WHAT BEGINS AS A TYPICAL NIGHT FOR JOHN CLEMENS ON Jan. 22 (actual call, but fictitious name) suddenly changes when he develops severe pain in the center of his chest at 1710 HRS.

Similar pain has bothered Clemens, a healthy 45 year old with no pertinent medical history, periodically during the previous two months. It has always gone away on its own, so he hasn’t consulted his doctor. This night, however, the pain is severe, unrelenting and traveling down his left arm. Thirty minutes after the onset of the pain, Clemens, nauseated and soaked in sweat, knows he has a serious problem and puts in a desperate call to 9-1-1.

At 1741, Aurora (Colo.) Fire Dept. (AFD) Engine 2 and Rural Metro ambulance 107 receive a “chest pain” dispatch to Clemens’ home. Four minutes later, both vehicles arrive and crews begin assessment and care. The patient’s pulse is a deceptively steady sinus rhythm at 82, but the 12-lead ECG tells a different story (see Figure 1). ST elevation is present in V2–V6, peaking at 5 mm in V3. AFD paramedic Roy Browning identifies a potentially deadly acute anterior myocardial infarction and notifies dispatch to initiate a Cardiac Alert.

At 1750, The Medical Center of Aurora receives the Cardiac Alert from AFD dispatch and mobilizes the hospital’s cath lab team, advising them of the patient’s ETA.

During 10 minutes of on-scene care and five minutes of transport time, Clemens receives 324 mg of oral ASA, three sublingual (SL) nitroglycerine (ntg) tablets and has two IVs established. Clemens arrives at the hospital at 1801, his condition unchanged, and rates his pain a 10 on a 1–10 scale.

Five minutes later, while in the ED, Clemens lapses into V-fib arrest. A single 200-watt/sec defibrillation administered by the ED staff restores his heartbeat, and he regains consciousness.

Clemens arrives at the cath lab alert and oriented. Percutaneous transluminal coronary angioplasty (PTCA) performed in the cath lab confirms that Clemens suffered from single-vessel coronary artery disease and had suffered an acute anterior-lateral MI. The cath lab inserts two stents in Clemens’ vessel, with no complications. Hospital door-to-balloon time is only 60 minutes for an “after hours” Cardiac Alert. Four days later, Clemens is discharged from the hospital, neurologically intact.

Time is muscle! You’ve heard this message relating to coronary care hundreds of times. The question: What is your service doing about it? Do you pile expensive 12-lead monitors on rigs, run crews through training and think you’ve justified the expense of a $17,000 cardiac monitor? Do you measure success by training hours and short scene times?

Scratch the surface of many EMS 12-lead ECG programs, and you might be shocked at what you find. Many systems lack specific outcome measurements, leading to dissatisfied paramedics.
and physicians, missed treatment opportunities, medications given too late in doses too low and little integration of field care with the receiving hospital’s treatment capabilities.

**Advancing AMI Care**

The revascularization era has changed how we manage patients with acute myocardial infarction (AMI). Research supports the importance of time in relation to the success of revascularization; clearly, early revascularization is critical in reducing both morbidity and mortality.\(^1\)\(^2\) The greatest benefit of reperfusion occurs in the first hour, followed by rapidly declining benefits as time passes.\(^1\)\(^2\)

How can an urban EMS system impact early revascularization of AMI patients? The answer for our EMS system came from analyzing processes from field management of AMI patients to their delivery to the cath lab. This created a tremendous challenge for our EMS system. Our goal was to improve patient outcomes by admitting patients directly from the field to the cardiac catheterization lab. Teamwork and trust between agencies and teams that had little interactive history were necessary to realize this goal (see sidebar, p. 33).

**The Aurora, Colo., experience**

AFD provides care to a population of 284,000 via 12 ALS engine companies. Rural Metro Ambulance, which maintains five 24-hour and two 12-hour ALS ambulances through an exclusive city-private contract, provides ALS support and transport.

