elevation myocardial infarction) has historical significance as one of the earliest chest pain decision rules that was widely implemented.
- A TIMI risk index and TIMI risk score for STEMI (ST-segment elevation myocardial infarction) also exist; however, in this review, “TIMI risk score” refers only to the TIMI risk score for UA/NSTEMI.
- A TIMI risk score of 0 or 1 point does not equal zero risk of adverse outcome. The original study showed that 4.7% of patients with a score of 0 or 1 point had adverse outcomes within 14 days.
- Validation studies showed that 1.7% to 2.1% of patients with a score of 0 still had adverse outcomes within 30 days.
- It is unclear whether this risk score can be used in patients with chest pain in the setting of cocaine use.
- The TIMI risk score was studied further as part of an accelerated diagnostic protocol in the ADAPT trial, which included estimation of pretest probability using TIMI, plus abnormal electrocardiogram (ECG) and high-sensitivity cardiac troponin I.

Advice

Patients in the 0 to 1 point group should be further risk stratified using another risk score or institutional practices, as their risk is not low enough to safely discharge them from the hospital. Many guidelines recommend aggressive medical intervention and/or early-invasive management for higher-risk patients.

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Why to Use

Chest pain is one of the most common complaints bringing patients to the ED for evaluation. The identification and acute management of STEMI is rarely a conundrum. However, UA/NSTEMI can go missed. Traditionally, the TIMI risk score for UA/NSTEMI can correlate the risk of adverse outcome in chest pain patients.

When to Use

The TIMI risk score for UA/NSTEMI can be used to help risk stratify patients with presumed ischemic chest pain. However, it was originally derived in patients with confirmed UA or NSTEMI.

Next Steps

- Patients with a score of 0 or 1 point are at lower risk of adverse outcome (death, MI, urgent revascularization) compared to patients with a higher risk score. However, the risk is not zero.
- Patients with a higher risk score may require more aggressive medical or procedural intervention.
- Newer chest pain risk scores such as the HEART score have been shown to be better at risk stratification than the TIMI risk score, particularly in patients with undifferentiated chest pain.

Abbreviations: HEART, history, electrocardiogram, age, risk factors, and troponin; MI, myocardial infarction; NSTEMI, non-ST-segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction; TIMI, thrombolysis in myocardial infarction; UA, unstable angina.

Evidence Appraisal

Antman et al (2000) used a merged database of 7081 UA/NSTEMI patients in the TIMI 11B and ESSENCE trials for the original derivation and validation of this TIMI risk score. The TIMI risk score was originally derived from 1957 UA/NSTEMI patients receiving unfractionated heparin in the TIMI 11B

trial, and was internally validated in 3 cohorts of patients from the rest of the merged data: 1953 patients receiving enoxaparin in the TIMI 11B trial; 1564 patient receiving unfractionated heparin in the ESSENCE trial; and 1607 patients receiving enoxaparin in the ESSENCE trial. The study included UA/NSTEMI patients with chest pain at rest who presented within 24 hours of symptoms, and who had ST-segment deviation on their presenting ECG, history of coronary artery disease, and a measured cardiac enzyme that was elevated. Patients were excluded if revascularization was performed within 24 hours or if the patient had a contraindication for anticoagulation. The primary end points were composite all-cause mortality, myocardial infarction (MI), or urgent revascularization within 14 days.

By the end of the 14 days, 16.7% of the derivation group had died, had an MI, or needed urgent revascularization. An increase in the TIMI risk score correlated with an increase in all-cause mortality, MI, or urgent revascularization. The same pattern was seen in the internally validated groups. There have been many external validation studies since the original derivation.

Scirica et al (2002) externally validated the TIMI risk score in patients from 9 sites in the TIMI III registry. This study included UA/NSTEMI patients with ischemic chest pain lasting more than 5 minutes who presented within 96 hours of symptom onset. Patients were excluded if they had a STEMI, chest pain of other origin, planned revascularization, or if the patient was in a prior TIMI trial. Primary end points were death, MI, and recurrent ischemia within 6 weeks and at 1 year.

As in the original derivation study and internal validation studies, there was an increase in mortality, MI, and recurrent ischemia with each increase in the TIMI risk score. However, this study modified the TIMI risk score definitions to some degree by substituting a patient's history of MI or revascularization history for "known coronary artery stenosis > 50%," and assigning 1 point for aspirin use in the past 24 hours, not the past 7 days as in the original trial by Antman et al. Still, this population was in a registry for patients with known UA/NSTEMI. This validation is less useful for patients with undifferentiated chest pain seen in the acute care setting of the emergency department (ED).

Pollack et al (2006) externally validated the TIMI risk score in a prospective observational cohort study of 3929 adult patients with chest pain in the ED. The study included adult chest pain patients aged > 24 years who were evaluated with ECG. Adults aged < 24 years were included if the chest pain was preceded by cocaine use within the previous week. Patients were excluded if they had a STEMI. Whereas the original derivation study looked at adverse outcomes within 14 days, and Scirica

et al (2002) validated the risk score looking up to 6 weeks and even 1 year, Pollack et al followed up with patients for up to 30 days from presentation for adverse outcomes of death, MI, or revascularization.

As in prior studies, the higher the TIMI risk score, the higher the likelihood of adverse outcome within the measured time period, which was 30 days in this study. However, the patient population was different in that there were more black patients and more female patients. Also, if no cardiac markers were ordered, a score of 0 was assumed and assigned to the category of cardiac enzymes.

Chase et al (2006) externally validated the TIMI risk score in a prospective observational study of 1458 patient visits in the ED. The study included patients aged > 30 years with nontraumatic chest pain who had an ECG performed in the ED. Whereas Pollack et al included patients with cocaine use, Chase et al excluded patients if cocaine was used in the 7 days prior to presentation. Like Pollack et al, Chase et al assigned a score of 0 to cardiac enzymes if they were not drawn. Chase et al also followed patients for up to 30 days. Within 30 days, 12.8% of patients had an adverse outcome of death, MI, or revascularization. In patients with a TIMI risk score of 0, 1.7% had an adverse outcome.

Although there was a general correlation of an increase in adverse outcome with higher TIMI risk score, this study did not show a similar step-wise increase. This is likely secondary to having a study population that was dissimilar to the original derivation group or other validation studies, as this study had patients with mostly low TIMI scores and included STEMI patients in the study population.

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