Special Report

Has the Time Come for a National Cardiovascular Emergency Care System?

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In 2007, there were ≈4 million visits to emergency departments in the United States with a primary diagnosis of cardiovascular disease.[1] Current forecasts estimate that the direct medical costs for cardiovascular disease in the United States will triple by 2030 to $800 billion dollars.[2] Acute cardiovascular emergencies, including ST-segment–elevation myocardial infarction (STEMI), non-STEMI/unstable angina, out-of-hospital cardiac arrest (OHCA), acute aortic dissection (AAD), abdominal aortic aneurysm (AAA), stroke, and acute decompensated heart failure/cardiogenic shock, require rapid, complex, and resource-intensive care and confer a high risk of mortality. Regionalized systems of care enable patients with complex and urgent medical needs to be systematically directed to hospitals that can provide the highest level of clinical expertise and resources (ie, designated centers). Historically, trauma systems have used this paradigm with improved outcomes. There is a growing focus on regionalized medical care as a strategy to leverage limited resources, to manage cost, and to improve outcomes for other medical emergencies. National cardiovascular organizations have already published recommendations for the establishment of centers and regional systems of care for STEMI,[3–6] cardiac arrest,[7–9] and stroke.[10,11]

The purpose of this article is to propose the concept of a cardiovascular emergency system, ie, a comprehensive regional system of care for cardiovascular emergencies led by a designated cardiovascular emergency receiving center. Over the past decade, the Minneapolis Heart Institute at Abbott Northwestern Hospital (MHI-ANW) has implemented regional systems of care for STEMI,[12] OHCA,[13] AAD,[14] non-STEMI, and AAA. These initiatives provide a demonstration of the clinical programs and supportive network that reflect the burgeoning framework of a cardiovascular emergency system. Informed by this work, we discuss the historical perspective of, rationale for, and proposed principal elements of a cardiovascular emergency system.

Historical Perspective

Trauma systems are the prototype for regionalized systems of care in emergency medicine and provide a salient proof of concept. Systematic reviews and meta-analyses have demonstrated that trauma systems are effective[15–20] and that mortality from traumatic injuries is reduced 15% to 20% in the presence of designated trauma centers.[16,17] Similarly, time-sensitive therapies and well-coordinated resources are being effectively delivered to stroke patients via primary stroke centers,[21] comprehensive stroke centers, and emerging regional stroke systems[10,11] with documented reductions in 12-month case fatality in the presence of comprehensive stroke centers and primary stroke centers.[22]

In recent years, there has been significant progress in the formation of regionalized systems of care for specific cardiovascular emergencies. For example, because only 25% of US hospitals are capable of performing percutaneous coronary intervention (PCI), regional systems to improve timely access to PCI for STEMI have been proposed[4–6] and successfully implemented.[12] The American Heart Association has developed certification criteria for STEMI referral and receiving centers as part of its Mission: Lifeline initiative.[23] With regard to acute coronary syndrome (ACS) and acute decompensated heart failure, the Society of Chest Pain Centers has instituted designations for both chest pain centers and heart failure centers. Recent AHA consensus statements regarding regionalized care for cardiac arrest emphasize the need to increase rapid access to therapeutic hypothermia (TH),[7–9] and progressive cardiology centers are pioneering regional systems of care for resuscitation that focus on the delivery of this therapy.[13]

Rationale for a Cardiovascular Emergency System Designation

As evidence for regional systems of care for cardiovascular emergencies grows, the concept of a comprehensive cardiovascular emergency system provides a number of synergistic advantages. First, and fundamentally, it is reasonable to recognize networks that offer an extensive and integrated level of cardiovascular emergency care over those that provide care for only 1 or 2 conditions. Second, because the intersection of cardiovascular emergency protocols is com-

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Table 1. A Comprehensive System of Care for Cardiovascular Emergencies

Acute Coronary Syndromes	Resuscitation	Aortic Emergencies	ADHF and Cardiogenic Shock	Stroke
Clinical objective				
Protocol-driven risk stratification for diagnosis and treatment of chest pain syndromes	Standardized viability assessment and use of advanced resuscitation techniques	Rapid event recognition, stabilization protocols, and algorithms for definitive treatment	Severity assessment and comprehensive treatment, including mechanical circulatory support	Determination of symptom onset and candidacy for advanced thrombolytic or interventional therapies
Prehospital/EMS care				
Early ECG assessment Short scene time Aspirin	Mechanical compression Advanced airways Initiate cooling in unresponsive patients with ROSC	Early identification of CV emergency and rapid transport to appropriate facility	Nitroglycerin Advanced airways	Symptom recognition Determination of symptom onset Aspirin
Referring/network hospitals				
Appropriate triage of spectrum of chest pain syndromes Determine need, mode, and timing of transfer to receiving center	Continue/initiate cooling in unresponsive patients with ROSC Determine need, mode, and timing of transfer to receiving center	Symptom recognition Initial diagnostic imaging Hemodynamic management Facilitate rapid transfer to receiving hospital Protocol-driven medication management (continued en route)	Administration of inotropic agents, diuretics Respiratory stabilization Determine need, mode, and timing of transfer to receiving center	Diagnostic imaging and neurological assessment Initiate thrombolytic therapy as advised by tertiary center Appropriate rapid transport for thrombolytic or neurointerventional therapy
CV emergency center				
Emergent therapy for STEMI Urgent therapy for non-STEMI Coordination of short-term outpatient follow-up for nontransferred patients Certified chest pain center with network hospital affiliates	Protocol-driven therapeutic hypothermia and rewarming Comprehensive neurological assessment, monitoring, and rehabilitation Certified resuscitation center	Surgical and endovascular intervention for AAD, AAA, and critical limb ischemia Coordinated medical therapy and follow-up imaging	Comprehensive advanced circulatory support Heart transplantation Certified heart failure center	Protocol for transfer Neurointerventional radiology Certified stroke center