A review of call volume and risk stratification of calls in our system revealed cardiac, respiratory and trauma patients as our high-volume/high-risk call focus. Cardiac patients represented the highest at-risk patient group (see Figure 2). Therefore, we began to examine our cardiac response system and the care our patients received once delivered to a hospital.

**Cardiac cath lab’s role in AMI treatment**

PTCA is the preferred treatment for revascularization of ischemic heart disease. This complex procedure, performed by a specialized team led by a cardiologist, occurs in a catheterization lab. PTCA is listed as a Class 1 treatment in American Heart Association (AHA) guidelines for the management of AMI “… only if performed in a timely fashion by individuals skilled in the procedure and supported by experienced personnel in high-volume centers.”\(^*\) The AHA guidelines further define the desired treatment time as “… balloon dilation within 60 to 90 minutes of diagnosis of AMI.”\(^*\)

During the procedure, a balloon-tipped catheter is introduced into the femoral artery and advanced into the coronary arteries. Once the occluded artery is found, the balloon is expanded and the clot is pressed against the artery wall to restore circulation to that area of the heart. A stent, an expandable metal device, is frequently left in place to keep the artery wall open. The standard time measure for performing this procedure is referred to as the *door-to-balloon* time.

Field triage of cardiac patients is an AHA Class I recommendation.\(^*\) The 12-lead ECG provides field personnel with the most definitive identification of an AMI.\(^1\)\(^3\) It provides the necessary information to indicate an AMI is occurring or has occurred. The 12-lead ECGs replacing earlier model four-lead ECGs on paramedic vehicles are rapidly becoming the standard prehospital cardiac evaluation device.

**Re-engineering acute coronary care procedures**

A review of our current practice revealed that, on the surface, we appeared to be rendering cardiac care at an acceptable level. Our cardiac on-scene times averaged 15 minutes, with transport times averaging 9.5 minutes. However, careful analysis of how this time was spent told a different story and indicated an opportunity for tremendous improvement, including the potential for reducing the time to get the patient into the cath lab by nearly 30 minutes through field notification of AMI (see Figure 3, below).

During the review process, we identified the following areas for improvement:

1. Inadequate paramedic 12-lead training;
2. Lack of coordination between prehospital and receiving hospital activities for time-sensitive AMI patients;
3. Inconsistent application of AMI patient-care protocols and widely varying protocols;
4. Poor-quality ECGs that result in low trust levels of AMI patient-care protocols and widely varying protocols;
5. Need for better distribution of on-scene EMT and paramedic tasks;
6. Need for improved paramedic/physician/ED staff satisfaction and trust; and
7. Better use of 12-lead ECGs (purchased by AFD at a total cost of more than $200,000) to ensure they positively impact patient care.

Interdisciplinary committees involving ED physicians, cardiologists and AFD leaders met and reviewed all available data pertaining to the care of AMI patients. We then developed a new vision of seamless patient care from the field to the cath lab. We called this new procedure the Cardiac Care Plan. Our goals were to standardize the approach to the cardiac patient, maximize drug administration, accurately identify infarcts, limit scene time and integrate smoothly with the hospital process. We developed an easy-to-use checklist for our paramedics to assist them in transitioning to the new process (see Figure 4).

We implemented the cardiac care plan in two phases. Phase 1 involved the implementation of all AFD clinical and operational changes, except for cath lab activation. Key activities included on-scene acquisition of a 12-lead ECG, taking the patient history and administering MONA (morphine, oxygen, nitroglycerine and aspirin). By the fifth minute on scene, responders would call a Cardiac Alert if the patient met the criteria. Phase 1 was initiated to exhibit the efficiencies of the new process and the ability of field crews to assess and determine those fitting the profile of patients needing cardiac catheterization. During this phase, the cardiac catheterization team was not activated. However, a cardiologist responded to the ED to meet the patient on arrival and assist in determining the patient’s need for catheterization.

Also, during this phase, the ED staff began to evaluate the AFD crews’ acute coronary care protocol compliance, and the ED staff and catheterization team reviewed their own AMI processes to improve and coordinate their patient management practices with the field process.

