

Chest Pain Triage in the Emergency Department: An Integrated Diagnostics Approach

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Despite several advances in the diagnosis of acute coronary syndrome (ACS), further improvements in rule-out and rule-in as well as resource utilization are needed. Combining high-sensitivity cardiac biomarker assays with noninvasive coronary imaging for evaluation of acute chest pain—an integrated diagnostic approach—has significant potential for facilitating these improvements.

By Luis LaSalvia, MD, MIB, Praveen Nadkarni, MD, Tricia A. Bal, MD, MBA



Cardiovascular disease (coronary heart disease/acute coronary syndrome, stroke, and other cerebrovascular diseases) accounted for 15 to 28 percent of deaths worldwide in 2004.¹ Acute coronary syndrome (ACS) results from either temporary or permanent obstruction of coronary arteries, and includes unstable angina (temporary obstruction without cell death), acute myocardial infarction (obstruction leading to cell death), and sudden cardiac death. ACS is the number one cause of death worldwide and accounted for 12 percent of the deaths in 2004.¹ It is also associated with significant patient morbidity.

Chest pain is a frequent symptom of ACS. In the U.S., chest pain and related symptoms are the second most common reason for presenting to the emergency department.²

What Is the Current Diagnostic Approach for Acute Coronary Syndrome?

Emergency department evaluation of acute chest pain patients suspected of ACS typically includes electrocardiography (ECG) and cardiac biomarker measurements. Currently, the biomarker of choice for diagnosis and risk stratification of ACS is cardiac troponin.^{3,4}

Patients with ACS are divided into two categories on the basis of ECG results: ST-elevation myocardial infarction (STEMI) patients, about 30 percent, and non-ST-elevation acute coronary syndrome (NSTEMI) patients, about 70 percent. NSTEMI includes unstable angina and non-ST-elevation myocardial infarction (NSTEMI). Patients with STEMI have a well-established treatment path, including drugs or percutaneous coronary intervention (PCI). NSTEMI patients present a challenge, as some may be harmed by fibrinolytic drug therapy, and PCI and other aggressive interventional treatments are typically only offered to those deemed to have high-risk NSTEMI.⁴

What Are the Current Challenges for Acute Coronary Syndrome?

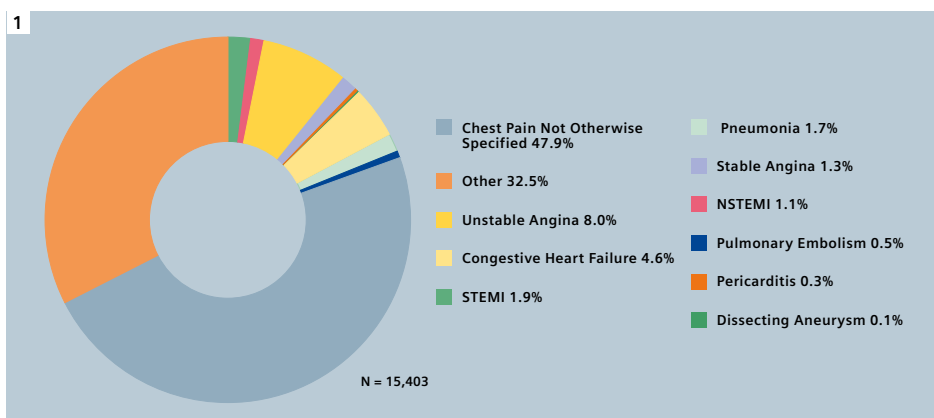
Rule-Out of Acute Coronary Syndromes

Emergency department clinicians have a difficult task—identifying which patients to admit and which patients to discharge home. Of the patients presenting to the emergency department for chest pain, 55 to 85 percent do not have a cardiac cause for their symptoms.⁵ Of those admitted for chest pain, more than 60 percent do not have acute coronary syndromes.^{6,7} Unnecessary admissions for chest pain in the U.S. alone cost billions of dollars annually.⁸

A study of over 15,000 emergency department chest pain patients found that 48 percent had a final emergency

department diagnosis of chest pain not otherwise specified (Figure 1).⁷ It is disturbing that no definitive diagnosis was made in such a large percentage of these patients, some of whom may have had ACS; missed diagnosis is associated with a twofold increased mortality risk.⁸ This rate is unacceptable from a patient and healthcare provider perspective.