ADHF indicates acute decompensated heart failure; EMS, emergency medical services; ROSC, return of spontaneous circulation; CV, cardiovascular; STEMI, ST-segment–elevation myocardial infarction; AAD, acute aortic dissection; and AAA, abdominal aortic aneurysm.

mon, aggregation of systems in this clinical area is pragmatic. Medical management of these events is generally afforded by a common set of providers, and high volume coupled with effective cross-management of the spectrum of emergent cardiovascular events is important for optimizing outcomes. Third, a coordinated approach promotes efficiency via shared system infrastructure. A single system surveillance tool can guide quality improvement activities for several conditions, and instruction across an integrated emergency medical services (EMS) network can be streamlined by bundling training sessions for multiple protocols. Fourth, the pressure to control healthcare costs while improving quality requires restructuring our fragmented healthcare system to provide bundled care within developing payment models. And finally, the formal designation of a cardiovascular emergency system provides a tangible, public affirmation of a synergistic, high-quality set of systems of care for cardiovascular emergencies, and such an endorsement serves to increase visibility and credibility among referral hospitals, physicians, EMS agencies, and the community. As advanced tertiary centers begin to build collections of condition-specific systems for cardiovascular emergency care, it is prudent to consider the operational and fiscal advantages of designing these systems of care within the broader framework of a comprehensive cardiovascular emergency system.

Proposed Elements of a Cardiovascular Emergency System

The conceptual model for a cardiovascular emergency system is a series of clinical programs anchored by a cardiovascular emergency receiving center and fortified by an integrated network of partnered community hospitals and EMS providers, as well as a landscape of infrastructure elements that provide essential center- and system-level support. In this section, we propose a principal set of clinical programs that constitute the scope of cardiovascular conditions managed within a cardiovascular emergency system, with a matrix (Table 1) depicting how coordinated care for these events is provided across 3 domains: in the prehospital setting, in the emergency departments of network hospitals, and at the cardiovascular emergency receiving center. Key providers, therapies, approaches, and infrastructure elements of the system (Table 2) and receiving center (Table 3) are also introduced for consideration.

Clinical Programs

Acute Coronary Syndrome

ACS results in ≈610 000 emergency department visits in the United States annually.[24] Optimal care of the ACS patient includes prehospital recognition of early symptoms by EMS

Table 2. Key Elements of a Regional System for Cardiovascular Emergency Care

- Providers
  - EMS
    - Air and ground transport vehicle fleets and personnel (dispatchers, paramedics, EMTs)
    - Local first responders (law enforcement, firefighters)
  - Emergency departments at participating network hospitals
  - Centralized, tertiary cardiovascular emergency receiving center
- Approach to clinical care
  - Evidence-based, standardized protocols
  - Predetermined plan for mobilization of staff and work flow
  - Care coordination
    - Well-defined individual roles
    - Elimination of redundancies in care
    - Coordination among supporting clinical services (eg, laboratory, imaging)
  - Standardized transfer protocols
- Access and communications
  - Protocols activated by a single, 1-step communication
  - Immediate phone access between regional care teams and cardiovascular emergency receiving center
  - Rapid patient transport optimized by local protocols
  - Continuous communication during patient transport
  - Reporting templates for transfer of patient information between care teams
- Education
  - Community education (eg, campaigns for AED use, compression-only CPR, symptom recognition)
  - Provider education
    - Recognition of clinical signs and symptoms
    - Protocol training (eg, medications, appropriate diagnostics)
    - Established clinical criteria on the appropriateness of transfer
    - Conducted at all participating hospitals and transport bases
  - Patient education (eg, condition information, follow-up monitoring schedules)
- Quality
  - Established set of metrics for performance evaluation
  - Detailed analysis of outcomes, complications, and quality measures
  - Protocol improvement driven by system evaluation and new research
  - Performance review with referral hospital and transport team within 24 h of event
- Data management
  - Electronic health record system with regional interconnectivity capability
  - Registry for tracking patients and monitoring performance indicators
  - Transfer of diagnostic imaging between network hospitals via PACS
  - Emerging telemedicine technologies

EMS indicates emergency medical services; EMT, emergency medical technician; AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; and PACS, picture archiving and communications systems.

