Rural and Remote Health
MEDLINE listed
Impact factor .820
The International Electronic Journal of Rural and Remote Health Research, Education, Practice and Policy
ISSN 1445-6354

REVIEW ARTICLE

Rural emergency medical technician pre-hospital electrocardiogram transmission

AM Powell, JM Halom, J Nelson

Landsbaum Center for Health Education, Indiana State University, Indiana, USA

Indiana University Health West Hospital, Avon, Indiana, USA

Submitted: *5 June 2013;* **Revised:** *13 September 2013;* **Accepted:** *14 September 2013;* **Published:** *2 May 2014*

Powell AM, Halom JM, Nelson J

Rural emergency medical technician pre-hospital electrocardiogram transmission
***Rural and Remote Health* 14: 2690. (Online) 2014**

Available: http://www.rrh.org.au

ABSTRACT

Introduction: Emergent care of the acute heart attack patient continues to be at the forefront of quality and cost reduction strategies throughout the healthcare industry. Although the average cardiac door-to-balloon (D2B) times have decreased substantially over the past few years, there are still vast disparities found in D2B times in populations that reside in rural areas. Such disparities are mostly related to prolonged travel time and subsequent delays in cardiac catherization lab team activation. Urban ambulance companies that are routinely staffed with paramedic level providers have been successful in the implementation of pre-hospital 12-lead electrocardiogram (ECG) protocols as a strategy to reduce D2B times.

Method: The authors sought to evaluate the evidence related to the risk and benefits associated with the replication of an ECG transmission protocol in a small rural emergency medical service. The latter is staffed with emergency medical technician–basics (EMT-B), emergency medical technician–advanced (EMT-A), and emergency medical technician–intermediate (EMT-I) level.

Results: The evidence reviewed was limited to studies with relevant data regarding the challenges and complexities of the ECG transmission process, the difficulties associated with ECG transmission in rural settings, and ECG transmission outcomes by provider level.

Conclusions: The evidence supports additional research to further evaluate the feasibility of ECG transmission at the non-paramedic level. Multiple variables must be investigated including equipment cost, utilization, and rural transmission capabilities. Clearly, pre-hospital ECG transmission and early activation of the cardiac catheterization laboratory are critical components to successfully decreasing D2B times.

Key words: ECG, electrocardiogram, emergency medical technician, EMT, rural, transmission.

Introduction

Cardiac disease has been the leading cause of death in the United States for over 75 years[1]. Not only has cardiac disease taken more lives than cancer, lower respiratory diseases, and accidents combined, but also accounts for nearly US$444 billion a year in healthcare costs and lost economic productivity[2]. American Heart Association data report that nearly one-third of all heart attacks in the USA are an ST-elevation myocardial infarction (STEMI)[3]. Efforts to impact cardiovascular mortality rates must consider all of the variables related to cardiac care. One of the critical aspects that must be addressed is the pre-hospital coordination of care for rural patients experiencing an STEMI[4]. ST-elevation can be seen quickly by utilizing an electrocardiogram (ECG) after the heart begins to lose blood supply. Revascularization of the heart muscle is the only form of definitive treatment for deadly heart attacks. Ultimately, the gold standard is reperfusion of the occluded artery within 90 minutes of presentation with the attack[5].

According to the US Census Bureau, nearly 60 million people, 19.3% of the population, live in rural areas[6]. Of those individuals, only about 47.3% have access to a facility inclusive of percutaneous coronary intervention (PCI) capabilities within 60 minutes or less[7]. In a sample of 2187 STEMI patients, only 2.9% resided within 30 minutes of a PCI facility, with the average transport time for those patients being 67 minutes[8]. Data demonstrate that patients who stop at the small rural hospitals prior to transfer to a PCI facility may experience a delay of 32–65 minutes[4]. In a situation where time is equal to heart muscle, rural providers must develop processes that help eliminate barriers to rapid diagnosis and treatment for STEMI patients. Successful STEMI programs implement comprehensive strategies that follow the patient from chest pain onset through revascularization. There must be thorough investigation of methods that allow partners across the care continuum to utilize rural resources to leverage a timely and coordinated effort to care for patients experiencing a STEMI. Coordination of care for rural STEMI patients must judiciously utilize the minutes that these patients are spending in the pre-hospital setting.

