Part 9: Acute Coronary Syndromes

2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations

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Note From the Writing Group: Throughout this article, the reader will notice combinations of superscripted letters and numbers (eg, “Chest Pain Observation UnitsACS-005A”) These callouts are hyperlinked to evidence-based worksheets, which were used in the development of this article. An appendix of worksheets, applicable to this article, is located at the end of the text. The worksheets are available in PDF format and are open access.

The International Liaison Committee on Resuscitation (ILCOR) ACS-MI Task Force included expert reviewers from Africa, Asia, Australia, Europe, North America, and South America. These experts reviewed 25 topics related to the acute initial management of acute coronary syndrome (ACS), which was further categorized as unstable angina, non–ST-elevation MI (UA/NSTEMI) and ST-elevation MI (STEMI). Topics were identified based on previous recommendations, emerging science, and clinical importance, using an iterative writing process involving all Task Force members. The Task Force reviewed the evidence specifically related to diagnosis and treatment of ACS in the out-of-hospital setting and the first hours of care in the in-hospital setting, typically in the emergency department (ED). The evidence review took place over several years, with ongoing refinement of recommendations being made as new evidence was published. The purpose of the review was to generate current, evidence-based treatment recommendations for healthcare providers who serve as the initial point of contact for patients with signs and symptoms suggestive of ACS.

The following is a summary of the most important changes in recommendations for diagnosis and treatment of ACS since the last ILCOR review in 2005.1 2

- In contrast, chest pain observation protocols are useful in identifying patients with suspected ACS and patients who require admission or may be referred for provocative testing for coronary artery disease (CAD) to identify reversible ischemia. Such strategies also reduce cost by reducing unnecessary hospital admissions and improve patient safety through more accurate identification of NSTEMI and STEMI.

- The acquisition of a prehospital 12-lead ECG is essential for identification of STEMI patients before hospital arrival and should be used in conjunction with pre-arrival hospital notification and concurrent activation of the catheter laboratory.

- Nonphysicians can be trained to independently interpret 12-lead ECGs for the purpose of identifying patients with STEMI, provided that appropriate and reliable STEMI criteria are used. This skill is of particular value in the prehospital setting where paramedics may independently identify STEMI, thus mitigating over-reliance on ECG transmission.

- Computer-assisted ECG interpretation can be used to increase diagnostic accuracy of STEMI diagnosis when used alone or in combination with ECG interpretation by a trained healthcare provider.

- STEMI systems of care can be implemented to improve the time to treatment. The following measures have been shown to reduce the time to primary percutaneous coronary intervention (PPCI): institutional commitment, use of a team-based approach, arranging single-call activation of the catheterization laboratory by the emergency physician or prehospital provider, requiring the catheterization laboratory to be ready in 20 minutes, having an experienced cardiologist always available, and providing real-time data feedback.

- Intravenous (IV) β-blockers should not be given routinely in the ED or prehospital setting, but may be useful in a subset of patients with hypertension or tachycardia in the setting of ACS.


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The routine use of high-flow supplemental oxygen in ACS is not recommended. Instead, oxygen administration should be guided by arterial oxygen saturation.

Reinforce the need for time targets for reperfusion beginning from the time of first medical contact (FMC). The clinical circumstances that favor fibrinolysis and PCI are discussed, including the role of prehospital fibrinolytics.

The prophylactic use of antiarrhythmics is discouraged.

Angiography and percutaneous coronary intervention (PCI) may be considered in patients with out-of-hospital cardiac arrest (OHCA) and return of spontaneous circulation (ROSC). It may also be acceptable to perform angiography in selected patients, despite the absence of ST-segment elevation on the ECG or prior clinical findings such as chest pain.

Despite progress in diagnostic and therapeutic strategies, numerous knowledge gaps have been identified during the discussions. These gaps include:

- Much of the research concerning the care of the patient with ACS has been conducted on in-hospital populations rather than specifically in the ED or out-of-hospital settings. By definition, extending the conclusions from such research to the early ED management or the out-of-hospital setting requires extrapolation.
- Strategies for improving layperson recognition of ACS and shortening time to diagnosis in vulnerable populations.
- The value of emergency dispatcher-initiated bystander administration of aspirin.
- Accurate decision rules for the early identification of patients with and without ACS in the prehospital and the ED settings.
- Feasibility of widespread paramedic interpretation of prehospital 12-lead ECGs versus reliance on transmission or computer interpretation.
- Impact on mortality of systems of care strategies designed to expedite reperfusion.
- The role of reperfusion including PCI in post–cardiac arrest care following either prehospital or in-hospital cardiac arrest, in the presence or absence of STEMI.
- The sensitivity and specificity of newer biomarkers for the detection of ACS.
- Is high-dose oxygen harmful in the setting of ACS?
- What is the role of analgesia and anxiolysis in patients with ACS?
- Optimal timing of platelet inhibition and anticoagulation in the prehospital and ED setting.
- While the time goals for reperfusion begin with first medical contact, time from symptom onset may be preferred, yet precise identification of this time point has been elusive.

The American Heart Association and the American College of Cardiology, the European Society of Cardiology, and others have developed comprehensive guidelines for the in-hospital management of patients with STEMI and UA/NSTEMI, and the reader is referred to these guidelines for more detailed recommendations regarding the care of patients with ACS. The ILCOR CoSTR statements are intended to supplement these other resources by having a specific focus on the initial evaluation and treatment in the prehospital and ED phases of care. It is envisioned that these CoSTR documents will be used to develop treatment guidelines to assist providers during the initial acute phase of care.

The prognostic and diagnostic use of the signs and symptoms of ACS, cardiac markers, and 12-lead ECG can have enormous impact on the initial impression and management of patients with suspected ACS. As such, it is important to evaluate the sensitivity, specificity, and clinical impact of various diagnostic strategies in ACS through a comprehensive evidence-based process.

The 12-lead ECG in the ED and out-of-hospital settings is central to the initial triage of patients with possible ACS. Neither signs and symptoms nor cardiac markers alone are sufficiently sensitive to diagnose AMI or ischemia in the prehospital setting or the first 4 to 6 hours in the ED.

### Diagnostic Tests in ACS

#### Risk Stratification

**Demographic Factors**

For patients with ACS, we evaluated whether any specific demographic factors (eg, age, sex, race, weight) were associated with delayed treatment and classified these delays according to whether they occurred before or after hospital arrival.

**Consensus on Science**

**Prehospital Treatment Delay.** Thirty-five studies (LOE P17.8, LOE P39–40) showed that demographic factors, such as older age, female gender, low socioeconomic status, and living alone are independent factors for prehospital treatment delay (symptom-to-door time).

Twenty studies indicated that old age, female gender, nonwhite race and/or living alone did not show any association with prehospital delay times (LOE P213; 

As many studies analyzed more than one demographic factor for prediction of treatment delay, and one factor may predict delay while another factor was not found to be independent for prediction of delay, 8 studies were mixed in identifying factors associated with treatment delays (LOE P2), 12,17,20,24,25,36,40,41.

**In-Hospital Treatment Delay.** Nineteen studies (LOE P8, LOE P39,10,14,19,29,39,42,55–62,66) showed that demographic factors, such as older age, female gender, nonwhite race, and low socioeconomic status, and living alone are independent factors in hospital treatment delay (door-to-balloon, door-to-needle, or door-to-reperfusion time).

Five studies indicated that older age, female gender, nonwhite race and/or living alone did not show any association with in-hospital delay times (LOE P3), 48,49,54,62,66. Most data on the impact of demographic factors on delay to treatment for patients with ACS have been derived from studies in North America.

**Treatment Recommendation**

Various patient-related factors impede seeking medical help rapidly, but also to further in-hospital treatment delay;
these factors include older age, racial and ethnic minorities, female gender, low socioeconomic status and residing alone. Providers should be trained to expeditiously identify patients with ACS irrespective of age, gender, socioeconomic status, or living arrangements.

**Accuracy of History and Physical Examination for Diagnosing ACS**

In patients with suspected ACS in various settings (eg, prehospital, emergency or in-hospital), do specific historical factors, physical examination findings, and test results, compared with normal, increase the accuracy of diagnosis ACS and MI?

**Consensus on Science: Diagnosis**

Fourteen studies (LOE 267–70; LOE 371–80) did not support the use of any of clinical signs and symptoms independent of ECG, cardiac biomarkers, or other diagnostic tests to rule in or rule out ACS in prehospital or ED settings. Although some signs are more sensitive and specific than others, no sign or symptom evaluated exceeded 92% sensitivity in the higher LOE studies (most reported sensitivity of 35% to 38%) or 91% specificity (range 28% to 91%).

Four LOE 1 studies71,81–83 and 32 studies (LOE 3 to 5)24,31,52,67–70,72–75,78,84–103 suggest that individual clinical signs and symptoms lack sufficient sensitivity and specificity to be used alone and independent of ECG, cardiac biomarkers, or other diagnostic tests to rule in or rule out ACS in prehospital or ED settings.

**Consensus on Science: Prognosis and Clinical Impact**

In 34 studies (LOE 171,83,92; LOE 224,67–70,84,87,94,95,100; LOE 331,52,72–74,76–79,82,85,86,89,90,93,96–99,101,104) a variety of signs and symptoms assisted in the diagnosis of ACS and had clinical impact (defined as triage and some treatment and investigational decisions) on the prehospital emergency management and risk assessment for coronary atherosclerosis and unstable syndromes.

Three LOE 1 meta-analyses/systematic reviews71,82,83 and 28 studies LOE 3 to 524,31,52,67–70,72–75,78,84–87,89–95,97–101,103 suggest that some clinical signs (eg, chest pain that radiates to the left arm, radiates to the right shoulder, or radiates to both arms, patients presenting with chest pain and sweating, S3 or hypertension, sweating, and/or vomiting, a history of risk factors [in addition to known coronary heart disease], and some demographic characteristics such as age) assisted in the diagnosis of ACS and had clinical impact (defined as influencing triage and some treatment and investigational decisions) on the out-of-hospital emergency management and risk assessment for ACS. One LOE 5 study103 and extrapolations from 27 other studies LOE 3 to 524,31,52,67–70,72–75,78,84–87,89–95,97–101 suggested that there are symptom clusters related to demographic factors such as age, race, and sex. These symptom clusters may have an impact on clinical decision making (defined as influencing triage and some treatment and investigational decisions). One systematic review/meta-analysis (LOE 114) found the sign of tenderness to chest wall palpation useful in ruling out a diagnosis of AMI.

**Treatment Recommendation**

Signs and symptoms alone are neither sensitive nor specific and should not be used without other data for making the diagnosis of ACS. Signs and symptoms may be useful in combination with other important information (biomarkers, risk factors, ECG, and other diagnostic tests) in making triage and some treatment and investigational decisions for ACS in the out-of-hospital and ED setting.

**ACS and Nitroglycerin**

In patients with suspected ACS/STEMI in the ED and prehospital settings, does the use of nitroglycerin, compared with no nitroglycerin, improve diagnosis of ACS/MI?

**Consensus on Science**

Five studies (LOE D368,78,105; LOE D4106,107) using reduction in pain after nitroglycerin administration as an end point, found that reduction of pain does not reliably identify presence of ACS.

