Defining and optimizing quality of care have become national priorities. Quality improvement may be viewed as “systematic, data-guided activities designed to bring about immediate improvements in health care delivery, in particular settings” [1]. In health care, this relies on collecting, measuring, and reviewing data on performance; assessing adherence to established evidence-based indicators; assuring and monitoring that systematic processes of care that are ideally linked to improving outcomes are implemented; and modifying practice patterns, processes, and systems and deploying tools to improve performance. Because the increased use of evidence-based medical therapies over the past twenty years has accounted for approximately half the decline in cardiovascular mortality during this period [2], the goal of any coordinated quality improvement initiative is to assure that outcome-driving therapies are applied reliably and consistently.

The present era of evidence-based cardiac care is supported by the American College of Cardiology (ACC) and American Heart Association (AHA) practice guidelines, performance measures, standard measurement sets, appropriateness and competency statements, and primary and secondary preventative guidelines [3], with major emphasis on global risk reduction [4]. Translating the guidelines and applying evidence-based therapies into relevant clinical practice is the next link in the quality improvement continuum. A major focus of quality management is based on risk assessment, and applying appropriate evidence-based therapies and technology.
The past 10 years have seen the science of evidence-based quality improvement grow, the application of system and process redesign, the incorporation of industrial models into clinical quality improvement [5], and the influence of external forces contributing to improving quality of care. Compliance with performance measures now is required by the Centers for Medicare and Medicaid Services (CMS) [6] and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) [7]. Performance measures and mortality rates for acute myocardial infarction (AMI) and heart failure (HF) are posted on the hospital compare Web site [8]. Public reporting and pay for performance programs have become established as means to improve the quality of care [9–11]. The National Quality Forum brings together consumers, employees, health plans, physicians, and professional societies to endorse quality measures [12]. Assuring quality medical care has become a major imperative of hospitals and physicians, with growing demands of accountability placed by the government, regulatory agencies, professional societies, and insurance and consumer groups. There is some evidence that reporting of adherence rates and processes of care and outcomes to the public and regulatory organizations and incentives lead to quality improvement [10,13–15]. A more recent study, however, showed that pay for performance was not associated with a significant improvement in quality of care or outcomes for AMI [11]. Adopting and applying the industrial model of system redesign and process reorganization has been used successfully in numerous high-profile local and regional quality improvement initiatives aimed at specific diseases [16–27]. The biggest challenge with regards to these programs has been inconsistent implementation, lack of reliable systems and mechanisms to overcome barriers to change, limited resources to obtain and feedback data, lack of sustainability and high costs required.

Improvement in the care and outcomes for the hospitalized patient with an acute cardiac disorder can be achieved by designing and aligning care processes and implementing tools that assure that the ACC/AHA Clinical Practice Guidelines are applied into practice [3,28]. The guidelines designate key treatment and evaluation priorities that define optimal care for cardiovascular patients with various conditions. They have been derived on the basis of the best available medical science. When applied at the site of care, therapeutic and diagnostic interventions backed by the strongest evidence of support lead to improved patient outcomes, and these comprise the ACC/AHA performance measures [29]. These condition-specific performance measures should be supported by strategies to assure and track their application. Feedback from the latter defines opportunities for quality improvement and achievement of higher quality of care. Data has emerged demonstrating direct and favorable links between the application of performance measures and improved clinical outcomes [30–38].

Much insight has been gained from multicenter registry studies (that measure and track performance, provide site-specific feedback and benchmark comparisons, and suggest quality improvement strategies for acute
cardiovascular conditions) [37–40] and numerous high-profile collaborative quality improvement initiatives regarding the characterization of successful quality improvements traits, practices, and interventions [17–28,41–45]. Traditional passive methods of facilitating guideline adoption such as continuing medical education (CME) lectures, education, and mailing of resources have not been very successful or of marginal benefit, especially when not coupled with an implementation plan [46].

The feasibility of implementing and measuring inpatient cardiovascular performance measures depends on the committed structure and systematic processes of care in place, especially those that embed guideline-based care, the quality improvement engagement skills (and passion) of the health care providers, and the reliability, relevance, sustainability, and use of data collection that documents and reports that the measures are applied. The transfer of clinical science to care is more effective and seamless if the information is evidence-based, clinically relevant, and applied by means of credible opinion leaders with academic detailing [42], and there is clinician buy-in. Although the science of implementing quality improvement is still in its infancy, very little evidence-based validation exists, and practicing physicians for the most part have not received formal education and are not very experienced in quality improvement methodology, a great deal of guidance and direction is provided by the ACC/AHA Practice Guidelines, Performance Measures and Data Standards, and numerous methodologies and tools have proven to be successful [3,28,44,45]. More work needs to be done in providing training and experience in translating guidelines into practice. In addition, despite authoritative and well-validated clinical practice guidelines, physicians are often reluctant or slow to incorporate these into practice because of lack of awareness of guidelines, incomplete understanding of the disease, lack of buy-in and consensus, personal preference and practice patterns, lack of data linking process application with improved outcomes, fear of reprisal if scorecard medicine is not followed, lack of dedicated resources to support quality improvement, relevance to their individual patients, and lack of incentives [47].

Application, documentation, and measurement of care defined by the performance measures have far-reaching implications beyond improved clinical outcomes and internal quality improvement—from the standpoint of credentialing and certification [7], consumer and external reporting of performance [3,10,48–51], reimbursement, pay for performance and financial incentives [9,10,13–15,52,53], and designation of centers of excellence to only those hospitals or practice settings that meet the standards [54]. There are growing demands of accountability by the government [6,55], regulatory agencies [7,56], professional societies [9,57], and consumer groups [12,48]. Therefore, reliable and failsafe methods to assure quality of care are being searched for, especially because the impact of financial incentives on improving care processes or outcomes has not been entirely consistent [9,11].