Table 3. Key Elements of a Cardiovascular Emergency Receiving Center

- Immediate access to specialty services
  - 24/7 Availability
    - Cardiologists (general, interventional, electrophysiology, advanced cardiac imaging)
    - Radiologist (immediate interpretation and consultation)
    - Intensivist
    - Hospitalist
    - Anesthesiologist
    - Neurologist
  - Within 30 min
    - Surgeons (cardiothoracic, vascular, transplant)
    - Heart failure specialist
    - LVAD coordinator
    - Neurointerventional radiologist
- Advanced therapies
  - Advanced percutaneous intervention
    - Coronary, endovascular, peripheral, cerebrovascular
    - Temporary percutaneous circulatory support (eg, Impella device)
  - Comprehensive cardiovascular surgery
    - Coronary artery bypass graft
    - Major vascular surgery (eg, ascending aorta, femoral bypass)
    - Valvular repair
    - Implanted LVAD as a bridge to transplantation/destination
    - Cardiac transplantation
  - Therapeutic hypothermia
  - Electrophysiology (eg, implantable cardiac defibrillators)
  - Comprehensive rehabilitation services
- Coordinated approach to care
  - Evidence-based standardized protocols
  - Multidisciplinary care teams
  - Communication with PCP (acute care results, discharge plan, follow-up recommendations)
  - Patient and family education around condition and monitoring
- Administration and oversight
  - Dedicated multidisciplinary committees to develop, direct, and monitor the center
  - Subspecialty-led clinical program directors
- Demonstrated leadership in research and clinical quality for cardiovascular emergency care
  - Outcomes and process analysis and continuous quality improvement programs
  - Participation in cooperative national registries
  - Peer-reviewed publications
  - Collaborative exchange with peer networks
  - Leaders in cutting-edge technologies and therapeutic approaches

LVAD indicates left ventricular assist device; PCP, primary care physician.

providers, appropriate triage, reperfusion therapy and monitoring in the acute care setting, and ultimately cardiac rehabilitation. Hospitals designated cardiovascular emergency centers will have a highly integrated system of care that achieves rapid transport of STEMI patients to the center for emergent PCI, efficient transfer of appropriate non-STEMI/unstable angina patients for early invasive PCI within 24 to 48 hours, and guideline-directed stress testing or computed tomographic coronary angiography for chest pain syndromes.

Formal accreditation of the receiving center ensures appropriate triage and treatment of the spectrum of chest pain syndromes.

Resuscitation

OHCA is a life-threatening event affecting nearly 295 000 Americans annually,[1] and ensuring broad, uniform access to state-of-the-art resuscitation therapies should be a primary focus of a cardiovascular emergency system. The most progressive resuscitation protocols will include techniques to augment the effectiveness of conventional cardiopulmonary resuscitation; TH after return of spontaneous circulation, including initiation of early cooling in the prehospital setting; and comprehensive neurological assessment and follow-up in survivors.

Aortic and Vascular Emergencies

Recently published inaugural guidelines on the diagnosis and management of AAD and AAA[25] highlight the challenges of detecting and managing these uncommon but catastrophic events. The guidelines underscore the need for improved symptom recognition, rapid use of appropriate diagnostic imaging to hasten definitive diagnosis, early hemodynamic control, and efficiencies to surgical intervention. Cardiovascular emergency systems will engage in system-wide provider education campaigns on risk factors and symptom recognition and implement standardized treatment protocols aligned with AHA/American College of Cardiology recommendations. The cardiovascular emergency receiving center will offer advanced surgical techniques for AAA, AAD, and acute limb ischemia.

Acute Decompensated Heart Failure/Cardiogenic Shock

Heart failure affects 5.8 million Americans, with total costs of $39.2 billion annually.[1] As the mortality for myocardial infarction declines and the population ages, the number of patients with advanced heart failure continues to increase, and heart failure now accounts for 1.1 million US hospital discharges per year.[1] Advanced heart failure with symptoms warranting urgent medical attention often requires hospitalization and advanced medical therapies such as ultrafiltration, inotropic and vasodilator management, and, in severe cases, mechanical circulatory support and cardiac transplantation. A cardiovascular emergency system will provide adept assessment of the severity of these episodes, with appropriate respiratory stabilization and rapid transport to the receiving center. The cardiovascular emergency center offers patients the most advanced short- and long-term surgical therapies, including implantation of mechanical circulatory support devices as a bridge to heart transplantation.[26]

Stroke

Stroke represents the leading cause of long-term disability and the third leading cause of death in the United States. Each year, there are >637 000 emergency department visits for stroke symptoms with total direct and indirect costs of $73.7 billion dollars in 2010.[1,24] The time-sensitive guidelines for thrombolytic therapy underscore the need for efficient diagnosis, direct access to neurology consultation, and a comprehensive treatment program that incorporates acute percutaneous intervention and ongoing speech and physical rehabilitation.

System Infrastructure

Criteria for a regional cardiovascular emergency system can be organized according to 6 distinctive features: (1) a network of collaborative providers; (2) a standardized, coordinated approach to high-quality care; (3) streamlined access to care and exchange of information; (4) effective delivery of provider, patient, and community education; (5) program monitoring and quality improvement activity; and (6) robust data management mechanisms, including integrated electronic systems (Table 2).