**Treatment Recommendations**

A reduction in chest pain following nitroglycerin administration may be unrelated to the presence or absence of ACS, and should not be used as a diagnostic test or strategy in the prehospital or ED setting.

**ED Interpretation of 12-Lead ECG for STEMI**

**12-Lead ECG**

In patients with suspected ACS in various settings (eg, prehospital or emergency), does the use of prehospital or emergency 12-lead ECG, compared with standard diagnostic techniques, increase sensitivity and specificity of diagnosis of ACS/MI?

**Consensus on Science**

One study showed that prehospital or emergency ECGs had a sensitivity of 76% and a specificity of 88% for diagnosing acute cardiac ischemia in patients with chest pain (LOE D1).108 For diagnosing AMI, prehospital ECG had a sensitivity of 68% and a specificity of 97%. Two studies indicated that diagnostic accuracy of the prehospital ECG can be improved by repeating the ECG on arrival in the ED and by serial measurement of cardiac markers (LOE D2).109,110 Two studies showed that computer-interpreted electrocardiography or field-transmitted electrocardiography can be applied if no adequate interpretation of the prehospital ECG is available on site (LOE D1111,112).

**Treatment Recommendation**

In patients with suspected ACS, a 12-lead-ECG should be acquired and interpreted by prehospital or emergency providers as soon as possible after first patient contact. The interpretation should be used in conjunction with the clinical signs and presentation for diagnosis and triage, including destination decisions and activation of the cardiac catheterization laboratory. If interpretation of the prehospital ECG is not available on site, field-transmission of the ECG for expert interpretation may be reasonable.

**Diagnosis of STEMI by Nonphysicians**

In patients with suspected ACS in the prehospital, ED, or in-hospital settings, can nonphysicians (eg, paramedics and nurses) accurately diagnose STEMI when compared to physicians?
Consensus on Science

Eight observational studies reported paramedics can diagnose STEMI in the prehospital setting without transmission of a 12-lead ECG for physician consultation (LOE D3113–115; LOE D4116–119; LOE D5120). The limited evidence available about paramedic false-negative diagnostic decisions, including decisions not to obtain a 12-lead ECG, may affect paramedics’ true overall diagnostic accuracy.

Eight observational studies reported that nurses can diagnose STEMI in the context of nurse-initiated fibrinolysis programs (LOE D3121; LOE D4116,122–124; LOE D5125–127). The literature largely describes the ability of nurses to avoid false-positive diagnosis in fibrinolysis programs without substantial evidence about false-negative decisions, which may affect true overall diagnostic accuracy.

Treatment Recommendations

It is reasonable for paramedics and nurses to identify STEMI on a 12-lead ECG independently as long there is a mandatory program of initial training and ongoing concurrent medical oversight of all ECG interpretations.

Computer-Assisted ECG Interpretation

In patients with suspected ACS, does the use of computer-assisted ECG interpretation, compared with standard diagnostic techniques (emergency physicians), increase accuracy of diagnosis (eg, of NSTEMI/STEMI)?

Consensus on Science

Two studies found evidence of improved diagnostic accuracy with the use of computerized ECG interpretation (LOE D5).128,129 Eight studies either found no effect or equivocal effect of the use of computerized ECG interpretation on diagnostic accuracy (LOE D1111,130–132; LOE D5133–136). Two studies found evidence that the use of computerized ECG interpretation decreased diagnostic accuracy (LOE D1).137,138 Three studies showed computer ECG interpretation relating to ACS to be reliable (LOE D1137; LOE 1111,110). The “gold standard” used most commonly was expert “electrocardiographer” review, although four studies used validated clinical diagnosis as the gold standard (LOE 1130; LOE D1111; LOE D1131; LOE D5133). Two studies reported a higher specificity for the computer-interpretation (identifying true negatives), while the physicians had a higher sensitivity (identifying true positives) (LOE 1111; LOE D1131). Three studies found that computer interpretation had a greater influence on nonexpert subject performance in interpreting ECGs than it did on more expert interpretation (LOE D1137; LOE D5135; LOE D5133).

Treatment Recommendation

Prehospital ECG interpretation should be augmented with computer interpretation. Computer interpretation of the ECG may increase the specificity of diagnosis of STEMI, especially for clinicians less experienced in reading ECGs. The benefit of computer interpretation is dependent on accuracy, and therefore computer-assisted ECG interpretation should not replace, but may be used as an adjunct to, interpretation by an experienced clinician. The computer interpretation should be considered in the clinical context.

Diagnostic and Prognostic Test Characteristics of Cardiac Biomarkers for ACS

Protein Markers of Coronary Ischemia

In patients with suspected ACS in various settings (eg, prehospital, emergency, or in-hospital), do abnormal protein markers compared with normal levels allow the clinician to accurately diagnose acute coronary ischemia?

Consensus on Science

Eight studies supported cardiac troponin testing alone in the diagnosis of AMI, when serum testing was drawn at least 6 hours from time of symptom onset or ED presentation, or drawn serially (LOE D2139–141; LOE D3142; LOE D4143–146). No studies showed adequate sensitivity of cardiac troponin testing outside of the ED or short-stay cardiac unit (LOE 2147; LOE 4148–150) including the ICU (LOE 4).151 Four studies showed increased sensitivity of new sensitive troponin assays compared with conventional troponin assays and supported their use to diagnose AMI (LOE D2152,153; LOE D3154; LOE D4155). Nine studies supported multimarker testing (CK-MB, ischemia-modified albumin or myoglobin) in combination with cardiac troponin in the diagnosis of AMI (LOE D2139,141,153,156–158; LOE D4145,156,159).

There were heterogeneous data on the use of troponin point-of-care testing (POCT) in the diagnosis of ACS: 5 studies supported the use of troponin POCT (LOE D2145; LOE D4145,160–163), and 5 studies opposed the use of troponin POCT in the ED and cardiac short-stay units (LOE D3164; LOE D4165–168). Two studies opposed the use of troponin POCT in the prehospital setting (LOE D4),148,149 and 1 opposed the use of troponin POCT in the outpatient clinic setting (LOE D2).147

Treatment Recommendations

Clinicians should take into account the timing of symptom onset, the sensitivity, precision, and institutional norms of the assay, and the release kinetics and clearance of the measured biomarker.

All patients presenting to the ED with symptoms suspicious of cardiac ischemia should have cardiac biomarker testing as part of an initial evaluation. A cardiac-specific troponin is the preferred biomarker. For patients who present within 6 hours of symptom onset suggestive of cardiac ischemia with negative cardiac troponin initially, it is recommended that a troponin level be remeasured between 6 and 12 hours after symptom onset. It is reasonable to use highly sensitive cardiac troponin assays, defined as having a 10% coefficient of variation at the 99th percentile, to evaluate patients with symptoms suspicious of cardiac ischemia. Multimarker evaluation with CK-MB or myoglobin in conjunction with troponin in patients with symptoms suspicious of cardiac ischemia may be considered to improve the sensitivity of diagnosing AMI.

There is no evidence to support the use of troponin POCT in isolation as a primary test in the prehospital setting to evaluate patients with symptoms suspicious of cardiac ischemia.

There is insufficient evidence to support the use of myoglobin, brain natriuretic peptide (BNP), NT-proBNP, D-dimer, C-reactive protein, ischemia-modified albumin...
pregnancy-associated plasma protein A (PAPP-A), and/or interleukin-6 in isolation as primary tests to evaluate patients with symptoms suspicious for cardiac ischemia.

**Prognosis for Discharge Versus Admission**

In patients with suspected ACS, does the presence of any specific factors (eg, history, examination, ECG, and/or biomarkers) or combination into a specific clinical decision rule compared with standard care increase accuracy of prediction of prognosis (eg, decision rule for early discharge)?

**Consensus on Science Statements**

There are no randomized controlled studies addressing clinical decision rules for ACS in the prehospital or ED settings. Existing studies do not adequately address the question because they are heterogeneous (LOE P1). There is not a single published clinical decision rule which is adequate and appropriate for identifying ED chest pain patients who can be safely discharged home from the ED (LOE P1). Younger patients with no history of previous ischemic heart disease, atypical presentations, negative serial biomarkers, and a nondiagnostic 12-lead ECGs have a very low short-term rate of adverse events. Five studies demonstrated that younger patients with no history of previous ischemic heart disease, atypical presentations, negative serial biomarkers, and nondiagnostic 12-lead ECGs have a very low short-term rate of adverse events (LOE P2). One study demonstrated that older patients are evaluated less effectively and the subset of older patients who can be safely discharged from the ED are less easily identified than younger patients (LOE P2).

Five studies demonstrated that the combined use of serial biomarkers and ECGs in selected patients (ie, low risk, sensation-free, and clinically stable) can assist in the identification of patients who can be safely discharged from the ED (LOE P2). This statement is not directly age-dependent, although older patients demonstrate higher rates of ACS diagnosis and adverse outcome.

Nine studies demonstrated that scoring systems derived from in-patient populations (eg, TIMI Risk Score or Goldman Criteria) are not appropriate for ED use and do not assist in the identification of patients who can be safely discharged from the ED (LOE P1; LOE P3).

**Treatment Recommendations**

None of the currently reported clinical decision rules should be used to select ED chest pain patients who can be safely discharged from the ED. Patients <40 years of age with non-classical presentations and lacking significant past medical history, who have normal serial biomarkers and 12-lead ECGs, have a very low short-term event rate.

**Chest Pain Observation Units**

In patients with suspected ACS, does the use of chest pain observation units (CPUs), compared with not using them, increase accuracy of diagnosis and safely identify patients who require admission or specific management of CAD?

CPUs have been developed to assess patients with chest pain and normal initial biomarkers and non-ischemic ECG. The elements that define a CPU vary depending on the characteristics of the individual organizations and the clinical context in which the unit is sited (eg, ED versus in-patient environment versus dedicated site).

Components of the CPU are typically a protocol or pathway based care strategy, dedicated physical space/infrastructure and staffing, use of an accelerated risk-stratification protocol comprising

- Measurement of serial biomarkers of acute infarction (eg, troponin or CK-MB)
- Serial ECG or continuous ECG monitoring
- A period of observation (6 hours)
- Integration with more advanced diagnostic testing (eg, exercise stress test, myocardial perfusion scan)

**Consensus on Science**

Eleven studies of patients with chest pain and normal initial biomarkers and nondiagnostic ECGs demonstrated that CPUs result in reduced length of stay, hospital admissions, quality of life measures, and healthcare costs (LOE 1). One large case-control multicenter study showed that care in CPUs did not reduce the proportion of patients with chest pain admitted to hospital and may have increased ED attendances when implemented across a healthcare system (LOE 2). Fifty-five studies from many healthcare settings demonstrate that CPUs enable evaluation of patients systematically, with a short length of stay, high diagnostic accuracy, and a low event rate at follow-up (LOE 4).

**Treatment Recommendations**

In patients with suspicion for ACS, normal initial biomarkers and nonischemic ECG, chest pain (observation) protocols may be recommended as a safe and effective strategy for evaluating patients in the ED.

Chest pain observation protocols should include a history and physical examination, a period of observation, serial electrocardiography, serial measurement of serum cardiac markers, and either an evaluation for anatomic coronary disease or for inducible myocardial ischemia at some point after AMI is excluded. These protocols may be used to improve accuracy in identifying patients requiring in-patient admission or further diagnostic testing, and those who may be discharged.