Research into effective quality improvement suggests that interventions that are simple, applied prospectively, led by physician champions and
opinions leaders, and guided by feedback of reliable, accurate, and clinically meaningful and relevant data, are the most successful [43]. The quality improvement process is sustainable if it involves sharing of ideas and resources, and identification and overcoming barriers between systems, especially when this is coordinated by the multidisciplinary teams that are engaged in the decision making and problem solving [28]. Focus always should be based on assuring that performance measures are applied reliably. All constituents and stakeholders need to be bonded by a shared mission.

The goal of this article is to summarize the indicators, processes, and dimensions of care that are linked to desired clinical outcomes of the most commonly encountered conditions in the acute cardiovascular care setting, and specifically, acute coronary syndromes and congestive HF. Additionally, it reinforces the concepts of best cardiovascular care practice and reviews some of the highly successful quality initiatives that have demonstrated a link between hospital process performance and outcomes. Particular attention is focused on the evidence-based treatments and diagnostic evaluation and processes of inpatient cardiovascular care, which lead to desired outcomes meaningful to patients and where available, provide physicians with the strategies and tools to be successful in translating scientific evidence into effective and rewarding care.

Performance measures

When defining performance for the most common hospital-based acute cardiac disorders, numerous guiding principles have been followed [29]. The core indicators must be the most reliable from the standpoint of assuring optimal care, based on the strongest evidence and easily interpretable and translatable. They should embrace numerous domains of care (therapeutic, diagnostic, patient education and engagement, and self-management and monitoring), measured reliably, and readily documented and fed back. A performance measure also needs to be one that is likely to be applied and widely accepted by physicians as clinically relevant [29]. Further credibility is derived if they are aligned with the CMS and JCAHO [58,59] and national performance measures and organizations developing quality standards. The processes of care must be linked to improved outcomes based on evidence and efficacy. The patient populations and dimensions of care need to be defined, reliable, and valid. In addition, there are numerous emerging care indicators and therapies supported by rapidly evolving clinical trial data. Although they do not fit precisely all the previously mentioned criteria, when applied in the day-to-day care of acutely decompensated cardiac patients, these emerging therapies lead to improved outcomes in subsets of patients. The acute care encounter is the best clinical setting to apply evidence-based secondary preventive therapies, as this has been shown to lead to sustainable compliance of evidence-based care after discharge [21,34,60–64].
A major impetus to the dissemination of practice guidelines and development of performance measures as a translatable science comes from multiple observations that have demonstrated that evidence-based treatments are underutilized across the entire spectrum of acute cardiovascular disorders [65–70]. Despite improvement in the management of acute coronary syndromes over time, which was associated with a significant reduction in the incidence of HF, stroke, myocardial infarction, and mortality, care was still less than optimal in hospitals participating in the Global Registry of Acute Coronary Events (GRACE) registry [36]. In order for hospital-based performance measures to be effective and useful for quality improvement, they need to be accepted and adapted by health care providers, applied and embedded into direct care with tools and care processes, and expected by administrative mandate and support. Self-monitoring of adherence rates will allow the systems to respond to deficiencies and develop and put into place corrective strategies, tactics and tools focused on assuring application.

**Acute coronary syndrome performance measures**

The set of performance measures targeted to patients who have ST segment elevation myocardial infarction and non-ST elevation acute coronary syndromes have been defined by ACC/AHA Task Force Writing Committees summarizing the diagnostic, therapeutic, and patient education engagement strategies and dimensions of care representing the strongest level of evidence and consensus [71]. The specific performance measures (which permit nonapplication if standardized contraindications are documented) and the time and setting domains in which they are applied, are:

- Administration of aspirin within 24 hours before or after hospital arrival and beta blockers within 24 hours after hospital arrival
- Low-density lipoprotein (LDL) cholesterol testing during hospital stay
- Prescription of lipid lowering medication (if LDL-C is greater than or equal to 100 mg/dL) at hospital discharge
- Prescription of angiotensin-converting enzyme inhibitor (ACE-I) or angiotensin receptor blocker (ARB) in patients who have left ventricular systolic dysfunction
- Prescription of aspirin and beta blocker at hospital discharge and smoking cessation counseling during hospital stay

Support for the use of additional potential performance measures is evolving rapidly, based on recent evidence-based clinical trials [72]. The role of upfront, high-dose clopidogrel has been established in the management of acute coronary syndromes [73,74]. Clopidogrel in ST segment elevation myocardial infarction has been linked to improved outcomes in patients treated with thrombolytic therapy and undergoing primary percutaneous coronary intervention [75,76]. Glycoprotein IIb/IIIa inhibitors are especially beneficial before cardiac catheterization in high-risk acute coronary syndrome patients.
and both clopidogrel and an intravenous GP IIb/IIIa afford additional benefit in patients with high-risk features or recurrent ischemic symptoms or if there is a delay to angiography [78]. An early invasive strategy is most appropriate for acute coronary syndrome patients presenting with high-risk features [79]. Anticoagulant therapy should be initiated as soon as possible after initial presentation with either unfractionated heparin or enoxaparin; acceptable options for anticoagulation have been expanded to include either bivalirudin (a thrombin inhibitor) or fondaparinux (factor XA inhibitor) based on the results of the Acute Catheterization and Urgent Intervention Triage Strategy (ACUITY) [80] and Organization to Assess Strategies in Acute Ischemic Syndromes (OASIS) 5 [81] studies, respectively. Intravenous beta blockers may be harmful in acute ST segment elevation myocardial infarction accompanied by HF or low output states or when the risk for congestive HF or shock is high [75]. It is appropriate to initiate oral beta blockers within the first 24 hours unless these conditions are present. Based on the Pravastatin or Atorvastatin Evaluation and Infection Therapy (PROVE-IT) trial [82], there is justification that lipid management (fasting lipid profile within 24 hours of admission and treatment with a statin if the LDL is greater than 70 mg/dL, in the absence of a contraindication) should be a performance measure. It makes good clinical sense to include dietary modification and referral to cardiac rehabilitation for all patients who present with acute coronary syndromes.