Pre-hospital or 'field' ECG transmission is one of the methods that can be utilized to facilitate early activation of the cardiac catheterization team and subsequently reduce time to revascularization. Pre-hospital activation is essential for rural patients that will arrive at a PCI facility following extensive transport times. Further investigation is required to evaluate the acquisition and transmission of 12-lead ECGs by emergency medical technicians–basics (EMT-B), emergency medical technicians–intermediate (EMT-I), and emergency medical technicians–advanced (EMT-A) as an integral part of the rural STEMI treatment process. The purpose of this article is to identify best practice recommendations and identify evidence-based protocols that will facilitate time-sensitive coordination of cardiac care for rural populations served by basic life support (BLS)-level providers.

Methods

The initial search criteria included key words such as *rural*, *myocardial infarction*, *STEMI*, and *ST-elevation myocardial infarction*, which were when entered into EBSCOhost databases and yielded 10 808 articles. Of these, 7795 originated from *Cumulative Index for Nursing and Allied Health Literature* (CINHAL), whereas 3013 were found in *Healthsource Nursing and Academic Edition*. Inclusion criteria included quantitative and qualitative studies published between 2005 and 2013 and by abstract review and included such key words as utilization of D2B, door-to-balloon, ECG, pre-hospital, basic, emergency medical technician, EMT, emergency medical services, and EMS (emergency medical services), which yielded 377 articles. Of the 377 articles, title review further reduced the article count to 96. Abstracts of the 96 articles were reviewed and 40 articles that contained no information specific to rural applications were also excluded. The final articles presented include retrospective, feasibility, prospective, and before-and-after cohort studies that were selected based on relevance and the strength of the evidence.

Results

While all patients with acute cardiovascular disease may encounter challenges, the rural population is at further disadvantage in the achievement of the recommended D2B times of <90 minutes. In 2008, Aguirre et al. noted in a study of 4278 patients, who were participating in inter-hospital transfer to primary PCI centers, that only 4.2% and 16.2% of patients achieved D2B times of <90 minutes and <120 minutes respectively[4]. The authors asserted that the major 'rate-limiting' delay occurred at rural STEMI referral centers in awaiting transport and packaging the patient for transport, but concluded in preliminary data that the use of pre-hospital 12-lead ECG acquisition can reduce those delays by up to 20 minutes[4].

A 2009 study evaluated 1437 STEMI patients that were treated at a single high-volume invasive PCI center[9]. A total of 616 patients were admitted by field triage and 821 through triage in the emergency department, also known as non-field triage[9]. The field triage group utilized 12-lead ECG transmission to the PCI receiving facility. If the ECG was positive for STEMI, the ambulance crew would bypass any outlying hospital and go directly to the PCI facility. The non-field triage group of patients was not evaluated until they entered the non-PCI facility either by themselves or with EMS crews that were not equipped with ECG transmission. If found to have a STEMI, the non-field triage group would subsequently be transferred to the PCI receiving facility. The researchers concluded that the use of pre-hospital ECG and field triage resulted in a 20% decrease in median D2B times and patients that were admitted by field triage had a reduced risk of reaching the combined endpoint of all-cause mortality[9]. This study helps validate the importance of pre-hospital interventions to expedite the treatment of STEMI patients and increase the likelihood of more positive cardiac outcomes.