In the U.S., about 5.8 million patients visit the emergency department (ED) for chest pain and related symptoms, and about 4.4 million for chest pain alone. As many as 79 percent of U.S. chest pain patients who visit the ED are low risk.⁹ At discharge, it is estimated that as many as 85 percent of chest pain patients do not have a cardiac diagnosis, and for 2 to 8 percent the diagnosis was missed (Figure 2).^{2,9-11}



1 Approximately 48% of patients presenting to the emergency department with acute chest pain are not given a specific diagnosis.⁷

Description	Statistics
Visits for chest pain and related symptoms	5.8 million
Chest pain visits	4.4 million
Missed diagnosis	2%–8%
Low-risk visits	79%
Return visits within 30 days of PCI	9%
Return visits within 3 months of initial ED visit	4%–19%
Non-cardiac discharges	55%–85%

2 U.S. chest pain statistics.^{2, 9-13}

Rule-In of Acute Coronary Syndromes

The introduction of specific biomarkers of cardiac necrosis has improved the diagnosis of ACS, and cardiac troponin is the test of choice. The diagnosis of acute myocardial infarction is made when blood levels of specific biomarkers of cardiac necrosis are elevated in patients with signs and symptoms consistent with ACS. An elevation is present if at least one value is above the 99th percentile of a healthy reference population.

Both professional laboratory (National Association of Clinical Biochemistry and the International Federation of Clinical Chemists) and clinical organizations (European Society of Cardiology, American College of Cardiology, American Heart Association, and the World Heart Federation) recommend the use of cardiac troponin assays that have a coefficient of variation (measure of precision) of ≤ 10 percent at the 99th percentile of a healthy reference population.^{3,4,14} Troponin assays that meet this precision recommendation will be referred to as high-sensitivity assays in this article.

High-sensitivity troponin assays have a higher sensitivity for the detection of myocardial infarction and meet clinical guidelines.^{3,4,15-17} High-sensitivity assays are also used to risk-stratify patients for future ACS events.^{3,15-17}

Various multimarker approaches have also been proposed as a means of improving rule-in and risk stratification in NTEACS patients, and the best approach is currently under investigation.^{8,18-20}

Resource Utilization in Acute Coronary Syndromes

In the U.S., the high rate of chest pain admissions of noncardiac origin—as high as 60 percent—results in suboptimal resource use and annual costs of approximately \$8 billion. Additionally, 20 percent of emergency department malpractice dollars are related to chest pain.⁵⁻⁸ Optimizing rule-out and rule-in therefore has the potential to facilitate better resource utilization (Figure 3).

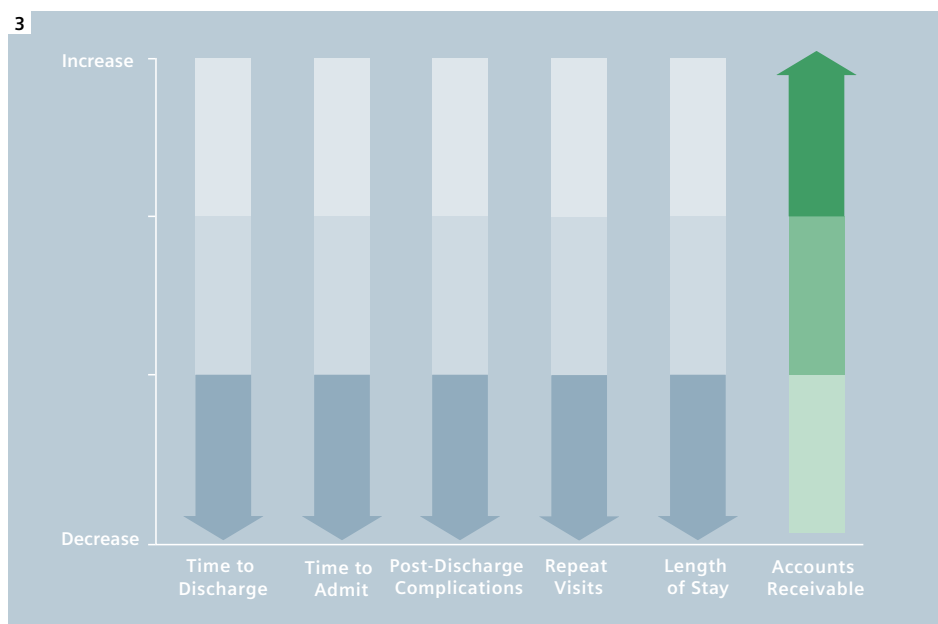
Key challenges for the management of acute chest pain in the emergency department are optimizing rule-out, rule-in, and resource utilization.