Phase 1 lasted four months and involved 28 patients, of whom 22 had emergent PTCA, and 17 had lab diagnosis of AMI.

Prior to moving into Phase 2 of the Cardiac Care Plan, we scheduled a review period to initiate a total quality improvement (TQI) feedback loop and monitor system performance. During this review period, 12 additional patients met the Cardiac Alert criteria and received Phase 1 treatment standards. Measurement of times and accuracy of tasks performed revealed that we met all major goals, and we determined that field assessment and protocol compliance were accurate. Therefore, we decided to conduct Phase 2.

During Phase 2, whenever a paramedic determined a patient met the Cardiac Alert criteria, they would dispatch alert the ED. The initial notification from the field to dispatch was limited to “Cardiac Alert. ETA 15 minutes.” The ED physician then activated the cath lab team.

Phase 2 lasted four months and involved 25 patients. Seventeen patients had emergent PTCA, and 15 had lab diagnosis of AMI.

We treated a total of 65 patients during the Phase 1 and 2 implementation periods, with 40 patients having a cath lab AMI diagnosis. Of these 40 patients, five experienced cardiac arrest (one in an ambulance, three in the ED and one in the cath lab), and one patient had recurrent V-tach. (These six patients survived with neurological recovery and were discharged from the hospital.) There was 0% prehospital and in-hospital mortality during the implementation period. The average age of the patients was 59. The median wait reported to EMS by the patients (from onset of symptoms until accessing 9-1-1) was 37 minutes.

Internal and external customer satisfaction was a major focus of the cardiac care program. On a 1-to-5 scale (from poor to outstanding), patient satisfaction with the program measured five. Paramedic satisfaction with both the new process and hospital response measured four. Physician satisfaction with the paramedics also rated four.

![Figure 4: Suspected Acute Coronary Care Procedure Checklist/Cardiac Alert Criteria](image-url)

### Figure 4: Suspected Acute Coronary Care Procedure Checklist/Cardiac Alert Criteria

**Door to Balloon**

<table>
<thead>
<tr>
<th>Decision</th>
<th>Drug</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>ASA</td>
<td>MS to 0/10</td>
</tr>
<tr>
<td>YES</td>
<td>Nitro</td>
<td>2nd ECG</td>
</tr>
<tr>
<td>NO</td>
<td>MS 2mg</td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>Amynhia Rx</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>Patient discharge hospital</td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>Alergies</td>
<td>Plast Hx</td>
</tr>
</tbody>
</table>

**Presentation** (circle all that apply)

- Naso-to-nasol pain/discomfort
- Syncpe
- Vital signs
- Malaise

**Complication**

- Hypotonia

**Administration**

- Defibr pads

### Table: Results of Cardiac Alert Program Implementation

<table>
<thead>
<tr>
<th>Category</th>
<th>Times Prior to Cardiac Alert</th>
<th>Times after Phase 2 Initiation</th>
<th>Accepted Industry Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-scene time</td>
<td>15 mins.</td>
<td>17 mins.</td>
<td>20 mins.</td>
</tr>
<tr>
<td>Transport time</td>
<td>9.5 mins.</td>
<td>8 mins.</td>
<td>N/A</td>
</tr>
<tr>
<td>Total patient time*</td>
<td>34 mins.</td>
<td>31 mins.***</td>
<td>N/A</td>
</tr>
<tr>
<td>Door-to-Balloon</td>
<td>121 mins. (median)</td>
<td>78 mins. (median)***</td>
<td>90 mins.**</td>
</tr>
</tbody>
</table>

* Time from 9-1-1 dispatch of EMS to transfer of patient care at the hospital.
** A three-minute reduction in total on-scene time.
*** A door-to-balloon time saving of 43 minutes.
Discussion

As a result of AFD’s Cardiac Care Plan, four major outcomes, which positively impacted the care of AMI patients, were realized:

1. Use of 9-1-1-to-balloon time as a system measurement: Paramedic systems save time in the critical two- to four-hour treatment window, in which morbidity and mortality outcomes are most greatly impacted. AMI treatment strategies, developed cooperatively between EMS and hospital systems, can greatly benefit AMI patients. Our Cardiac Alert system shaved 43 minutes from the hospital door-to-balloon time. This time reduction allows for a major impact on patient care and survivability.

