# Misconceptions in Advanced Life Support

## 2015 VIRGINIA EMS SYMPOSIUM

**Mario J. Weber, JD, MPA, NRP**
**Hilary Gates, BA, NRP**

# Overview

- Introduction
- Common Misconceptions
- Evidence Basis
- The Way Forward?

# CHEST PAIN HISTORY

# What Can Chest Pain History Tell Us?

# Value and Limitations of Chest Pain History in the Evaluation of Patients With Suspected Acute Coronary Syndromes

Clifford J. Swap, MD, MS
John T. Nagurney, MD, MPH

**Context** The chest pain history, physical examination, determination of coronary artery disease (CAD) risk factors, and the initial electrocardiogram compose the information immediately available to clinicians to help determine the probability of acute myocardial infarction (AMI) or acute coronary syndrome (ACS) in patients with chest pain. However, conflicting data exist about the usefulness of the chest pain history and which components are most useful.

**Objective** To identify the elements of the chest pain history that may be most helpful to the clinician in identifying ACS in patients presenting with chest pain.

**Evidence Acquisition** MEDLINE and Ovid were searched from 1970 to September 2005 by using specific key words and Medical Subject Heading terms. Reference lists of these articles and current cardiology textbooks were also consulted.

**Evidence Synthesis** Certain chest pain characteristics decrease the likelihood of ACS or AMI, namely, pain that is stabbing, pleuritic, positional, or reproducible by palpation (likelihood ratios [LRs] 0.2-0.3). Conversely, chest pain that radiates to one shoulder or both shoulders or arms or is precipitated by exertion is associated with LRs (2.3-4.7) that increase the likelihood of ACS. The chest pain history itself has not proven to be a powerful enough predictive tool to obviate the need for at least some diagnostic testing. Combinations of elements of the chest pain history with other initially available information, such as a history of CAD, have identified certain groups that may be safe for discharge without further evaluation, but further study is needed before such a recommendation can be considered reasonable.

**Conclusion** Although certain elements of the chest pain history are associated with increased or decreased likelihoods of a diagnosis of ACS or AMI, none of them alone or in combination identify a group of patients that can be safely discharged without further diagnostic testing.

*JAMA. 2005;294:2623-2629* www.jama.com

Differentiating acute coronary syndromes (ACS) from benign causes of chest pain is critical because of the consequences of misdiagnosis in either direction. Despite diagnostic advances, missed acute myocardial infarction (AMI) and ACS remain problematic, with estimates ranging between 2% and 10%.[1-5] Conversely, a large proportion of patients with chest pain who are admitted do not turn out to have ACS.[6] This overtriage has enormous economic implications for the US health care system, estimated at $8 billion in annual costs.[7,8]

Distinguishing whether a patient presenting with chest pain has ACS or a non-ACS problem is at best difficult. The differential diagnosis of chest pain is broad and includes many systems, such as pulmonary, musculoskeletal, gastrointestinal, dermatologic, psychiatric, and cardiovascular (including ACS and non-ACS).[9,10] In addition to ACS, this differential includes other immediately life-threatening diseases such as pulmonary embolism, tension pneumothorax, and aortic dissection, necessitating rapid diagnosis and treatments that are markedly different than those for ACS.

The tools most readily available to guide disposition of the patient with chest pain are the patient's age and sex, history of coronary artery disease (CAD) or its risk factors, and the chest pain history. Usually, an initial 12-lead electrocardiogram (ECG) is added as well. In patients without significant ECG changes, risk factors for CAD have been shown to be poor predictors of AMI or ACS.[4,11,12] The initial 12-lead ECG has a sensitivity of only 20% to 60% for AMI,[13-15] and a single set of biochemical markers also has poor sensitivity.[14-16] Because none of these tools used alone is a reliable predictor of ACS, the chest pain characteristics are usually used in conjunction with them to help determine disposition. Although this article dis-

**CME available online at www.jama.com**

**Author Affiliations:** Massachusetts General Hospital, Boston.
**Corresponding Author:** John T. Nagurney, MD, MPH, Massachusetts General Hospital, 55 Fruit St, Clinics 115, Boston, MA 02114 (jnagurney@partners.org).
**Clinical Review Section Editor:** Michael S. Lauer, MD. We encourage authors to submit papers for consideration as a "Clinical Review." Please contact Michael S. Lauer, MD, at lauerm@ccf.org.

©2005 American Medical Association. All rights reserved.



## Swap & Nagurney (2005)

- Reviewed research studies for evidence of relationship between chest pain history and AMI/ACS diagnoses.
- Prospective and retrospective observational investigations.
- Systematic reviews.
- Medical textbooks.

# Location of Chest Pain

- Sub-sternal?
- Mid-chest?
- Left-chest?
- Epi-gastric?

# Location of Chest Pain

- ~~Sub-sternal?~~ NOT PREDICTIVE OF AMI
- Mid-chest?
- Left-chest?
- Epi-gastric?

# Location of Chest Pain

- ~~Sub-sternal?~~ NOT PREDICTIVE OF AMI
- ~~Mid-chest?~~ NOT PREDICTIVE OF AMI
- Left-chest?
- Epi-gastric?

# Location of Chest Pain

- ~~Sub-sternal?~~ NOT PREDICTIVE OF AMI
- ~~Mid-chest?~~ NOT PREDICTIVE OF AMI
- ~~Left-chest?~~ SUGGESTIVE OF NON-AMI
- Epi-gastric?

# Location of Chest Pain

- ~~Sub-sternal?~~ NOT PREDICTIVE OF AMI
- ~~Mid-chest?~~ NOT PREDICTIVE OF AMI
- ~~Left-chest?~~ SUGGESTIVE OF NON-AMI
- ~~Epi-gastric?~~ NOT PREDICTIVE OF AMI

# Onset/Provocation

- Heavy exertion in the hour prior?
- Not associated with exertion?

# Onset/Provocation

- Heavy exertion in the hour prior? PREDICTIVE OF AMI!
- Not associated with exertion?

# Onset/Provocation

- Heavy exertion in the hour prior? PREDICTIVE OF AMI!
- ~~Not associated with exertion?~~ NOT PREDICTIVE

# Quality

- Pressure?
- Sharp?
- Stabbing?
- Worse than normal angina?
- Similar to previous MI?

# Quality

- Pressure? WEAK PREDICTOR
- Sharp?
- Stabbing?
- Worse than normal angina?
- Similar to previous MI?

# Quality

- Pressure? WEAK PREDICTOR
- ~~Sharp?~~ SUGGESTIVE OF NON-AMI
- Stabbing?
- Worse than normal angina?
- Similar to previous MI?

# Quality

- Pressure? WEAK PREDICTOR
- ~~Sharp?~~ SUGGESTIVE OF NON-AMI
- ~~Stabbing?~~ SUGGESTIVE OF NON-AMI
- Worse than normal angina?
- Similar to previous MI?

# Quality

- Pressure? WEAK PREDICTOR
- ~~Sharp?~~ SUGGESTIVE OF NON-AMI
- ~~Stabbing?~~ SUGGESTIVE OF NON-AMI
- Worse than normal angina? GOOD PREDICTOR!
- Similar to previous MI?

# Quality

- Pressure? WEAK PREDICTOR
- ~~Sharp?~~ SUGGESTIVE OF NON-AMI
- ~~Stabbing?~~ SUGGESTIVE OF NON-AMI
- Worse than normal angina? GOOD PREDICTOR!
- Similar to previous MI? GOOD PREDICTOR!

# Radiation

- Radiates to left arm/shoulder?
- Radiates to right arm/shoulder?
- Radiates to both arms/shoulders?

# Radiation

- Radiates to left arm/shoulder? GOOD PREDICTOR
- Radiates to right arm/shoulder?
- Radiates to both arms/shoulders?

# Radiation

- Radiates to left arm/shoulder? GOOD PREDICTOR
- Radiates to right arm/shoulder? BETTER PREDICTOR!
- Radiates to both arms/shoulders?

# Radiation

- Radiates to left arm/shoulder? GOOD PREDICTOR
- Radiates to right arm/shoulder? BETTER PREDICTOR!
- Radiates to both arms/shoulders? BETTER PREDICTOR!

# Severity

- Rates pain 0-5?
- Rates pain 5-10?

NO SIGNIFICANT DIFFERENCE IN PREDICTING AMI!

# Time

- Lasted a few seconds?
- Lasted 2-10 minutes?
- Lasted 10-30 minutes?
- Lasted several days?

LIMITED DATA TO SUPPORT TIMING DISTINCTIONS

# Relief or Aggravation

- Worse on inspiration or coughing?
- Worse on movement?
- Worse on palpation?
- Relieved by nitroglycerin?

# Relief or Aggravation

- Worse on inspiration or coughing? SUGGESTS NON-AMI
- Worse on movement? SUGGESTS NON-AMI
- Worse on palpation? SUGGESTS NON-AMI
- Relieved by nitroglycerin?

# Relief or Aggravation

- Worse on inspiration or coughing? SUGGESTS NON-AMI
- Worse on movement? SUGGESTS NON-AMI
- Worse on palpation? SUGGESTS NON-AMI
- ~~Relieved by nitroglycerin?~~ NOT PREDICTIVE OF AMI!

# Value and Limitations of Chest Pain History in the Evaluation of Patients With Suspected Acute Coronary Syndromes

Clifford J. Swap, MD, MS
John T. Nagurney, MD, MPH

**Context** The chest pain history, physical examination, determination of coronary artery disease (CAD) risk factors, and the initial electrocardiogram compose the information immediately available to clinicians to help determine the probability of acute myocardial infarction (AMI) or acute coronary syndrome (ACS) in patients with chest pain. However, conflicting data exist about the usefulness of the chest pain history and which components are most useful.

**Objective** To identify the elements of the chest pain history that may be most helpful to the clinician in identifying ACS in patients presenting with chest pain.

**Evidence Acquisition** MEDLINE and Ovid were searched from 1970 to September 2005 by using specific key words and Medical Subject Heading terms. Reference lists of these articles and current cardiology textbooks were also consulted.

**Evidence Synthesis** Certain chest pain characteristics decrease the likelihood of ACS or AMI, namely, pain that is stabbing, pleuritic, positional, or reproducible by palpation (likelihood ratios [LRs] 0.2-0.3). Conversely, chest pain that radiates to one shoulder or both shoulders or arms or is precipitated by exertion is associated with LRs (2.3-4.7) that increase the likelihood of ACS. The chest pain history itself has not proven to be a powerful enough predictive tool to obviate the need for at least some diagnostic testing. Combinations of elements of the chest pain history with other initially available information, such as a history of CAD, have identified certain groups that may be safe for discharge without further evaluation, but further study is needed before such a recommendation can be considered reasonable.

**Conclusion** Although certain elements of the chest pain history are associated with increased or decreased likelihoods of a diagnosis of ACS or AMI, none of them alone or in combination identify a group of patients that can be safely discharged without further diagnostic testing.

*JAMA. 2005;294:2623-2629* www.jama.com

Differentiating acute coronary syndromes (ACS) from benign causes of chest pain is critical because of the consequences of misdiagnosis in either direction. Despite diagnostic advances, missed acute myocardial infarction (AMI) and ACS remain problematic, with estimates ranging between 2% and 10%.[1-5] Conversely, a large proportion of patients with chest pain who are admitted do not turn out to have ACS.[6] This overtriage has enormous economic implications for the US health care system, estimated at $8 billion in annual costs.[7,8]

Distinguishing whether a patient presenting with chest pain has ACS or a non-ACS problem is at best difficult. The differential diagnosis of chest pain is broad and includes many systems, such as pulmonary, musculoskeletal, gastrointestinal, dermatologic, psychiatric, and cardiovascular (including ACS and non-ACS).[9,10] In addition to ACS, this differential includes other immediately life-threatening diseases such as pulmonary embolism, tension pneumothorax, and aortic dissection, necessitating rapid diagnosis and treatments that are markedly different than those for ACS.