An organization of highly-trained providers in 3 care domains—the prehospital setting, the referral hospital, and the receiving center—is the foundation of the system, and these entities in concert provide lifesaving first response, early diagnostics and stabilization, rapid transport, and advanced tertiary care. Standardized, evidenced-based protocols and clearly articulated individual roles promote a coordinated and consistent approach to care. Importantly, event-specific protocols are activated within the system by a simple, multipoint notification mechanism that enables providers to mobilize and initiate care preparations, expediting patient transfer and receipt. Care teams have immediate and continuous access to specialists at the receiving center and use standardized templates to ensure the exchange of vital patient information. System-wide provider education focuses on symptom recognition, protocol training and adherence, and clinical guidelines for the appropriateness of patient transfer to the cardiovascular emergency center. Patients and families receive condition-specific education about disease management and follow-up care, and community education campaigns emphasize early warning signs and the importance of bystander intervention and EMS activation. The system is committed to capitalizing on emerging health information technologies to improve event communications, to promote electronic health record interoperability, to ensure consistent point-of-care clinical decision support, to monitor system quality, and to aid patients with Web-based health tools.

Prehospital Care

With direction from the cardiovascular emergency center and its program committees, EMS providers across the cardiovascular emergency system coordinate training and education around symptom recognition, critical early interventions, and prescriptive transport protocols based on specific patient and facility criteria. Effectuating a standardized EMS base across a cardiovascular emergency system presents a significant challenge, however. EMS agencies are notoriously underresourced, and the current milieu of EMS care across any broad geographic area is a collection of fragmented agencies with highly variable care models, resources, and competencies. Because EMS serves as the point of entry into the cardiovascular emergency system for the majority of patients, it is crucial to provide appropriate initial support as agencies

establish their membership with the system and to ensure the quality of system-related care going forward.

Referral Hospitals

Hospitals across the system are responsible for the assessment, stabilization, and initiation of standardized treatment protocols and for the rapid transfer of appropriate patients to the tertiary hospital. As with other systems of care, available staffing, facilities, and technology at network hospitals should dictate predetermined criteria and plans for patient transfer. In contrast to single-condition systems of care (eg, the Mission: Lifeline model for STEMI care), the evaluation and planning process for referral hospitals in a cardiovascular emergency system is further complicated by the need to develop and follow condition-specific transfer protocols for each of the clinical event types treated by the system. For example, a specific network hospital might be capable of optimally managing the majority of STEMI patients but might need to have transfer protocols in place for OHCA, cardiogenic shock, or AAD. Disease-specific committees across the system ideally would systematically assess and categorize network hospitals on the basis of resources and ongoing quality assessment. Clearly defined facility ratings for each condition and strong point-of-care decision support tools can assist in managing this complexity clinically, but the implications for reimbursement need to be elucidated further.

The Cardiovascular Emergency Receiving Center

The cardiovascular emergency center is the tertiary hospital that serves as the hub of the system, providing direction, oversight, education, infrastructure, resources, and, most important, the most advanced clinical care provided by the system (Table 3). Within the center, patients have immediate, 24-hour access to a range of specialty providers with expertise in emergent and chronic cardiovascular care and radiological interpretation. The receiving center must deliver state-of-the-art clinical care, including PCI, a full spectrum of cardiac and vascular surgeries such as mechanical support and cardiac transplantation, formal TH, electrophysiology, and comprehensive rehabilitation services.

In addition to technical excellence in cardiovascular care, hospitals with this distinction will assume responsibility for operationalizing, managing, and advancing the cardiovascular emergency system. Cardiovascular leadership at the receiving center will have core accountabilities for clinical program development and implementation, care coordination, affiliations with system providers, and scientific inquiry and dissemination. Each of the clinical programs of the system will be developed and monitored at the center by a multidisciplinary committee and program director. A highly coordinated care experience is achieved through the use of multidisciplinary care teams and evidence-based institutional protocols that both guide clinical decision-making and facilitate processes such as interprovider communications and patient/family engagement. The cardiovascular emergency center is responsible for forging critical partnerships with hospitals and EMS providers throughout the region and directing system-wide training and education. It is expected that cardiovascular researchers at the center will participate in consortium registries, will engage in collegial exchange with other cardiovascular emergency systems, and will be actively committed to the broader advancement of cardiovascular emergency care. The receiving center should be a regional leader in innovative health information technologies and use a suite of integrated electronic tools to enhance communications, to facilitate system surveillance, and to improve the quality of care.

Early Model of a Cardiovascular Emergency System: The Cardiovascular Emergencies Program at the Minneapolis Heart Institute

Overview

As a byproduct of longstanding relationships with a broad network of hospitals throughout the upper Midwest, MHI-ANW has formally defined a network of >50 community hospitals and clinics and >75 EMS agencies within a 500-mile radius of ANW to connect patients in the upper Midwest with the highest level of cardiovascular care. Initially constructed to support a regional STEMI system in 2003 (Figure 1), the network has cumulatively annexed protocols, training, and tool kits for AAD, non-STEMI, AAA, and TH after OHCA and has expanded to receive patients from the broader 5-state region. In this applied setting, the system frequently must manage patients presenting with multiple cardiovascular emergency diagnoses (Figure 2).