In 2012, researchers conducted a retrospective study of 21 742 patients that were evaluated by EMS for chest pain between January 2003 and April 2008 with the use of pre-hospital ECG acquisition. The first responder crews consisted of units deployed with three EMTs and one paramedic[10]. However, the authors were not clear if the paramedic or EMT did the pre-hospital ECG. They did note that the design of their EMS crews including a paramedic increases the efficiency of rapid patient assessment[10]. There were 12 111 cases before the institution of pre-hospital ECG and 9631 cases reported after the implementation of the pre-hospital ECG protocol. The number of STEMI vs non-STEMI cases has decreased scene-to-hospital by nearly 3 minutes[10]. This study did not take into consideration actual D2B times, which historically have proven to be dramatically decreased with pre-hospital ECG. The authors instead wanted to evaluate the scene-to-door time in an effort to reflect the additional reduction in total ischemic time, suggesting that previous reports of reduced ischemic time with pre-hospital ECG may have been underestimated[10].

A 2012 feasibility study in Canada of 134 patients evaluated suspected STEMI patients that were hemodynamically stable and transferred for primary PCI[11]. The patients were triaged in the field and transferred by primary care paramedics only. Patients with suspected STEMI on the prehospital ECG bypassed the closest hospital for emergent coronary angiography and primary PCI[11]. The study was performed in a county with a population of approximately 430 000 people and had a primary endpoint to assess the successful identification of pre-hospital ECG and subsequent safe transport to a primary-PCI facility by the primary care paramedics[11]. (The primary care paramedic is considered the lowest credentialed provider of the three levels of paramedics in Canada, somewhat comparable to the EMT–basic in the USA.) The authors reported the median first medical contact to balloon time was 91 minutes, which includes arrival to the scene, transport time and catheterization lab time[11]. Considering that the standard D2B time of less than 90 minutes accounts for when a patient enters the emergency department, these times are significant because they consider the other variables such as scene and transport time. For the

124 patients transferred the average transport time was 43 minutes with only one patient developing a complication (rapid atrial flutter) that required advanced care paramedic level skills[11]. While the study was limited to hemodynamically stable patients and a small sample size, the findings do suggest that STEMI patients can be safely and effectively transported directly to primary-PCI centers by medics without advanced training[11].

In 2009, a feasibility study was published regarding the ability of BLS providers to reliably transmit a 12-lead ECG[12]. Prior to this Ohio county study, EMTs–basic were not allowed to transmit ECGs. The 1-year study was a prospective, unblinded examination of consecutive patients with a chief complaint of chest pain in which 55 volunteer EMTs from five different ambulance companies were selected to participate[12]. Each service received comprehensive 4-hour training sessions on countywide chest pain protocols, ECG lead placement using a template, operation of the satellite telephone and defibrillator monitor, ECG transmission, and in-hospital verification of lead placement. Data collection included scene time, transport time, and quality of ECG[12]. The study demonstrated that of 90 patients with pre-hospital ECGs performed, 89 were successfully transmitted by EMTs–basic. Of the ECGs transmitted, 95.5% met the standard for diagnostic quality, and on-scene times were not significantly different than pre-study times. Of the four STEMI patients transported during this pilot study, D2B times were lowered from the 99-minute baseline to 68 minutes during the trial. The authors also reported that following this study the Ohio Division of Emergency Medical Services changed the scope of practice of EMTs-basic to include acquisition and transmission of pre-hospital ECGs[12].

Discussion

Vast arrays of studies are available to support the use of pre-hospital ECG as a strategy to reduce D2B supported through organizations including the National Heart Attack Alert Program; National Heart, Lung, and Blood Institute; National Institutes of Health; American Heart Association; Emergency Cardiovascular Care Committee; Council on Cardiovascular Nursing; and the Council on Clinical Cardiology[5,13,14]. Pre-hospital ECG impacts are supported by demonstrated reduced D2B times[15-17] and the associated reduction in complications and myocardial tissue damage[18]. Study designs included prospective interventional studies with 349 consecutive patient encounters[17] and a retrospective analysis of 4278 patients from the National Myocardial Infarction Data Registry[7]. Overall, there is strong evidence to support pre-hospital ECG transmission.

