1-1-2013

Rural acute myocardial infarction survey (RAMIS)

Nikiah Nudell BA, NRP
PrioriHealth Partners

Tom Bouthillet NREMT-P
Hilton Head Fire and Rescue

Don Rice MD
EMS Physician Medical Director, Beatrice EMS/Fire

John A. Gale MS
University of Southern Maine, Muskie School of Public Service, Maine Rural Health Research Center

Gary Wingrove EMT-P
PrioriHealth Partners

Recommended Citation

Nudell, N., Bouthillet, T., Wingrove, G., Rice, D., & Gale, J. A. (2013). Rural acute myocardial infarction survey (ramis). International Paramedic Practice, 2(1), 169-175.

Rural acute myocardial infarction survey (RAMIS)

Nikiah Nudell, BA, NRP; PrioriHealth Partners, LLP. **Don Rice**, MD; EMS Physician Medical Director, Beatrice EMS/Fire. **John A. Gale**, MS; Maine Rural Health Research Center, Muskie School of Public Service, University of Southern Maine. **Gary Wingrove**, EMT-P (ret.); PrioriHealth Partners, LLP. **Tom Bouthillet**, NREMT-P; Hilton Head Fire & Rescue
Email for correspondence: nick@priorihealth.com

Abstract

Objectives: The purpose of this study was to evaluate why current treatment goals for patients with Acute Myocardial Infarction are not being achieved despite a large body of evidence supporting regionalised ST Elevation Myocardial Infarction (STEMI) systems.

Background: Executing a STEMI system in a pre-hospital environment varies not only from state to state but also region to region. Statewide EMS treatment protocols serve to shield an ambulance service from litigation when following the published statewide protocols. Many critical access hospitals also have standardised protocols in place for the identification and treatment of STEMI patients. We sought to understand whether these plans are followed as many system providers believe they are. If deviations were found we sought to understand the reasons for those deviations.

Methods: Because all of these delay factors center around rural hospitals, the project team developed a simple online survey tool to poll the critical access hospitals of Nebraska.

Results: We found that the rural STEMI care system lacks a coordinated system that is considered to be essential for urban areas. When looking at why rural STEMI patients have a higher 30 day mortality compared to patients treated in an urban environment, several areas of potential failure have been identified.

Conclusion: We qualitatively demonstrated that STEMI patients in the rural setting of Nebraska are not receiving timely reperfusion even though data describing the number of persons and delays experienced are not widely tracked. Although currently lacking, individuals surveyed expressed a desire for a statewide coordinated STEMI care system.

Key words
● Complications ● Electrocardiography ● Emergency medical services ● Medical complications ● Rural health Services

Accepted for publication 14 December 2012

Reperfusion is so central to the modern treatment of acute ST-elevation myocardial infarction (STEMI) that we are said to be in the reperfusion era. Many studies have shown a significant relationship between time-to-treatment resulting in reperfusion and mortality.

There are two main strategies to achieve reperfusion: thrombolytic therapy and percutaneous coronary intervention (PCI). Over the last 40 years the mantra 'time is muscle' has been popularised to describe the urgency of identifying and treating myocardial infarctions. In those early days of EMS it was thought that the treatment should happen within three hours of onset. Later treatment guidelines focused on treatment within two hours but suggested a 'golden hour' was even better. Although many historical studies have concluded with conflicting results, more recent data demonstrates that a shorter time-to-reperfusion will result in improved cardiac function.

In 2004, the American College of Cardiology (ACC)/American Heart Association (AHA) STEMI guidelines were updated to suggest the goal for stent or balloon angioplasty (also known as D2B or door-to-balloon time) of ≤90 minutes for at least 75% of non-transfer PCI patients with STEMI in all participating hospitals performing primary PCI, while clot-busting medications should be given in 30 minutes (also known as D2N or door-to-needle time) to patients who do not have significant risk factors for bleeding issues. At the time, only 25% of cardiac catheterisation labs were achieving D2B times of 92 minutes while less than 5% of patients transferred from other hospitals were seeing D2B times of less than 90 minutes.

