Study objective: We evaluate the safety and feasibility of a critical care pathway protocol in which patients with acute chest pain who are low risk for coronary artery disease and short-term adverse cardiac outcomes receive outpatient stress testing within 72 hours of an emergency department (ED) visit.

Methods: We performed an observational study of an ED-based chest pain critical pathway in an urban, community hospital in 979 consecutive patients. Patients enrolled in the protocol were observed in the ED before receiving 72-hour outpatient stress testing. The pathway was primarily analyzed for rates of death or myocardial infarction in the 6 months after ED discharge and outpatient stress testing. Secondary outcome measures included need for coronary intervention at initial stress testing and within 6 months after discharge, subsequent ED visits for chest pain, and subsequent hospitalization.

Results: Of 871 stress-tested patients aged 40 years or older, who had low risk for coronary artery disease and short-term adverse cardiac events, and had 6-month follow-up, 18 (2%) required coronary intervention, 1 (0.1%) had a myocardial infarction within 1 month, 2 (0.2%) had a myocardial infarction within 6 months, 6 (0.7%) had normal stress test results after discharge but required cardiac catheterization within 6 months, and 5 (0.6%) returned to the ED within 6 months for ongoing chest pain. Hospital admission rates decreased significantly from 31.2% to 26.1% after initiation of the protocol (P<.001).


SEE RELATED EDITORIAL, P. 436.

INTRODUCTION

In the United States, most patients treated in the emergency department (ED) for chest pain are admitted to the hospital to rule out either myocardial infarction or unstable angina, but only 25% of these patients ultimately receive a diagnosis of acute coronary syndrome; the remainder are discharged with noncardiac diagnoses. Meanwhile, 2% to 3% of patients treated in the ED for acute myocardial infarction are misdiagnosed and mistakenly sent home. Against this background, there has been growing interest in establishing protocols to treat ED patients with chest pain. Critical pathways allow for standardized care of chest pain patients and may help to decrease unnecessary hospitalizations and the costs associated with them. Ideally, a critical pathway for ED chest pain patients identifies those at low-risk for acute coronary syndrome who can be safely discharged from the ED while preventing the release of patients with undiagnosed myocardial infarction. Whereas previous studies attempted to identify ED patients with unstable angina or acute myocardial infarction, a more

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MATERIALS AND METHODS

Study Design

We performed an observational study of an ED-based chest pain critical pathway. We analyzed the diagnoses and medical outcomes of all patients enrolled in the outpatient arm of the hospital’s chest pain protocol (see below) between January 2002 and September 2003. This study was reviewed by the hospital institutional review board, qualified for expedited review, and was approved.

Setting

The study took place at an urban, community hospital with a yearly ED census of 45,000 patients. Facilities for triage of patients with suspected acute coronary syndrome include the coronary care unit, an inpatient telemetry unit, and an ED observation unit with 16 beds for telemetry monitoring. Exercise treadmill testing and myocardial perfusion studies are available on weekdays.

Selection of Participants

Study participants included all patients scheduled for outpatient, 72-hour exercise stress testing as per the hospital’s chest pain critical pathway from the period January 2002 through September 2003.

In January 2001, the ED implemented its current chest pain protocol (for a reproduction of the protocol, please refer Figure E1, available online at http://www.annemergmed.com). A 3-page critical care pathway for accelerated chest pain stratification was drafted by a team of emergency physicians using national clinical practice guidelines. The worksheet was adapted from 3 primary sources: the Goldman et al.14 criteria for complications in ED patients with suspected acute cardiac ischemia, the Agency for Health Care Policy and Research guidelines for short-term risk of fatal or nonfatal myocardial infarction,15 and the ACC/AHA guidelines for management of unstable angina and non–ST-elevation myocardial infarction.16 The protocol is designed to identify patients with chest pain who are at low-risk for both coronary artery disease and short-term adverse cardiac events.

A multidisciplinary team of physicians—including emergency physicians, cardiologists, and hospitalists—reviewed the protocol and ultimately approved it because it was consistent with an evidence-based standard of care for treatment of ED chest pain patients. The critical care pathway was then ratified by a regional cardiology committee and adopted as formal policy by the Departments of Emergency Medicine, Hospital-Based Specialists, and Cardiology. Consent for exercise testing was obtained from all patients enrolled in the protocol, and patient outcomes were periodically monitored by internal quality assurance review.