There is little published data related to non-paramedic transmission of ECGs. The primary focus of 12-lead ECG transmissions has historically been aimed at urban ambulance services with fully trained paramedics. The data has suggested that coordinated systems of care with integration of 12-lead ECG can positively impact urban residents but often fails to address rural scenarios. Only small amounts of published data is available regarding outcomes for rural EMS services without paramedic providers to build a foundation of quality around. The key component to successful ECG transmission is the education and competency of the end user. Once again, the data available is detailed with regards to the ability of a paramedic-level provider to acquire, transmit, and possibly interpret an ECG. Only one available study documented accuracy of obtaining and transmitting and ECG at the EMT-B level.

There are many considerations when investigating the use of pre-hospital ECGs in rural settings. One consideration is the amount of time/distance to a PCI facility[5,7,12]. For rural areas, where timely mechanical thrombolysis by PCI cannot be achieved, the option of pharmacological thrombolysis must be investigated. As of 2000, 79% of the adult population in the USA lived within 60 minutes of a PCI facility[7]. Ninety-eight per cent of urban residents lived within 60 minutes of a PCI facility. However, only 47.8% of rural residents lived within 60 minutes of a PCI hospital[7].

In addition to distance to PCI facilities, consideration must be also given to the technical ability to transmit based on cellular (mobile) coverage area[12]. There is a gap noted in the literature related to the current cellular technology. The pre-hospital ECG has been well established as a useful tool in assisting emergency room physicians, and STEMI teams rapidly and accurately prepare definitive treatment plans for patients with a STEMI[19]. For rural areas that have no paramedic service, the patient will not receive definitive treatment prior to arrival at the hospital. Pre-hospital ECG transmission allows the STEMI team time to effectively plan for definitive treatment. There is an imperative need to review the research and assess the potential outcome impacts of a comprehensive rural field ECG transmission program.

Implications for rural organizations and providers

Although the evidence related to pre-hospital ECG transmission by EMTs is limited, there is vast evidence to support the importance of implementing strategies that reduce D2B times. Clearly more research is needed to support the feasibility of ECG transmission by non-paramedic providers. Future research must address cost considerations related to training, equipment and sustainability; equipment availability; rural broadband coverage; and the ability of EMS personnel to consistently deploy the device. In addition there should be investigation into the overall impact of such programs including parameters such as scene to EKG time, first patient contact to EKG time, and scene-to-balloon times. Not only does the research suggest strong clinical implications in relation to cardiac outcomes and mortality when acute heart attacks are treated quickly and effectively, but also an ever-increasing case from a financial justification standpoint to decrease D2B times. Patients with less residual damage in heart muscle and function, secondary to their heart attack, will require fewer medications and have less risk of re-hospitalization. An additional consideration is the importance to hit the 90-minute D2B time metric as it relates to the quality portion of value-based purchasing and other key reimbursement objectives that are often payer-specific. With the implementation of value-based purchasing, hospitals are at risk of losing 1% of their reimbursement from the Centers for Medicare and Medicaid even with potential to lose nearly 2% by the year 2017. Given that one of the metrics of value-based purchasing is, 'heart attack patients given PCI within 90 minutes of arrival'[20], it becomes more imperative to support initiatives that will drive D2B times below the 90-minute threshold all of the time.