In 2006, fewer than half of hospitals were capable of performing PCI within the recommended 90 minute D2B guideline. The fact that comparatively few hospitals were meeting the established guidelines prompted the ACC to launch the D2B Alliance and the AHA to launch Mission: Lifeline (M:L) to support development of regionalised systems of care for acute STEMI. As part of its focus on supporting regional systems of care, M:L focuses on clarifying the roles and standards of performance for three broad venues of

Table 1. User-perceived attributes of teaching and assessment methods

Question and question number		Reference
1	Please provide your name and contact information.	Table 3: Table of Critical access hospital self-reported demographics
2	Please provide your level licensure.	N/A
3	Please help the survey team identify the trends, issues, barriers, and obstacles to caring for STEMI patients in rural communities	Table 4: Trends, Issues, Barriers, and Obstacles
4	Please rate how critical the following issues may be in rapidly identifying and treating STEMI patients in your community	Table 2: Table of Survey Point Criticality
5	Please provide a few more answers: • Approximately how many STEMIs were seen in your emergency department in 2010? • Approximately how many Non-STEMIs were seen in your emergency department in 2010? • Approximately how many Strokes were seen in your emergency department in 2010? • Approximately how many Traumas were seen in your emergency department in 2010? • How many different physician providers cover your emergency department? • How many different mid-level providers cover your emergency department? • What is the expected response time for ED providers after-hours for a time critical activation (STEMI, Stroke, Trauma, etc)? • Approximately how many interfacility transports were initiated by your ED providers in 2010 for a time critical diagnoses (STEMI, Stroke, Trauma, etc)?	N/A

emergency care: EMS, hospitals that receive STEMI patients but cannot perform PCI (STEMI referring hospital), and STEMI receiving hospitals that are PCI capable .

These combined efforts have been very effective at reducing the D2B and D2N times for patients across the country, particularly those in suburban and urban areas, who have immediate access to interventional cardiac catheterisation (cath) labs. By the end of 2010, more than 90% of hospitals were achieving D2B times <90 minutes with a median time of 64 minutes. These gains in reducing the time to reperfusion are credited in large part to the gathering of evidence and sharing of best practices.

The main factors behind delays at the referral hospitals for those without immediate access to PCI were caused by: awaiting transportation (26%), emergency department delays (14%), diagnostic dilemma (9%), initial negative test for heart attack (9%), and cardiac arrest (6%).

Bradley et al discovered that best practice strategies of a single-call system of activation and the use of pre-hospital electrocardiograms while the patient is en route to the hospitals were used by less than one third of hospitals surveyed. Given the strong evidence of the impact of these strategies on D2B times and the persistent underuse of effective strategies, there remains tremendous opportunity to improve quality of care and reduce mortality for patients with STEMI .

Bradley et al also concluded that:

> *'building the necessary systems of care to coordinate Emergency Medical Services and hospitals so that catheterization (cath) laboratories can be activated before the patient arrives at the hospital may require capital equipment, training of emergency medical personnel and collaboration across service providers not under the control of the hospital. Nevertheless, recent studies have shown that such systems of care with emergency medical services are feasible and effective, suggesting this approach could be a powerful intervention to improve STEMI care. (Bradley et al, 2008)*

Comparatively, less attention has been paid to STEMI patients who report to non-PCI hospitals, particularly in rural environments. In the rural setting, it is often not possible to get patients to a cath lab within 90 minutes of first medical contact, making thrombolytic therapy the preferred initial therapy. However, thrombolytic therapy requires an extensive review of contraindications, leaving many patients ineligible.

In addition, studies have shown that thrombolytic therapy will be ineffective up to 30% of the time

(<50% resolution of ST-elevation 90 minutes following thrombolytic therapy). It therefore seems reasonable to transfer all STEMI patients to PCI centers regardless of the initial strategy chosen as some will require 'rescue PCI'.

Recent studies, have shown that a small minority of non-PCI hospitals are capable of achieving 'door-in' to 'door-out' (DIDO) times of less than 30 minutes, and that mortality is higher when transfer times are delayed. In addition, it is not clear that non-PCI hospitals routinely achieve D2N times of less than 30 minutes when thrombolytic therapy is selected as the primary reperfusion strategy.