The tools most readily available to guide disposition of the patient with chest pain are the patient's age and sex, history of coronary artery disease (CAD) or its risk factors, and the chest pain history. Usually, an initial 12-lead electrocardiogram (ECG) is added as well. In patients without significant ECG changes, risk factors for CAD have been shown to be poor predictors of AMI or ACS.[4,11,12] The initial 12-lead ECG has a sensitivity of only 20% to 60% for AMI,[13-15] and a single set of biochemical markers also has poor sensitivity.[14-16] Because none of these tools used alone is a reliable predictor of ACS, the chest pain characteristics are usually used in conjunction with them to help determine disposition. Although this article dis-

**CME available online at www.jama.com**

**Author Affiliations:** Massachusetts General Hospital, Boston.
**Corresponding Author:** John T. Nagurney, MD, MPH, Massachusetts General Hospital, 55 Fruit St, Clinics 115, Boston, MA 02114 (jnagurney@partners.org).
**Clinical Review Section Editor:** Michael S. Lauer, MD. We encourage authors to submit papers for consideration as a "Clinical Review." Please contact Michael S. Lauer, MD, at lauerm@ccf.org.

©2005 American Medical Association. All rights reserved.



## Swap & Nagurney (2005)

- "No single element of the chest pain history is a powerful enough predictor of non-ACS or non-AMI to allow the clinician to make decisions according to it alone."
- "In particular, no single element of the chest pain history conveys a powerful enough likelihood ratio to safely allow the clinician to discharge a patient without some additional testing."

Acute Ischemic Heart Disease

# Development and validation of a prioritization rule for obtaining an immediate 12-lead electrocardiogram in the emergency department to identify ST-elevation myocardial infarction

Seth W. Glickman, MD, MBA,[a] Frances S. Shofer, PhD,[a] Michael C. Wu, PhD,[a] Matthew J. Scholer, MD, PhD,[a] Adanma Ndubuizu, MD, MPH,[a] Eric D. Peterson, MD, MPH,[b] Christopher B. Granger, MD,[b] Charles B. Cairns, MD,[a] and Lawrence T. Glickman, VMD, DrPH[a] *Chapel Hill, and Durham, NC*

**Background** Current guidelines recommend an immediate (eg, <10 minutes) 12-lead electrocardiogram (ECG) to identify ST-elevation myocardial infarction (STEMI) among patients presenting to the emergency department (ED) with chest pain. Yet, one third of all patients with myocardial infarction do not have chest pain. Our objective was to develop a practical approach to identify patients, especially those without chest pain, who require an immediate ECG in the ED to identify STEMI.

**Methods** An ECG prioritization rule was derived and validated using classification and regression tree analysis among >3 million ED visits to 107 EDs from 2007 to 2008.

**Results** The final study population included 3,575,178 ED patient visits; of these, 6,464 (0.18%) were diagnosed with STEMI. Overall, 1,413 (21.9%) of patients with STEMI did not present to the ED with chest pain. Major predictors of those requiring an immediate ECG in the ED included age ≥30 years with chest pain; age ≥50 years with shortness of breath, altered mental status, upper extremity pain, syncope, or generalized weakness; and those with age ≥80 years with abdominal pain or nausea/vomiting. When the ECG prioritization rule was applied to a validation sample, it had a sensitivity of 91.9% (95% CI 90.9%-92.8%) for STEMI and a negative predictive value 99.98% (95% CI 99.98%-99.98%).

**Conclusion** A simple ECG prioritization rule based on age and presenting symptoms in the ED can identify patients during triage who are at high risk for STEMI and therefore should receive an immediate 12-lead ECG, often before they are seen by a physician. (Am Heart J 2012;163:372-82.)

Coronary heart disease including ST-elevation myocardial infarction (STEMI) is the leading cause of death worldwide, although outcomes for patients with STEMI can be significantly improved by timely reperfusion therapy.[1-3] A critical component of STEMI care is prompt diagnosis with a 12-lead electrocardiogram (ECG) in either the emergency department (ED) or prehospital setting. The American College of Cardiology/American Heart Association guidelines state that an "ECG should be performed within 10 minutes of ED arrival for all patients with *chest discomfort* or *other symptoms suggestive of STEMI*."[4]

One challenge for early diagnosis of STEMI is that one third of patients with myocardial infarction (MI) will not have chest pain.[5-9] Current guidelines do not include a standardized approach to determine which patients without chest pain should receive an immediate ECG at triage in the ED. Women and the elderly with STEMI are particularly likely to present with atypical chief complaints such as dyspnea and weakness. Such patients experience significant delays in door-to-ECG time and treatment and have increased morbidity and mortality compared with patients who present with chest pain.[5,9-12] Despite numerous studies over the past decade documenting delays in treatment of patients with atypical acute MI presentations, the problem persists.

One option would be to perform an immediate ECG for all adults presenting to EDs regardless of their chief

From the [a]Department of Emergency Medicine, University of North Carolina (UNC) School of Medicine, Chapel Hill, NC, and [b]Department of Biostatistics, UNC Gillings School of Global Public Health, and the Duke Clinical Research Institute, Duke University Medical Center, Durham, NC.

Mauricio G. Cohen, MD served as guest editor for this article.
Submitted March 17, 2011; accepted October 15, 2011.

Reprint requests: Seth Glickman, MD, MBA, 170 Manning Drive, CB #7594, Chapel Hill, NC, 27599.
Email: swglick@med.unc.edu

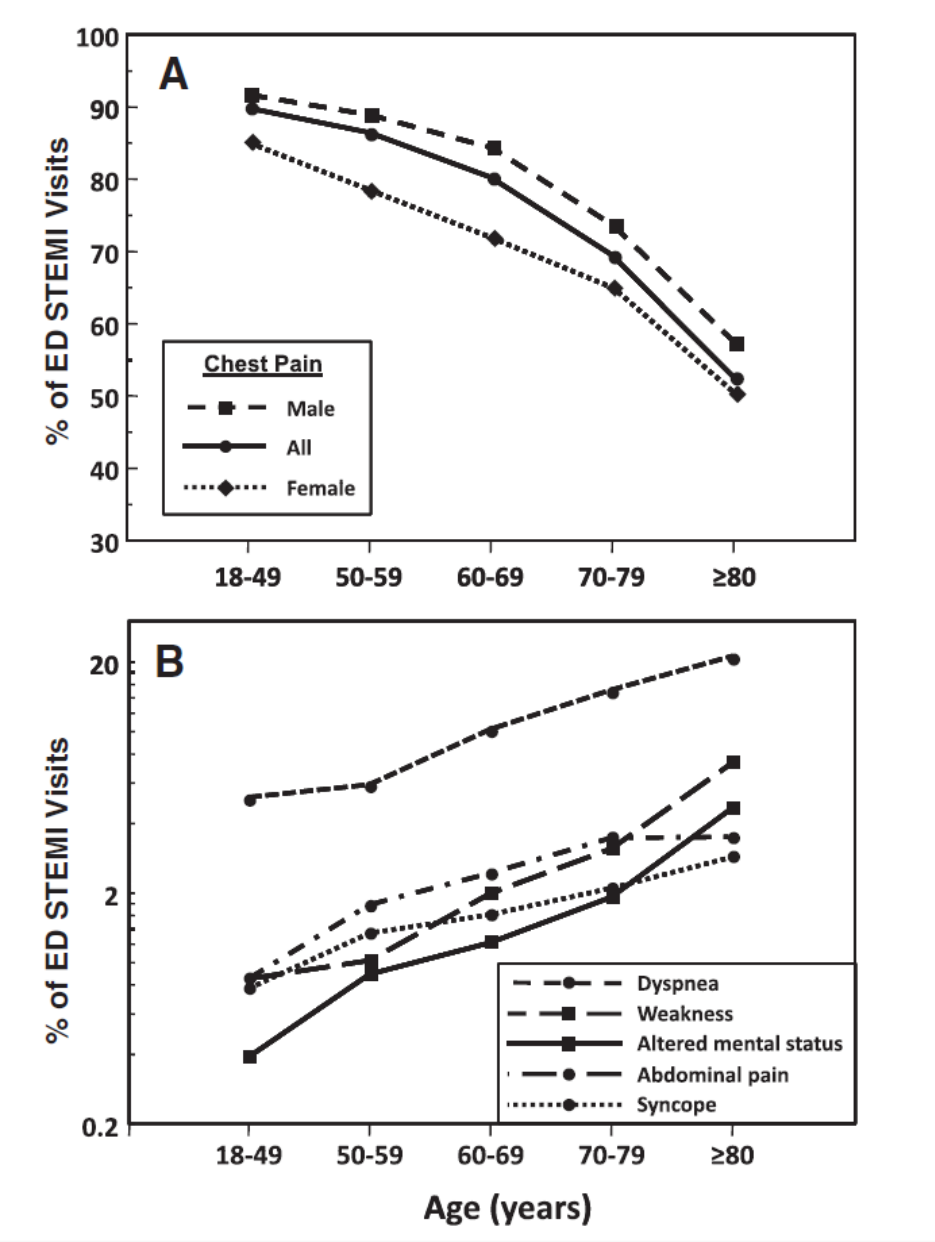
0002-8703/$ - see front matter

© 2012, Mosby, Inc. All rights reserved.

doi: 10.1016/j.ahj.2011.10.021

## Glickman et al. (2011)

- One-third of patients with AMI do not have chest pain!
- Such patients experience significant delays in door-to-ECG time and treatment.
- Such patients have increased morbidity and mortality compared with patients with chest pain.




Glickman et al. (2011)

- Women and the elderly with STEMI are particularly likely to present with atypical chief complaints.

- Dyspnea
- Weakness
- AMS
- Abdominal Pain
- Syncope

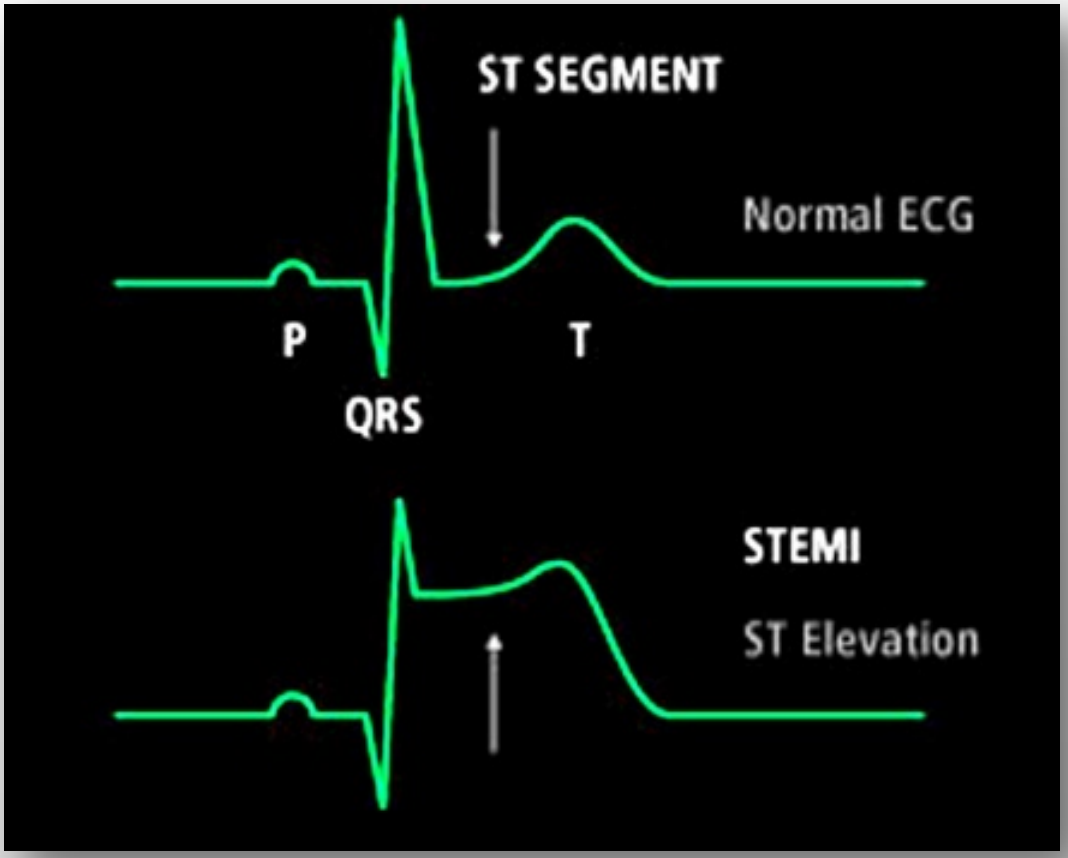
- Swap & Nagurney (2005): Diaphoresis and Nausea/Vomiting are good predictors of AMI!