Treatment of ACS

In 2003, MHI-ANW implemented the Level 1 MI Program,[12] a coordinated regional system of care that provides the rapid transfer of patients with STEMI for primary PCI. The coverage area is divided into 2 zones to optimize reperfusion therapies based on the time to PCI (Figure 1). The initial results demonstrated rapid treatment times, high use of guideline-recommended medications, and an overall in-hospital mortality rate of 4.2%.[12] Currently, >3000 patients have been treated, and the framework of the Level 1 program has since been used to broaden the treatment of ACS through the development of a Level 2 protocol for urgent non-STEMI patients, and in 2008, ANW became an accredited Chest Pain Center. These care processes and protocols allow MHI-ANW to manage the entire spectrum of ACS.

Therapeutic Hypothermia

In 2006, MHI-ANW implemented Cool It, a transformational initiative that has improved survival and neurological recovery after OHCA by securing induced hypothermia as the standard of care for resuscitated cardiac arrest patients across Minnesota.[13] Cool It affords the rapid and coordinated transfer of patients to MHI-ANW for TH via an integrated network and the use of a standardized protocol that incorporates TH care elements across the course of care, from initial prehospital response to post-TH support. We recently reported the initial 140 TH patients who had a 56% survival to hospital discharge, and among those who survived, 92% experienced a return to normal or near-normal neurological functioning (Figure 3).[13]

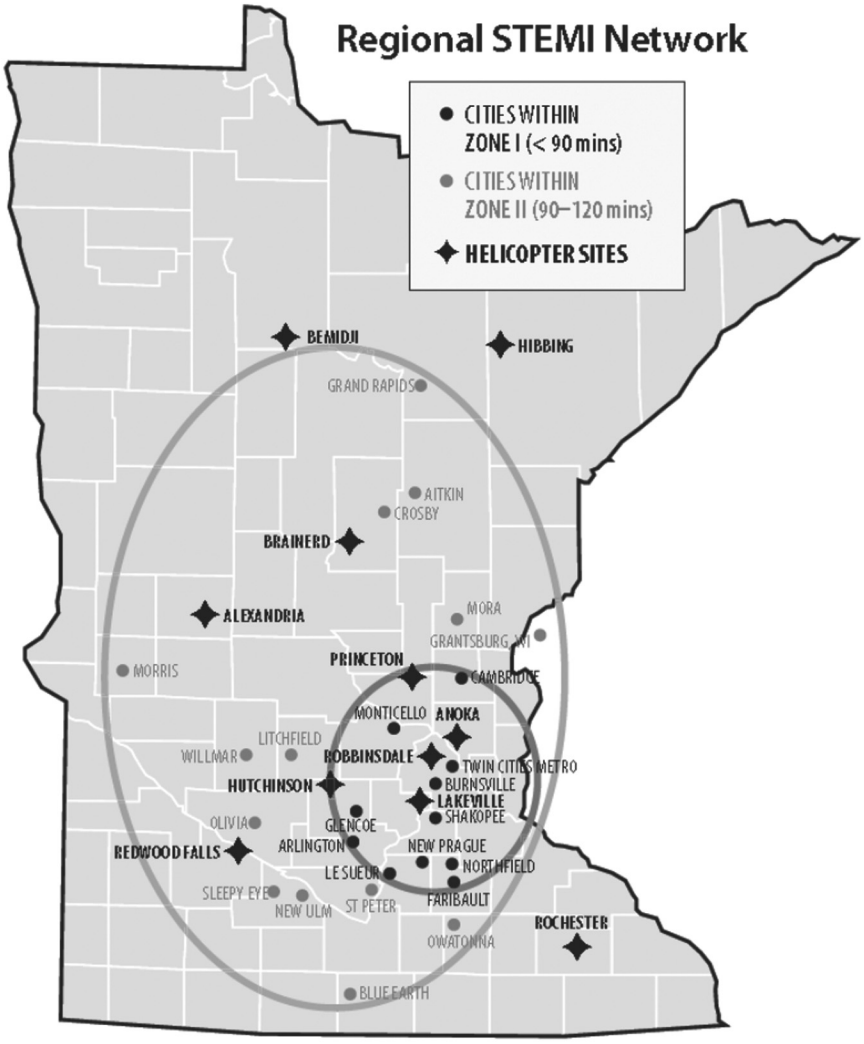


Figure 1. Minneapolis Heart Institute regional ST-segment–elevation myocardial infarction (STEMI) network coverage area.