We hypothesised that STEMI patients in the rural setting may not be receiving timely reperfusion in the State of Nebraska. Nebraska is served by 65 CAHs that are not in suburban communities and most are more than an hour drive from the closest cath lab. We also sought to better understand the resources, capabilities, and challenges of Nebraska's 65 CAHs and identify whether Nebraska myocardial infarction patients receive timely reperfusion in accordance with current guidelines and best practices.

Methods

We conducted a quantitative study using a structured web-based survey (see *Table 1*) of Nebraska CAH based respondents. Participants were recruited from all 65 CAH facilities via email. The survey consisted of five categories with 49 total data points in addition to contact information. Questions provided multiple choice, Likert scale, or discrete choices.

Up to three additional email reminders and personal phone calls from Nebraska EMS/Trauma Programme staff encouraging survey completion resulted in a 100% response rate.

A phenomenological approach was used to evaluate survey responses. Respondents who marked 'uncertain' for any answer were then selected for additional telephone interviews. Additional questions were designed to inform the authors about facility policies and physician practices. Final analysis was conducted by a four-person team, employing the constant comparative method to identify recurrent themes.

The survey was collected securely and hosted by PrioriHealth Partners via the open source Limesurvey® tool (www.limesurvey.org) into a Microsoft SQL® 2008 database. Survey responses were exported to and analysed with Microsoft Excel® 2010 (www.microsoft.com).

Results

Responses (*Table 2*, *Table 3*, *Table 4* and *Figure*

Table 2. Table of survey point criticality.

	Please rate how critical the following issues may be in rapidly identifying and treating STEMI patients in your community. 1= Not critical to 5= Very critical
A	EMS responders equipped and trained to acquire and interpret EKGs for STEMI activation.
B	EMS responders equipped and trained to acquire and transmit EKGs for physician interpretation.
C	AMI occurs seldom and so we are unfamiliar or uncomfortable with thrombolytic protocols.
D	Availability of air ambulance transport.
E	Availability of ground ambulance transport
F	Identifying an accepting physician at a referral facility
G	Cost or availability of labs (troponin, CRP, etc.)
H	Equipment technical know-how (EKG, IV pumps, ventilators, etc.)
I	Equipment availability (EKG, IV pumps, ventilators, etc.)
J	Storage/preparation of thrombolytics
K	Cost of thrombolytics
L	Pharmacist availability
M	Physician availability

Table 3. Table of critical access hospital self-reported demographics

2010 CAH Self-Reported Data	SUM	STDev	MEAN	MIN	MAX	RANGE
Approximate numbers of STEMIs seen in ED	419	8.0	7.8	0	31	31
Approximate numbers of Non-STEMIs seen in ED	657	14.5	12.4	0	75	75
Approximate numbers of Strokes seen in ED	393	8.1	8.9	1	30	29
Approximate numbers of Traumas seen in ED	1962	27.9	40.9	0	81	81
Approximate numbers of Physicians cover ED	216	2.3	4.3	1	12	11
Approximate numbers of Mid-level cover ED	146	1.4	2.7	0	6	6
Expected response time for ED providers after-hours for a time critical activation (STEMI, Stroke, Trauma, etc.)	1134	9.1	21.8	0	30	30
Approximate numbers of Interfacility transports for a time critical diagnoses (STEMI, Stroke, Trauma, etc.)	1814	45.1	36.3	0	300	300

1) were received from all 65 CAHs collectively representing 1346 hospital beds or 27% of the statewide adult acute care capacity, of which 76% of the surveys were completed by RNs, 7% by MDs, 5% by NREMT-Bs, 4% by PAs and NREMT-Ps, 3% by NPs, and 1% by DOs. These CAH respondents reported seeing a mean of 7.8 STEMI, 12.4 NSTEMI, 8.9 stroke, and 40.9 trauma patients in calendar year 2010.