# The Way Forward?

- Obtain a complete medical history.
  - Current event
  - Past medical history
- Perform a physical assessment.
  - Palpation
  - Auscultation
- Acquire and interpret a 12-Lead EKG.
  - Chest pain
  - Anginal equivalents
  - Index of suspicion

# ST-ELEVATION = MI (STEMI)

# What Does ST Elevation Tell Us?



# Most Common Cause of STE?

- Acute myocardial infarction (AMI)?
- Left bundle branch block (LBBB)?
- Right bundle branch block (RBBB)?
- Ventricular rhythm?
- Left ventricular hypertrophy (LVH)?
- Pericarditis?
- Benign early repolarization (BER)?

# Most Common Cause of STE?

- ~~Acute myocardial infarction (AMI)?~~
- ~~Left bundle branch block (LBBB)?~~
- ~~Right bundle branch block (RBBB)?~~
- ~~Ventricular rhythm?~~
- ~~Left ventricular hypertrophy (LVH)?~~
- ~~Pericarditis?~~
- ~~Benign early repolarization (BER)?~~

# Cause of ST Segment Abnormality in ED Chest Pain Patients

WILLIAM J. BRADY, MD,* ANDREW D. PERRON, MD,* MARCUS L. MARTIN, MD,* CHARLOTTE BEAGLE, MSN,† AND TOM P. AUFDERHEIDE, MD‡

The objective of this study was to determine the electrocardiographic diagnoses of chest pain patients with ST segment elevation (STE) on the 12-lead electrocardiogram (ECG). This study was a retrospective ECG review of adult chest pain patients in a university hospital emergency department (ED) over a 3-month period (January 1, 1996 to March 31, 1996). STE was determined if the ST segment was elevated ≥1 mm in the limb leads and ≥2 mm in the precordial leads in at least two anatomically contiguous leads. Results showed 902 patients who met entry criteria and of whom 202 (22.4%) had STE. Thirty-one (15%) patients had STE acute myocardial infarction (AMI) as the final hospital diagnosis which caused the STE; 171 (85%) patients with STE had non-AMI diagnosis responsible for the ST segment elevation, including left ventricular hypertrophy (LVH) 51 (25%), left bundle branch block (LBBB) 31 (15%), benign early repolarization (BER) 25 (12%), right bundle branch block 10 (5%), nonspecific bundle branch block 10 (5%), left ventricular aneurysm 5 (3%), acute pericarditis 2 (1%), ventricular paced rhythm 2 (1%), and undefined ST segment elevation 35 (17%). Forty-four patients had AMI as the final diagnosis of whom 31 showed STE on presentation to the ED. In 2 of 31 (6%) cases of STE AMI, the ST segment waveform was atypical for acute infarction. We concluded that AMI is not the most common cause of STE in ED chest pain patients. LVH is most often responsible for electrocardiographic STE followed by AMI and LBBB which occur at equal frequencies. (Am J Emerg Med 2001;19:25-28. Copyright © 2001 by W.B. Saunders Company)

The emergency physician (EP) must be an expert in the interpretation of the electrocardiogram (ECG). Patients with chest pain and ST segment elevation (STE) on the 12-lead ECG who are experiencing acute myocardial infarction (AMI) may be candidates for urgent coronary reperfusion via either thrombolysis or primary angioplasty. Such therapy, to maximize benefit, must be delivered as early as possible after the onset of infarction. Other such chest pain patients with electrocardiographic STE may be suffering from a noncoronary (ie, non-AMI) chest discomfort syndrome. The correct identification of these non-AMI patients—both clinically and electrocardiographically—must be made to offer the most appropriate treatments and to avoid potentially dangerous therapies. The following investigation focuses on the various causative syndromes responsible for electrocardiographic STE in the emergency department (ED) chest pain patient.

## METHODS

A retrospective review of all adult patients with the chief or secondary complaint of atraumatic chest pain was performed over a 3-month period (January 1, 1996 to March 31, 1996). The study group included all patients admitted to an ED-based chest pain center (CPC). From this group of adult chest pain patients, all individuals with ST segment elevation in two anatomically contiguous electrocardiographic leads meeting the following criteria were used for data analysis: (1) greater than/equal to 1 millimeter (mm) in the limb leads; and (2) greater than/equal to 2 mm in the precordial leads.

The setting of the study was a university hospital ED with an annual patient volume of 60,000 serving a primarily suburban and rural area with an urban section of approximately 40,000 persons; the general population of the area is approximately 120,000. The ED is staffed by emergency medicine resident- and attending-level physicians 24 hours a day. Patients presenting to the ED with atraumatic chest pain who were aged more than 25 years were admitted to the CPC directly from either the triage area or ambulance entrance; additionally, patients aged more than 18 years with atraumatic chest pain and cocaine use were admitted directly to the CPC. Patients with such complaints who were initially admitted to the general ED were also transferred to the CPC. In all cases, the original 12-lead ECG (the study ECG) performed in the ED-based CPC was used for study review.

To determine if STE was present, the study ECG was interpreted by a single investigator retrospectively who measured the ST segments using criteria the following criteria: (1) greater than/equal to 1 mm in the limb leads; and/or (2) greater than/equal to 2 mm in the precordial leads; STE was considered present if either condition was met. For purposes of ST segment measurement, the initial portion of the ST segment was defined as starting at the J point—the juncture point of the QRS complex and ST segment. This phase of the study did not involve ECG interpretation nor determination of the cause responsible for the ST segment elevation. The single electrocardiographic reviewer for the study was a residency-trained/board-certi-

From the *Department of Emergency Medicine, University of Virginia School of Medicine, Charlottesville, VA; the †Department of Emergency Medicine, University of Virginia Health Systems, Charlottesville, VA; and the ‡Department of Emergency Medicine, Medical College of Wisconsin, Milwaukee, WI.

Manuscript received June 16, 1999, returned July 6, 1999, revision received May 9, 2000, accepted May 16, 2000.

Supported by an unrestricted educational grant from the Department of Emergency Medicine, University of Virginia School of Medicine, Charlottesville, VA.

Presented at the Seventh International Conference on Emergency Medicine, March 1998, Vancouver, British Columbia; the Society for Academic Emergency Medicine Mid-Atlantic Regional Meeting, April 17, 1998, Charlottesville, VA; and the Society of Chest Pain Centers, Baltimore, MD, October 2000.

Reprints are not available.

*Key Words:* Electrocardiogram, ST segment elevation, emergency department.

Copyright © 2001 by W.B. Saunders Company

0735-6757/01/1901-0006$10.00/0
doi:10.1053/ajem.2001.18029



## Brady et al. (2001)

- AMI is **NOT** the most common cause of ST elevation (STE) in ED chest pain patients.
- Only **15%** of patients with STE diagnosed with AMI.
- Non-AMI accounted for **85% of STEMI**, including:
- **LVH (25%)**
- **LBBB (15%)**
- BER (12%)
- RBBB (5%)
- Pericarditis (1%)
- Ventricular rhythm (1%)
- Undefined (17%)

# Paramedic Ability to Recognize ST-segment Elevation Myocardial Infarction on Prehospital Electrocardiograms

Francis Mencl, MD, MS, Scott Wilber, MD, MPH, Jennifer Frey, PhD, Jon Zalewski, NREMT-P, RN, Jarrad Francis Maiers, MD, Mary C. Bhalla, MD

Abstract

**Background.** Identifying ST-segment elevation myocardial infarctions (STEMIs) by paramedics can decrease door-to-balloon times. While many paramedics are trained to obtain and interpret electrocardiograms (ECGs), it is unknown how accurately they can identify STEMIs. **Objective.** This study evaluated paramedics' accuracy in recognizing STEMI on ECGs when faced with potential STEMI mimics. **Methods.** This was a descriptive cohort study using a survey administered to paramedics. The survey contained questions about training, experience, and confidence, along with 10 ECGs: three demonstrating STEMIs (inferior, anterior, and lateral), two with normal results, and five STEMI mimics (left ventricular hypertrophy [LVH], ventricular pacing, left and right bundle branch blocks [LBBB, RBBB], and supraventricular tachycardia [SVT]). We calculated the overall sensitivity and specificity and the proportion correct with 95% confidence intervals (CIs). **Results.** We obtained 472 surveys from 30 municipal emergency medical services (EMS) agencies in five counties with 15 medical directors from seven hospitals. The majority (69%) reported ECG training within the preceding year, 31% within six months; and 74% were confident in recognizing STEMIs. The overall sensitivity and specificity for STEMI detection were 75% and 53% (95% CI 73%–77%, 51%–55%), respectively. Ninety-six percent (453/472, 95% CI 94%–98%) correctly identified the inferior myocardial infarction (MI), but only 78% (368/472, 94% CI 74%–82%) identified the anterior MI and 51% (241/472, 46%–56%) the lateral MI. Thirty-seven percent (173/472, 95% CI 32%–41%) of the paramedics correctly recognized LVH, 39% (184/472, 95% CI 35%–44%) LBBB, and 53% (249/472, 95% CI 48%–57%) ventricular pacing as not a STEMI. Thirty-nine percent (185/472, 95% CI 35%–44%) correctly identified all three STEMIs; however, only 3% of the paramedics were correct in all interpretations. The two normal ECGs were recognized as not a STEMI by 97% (459/472, 95% CI 95%–99%) and 100% (472/472, 95% CI 99%–100%). There was no correlation between training, experience, or confidence and accuracy in recognizing STEMIs. **Conclusions.** Despite training and a high level of confidence, the paramedics in our study were only able to identify an inferior STEMI and two normal ECGs. Given the paramedics' low sensitivity and specificity, we cannot rely solely on their ECG interpretation to activate the cardiac catheterization laboratory. Future research should involve the evaluation of training programs that include assessment, initial training, testing, feedback, and repeat training. **Key words:** paramedic; ECG; STEMI

PREHOSPITAL EMERGENCY CARE 2013;17:203–210

## Introduction

ST-segment elevation myocardial infarction (STEMI) is a significant public health problem, with an estimated 500,000 events per year in the United States.[1] The American Heart Association (AHA) has suggested that every minute of delay in revascularization by angioplasty affects mortality.[2] The AHA, along with the American College of Cardiologists (ACC), initially set the goal for door-to-balloon time of less than 90 minutes.[1] More recently, guidelines have stressed a goal of 90 minutes from the first medical contact, which is often emergency medical services (EMS), to angioplasty, rather than door-to-balloon time.[3,4]

The ACC/AHA guidelines say that EMS personnel should perform 12-lead ECGs on all patients suspected of having a STEMI.[1] The AHA also recommends prearrival catheterization laboratory activation based on prehospital ECG interpretation.[5] Suggested methods of interpretation include computer reading, trained paramedic interpretation, and electronic transmission of ECGs with physician interpretation.[5] There are no data currently to compare the effectiveness or accuracy of these different approaches.[5]

Paramedic interpretation of STEMI in the field and transfer to an appropriate treatment facility can reduce door-to-balloon time and have a positive effect on in-hospital mortality.[6–9] Clark et al. found that prehospital cardiac catheterization laboratory activation, as well as in-hospital processes, and not scene or transport times, predicted rapid scene-to-reperfusion intervals, further stressing the need for prehospital activation.[10] Studies have reported that trained

Received July 30, 2012, from the Department of Emergency Medicine (FM, SW, MCB) and the Emergency Medicine Research Center (JF), Summa Akron City Hospital (JZ), Akron, Ohio; and the San Juan Regional Medical Center (JFM), Farmington, New Mexico. Revision received October 5, 2012; accepted for publication October 5, 2012; published online February 12, 1013.