What is the Potential Role for Integrated Diagnostics?

Integrated diagnostics uses both imaging in vivo and in vitro testing in the diagnostic process. While this approach—integration of cardiac markers with echocardiography or nuclear imaging—is not new, novel roles are emerging for computed tomography (CT) and magnetic resonance imaging (MR) in conjunction with high-sensitivity troponin assays. Due to its 100 percent negative predictive value seen consistently across studies,^{5,6,8,22} coronary computed tomographic angiography (CCTA) can quickly and accurately help to rule out potentially life-threatening ACS as the source of chest pain. Thus, CCTA could improve patient care and resource utilization in the emergency department. Improvements in CT technology resulting in ultrafast acquisition of high-quality images of the heart and coronary arteries have made CT a feasible tool for this

application. Faster image acquisition also reduces procedure time, improves workflow, and reduces radiation exposure. For example, the latest improvements in CT technology, primarily dual-source CT, allow a subsecond no-breath-hold exam, overcoming heart rate limitations and obviating the administration of beta blockers.

In the future, evaluation of ACS in the emergency department may include routine assessment by dual-source CCTA for low- to intermediate-risk patients presenting with acute chest pain. The role of MR is also under investigation. MR use has been studied as a prognostic indicator in patients with a previous history of myocardial infarction and a negative coronary angiography as well as in the assessment of NTSTEACS.²²⁻²⁴ MR could potentially aid in evaluating patients with a positive high-sensitivity troponin without clinically significant coronary artery disease.



3 Desired effects of an integrated diagnostics approach.

What Does the Available Data Show?

Recent studies have shown that adding CCTA to the standard diagnostic tools (cardiac biomarkers and ECG) can improve rule-out of ACS and positively affect resource utilization.^{2,6,8,21,25,26} Studies have also shown roles for MR as an aid in the evaluation of chest pain.^{22,27}

Impact on Rule-In, Rule-Out, and Prognosis

Good rule-out performance is reflected in high sensitivity and high negative predictive values; CCTA has been demonstrated to have both. Indeed, patients who would have been admitted using standard diagnostic tools have been sent home when CCTA was included in the diagnostic process.^{6,25,26} CCTA had a negative predictive value of 100 percent for ACS in a blinded prospective study of 103 (40 percent female, 60 percent male; mean age 54 ± 12 years) low-risk chest pain patients (negative initial biomarkers and no ischemic ECG changes), demonstrating good rule-out performance.⁸

An investigation looking simultaneously at the role of CCTA in rule-out (high sensitivity and negative predictive values), rule-in (high specificity and positive predictive values), and prognosis of ACS in low-risk chest pain patients ($N = 58$; no new ECG changes or elevated biomarkers) found good CCTA performance for rule-out and for rule-in. The sensitivity was 100 percent, the negative predictive value was 100 percent, the specificity was 92 percent, and the positive predictive value was 87 percent.^{8,21} Performance for prognosis was also good. There were no deaths or myocardial infarctions at a 15-month follow-up among the patients (60 percent) who were discharged using CCTA findings.^{8,21}

MR may also play a useful role in the follow-up of patients who presented to the ED with chest pain and elevated troponin but had unobstructed coronary arteries. In a study by Assomull et al., MR was able to identify a reason for the troponin elevation in 65 percent of the



The integrated diagnostics approach, through reduction of the average diagnostic time from 12 to 4 hours and associated reduction in estimated costs from \$4,800 to \$1,200 per episode of care, would cost \$1.95 million and therefore could potentially save the hospital \$5.85 million annually.