A mean of 4.3 physicians and 2.7 mid-level providers provide emergency department coverage at the CAHs. Representing a variety of rural communities and coverage plans, respondents reported a mean of 21.8 minutes as the expected response time for ED providers after-hours. Respondents also report a mean of 36.3 interfacility transports for a time critical diagnoses (STEMI, Stroke, Trauma etc.) in 2010.

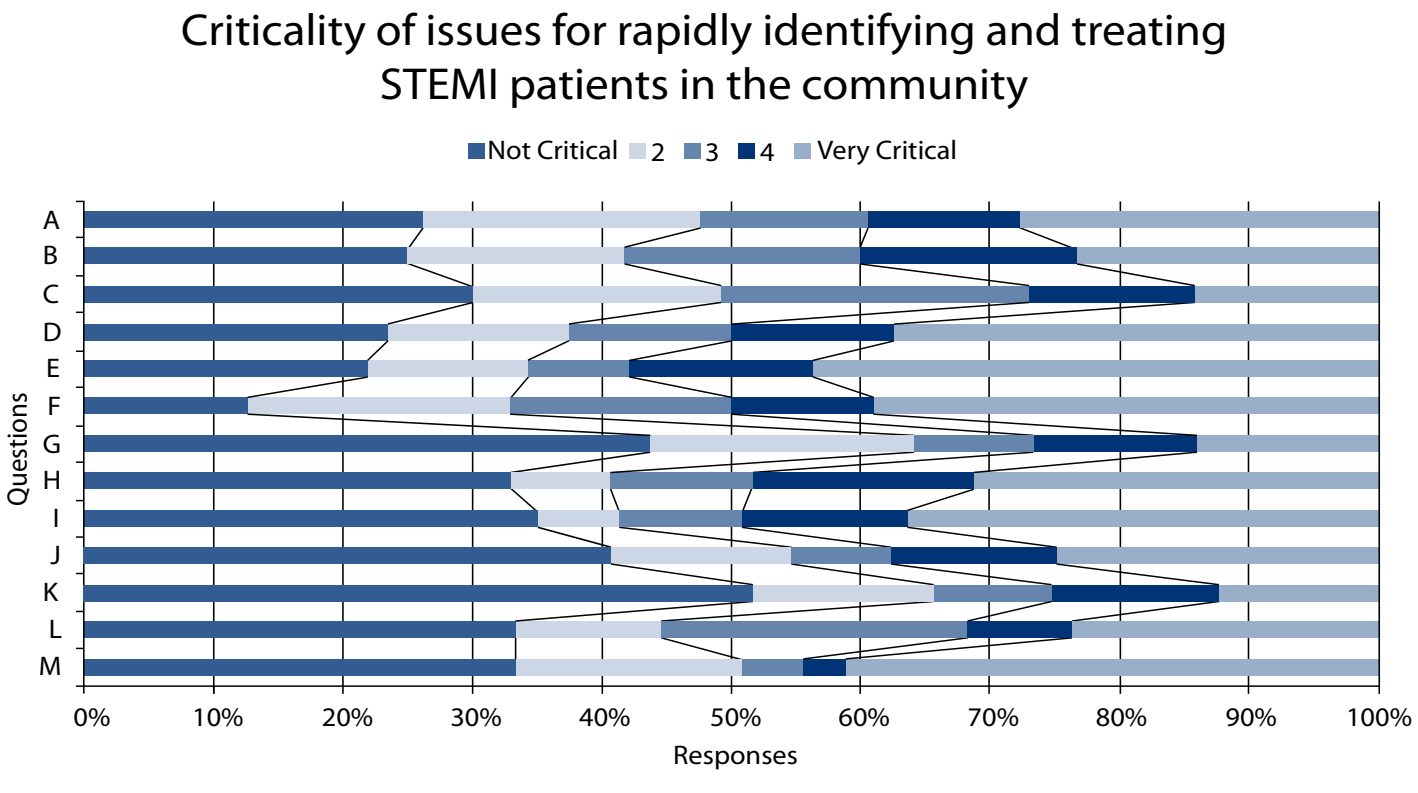

Table 4: Trends, Issues, Barriers, and Obstacles
Does your facility have an emergency room that receives patients (either walk in or by ambulance)?
Does your facility have standing patient acceptance agreements with regional STEMI centers?
Does your emergency room give thrombolytics for STEMI?
Is giving thrombolytics for STEMI up to an individual provider?
Do you have providers that trend towards transferring STEMI patients without giving thrombolytics?
Do you have a local Advanced Life Support (paramedics) ambulance service?
Is there a local requirement that a RN accompany a STEMI patient that has been given thrombolytics?
Have you identified obstacles or barriers to providing timely care to STEMI patients?
Does your facility have standing patient acceptance agreements with regional Stroke centers?
Does your facility have standing patient acceptance agreements with regional Trauma centers?
Does your emergency room give thrombolytics for ischemic CVA?
Is giving thrombolytics for CVA up to an individual provider?
Do you direct/allow/request that local paramedics bypass your facility for regional STEMI centers?
Do you direct/allow/request that local paramedics bypass your facility for regional Stroke centers?
Do you direct/allow/request that local paramedics bypass your facility for regional Trauma centers?
Do your local EMS responders perform 12-lead acquisition?
Do your local EMS responders perform 12-lead interpretation?
Do your local EMS responders transmit 12-leads to your facility for interpretation during an EMS call?
Do your local EMS responders transmit 12-leads to a regional STEMI center for interpretation during an EMS call?

Overall, 41.5% do not have standing patient acceptance agreements with regional STEMI centers (2: Yes, 27: No, 7: Uncertain). Similarly 52.3% do not have agreements with regional stroke centers (25 yes, 34: No, 3: Uncertain) while 21.5% do not have agreements with regional trauma centers (48: Yes, 14: No, 3: Uncertain).