A preliminary analysis of partial data collection was presented as a poster at the 2010 Midwest Society for Acedemic Emergency Medicine Annual Meeting in Dayton, Oh and the 2011 National Association for EMS Physicians Annual Meeting in Bonita Springs, FL.

The authors report no conflicts of interest.

Address correspondence and reprint requests to: Mary C. Bhalla, MD, Summa Akron City Hospital, Emergency Medicine, 525 East Market Street, Akron, OH 44304, mcmcquown@yahoo.com

doi: 10.3109/10903127.2012.755585



## Mencl et al. (2013)

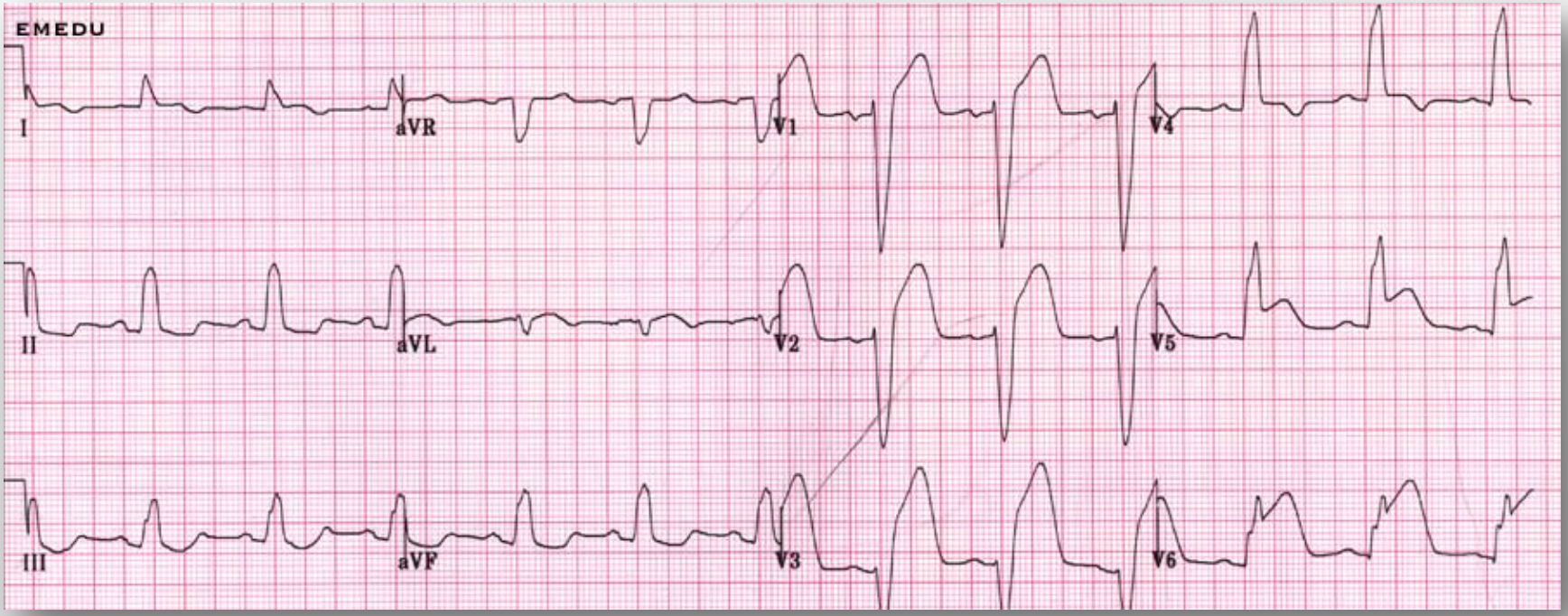
- Paramedics are often **confused by LVH and LBBB.**
  - LVH: 37% accuracy
  - LBBB: 39% accuracy
- Paramedics also have **difficulty identifying non-inferior STEMI.**
  - Inferior STEMI sensitivity: 96%
  - **Anterior STEMI** sensitivity: 78%
  - **Lateral STEMI** sensitivity: 51%
- **Low overall sensitivity for STEMI: 75%**
  - 53% specificity

# The Way Forward?

- Training should focus on better recognition of potential STEMI mimics.
  - LVH
  - LBBB
- Training should focus on non-inferior STEMI recognition.
  - Anterior STEMI
  - Lateral STEMI
- “False activation” vs. “Activation without intervention”
  - First, do no harm

# LEFT BUNDLE BRANCH BLOCK

# Can You Diagnose a STEMI in LBBB?

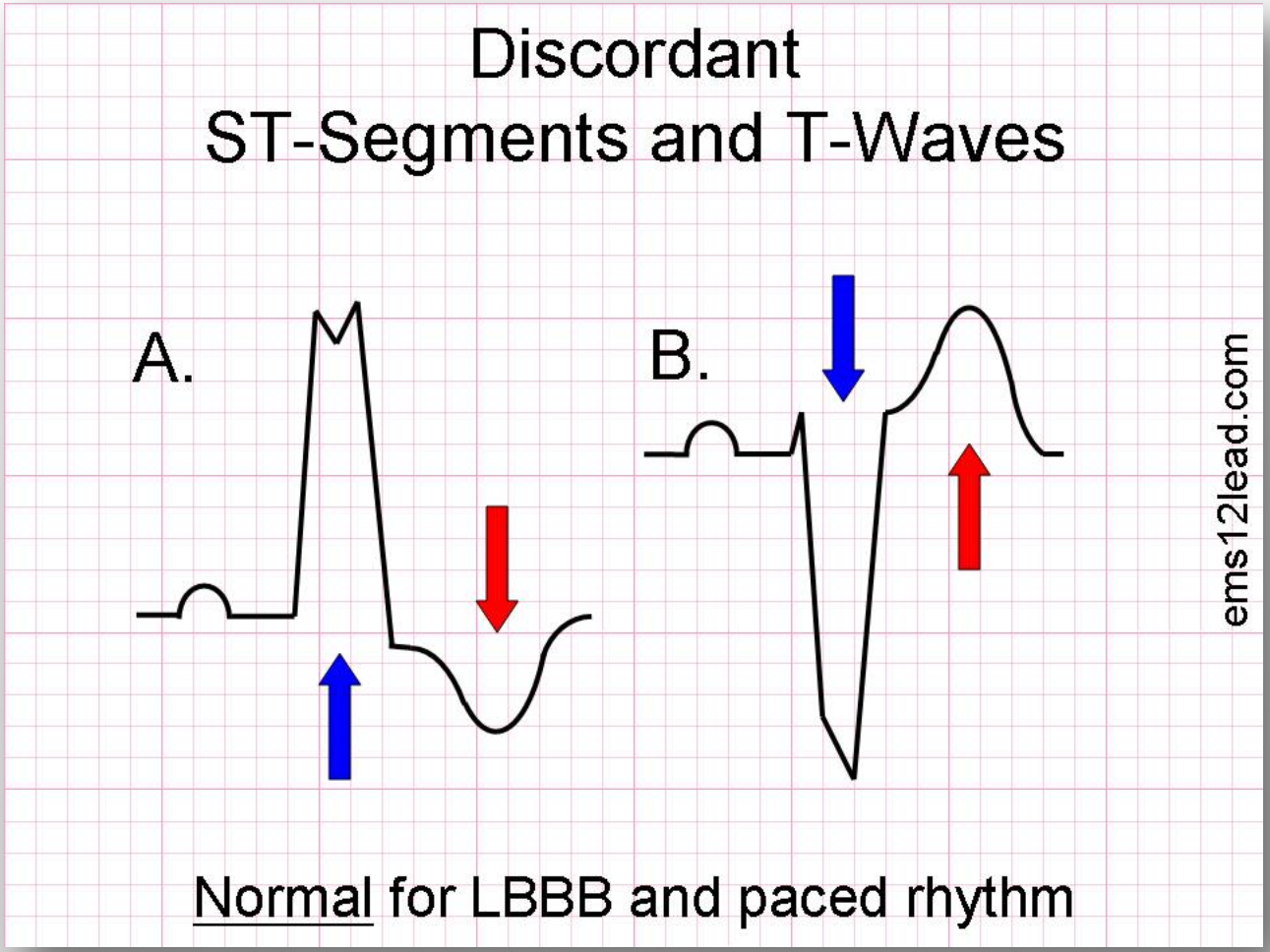


# Can You Diagnose a STEMI in LBBB?

<u>Diagnostic Criteria</u>

- P-wave present
  - Sinus rhythm
- QRS > 120 milliseconds
  - “Rabbit ears” are not a diagnostic criteria!
- Dominant S-wave in V1
- Discordance between ST/T and QRS

# Can You Diagnose a STEMI in LBBB?



The New England
Journal of Medicine

©Copyright, 1996, by the Massachusetts Medical Society

Volume 334 FEBRUARY 22, 1996 Number 8

# ELECTROCARDIOGRAPHIC DIAGNOSIS OF EVOLVING ACUTE MYOCARDIAL INFARCTION IN THE PRESENCE OF LEFT BUNDLE-BRANCH BLOCK

Elena B. Sgarbossa, M.D., Sergio L. Pinski, M.D., Alejandro Barbagelata, M.D., Donald A. Underwood, M.D., Kathy B. Gates, Eric J. Topol, M.D., Robert M. Califf, M.D., and Galen S. Wagner, M.D., for the GUSTO-1 (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) Investigators

**Abstract** *Background.* The presence of left bundle-branch block on the electrocardiogram may conceal the changes of acute myocardial infarction, which can delay both its recognition and treatment. We tested electrocardiographic criteria for the diagnosis of acute infarction in the presence of left bundle-branch block.

*Methods.* The base-line electrocardiograms of patients enrolled in the GUSTO-1 (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) trial who had left bundle-branch block and acute myocardial infarction confirmed by enzyme studies were blindly compared with the electrocardiograms of control patients who had chronic coronary artery disease and left bundle-branch block. The electrocardiographic criteria for the diagnosis of infarction were then tested in an independent sample of patients presenting with acute chest pain and left bundle-branch block.

*Results.* Of 26,003 North American patients, 131 (0.5 percent) with acute myocardial infarction had left bundle-branch block. The three electrocardiographic criteria with independent value in the diagnosis of acute infarction in these patients were ST-segment elevation of 1 mm or more that was concordant with (in the same direction as) the QRS complex; ST-segment depression of 1 mm or more in lead $V_1$, $V_2$, or $V_3$; and ST-segment elevation of 5 mm or more that was discordant with (in the opposite direction from) the QRS complex. We used these three criteria to develop a scoring system (0 to 5), which allowed a highly specific diagnosis of acute myocardial infarction to be made.

*Conclusions.* We developed and validated a clinical prediction rule based on a set of electrocardiographic criteria for the diagnosis of acute myocardial infarction in patients with chest pain and left bundle-branch block. The use of these criteria, which are based on simple ST-segment changes, may help identify patients with acute myocardial infarction, who can then receive appropriate treatment. (N Engl J Med 1996;334:481-7.)
©1996, Massachusetts Medical Society.

THE optimal use of coronary reperfusion therapies relies on a rapid diagnosis of evolving myocardial infarction.[1,2] For most patients presenting with cardiac chest pain, the electrocardiogram is a powerful aid in diagnosing the cause of the pain and selecting the appropriate therapy.[2] In patients who present with concomitant left bundle-branch block, however, the electrocardiographic manifestations of acute myocardial injury may be masked. During the past five decades, several electrocardiographic signs have been proposed to aid in the diagnosis of infarction in such patients, but because of methodologic limitations,[3-9] none of these signs have gained widespread acceptance. Many physicians believe that acute myocardial injury cannot be detected accurately in patients with left bundle-branch block.[10] We examined the value of the standard electrocardiogram for the diagnosis of acute myocardial infarction in the presence of left bundle-branch block in a large population of patients.