Heart failure

The ACC/AHA Inpatient Heart Failure Performance Measures were selected to drive the application of therapeutics and processes that increase the likelihood of optimal outcomes of hospitalized adult patients with HF and impaired systolic function [83]. As there is very little evidence-based support from appropriate and well-designed randomized controlled trials of the treatment and diagnosis of acutely decompensated HF (see the article by Nuenschwander and Baliga, in the previous issue of Critical Care Clinics), aligned performance measures have not been developed. Overall consensus was reached by the performance measurement committee on several inpatient measures, based on meeting criteria of favorable outcome linkage, applicability and measurability [83]:

- Documentation that left ventricular systolic function was assessed before arrival, during hospitalization or is planned after discharge
- Prescription of ACE-I or ARB at hospital discharge
- Prescription of warfarin in HF patients with chronic/recurrent atrial fibrillation
- Smoking cessation counseling
- Documentation of discharge instructions addressing activity guidelines, diet, discharge medication, follow-up appointment, weight monitoring and symptom recognition and response
Use of a comprehensive cardiovascular discharge document that imbeds the key indicators and processes of care has been shown to improve short- and long-term outcomes, morbidity and mortality, and readmissions [26,27,84–86]. As in acute coronary syndromes, there are numerous additional therapies in which there is reasonable and evolving evidence to recommend application for any patients who have systolic dysfunction HF. Appropriate therapies, based on strong clinical evidence supporting the criteria of the right thing to do, include:

- The equivalency of angiotensin II receptor blockers in patients who have systolic dysfunction [87,88], especially when ACE-Is are not tolerated
- Implantation of an internal cardiodefibrillator for primary prevention of stabilized ischemic and nonischemic cardiomyopathy with left ventricular ejection fraction less than 35% [89,90]
- Cardiac resynchronization therapy for refractory HF associated with left ventricular ejection fraction less than 30%, and clear-cut evidence of dysynchronous depolarization (as manifested by a QRS duration greater than 0.14) [91]

These life-sustaining therapies should be applied only in centers with expertise and capabilities to implant, monitor, and troubleshoot these devices.

Digoxin has been shown to improve clinical HF endpoints, left ventricular function, and functionality, but not mortality [92]; therefore, it may be an appropriate performance measure in systolic dysfunction. More recently, a fixed-dose combination of hydralazine and nitrates has been shown to make a significant impact on mortality and HF endpoints in African Americans with systolic dysfunction [93]. Two key studies have demonstrated the mortality, functional, and structural benefits of aldosterone antagonists in patients who have systolic dysfunction and HF [94,95]. Recently, however, concern has been raised regarding wide applicability of the results of unintended use, especially with regards to potential adverse effects [96].

Treatment with specific cardioselective beta blockers for patients with HF and left ventricular systolic dysfunction and specifically, carvedilol, metoprolol succinate, and bisoprolol, has been shown to reduce symptoms, improve clinical and functional status of patients, increase left ventricular ejection fraction, and reduce the risk of death and hospitalizations [97–102]. Most patients, even with the traditional exclusion criteria, can be treated safely with beta blockers, which are tolerated well in most clinical situations. Although there is no guideline recommendation for the initiation of beta blocker in the inpatient setting, it is recommended that one of the HF-specific beta blockers be started when patients are clinically stable [83].

There are no performance measures for the treatment of HF with preserved left ventricular systolic function; the angiotensin II receptor blocker Candesartan has been shown to reduce hospitalization for HF based on the Candesartan in heart failure: assessment of reduction in mortality and morbidity (CHARM) study [103]. It is clinically intuitive to treat ischemia,
hypertension, and obesity; control the rate response to atrial fibrillation, improve chronic kidney disease; and reduce fluid overload in patients with HF and preserved systolic function present. Reversing such factors as anemia, renal insufficiency, hypothyroidism, and obstructive sleep apnea may impact favorably on HF functional endpoints.

**Ventricular arrhythmias, sudden cardiac death, atrial fibrillation**

Recently, the AHA, ACC, and European Cardiology Society jointly published a practice guideline on ventricular arrhythmias and sudden death [104] and an update of the atrial fibrillation guidelines [105]. The development of aligned performance measures is in progress. The management of atrial fibrillation is covered in detail in the previous issue of *Critical Care Clinics*.

**Hypotension**

Hypotension is a commonly encountered acute problem in patients admitted to cardiac care units and encompasses numerous primary cardiac disorders and/or decompensation of associated comorbid conditions. There are no practice guidelines or comprehensive algorithms to guide the practicing physician with a rapid and effective approach to the patient with hypotension (defined as persistent blood pressure less than 90 despite fluid challenge). Additional insight regarding this topic is available in the article on cardiogenic shock in the previous issue of *Critical Care Clinics*.

The top 10 causes of hypotension in the acute cardiac care setting include hypovolemia, bleeding (especially after invasive procedures and interventions), cardiogenic shock resulting from a large myocardial infarction (involving greater than 40% of myocardium), mechanical valvular defects (acute ventricular septal defect and mitral insufficiency), cardiac rupture, pericardial tamponade, right ventricular infarction, aortic dissection, large pulmonary embolization, pneumothorax, endocarditis with acute valvular insufficiency, and sepsis. Adrenal insufficiency rarely if ever is encountered as a primary hypotensive producing disorder in the acute cardiac care setting.