All but one reported thrombolytics are administered for STEMI although most leave the decision to administer thrombolytics up to the individual provider (58: Yes, 7: No) and 23% report having providers that trend towards not administering thrombolytics prior to interfacility transfer (15: Yes, 39: No, 11 Uncertain). For stroke 67.7% administer thrombolytics (44: Yes, 17: No, 3: uncertain) while 78.5% leave the decision up to the provider (51 Yes, 9: No, 2: Uncertain).

Respondents were equally likely to have access to local advanced life support (paramedics) ambulance service although 20% (13 yes, 47 no, 4 uncertain) require a registered nurse to accompany a STEMI patient that has been given thrombolytics, which is a potential barrier to the administration of thrombolytics by those facilities. Nearly half have identified obstacles or barriers to providing timely care for STEMI patients (28: Yes, 33: No, 3: Uncertain).

70.1% do not direct/allow/request local paramedics bypass their facility for regional STEMI centers (8: Yes, 46: No, 3: Uncertain). 69.2% have the same policy for stroke care (8: Yes, 45: No, 4: Uncertain) and 63.1% have the same policy for trauma care (14: Yes, 41: No, 3: Uncertain).

Local EMS responders perform 12-lead acquisition 16.9% of the time (11: Yes, 50: No, 2: Uncertain), 12-lead interpretation 7.7% (5 yes, 54 no, 5 uncertain), transmit 12-leads to CAH for interpretation during an EMS call 3% (2: Yes, 59: No, 3: Uncertain), and transmit 12-leads to regional STEMI center for interpretation during an EMS call in one location (1: Yes, 60: No, 3: Uncertain).

The results of the survey showed that although the vast majority of critical access hospitals were capable of giving thrombolytic therapy, a significant number elected to transfer patients to a PCI center without giving thrombolytic therapy.

Therefore, a series of follow-up questions were asked through a selective telephone survey to determine the reason that primary PCI was selected as the reperfusion strategy. The results of the second survey showed the perceived benefits of a statewide coordinated approach to STEMI care from the CAH representatives. The following comments were also received by the project team while discussing regional issues with CAH representatives but were not components of the survey itself:

1. Overwhelmingly, Critical Access Hospitals report the reperfusion strategy is decided by the receiving cardiologist at the PCI-hospital:

'I can't say I've noticed a trend toward transferring patients for primary PCI because it completely depends on which cardiologist is on call. Interviewee number 16.