Comparison of simplified standard diagnostic and integrated diagnostic approaches.

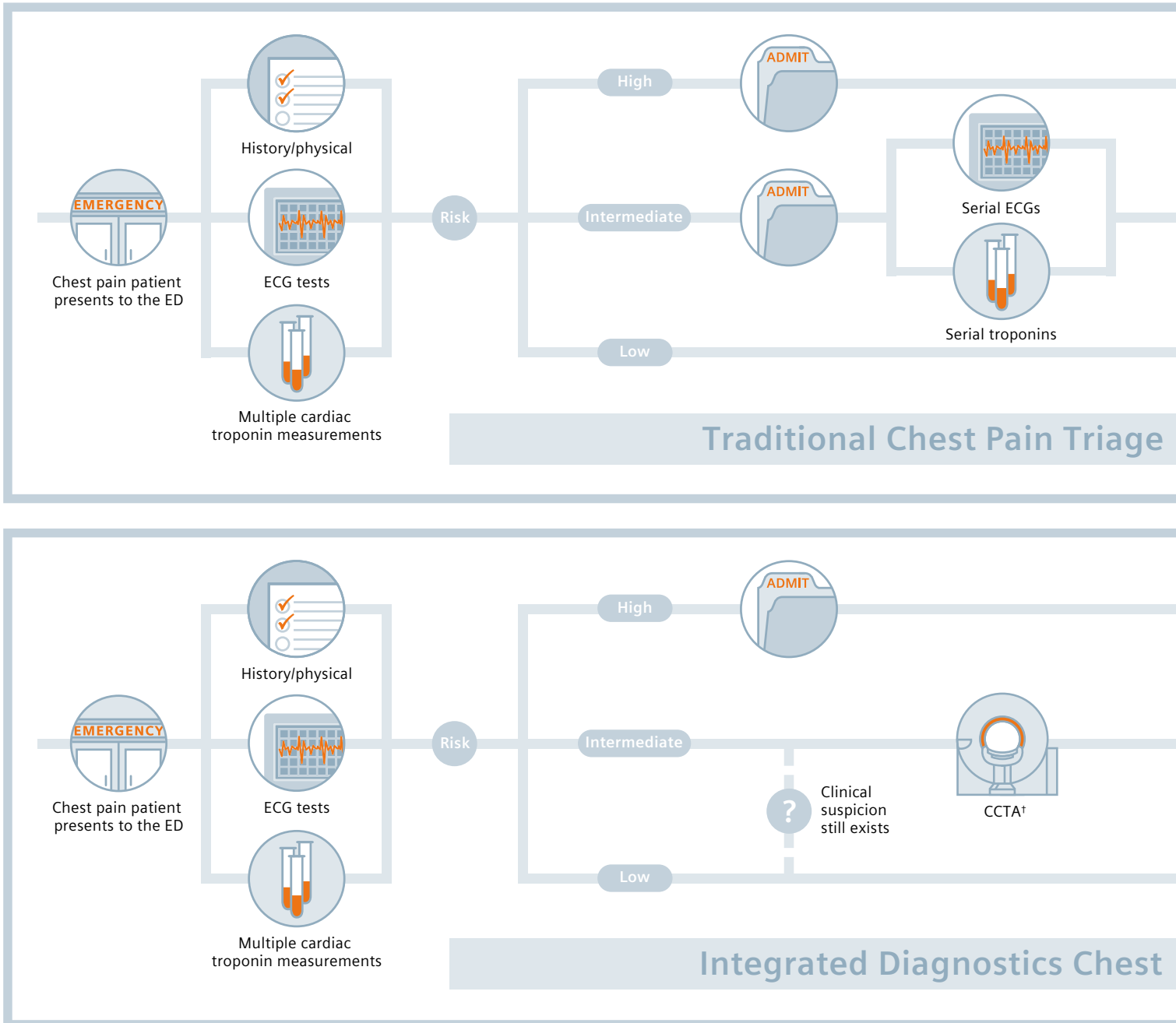


Figure 4.