The diagnostic and management approaches to hypotension require a rapid clinical assessment and algorithm checklist to rule out the previously mentioned potential etiologies. The presence of hypotension should be confirmed manually and if there is any question as to its reliability (because of local factors or constricted extremities), and especially, if ongoing hemodynamic monitoring is required, an invasive arterial line should be placed. Volume status should be assessed based on physical examination focusing on skin turgor, fullness and pattern of neck veins, presence of edema, and rales. A very pale skin color is often a reliable sign that the patient is bleeding. If hypotension occurs after an invasive procedure, the site of access and
surrounding tissue should be examined for hematoma or retroperitoneal bleed. If there is any question of hemorrhagic shock, stat hemoglobins should be obtained and followed serially; a careful and targeted investigation for the source of bleeding needs to be implemented. If the etiology of the hypotension is uncertain, then an electrocardiogram should be performed along with a stat echocardiogram. An echocardiogram will provide an indicator of intravascular volume and rapidly assess left ventricular function, right ventricular involvement, segmental wall motion abnormalities, valvular insufficiency, pericardial compromise, possible dissection, and prominent right-sided chambers in the setting of acute massive pulmonary embolization. The role of B-Natriuretic Peptide (BNP) testing in cardiac-mediated hypotension has not been defined. Sepsis should be considered in any patient who has hypotension, fever, and elevated white count. As both tachycardias and bradycardias can lead to hypotension, these should be reversed rapidly. As there is a shift in the placement of invasive therapeutic and diagnostic lines to the subclavian site because of concern of infection, it is expected that the risk for pneumothorax may increase. Hypotension after placement of such a line requires a rapid clinical and radiographic approach to rule out pneumothorax. The diagnosis and management of cardiogenic shock and aortic dissection are covered in detail by Gurm and Bates and Kamalakannan and colleagues in their articles in the previous issue of *Critical Care Clinics*. The diagnosis and management of pulmonary embolization is beyond the scope of this article, but is reviewed briefly in the article on CT imaging of acute thoracic cardiovascular emergencies by Chughtai and Kazerooni in the previous issue of *Critical Care Clinics*.

The management of hypotension is based on appreciation of the etiologies and understanding of the pathophysiological consequences. Once hypotension is defined, the patient is assessed clinically, and potential etiologies are defined; specific targeted interventions can be applied in an intuitive, practical and orderly fashion. A rapidly reversible mechanical process needs to be defined thoroughly and reversed; therapies must be targeted to reversing the precise pathophysiology and preventing deterioration of the hemodynamic status and its consequences, along with applying specific pharmacotherapies. The role of hemodynamic monitoring and tailored targeted therapy has been controversial, with the only benefit demonstrated in the management of acutely decompensated HF [106]. Based on numerous randomized controlled studies, the role of pulmonary artery catheters in the critical care setting to improve clinical outcomes has not been established [107], and numerous retrospective, case-matched observational studies suggested the possibility of adverse outcomes with the use of the catheter [108–110]. The modes of action, clinical situations for, dosing of, and potential adverse reactions of specific pharmacological agents to treat hypotension are beyond the scope of this article, especially because the effectiveness of these therapies is based mostly on empiric observation rather than based on large, randomized controlled trials.
Quality improvement initiatives to optimize care and outcomes in acute cardiac care

Since 1987, the northern New England Cardiovascular Disease Study Group, a voluntary, regional consortium, has pioneered multidisciplinary and collaborative efforts to improve the care of patients who have cardiovascular disease [111]. The core strategies of this collaborative effort have been to assure that key stakeholders are at the table; there is internal confidential review of quality-assured, relevant, concurrent, and accurate data; and reliable study design is in place with appropriate statistical analysis. Feedback of data must be timely, and data continuously are updated to assure reliability of outcomes assessment and benchmark comparison. By providing training and dedicated experience in quality improvement, multidisciplinary teams map the dimensions, processes, and organization of patient care, and based on reliable data feedback, use the latter to direct quality improvement opportunities and activities. The collaborative has been very successful in improving the outcomes of coronary artery bypass surgery and percutaneous coronary intervention, and identifying predictors of outcomes [112].

There has been increasing emphasis on the promotion of quality of care, especially in high-profile cardiac conditions such as AMI and HF. Multiple government and regulatory agencies (CMS), the ACC and the AHA, accreditation organizations (JCAHO), and payors have defined performance and process of care measures (with the expectation of link to quality), and as emphasized before, the publishing of these measures has formed the basis for public reporting, certification, reimbursement, center of excellence designation, pay for performance/participation, and influencing referrals.

Quality improvement in ACS

Multiple clinical trials of acute coronary syndromes have identified the best management strategies resulting in improved clinical outcomes, which have been incorporated into the ACC/AHA practice guidelines [3,72]. Despite favorable secular and temporal changes in medical practice, however, the expected seamless translation of the recommendations to actual care has not been realized fully. Reperfusion and other lifesaving therapies often are underutilized and not timely [33,65–70]. Observational and registry studies suggest that hospital-applied guideline care in the management of acute coronary syndromes is less than ideal, and multiple structural, process and patient-related disparities exist [37–39,112–126].

The Cooperative Cardiovascular Project demonstrated that the care of patients with AMI could be improved by motivating participating hospitals in four states to develop quality improvement plans based on performance feedback [17]. After data feedback by the peer review organization, there was significant and sustainable improvement in the application of acute and discharge quality AMI indicators in the targeted states compared with
controls and the patients who had AMI in nonintervention states, and this translated into lower mortality [18]. In 1998, Soumoir and colleagues demonstrated the effectiveness of local opinion leaders on AMI care [42]. These quality champions were expected to review the key evidence and baseline performance with their peers, address barriers to change, and develop action plans to improve hospital-based care. As a result of the interventions, acute use of aspirin and beta blockers for elderly AMI patients improved significantly in the intervention hospitals compared with the control hospitals.

Lessons learned from these studies include the pivotal role of high-quality, reliable and clinically relevant performance data, the value of opinion leaders and peer review organizations, and the need to implement dedicated and focused quality improvement action plans and systematic changes in care processes. Enormous resources, however, are needed to conduct quality improvement projects reliably and consistently. Given the temporal and secular changes in practice, the spontaneous infusion of evidence-based medicine, the impact of pharmacological drug detailing, simultaneous internal attempts at quality improvement, and reliance on historical and observational matched controls, only a true randomized controlled trial of a quality improvement intervention can prove that an intervention leads to improved process implementation and outcomes of care.