'All decisions regarding care come from the cardiologist at the PCI hospital which is about 2 hours away. There is another PCI hospital about 1 hour away but we do not consult with those cardiologists.' Interviewee number 39.

2. In a majority of instances the receiving cardiologist asks about the time of onset of symptoms and the expected transfer time prior to selecting the reperfusion strategy:

'Some patients are transferred to [Hospital A] which is 25 minutes away and others are transferred to [Hospital B] which is 2 hours away depending on the patient's preference.' Interviewee number 44.

3. The receiving cardiologist occasionally asks for additional information including cardiac biomarkers although this information is often obtained for most patients by protocol prior to contacting the cardiologist:

'Our local ambulance is staffed by volunteers and they do not have the training, education, or equipment to handle long transfers of STEMI patients and it's a liability.' Interviewee number 16.

4. Most Critical Access Hospitals report the STEMI diagnosis takes 0–30 minutes from the time of the patient's arrival:

'We do not consider the prehospital 12-lead ECG to be diagnostic so the 12-lead ECG is repeated in the emergency department.' Interviewee number 3.

5. Critical Access Hospitals report that STEMI patients spend a total of 60–90 minutes of total time at the Critical Access Hospital prior to transfer:

'It would be helpful if there was a standardised system because the care is inconsistent.' Interviewee number 24.

Discussion

This study is the first to examine the reasons why thrombolytic therapy is not given to eligible patients in rural Nebraska when transfer times are prolonged.

We found that receiving cardiologists are considering the time of onset of symptoms and the expected transfer time prior to selecting the reperfusion strategy but are underestimating the total time from first-medical-contact to reperfusion, primarily due to the time required to arrange for and conduct an interfacility transfer to the PCI center from a CAH.

To better illustrate the components of this rural treatment plus interfacility interval, consider the following elements:

- Patient recognises symptoms
- Initial 9-1-1 call, EMS response, and transport
- Arrival of the patient at the Critical Access Hospital (EMS or walk-in)
- Diagnosis of acute STEMI (physician, PA or NP is 'on-call' during off hours)
- Consultation with cardiologist at PCI hospital (sometimes only occurring after results of cardiac biomarkers are available)
- Selection of transfer mode (ground or air ambulance)
- Preparation (duplication) of medical records, X-rays, lab tests for PCI center
- Reaction time of ground or air ambulance to the CAH
- Transition time while report is given and patient is loaded for transport
- Travel time from CAH to PCI center
- Arrival at PCI-hospital (including in house processes for intake)
- D2B at PCI-hospital

This study did not consider the timeliness of thrombolytic therapy at CAHs when thrombolytic therapy is chosen as the initial or primary reperfusion strategy. Since virtually all STEMI patients (with very few exceptions) are ultimately transferred out of CAHs and the cardiologist at the receiving hospital selects the reperfusion strategy it is likely that D2N times exceed the recommended 30 minutes.

With a focus on reducing the first-medical-contact to reperfusion time there are additional aspects of the EMS, CAH, PCI center STEMI care system that

could be addressed. For example, we found that:

1. EMS in rural areas is often provided by BLS-trained volunteers who are not equipped with 12-lead ECG monitors and training guidelines do not include this procedure.

- This could be addressed by equipping BLS ambulances with 12-lead ECG monitors and the technology to transmit in addition to including the procedure in state training guidelines.

2. Critical access hospitals may not see enough STEMI patients to be proficient at STEMI diagnosis based on ECG findings alone or may not be comfortable giving thrombolytic therapy.

- This could be addressed by implementing telemedicine to speed the diagnosis and provide clinical support to critical access hospitals. Providing targeted educational support through standardised online learning tools to aid in the STEMI diagnosis.

3 Current protocols may have been developed years ago before regionalised systems of care were developed in the USA.

- This could be addressed by not requiring additional testing (for example, cardiac biomarkers) prior to arranging transfer for STEMI patients.

4. Some critical access hospitals do not have standing transfer agreements with PCI-hospitals and/or use cardiologists from hospitals that are further away than the closest PCI-hospital

- This could be addressed by developing state-wide protocols for the transfer of STEMI patients to the closest PCI hospital regardless of longstanding system affiliations and hospital relationships.