Patients were considered appropriate for inclusion in the protocol if they were older than 40 years and presented to the ED with chest pain.

At arrival in the ED, patients underwent a medical history-taking and physical examination, ECG, and a set of cardiac

Outpatient Stress Testing for Acute Chest Pain Patients

Meyer, Mooney & Sekera

Editor’s Capsule Summary

What is already known on the topic

Critical pathways for possible acute coronary syndromes recommend that patients be evaluated with provocative testing before or soon after discharge from the emergency department (ED). Exercise treadmill testing represents a proven, low-cost method for evaluating chest pain in patients presenting to the ED.

What question this study addressed

In an observational study of low-risk ED chest pain patients, exercise treadmill testing was performed within 72 hours of ED discharge. This study evaluated rates of death or myocardial infarction at 6 months to evaluate the feasibility and safety of outpatient stress testing after ED discharge.

What this study adds to our knowledge

The 841 patients who had negative post–ED discharge exercise treadmill testing results had few adverse cardiac events within 6 months of presentation.

How this might change clinical practice

In patients presenting to the ED with low-risk chest pain and negative serial cardiac biomarker and ECG test results, exercise treadmill testing can identify patients unlikely to have adverse cardiac outcomes in 6 months. A patient population willing to return for testing within 72 hours after ED discharge is essential for these safety benefits to be realized.

current paradigm focuses on the safety of management strategies rather than the diagnosis per se.9-11

In this study, we evaluated one such critical pathway recently implemented at our hospital. This pathway includes outpatient stress testing of patients at low risk for coronary artery disease and short-term adverse cardiac events, as has been recommended by the current American College of Cardiology (ACC)/American Heart Association (AHA) guidelines for the management of unstable angina. For patients who lack objective signs of infarction or ischemia, the ACC/AHA guidelines suggest stress testing at or soon after discharge from the ED.12 We studied patients enrolled in the protocol during a 21-month period to assess its performance. We hoped to demonstrate a low level of adverse events associated with outpatient stress testing, as well as reduced hospital admission rates among patients at low risk for ischemic complications: critical pathways for diagnosing and treating chest pain have previously been shown to improve patient outcomes.9,13 We hypothesized that patients who were carefully selected as low-risk according to an evidence-based pathway could safely undergo stress testing using a short-term (72-hour) outpatient referral system.
markers: troponin and creatine kinase, myocardial bound (CK-MB). It is the established practice at our hospital to measure troponin and CK-MB in the evaluation of patients with chest pain; therefore, for the purposes of the critical pathway, both markers were used (although measurement of serum troponin alone would probably have been sufficient). Patients in whom ECGs showed evidence of acute ST-elevation myocardial infarction received thrombolytic agents.12,14 Patients in whom ECGs showed evidence of cardiac ischemia or who had positive cardiac markers were treated as having acute coronary syndrome: they received aspirin, nitrates, and β-blockade or heparin if indicated.12,14 In certain groups, glycoprotein IIb/IIIa inhibitors also were administered.12,14

The remaining patients were considered to have “possible” acute coronary syndrome: they had normal or nondiagnostic ECG and normal cardiac enzyme results. All patients were screened with a set of cardiac markers at least 6 hours after the onset of chest pain. These patients were then classified using a risk stratification worksheet (Appendix E1, available online at http://www.annemergmed.com)14-16 as high, intermediate, or low risk for clinically significant coronary artery disease by their medical history and cardiac risk factors. Patients were also categorized according to their risk for short-term death or morbidity.

Patients at high risk were admitted to the hospital to complete further risk stratification. Patients at intermediate risk were treated by a hospitalist and were admitted to the hospital or observation unit; stress testing was performed before discharge. Patients at low risk for coronary artery disease and for short-term adverse cardiac events were considered appropriate candidates for outpatient stress testing.

Appropriate candidates for outpatient stress testing were scheduled for an exercise treadmill test within 72 hours of ED discharge using a computerized scheduling system. Patients were enrolled in the protocol during day, evening, and night shifts and on all 7 days of the week. Each patient received an instruction sheet about the exercise treadmill test. Patients unable to complete an exercise treadmill test (ie, exercise intolerance, difficulty ambulating, or abnormal ECG result) received cardiology consultation to determine an appropriate method of risk stratification.

When the program began, ED physicians were given in-service education about the chest pain protocol. Subsequent care of individual patients was at the discretion of the treating physician.