Expanding on the success of the Cooperative Cardiovascular Project, Ellerbach and colleagues [19] provided hospital-specific performance, aggregate and statewide data to multiple hospitals in Iowa and then requested that the hospitals work with their peer-reviewed organizations (PROs) to develop plans to improve the care of patients who had AMI. Quality of care improved in most AMI quality indicators, especially in those hospitals that implemented systematic care improvements (eg, educational activities, physician leaders, standard order sets, clinical pathways) and audited their own performance. Although this study lacked a true control group and focused only on process rather than outcome measures of quality, it established that quality-improving activities supported by a peer review organization are associated with improvement in the quality of AMI care.

Implementation of an institutional multifactorial quality improvement project directed at health care providers and patients translated into high adherence to AMI quality-of-care indicators [127]. The key quality improvement strategies consisted of numerous tools, including a critical pathway, a standardized care map incorporating and embedding AMI guideline-recommended care into the care itself, a predischarge patient education and compliance tool, monthly lectures to house staff of AMI care priorities, and a pocket guideline. The patient education tools served as a reminder to health care providers to prescribe and document discharge care and contracted patients into their own care. Use of these tools achieved near ideal performance.

On the basis of this and studies focusing on improving the care of patients who have AMI, an inventory of tools, interventions and strategies
has been applied and tested as change packages with varying degree of success and linkage to improved outcomes. These tools, interventions, and strategies are listed in Box 1.

After implementation and/or adoption of some and often many of these strategies, collaborative multifaceted quality improvement usually leads to modest improvement in some but not all indicators, with the most successful results in those indicators with the lowest adherence rates at baseline and some of the nonmedication indicators such as smoking cessation and referral to cardiac rehabilitation. As the use of these quality-driving tools has been less than ideal, even in high-profile projects, demonstrating the link between the implementation of the interventions with improved clinical outcomes has not been entirely consistent across all indicators.

Registry studies

Since 1990, numerous acute coronary syndrome registries and specifically, National Registry of Myocardial Infarction (NRMI), Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the ACC/AHA Guidelines (CRUSADE), and GRACE, have collected data on demographics, clinical presentations and characteristics, temporal trends in practice patterns, processes of care,

<table>
<thead>
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<th>Box 1. Tools, interventions, and strategies tested as change packages</th>
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<tr>
<td>Reliable and consistent use of evidence-based clinical pathways</td>
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<td>Regular performance feedback and reports of guideline-derived process indicators</td>
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<td>Standardized order sets embedded with guideline-recommended care measures</td>
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<td>Multidisciplinary quality improvement action teams</td>
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<td>Providing education to health care providers</td>
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<td>Peer academic detailing and opinion leaders</td>
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<td>Physician decision support reminder systems</td>
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<td>Patient-focused instructions and self-management</td>
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<td>Wall charts and reminder tools (such as pocket cards and guidelines) to support adherence to guideline recommendations</td>
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<td>Check lists and chart stickers</td>
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<tr>
<td>Pharmacist-directed physician supports and patient education and self-management programs</td>
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<td>Electronic generated discharge summaries with management targets</td>
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adherence to guideline-recommended therapies, and short-term outcomes of patients presenting with a full spectrum of acute coronary syndromes, with the intention of fostering quality improvement by means of data feedback on performance, regional and national benchmarking, and providing quality improvement recommendations, resources, and tools [37–39]. The link between implementing specific processes of coronary care, improving performance adherence, and better patient outcomes has been demonstrated amply in most database registry studies. A wealth of insight has been derived from analysis of the observational data in these registry quality initiatives. Adherence to guideline-recommended therapies is associated directly with improved clinical outcomes and reduced mortality; health disparities still exist, especially management gaps in treatment in females; elderly patients; patients who have chronic kidney disease, diabetes, and HF; and certain ethnic groups, suggesting that specific customized and patient population-tailored quality improving tools need to be designed, implemented, and tested in prospective studies. Hospitals with mature and advanced processes of care and are more effective in implementing and using evidence-based tools adhere better and have better outcomes. Structural aspects of care associated with better performance have been defined, and specifically the size, type and academic status of the hospital (larger, teaching hospitals adhere better and have improved clinical outcomes) and the presence of interventional services and their degree of specialization; the importance of evidence-based dosing of medications in relation to safety, especially bleeding; and predictors of poor outcomes. Treatment by a cardiologist yields higher composite adherence rates. Although adherence to guideline-recommended care has improved over time, therapeutic opportunities still exist, especially with embedding the newer antithrombotic therapies into the care of the higher risk patient. As new therapies evolve and achieve evidence-based status, processes need to be in place and upgraded and stakeholders aligned, along with tools to assure that the new evidence-based therapies are integrated into the care.