Treatment of Aortic/Vascular Emergencies

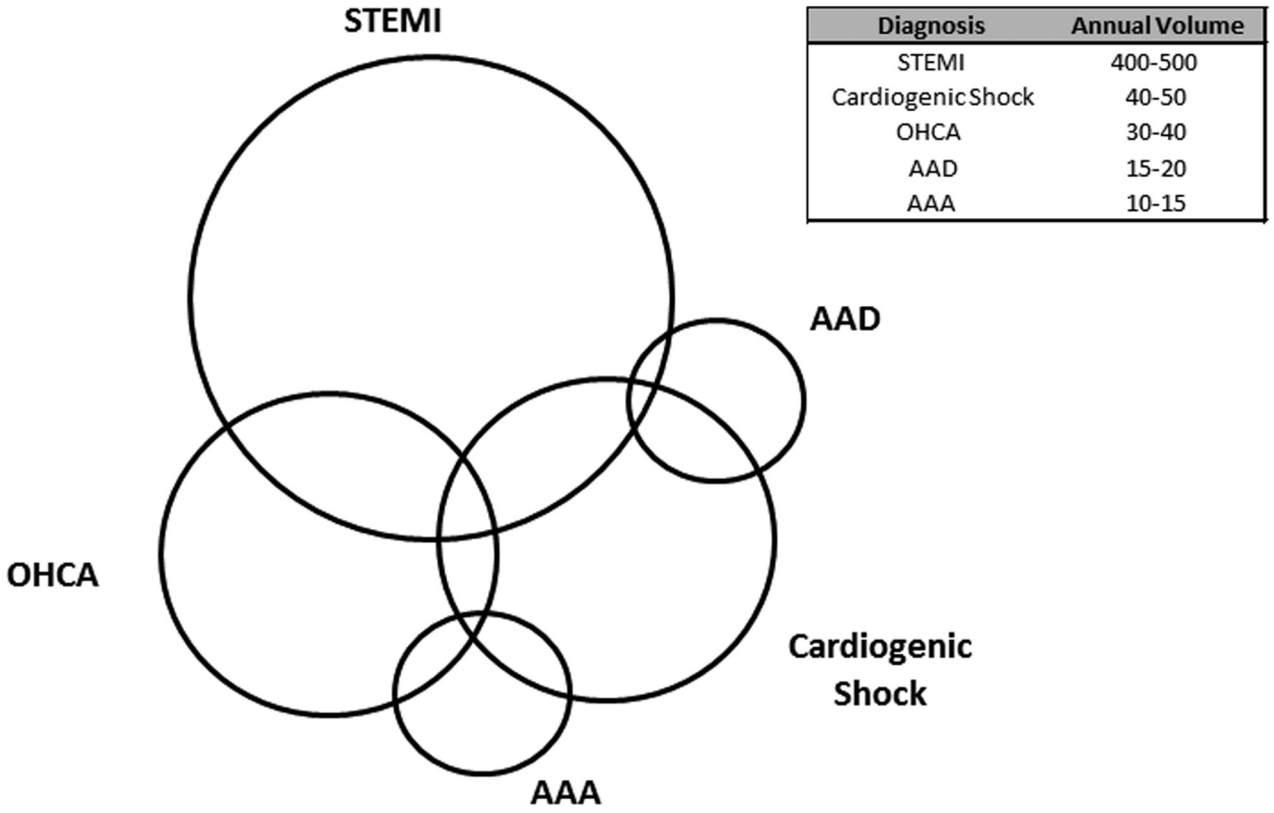
A protocol for standardized AAD care was added to the system in 2005.[14] The protocol includes guidelines for imaging, education at regional sites on the signs and symptoms of AAD, and streamlined transfer and patient flow processes that expedite surgical intervention. The AAD program has treated 142 patients since 2005 and recently reported reductions in the time from presentation to AAD diagnosis and definitive therapy by 43% and 55%, respectively (Figure 4). The absolute mortality rate has fallen to 21%,[14] a rate ≈22% lower than the mortality rate reported by the International Registry of Aortic Dissection.[28] In 2008, a separate protocol was introduced to improve care for patients with ruptured AAA.

Management of Acute Decompensated Heart Failure/Cardiogenic Shock

The most recent system-wide initiative, begun in late 2009, targets the management of acute decompensated heart failure and cardiogenic shock through standardized protocols and a collaborative team approach. Given the frequency of the dual diagnosis of STEMI and cardiogenic shock,[28] this program is being implemented in close coordination with the Level 1 regional STEMI program with input from a multidisciplinary team of specialists, including cardiologists, emergency medicine physicians, intensivists, and cardiovascular surgeons. Patients with MI in cardiogenic shock experience mortality rates of up to 50% in the initial postinfarct period[29]; therefore, a key component of the cardiogenic shock program is the early use of temporary mechanical circulatory support to limit end-organ hypoperfusion while myocardial viability and neurological function can be assessed and appropriate treatment identified.