Methods of Measurement

Patients were classified according to the chest pain protocol at arrival in the ED, when initial clinical data were recorded by the emergency physician. Patients who were scheduled for outpatient exercise treadmill test were subsequently entered into a log monitored by a nurse-coordinator, who would twice telephone any patient who missed an appointment. If no response was obtained, a certified letter was sent to the patient’s home address. If no response to this letter was received, the patient’s primary care physician was notified. All exercise treadmill tests were administered by a cardiology laboratory technician in conjunction with a cardiologist, according to the Bruce protocol. They were interpreted by a cardiologist who classified them as normal or abnormal. Abnormal exercise treadmill tests were further stratified as positive or nondiagnostic using standard criteria for the interpretation of exercise treadmill tests. Criteria for a positive exercise treadmill test included greater than 1 mm of horizontal or downsloping ST-segment depression or elevation 80 ms after the J point, greater than 10 mm Hg decrease in the systolic blood pressure, coupled ventricular ectopic beats, sustained supraventricular dysrhythmia, or significant symptoms. An exercise treadmill test was defined as nondiagnostic when the peak pulse rate was less than 85% of the age-predicted maximum. All myocardial perfusion studies were administered and interpreted by a nuclear medicine physician: they were classified as normal or abnormal at the discretion of the nuclear medicine physician.

Myocardial infarction was defined using criteria established by the World Health Organization and the Joint European Society of Cardiology/American College of Cardiology Committee.17,18 Criteria for myocardial infarction included a typical rise and fall of serum cardiac troponin I in conjunction with one of the following: ischemic symptoms, electrocardiographic changes (new Q waves, ST-segment elevation or depression greater than 1 mm in 2 contiguous leads), or pathologic findings of acute myocardial infarction.17,18 All myocardial infarctions were confirmed by a cardiologist. Percutaneous coronary intervention was defined as any form of coronary angiographic intervention, including angiography, angioplasty, or angiography/angioplasty with stent placement; the results of percutaneous coronary intervention were confirmed by the presence of a postoperative note. Coronary artery bypass graft surgery was also confirmed by a postoperative note.

Troponin I and CK-MB levels were measured using the Abbott Assym immunoassay (Abbott Park, IL); a level greater than 0.2 is considered positive (exceeding the 99th percentile of a reference control group).

Data Collection and Processing

Six-month outcomes and data about exercise treadmill tests, myocardial perfusion scans, repeated ED visit or hospitalization, cardiac catheterization, and coronary artery bypass graft surgery were obtained by medical record review. In addition, our health care organization maintains a computer registry that documents any deaths, admissions to the hospital, transfers to outside hospitals, or admissions to other hospitals: this registry was reviewed for each patient entered into the chest pain protocol.

A χ² test was used to assess difference in hospitalization rates before and during the study period. Statistical significance was measured at P<.05.
Table 1. Disposition of the 7,178 patients older than 40 years who visited the ED for chest pain during the study period.

<table>
<thead>
<tr>
<th>Disposition</th>
<th>Patients, No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admitted to the hospital</td>
<td>1,875</td>
</tr>
<tr>
<td>Held in observation unit for next-day stress testing</td>
<td>1,057</td>
</tr>
<tr>
<td>Scheduled for 72-h outpatient exercise treadmill test</td>
<td>979</td>
</tr>
<tr>
<td>Died in ED</td>
<td>3</td>
</tr>
<tr>
<td>Transferred to other hospital*</td>
<td>28</td>
</tr>
<tr>
<td>Discharged home (thought to have noncardiac diagnoses)†</td>
<td>3,236</td>
</tr>
</tbody>
</table>

*Patients transferred because of insurance reasons or patient preference.
†Five most common discharge diagnoses were chest wall pain, atypical/noncardiac chest pain, gastroesophageal reflux disease, upper respiratory infection/pneumonia/bronchitis, anxiety.

Outcome Measures

All patients who underwent outpatient stress testing were evaluated for negative outcomes within 6 months of ED discharge. The primary outcome measure was defined as death from any cause or myocardial infarction within 6 months after ED discharge. A secondary outcome measure was the percentage of patients requiring coronary intervention—either percutaneous coronary intervention or coronary artery bypass graft surgery—at both initial evaluation and during the 6 months after stress testing. Another secondary outcome was defined as either repeated ED presentation with a complaint of chest pain or other hospitalization episode within 6 months of ED discharge. Finally, rates of hospital admission for chest pain during the 21-month study period were compared with admission rates during the 21 months before the study. To obtain this information, we used hospital admission data to first identify all patients who were admitted to the hospital during the study period and the comparison period; we then identified patients whose chief complaint on ED registration was “chest pain,” “chest pressure,” or “chest discomfort.” This method of identification remained consistent for both comparison periods.