**High-profile quality improvement initiatives**

A great deal of insight on how to implement an inpatient quality improvement project to improve the care of acute cardiovascular disease and decrease the disparity between guideline-recommended care and that which actually is delivered at the site of care has been derived from the ACC AMI Guidelines Applied in Practice projects [22,28,34,128–132], the AHA Get with the Guidelines program [23], and the Cardiac Hospitalization Arteriosclerosis Management Program (CHAMP) [21]. In 1999, the ACC embarked on the Guidelines Applied in Practice (GAP) program to design, implement, and conduct demonstration projects, with the expressed goal that by embedding the ACC/AHA AMI guidelines directly into the care of patients, the well-documented underutilization of guideline-recommended therapies would
be reversed and quality of AMI care improved. Many lessons have been learned from the successful completion of three key studies involving 33 hospitals in southeast Michigan [22,28,34,128–132]. Each project was founded on a high-profile partnership with the ACC (providing professional resources and expertise, funding, and support), the Michigan Quality Improvement Organization (quality improvement expertise and data collection and analysis), local businesses, insurance and health coalition forums (providing endorsement and external credibility to the project), and hospital-based multidisciplinary AMI Care teams (the driver of the projects). These teams were led by physician champions and project leads and focused on designing and implementing systematic processes of care to assure high use of tools embedded with and driving the key priorities of AMI Care. The projects targeted the health care providers and the patients. Rapid-cycle learning and sharing sessions nurtured and sustained the quality improvement initiative by engaging the teams directly and actively with the various phases of the project and namely, planning, implementation, monitoring tool use, measurement, and results [28]. Each of these phases was supported by a change package consisting of a collaborative learning and sharing session and overcoming barriers using a plan-do-study-act method of quality improvement, based on a modification of the Institute for Healthcare Improvement (IHI) Breakthrough Series [28,133]. The ACC GAP AMI projects in southeast Michigan demonstrated that rapid-cycle quality improvement could be achieved and when AMI-specific tools, and specifically standard order sets and a discharge document embedded with guideline recommended care are used, adherence rates for the core measures are increased [22,28,130–132]. Documented use of the discharge document was associated with a reduction in short- and long-term mortality [34]. Similar reductions in 1-year mortality were achieved by Fonorow and colleagues [21] and Lappe and colleagues [134] after implementing guideline-based discharge management programs in patients hospitalized for acute cardiovascular disorders. Correlates of high tool use include:

- Large teaching hospitals
- Highly engaged physician champions and project leaders
- Active involvement of the emergency department
- Strong administrative support for quality improvement
- Shared missions and goals for quality improvement
- Ability to successfully overcome barriers, especially physician resistance
- Unit leaders
- Multidisciplinary action teams
- Assuring that care processes are in place, especially electronic order and entry
- Feedback of high-quality data

Other key lessons learned were that hospitals were eager to participate in a high-profile partnership; they valued the support given, and collaborative quality improvement could be achieved.
One of the first studies to demonstrate the impact of process and systems change to improve adherence to evidence-based therapies was the University of California Los Angeles (UCLA) Medical Center’s CHAMP program [20,21]. By implementing care protocols, standard orders, and feedback to physicians in a single academic center, there was substantial improvement in application of aspirin, beta blocker, ACE-I, and lipid-lowering therapies. Compliance with long-term lipid-lowering therapy was driven by the high prescription at the time of discharge. Most importantly, the rates of death and recurrent myocardial infarction also were reduced significantly as a result of implementation of the program.

The AHA Get With The Guidelines program [23] is also a multihospital-based collaborative quality improvement program designed to increase adherence to secondary prevention guidelines by:

- Best practice/guideline review presentations
- Multidisciplinary team workshops strategizing implementation and overcoming barriers
- Physician champions
- Use of a customized tool kit of care protocols and standardized orders
- An interactive web-based management tool for data collection and feedback and prompt reminders of guideline recommended care

Participating hospitals have increased adherence to smoking cessation counseling, lipid management, and cardiac rehabilitation referral significantly, and maintained high adherence rates to the standard core measures.

With the insight gained from participation in the GAP projects, adherence rates to AMI core measures have been achieved at our institution. The author and colleagues conduct a monthly multidisciplinary AMI care committee, in which adherence rates to the core measures are reviewed along with variances and their root causes; in response to the latter, corrective actions are put into place. Resources and processes are in place to assure that standardized AMI order sets and a comprehensive cardiovascular discharge document embedding the core measures are applied reliably. Data feedback is given to practitioners, nursing staff, and members of the team. Patients admitted to the cardiac care units are reviewed concurrently on a daily basis by an aligned doctor of pharmacy to assure that evidence-based therapies are applied. Immediate correction of the care deficiencies is implemented. The primary care nurses are engaged by means of education regarding the core measures, and expectations are placed on them to review their own patients. In addition, specialized advanced practice nurses likewise assure that guideline treatments are applied by concurrent chart review in their role of providing discharge services to the physicians. Smoking cessation information packages are added automatically to the admission orders by the ward secretaries. In addition, there is alignment of the medical record coders regarding AMI diagnoses, and feedback is given regarding any missed opportunities. A daily hotline is printed of positive troponins, so that cases can be
reviewed and adjudicated concurrently and acted on accordingly. Physician queries are placed on the chart regarding care deficiencies, and physicians receive notification letters if there are any omissions of core measures. The charge nurses responsible for each of the units have a checklist worksheet to further assure that AMI core measures are applied both upon admission and at discharge. The most reliable intervention, however, has been holding the emergency department accountable. Whenever a troponin is drawn for whatever reason, there is a linked automatic prescription of aspirin and beta blockers unless contraindicated. As a result of these high-intensity initiatives, adherence rates are nearly 100% for all of the CMS-aligned performance measures.

The previously described prospective, methodological and observational approaches to quality improvement can serve as a model for any project in which the focus is to optimize the care of a cardiovascular condition. These high-profile initiatives have established the science of evidence-based quality improvement implementation.

Primary percutaneous coronary intervention has evolved as the preferred strategy for reperfusion of ST segment elevation-MI [135] and reducing time to treatment decreases mortality [136–138]. Based on this, the ACC/AHA guidelines have established a benchmark that primary percutaneous coronary intervention should be performed within 90 minutes [71]. Numerous observational and registry studies have identified key pre- and hospital-based strategies that result in shortened door-to-balloon (D2B) times [139].