Hospitals and hospital systems that strive to incorporate 12-lead ECG transmission into their standard of care need to utilize a multi-faceted approach of implementation. The use of 12-lead ECG transmission is a large undertaking that involves coordination of multiple departments and personnel not only within the PCI receiving facility but also beyond the hospital walls and into the EMS crews that are within the service region. One of the most limiting factors in the process of implementation is the expense of available technology to capture and transmit the 12-lead ECG from the field. According to a survey that comprised data of EMS systems in 200 US cities, only 67% had pre-hospital 12-lead capabilities, with the average population served by those areas being 459 804[21]. Rural areas may have even greater disparities in regards to EMS crews with the capability of transmitting 12-lead ECGs. Healthcare providers wishing to implement this technology will have to consider the cost of the equipment versus the enhancement in patient care and reduction in D2B times. Careful planning and coordination will be critical to ensure all EMS crews are equipped with the appropriate technology. In addition, individuals are strongly encouraged to pursue non-traditional funding methods such as grants to ensure community foundation support.

Another key component to successful implementation is the collaboration of the emergency department providers and nursing staff with the EMS crews. Providers and nursing staff are critical in helping to educate the EMS crews regarding ECG interpretation and transmission. Thorough education among all EMS staff will also enhance knowledge regarding the specifics of what the cardiac catheter laboratory team does during a primary PCI, and will subsequently allow for more rapid preparation of a STEMI patient. In rural settings, where first responders may be limited to EMT and non-paramedics, rapport with the emergency department providers and cardiologists will be critical to ensure trust in levels of expertise and competency. Moreover, establishing continuous and timely communication and feedback among all staff involved is essential in developing success of an integrated STEMI process of care.

Conclusions

For the nearly 25% of people in the USA that live in rural areas, obtaining rapid and definitive cardiac care is complicated[22]. However, positive cardiovascular outcomes and survival dramatically improve when reperfusion times of the occluded heart artery are decreased. Due to time delays, patients in rural populations face more disparities in cardiac outcomes than their urban counterparts. As this article demonstrates, the use of pre-hospital ECG transmission protocols is well supported by current evidence as a best practice to implement for D2B systems of care. While the evidence provides some clear knowledge regarding the D2B processes with paramedic-level providers, each rural community must be evaluated without overlooking its unique EMS staffing paradigm. Rural regions of care with EMT level providers will require a thorough investigation of all resources available and should strongly consider the use of D2B protocols that promote the use of pre-hospital ECG transmission as a critical component of urgent cardiovascular care.

References

1. Hoyert D. *75 years of mortality in the United States, 1935–2010*. (Online) Available: http://www.cdc.gov/nchs/data/databriefs/db88.html (Accessed 14 October 2012).

2. US Department of Health and Human Services. *About heart disease and stroke: consequences and costs* (Online). Available: http://millionhearts.hhs.gov/abouthds/cost-consequences.html (Accessed 6 September 2012).

3. Rosamond W, Flegal K, Furie K, Go A, Greenlund K, Haase N, et al. Heart disease and stroke statistics – 2008 update. A report from the American Heart Association Statistics Committee. *Circulation* 2008; **117:** e25-e146.

4. Aguirre F, Varghese J, Kelley M, Lam M, Lucore C, Gill J, et al. Rural interhospital transfer of st-elevation myocardial infarction patients for percutaneous coronary revascularization. *Circulation* 2008; **117:** 1145-1152.

5. Krumholz HM, Anderson JA, Bachelder BL, Fesmire FM, Fihn SD, Foody JM, et al. ACC/AHA 2008 performance measures for adults with st-elevation and non-st-elevation myocardial infarction: A report of the American College of Cardiology/American Heart Association task force on performance measures. *Circulation.* 2008; **118***:* 2596-2648.

6. United States Census Bureau. *2010 census urban area FAQ's* (Online) Available: http://www.census.gov/geo/reference/ua/uafaq.html (Accessed 13 November 2012).

7. Nallamothu B, Bates E, Wang Y, Bradley E, Krumbolz HM. Driving times and distances to hosptials wtih percutaneous coronary intervention in the United States: implications for prehospital triage of patients with st-elevation myocardial infarction. *Circulation* 2006; **113:** 1189-1195.