Chest pain protocols may be recommended as a means to reduce length of stay, reduce hospital admissions, reduce healthcare costs, improve diagnostic accuracy, and improve quality of life. Since CPUs have not been shown to a reduce hospital admission rates, these protocols must be monitored so that they do not lead to overutilization of hospital resources. There is also no direct evidence demonstrating that CPUs or observation protocols reduce adverse cardiovascular outcomes, particularly mortality for patients presenting with possible ACS, normal serum cardiac biomarkers, and a nondiagnostic ECG.

**Imaging Techniques**

**Imaging Techniques and Diagnosis**

In patients with suspected ACS, does the use of specific imaging techniques (eg, CT angiography, MRI, nuclear, echocardiography), compared with not using them, increase accuracy of diagnosis (eg, of ACS).
**Consensus on Science**

Data from 1 study (LOE D2) documented a sensitivity of 89% and a specificity of 77% for detection of ACS when myocardial perfusion imaging was used in adults presenting to the ED with chest pain, a nondiagnostic ECG, and negative cardiac biomarkers. Supportive evidence was also provided by 4 other studies (LOE D4) for adults presenting to the ED with chest pain.

Data from 2 studies showed high sensitivity (95%) and specificity (90%) for detection of ACS in adults who received multidetector CT angiography (MDCT, 64-slice scanner) after presentation to the ED with chest pain, a nondiagnostic ECG, and negative cardiac biomarkers (LOE D2). This finding was also supported by 4 studies (LOE D4).

Data from 1 study documented sensitivity 93% and specificity 66% when rest echocardiography is used for detection of ACS in low-risk patients who presented to the ED with chest pain, a nondiagnostic ECG, and negative cardiac biomarkers (LOE D2). Supportive evidence was also provided by one prospective cohort study (LOE D4).

Data from 2 studies documented high sensitivity (85%), specificity (84%), and negative predictive value (95%) for the diagnosis of ACS in adult patients who received MRI within 24 hours of presentation to the ED with chest pain after a nondiagnostic ECG and negative cardiac biomarkers (LOE D4).

**Treatment Recommendations**

A noninvasive test (CT angiography, cardiac MR, myocardial perfusion imaging, and echocardiography) may be considered in selected patients who present to the ED with chest pain and initial noninvasive conventional work-ups.

It is reasonable to consider both the exposure to radiation and iodinated contrast when utilizing MDCT and myocardial perfusion imaging.

**Imaging Techniques and Outcome**

In patients with suspected ACS, does the use of specific imaging techniques (eg, CT angiography, MRI, nuclear, or echocardiography), compared with not using them, improve outcome (survival, length of ED stay, hospital admission rate, cost)?

**Consensus on Science Statements**

Data from 2 studies of low-risk ED patients with an initial negative work-up of ACS with negative cardiac enzymes and non diagnostic ECGs, who received SPECT perfusion imaging, demonstrated low rates of cardiac events, reduced costs, and reduced length of stay (LOE 4).

Data from 3 studies of 64-slice MDCT utilized within 24 hours in adult patients presenting to the ED with chest pain, showed that the procedure decreases time to diagnosis, reduces costs, reduces length of stay, is predictive of major adverse events, and can lead to safe discharge from the ED (LOE 1; LOE 4).

Data from 5 studies of echocardiography performed in adult ED patients presenting with chest pain, negative cardiac enzymes, and non-diagnostic ECG’s demonstrated decreased mean length of stay and reduced costs and predicted a low cardiovascular event rate (LOE 1; LOE 4).

**Treatment Recommendations**

Based on studies which investigated limited numbers of selected individuals, patients presenting to the ED with suspected ACS and having a negative initial work-up, including a nondiagnostic ECG and negative cardiac biomarkers, an evaluation with a noninvasive test (CT angiography, myocardial perfusion imaging, or stress echocardiography) may be considered. In selected groups, these noninvasive tests may decrease costs, length of stay, and time to diagnosis and provide valuable short-term and long-term prognostic information of future major cardiac events. There is insufficient data to assess impact on mortality.

**Initial Therapeutic Interventions**

Few studies have been published that directly address out-of-hospital or ED interventions for ACS. In some situations, extrapolation from in-hospital evidence was needed to provide some guidance for out-of-hospital and early ED management.

**Oxygen Therapy**

**Supplemental Oxygen**

In patients with suspected ACS in various settings (eg, prehospital, emergency or in-hospital) and normal oxygen saturations, does the use of supplemental oxygen, compared with room air, improve outcomes (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

**Consensus on Science**

One study reported improvement in ST changes if oxygen was given to 17 patients with myocardial infarction (LOE 4). One LOE 1 trial conducted before the introduction of reperfusion therapy reported that the amount of aspartate aminotransferase released in the circulation was higher in patients who received oxygen therapy. Ventricular tachycardia (VT) and mortality was not significantly different in the two groups. Another LOE 1 study involving myocardial infarction patients treated with streptokinase showed no impact of oxygen on the occurrence of VT. Severe hypoxemia occurred less often in patients given oxygen therapy. One LOE 1 study found that studies were small and lacked statistical power to detect a true influence on clinical outcomes. The review found no definite proof of a harmful effect of oxygen therapy; however, there is absolutely no evidence that oxygen was beneficial to patients with myocardial infarction unless complicated by hypoxemia.

**Treatment Recommendations**

There is insufficient evidence to support or refute the empirical use of high-flow oxygen therapy in patients with uncomplicated AMI without signs of hypoxemia and/or heart failure. There are insufficient data to support or refute the fact that high-flow oxygen therapy might be harmful in this setting. In addition, there is lack of evidence to suggest that low flow oxygen is of any benefit in patients with normal oxygen saturation levels.

Oxygen therapy should be initiated if breathlessness, hypoxemia, or signs of heart failure or shock are present.
Noninvasive monitoring of oxygen saturation may be used to decide on the need for oxygen administration.

**ACS and Nitroglycerin**

*ACS-030A-1, ACS-030A-2*

In patients with suspected ACS/STEMI in the ED and prehospital settings, does the use of nitroglycerin, compared with no nitroglycerin, improve outcome (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

**Consensus on Science**

Despite multiple studies performed in the pre-reperfusion era that have shown a benefit of early nitroglycerin administration in patients with a myocardial infarction, no trial specifically evaluated patients in the ED or prehospital settings. The greatest reduction in infarct size was noted in those treated within 3 hours of symptom onset in 3 studies of patients treated in the intensive care unit (ICU) (LOE 5).269–271 In addition, 2 trials suggested that concomitant treatment of nitroglycerin and fibrinolytics may impair reperfusion (LOE 2).272,273 One study of patients with NSTEMI showed a reduction in myocardial infarction size in those treated with diltiazem compared with intravenous glyceryl trinitrate (LOE 1).274 There is insufficient evidence to determine the benefit or harm of initiating nitroglycerin treatment in the prehospital setting or ED.

**Treatment Recommendations**

Although it is reasonable to consider the early administration of nitroglycerin in selected patients without contraindications, insufficient evidence exists to support or refute the routine administration of nitroglycerin in the ED or prehospital setting in patients with a suspected ACS. There may be some benefit if nitroglycerin administration results in pain relief.

**Analgesics and Sedation**

The worksheet on the topic of Analgesics and Sedation was not completed for the 2010 International Consensus Conference, but the task force felt the topic was important to the care of patients with ACS. As a result, this topic was reviewed by the task force, and they developed the summary of science and treatment recommendations.

In patients with suspected ACS/STEMI in the ED and prehospital settings, does the use of analgesic and/or sedation, (including NSAIDs, opiates, and benzodiazepines) compared with no analgesia or sedation, improve outcome (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

**Consensus on Science**

One study suggested increased mortality and myocardial infarction rates associated with the use of intravenous morphine in patients presenting with high-risk NSTEMI (LOE 4).279 One study demonstrated that the early use of lorazepam with nitroglycerin was more effective than nitroglycerin alone and appears to be safe in relieving cocaine-associated chest pain (LOE 1).276 One study was neutral when diazepam was compared with placebo on the end points of tachyarrhythmias, self-assessed anxiety, or other symptoms in undifferentiated patients with AMI (LOE 1).277

One analysis of case control and cohort studies studying patient exposure to NSAIDs (LOE 1)278 and a large analysis of clinical trials randomizing patients to Cox inhibitors over placebo (LOE 1)279 revealed an increased risk for developing myocardial infarction with use of NSAIDs. The risk appeared most consistent with rofecoxib, and was less consistently observed with celecoxib, naproxyn, ibuprofen, and diclofenac. One study suggested increased harm with the initiation or continuation of NSAID (except aspirin) in patients with suspected ACS (LOE 4).280

**Treatment Recommendations**

Morphine should be administered intravenously and titrated to pain relief in patients with STEMI. Morphine may be considered for pain relief in subjects with suspected NSTEMI. Some form of analgesia should be considered for patients with active chest discomfort. While anxiolytics may be administered to patients with ACS to alleviate apprehension and anxiety, there is no evidence that anxiolytics facilitate ECG resolution, reduce infarct size, or decrease mortality in undifferentiated patients with suspected ACS. Lorazepam with nitroglycerin may be considered to alleviate pain in patients with cocaine-associated chest pain. NSAIDs should not be administered and may be harmful in subjects with suspected ACS. Patients with suspected ACS who are taking NSAIDs should have them discontinued when feasible.

**Aspirin (Acetylsalicylic Acid)**

**Timing of Aspirin Administration**

*ACS-003B*

In patients with suspected ACS, does dispatcher guided administration of aspirin by bystanders before arrival of EMS, compared with later administration of aspirin by paramedic or ED staff, improve outcome?

**Consensus on Science**

There was no clear evidence to support or refute the use of prehospital or EMS dispatch directed (versus hospital administered) aspirin. One study found that aspirin, given before fibrinolysis, increased long-term survival (LOE 1).281 One study showed a benefit in STEMI patients with a decrease in in-hospital complications and 7- and 30-day mortality when given prehospital (LOE 4).282 There was clear evidence that aspirin is associated with a reduction in long-term mortality, which is greatest when the aspirin is administered in the first 4 hours of after an event. One study showed no benefit with administration within the first 4 hours of symptoms, compared with later administration (LOE 1).283 Two other studies showed that the potential benefit from early aspirin administration outweighs potential harm (LOE 1).284,285

**Treatment Recommendations**

Despite limited direct evidence to support or refute the practice, it may be reasonable to consider EMS or dispatcher-guided bystander aspirin administration, provided an adequate history to exclude a true allergy or a bleeding disorder, can be obtained.
Clopidogrel and Other Platelet Antagonists

**Clopidogrel (and Similar Drugs)**

In patients with non–ST-elevation ACS (NSTE ACS), STEMI managed with fibrinolysis, and STEMI managed with PCI, in prehospital and ED settings, does the use of clopidogrel or newer oral antiplatelet agents (prasugrel, ticagrelor) compared with standard management (eg, no prehospital or ED use of clopidogrel or compared to clopidogrel or new thienopyridines), improve outcome (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 day mortality)?