Given the significance of the potential reduction in morbidity and mortality, 12-lead-capable paramedic systems should mandate collaboration with their hospitals and cath lab teams.

NOT JUST ANY 43 MINUTES

The science behind why that time is so important

Damage to the heart from AMI is extremely time-dependent. If reversed within the first hour, there may be no damage at all. The second through fourth hour is when most cardiac damage occurs. By the sixth hour, myocardial damage is complete. Through to the 12th hour, however, there’s still some benefit of revascularization with electrical stabilization. However, after 12 hours revascularization efforts cease.

The first five minutes on scene set the course for rapid treatment. Staffing is at its maximum, and the patient is stationary, allowing for a clean ECG. Early activation of the cath lab brings the critical measurement of door-to-balloon time under the 90-minute mark, making this an AHA Class 1 treatment.

The 43 minutes saved by the Aurora Cardiac Alert program fall within the period when most myocardial damage occurs. Optimally, if a patient calls 9-1-1 within 15 minutes of their attack, Aurora EMS resources get the patient to the hospital within 30 minutes and there’s a 60 minute ED door-to-balloon time, no measurable damage to the myocardium will occur. This would be measured on the echocardiogram in ejection fraction.


From onset of symptoms to balloon revascularization, 50% of our patients were revascularized in less than two hours and 26 minutes (37 minutes onset-to-9-1-1 + 31 minutes patient time + 78 minutes hospital door-to-balloon time).

This program demonstrates that the standard hospital door-to-balloon measurement may no longer be the best measure to evaluate collaborative success of field and hospital treatment. We believe 9-1-1-to-balloon time is now the best system measurement because it includes dispatch, response, on-scene care, transport time, ED involvement and cath lab time.

Our median 9-1-1-to-balloon time was 109 minutes. Our data supported the original belief that performing a 12-lead ECG would not add significantly to field time. While on-scene time increased by two minutes, total patient time (time from 9-1-1 dispatch to transfer of patient care at the hospital) decreased by three minutes. This three-minute improvement is felt to be the result of decreased transport times and improved efficiencies in the transfer of patient care at the hospital (see Figures 5 and 6, pp. 29 and 30).

2. EMS systems can successfully activate hospital cardiac catheterization teams: Using trauma team activations as a model, EMS activation of cath labs and personnel did not result in any significant increased cost to the hospital, an early concern of hospital administration. The time reduction and increased rate of patient resuscitation and discharge offer multiple benefits to the receiving hospital, such as the opportunity for more rapid access to the PTCA treatment option, a critical factor in the success of the Cardiac Alert Plan.

In addition, the program resulted in increased paramedic satisfaction and commitment. By eliminating the use of lower quality ECG transmission by cellular phone and sending the signal directly from the cardiac monitor, additional time was saved on scene, and hospital staff gained confidence in the paramedics’ ECG expertise.
3. EMS systems should use the fifth D—Destination: The four “Ds” of cardiac care concept (door, data, decision, drugs) was originally developed for in-hospital treatment of AMI patients with thrombolytics. Its application to EMS field treatment is useful. When PTCA is available, paramedics utilizing 12-lead ECGs and alerting protocols developed in collaboration with cardiologists and in-patient units have the potential to produce groundbreaking results. However, not all hospitals are capable of performing PTCA. This causes a destination dilemma that must be addressed during your planning process. The importance of a qualified receiving destination means a fifth “D” should be added to the cardiac care concept.

4. EMS system-initiated change: In traditional roles, hospital physicians—by committee or through accepted local standards—initiate change in EMS practices. It’s rare for an EMS system to initiate change that affects a hospital’s operating procedures. A hospital’s willingness to cooperate and collaborate with EMS depends on several key elements:

- The creativity to look at all available data critically and openly.

Involvement of all the key stakeholders at the beginning of this program resulted in their buy-in and, ultimately, the success of the joint venture.