5. Some critical access hospitals may not know how many STEMI patients they see in a given year.

- This could be addressed by creating a state-wide registry for STEMI patients for data collection and quality improvement.

6. There is no funding for 12-lead ECG monitors, ECG transmission, additional training, data abstraction, quality improvement efforts.

- This could be addressed by seeking additional sources of funding from grants or charitable donations.

7. There is no political support for building regional system of care for acute STEMI.

- This could be addressed by partnering with the American College of Emergency Physicians, Emergency Nurses Association, AHA, ACC, and National Association of EMS Physicians.
- Look to other states that have managed to develop political support through collaboration.

These issues and suggestions for improving the quality of care delivered to rural Nebraska STEMI patients would foster the development of a coordinated system of STEMI care.

Conclusion

We qualitatively demonstrated that STEMI patients in the rural setting of Nebraska are not receiving timely reperfusion, and that even data describing the number of persons and delays experienced are not widely tracked. Although currently lacking, individuals surveyed expressed a desire for a statewide coordinated STEMI care system.

Furthermore, the reasons why there are DIDO delays or policies not allowing EMTs to acquire a diagnostic 12–lead EKG or bypass a CAH hospital, were reasons mostly revolving around issues in which very basic education of both the staff at the CAH and the receiving cardiologists could mitigate further patient delays and improve treatment.

Acknowledgements

We would like to acknowledge the tremendous help and support provided by Dean Cole, Nebraska EMS/ Trauma Program Administrator and the staff of the Nebraska EMS/Trauma Programme, including Doug Fuller, Julie Smithson, Carrie Crawford, Sharon Steele, Larry Wallace (ret.), and Carol Jorgensen. Without their diligent assistance the survey response rate would not have been as remarkable as it was, at 100%.

Funding

Funding for the RAMIS project was provided by the Nebraska Department of Rural Health led by former Administrator Dennis Berens and interim Administrator and FLEX Coordinator David Palm.

Bradley E, Brahmjee KN, Amy FS et al (2008) *Contemporary evidence: baseline data from the D2B Alliance*. www.ncbi.nlm.nih.gov/pmc/articles/PMC2525646/ (accessed 7 January 2012)

Maroko PR, Kjekshus JK, Sobel BE et al (1971) Factors influencing infarct size following experimental coronary artery occlusions. *Circulation* **43**(1): 67–82

Reimer K, Jennings R, Hall M (1981) Total Ischemia in Dog Hearts, in Vitro. *Circulation Research* **49**: 901–11

Antman E (2008) Time Is Muscle. *J Am Coll Cardiol* **52**(15): 1216–21. content.onlinejacc.org/cgi/content/full/52/15/1216 (accessed 7 January 2012)

Maroko PR, Kjekshus JK, Sobel BE et al (1971) Factors influencing infarct size following experimental coronary artery occlusions. *Circulation* **43**(1): 67–82

Zijlstra F, van't Hof AWJ, Liem AL et al (1996) Transferring patients for primary angioplasty: a retrospective analysis of 104 selected high risk patients with acute myocardial infarction. *Heart* **78**: 333–336 doi:10.1136/hrt.78.4.333 heart.bmj.com/content/78/4/333.abstract (accessed 7 January 2012)

Newby LK, Rutsh WR, Califf RM et al (1996) Time from symptom onset to treatment and outcomes after thrombolytic therapy. *J Am Coll Cardiol* **27**(7): 1646–55. content.onlinejacc.org/cgi/content/abstract/27/7/1646

Boersma E, Maas AC, Deckers JW (1996) Early thrombolytic treatment in acute myocardial infarction: reappraisal of the golden hour. *Lancet* **348**(9030): 771–5 www.ncbi.nlm.nih.gov/pubmed/8813982.1 (accessed 7 January 2012)

Zijlstra F, van't Hof AWJ, Liem AL et al (1998) Influence of treatment delay on infarct size and clinical outcome in patients with acute myocardial infarction treated with primary angioplasty. *J Am Coll Cardiol* **32**: 629–33 content.onlinejacc.org/cgi/content/full/32/3/629 (accessed 7 January 2012)