RESULTS

Characteristics of Study Subjects

During the study period, 7,178 patients older than 40 years visited the ED for chest pain evaluation. Table 1 describes the disposition of these patients. Of the 7,178 patients, 979 (13.6%) were considered appropriate candidates for outpatient exercise treadmill test and were initially scheduled to receive it. Of these, 903 (92.2%) completed a stress test; 76 patients (7.8%) did not undergo stress testing.

Table 2 presents the clinical profiles of the 979 patients who were initially scheduled for outpatient 72-hour exercise treadmill test. Seventy-six patients who were categorized as low risk at their initial ED visit never completed a stress test. Three patients arrived for the appointment, but the test was cancelled and never rescheduled; the remaining 73 patients failed to keep their appointment. Six-month follow-up information was available for 67 (88.2%) of the 76 patients: none of these 67 patients died, were diagnosed with myocardial infarction, or required coronary intervention. Three patients revisited the ED with chest pain within 6 months; all were admitted and subsequently had normal perfusion study or exercise treadmill test results. One patient was hospitalized in the 6 months after a missed exercise treadmill test appointment: he was diagnosed with brain cancer 2 days after the ED visit.

Of the 979 patients initially scheduled for outpatient 72-hour exercise treadmill test, 903 successfully completed stress testing (Table 2). Exercise treadmill test was not done in 17 of these patients either because they were unable to exercise or because they had baseline ECG abnormalities; these patients underwent an alternate form of stress testing. Table 2 also shows the mean interval from ED discharge to exercise treadmill test completion.

Table 2. Clinical profiles of the 979 patients scheduled for outpatient 72-hour exercise treadmill test.

<table>
<thead>
<tr>
<th>Clinical Profiles</th>
<th>76 Patients Not Risk Stratified*</th>
<th>903 Patients Risk Stratified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age</td>
<td>55 y (Range 41-90 y)</td>
<td>59 y (Range 41-92 y)</td>
</tr>
<tr>
<td>Cardiac risk factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 Patients (42.1%)</td>
<td>443 Patients (49.1%)</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Patients (17.1%)</td>
<td>112 Patients (12.4%)</td>
<td></td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 Patients (48.7%)</td>
<td>466 Patients (51.6%)</td>
<td></td>
</tr>
<tr>
<td>History of coronary artery disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Patients (6.6%)</td>
<td>72 Patients (8%)</td>
<td></td>
</tr>
<tr>
<td>Type of stress test received</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETT: 886 patients (98.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myocardial perfusion scan: 15 patients (1.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echocardiogram: 1 patient (0.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac catheterization: 1 patient (0.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean delay from ED discharge to stress testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4 Days: 613 patients (67.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-7 Days: 193 patients (21.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;7 Days: 97 patients (10.7%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Patients not risk stratified because of inability to exercise (1 patient), refractory hypertension (1 patient), abnormality on ECG (1 patient), or failure to keep appointment (73 patients). Six-month outcomes were available for 67 of these patients: none had a cardiac event, 3 had recurrent chest pain (including 2 patients with normal myocardial perfusion scan results and 1 patient with a normal ETT result), and 1 was diagnosed with brain cancer.

†ETT not performed in these 17 patients because of inability to exercise (7 patients) or abnormality on ECG (10 patients).
Main Results

The Figure describes findings and further testing received by the 903 patients who completed stress testing. Of these, 886 patients completed an exercise treadmill test: 150 patients had an abnormal exercise treadmill test result (47 positive, 103 nondiagnostic). Seventeen of the 903 patients were unable to complete an exercise treadmill test and underwent an alternate form of stress testing: one of these patients had an abnormal myocardial perfusion study result, whereas the other 16 patients demonstrated normal stress test results (myocardial perfusion study, echocardiogram, or cardiac catheterization). Ultimately, 30 of the 903 patients required cardiac catheterization: 12 patients had normal angiogram results, 11 (1.2%) patients required percutaneous coronary intervention with stent, and 7 (0.8%) patients were referred for coronary artery bypass graft surgery.