**Consensus on Science**

**Clopidogrel.** Seven studies (LOE 1286–289; LOE 2290,291; LOE 3298,299; LOE 5296) documented consistent improvement, and 1 study (LOE 5)293 was neutral in demonstrating benefit in the combined event rate of cardiovascular mortality, nonfatal infarction, nonfatal stroke, and overall mortality. There was a small increase in major bleeding when clopidogrel was administered by providers in the ED or hospital to patients with non–ST-elevation ACS.

Six studies documented consistent improvement in combined event rate of cardiovascular mortality, nonfatal infarction, and nonfatal stroke, with a resultant small increase in major bleeding when clopidogrel was administered by providers in the ED or prehospital to patients <75 years with STEMI managed with fibrinolysis (LOE 1294–297; LOE 2298,299).

Five studies documented improvement in combined event rate (cardiovascular mortality, nonfatal infarction, and nonfatal stroke) and mortality with a resultant small increase in major bleeding when clopidogrel was administered by ED, hospital, and/or prehospital providers to patients with STEMI managed with PCI (LOE 2300,301; LOE 3298,299; LOE 5296).

There was little evidence on the use of a loading dose of clopidogrel in patients ≥75 years of age treated by PCI, and they were excluded from studies if treated with fibrinolysis.

**Prasugrel.** There was no direct evidence of use of prasugrel in the ED or prehospital setting for non-ST-elevation ACS. Extrapolating evidence from in-hospital setting, 5 studies (LOE 5)302–306 documented improvement and 1 study (LOE 1)307 documented no benefit in combined event rate (cardiovascular mortality, nonfatal infarction, and nonfatal stroke) or mortality, but with a resultant increase in major bleeding when prasugrel (compared to clopidogrel) was administered after angiography to patients with non-ST-elevation ACS and stenoses suitable for PCI.

There was no direct or indirect evidence of benefit or risk of prasugrel administered by hospital, ED, or prehospital providers to patients with STEMI managed with fibrinolysis. There was no direct evidence of the use of prasugrel in the ED or prehospital setting for patients with STEMI ACS. There was no direct evidence of the use of prasugrel in the ED or prehospital setting for patients with STEMI ACS managed with PCI. Six studies demonstrated small improvements in combined event rate (cardiovascular mortality, nonfatal infarction, and nonfatal stroke) and/or mortality when prasugrel compared with clopidogrel was administered in the hospital setting before, during, or after angiography to patients with STEMI managed with PCI (LOE 5).302–306,308

**Posthoc exploratory analysis of a randomized control trial in STEMI and non-ST-elevation ACS patients treated by PCI identified risk factors associated with a higher rate of bleeding complications with prasugrel: patients ≥75 years of age, history of stroke or transient ischemic attack (TIA), and body weight less than 60 kg (LOE 5).302**

**Ticagrelor.** One study documented improvement in overall mortality and combined event rates (death from vascular causes, MI, or stroke) with a marginal increase in bleeding and an increase in dyspnea when ticagrelor, given by in-hospital providers to patients with high-risk non-ST elevation ACS, was compared with clopidogrel (LOE 1).309 There was no direct or indirect evidence of benefit or risk of ticagrelor administered by hospital, ED, or prehospital providers to patients with STEMI managed with fibrinolysis. One study documented improvement in overall mortality and combined event rates (death from vascular causes, MI, or stroke) with a marginal increase in bleeding and an increase in dyspnea when ticagrelor was administered compared to clopidogrel by in-hospital providers to patients with STEMI managed by PCI (LOE 1).309

**Treatment Recommendations**

**Clopidogrel.** Administration of clopidogrel in addition to standard care (aspirin, anticoagulants, and/or reperfusion) for patients determined to have moderate to high-risk non-ST elevation ACS and STEMI is recommended. The ideal oral loading dose of clopidogrel in patients <75 years of age is dependent on the planned approach: 600 mg in a planned invasive strategy; or 300 mg in a planned noninvasive strategy or together with fibrinolysis. The ideal dose in patients >75 years of age has not yet been delineated, but may range from 75 to 600 mg.

**Prasugrel.** Prasugrel may be administered after angiography to patients with NSTEMI presenting with stenoses amenable to PCI. ED or prehospital administration of clopidogrel should be withheld even in patients who are not at high risk for bleeding (age <75 years, no history of previous stroke or TIA, and body weight >60 kg), pending consideration of prasugrel administration following angiography. In patients who are not at high risk for bleeding with planned PCI, prasugrel (60 mg oral loading dose) may be substituted for clopidogrel for patients determined to have STEMI less than 12 hours after the initial symptoms. Prasugrel is not recommended in STEMI patients receiving fibrinolysis.

**Ticagrelor.** Administration of ticagrelor (180-mg oral loading dose) in addition to standard care (aspirin, anticoagulants, and/or reperfusion) determined to have non-ST elevation ACS or STEMI managed with early invasive strategy by hospital personnel may be an option instead of clopidogrel. The risks and/or benefits of ticagrelor in STEMI patients managed with fibrinolysis is unknown.

**Combination.** The risks and/or benefits of combining these agents (clopidogrel, prasugrel, and/or ticagrelor) for loading and maintenance dosing has not been sufficiently determined.

**Heparins**

**Anticoagulants and Non–ST-Elevation ACS**

In patients with suspected non–ST-elevation myocardial infarction in the prehospital and ED setting, does the use of new anticoagulants (ie, pentasaccharide, enoxaparin, bivalirudin),...
compared with standard management (placebo, unfractionated heparin [UFH], other anticoagulant, or no anticoagulant), improve outcomes (eg, mortality, reinfarction, revascularization, bleeding, stroke)?

Consensus on Science
Twenty-two studies demonstrated improved combined end points (death, MI, revascularization) with an increase in the proportion of patients with bleeding complications when enoxaparin was administered in-hospital rather than UFH in patients with AMI (LOE 1310–320; LOE 2321–326; LOE 5327–329).

Four randomized, controlled trials (RCTs, LOE 1),330–332,333 3 meta-analyses (LOE 1),334–336 6 nonrandomized control trials (LOE 2 to 4),337–344 and 5 additional studies (LOE 4 to 5)345–349 did not demonstrate a difference for outcomes among in-hospital patients given enoxaparin compared with UFH.

One RCT (LOE 1),350 3 nonrandomized control studies (LOE 2),351–353 and 2 additional studies (LOE 5)354,355 demonstrated improved combined end points (death, MI, revascularization) without increased bleeding when fondaparinux, compared with UFH, was administered in-hospital in patients with AMI. Three studies did not demonstrate a difference in outcomes for fondaparinux compared with UFH when given in-hospital (LOE 2356.357; LOE 5358). One RCT indicated fondaparinux may lead to excess catheter thrombosis when used as part of an invasive approach without the use of adjunctive medications (LOE 1).350

Twenty-eight studies (LOE 1359–364; LOE 2 to 4365–375; LOE 5376–386) did not demonstrate a difference in combined outcomes for major adverse cardiac events but did demonstrate less bleeding for bivalirudin administered in-hospital compared with UFH.

Treatment Recommendations
For patients with non–ST-elevation ACS managed with a planned initial conservative approach, either fondaparinux or enoxaparin are reasonable alternatives to UFH. For patients with non–ST-elevation ACS managed with a planned invasive approach, either enoxaparin or UFH are reasonable choices. Bivalirudin may be considered as an alternative, but does not appear to offer an advantage over UFH. Fondaparinux may be used in the setting of PCI, but requires co-administration of UFH and does not appear to offer an advantage over UFH alone.

For patients with non–ST-elevation ACS and renal insufficiency, bivalirudin or UFH may be considered. For patients with non–ST-elevation ACS and increased bleeding risk, where anticoagulant therapy is not contraindicated, fondaparinux or bivalirudin are reasonable, and UFH may be considered. There is no specific evidence for or against anticoagulant use in non–ST-elevation ACS in the prehospital setting. There is currently insufficient evidence on other anticoagulants to make recommendations.

Anticoagulants and STEMI Treated With Fibrinolysis
In patients with suspected STEMI in the prehospital and ED setting treated with fibrinolysis, does the use of new anticoagulants (ie, pentasaccharide, enoxaparin, bivalirudin), compared with standard management (placebo, unfractionated heparin, other anticoagulant, or no anticoagulant), improve outcomes (eg, mortality, reinfarction, revascularization, bleeding, or stroke)?

Consensus on Science
Enoxaparin. For patients with STEMI to be treated with fibrinolysis, 17 studies supported enoxaparin over UFH (LOE1336,387–393; LOE 2394,395,396; LOE 4397; LOE 5398–401) Twelve other studies were neutral comparing enoxaparin and UFH.

Reviparin. One study demonstrated improved clinical outcome with reviparin compared with UFH in STEMI patients treated with fibrinolysis (LOE 1).

Other LMWH. There were 2 neutral meta-analyses of dalteparin, nadroparin, reviparin, and parnaparin (LOE 1),413,414 1 dalteparin supporting study using a surrogate end point (LOE 1),415 and 3 neutral studies of LOE 1416 for nadroparin418 and parnaparin.417,418

Fondaparinux. One study demonstrated superiority in clinical outcomes when fondaparinux was compared with UFH in patients treated with fibrinolysis (LOE 1).419 Two studies did not demonstrate a significant difference in outcomes (LOE 1420; LOE 2421).

Bivalirudin. Two studies did not demonstrate a significant difference in outcomes with bivalirudin (LOE 1422; LOE 2423).

Treatment Recommendations
Enoxaparin: For patients with STEMI managed with fibrinolysis, it is reasonable to administer enoxaparin instead of UFH. For prehospital patients with STEMI managed with fibrinolysis, adjunctive enoxaparin instead of UFH may be considered. Patients initially treated with enoxaparin should not be switched to UFH and vice versa to avoid increased bleeding risk.

Fondaparinux: May be considered in the hospital for patients treated specifically with non–fibrin-specific thrombolytics (ie, streptokinase), provided the creatinine level is <3 mg/dL.

Other LMWH or bivalirudin: There are insufficient data to recommend other LMWH or bivalirudin over UFH in patients treated with fibrinolysis in STEMI.

Anticoagulants and STEMI Treated With PCI
In patients with suspected STEMI in the prehospital and ED setting to be treated with PCI, does the use of new anticoagulants (ie, pentasaccharide, enoxaparin, bivalirudin), compared with standard management (placebo, unfractionated heparin, other anticoagulant, or no anticoagulant), improve outcomes (eg, mortality, reinfarction, revascularization, bleeding, or stroke)?

Consensus on Science
Bivalirudin. Two studies resulted in less bleeding and a short- and long-term reduction in cardiac events and overall mortality with bivalirudin compared with UFH plus a glycoprotein inhibitor in patients with STEMI and planned PCI
Compared with other antithrombins (LOE 5). A study demonstrated better outcome of patients with cardiogenic shock if treated with or without a glycoprotein IIb/IIIa inhibitor, compared with UFH plus a glycoprotein IIb/IIIa inhibitor (LOE 4). One study with prehospital initiation of bivalirudin versus UFH showed no difference (LOE 3). One analysis showed no difference when bivalirudin and UFH were compared for PCI (LOE 5). In 2 studies of bivalirudin versus UFH, outcomes were similar (LOE 2430; LOE 4431).