**Conclusions**

AFD’s collaborative effort in developing the Cardiac Alert Plan validated the belief that prehospital care personnel are a vital link in the chain of survival for optimal treatment of AMI patients.

Our TQI process resulted in new relationships with in-patient areas that had not previously interacted with prehospital care personnel. Activation of the cardiac catheterization team on the basis of prehospital ECG findings did not result in prolonged on-scene time or wasted resources from unnecessary activation of the cardiac cath lab.

PTCA is the optimal treatment for AMI calls and should be added to EMS system responses. Even urban EMS systems with short scene and transport times could realize tremendous improvement opportunities. Paramedics should utilize 12-lead ECGs to the fullest extent to positively impact patient care and add destination as the fifth “D” to their cardiac treatment strategy.

9-1-1-to-balloon time should be a new, multidisciplinary standard to measure EMS system effectiveness.

**Future Challenges**

Four areas the collaborative teams identified for future investigation were:

1. How EMS can integrate their activities with other hospital service delivery areas;
2. How EMS systems can assist communities in thinking globally (not territorially) to improve patient outcomes (conquering domains of expertise that hamper collaboration);
3. The need for additional study in both similar and diverse EMS systems to further validate the impact of reduced door-to-balloon time; and
4. The need to explore the potential secondary effect of the program on walk-in AMI patients; 50% of AMI patients present for treatment to EDs in this manner.

The Cardiac Alert notification system reduced the time to get patients into the cath lab by nearly 30 minutes.

**PHOTO JEFF FORSTER**

**PHOTO JEFF FORSTER**

The Cardiac Alert notification system reduced the time to get patients into the cath lab by nearly 30 minutes.

**Future Challenges**

Four areas the collaborative teams identified for future investigation were:

1. How EMS can integrate their activities with other hospital service delivery areas;
2. How EMS systems can assist communities in thinking globally (not territorially) to improve patient outcomes (conquering domains of expertise that hamper collaboration);
3. The need for additional study in both similar and diverse EMS systems to further validate the impact of reduced door-to-balloon time; and
4. The need to explore the potential secondary effect of the program on walk-in AMI patients; 50% of AMI patients present for treatment to EDs in this manner.

**PHOTO JEFF FORSTER**

**PHOTO JEFF FORSTER**

The Cardiac Alert notification system reduced the time to get patients into the cath lab by nearly 30 minutes.

**Future Challenges**

Four areas the collaborative teams identified for future investigation were:

1. How EMS can integrate their activities with other hospital service delivery areas;
2. How EMS systems can assist communities in thinking globally (not territorially) to improve patient outcomes (conquering domains of expertise that hamper collaboration);
3. The need for additional study in both similar and diverse EMS systems to further validate the impact of reduced door-to-balloon time; and
4. The need to explore the potential secondary effect of the program on walk-in AMI patients; 50% of AMI patients present for treatment to EDs in this manner.

**PHOTO JEFF FORSTER**

**PHOTO JEFF FORSTER**

The Cardiac Alert notification system reduced the time to get patients into the cath lab by nearly 30 minutes.

**Future Challenges**

Four areas the collaborative teams identified for future investigation were:

1. How EMS can integrate their activities with other hospital service delivery areas;
2. How EMS systems can assist communities in thinking globally (not territorially) to improve patient outcomes (conquering domains of expertise that hamper collaboration);
3. The need for additional study in both similar and diverse EMS systems to further validate the impact of reduced door-to-balloon time; and
4. The need to explore the potential secondary effect of the program on walk-in AMI patients; 50% of AMI patients present for treatment to EDs in this manner.

**PHOTO JEFF FORSTER**

**PHOTO JEFF FORSTER**

The Cardiac Alert notification system reduced the time to get patients into the cath lab by nearly 30 minutes.
The Cardiac Alert Program in Aurora, Colo., succeeded because of the combined efforts of The Aurora Fire Department, The Medical Center of Aurora, Rural-Metro Ambulance and the Colorado Heart Institute. This included a cohesive effort in the design of the quality assurance program. The fire department’s immediate involvement with the medical center once the idea was considered proved significant to the success of this EMS-initiated program.