Table 3 shows outcome information for the 903 low-risk patients who completed outpatient stress testing. Data were available for 871 (96.4%) patients. One patient (0.1%) had a myocardial infarction within 1 month. This patient had a normal exercise treadmill test after ED discharge, but developed chest pain immediately after. The patient was subsequently admitted to the hospital and was diagnosed with a non–ST-elevation myocardial infarction. She underwent percutaneous coronary intervention with placement of a right coronary artery stent. Two additional patients (0.2%) had a myocardial infarction within 6 months; 1 patient had a normal perfusion study obtained.
scan after ED discharge but returned to the ED within 5 months and was diagnosed with a non–ST-elevation myocardial infarction. Cardiac catheterization showed multivessel disease, for which the patient underwent coronary artery bypass graft. The other patient had a normal exercise treadmill test result after ED discharge but was diagnosed with a non–ST-elevation myocardial infarction after 4 months. Cardiac catheterization showed normal coronary vasculature, and the myocardial necrosis was attributed to a concomitant pulmonary embolus.

Six (0.7%) of the 903 patients had normal stress test results immediately after ED discharge but underwent cardiac catheterization within 6 months (Table 3). Angiography showed normal vasculature in 2 of these patients, and 4 (0.5%) patients required stent placement. No patients with normal stress test results required coronary artery bypass graft surgery in the 6 months after completing outpatient risk stratification.

Within 6 months of ED discharge, 5 (0.6%) of the 903 patients returned to the ED with ongoing chest pain. Four of these patients underwent repeated exercise treadmill tests and showed no evidence of cardiac ischemia. One patient had a perfusion study that suggested reversible ischemia; he was referred for medical management.

Hospital admission rates for chest pain decreased from 31.2% (2,162 of 6,926 patients) to 26.1% (1,875 of 7,178 patients) during the study period, reflecting a 5.1% reduction. This decrease was statistically significant (P<.001).

LIMITATIONS

Our study has several potential weaknesses. First, the chest pain critical pathway was designed for low-risk patients. However, a few of our patients had advanced age, diabetes, or a history of coronary artery disease, risk factors that would suggest a more intermediate (or even high) risk of short-term morbidity. Subanalysis showed that the 29 patients whose exercise treadmill test results suggested ischemia had a high proportion of risk factors that should have excluded them from the protocol: 8 patients were older than 70 years, 5 patients had diabetes, and 3 patients had a history of myocardial infarction or percutaneous coronary intervention. Twelve of these patients would not have been sent home had the treating physician adhered strictly to the protocol; nonetheless, this finding strengthens our claim that 72-hour stress testing is safe in low-risk patients. Greater compliance with the protocol could have resulted in a lower incidence of coronary artery disease among the group sent home.

Second, our protocol was designed to administer outpatient stress testing within a 72-hour window. However, only 67.9% of patients enrolled in the pathway actually underwent stress testing within 4 days. It is unclear whether these delays resulted from difficulty in scheduling the test within the required period or from patient delays (unable to keep appointment, missed appointment). Although there is no evidence that patients who completed stress testing later (5-7 days or >7 days) had a higher rate of complications, common sense suggests that greater compliance with the time limits would ultimately result in a higher safety profile. This is an issue that would benefit from improvement.

Similarly, our critical pathway used age greater than 40 years as a selection criterion for application of the risk stratification tool and outpatient stress testing strategy. However, a review of all cases of myocardial infarction (using the criteria established in the Methods of Measurement section) revealed that 17 patients younger than 40 years were diagnosed with confirmed myocardial infarction during the study period. These data suggest that future protocols should be amended to include patients of a younger age, rather than imposing an arbitrary age cutoff.

After an initial in-service, the care of individual patients was left to the discretion of the treating physician. As such, there may have been some selection bias on the part of the physician about which patients were entered into the critical pathway and which were not. It is possible that some patients who were low risk for both coronary artery disease and adverse outcomes were not entered into the protocol but were instead admitted to the hospital or subjected to immediate stress testing; our method of data collection precluded identification of such patients. Even with an established protocol in place, the physician must ultimately rely on his or her judgment about the nature of the patient’s chest pain.

We were unable to obtain 6-month follow-up data on 32 of the 903 patients who underwent initial stress testing. Although 31 of the patients had normal stress test results, 1 had a positive treadmill test result. This patient moved to another state after her stress test, and several attempts to reach her by telephone were unsuccessful. It is possible that she experienced a negative outcome that we were unable to document.