**Enoxaparin.** Three studies of PCI after fibrinolysis resulted in favorable outcome when enoxaparin was compared with UFH (LOE 4397; LOE 5398). Eight other studies showed no benefit using enoxaparin compared with UFH (LOE 2432, 4334; LOE 4405, 409, 435, 436; LOE 5345).

**Fondaparinux.** One clinical trial comparing fondaparinux with UFH documented similar rates of cardiovascular events but a lower rate of bleeding (LOE 1). One trial, which included patients with NSTEMI and patients undergoing elective PCI, was neutral in outcomes (LOE 5). One analysis of NSTEMI patients documented fewer acute cardiac events and less bleeding using fondaparinux and PCI compared with other antithrombins (LOE 5). Thrombus formation on catheter material in patients on fondaparinux required the addition of UFH during PCI.

**Other LMWH.** One nonrandomized study compared dalteparin with UFH in STEMI patients undergoing PCI and showed a neutral result (LOE 2).

**Treatment Recommendations**

For patients with STEMI undergoing contemporary PCI, enoxaparin may be considered a safe and effective alternative to UFH. To avoid increased bleeding risk, patients initially treated with enoxaparin should not be switched to UFH and vice versa.

In comparison with UFH, fondaparinux reduces the bleeding risk in STEMI patients undergoing PCI. There is an increased risk of catheter thrombi with fondaparinux alone; additional UFH (50 to 100 U/kg BW bolus) may help to avoid this complication, but using these 2 agents is not recommended over UFH alone. The dose of fondaparinux and enoxaparin requires adjustment in patients with renal impairment.

Bivalirudin may be superior to UFH plus glycoprotein IIb/IIIa inhibitors with respect to bleeding and reduces adverse cardiac events and mortality in STEMI patients undergoing PCI. An increased rate of stent thromboses has been observed with bivalirudin within the first 24 hours after PCI.

There are insufficient data to recommend other LMWH than enoxaparin for antithrombin treatment in STEMI patients undergoing PCI.

**Glycoprotein IIb/IIIa Inhibitors**

In patients with suspected ACS/MI in prehospital and ED settings, does the use of glycoprotein IIb/IIIa inhibitors, compared with standard management, improve outcomes (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

**Reperfusion Strategies**

In the majority of patients, STEMI occurs as the result of a recent acute occlusion of a major epicardial coronary artery due to the disruption of atherosclerotic plaque and thrombus formation. Strategies aimed at restoring myocardial perfusion are an important part of the management of these patients. Restoring coronary blood flow and myocardial perfusion either by pharmacologic (fibrinolytics) and/or mechanical therapy (PCI) has been demonstrated to improve outcomes in patients presenting within 12 hours of symptom onset and later other patients group such as those with cardiogenic shock. There is evidence that prehospital fibrinolysis reduces delay to treatment, especially in rural areas with long transit times. In these settings prehospital fibrinolysis is a reasonable treatment strategy.

**Out-of-Hospital Fibrinolytics for STEMI**

**Prehospital Fibrinolytics for STEMI**

In patients with STEMI in the prehospital setting, does the use of prehospital fibrinolytics, compared with in-hospital fibrinolytics, improve outcomes (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

**Consensus on Science**

Twelve larger randomized studies and metaanalyses (LOE 1)338–449 and 2 smaller randomized studies450, 451 consistently reported better clinical outcome with use of glycoprotein IIb/IIIa inhibitors compared with placebo. This result was supported by many studies which consistently reported better outcomes with upstream or early use of glycoprotein IIb/IIIa inhibitor compared with deferred treatment or other strategies (LOE 1452–467; LOE 2468–473; LOE 3474; LOE 4475–478; LOE 5479).

There were 12 studies with neutral outcomes/evidence (LOE 1),473, 480–487, LOE 4,488, 489, LOE 5. Four studies showed worse outcomes, or at least more bleeding and need for transfusion without clinical advantage, with glycoprotein IIb/IIIa inhibitors compared with standard/alternative procedures. In most of the supporting, as well as neutral and opposing, studies a higher rate of (major) bleedings has been observed.

**Treatment Recommendations**

There were insufficient data to support the routine use of glycoprotein IIb/IIIa inhibitors in patients with suspected STEMI or NSTEMI in the prehospital or ED settings. For selected high-risk patients with NSTEMI, abciximab, eptifibatide, or tirofiban administration may be acceptable, provided PCI is planned. There is an increased bleeding risk with routine glycoprotein IIb/IIIa inhibitors when used with heparins. Alternatives for anticoagulation and antiplatelet treatment might be considered instead.
nurses, or paramedics (LOE 1\textsuperscript{496,497,498,499–501} LOE 2\textsuperscript{214,502–510}, LOE 3\textsuperscript{511–513}).

Eleven studies showed that a greater proportion of the patients treated with prehospital fibrinolysis had shorter duration and increased frequency of total resolution of chest pain by the time of admission, ECG resolution, and decreased mortality (LOE 1\textsuperscript{496,499,500,514–516}, LOE 2\textsuperscript{505,506,508,511,513}).

**Treatment Recommendations**

In patients with STEMI diagnosed in the prehospital setting, reperfusion may be achieved by administration of fibrinolytics by healthcare providers in the field. Alternately, fibrinolytic therapy may be administered on arrival at hospital. If fibrinolysis is chosen as the reperfusion strategy, it should be started as soon as possible, ideally in the prehospital setting, and should be administered by paramedics, nurses, or doctors using well-established protocols, competency training programs, and quality assurance programs, under medical oversight.

**Choice of Reperfusion Strategy in the Hospital**

**PPCI Versus Fibrinolytic Therapy for STEMI**\textsuperscript{ACS-025B}

In patients with suspected STEMI in the ED setting, does the use of PPCI compared with fibrinolytic therapy, improve outcome (eg, arrhythmias, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

PPCI is an effective reperfusion strategy. When provided in a timely manner, at a capable center, by an experienced interventionalist, PPCI may be superior to fibrinolysis. Application of PPCI has been limited by access to catheter laboratory facilities and appropriately skilled clinicians. Fibrinolytic therapy is a widely available reperfusion strategy and may be used if delays to PPCI are anticipated. Both treatment strategies are well established and have been the subject of large randomized multicenter trials over the last 2 decades.

**Consensus on Science**

For patients admitted to hospital with PCI facilities, evidence from 2 studies demonstrated that PPCI conferred clinical benefit compared with fibrinolysis both in terms of mortality and morbidity (reinfarction/stroke) for the majority of patients (LOE 1\textsuperscript{517,518}). The evidence from 2 studies was scant for additional benefit of PCI over fibrinolysis for specific subgroups such as post CABG patients or patients with renal failure (LOE 1\textsuperscript{519}; LOE 3\textsuperscript{520}).

For patients admitted to hospital without PCI facilities, 2 studies showed benefit associated with transferring patients for PPCI versus on-site fibrinolysis in terms of reinfarction and stroke and a trend to a lower mortality in the PPCI group (LOE 2\textsuperscript{521,522}). The average time from randomization to PCI varied among the separate trials in this meta-analysis and ranged between 82 and 122 minutes. The benefit was correlated directly to risk status of the patient, with those at high risk benefiting more from transfer.

For patients with cardiogenic shock, evidence from 1 randomized trial demonstrated that early revascularization improves survival at 6 months (LOE 1\textsuperscript{523}). The survival benefit was seen mainly in patients less than 75 years of age.

Data from registries\textsuperscript{524} and a meta-analysis from previously published studies\textsuperscript{525} highlight the variability in PCI-related time delay (between 40 and 179 minutes), that mitigated the benefit of mechanical intervention over fibrinolysis (LOE 3\textsuperscript{524,525}). This variability was influenced by several factors including age, symptom duration, and location of infarction. Similarly 1 study showed that the benefit of PCI over fibrinolytic therapy is offset when PCI is carried out in low-volume PCI centers (LOE 1\textsuperscript{526}).

**Treatment Recommendations**

Programs should be implemented to reduce the time to PCI. Shorter intervals to reperfusion increase myocardial salvage, whereas delays to reperfusion increase morbidity and mortality. The precise threshold of PPCI-related delays that should trigger the decision for fibrinolysis has not been definitively established, but time to PCI should be as short as possible. Individual Councils will determine the acceptable limit or target interval from first medical contact to PCI in light of likely patient factors and available healthcare system resources, and the reader is referred to those Council-specific guidelines for more detailed information.

For patients presenting within 12 hours of symptom onset and with ECG findings consistent with STEMI, reperfusion should be initiated as soon as possible independently of the method chosen. The benefit of mechanical intervention over fibrinolysis varied considerably depending on the patient’s condition and the duration of PPCI-related delays. For those patients with a contraindication to fibrinolysis, PCI should still be pursued despite the delay, rather than offering no reperfusion therapy.

For those STEMI patients presenting in shock, PCI (or coronary artery bypass surgery) is the preferred reperfusion treatment. Fibrinolysis should only be considered if there is a substantial delay to PCI.

**Combined PCI and Fibrinolysis**

**Fibrinolytics and Immediate PCI (Facilitated PCI) Versus Immediate PCI**\textsuperscript{ACS-025A, ACS-025B}

In patients with suspected STEMI in the ED and prehospital settings, does the use of fibrinolytics and immediate PCI, compared with immediate PCI, improve outcome (eg, chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

Fibrinolytics and PCI may be used in a variety of combinations to restore coronary blood flow and myocardial perfusion. There are several ways in which the 2 therapies can be combined. There is some lack of uniformity in the nomenclature used to describe these regimes. In this analysis, facilitated PCI is used to describe PCI performed immediately after fibrinolysis, a pharmaco-invasive strategy refers to PCI performed routinely 2 to 6 hours after fibrinolysis, and rescue PCI is defined as PCI performed for a failed reperfusion (as evidenced by <50% resolution of ST-segment elevation at 60 to 90 minutes post-lytic). These strategies are distinct from a routine PCI approach where the angiography and intervention is performed more than 12 hours after successful fibrinolysis.
Consensus on Science
Twelve studies demonstrated poorer outcome with routine PCI shortly after fibrinolysis (LOE 1\textsuperscript{481,527,528,529–532} LOE 2\textsuperscript{533}, LOE 5\textsuperscript{534–537}). Most of these studies have been performed in recent years. Eleven studies supported a facilitated PCI strategy (LOE 1\textsuperscript{538}; LOE 2\textsuperscript{2,464,539–541} LOE 3\textsuperscript{542–544}; LOE 5\textsuperscript{545–547}). Thirty studies show no benefit of PPCI over fibrinolysis (LOE 1\textsuperscript{405,491,548–554}; LOE 2\textsuperscript{555–560}; LOE 5\textsuperscript{551,561–566,567–574}).

Treatment Recommendations
The routine use of fibrinolysis-facilitated PPCI, compared with PPCI, is not recommended in patients with suspected STEMI. It is reasonable to perform angiography and possible PCI in patients with failed fibrinolysis according to clinical signs and/or insufficient ST-segment resolution.

Additional Medical Therapy
Several additional medical therapies have been proposed for ACS patients with the goal of reducing complications from myocardial ischemia, major adverse cardiac events, and ultimately long-term survival. Therapeutic options include antiarrhythmics, β-blockers, angiotensin-converting enzyme (ACE) inhibitors, and HMG-CoA reductase inhibitors (statins). The bulk of data available to determine the usefulness of these therapies has not been derived from patients in the prehospital or ED settings. Traditional preventive interventions usually start with the first admission with a confirmed diagnosis of ACS. The current evidence indicates that none play a significant role in the out-of-hospital and ED management of ACS.