## Methods

### Derivation Sample

Criteria for the diagnosis of acute myocardial infarction in the presence of left bundle-branch block were developed from two populations (the study and control groups), which constituted the derivation sample. The study group consisted of the subgroup of North American patients enrolled in the GUSTO-1 (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) trial[11] who had acute myocardial infarction documented by serum enzyme changes and evidence of complete left bundle-branch block on their base-line electrocardiograms. The control group was assembled by randomly selecting from the Duke Databank for Cardiovascular Disease an equal number of patients with

From the Cleveland Clinic Foundation, Cleveland (E.B.S., S.L.P., D.A.U., E.J.T.); the Fundación Favaloro, Buenos Aires, Argentina (A.B.); and Duke University Medical Center, Durham, N.C. (K.B.G., R.M.C., G.S.W.). Address reprint requests to Dr. Sgarbossa at the Department of Cardiology, Desk M-24, Cleveland Clinic Foundation, Cleveland, OH 44195.

Supported by grants from Bayer, Genentech, CIBA–Corning, ICI Pharmaceuticals, and Sanofi Pharmaceuticals.

Downloaded from www.nejm.org by RICARDO PIZARRO on July 31, 2007 .
Copyright © 1996 Massachusetts Medical Society. All rights reserved.

## Sgarbossa et al. (1996)

- You CAN diagnose a STEMI in the presence of LBBB.

"Sgarbossa Rule"

# Diagnosis of ST-Elevation Myocardial Infarction in the Presence of Left Bundle Branch Block With the ST-Elevation to S-Wave Ratio in a Modified Sgarbossa Rule

Stephen W. Smith, MD, Kenneth W. Dodd, MD, Timothy D. Henry, MD, David M. Dvorak, MD, Lesly A. Pearce, MS

*From the Hennepin County Medical Center, Minneapolis, MN (Smith, Dodd); the University of Minnesota School of Medicine, Minneapolis, MN (Smith); the Minneapolis Heart Institute, Abbott Northwestern Hospital, Minneapolis, MN (Henry); the Fairview Southdale Hospital, Edina, MN (Dvorak); and Biostatistical Consulting, Minot, ND (Pearce).*

**Study objective:** Sgarbossa's rule, proposed for the diagnosis of acute myocardial infarction in the presence of left bundle branch block, has had suboptimal diagnostic utility. We hypothesize that a revised rule, in which the third Sgarbossa component (excessively discordant ST-segment elevation as defined by ≥5 mm of ST-segment elevation in the setting of a negative QRS) is replaced by one defined proportionally by ST-segment elevation to S-wave depth (ST/S ratio), will have better diagnostic utility for ST-segment elevation myocardial infarction (STEMI) equivalent, using documented coronary occlusion on angiography as reference standard.

**Methods:** We collected admission ECGs for all patients with an acutely occluded coronary artery and left bundle branch block at 3 institutions. The ECGs of emergency department patients with chest pain or dyspnea and left bundle branch block, but without coronary occlusion, were used as controls. The R or S wave, whichever was most prominent, and ST segments, relative to the PR segment, were measured to the nearest 0.5 mm. The ST/S ratio was calculated for each lead that has both discordant ST deviation of greater than or equal to 1 mm and an R or S wave of opposite polarity; others were set to 0. The cut point for the most negative ST/S ratio with at least 90% specificity was determined. The revised rule is unweighted, requiring just 1 of 3 criteria. Diagnostic utilities of the original and revised Sgarbossa rules were computed and compared. McNemar's test was used to compare sensitivities and specificities.

**Results:** The study and control groups included 33 and 129 ECGs, respectively. The cut point selected for relative discordant ST-segment elevation was −0.25. Excessive absolute discordant ST-segment elevation of 5 mm was present in at least one lead in 30% of ECGs in patients with confirmed coronary occlusion versus 9% of the control group, whereas excessive relative discordant ST-segment elevation less than −0.25 was present in 58% versus 8%. Sensitivity of the revised rule in which ST-segment elevation with an ST/S ratio less than or equal to −0.25 replaces ST-segment elevation greater than or equal to 5 mm was significantly greater than either the weighted ($P<.001$) or unweighted ($P=.008$) Sgarbossa rule: 91% (95% confidence interval [CI] 76% to 98%) versus 52% (95% CI 34% to 69%) versus 67% (95% CI 48% to 82%). Specificity of the revised rule was lower than that of the weighted rule ($P=.002$) and similar to that of the unweighted rule ($P=1.0$): 90% (95% CI 83% to 95%) versus 98% (95% CI 93% to 100%) versus 90% (95% CI 83% to 95%). Positive and negative likelihood ratios for the revised rule were 9.0 (95% CI 8.0 to 10) and 0.1 (95% CI 0.03 to 0.3). The revised rule was significantly more accurate than both the weighted (16% difference; 95% CI 5% to 27%) and unweighted (12% difference; 95% CI 2% to 22%) Sgarbossa rules.

**Conclusion:** Replacement of the absolute ST-elevation measurement of greater than or equal to 5 mm in the third component of the Sgarbossa rule with an ST/S ratio less than −0.25 greatly improves diagnostic utility of the rule for STEMI. An unweighted rule using this criterion resulted in excellent prediction for acute coronary occlusion. [Ann Emerg Med. 2012;60:766-776.]

Please see page 767 for the Editor's Capsule Summary of this article.

A **feedback** survey is available with each research article published on the Web at www.annemergmed.com.
A **podcast** for this article is available at www.annemergmed.com.

0196-0644/$-see front matter
Copyright © 2012 by the American College of Emergency Physicians.
http://dx.doi.org/10.1016/j.annemergmed.2012.07.119

## INTRODUCTION

Timely and accurate identification of acute coronary occlusion in the setting of ischemic symptoms is critical to initiating urgent angiography and appropriate reperfusion therapy. Although the increase or decrease of cardiac biomarker levels is essential to the diagnosis of acute myocardial infarction, positive biomarker results alone do not differentiate ST-elevation myocardial infarction (STEMI) from non-STEMI. ST

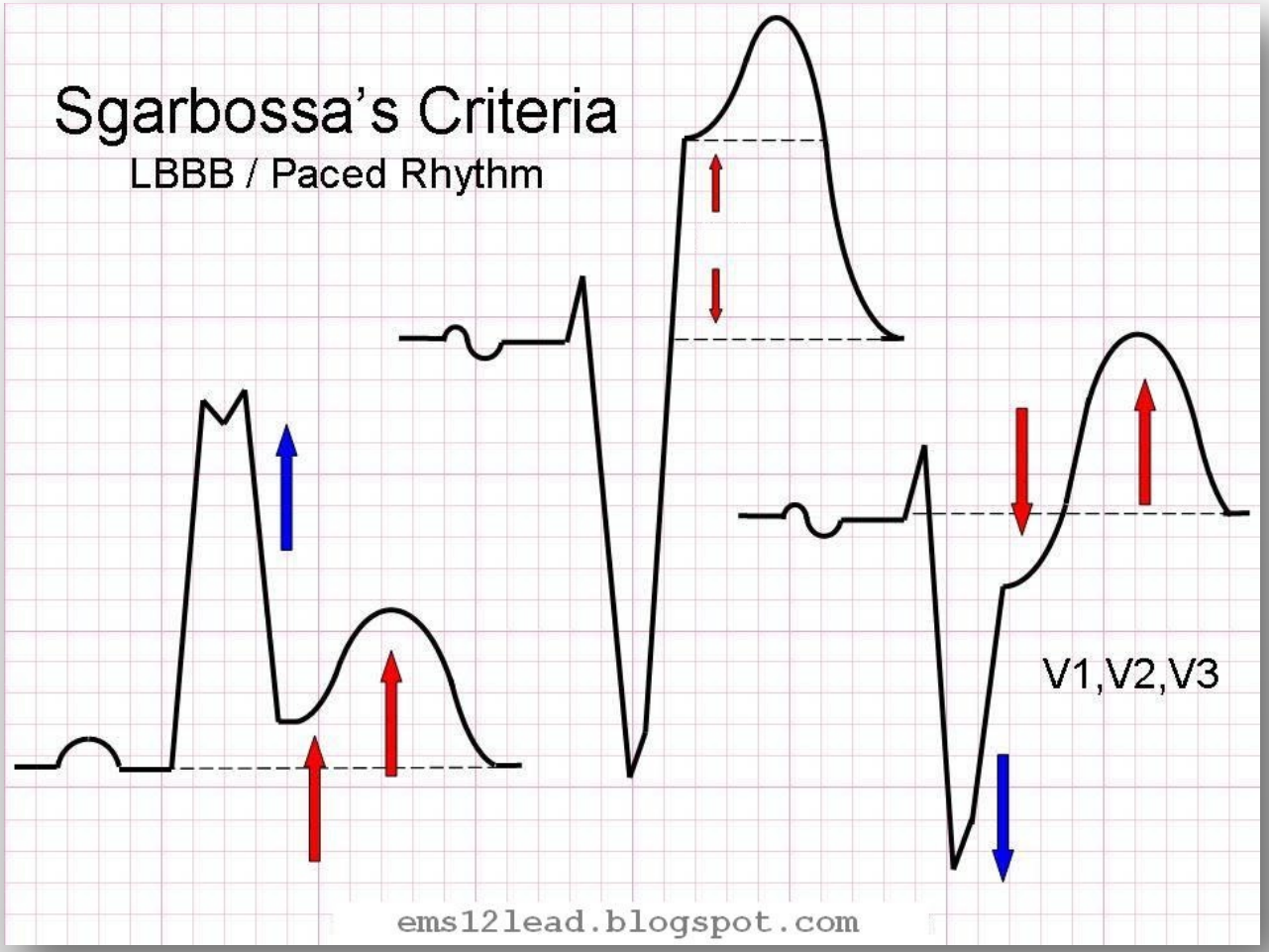


## Smith et al. (2012)

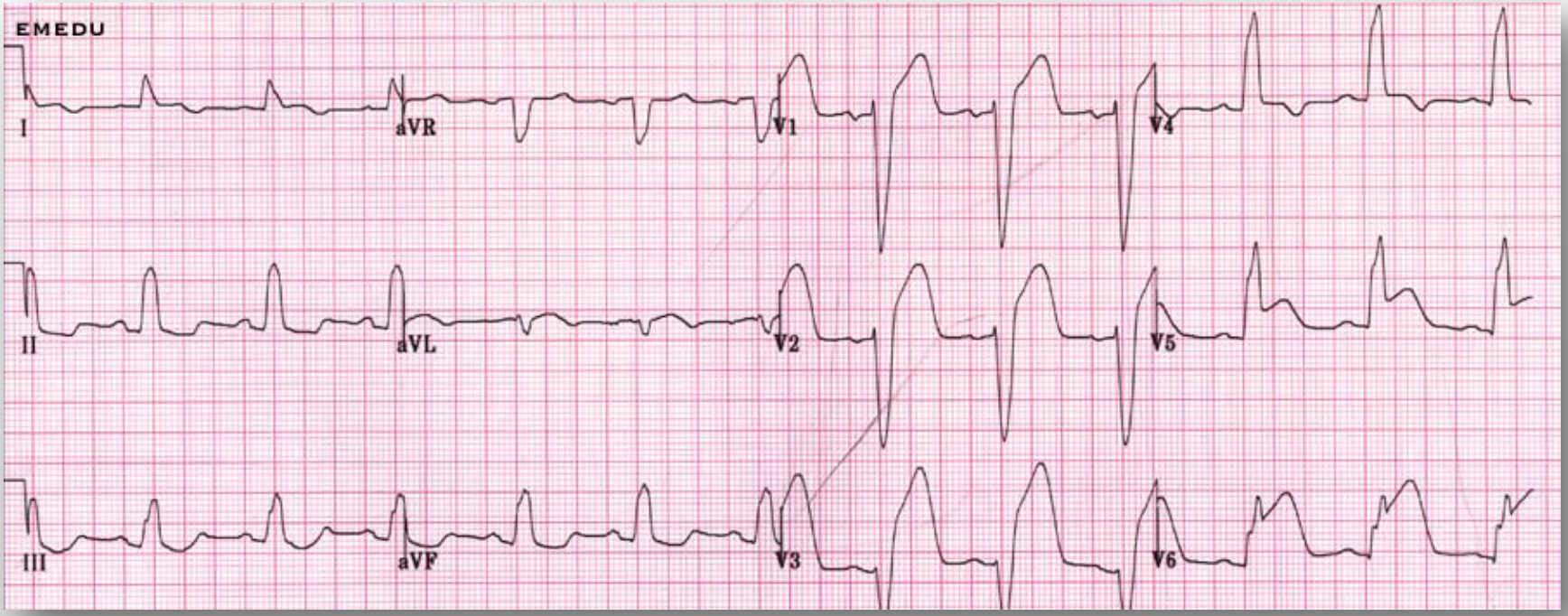
### Modified "Sgarbossa Rule"