Stroke

ANW has been a certified primary stroke center since 2006. In 2007, the Neuroscience Institute at ANW initiated the Neurological Emergency Treatment Network, which provides 24-hour access to neurologists, interventional neuroradiologists, and neurosurgeons for the acute management of ischemic and hemorrhagic stroke, seizures, and central nervous system tumors. Today, the program treats >500 ischemic strokes per year in collaboration with a network of 11 regional referral hospitals. Through the use of tele-health connections that facilitate remote neurological evaluation, the program has successfully increased the use of guideline-



Diagnosis	Annual Volume
STEMI	400-500
Cardiogenic Shock	40-50
OHCA	30-40
AAD	15-20
AAA	10-15

Figure 2. Graphic depiction of concurrent diagnoses* and annual volumes of patients treated via the Minneapolis Heart Institute (MHI) Cardiovascular Emergencies Program, 2003 to 2010. STEMI indicates ST-elevation myocardial infarction; OHCA, out-of-hospital cardiac arrest; AAD, acute aortic dissection; and AAA, abdominal aortic aneurysm. *Currently at MHI, 20% of cardiovascular emergencies require advanced care from >1 cardiovascular emergency program.

recommended thrombolytic therapy, particularly in patients presenting at smaller regional hospitals that previously may not have had access to acute therapies. Grounded by a comprehensive approach to the initial treatment of ischemic stroke and a collaborative, interdisciplinary rehabilitation team, ANW has achieved clinical outcomes in ischemic stroke that are in the top 5% of programs nationally.

System Communications and Improvement

A fundamental component of the MHI model is a concentration on process improvement, communications, and relationship building. An underlying philosophy is that input from all levels of care—physicians, nurses, paramedics, technicians, etc—optimizes system improvement, cultivates the formation of a strong care alliance, and combats fragmented care. For each clinical program, a steering committee with representation from these various professions is tasked with program development with a focus on continuous quality improvement. Program directors continually evaluate system performance and routinely conduct event-specific reviews with involved care teams within 24 hours of an event. These exchanges are constructive and are designed to promote collaborative and timely resolution of operational deficiencies. Finally, a commitment to ongoing provider education

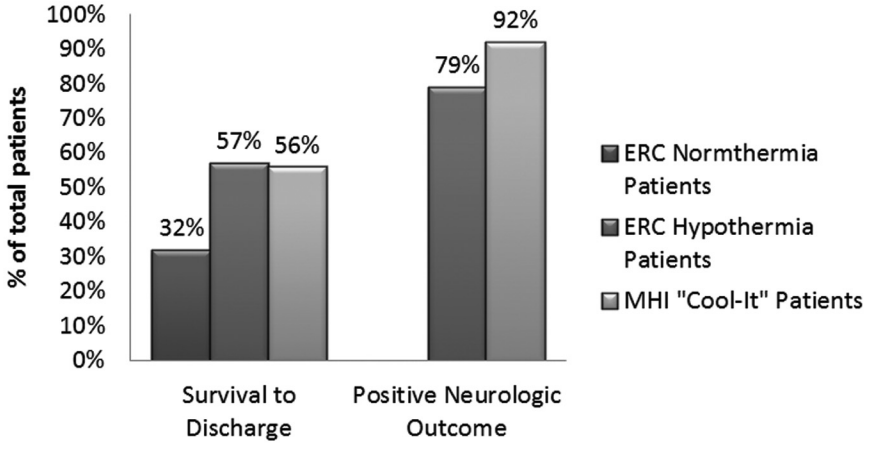


Figure 3. Therapeutic hypothermia for cardiac arrest. ERC indicates European Resuscitation Council; MHI, Minneapolis Heart Institute; Positive Neurologic Outcome: Cerebral Perfusion Category score of 1 or 2. Data source: Arrich.[27]

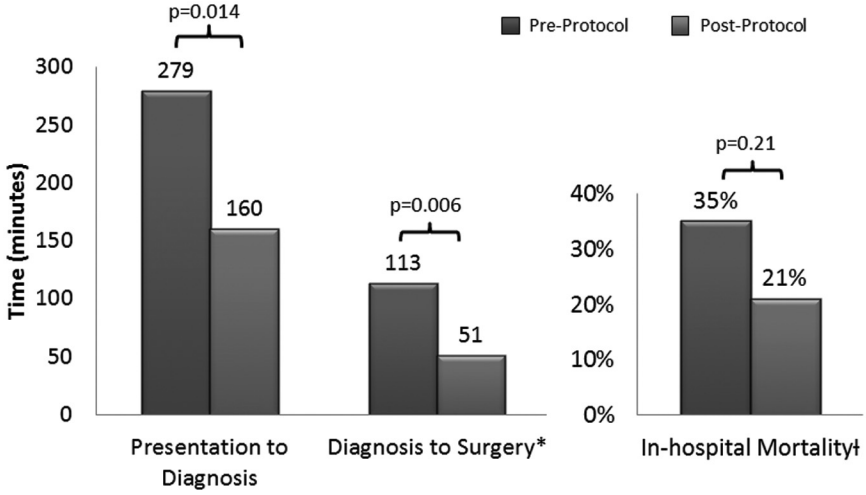


Figure 4. Acute aortic dissection. *Within tertiary facility; †type A surgical cases. Data source: Harris et al.[14]

and training has ensured that the MHI system remains flexible as new care elements and processes are identified.