8. Pathak EB, Forsyth CJ, Anic G, Tanner JP, Comins MM, Strom JA. Transfer travel times for primary percutaneous coronary intervention from low-volume and non-purcutaneous coronary intervention-capable hospitals to high-volume centers in Florida. *Annals of Emergency Medicine* 2011; **58:** 257-266.

9. Penderson SH, Galatius S, Hansen PR, Mogelvang R, Abildstrom SZ, Sorensen R, et al. Field triage reduces treatment delay and improves long-term clinical outcome in patients with acute ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention. *Journal of the American College of Cardiology* 2009; **54(24):** 2296-2302.

10. Patel M, Dunford JV, Aguilar S, Castillo E, Patel E, Fisher R, et al. Pre-hospital electrocardiography by emergency medical personnel: effects on scene and transport times for chest pain and ST-segment elevation myocardial infarction patients. *Journal of the American College of Cardiology* 2012; **60(9):** 806-811.

11. Cantor WJ, Hoogeveen P, Robert A, Elliott K, Goldman LE, Sanderson E, et al. Prehospital diagnosis and triage of ST-elevation myocardial infarction by paramedics without advance care training. *American Heart Journal* 2006; **164(2):** 201-206.

12. Werman HA, Newland R, Cotton B. Transmission of 12-lead electrocardiographic tracings by emergency medcial technician-basics and emergency medical technician-intermediates: a feasibility study. *American Journal of Emergency Medicine* 2011; **29:** 437-440.

13. Sillesen M, Sejerseten M, Strange S, Nielsen SL, Lippert F, Clemmensen P. Referral of patients with ST-segment elevation acute myocardial infarction directly to the catherization suite based on prehospital teletransmission of 12-lead electrocardiogram. *Journal of Electrocardiology* 2008; **41(1):** 49-53.

14. Ting HH, Krumholz HM, Bradley EH, Cone DC, Curtis JP, Drew BJ, et al. Implementation and integration of prehospital ECGs into systems of care for acute coronary syndrome. *Circulation* 2008; **118:** 1066-1079.

15. American College of Cardiology. *Door to balloon: sustain the gain*. (Online) Available: http://d2b.acc.org (Accessed 27 October 2012).

16. Soon C, Chan W, Tan H. The impact of time-to-balloon on outcomes in patients undergoing modern primary angioplasty for acute myocardial infarction. *Singapore Journal of Medicine* 2007; **48(2):** 131-136.

17. Hutchison AW, Malaiapan, Y, Jarvie I, Barger B, Watkins E, Braitberg G, et al. Prehospital 12 lead ECG to triage ST-elevation myocardial infarction and emergency department activation of the infarct team significantly improves door-to-balloon times. *Circulation* 2009; **2(6):** 528-534.

18. Kim L, Aggarwai S, Cuomo L, Feldman D, Wong S, Minutello R. Door-to-balloon time in percutaneous coronary intervention predicts degree of myocardial necrosis as measured using cardiac biomarkers. *Texas Heart Institute Journal* 2010; **37(2):** 161-165.

19. Fergeson JD, Brady WJ, Perron AD, Kielar ND, Benner JP, Currance SB, et al. The prehospital 12-lead electrocardiogram: impact on management of out-of-hospital acute coronary syndrome patient. *American Journal of Emergency Med.* 2003; **21(2):** 136-142.

20. US Department of Health and Human Services. Hospital value based purchasing: measure explanations (Online). Available: http://www.healthcare.gov/news/factsheets/2011/04/valuebasedpurchasing04292011b.html (Accessed 2 October 2012).

21. Williams D. JEMS 200 city survey: A snapshot of facts and trends to create benchmarks for your service (Online) 2004. Available: http://www.jems.com/sites/default/files/2004-200CitySurvey04_tcm16-12234.pdf (Accessed 13 November 2012).

22. Kochanek K, Xu J, Minino A, Kung H. Deaths: final data for 2009. *National Vital Statistics Report* 2011; **60(3):** 8.