patients. The most common underlying causes for troponin elevation were myocarditis (50 percent), followed by myocardial infarction (11.6 percent), and cardiomyopathy (3.4 percent). Among the 35 percent of patients for whom cardiac MR did not demonstrate an underlying cause for troponin elevation, significant myocardial infarction and fibrosis were ruled out.²³

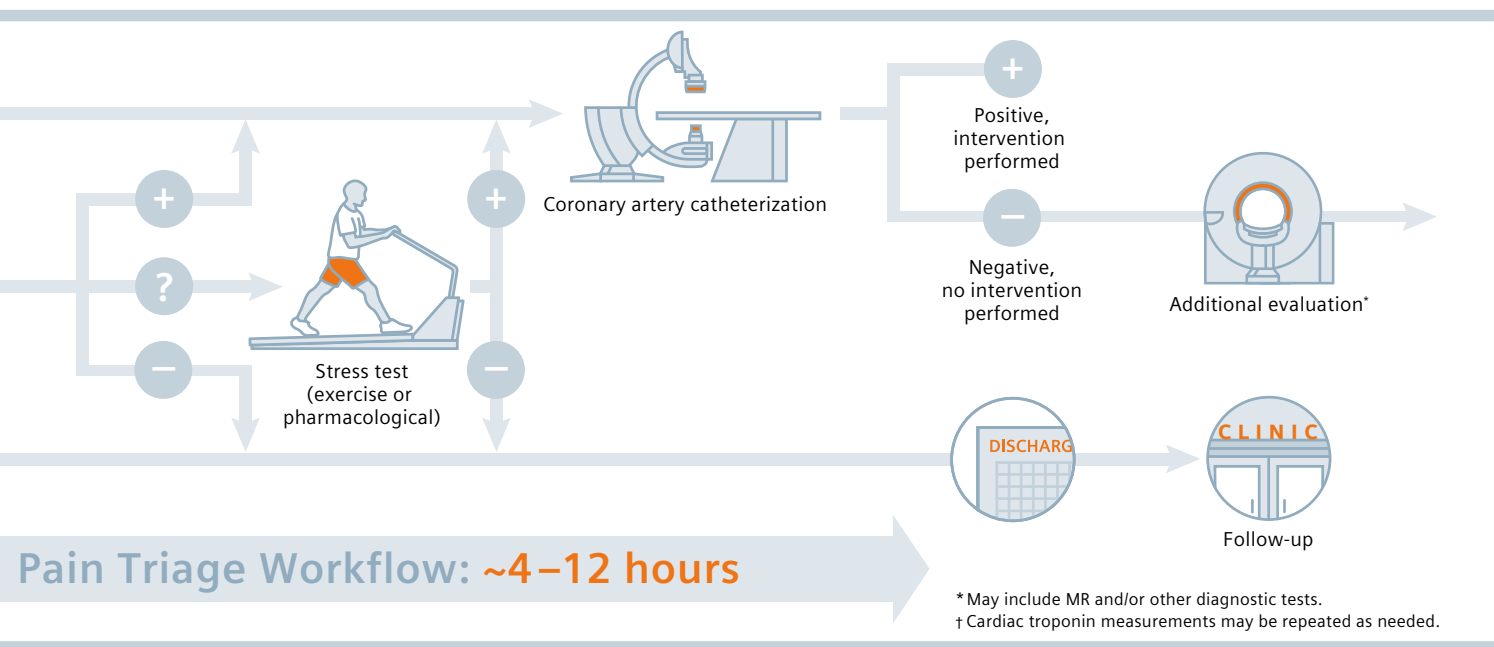
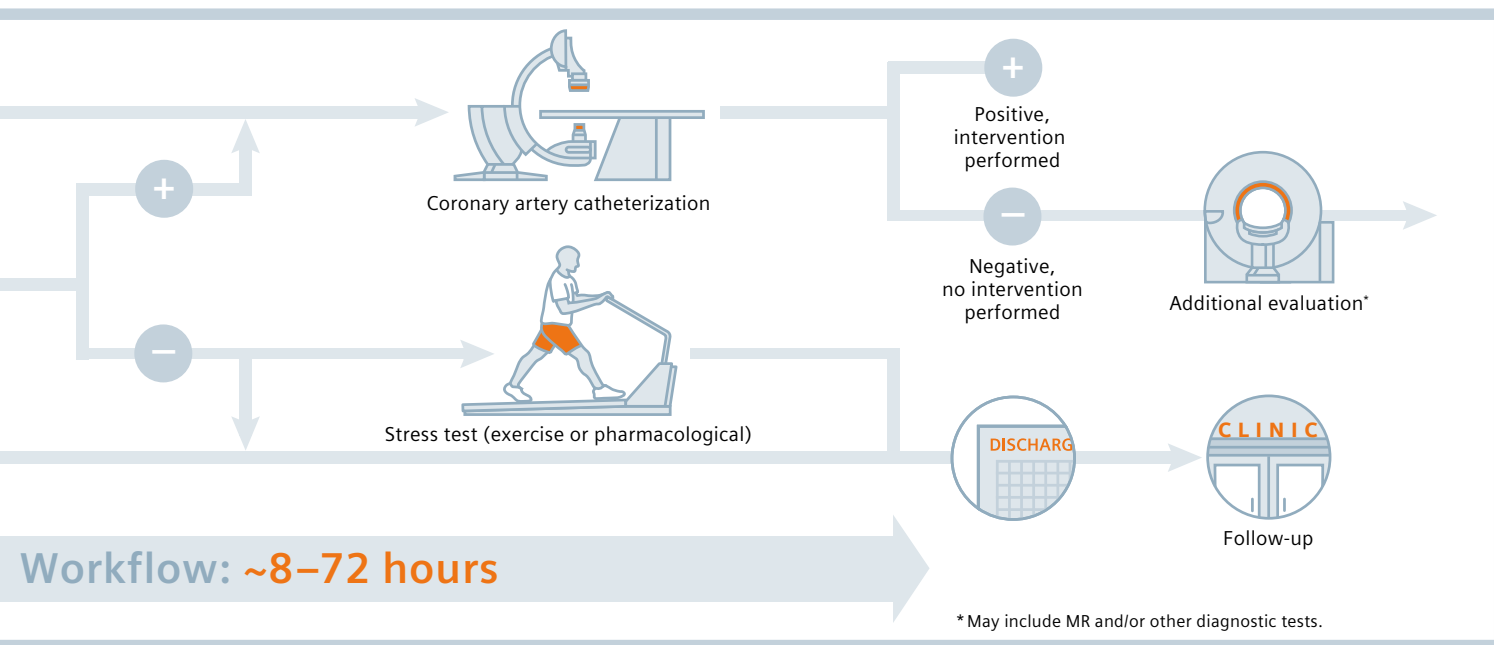
Cardiac MR and CT have been shown to be useful aids in the evaluation of chest pain, underscoring their value in combination with cardiac biomarkers such as cardiac troponin in the integrated diagnostics approach.