- Concordant STE ≥ 1 mm
  - Any lead
- Concordant STD ≥ 1 mm
  - Leads V1-V3
- Excessive discordance
  - ≥ 25% QRS amplitude
  - Any lead

# Modified Sgarbossa Criteria

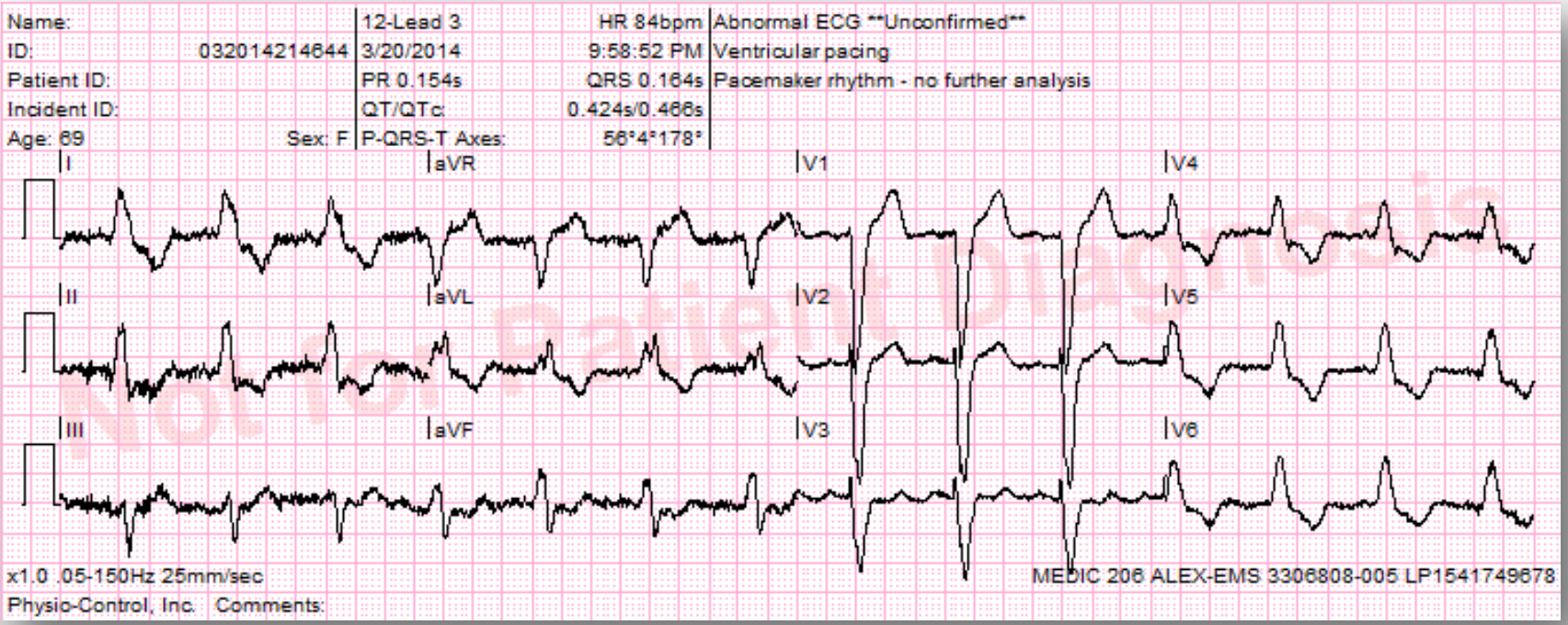


# Can You Diagnose a STEMI in LBBB?



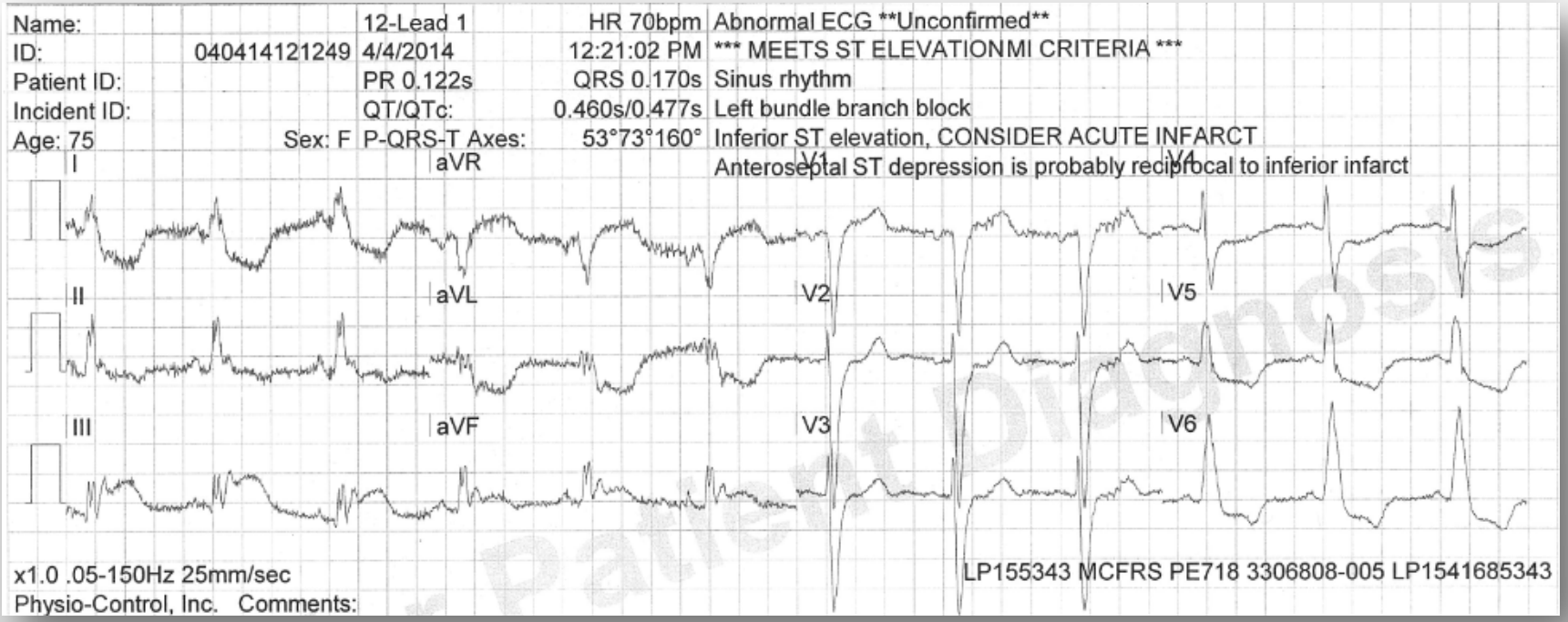

| Concordant STE ≥ 1 mm? | Concordant STD ≥ 1 mm? | Excessive discordance? |
|---|---|---|
| Any lead | Leads V1-V3 | Any lead |

# STEMI?




| Concordant STE ≥ 1 mm? | Concordant STD ≥ 1 mm? | Excessive discordance? |
|---|---|---|
| Any lead | Leads V1-V3 | Any lead |

# STEMI?

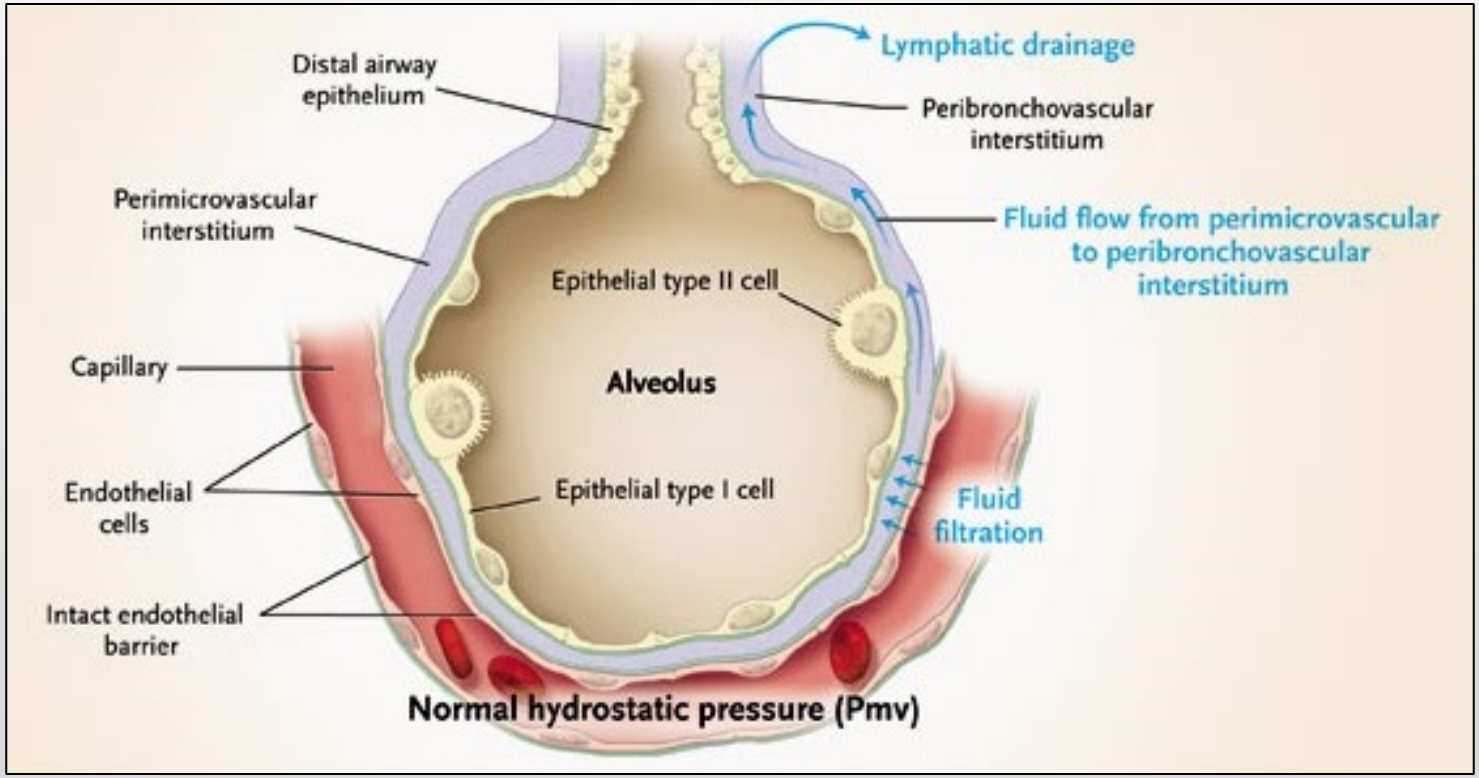



| Concordant STE ≥ 1 mm? | Concordant STD ≥ 1 mm? | Excessive discordance? |
|---|---|---|
| Any lead | Leads V1-V3 | Any lead |