Antiarrhythmics

Prophylactic Antiarrhythmics\textsuperscript{ACS-021B}
In patients with suspected ACS/MI in prehospital and ED settings, does the use of prophylactic antiarrhythmics, compared with standard management (ie, no prehospital and ED use of β-blockers), improve outcome (eg, arrhythmias, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

Consensus on Science
Evidence from 3 studies suggested a reduction in ventricular fibrillation (VF), which was not statistically significant; however, there was no improvement in survival to hospital discharge (LOE 1\textsuperscript{575–577}; LOE 4\textsuperscript{578}). The studies had heterogeneous clinical protocols, and most were underpowered. Twelve studies showed no improvement in suppression of ventricular arrhythmias (LOE 1\textsuperscript{579–588}; LOE 2\textsuperscript{589}; LOE 4\textsuperscript{590}). The studies showed no improvement in survival to hospital discharge. Four studies showed worsening of arrhythmias and the potential for harm (LOE 1\textsuperscript{584,591,592}; LOE 2\textsuperscript{593}).

Lidocaine is the antiarrhythmic drug that has been studied most extensively in this clinical setting. The majority of the evidence suggests lidocaine is not associated with improved clinical outcomes. There were 3 studies supporting arrhythmia suppression with lidocaine; however, no clinical benefit was shown (LOE 1\textsuperscript{575–577}; LOE 4\textsuperscript{578}). There were 8 studies that were neutral for demonstrating arrhythmia suppression with lidocaine (LOE 1\textsuperscript{581,583,586–588}; LOE 2\textsuperscript{589,593}; LOE 4\textsuperscript{590}). There were 2 studies that showed harm (LOE 1\textsuperscript{580,592}). One trial showed a statistically significant benefit in decreasing the incidence of VT using sotalol (LOE 1\textsuperscript{594}). Three studies were neutral with respect to tocainide and disopyramide (LOE 1\textsuperscript{582} mexiletine (LOE 1\textsuperscript{579} and tocainamide (LOE 1\textsuperscript{585}). One study showed harm with amiodarone (LOE 1\textsuperscript{584} and 1 trial (LOE 1\textsuperscript{591}) showed harm with a variety of drugs, including β-blockers.

Treatment Recommendations
Prophylactic antiarrhythmics are not recommended for patients with suspected ACS or myocardial infarction.

β-Blockers\textsuperscript{ACS-023A}
In patients with suspected ACS/MI in prehospital and ED settings, does the use of β-blockers, compared with standard management (ie, no prehospital and ED use of β-blockers), improve outcome (eg, arrhythmias, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)? Studies of β-blockers are heterogeneous with respect to the time of β-blocker administration. There is a paucity of data on the administration of β-blockers in the prehospital or early ED settings (ie, within the first hour of a suspected ACS).

Eight studies showed no advantage for IV β-blockers on mortality, infarct size, prevention of arrhythmias, or reinfarction (LOE 1\textsuperscript{595–602}). None of the papers reviewed showed that β-blockers caused irreversible harm when given early in the development of suspected ACS. One study showed a statistically significant reduction in 6-week mortality in a subgroup of low-risk (ie, Killip Class I) patients (LOE 1\textsuperscript{596}). Other studies (LOE 1) have shown reduced mortality\textsuperscript{603,604} and decreased infarct size\textsuperscript{605,606,607} with early IV β-blocker use. Four studies showed that early β-blocker administration helped prevent dangerous arrhythmias, (LOE 1\textsuperscript{604,606,608,609} while 2 studies showed a prevention of reinfarction but increased incidence of cardiogenic shock (LOE 1\textsuperscript{604,608}). Many of the β-blocker trials in the early 1980s were small and had wide confidence intervals. One study suggested that the earlier IV β-blockers were administered, the greater the reduction in infarct size and mortality (LOE 3\textsuperscript{610}).

Treatment Recommendations
For patients with ACS, there is no evidence to support the routine administration of IV β-blockers in the prehospital setting or during initial assessment in the ED. It may be reasonable to administer IV β-blockers in specific situations, such as severe hypertension or tachycardia, in patients without contraindications. Starting oral β-blockers at low doses is recommended once the patient’s condition has been stabilized.

Angiotensin Converting Enzyme Inhibitors

Angiotensin Converting Enzyme (ACE) Inhibitors and Angiotensin Receptor Blockers (ARBs)\textsuperscript{ACS-022A}
In patients with suspected ACS/MI in prehospital and ED settings, does the use of ACE inhibitors or ARBs, compared with standard management (ie, no prehospital and ED use of ACE inhibitors), improve outcome (eg, infarct size, survival to discharge, 30/60 days mortality)?
Consensus on Science
Despite multiple studies that have shown a benefit for ACE inhibitors and ARBs in patients with a myocardial infarction, no trial specifically evaluated patients in the ED or prehospital settings. One randomized trial showed a reduction in mortality for patients treated with ACE inhibitors soon after presentation, despite causing some hypotension (LOE 1).611 Three randomized trials showed a reduction in the rate of heart failure and mortality in patients treated soon after fibrinolysis (LOE 1).612–614 One study (LOE 1)613 failed to show a benefit with the use of ACE inhibitors within 1 hour of reperfusion and 2 meta-analyses (LOE 1)615,616 documented no benefit with ACE inhibitor administration.

Treatment Recommendations
ACE inhibitors and ARBs reduce mortality in patients with AMI; however, there is insufficient evidence to support the routine initiation of ACE inhibitors and ARBs in the prehospital or ED setting in patients with a myocardial infarction.

HMG CoA Reductase Inhibitors (Statins)
A & B StatinsACS-024B
In patients with suspected ACS/MI in prehospital and ED settings, does the use of statins, compared with standard management (ie, no prehospital and ED use of statins), improve outcome (eg, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

Consensus on Science
Nineteen studies documented a reduction in short- and long-term major adverse cardiovascular events after intensive treatment with statins within the first 24 hours after hospital admission for patients with ACS (LOE 1617–622; LOE 2623–635). Multiple studies reported consistently reduced short-term mortality and reduced incidence of death and nonfatal myocardial infarction during the 30-day follow-up with continued statin treatment or early initiation of this treatment, compared with discontinuation of statins at hospital admission of ACS patients (LOE 3636; LOE 4637–645). Some of the studies also report the reduction in markers of myocardial necrosis or inflammation in statin treatment in patient groups undergoing PCI. One meta-analysis (LOE 1)646 and 2 other studies (LOE 4)647,648 were neutral with regard to death and nonfatal myocardial infarction during the 30-day follow-up. There were no reports on the risk or safety considerations of early initiation of statin treatment in ACS.

Treatment Recommendations
Intensive statin treatment should be considered early after onset of an ACS event (eg, immediately after hospital admission) in patients presenting with ACS unless contraindicated (eg, by proven intolerance). Pre-existing statin therapy should be continued in patients presenting with an ACS.

Healthcare System Interventions for ACS
Several systems-related strategies have been developed to improve quality of care for patients with ACS and reduce reperfusion delays for patients with STEMI. Strategies exist for patients identified in the prehospital setting and in the ED. These strategies focus on the use of prehospital 12-lead ECG and time-saving strategies to facilitate early diagnosis and rapid treatment for patients with STEMI.

12-Lead Out-of-Hospital ECG and Advance ED Notification
Prehospital ECGsACS-026B
In patients with suspected ACS/MI in prehospital setting, does the use of prehospital ECG and advance ED notification, compared with no prehospital ECG, improve outcome (eg, arrhythmias, infarct size, ECG resolution, survival to discharge, 30/60 days mortality)?

Consensus on Science
Eight studies demonstrated a reduction in the door-to-needle time interval ranging from 20 to 60 minutes when physician- or paramedic-interpreted prehospital 12-lead ECG was used to evaluate patients with suspected AMI who are then treated with a fibrinolytic (LOE 1649–652; LOE 2116,117,653,654).

Eight studies demonstrated a reduction in the reperfusion delay (with varied time interval definitions) ranging from 15 to 65 minutes in patients treated with PCI (LOE 2655–658; LOE 3612,659,660; LOE 4661).

Two studies suggested that the time saved by using prehospital ECGs was dependent on advanced hospital notification of an incoming STEMI patient and activation of the catheterization team before the patient’s arrival (LOE 2).655,660 When comparing the door-to-reperfusion time for patients with a prehospital ECG and prehospital activation to patients with no prehospital ECG, the mean door-to-reperfusion interval was reduced by more than 30 minutes.660 Two nonrandomized trials reported no significant reductions in mortality with the use of prehospital ECGs (LOE 2).117,657 In one of these studies in-hospital all-cause mortality was 15.6% in a group of STEMI patients brought by EMS to the ED without prehospital ECGs, and 8.4% for patients who had a prehospital ECG and were brought directly to the critical care unit for fibrinolysis.117 The study was not powered to detect a mortality difference. The second study reported an 11% in-hospital mortality for STEMI patients brought by EMS without a prehospital ECG versus 5% in those with a prehospital ECG.657

Treatment Recommendations
Prehospital 12-lead ECGs facilitate earlier diagnosis of STEMI and provide the opportunity for rapid prehospital reperfusion or for rapid triage of patients to awaiting institutions able to provide such reperfusion. EMS personnel should acquire a prehospital 12-lead ECG on all patients exhibiting signs and symptoms of ACS and provide advance notification to receiving institutions for patients diagnosed with STEMI. Advance notification may be achieved with direct transmission of the ECG or with interpretation of the ECG by prehospital personnel. Advance notification should prompt preparations at the receiving institution for rapid reperfusion of the arriving STEMI patient.

Improving Systems of Care for ACSACS-009A
In patients with suspected STEMI, do any specific techniques improve STEMI system or process of care, compared with...
standard management, to improve time to treatment and clinical outcome?

**Consensus on Science**

**Emergency Physician or Prehospital Activation of the Catheterization Laboratory Team.** Two studies suggested an association between the ability of emergency physicians to activate the catheterization laboratory team and decreased door-to-balloon time interval (LOE 5),662,663 Twelve studies demonstrated that emergency physician activation of the catheterization laboratory was associated with significant reductions in door-to-balloon time intervals (20 to 68 minutes) (LOE 2664–666; LOE 3667–673; LOE 5663,674). False-positive activation rate in these studies ranged from 0% to 15%.674,663–673

**Prehospital Activation of the Catheterization Laboratory.** Seven studies demonstrated the effectiveness of prehospital activation on reducing door-to-balloon time intervals (22 to 69 minutes) (LOE 2566,675; LOE 3676,677; LOE 4660,678). The studies were variable in their implementation and all had significant limitations. False-positive activation of the catheterization laboratory was not assessed by any of the studies.

**Single Call to a Central Page Operator.** One qualitative survey suggested an association between single call to a central page operator and reduced reperfusion delay (LOE 5).679 There were no studies that investigated the effect of this specific technique in isolation.

**Real-Time Data Feedback.** Four studies demonstrated a positive impact of feedback on reducing the door-to-balloon interval (10 to 54 minutes) (LOE 3667–673; LOE 5679,680). These studies were heterogeneous and had significant limitations.