Tier 1 strategies include:

- Empowering the emergency department to activate the cardiac catheterization laboratory (with prehospital EKGs improving times even further)
- Multidisciplinary team approaches to quality improvement with quality champions and a shared goal of reducing D2B times
- Single call to operator to activate the cardiac catheterization laboratory
- Cardiac catheterization laboratory staff and interventionalist readiness within 30 minutes
- Administrative support and aligned organizational culture
- Real-time performance feedback on D2B times with concurrent corrective action [139]

Guided by the ACC D2B alliance for quality [140], the author and colleagues have next focused our AMI quality improvement efforts on reducing D2B times, especially since expected times were not being achieved and there was wide variation in practice patterns among numerous highly qualified interventional cardiologists. Our tactics were the following: two simultaneous multidisciplinary teams meeting once a month, one being a 6-Sigma team reviewing timeline expectations and variances, and processing defects with recommended correction actions. The second was a monthly AMI care committee with the mandate to implement tier 1 and best practice strategies as
defined by the ACC Alliance for Quality. These efforts were led by fully engaged physicians and nursing quality champions. The emergency department physicians were empowered to activate the cardiac catheterization laboratory; parallel processing was put into place with expected timelines. A patient presenting to the emergency department with STE-MI was treated as a priority one (similar to a trauma patient). An AMI care kit was developed consisting only of aspirin, oral metoprolol, heparin bolus alone, clopidogrel, and standard orders, but no infusions that would require time to prepare. The author and colleagues carefully reviewed, modified, adapted, and implemented the ACC tools [140]; high expectations were placed on the emergency department, and buy-in was achieved from the interventional cardiologists regarding callback in 5 minutes of the emergency department page, being available in the catheterization laboratory within 30 minutes, and if unavailable, having a stand-in replacement found and designated by the catheter laboratory staff. Staff from the catheter laboratory and the clinical research coordinator are deployed to facilitate patient transfer to the catheter laboratory. In the event of any uncertain ECG diagnosis, the ECGs are faxed to a cardiologist for adjudicated review. The timelines of all STE-MIs are reviewed with concurrent feedback to all stakeholders, and 6-Sigma analysis is applied to correct any process or timeline breakdowns. The author and colleagues have submitted a grant to purchase electrocardiographic equipment for regional ambulances that can be used for wireless transfer of ECGs taken in the field, and to purchase text-pagers for covering cardiologists to respond to “code STEMI.” As a result of these interventions, there already are dramatic improvements in D2B times, with the institutional goal being 100% of STE-MI treated in less then 90 minutes.

Quality improvement in heart failure

As in acute coronary syndromes, the quality of care for patients admitted with HF is less than ideal, and adherence rates to the evidence-based guideline-derived performance measures [83] is suboptimal [141]. Many of the same interventions, system changes, and process improvement initiatives and tools that have been successful in improving the quality of care for patients who have acute coronary syndromes have been applied to hospitalized patients who have acute HF [26,27,64,141]. Clinical decision support reminders; academic detailing by means of opinion leaders; structured and Web-based education and collaborative seminars; evidence-based best practice algorithms; critical pathways; patient self-management strategies; process improvement care initiatives, and specifically, care paths, standard order sets and discharge documents and checklists; and real-time feedback on performance measures have been most successful. Improved clinical outcomes result when care for the HF patient is provided by hospitalists and cardiologists [141]. Data linking the application of guideline-based HF care with improving clinical outcome is less robust than with acute coronary syndromes, however.
There are no guideline-recommended therapies or performance measures for acutely decompensated HF, so much of the recommendations are based on consensus or from insight from registry studies. The Acute Decompensated Heart Failure National Registry (ADHERE) is a database registry of the characteristics, management, and outcomes of patients hospitalized with acute HF [141]. Much insight has been derived from observations in this database. Significant variation of care has been documented along with underutilization of guideline-recommended care. Early initiation of targeted acute decompensated HF therapy in the emergency department is associated with a shorter length of stay and less need for transfer to an ICU. Vasoactive therapy appears to be associated with a lower in-hospital mortality than with positive inotropic therapy, and treatment gaps persist, especially in women. Although high-risk predictors for poor outcomes have been defined, effective risk-stratified management strategies are lacking. This very robust registry has defined multiple opportunities to improve the quality of care for patients admitted with acute HF [141].

The Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients With Heart Failure (OPTIMIZE-HF) is a national, multihospital collaborative initiative to enhance application of guideline-recommended care and performance measures for patients hospitalized with HF [142,143]. Fonorow and colleagues [26], demonstrated that using a Web-based, patient data submission registry of patient characteristics, admission, hospital and discharge care, and outcomes, coupled with real-time feedback on performance measures and provision of standard process of care improvement tools, resulted in increased use of evidence-based therapies and adherence to performance measures, decreased length of stay in patients hospitalized with HF, and lower risk adjusted in hospital mortality. The use of process of care improvement tools was linked directly to the increased rate of adherence to the JCAHO Heart Failure Performance Measures, and was associated independently with reduction in hospital mortality.

By providing data feedback on a quarterly basis to multiple accredited hospitals, JCAHO demonstrated an improvement in adherence to HF performance measures [144]. Those hospitals with the lowest baseline performance showed the most improvement. Because these and many other quality improvement projects do not have the rigor of randomized clinical trials with a concurrent control group, improvements in the performance measures may have been influenced by secular trends, spontaneous improvement, and unmeasured confounding variables that were not evaluated. The degree of improvement in these before-and-after and observational studies, however, is consistent with improvement found in quality improvement projects that used either historical, concurrent or nonparticipatory controls and comparable to that of the GAP projects.

In addition to the standard performance measures, clinical indicators felt to be clinically relevant and measures of quality of care in the patient hospitalized with heart failure include: identifying the etiology of HF and
potential acute precipitants of HF; potentially deleterious agents to be avoided; assuring compliance with fluid and sodium restriction; reinforcing weight monitoring; and applying deep vein thrombosis prophylaxis. Extra cardiac factors that might be contributing to HF such as thyroid abnormalities, obstructive sleep apnea, fluid overload, anemia, uncontrolled rates in atrial fibrillation, chronic kidney disease, lack of exercise and inadequate blood pressure, blood sugar and lipid control likewise should be addressed.