# WHEEZING

# What Does Wheezing Tell Us?

- Wheezing can signal a cardiac problem (acute CHF).
  - Increased hydrostatic pressure in the pulmonary capillaries



# Paramedic Identification of Acute Pulmonary Edema in a Metropolitan Ambulance Service

Teresa A. Williams, PhD, MHlthSci (Res), PG Dip Clin Epi, ICU Cert, RN, Judith Finn, PhD, MEdSt, GradDipPH, BSc, DipAppSc, RN, RM, ICCert, FACN FAHA, Antonio Celenza, MBBS MClinEd FACEM FCEM, Tiew-Hwa Teng, BSc(Pharm) GradDip Bus Admin GradDip Int Mktg MPH PhD, Ian G. Jacobs, BAppSc, DipEd, PhD, RN, FCNA, FACAP, FERC, FAHA

Abstract

**Introduction.** Acute pulmonary edema (APE) is a common cause of acute dyspnea. In the prehospital setting, it is often difficult to differentiate APE from other causes of shortness of breath (SOB). Radiography and echocardiography aid in the identification of APE but are often not available. There is little information on how accurately ambulance paramedics identify patients with APE. **Objectives.** This study aimed to 1) describe the prehospital clinical presentation and management of patients with a clinical diagnosis of APE and 2) compare the accuracy of coding of APE by paramedics against the emergency department (ED) medical discharge diagnosis. **Methods.** This study included a retrospective cohort of all patients who had episodes identified as APE by ambulance paramedics and were transported to a metropolitan hospital ED in 2011. Two databases were used: an ambulance database and the Emergency Department Information System. The ED medical discharge diagnosis (using *International Statistical Classification of Diseases and Related Problems, 10th Revision, Australian Modification* [ICD-10-AM] codes) was used as the comparator with paramedic-assigned problem codes for APE. The outcomes for the study were the positive predictive value, i.e., the proportion of patients identified as having APE in the ambulance database who also had an ED discharge diagnosis of APE, and the sensitivity of paramedic identification of APE, i.e., the proportion of patients with an ED discharge diagnosis of APE that were correctly identified as APE by the ambulance paramedics. **Results.** Four hundred ninety-five patients were transported to an ED with APE identified by the paramedics as the primary problem code. Shortness of breath, crepitations, high systolic blood pressure, and chest pain were the most common presenting signs and symptoms. Pink frothy sputum was rare (3% of patient episodes of APE). One hundred eighty-six patients received an ED discharge diagnosis of APE, i.e., a positive predictive value of 41%. Of 631 ED presentations with APE, paramedics identified 186, i.e., a sensitivity of 29%. **Conclusion.** Acute pulmonary edema is difficult to identify in the prehospital setting because of the variability in the signs and symptoms associated with this condition. Improved identification of APE is essential in the initiation of appropriate and timely care. Ambulance paramedics need to be aware of such variability when considering patients who may be suffering from APE. **Key words:** pulmonary edema; acute pulmonary edema; emergency medical services; ambulance; paramedics

PREHOSPITAL EMERGENCY CARE 2013;Early Online:1–9

Received December 10, 2012, from the Discipline of Emergency Medicine (TW, JF, AC, THT, IGJ), the Discipline of Medical Education (AC), the Education Centre (AC), and the Faculty of Medicine, Dentistry and Health Sciences (AC), University of Western Australia, Crawley, Perth, Western Australia; St John Ambulance Western Australia (JF, IGJ), Belmont, Perth, Western Australia; the School of Population Health & Preventive Medicine, Monash University (JF), Melbourne, Victoria, Australia; and the Discipline of Emergency Medicine, Sir Charles Gairdner Hospital (AC), Nedlands, Perth, Western Australia. Revision received December 22, 2012; accepted for publication January 15, 2013.

Dr. Williams is a National Health and Medical Research Council Clinical Research Postdoctoral Fellow. Prof. Finn receives partial salary support from St John Ambulance Western Australia. Prof. Jacobs is the Clinical Services Director for St John Ambulance Western Australia. St John Ambulance Western Australia played no role in the study design, conduct, or interpretation of the results.

Address correspondence and reprint requests to: Dr. Teresa Williams, The University of Western Australia, Emergency Medicine (M516), 35 Stirling Highway, Crawley, 6009 Australia. e-mail: teresa.williams@uwa.edu.au

doi: 10.3109/10903127.2013.773114

## Introduction

Acute pulmonary edema (APE) is a common cause of acute dyspnea, often caused by an acute exacerbation of heart failure. Heart failure is a major public health issue, with high prevalence and poor outcomes.[1] In the United States, it was estimated that 6.6 million adults (2.8%) had heart failure in 2010, and the number is predicted to increase by 25% over the next 20 years.[2] In patients older than 65 years, heart failure is the leading cause of hospitalization, and the prevalence increases with age. At the age of 40 years, the lifetime risk of developing heart failure is about 20% in both men and women.[3] There are no data on the incidence of APE, but it is estimated that most patients with congestive heart failure (CHF) will have at least one episode of acute exacerbation of heart failure manifesting as APE.[4] Of those patients hospitalized with acute exacerbation of heart failure, the EuroHeart Failure Survey II from 30 European countries reported that APE was present in 16% of patients.[5]

Distinguishing APE from other causes of shortness of breath (SOB) relies on history and physical

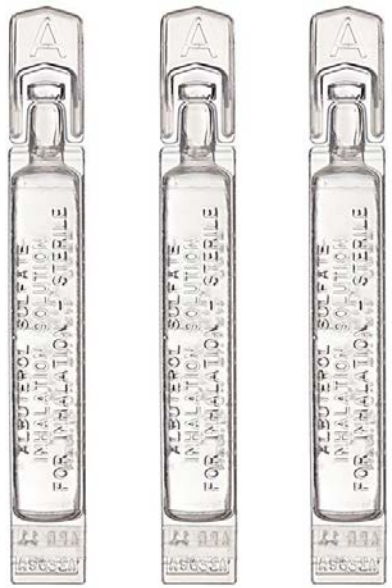


## Williams et al. (2013)

- Acute pulmonary edema is difficult to identify in the prehospital setting.
  - 41% specificity
  - 29% sensitivity
- Signs and symptoms vary and include respiratory distress.
- Patients not identified as having acute pulmonary edema were predominantly identified as having respiratory conditions.

# Can Albuterol Make It Worse?

- Albuterol can produce significant cardiac effects.
  - 10-50% of beta receptors in the heart are beta-2 receptors



# The Way Forward?

- Consider possible cardiac etiology for wheezing.
  - Especially in older patients
- Avoid reflexive use of nebulized Albuterol.
  - Exercise caution in patients with cardiac history
- Consider CPAP if cardiac involvement is suspected.
  - Improves work of breathing regardless of etiology
- Consider Nitroglycerin if appropriate.
  - Reduces hydrostatic pressure in the pulmonary capillaries
  - Address the problem, not just the presentation

# SULFA DRUG ALLERGY

# Are Any EMS Meds Contraindicated?

# Are Any EMS Meds Contraindicated?

- Sulfates
  - Chemicals that contain the element sulfur
  - You cannot be allergic to sulfur
- Sulfa drugs
  - Class of drugs called sulfonamides
  - You can be allergic to sulfa drugs
- There is NO allergy connection between the two
  - You CAN be allergic to the OTHER end of a sulfate molecule (e.g., the Morphine in Morphine Sulfate)

# MECHANICAL CPR

# Is Mechanical CPR Better?

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical Paper

# Manual vs. integrated automatic load-distributing band CPR with equal survival after out of hospital cardiac arrest. The randomized CIRC trial☆,☆☆

Lars Wik[a,*], Jan-Aage Olsen[a,b], David Persse[c], Fritz Sterz[d], Michael Lozano Jr.[e,f], Marc A. Brouwer[g], Mark Westfall[h,i], Chris M. Souders[c], Reinhard Malzer[j], Pierre M. van Grunsven[k], David T. Travis[e], Anne Whitehead[l], Ulrich R. Herken[m], E. Brooke Lerner[n]

[a] Norwegian Center for Prehospital Emergency Care, Oslo University Hospital, Oslo, Norway
[b] Institute of Clinical Medicine, University of Oslo, Oslo, Norway
[c] Houston Fire Department and the Baylor College of Medicine, Houston, TX, United States
[d] Department of Emergency Medicine, Medical University of Vienna, Vienna, Austria
[e] Hillsborough County Fire Rescue, Tampa, FL, United States
[f] Department of Emergency Medicine, Lake Erie College, Bradenton, FL, United States
[g] Heart Lung Center, Department of Cardiology, Radboud University Medical Center, Nijmegen, The Netherlands
[h] Gold Cross Ambulance Service, Appleton Neenah-Menasha and Grand Chute Fire Departments, WI, United States
[i] Theda Clark Regional Medical Center, Neenah, WI, United States
[j] Wiener Rettung, Municipal ambulance service of Vienna, Vienna, Austria
[k] Regional Ambulance Service Gelderland-Zuid, Nijmegen, The Netherlands
[l] Medical and Pharmaceutical Statistics Research Unit, Department of Mathematics and Statistics, Fylde College, Lancaster University, Lancaster, United Kingdom
[m] ZOLL Medical Corporation, Chelmsford, MA, United States
[n] Department of Emergency Medicine, Medical College of Wisconsin, Milwaukee, WI, United States

ARTICLE INFO

*Article history:*
Received 20 January 2014
Received in revised form 7 March 2014
Accepted 7 March 2014
Available online xxx

*Keywords:*
Cardiac arrest
Cardiopulmonary resuscitation
Survival
Load distributing band

ABSTRACT

*Objective:* To compare integrated automated load distributing band CPR (iA-CPR) with high-quality manual CPR (M-CPR) to determine equivalence, superiority, or inferiority in survival to hospital discharge.
*Methods:* Between March 5, 2009 and January 11, 2011 a randomized, unblinded, controlled group sequential trial of adult out-of-hospital cardiac arrests of presumed cardiac origin was conducted at three US and two European sites. After EMS providers initiated manual compressions patients were randomized to receive either iA-CPR or M-CPR. Patient follow-up was until all patients were discharged alive or died. The primary outcome, survival to hospital discharge, was analyzed adjusting for covariates, (age, witnessed arrest, initial cardiac rhythm, enrollment site) and interim analyses. CPR quality and protocol adherence were monitored (CPR fraction) electronically throughout the trial.
*Results:* Of 4753 randomized patients, 522 (11.0%) met post enrollment exclusion criteria. Therefore, 2099 (49.6%) received iA-CPR and 2132 (50.4%) M-CPR. Sustained ROSC (emergency department admittance), 24 h survival and hospital discharge (unknown for 12 cases) for iA-CPR compared to M-CPR were 600 (28.6%) vs. 689 (32.3%), 456 (21.8%) vs. 532 (25.0%), 196 (9.4%) vs. 233 (11.0%) patients, respectively. The adjusted odds ratio of survival to hospital discharge for iA-CPR compared to M-CPR, was 1.06 (95% CI 0.83–1.37), meeting the criteria for equivalence. The 20 min CPR fraction was 80.4% for iA-CPR and 80.2% for M-CPR.
*Conclusion:* Compared to high-quality M-CPR, iA-CPR resulted in statistically equivalent survival to hospital discharge.

© 2014 Elsevier Ireland Ltd. All rights reserved.

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2014.03.005.
☆☆ Registration Name and Number: ClinicalTrials.gov Identifier: Circulation Improving Resuscitation Care (CIRC) NCT00597207.
* Corresponding author at: Oslo University Hospital, NAKOS, Kirkeveien 166, 0407 Oslo, Norway.
*E-mail address:* lars.wik@medisin.uio.no (L. Wik).

http://dx.doi.org/10.1016/j.resuscitation.2014.03.005
0300-9572/© 2014 Elsevier Ireland Ltd. All rights reserved.