**Institutional Commitment.** Two qualitative studies suggested that senior management commitment and leadership was crucial to improving treatment of STEMI. However, no other studies proved this relationship (LOE 5).681,682

**Team Based Approach.** One qualitative study suggested a team-based approach led to improvements in STEMI systems of care (LOE 5).681 However, no other studies proved this relationship empirically.

**Expecting the Catheterization Laboratory Staff to Arrive in 20 Minutes.** One study established an association between hospitals that expect the catheterization team to arrive in 20 minutes and having decreased door-to-balloon time (LOE 5).679 However, no studies have investigated the impact of implementing this specific technique in isolation. One study used this specific expectation of arrival of catheterization laboratory staff along with other methods as part of a quality improvement initiative (LOE 3).667 Another study evaluated the outcomes of patients that presented during peak hours compared with off-peak hours and found decreased door-to-balloon time intervals among patients who presented when the catheterization laboratory team was in house (LOE 5).683

**Having an Interventional Cardiologist Immediately Available at the Hospital.** One study demonstrated an association between having an interventional cardiologist always at the hospital and decreased door to balloon times of 8.2 minutes (LOE 5).670 No studies have investigated the impact of implementing this specific technique on reperfusion delay. No studies demonstrated direct effect on mortality or other outcomes data.

**Treatment Recommendations**

Hospitals should implement prehospital activation of the catheterization laboratory for patients with suspected STEMI who arrive by EMS and should implement first-physician-contact activation of the catheterization laboratory for patients suspected of having STEMI arriving by other means. Hospitals may implement additional institution-specific techniques to improve STEMI systems of care; however there is little evidence to support their widespread implementation. These techniques include:

- Arranging single-call activation of the catheterization laboratory
- Requiring the catheterization laboratory to be ready in 20 minutes
- Having the interventional cardiologist immediately available at the hospital
- Providing real-time data feedback
- Fostering the commitment of senior management
- Encouraging a team-based approach

**Out-of-Hospital Triage for PCI**

In patients with ST-elevation identified on prehospital ECG, does the use of direct transport to PCI, compared with transport to the closest hospital, improve outcomes (mortality, left ventricular function, re-infarction, or stroke) as compared with other standard strategies?

**Consensus on Science**

Two studies suggested that transportation of STEMI patients diagnosed by paramedics directly to PCI centers for PCI as part of a coordinated regional response to STEMI reduced in-hospital mortality when compared with historical controls with a strategy of transportation to the closest hospital for fibrinolysis (LOE 3684; LOE 5685).

Four studies failed to show that a strategy of prehospital diagnosis and direct transportation for PCI was any better than prehospital fibrinolysis followed by early PCI in patients with STEMI (in systems involving the presence of physicians in mobile intensive care units) in reducing the composite outcome of death, nonfatal reinfarction, and nonfatal stroke at 30 days (LOE 1562,686,687; LOE 4555).

Three studies suggested a benefit of prehospital fibrinolysis (when coupled with an early invasive strategy) over that of PCI for patients presenting early after the onset of chest pain (less than 2 hours) and in certain clinical subsets (<65 years-of-age, anterior STEMI) in reduction of mortality (LOE 1688; LOE 4525,680).

Six studies comparing interfacility transfer for PCI with on-site ED fibrinolysis in STEMI patients diagnosed in the ED demonstrated improved outcomes, including the triple end point of death, reinfarction, and stroke at 30 days; and outcomes for 30-day survival alone and reinfarction alone supported the strategy of direct transport for PCI over fibrinolysis (LOE 5).527,530,690–693

Eleven studies demonstrated improved outcomes for patients diagnosed with STEMI in the prehospital setting and brought directly to PCI centers for PCI compared with STEMI patients diagnosed in the ED of a non-PCI hospital who were transferred for PCI (LOE 4115,676,678,694–700; LOE 5685). Clinical outcomes that were reported to improve with...
diversion for PPCI in this group included left ventricular function, in-hospital mortality, long-term mortality, and a triple end point of death, reinfarction, or stroke at 30 days.

Thirteen studies suggested equivalent outcomes between a strategy of transfer for PPCI and of fibrinolysis in the prehospital or hospital setting, particularly in patients presenting early after the onset of chest pain (<2 hours) and in certain clinical subsets (≤65 years-of-age, anterior STEMI) (LOE 2657;767; LOE 4405,450,456,487,701–707; LOE 552). Treatment Recommendations

It is reasonable to consider direct transport to PCI capable facilities for PPCI for patients diagnosed with STEMI by EMS in the prehospital setting, bypassing closer EDs as necessary, in systems where time intervals between first medical contact and balloon time are brief. In patients presenting early after the onset of chest pain (<2 hours) and in certain clinical subsets (≤65 years-of-age, anterior STEMI), prehospital fibrinolysis may offer similar outcomes compared to PPCI.

PCI Following ROSC

In patients with ROSC after cardiac arrest, does the routine use of PCI, compared with standard management (without PCI), improve outcomes (eg, survival, re-arrest, etc)? There is evidence of underlying ischemic heart disease in the majority of patients who have an out-of-hospital cardiac arrest (OHCA). Acute coronary artery occlusion is known to be the precipitating factor in many of these patients. While coronary artery occlusion after cardiac arrest is associated with ECG ST-elevation or left bundle branch block (LBBB), it can also occur in the absence of these findings. Fibrinolysis in setting of OHCA is addressed in Part 8: “Advanced Life Support.”

Consensus on Science

One study suggested that cardiac angiography and PCI, when used as part of a standardized advanced post–cardiac arrest protocol, may be associated with improved survival to hospital discharge when compared with no standardized protocol (LOE 3).208 Sixteen studies suggested that percutaneous intervention (PCI) was feasible following ROSC (LOE 3708; LOE 4709–724). These studies demonstrated that successful PCI versus no PCI may be associated with improved cardiac ejection fraction and survival,234 and coronary angiography may be favorably associated with neurologically intact survival.235 In most of the patients in these studies, immediate angiography and PPCI were performed.

Evidence from 2 studies suggested that outcomes after angiography and PCI vary considerably depending on patient-related factors (LOE 4).709,711 The survival in patients who had witnessed VF-arrests of short durations, STEMI, and one study showed that therapeutic hypothermia in combination with PPCI was feasible and safe in patients resuscitated after cardiac arrest (LOE 4).725 One study compared PCI with fibrinolysis and demonstrated no difference in functional neurologic recovery or survival at 6 months in patients with ROSC after cardiac arrest (LOE 4).726 Two additional retrospective case series (LOE 4726;727 compared outcomes of PCI in patients with and without cardiac arrest. One study compared 20 post–cardiac arrest patients who underwent PCI and mild hypothermia with a control group of 70 patients who underwent mild hypothermia without PCI. There was no difference in the rate of arrhythmias (the primary end point) or other adverse events between the 2 groups.727 In the other retrospective study728 of 948 STEMI patients without cardiogenic shock treated by PPCI, 20 were post–cardiac arrest. There was no difference in one-month mortality between the non-arrest (cardiogenic shock) group and the post–cardiac arrest group, but non-cardiac mortality was higher in the post–cardiac arrest group.728 Recent publications provide additional information about the survival and functional outcome of patients who have PCI following ROSC after cardiac arrest. One retrospective series (LOE 4729) of 98 post–cardiac arrest patients who had ECG evidence of STEMI and underwent emergent angiography included 59 patients who were unresponsive. The survival rate to discharge (and proportion of these with full neurological recovery) was 64% (92%) overall and 44% (88%) among the initially unresponsive patients.270 In a prospective observational registry (LOE 3729) of out-of-hospital cardiac arrest patients, (the Parisen Regional Out of hospital Cardiac Arrest Trial [PROCAT]), 435 patients had no obvious extracardiac cause and all underwent immediate coronary angiography, followed by PCI if indicated. At least one significant coronary artery lesion was found in 128 (96%) of 134 patients with STEMI on the ECG and in 176 (58%) of 301 patients without STEMI. In patients with a significant coronary lesion, PCI was successful in 99 of the 128 STEMI patients and in 78 of the 176 patients with other ECG patterns. Hospital survival was 40%. Multivariate analysis showed successful PCI to be an independent predictor of survival, regardless of the post-resuscitation ECG (odds ratio 2.06; 95% CI 1.16–3.66).730 Treatment Recommendations

In OHCA patients with STEMI or new LBBB on ECG following ROSC, early angiography and PPCI should be considered. It is reasonable to perform early angiography and PPCI in selected patients despite the absence of ST-segment elevation on the ECG or prior clinical findings, such as chest pain, if coronary ischemia is considered the likely cause on clinical grounds. Out-of-hospital cardiac arrest patient are often initially comatose but this should not be a contraindication to consider immediate angiography and PCI. It may be reasonable to include cardiac catheterization in a standardized post–cardiac-arrest protocol as part of an overall strategy to improve neurologically intact survival in this patient group. Therapeutic hypothermia is recommended in combination with primary PCI, and should be started as early as possible, preferably before initiation of PCI.

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### Disclosures

#### CoSTR Part 9: Writing Group Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be “significant” if (a) the person receives $10,000 or more during any 12-month period, or 5% or more of the person’s gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10,000 or more of the fair market value of the entity. A relationship is considered to be “modest” if it is less than “significant” under the preceding definition.

*Modest. †Significant.
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<td>None</td>
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This table represents the relationships of worksheet collaborators that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all worksheet collaborators are required to complete and submit. A relationship is considered to be “significant” if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person’s gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be “modest” if it is less than “significant” under the preceding definition.