Finally, our protocol was intended to select low-risk patients who would otherwise have been slated for admission and a “soft rule-out.” However, some of our study subjects may have been culled from a group who would have been discharged home regardless of stress testing options, which would explain why our rate of chest pain admissions decreased by only 5.1% even though 13.6% of patients who presented to the ED with chest pain during the study period were considered appropriate candidates for outpatient 72-hour stress testing. Two factors are worth noting: the 5% decline in chest pain admissions during the study period and the presence of cardiac risk factors in some patients. These facts suggest that at least a segment of our study group represented a population in whom outpatient exercise treadmill test administered without delay facilitated the decision to discharge the patient.

DISCUSSION

Several critical pathways for stratifying chest pain patients have been published.6,19-25 In an attempt to reduce hospitalization rates, these pathways variably used observation units, shortened protocol periods, or immediate stress testing in low-risk chest pain patients.6,19-25

However, one disadvantage to such protocols is that they require constantly available stress testing resources.
Furthermore, although hospitalization rates may ultimately decrease, low-risk patients awaiting exercise treadmill tests occupy ED beds, which are better used for acutely ill patients. At the same time, many physicians worry about the legal ramifications of mistakenly discharging a patient with an undiagnosed myocardial infarction. Consequently, no other study has addressed whether low-risk chest pain patients can safely receive outpatient exercise treadmill testing administered without delay.

Our study demonstrates that evidence-based clinical indicators can reliably identify patients at low risk for significant coronary artery disease and short-term adverse outcomes. Of the 903 patients who completed outpatient risk stratification, only 18 (2%) were diagnosed with coronary artery disease requiring intervention, and 11 (1.2%) had exercise treadmill test results suggesting coronary artery disease but either received medical management or refused further evaluation. The protocol also effectively predicted patients at low risk for short-term adverse events. Of the 903 patients, none died in the 6 months after ED discharge, and the myocardial infarction rate was just 0.3% (3 patients). Although 79 patients never completed risk stratification, 87.3% of these patients did not experience a cardiac event in the 6 months after ED discharge, arguing against a high rate of coronary artery disease in the group.

One other study has attempted to track event rates in low-risk ED chest pain patients who were discharged home without stress testing. Lai et al followed up 344 chest pain patients discharged home without a stress test. Patients were instructed to follow up with their primary care physician; ultimately, only 43% underwent a stress test; 2 (0.6%) patients died within 2 months, and none experienced myocardial infarction. In contrast, our study used a protocol specifically designed to identify low-risk patients. Moreover, all patients were scheduled for a stress test before discharge, and 92% completed testing. That our event rates were lower is not coincident: in our study, the group sent home had no deaths and had a 0.3% rate of myocardial infarction. The lower rates of death and myocardial infarction in our study are probably directly related to 2 facts: most of our patients completed risk stratification, and only low-risk patients were discharged home.

Clearly, fewer episodes of acute coronary syndrome are missed if more chest pain patients are admitted. Another approach is to admit fewer patients and recognize that a small percentage will show evidence of coronary artery disease on exercise treadmill test; however, if appropriately screened for risk of short-term events, these patients will probably fare just as well. During the past decades, we have come to realize that not all patients with acute coronary syndrome require ICU monitoring: most fare well when admitted to telemetry beds. Our study implies that a similar group of patients fare well with rapid outpatient risk stratification. The exact risk after discharge from a chest pain unit without stress testing has not been well studied. Nonetheless, current guidelines state that hospital admission is not required for chest pain patients who are carefully identified as low risk for acute myocardial infarction and subsequent negative outcomes but that these patients should receive noninvasive stress testing in 48 to 72 hours. Our results support these guidelines for the management of unstable angina.

A detailed analysis of the exercise treadmill test is beyond the scope of this article. However, it is worth noting that the exercise treadmill test is far from perfect. The sensitivity of the test has been estimated at 90%, with a negative predictive value of 98%. In addition, exercise treadmill test in women is controversial. In our study, 8 patients with negative exercise treadmill test results experienced myocardial infarction within 6 months or required percutaneous coronary intervention. These rates echo results reported by other studies. Polanczyk et al noted a 2% rate of cardiac events, including myocardial infarction, percutaneous coronary intervention, and coronary artery bypass graft, within 6 months of normal exercise stress testing; Diercks et al reported a 1-year cardiac complication rate of 1.1%—defined as coronary artery bypass graft, percutaneous coronary intervention, cardiogenic shock, ventricular fibrillation, or myocardial infarction—in patients with normal stress test results. In a study of 1,000 patients who had normal exercise treadmill test results, Amsterdam et al reported no deaths and a myocardial infarction rate of 0.15% at 30 days. It has been suggested that an increased use of stress nuclear and stress echo imaging in these patients might decrease the proportion of missed disease. However, current guidelines recommend stress imaging in patients with intermediate rather than low pretest probability of coronary artery disease. In general, low-risk patients with negative exercise treadmill test results are at very low-risk of subsequent cardiac events in the 6 months after testing.