Francone M, Bucciarelli-Ducci C, Carbone I et al (2009) Impact of primary coronary angioplasty delay on myocardial salvage, infarct size, and microvascular damage in patients with ST-segment elevation myocardial infarction: insight from cardiovascular magnetic resonance. *J Am Coll Cardiol* **54**(23): 2145–53. content.onlinejacc.org/cgi/content/abstract/54/23/2145 (accessed 7 January 2012)

Dentkas A, Anderon HV, McCarthy J (2011) Total Ischemic Time: The Correct Focus of Attention for Optimal ST-Segment Elevation Myocardial Infarction Care. *J Am Coll Cardiol Intv* **4**(6): 599–604. interventions.onlinejacc.org/cgi/content/abstract/4/6/599 (accessed 7 January 2012)

Antman E, Anbe DT, Armstrong PW et al (2004) ACC/AHA guidelines for the management of patients with ST-Elevation myocardial infarction—executive summary. *J Am Coll Cardiol* **44**(3): 671–719. content.onlinejacc.org/cgi/content/full/44/3/671 (accessed 7 January 2012)

Nallamothu BK, Bates ER, Herrin J (2005) Times to treatment in transfer patients undergoing primary percutaneous coronary intervention in the United States: National Registry of Myocardial Infarction (NRMI)-3/4 analysis. *Circulation* **111**: 761–7

Antman EM and Smith SC (2011) "St-elevation myocardial infarction: The first 24 hours." Medscape News. www.medscape.com/viewarticle/567620

Deborah Diercks MD (2010) American Heart Association Mission Lifeline: Developing a STEMI Regional Care System", American Heart Association Mission Lifeline. www.emcreg.org/publications/monographs/acep/2009/ACEP2009_dbd.pdf (accessed 7 January 2012)

Curtis JP et al (2006) The Pre-Hospital Electrocardiogram and Time to Reperfusion in Patients With Acute Myocardial Infarction 2000–2002. *J Am Coll Cardiol* **47**(80): 1544–52 content.onlinejacc.org/cgi/content/abstract/47/8/1544 (accessed 7 January 2012)

Krumholz H, Herrin J, Miller L et al (2011) Improvements in door-to-balloon time in the United States 2005 to 2010. *Circulation*. circ.ahajournals.org (accessed 7 January 2012)

Bradley E, Brahmjee KN, Amy FS et al (2008) *Contemporary evidence: baseline data from the D2B Alliance*. www.ncbi.nlm.nih.gov/pmc/articles/PMC2525646/ (accessed 7 January 2012)

Swor R, Hegerberg S, McHugh-McNally A (2006) Prehospital 12-lead ECG: efficacy or effectiveness? *Prehosp Emerg Care* **10**(3): 374–7

Ting HH, Rihal CS, Gersh BJ (2007) Regional systems of care to optimize timeliness of reperfusion therapy for ST-elevation myocardial infarction: the Mayo Clinic STEMI Protocol. *Circulation* **116**(7): 729–36

Henry TD, Unger BT, Sharkey SW (2005) Design of a standardized system for transfer of patients with ST-elevation myocardial infarction for percutaneous coronary intervention. *Am Heart J* **150**(3): 373–84

Gale J, FLEX Monitoring Team (2011) *Developing Regional STEMI Systems of Care: A Review of the Evidence and the Role of the Flex Program*. flexmonitoring.org/documents/STEMI-BriefingPaper29.pdf (accessed 7 January 2012)

Fredi JL STEMI Network (2011) Vanderbilt Heart & Vascular Institute Publications. www.mc.vanderbilt.edu/documents/heart/files/STEMI%20Newsletter~Winter%202011_web.pdf (accessed 7 January 2012)

Terkelsen C, Sørensen J, Maeng M et al (2010) System Delay and Mortality Among Patients With STEMI Treated With Primary Percutaneous Coronary Intervention. *JAMA* **304**(7): 763–771 jama.jamanetwork.com/article.aspx?articleid=186426 (accessed 7 January 2012)