As EMS medical director of the medical center, I was invited by the fire department to participate in its quality assurance (QA) process and remained intimately involved in the program. I assisted with process review and was a conduit for information and feedback to the ED physicians and staff as well as the cardiologists of the heart institute. Case reviews resulted in a focus on specific inclusion criteria, such as ECG presentations (e.g., wide complex rhythms) and atypical presentations (e.g., syncope). Agreement on criteria that would initiate a Cardiac Alert was ensured by a combined effort. An intimate medical center involvement in the QA process was crucial to buy-in from medical center and heart institute staff members.

This EMS-initiated program also impacted and was incorporated into the medical center’s own QA programs. Staff within the ED and the Colorado Heart Institute had their attention drawn to the care of all patients presenting to the ED with acute coronary syndromes. This included walk-in patients who did not fall within the formal Cardiac Alert program.

As the medical center’s staff were reminded that “time is muscle,” they felt a heightened urgency to transfer the patient from the ED to the cath lab. The rush to the cath lab led to medication delivery errors, noted on case reviews. A root-cause analysis and multidisciplinary review of the process resulted in process improvement and greater efficiency of the transfer of care from the ED to the Colorado Heart Institute cath lab (visit www.jems.com to review the Root-Cause Analysis Diagram).

The first improvement was the development of a standardized order sheet, which includes medication dosing and a verification check-off site for nursing staff. This helped prevent medication errors, such as improper dosing and missed administration, which had occurred in earlier cases. Both cath team members and ED staff designed, initiated and implemented the use of this order sheet.

A second improvement was the development of a Cardiac Attack Pack (see photo below). This kit contains equipment and medications routinely used for the Cardiac Alert patient. The pack includes IV starter kits, tubing, fluids, aspirin, nitroglycerin SL tabs and premixed solutions, beta blockers and heparin. Only controlled substances (e.g., morphine) and refrigerated substances (e.g., Integrelin) are kept outside the kit.

Prior to adopting use of this kit, nurses and technicians had to repeatedly access multiple areas and electronic supply and medication dispensers to obtain the needed materials. A pharmacy team solely dedicated to the ED played a critical role in designing and implementing the Cardiac Attack Pack.

The impact of the AFD Cardiac Alert program on the hospital’s patient management process is impressive. The internal changes that occurred as a result of the Cardiac Alert program will affect patients presenting to the ED by ambulance and by private vehicle. Now that the relationship has proven a success, we anticipate future combined efforts will improve the care of patients with other life-threatening events. The City of Aurora’s Cardiac Alert program should serve as a model for future EMS and hospital quality assurance programs.

Gilbert Pineda, MD, FACEP, is EMS medical director of The Medical Center of Aurora.
ness. EMS agencies can dramatically influence improvement in a hospital’s approach to AMI patients. Field activation of the cath lab is a reality. Time is muscle. Now is the time for you to make a significant impact in your service area.

Guy W. Bull, BA, EMT-P, is the EMS quality systems administrator for the Aurora (Colo.) Fire Department. He has been a paramedic for 25 years and an EMS instructor for 21 years. Contact him via e-mail at gbull@ci.aurora.co.us.

Danny Willcox, BS, EMT-P, is battalion chief of the Aurora Fire Department EMS Bureau. He has served as a firefighter for more than 20 years, with 10 years experience as a paramedic. Contact him via e-mail at dwillcox@ci.aurora.co.us.

References

Visit www.jems.com for additional information on AFD’s quality improvement program.

The authors wish to acknowledge the involvement and support of the AFD EMTs and paramedics who—through their hard work and commitment to improve patient care—turned theory into a reality that changed people’s lives. The Cardiac Alert program could not have been a success without the same commitment from the Medical Center of Aurora, The Colorado Heart Institute and University Hospital of Denver and Rural-Metro Ambulance. Finally, all great changes start with a vision. The vision and leadership to bring this diverse group together for the two-year project was provided by AFD medical director Eugene Eby, MD.