*Modest.
†Significant.
### CoSTR Part 9: Worksheet Appendix

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<tr>
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<tr>
<td>ACS</td>
<td>ACS-002</td>
<td>In patients with ACS (P) does the presence of any specific demographic factors (eg. age, sex, race, weight) (I), compared with their absence (O), increase accuracy of prediction of delayed treatment (D)?</td>
<td>Demographic factors</td>
<td>Patrick Meyboom, Aaron Wong</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-002.pdf">http://circ.ahajournals.org/site/C2010/ACS-002.pdf</a></td>
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<td>ACS</td>
<td>ACS-003B</td>
<td>In patients with suspected ACS (P), does dispatcher guided administration of aspirin by bystanders before arrival of EMS (I), compared with later administration of aspirin by paramedic or emergency department staff (O), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (D)?</td>
<td>Timing of aspirin administration</td>
<td>Brian J. O’Neil</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-003B.pdf">http://circ.ahajournals.org/site/C2010/ACS-003B.pdf</a></td>
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<td>ACS</td>
<td>ACS-004B</td>
<td>In patients with suspected ACS (P), does the presence of any specific factors (eg. history, examination, ECG, and/or biomarkers) or combination into a specific clinical decision rule (I), compared with standard care (O), increase accuracy of prediction of prognosis (eg. decision rule for early discharge) (D)?</td>
<td>Prognosis for discharge vs admission</td>
<td>William J. Brady, Dirk Mueller</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-004B.pdf">http://circ.ahajournals.org/site/C2010/ACS-004B.pdf</a></td>
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<td>ACS</td>
<td>ACS-005A</td>
<td>In patients with suspected ACS (P), does the use of chest pain observation units (I), compared with not using them (O), increase accuracy of to safely identify patients who require admission or specific management of CAD (D)?</td>
<td>Chest pain observation units</td>
<td>Chris Ghaemmaghami, Darren L. Walters</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-005A.pdf">http://circ.ahajournals.org/site/C2010/ACS-005A.pdf</a></td>
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<td>ACS</td>
<td>ACS-006-1A</td>
<td>In patients with suspected ACS (P), does the use of specific imaging techniques (eg. CT angiography/nuclear testing/ECG) (I), compared with not using them (O), increase accuracy of diagnosis (eg. of ACS) (D)?</td>
<td>Imaging techniques and diagnosis</td>
<td>Julian J. Owen, Karen Woolfrey</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-006-1A.pdf">http://circ.ahajournals.org/site/C2010/ACS-006-1A.pdf</a></td>
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<td>In patients with suspected ACS (P), does the use of specific imaging techniques (eg. CT angiography/nuclear testing/ECG) (I), compared with not using them (O), increase accuracy of diagnosis (eg. of ACS) (D)?</td>
<td>Imaging techniques and diagnosis</td>
<td>Hiroshi Nonogi</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-006-1B.pdf">http://circ.ahajournals.org/site/C2010/ACS-006-1B.pdf</a></td>
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<td>ACS-006-2A</td>
<td>In patients with suspected ACS (P), does the use of specific imaging techniques (eg. CT angiography/nuclear testing/ECG) (I), compared with not using them (O), improve outcome (eg. size of infarct, LV function, survival) (D)?</td>
<td>Imaging techniques and outcome</td>
<td>Julian J. Owen, Karen Woolfrey</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-006-2A.pdf">http://circ.ahajournals.org/site/C2010/ACS-006-2A.pdf</a></td>
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<td>ACS</td>
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<td>In patients with suspected ACS (P), does the use of specific imaging techniques (eg. CT angiography/nuclear testing/ECG) (I), compared with not using them (O), improve outcome (eg. size of infarct, LV function, survival) (D)?</td>
<td>Imaging techniques and outcome</td>
<td>Hiroshi Nonogi</td>
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<td>ACS</td>
<td>ACS-007B</td>
<td>In patients with suspected ACS in the prehospital, emergency department or in-hospital settings (P), can non-physicians (eg. paramedics and nurses) (I) accurately diagnose STEMI (O), when compared to physicians (O)?</td>
<td>Diagnosis of STEMI by non-physicians</td>
<td>Alan M. Craig</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-007B.pdf">http://circ.ahajournals.org/site/C2010/ACS-007B.pdf</a></td>
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<td>ACS</td>
<td>ACS-008A</td>
<td>In patients with suspected ACS (P), does the use of computer-assisted ECG interpretation (I), compared with standard diagnostic techniques (emergency physicians) (C), increase accuracy of diagnosis (eg. of NSTEMI/STEMI) (O)?</td>
<td>Computer-assisted ECG interpretation</td>
<td>Judith Finn</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-008A.pdf">http://circ.ahajournals.org/site/C2010/ACS-008A.pdf</a></td>
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<td>ACS</td>
<td>ACS-009A</td>
<td>In patients with suspected ACS (P), do any specific techniques (I), improve ACS/MI system or process of care compared with standard management (C), to improve time to treatment and clinical outcome (O)?</td>
<td>Improving systems of care for ACS</td>
<td>Teresa R. Camp-Rogers, Michael C. Kurz</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-009A.pdf">http://circ.ahajournals.org/site/C2010/ACS-009A.pdf</a></td>
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<td>ACS</td>
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<td>In patients with ROSC after cardiac arrest (P), does the routine use of PCI (I), compared with standard management (without PCI) (O), improve outcomes (eg. TBO survival/re-arrest/etc) (D)?</td>
<td>PCI following ROSC</td>
<td>Terry Vander Heek</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-010A.pdf">http://circ.ahajournals.org/site/C2010/ACS-010A.pdf</a></td>
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<td>In patients with ROSC after cardiac arrest (P), does the routine use of PCI (I), compared with standard management (without PCI) (O), improve outcomes (eg. TBO survival/re-arrest/etc) (D)?</td>
<td>PCI following ROSC</td>
<td>Darren L. Walters</td>
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<td>ACS</td>
<td>ACS-011</td>
<td>In patients with suspected ACS in various settings (eg. prehospital, emergency or in-hospital) (P), do specific historical factors, physical examination findings and test results (I), compared with normal (C), improve accuracy of diagnosis ACS and MI (O)?</td>
<td>Accuracy history and PE for diagnosing ACS and MI</td>
<td>Hans-Richard Arntz, Peter T. Morley, Darren L. Walters</td>
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<td>ACS</td>
<td>ACS-013B</td>
<td>In patients with suspected ACS in various settings (eg. prehospital, emergency or in-hospital) (P), do abnormal protein markers, compared with normal levels (C) allow the clinician to accurately diagnose acute coronary ischemia? (D)?</td>
<td>Protein makers of coronary ischemia</td>
<td>Steve Lin, Hiroyuki Yokoyama</td>
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<td>In patients with suspected ACS in various settings (eg. prehospital or emergency) (P), does the use of prehospital or emergency 12 lead ECG (I), compared with other diagnostic techniques (C), increase sensitivity and specificity of diagnosis of ACS/MI (O)?</td>
<td>12 lead ECG</td>
<td>Marc J. Claeys, Dirk Mueller</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-014.pdf">http://circ.ahajournals.org/site/C2010/ACS-014.pdf</a></td>
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<td>ACS</td>
<td>ACS-015</td>
<td>In patients with suspected ACS in various settings (eg. prehospital, emergency or in-hospital) and normal oxygen saturations (P), does the use of supplemental oxygen (I), compared with room air (C), improve outcomes (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Supplemental oxygen</td>
<td>Kimberly A. Shelging, Nicos R. Van de Veire</td>
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<td>ACS</td>
<td>ACS-017</td>
<td>In patients with suspected ST-elevation myocardial infarction in the prehospital and emergency department setting (P) treated with fibrinolytics, does the use of new anticoagulants (I), compared with standard management (unfractioned heparin) (C), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Anticoagulants and STEMI</td>
<td>Hans-Richard Amtz, Michelle Welsford</td>
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<td>ACS</td>
<td>ACS-017-2</td>
<td>In patients with suspected ST-elevation myocardial infarction in the prehospital and emergency department setting (P) to be treated with primary PCI, does the use of new anticoagulants (I), compared with standard management (unfractionated heparin) (C), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Anticoagulants plus PCI</td>
<td>Hans-Richard Amtz, Michelle Welsford</td>
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<td>ACS</td>
<td>ACS-017-3</td>
<td>In patients with suspected non-ST-elevation ACS in prehospital and emergency department settings (P), does the use of new anticoagulants (ie. pentasaccharide, enoxaparin, bivalirudin (I), compared with standard management (unfractionated heparin or other anticoagulant) (C), improve outcome (eg. mortality, reinfarction, bleeding) (O)?</td>
<td>Anticoagulants and non ST-elevation ACS</td>
<td>Hans-Richard Amtz, Michelle Welsford</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-017-3.pdf">http://circ.ahajournals.org/site/C2010/ACS-017-3.pdf</a></td>
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<td>ACS</td>
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<td>In patients with STEMI in the prehospital setting (P), does the use of prehospital fibrinolytics (I), compared with in-hospital fibrinolytics (C), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Prehospital fibrinolytics for STEMI</td>
<td>Dirk Mueller, Valeria Rac</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-018B.pdf">http://circ.ahajournals.org/site/C2010/ACS-018B.pdf</a></td>
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<td>ACS-019A</td>
<td>In patients with non-ST elevation ACS/STEMI and fibrinolytic/ suspected STEMI and PCI in prehospital and emergency department settings (P), does the use of clopidogrel (I) compared with standard management (ie. no prehospital or ED use of clopidogrel (I) or new thienopyridines, prasugrel) (II) compared to clopidogrel (C), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Clopidogrel (and similar drugs) and non-ST elevation ACS</td>
<td>Michelle Welsford</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-019A.pdf">http://circ.ahajournals.org/site/C2010/ACS-019A.pdf</a></td>
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<td>ACS</td>
<td>ACS-019B</td>
<td>In patients with non-ST elevation ACS/STEMI and fibrinolytic/ suspected STEMI and PCI in prehospital and emergency department settings (P), does the use of clopidogrel (I) compared with standard management (ie. no prehospital or ED use of clopidogrel (I) or new thienopyridines, prasugrel) (II) compared to clopidogrel (C), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Clopidogrel (and similar drugs) and non-ST elevation ACS</td>
<td>Ian Jacobs, Christian SpaULDING</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-019B.pdf">http://circ.ahajournals.org/site/C2010/ACS-019B.pdf</a></td>
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<td>ACS</td>
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<td>In patients with suspected ACS/MI in prehospital and emergency department settings (P), does the use of IIB/IIIa inhibitors (I), compared with standard management (C), improve outcome (eg. chest pain resolution, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>IIB IIIa inhibitors</td>
<td>Hans-Richard Amtz, Venu Menon</td>
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<td>In patients with suspected ACS/MI in prehospital and emergency department settings (P), does the use of Prophylactic Antiarrhythmics (I), compared with standard management (ie. no Prophylactic Antiarrhythmics) (C), improve outcome (eg. arrhythmias, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Prophylactic Antiarrhythmics</td>
<td>Joseph P. Ornato, Peter T. Morley</td>
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<td>ACS</td>
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<td>In patients with suspected ACS/MI in prehospital and emergency department settings (P), does the use of Prophylactic Antiarrhythmics (I), compared with standard management (ie. no Prophylactic Antiarrhythmics) (C), improve outcome (eg. arrhythmias, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Prophylactic Antiarrhythmics</td>
<td>Russell Demman</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-021B.pdf">http://circ.ahajournals.org/site/C2010/ACS-021B.pdf</a></td>
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<td>In patients with suspected ACS/MI in prehospital and emergency department settings (P), does the use of ACE inhibitors (I), compared with standard management (ie. no prehospital and emergency department use of ACE inhibitors) (C), improve outcome (eg. infarct size, survival to discharge, 30/60 d mortality) (O)?</td>
<td>ACE inhibitors</td>
<td>Deborah Diencks</td>
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<td>ACS</td>
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<td>In patients with suspected ACS/MI in prehospital and emergency department settings (P), does the use of beta-blockers (I), compared with standard management (ie. no prehospital and emergency department use of beta-blockers) (C), improve outcome (eg. arrhythmias, infarct size, ECG resolution, survival to discharge, 30/60 d mortality) (O)?</td>
<td>Beta-blockers</td>
<td>Gilbert Felissa Filho, Dawn Yee Lim</td>
<td><a href="http://circ.ahajournals.org/site/C2010/ACS-023A.pdf">http://circ.ahajournals.org/site/C2010/ACS-023A.pdf</a></td>
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initial coronary flow and early ST-segment resolution in patients with

pharmacological facilitation with glycoprotein IIb/IIIa inhibitors in
diabetic patients undergoing primary angioplasty for STEMI. A subanal-
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size, improved LV function and lower incidence of heart failure: results
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**Key Words:** acute coronary syndrome ■ fibrinolysis ■ non-ST-segment elevation acute coronary syndromes ■ percutaneous coronary intervention ■ STEMI