Assessment of left ventricular ejection is pivotal in the management of HF because a depressed left ventricular ejection fraction should trigger the application of specific evidence-based therapy known to be lifesaving (as summarized in the performance measures section); specifically, an ACE-I or angiotensin-II receptor blocker, an aldosterone antagonist, and/or beta blocker (if the left ventricular ejection fraction is less than 40%) and consideration of referral for an internal cardio-defibrillator and/or chronic resynchronization therapy. Eligible patients should be provided warfarin in atrial fibrillation along with targeted rate control.

Guidelines regarding evidence-based therapies for acutely decompensated HF are lacking, and there are very few randomized controlled trials. As a result, performance measures have not been derived. As randomized controlled trials evolve, the impact of study therapies will need to be gauged on such outcomes as length of stay, cost of care, mortality, medical complications, short-term readmission, and impact of inpatient adherence to the performance measures on compliance with outpatient management of HF. Higher rates of adherence of secondary preventive, evidence-based HF therapies have been facilitated by use of the discharge document [26,27,86,145,146], having cardiologists involved in the care [141], and assessment of left ventricular function.

Factors associated with quality performance

The most influential study identifying the factors associated with successful cardiovascular quality improvement is that of Bradley and colleagues [43]. Using a qualitative evaluation method, hospitals that were most successful in improving rates to beta blocker use after myocardial infarction were surveyed. Four key characteristics were demonstrated: shared goals for improvement; substantial support from senior administrative leadership to design, implement, and sustain process improvement; engaged physician champions; and valid and credible data feedback on performance.

The relationship between patient and hospital characteristics, physician care, and performance improvement initiatives on quality of care indicators has been reviewed. Knowledge of those factors that are associated with high adherence to performance measures provide opportunities to focus quality improvement interventions, redesign processes of care, and reproduce successful structural components of care. The type, size, and teaching status
of hospitals; the volume of the specific disease diagnosis-related group (DRG); availability of interventional services and degree of specialization; care coordinated by a cardiologist; and strong collaboration with the emergency department have been the key structural components that have been linked to better performance. Numerous registry studies have highlighted significant geographic variation in application of evidence-based cardiovascular therapies, which is independent of most of the other factors [37–39,141]. This needs to be factored in when assuring the reporting of outcomes and targeting quality improvement efforts. Patients with high-risk characteristics, and therefore the ones who would benefit most from guideline-recommended therapies, are less likely to receive evidence-based treatments [38]. Hospitals with the poorest baseline performance show the greatest degree of improvement in their subsequent performance. Implementation of disease-specific computerized decision support systems into practice at time of care (such as physician order and entry embedded automatically into the discharge process for both AMI and congestive HF) has been shown to improve compliance with their respective performance measures. Prescription of medications at the time of discharge is the single most important predictor of long-term compliance. Although highly rated, benchmark hospitals (America’s Best Hospitals by US News and World Report and Solucient Top 100) have lower AMI and HF mortality, they have not scored consistently high in their composite score of use of life-saving therapies in cardiovascular conditions [113]. Participation in programs, projects, and initiatives designed to improve quality has been shown to promote the use of lifesaving treatments, but the extent to which the improvement is caused by the specific efforts is often uncertain. Public reporting and financial rewards are considered strong incentives to improve cardiac care measure compliance. The merging of quality core measures by CMS and JCAHO, which are aligned with the ACC/AHA performance measure, has allowed the streamlining of the process of data collection, and provides a strong incentive to identify gaps and correct them with quality improvement interventions. The relationship of direct involvement by statewide quality improvement organizations with their expertise in data collection and analysis and quality improvement consultation in facilitating quality improvement has been confirmed [147]. Partnership with the statewide PRO was felt to be a key factor in the success of the Cooperative Cardiovascular and AMI GAP projects [17,18,22]. Focused interventions of the CMS improvement organization recently have been supplemented with public reporting of provider performance [148]. Performance of specific hospitals on the core measures can be assessed by the public at www.hospitalcompare.com. Considerable variation exists in performance with the level of accreditation by JCAHO; hospitals accredited with accommodation were more likely to prescribe life-saving therapies and have lower mortality, but JCAHO accreditation has only a modest ability to assure quality of care [149]. The quality of cardiovascular care can be enhanced mostly by
performance feedback and focusing on implementing systematic processes and care tools that drive desired outcomes.

The physician as a quality champion

A physician caring for the hospitalized patient with an acute cardiovascular disorder can be effective as a quality champion by role modeling excellent practice outcomes and applying passion and enthusiasm to achieve high performance indicators. Knowledge of process design and implementation is crucial. To be effective as an opinion leader, the clinician needs to be knowledgeable of the ACC/AHA Practice Guidelines and Performance Measures, understand current processes and culture of the practice setting, and bring quality-improving skills, vision, and innovation to the bedside. One needs to be willing to devote time to the development and application of the quality improvement interventions. Specific roles include:

- Providing clinical direction and oversight of the projects
- Assuring that interventions and tools are evidence-based and applied and monitored reliably
- Being a virtual consultant and clinical resource to the quality improvement team
- Serving as an active participant on the multidisciplinary quality improvement committee.

Securing medical staff buy-in and engagement of administrative and senior leadership support are key ingredients for success. The latter is accomplished by advocating the advantages of participation (at medical staff meetings and one-on-one academic detailing) and specifically, success with quality audits; accreditation and certification; financial incentives; and high adherence to performance measures, which result in better patient clinical outcomes. Most importantly, consensus will drive standardized, best-practice processes of care. The effective Physician Quality Champion partners with the project lead of the quality action team to develop, adapt, and implement quality improvement initiatives and tools, assure that they are being applied and used, and that their use is being monitored. The physician leader should assist in monitoring the progress of the project, identifying and overcoming barriers, and facilitating consensus. Throughout the project, the physician leader should partner with stakeholders and seek support from regional health plans, payors, quality improvement organizations, professional societies, and community health coalitions.

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