It is also worth noting the demographics of our ED population. Our ability to capture 92.2% of outpatient stress test candidates for actual test completion is largely due to the fact that our hospital is part of a managed health care organization. The majority of our patients are insured and are members of the health care organization; there is no financial disincentive to completing outpatient stress testing. Our chest pain protocol relies on a responsible patient population with no social or financial impediments to meeting their follow-up appointments and, as such, might be difficult to implement in less stable patient populations.

This study is an observational study of a chest pain protocol already implemented at our hospital. As such, it represents a good first step but cannot replace a blinded, randomized trial. Future investigations into the safety of rapid, outpatient stress testing would ideally compare patients sent home for stress tests with a cohort of similar patients admitted to the hospital or to observation units for stress testing before discharge, in accordance with a more standard approach to risk stratification. Our study paves the way for such investigations because it suggests that low-risk chest pain patients can be ethically discharged home.
Finally, in an era of skyrocketing medical care costs, outpatient stress testing of low-risk chest pain patients is associated with a substantial decrease in hospital costs. Gaspoz et al. suggested that the average “soft rule-out admission” costs about $1,000. A review of our hospital’s cost management information system revealed that a hospital admission for “rule-out myocardial infarction” and risk stratification cost about $3,033 during the study period; this compared with a total cost of $528 for an ED visit with 72-hour outpatient stress testing. As noted by Fleischmann et al., a 5% decrease in admissions corresponds to a savings of $100,000,000 per year nationally if more than 2 million people are hospitalized for soft rule-outs each year. Moreover, these calculations probably underestimate potential savings: many low-risk patients admitted to the hospital undergo additional laboratory examination and procedures such as echocardiography or catheterization, procedures that can rapidly increase the cost of the admission. We cannot comment on the impact of our chest pain protocol on patient satisfaction, because we did not attempt to contact individuals. However, an interesting follow-up study would be to query patients about whether they preferred outpatient stress testing with the more standard hospital admission approach.

In summary, we explored the hypothesis that patients at low-risk for cardiac ischemia and short-term negative outcomes can safely receive outpatient stress testing. Our results suggest that this approach, to our knowledge not yet tested, is indeed safe and is associated with lower rates of hospital admission for chest pain. Our chest pain critical pathway is a simple but effective means of triaging chest pain patients in the ED.

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Supervising editor: W. Brian Gibler, MD

Author contributions: MCM and RPM conceived and designed the study. MCM and AKS supervised data collection. MCM analyzed the data and drafted the manuscript; RPM and AKS contributed substantially to its revision. MCM takes responsibility for the paper as a whole.

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Reprints not available from the authors.

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REFERENCES


The American Board of Emergency Medicine (ABEM) and the American Board of Preventive Medicine (ABPM) will administer the certifying examination in Undersea and Hyperbaric Medicine on October 2–6 and October 9–13, 2006.

Physicians must submit an application to the board through which they are certified. Physicians certified by an American Board of Medical Specialties member board other than ABEM and ABPM and who fulfill the eligibility criteria must apply to ABPM. Upon successful completion of the examination, certification is awarded by the board through which the physician submitted the application.

The eligibility criteria are available from the ABEM office or at www.abem.org.

Application materials are now available for ABEM diplomates and will be accepted with postmark dates through July 1, 2006. ABPM diplomates should contact ABPM for application cycle information.
Figure E1. Management of an ED chest pain patient.
Appendix E1: Part A. Chest Pain Worksheet

This worksheet is based on national guidelines for evaluation and disposition of patients with CP and is intended to guide but not substitute for clinical judgment.

I. HISTORY, PHYSICAL, EKG:
   Treat and admit acute MI.
   If unable to perform EST (disability, age, LBBB, marked chronic EKG changes etc), exit guideline.