Barriers and Challenges to Implementation

Our current healthcare system is fragmented and inefficient. These inefficiencies are magnified in the setting of acute cardiovascular emergencies.[5] Barriers to rapid diagnosis and treatment of cardiovascular emergencies occur at the prehospital level (scarce resources for prehospital ECGs and training), at the referral hospital (nonstandardized diagnostic algorithms, diagnostic dilemmas), in transport (availability, distance, and weather), and at the tertiary center (catheterization laboratory and operating room team delays, complex procedures, hemodynamic instability).[30] Further fragmentation in care occurs during the patient's transition to his or her community. Theoretically, a coordinated cardiovascular emergency care system would address many of these issues. On the other hand, the development of such a system would present new challenges. For example, many states or regions have multiple tertiary care centers that would create competition issues. Similar to the level 1 trauma model, there may be a need for multiple cardiovascular emergency centers in a metropolitan area driven by the clinical volumes and existing referral patterns for the region. State and regional governments and/or specialty societies would work to develop guidelines and requirements, including certification of these centers, similar to the current trauma system or the STEMI system guidelines developed by Mission: Lifeline.[23] In Minnesota, for example, the development of the first STEMI network led to the rapid adoption and deployment of multiple regional STEMI networks based on existing referral patterns that have improved the treatment of STEMI for patients throughout the region.[31,32] In addition, mechanisms for training medical students, residents, and fellows would need to be built into the system.

Fiscal Responsibility and Stewardship of Healthcare Resources

The 2010 Patient Protection and Affordable Care Act has brought the cost of American healthcare, currently 17% of the gross domestic product, to the forefront of public policy dialog. Driven by objectives of higher-quality care, universal insurance coverage, and increased efficiency through payment reform and the development of accountable care organizations, the ubiquitous challenge in healthcare is to devise new models of care that afford superior clinical outcomes while reducing costs.

The historical success of trauma, stroke, and STEMI systems and the early success of the Cardiovascular Emergencies Program at MHI offer compelling evidence that cardiovascular emergency systems provide an opportunity to improve outcomes for cardiovascular emergency events nationally through enhanced regional network collaboration. Whether the system-of-care model represents responsible fiscal stewardship of ever-limited healthcare resources remains to be determined, but a recent comparison of the costs and benefits of establishing regional STEMI networks with funding additional PCI capable facilities found the regional transfer strategies to be both less costly and more effective.[33] A single hospital financial analysis of implementing an STEMI system identified cost savings of $10 000 per patient for the index event and an additional $4000 in savings for subsequent medical care during the 1 year after hospital discharge.[34] Additionally, Merchant et al[35] evaluated the cost-effectiveness of TH and found that among patients who survive a cardiac arrest, TH improves clinical outcomes at a cost comparable to many widely accepted interventions. A cardiovascular emergency system fosters the broad clinical integration required for successful implementation of new payment structures but must be coupled with a redefined payment model that rewards quality outcomes and acknowledges the collaborative role of each participant (eg, EMS providers, community and referral hospitals, physicians, support staff). The development of a cardiovascular accountable care organization for a cardiovascular emergency system, consistent with the recently proposed concept of "turbo–accountable care organizations,"[36] can link the fragmented entities providing emergency cardiovascular care around the common objective of accountability for value. Reductions in the total cost of care can be achieved through quality and cost measurement and standardization, reduced complication rates, elimination of redundant testing and waste, efficient use

of limited capital resources (PCI centers, operating room staffing, advanced surgical expertise, cardiovascular staff cross-training), and implementation of continued process improvements. Specialty care for cardiovascular emergencies is most successful when a team of specialists work together to achieve optimal outcomes. The development of centers of excellence and integrated cardiovascular service lines represent a shift toward this new paradigm of collaboration.

Improved coordination and collaboration between the fragmented participants providing care for cardiovascular emergency patients will promote the development of market-driven payment reform. These payment reforms may include the formation of bundled payments for cardiovascular emergency diagnoses, allowing each participant to receive appropriate reimbursement for providing care. Additionally, the development of an accountable care organization would provide a mechanism for community hospitals, tertiary hospitals, and EMS transport companies to equitably divide shared savings from total cost-of-care reductions throughout the network. The protocol for management of acute coronary syndromes identifies those low-risk patients who can be managed effectively in the community hospital without the need for transfer. In addition, the care system would include guideline-recommended secondary prevention and follow-up in the local community.

In 2008, there were >54 000 acute hospitalizations for heart disease in Minnesota. Hospital charges for these events exceeded $1.8 billion dollars. With >20% of deaths in Minnesota attributed to heart disease,[37] the potential for improved clinical outcomes and cost savings with a cardiovascular emergency system remains significant.

Conclusions

A cardiovascular emergency system has the potential to improve clinical outcomes; to provide ongoing education for patients, providers, and the community; and to serve as a foundation for cost-effective care through cardiovascular accountable care organizations. Through a new paradigm of collaboration and conscientious management of limited healthcare resources, cardiovascular emergency systems can reduce morbidity and mortality and optimize care on a national level. The time has come to convene stakeholders and to standardize the criteria and clinical outcome metrics for cardiovascular emergency systems nationally.

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Disclosures

None.

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