Impact on Resource Utilization

The current standard diagnostic evaluation for chest pain patients can involve spending 8 or more hours in the emergency department before either discharge or admission (Figure 4).

Emergency department crowding due to prolonged stays and unnecessary hospital admissions resulting in bed shortages can contribute to suboptimal resource utilization. Thus, improving the ability to accurately rule out ACS could optimize emergency department triage of chest pain patients in the figures above.

The impact of CCTA on resource utilization shows great promise. Adding CCTA to the standard of care changed diagnosis from ACS to non-ACS in 44 percent of patients and led to cancelled hospitalizations in



45 percent of patients.²² These data illustrate how CCTA can dramatically change resource utilization in both the emergency department and the hospital.

Similar changes in emergency department and hospital resource utilization were demonstrated in another study. Hospital length of stay and the percent of unnecessary hospital admissions decreased among patients who were evaluated using a CCTA-based approach compared to the standard approach.

Hospital length of stay was reduced by 8 percent ($P = 0.049$), and the percentage of unnecessary admissions was significantly reduced from 15 percent to 4 percent ($P = 0.007$), a 73 percent reduction.²⁶

CCTA has also been shown to affect diagnostic time and costs. It reduced initial diagnostic evaluation time from 15 hours to 3.4 hours ($P < 0.001$), a threefold reduction. CCTA also reduced costs by 16.5 percent from \$1,872 to

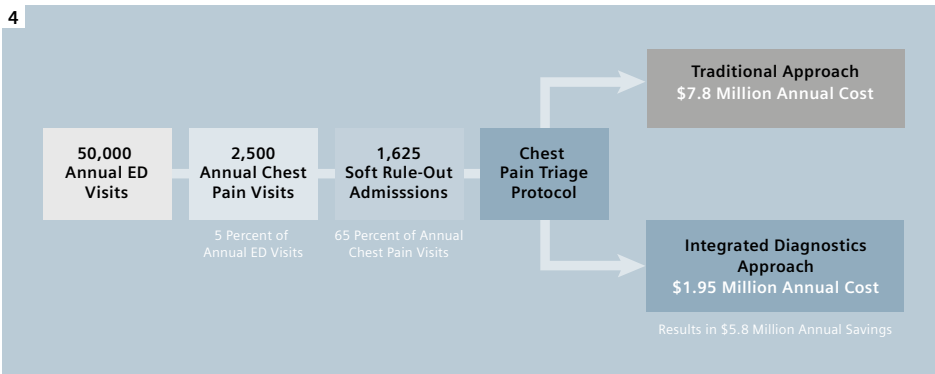
\$1,582 ($P < 0.001$). Interestingly, patients evaluated by CCTA also had 3.5-fold fewer repeat evaluations for chest pain.²⁸

Thus, when CCTA is used in the diagnostic process, it can reduce unnecessary hospital admissions, change diagnosis, reduce diagnostic evaluation time, and lower diagnostic costs—all of which can facilitate better resource utilization. For example, using the traditional approach, a hospital with an annual chest pain ED visit volume



of 2,500, of which 1,625 (65 percent) are low-risk patients, could spend \$7.8 million (estimated costs of \$400/hour for a 12-hour visit, which includes telemetry bed use, staff, and observation time costs) just managing these low-risk patients (Figure 4). The integrated diagnostics approach, through reduction of the average diagnostic time from 12 to 4 hours and associated reduction in estimated costs from \$4800 to \$1200 per episode of care, would cost \$1.95 million and therefore could potentially save the hospital \$5.85 million annually (Figure 4).

The ability of the integrated diagnostics approach to provide better rule-out could also reduce the need to use more invasive procedures such as coronary catheterization for diagnosis. This could have a potentially positive impact on patients and help to optimize resource utilization (Figure 5).



Conclusion

High-sensitivity troponin assays and CCTA have each enhanced chest pain triage in the emergency department. CCTA, by improving rule-out and optimal resource utilization, has facilitated reductions in the need to use invasive diagnostic procedures; and high-sensitivity assays have facilitated earlier diagnosis of myocardial infarction and have improved risk stratification. The role of MRI is emerging and has already shown some potential.

An integrated diagnostics strategy in the acute care setting presents several opportunities for optimizing patient care and resource utilization that can provide benefits for the key stakeholders in the healthcare system—patients, clinicians, and healthcare institutions.

4 Estimated cost savings using the integrated diagnostics approach. Cost estimates of \$400/hr were based on internal research and include telemetry bed use, staffing, observation time, and CT equipment amortized over 7 years.

5

Improve clinical outcomes and quality metrics while gaining a competitive advantage

Reduce LOS	<ul style="list-style-type: none"> Free up telemetry/inpatient beds Reduce costs Improve productivity
Optimize Throughput	<ul style="list-style-type: none"> Improve patient access/experience Prevent patient boarding, ED overflow, Improve access/care for mid- to high-risk patients
Mitigate Risk	<ul style="list-style-type: none"> Missed diagnosis Post-discharge complications Non-reimbursed repeat visits

5 Integrated diagnostics and resource utilization.

For more information

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