   ANGINA:
   ● Chest pain occurring with exertion or stress and relieved by rest or nitrates.
   ● Possible anginal equivalent (jaw, neck, ear, arm pain, dyspnea) with exertion or stress and relieved by rest or nitrates.

<table>
<thead>
<tr>
<th>ANGINA LIKELIHOOD:</th>
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<tbody>
<tr>
<td>□ DEFINITE</td>
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<tr>
<td>□ PROBABLE</td>
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<tr>
<td>□ PROBABLY NOT</td>
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</table>

II. LIKELIHOOD OF SIGNIFICANT CAD:

Y  N  Hx of prior MI or invasive, corrective procedures (CABG, stent, etc.)
Y  N  Chest or left arm pain or discomfort as chief sx reproducing prior angina. (if pt has no hx of CAD, answer NO)
Y  N  New MR, hypotension, diaphoresis, or rales
Y  N  Dynamic ST segment deviation (>0.5 mm) with sx
Y  N  New MR, hypotension, diaphoresis, or rales
Y  N  T-wave inversion (>2 mm) in 2 contiguous leads with sx
Y  N  ST segment elevation or depression >1 mm

Any yes to the above, HIGH likelihood of CAD. Otherwise, continue:

Y  N  Chest or left arm pain or discomfort as chief sx (if clearly not cardiac-chest wall pain, GERD, or pleurisy, answer NO)
Y  N  Chest pain probably not angina with 2-3 cardiac risk factors
Y  N  Diabetes
Y  N  Extracardiac vascular disease (CVA, PVD, bruits, etc.)
Y  N  ST depression 0.5 to 1 mm
Y  N  T wave inversion ≥1 mm in leads w/ dominant R waves
Y  N  Pathological Q waves

Any yes to above, INTERMEDIATE likelihood of CAD. Otherwise, LOW likelihood of CAD, consider outpatient evaluation for noncardiac CP.

<table>
<thead>
<tr>
<th>CAD LIKELIHOOD:</th>
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<tbody>
<tr>
<td>□ HIGH</td>
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<tr>
<td>□ INTERMEDIATE</td>
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<tr>
<td>□ LOW</td>
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</table>
Appendix E1: Part B. Unstable Angina:\(^1\)

- Rest angina - occurring at rest > 20 minutes occurring within one week of presentation
- New onset angina - angina of at least Canadian Cardiovascular Society Classification (CCSC) III severity (walking < 2 blocks or climbing 1 flight stairs) within two months of presentation
- Increasing angina - previously diagnosed angina that is distinctly more frequent, longer in duration or lower in threshold (but should be increased by at least one CCSC class within 2 months of initial presentation to at least CCSC III)

III. RISK OF SHORT-TERM DEATH OR MORBIDITY:

- Y N Accelerating tempo of anginal sx in preceding 48 hrs
- Y N Ongoing chest pain > 20 minutes. (Exclude chest pain not relieved by nitrates or analgesics, “probably not angina”.)
- Y N Angina w/ physiologic abnormality (S3, new/worse rales, murmur, hypotension, new or worsening MR).
- Y N Angina at rest (with dynamic ST changes ≥ 1 mm, new TWI, new BBB, VT)

Any yes, **HIGH** Risk → admit. Otherwise, continue:

- Y N Prior MI, PVD, CVA, or CABG
- Y N Prolonged (≥20 min) rest angina resolved (but not low likelihood CAD)
- Y N Rest angina (<20 min) relieved with rest or sl NTG
- Y N Age > 70
- Y N New onset CCSC III (walking > 2 blocks or climbing 1 flight stairs) or CCSC IV (minimal exertion or rest) but not low likelihood CAD
- Y N T-wave inversions > 2 mm or pathological Q waves

Any yes, **INTERMEDIATE** Risk → Med/Card consult, admit, or go to Page 3. If all no, pt is considered **LOW** risk, may have outpatient evaluation and/or 72 hour EST.

- Y N Increased chest pain frequency, severity, duration, lower threshold but not CCSC III or IV
- Y N New onset chest pain within 2 weeks to 2 months
- Y N Chest pain occurred ≥ 24 hours ago?

Any yes, **LOW** Risk → 72 hr EST. Otherwise, follow-up with PMD or routine EST.

<table>
<thead>
<tr>
<th>RISK OF SHORT-TERM MORBIDITY AND MORTALITY:</th>
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<td>☐ HIGH</td>
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- High risk → Admit (Consult HBS)
- Intermediate risk → consider CPU (Consult HBS)
- Low risk → home