## Wik et al. (2014)

- The "CIRC" trial.
  - RCT of AutoPulse.
- "[Mechanical CPR] is equivalent to high-quality [manual CPR] for survival to hospital discharge."
- Neurologic outcome did not differ.

Original Investigation

# Mechanical Chest Compressions and Simultaneous Defibrillation vs Conventional Cardiopulmonary Resuscitation in Out-of-Hospital Cardiac Arrest

## The LINC Randomized Trial

Sten Rubertsson, MD, PhD; Erik Lindgren, MD; David Smekal, MD, PhD; Ollie Östlund, PhD; Johan Silfverstolpe, MD; Robert A. Lichtveld, MD, PhD; Rene Boomars, MPA; Björn Ahlstedt, MD; Gunnar Skoog, MD; Robert Kastberg, MD; David Halliwell, RN; Martyn Box, RN; Johan Herlitz, MD, PhD; Rolf Karlsten, MD, PhD

**IMPORTANCE** A strategy using mechanical chest compressions might improve the poor outcome in out-of-hospital cardiac arrest, but such a strategy has not been tested in large clinical trials.

**OBJECTIVE** To determine whether administering mechanical chest compressions with defibrillation during ongoing compressions (mechanical CPR), compared with manual cardiopulmonary resuscitation (manual CPR), according to guidelines, would improve 4-hour survival.

**DESIGN, SETTING, AND PARTICIPANTS** Multicenter randomized clinical trial of 2589 patients with out-of-hospital cardiac arrest conducted between January 2008 and February 2013 in 4 Swedish, 1 British, and 1 Dutch ambulance services and their referring hospitals. Duration of follow-up was 6 months.

**INTERVENTIONS** Patients were randomized to receive either mechanical chest compressions (LUCAS Chest Compression System, Physio-Control/Jolife AB) combined with defibrillation during ongoing compressions (n = 1300) or to manual CPR according to guidelines (n = 1289).

**MAIN OUTCOMES AND MEASURES** Four-hour survival, with secondary end points of survival up to 6 months with good neurological outcome using the Cerebral Performance Category (CPC) score. A CPC score of 1 or 2 was classified as a good outcome.

**RESULTS** Four-hour survival was achieved in 307 patients (23.6%) with mechanical CPR and 305 (23.7%) with manual CPR (risk difference, −0.05%; 95% CI, −3.3% to 3.2%; $P > .99$). Survival with a CPC score of 1 or 2 occurred in 98 (7.5%) vs 82 (6.4%) (risk difference, 1.18%; 95% CI, −0.78% to 3.1%) at intensive care unit discharge, in 108 (8.3%) vs 100 (7.8%) (risk difference, 0.55%; 95% CI, −1.5% to 2.6%) at hospital discharge, in 105 (8.1%) vs 94 (7.3%) (risk difference, 0.78%; 95% CI, −1.3% to 2.8%) at 1 month, and in 110 (8.5%) vs 98 (7.6%) (risk difference, 0.86%; 95% CI, −1.2% to 3.0%) at 6 months with mechanical CPR and manual CPR, respectively. Among patients surviving at 6 months, 99% in the mechanical CPR group and 94% in the manual CPR group had CPC scores of 1 or 2.

**CONCLUSIONS AND RELEVANCE** Among adults with out-of-hospital cardiac arrest, there was no significant difference in 4-hour survival between patients treated with the mechanical CPR algorithm or those treated with guideline-adherent manual CPR. The vast majority of survivors in both groups had good neurological outcomes by 6 months. In clinical practice, mechanical CPR using the presented algorithm did not result in improved effectiveness compared with manual CPR.

**TRIAL REGISTRATION** clinicaltrials.gov Identifier: NCT00609778

*JAMA*. 2014;311(1):53-61. doi:10.1001/jama.2013.282538
Published online November 17, 2013.

**Author Affiliations:** Author affiliations are listed at the end of this article.

**Corresponding Author:** Sten Rubertsson, MD, PhD, Department of Surgical Sciences/Anaestesiology and Intensive Care, Uppsala University, Uppsala University Hospital, SE 75185 Uppsala, Sweden (sten.rubertsson@akademiska.se).



Copyright 2014 American Medical Association. All rights reserved.

## Rubertsson et al. (2014)

- The "LINC" trial.
  - RCT of Lucas device
- "[Mechanical chest compressions] provided no survival advantage over manual CPR."
  - 4-hour, ICU discharge, hospital discharge, 1 month, and 6 months
- No difference in neurological outcome.

# Mechanical versus manual chest compression for out-of-hospital cardiac arrest (PARAMEDIC): a pragmatic, cluster randomised controlled trial

Gavin D Perkins, Ranjit Lall, Tom Quinn, Charles D Deakin, Matthew W Cooke, Jessica Horton, Sarah E Lamb, Anne-Marie Slowther, Malcolm Woollard, Andy Carson, Mike Smyth, Richard Whitfield, Amanda Williams, Helen Pocock, John J M Black, John Wright, Kyee Han, Simon Gates, PARAMEDIC trial collaborators*

## Summary

**Background** Mechanical chest compression devices have the potential to help maintain high-quality cardiopulmonary resuscitation (CPR), but despite their increasing use, little evidence exists for their effectiveness. We aimed to study whether the introduction of LUCAS-2 mechanical CPR into front-line emergency response vehicles would improve survival from out-of-hospital cardiac arrest.

**Methods** The pre-hospital randomised assessment of a mechanical compression device in cardiac arrest (PARAMEDIC) trial was a pragmatic, cluster-randomised open-label trial including adults with non-traumatic, out-of-hospital cardiac arrest from four UK Ambulance Services (West Midlands, North East England, Wales, South Central). 91 urban and semi-urban ambulance stations were selected for participation. Clusters were ambulance service vehicles, which were randomly assigned (1:2) to LUCAS-2 or manual CPR. Patients received LUCAS-2 mechanical chest compression or manual chest compressions according to the first trial vehicle to arrive on scene. The primary outcome was survival at 30 days following cardiac arrest and was analysed by intention to treat. Ambulance dispatch staff and those collecting the primary outcome were masked to treatment allocation. Masking of the ambulance staff who delivered the interventions and reported initial response to treatment was not possible. The study is registered with Current Controlled Trials, number ISRCTN08233942.

**Findings** We enrolled 4471 eligible patients (1652 assigned to the LUCAS-2 group, 2819 assigned to the control group) between April 15, 2010 and June 10, 2013. 985 (60%) patients in the LUCAS-2 group received mechanical chest compression, and 11 (<1%) patients in the control group received LUCAS-2. In the intention-to-treat analysis, 30 day survival was similar in the LUCAS-2 group (104 [6%] of 1652 patients) and in the manual CPR group (193 [7%] of 2819 patients; adjusted odds ratio [OR] 0·86, 95% CI 0·64–1·15). No serious adverse events were noted. Seven clinical adverse events were reported in the LUCAS-2 group (three patients with chest bruising, two with chest lacerations, and two with blood in mouth). 15 device incidents occurred during operational use. No adverse or serious adverse events were reported in the manual group.

**Interpretation** We noted no evidence of improvement in 30 day survival with LUCAS-2 compared with manual compressions. On the basis of ours and other recent randomised trials, widespread adoption of mechanical CPR devices for routine use does not improve survival.

**Funding** National Institute for Health Research HTA – 07/37/69.

**Copyright** © Perkins et al. Open Access article distributed under the terms of CC BY.

Published Online November 16, 2014 http://dx.doi.org/10.1016/S0140-6736(14)61886-9

See Online/Comment http://dx.doi.org/10.1016/S0140-6736(14)61941-3

*Collaborators listed at end of paper

**Warwick Clinical Trials Unit, University of Warwick, Coventry, UK** (Prof G D Perkins MD, R Lall PhD, Prof M W Cooke PhD, J Horton MSc, Prof S E Lamb DPhil, A-M Slowther DPhil, M Smyth MSc, Prof S Gates PhD); **Heart of England NHS Foundation Trust, Birmingham, UK,** (Prof G D Perkins); **Surrey Peri-operative Anaesthesia Critical care collaborative Research Group, Faculty of Health and Medical Sciences, University of Surrey, Guildford, UK** (Prof T Quinn M Phil, Prof M Woollard MPH, Prof C D Deakin MD); **South Central Ambulance Service NHS Foundation Trust, Otterbourne, UK** (Prof C D Deakin, H Pocock MSc, J J M Black FCEM); **NIHR Southampton Respiratory Biomedical Research Unit, University Hospital Southampton NHS Foundation Trust, Southampton Hampshire** (Prof C D Deakin); **University of Oxford, Oxford, UK** (Prof S E Lamb); **West Midlands Ambulance Service NHS Foundation Trust, Brierley Hill, UK** (A Carson FRCGP, M Smyth); **Welsh Ambulance Services NHS Trust, Denbighshire, Wales, UK** (R Whitfield BSc, A Williams MA); **North East Ambulance Service NHS Foundation Trust, Newcastle upon Tyne, UK** (J Wright FCEM, K Han FCEM); **and Royal Victoria Infirmary, Newcastle upon Tyne, UK** (J Wright)

## Introduction

The burden of cardiac arrest out of hospital is substantial, with an estimated 424 000 cardiac arrests occurring each year of about in the USA[1] and 275 000 in Europe.[2] As few as one in 12 victims of cardiac arrest out of hospital survive to return home.[3,4] High-quality chest compressions of sufficient depth[5] and rate,[6] with full recoil of the chest between compressions[7] and avoidance of interruptions[8] are crucial to survival. Maintenance of high-quality compressions during out-of-hospital resuscitation is difficult because of the small number of crew present, fatigue, patient access, competing tasks (eg, defibrillation, vascular access) and difficulty of performing resuscitation in a moving vehicle.[9]

Mechanical compression devices suitable for use in the pre-hospital environment have been developed to automate and potentially improve this process. At the time of initiating this study, one large randomised trial of a load distributing band mechanical device had been done and was terminated early because of the worsened long-term outcomes in patients allocated to mechanical compression.[10] The subsequent Cochrane review reported insufficient evidence to conclude that mechanical chest compressions are associated with benefit or harm and their widespread use is not supported.[11] Since then, two further large randomised efficacy trials have been reported. The CIRC trial[12] assessed the load distributing band and reported it was equivalent to manual cardiopulmonary resuscitation



## Perkins et al. (2014)

- The "PARAMEDIC" trial.
  - RCT of Lucas-2 device
- "[Mechanical chest compressions] did not improve survival to 30 days."
- Possibly worse neurologic outcome.
- Possibly lower survival for patients presenting in a shockable rhythm.

# Why Not?

- Improves end-organ perfusion.
- Enhances cerebral blood flow.
- Results in higher EtCO2 readings.
- Increases ROSC.

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL

Clinical Paper

# Mechanical chest compressions improved aspects of CPR in the LINC trial☆

Alexander Esibov[a,*], Isabelle Banville[a], Fred W. Chapman[a], René Boomars[b], Martyn Box[c], Sten Rubertsson[d]

[a] Physio-Control, Inc., 11811 Willows Road NE, Redmond, WA 98052, USA
[b] Regional Ambulance Service Utrecht, Jan van Eyck Lane 6, 3723 BC Bilthoven, Utrecht, The Netherlands
[c] South Western Ambulance Service NHS Foundation Trust, Abbey Ct, Exeter EX2 7HY, England, United Kingdom
[d] Department of Surgical Sciences/Anaesthesiology and Intensive Care Medicine, Uppsala University, Akademiska sjukhuset entrence 70, 1 tr, Uppsala, Sweden

ARTICLE INFO

*Article history:*
Received 3 September 2014
Received in revised form 12 January 2015
Accepted 8 February 2015

*Keywords:*
Cardiopulmonary resuscitation (CPR)
Mechanical CPR
Out-of-hospital cardiac arrest (OHCA)
Chest compression fraction
Perishock pause
Defibrillation

ABSTRACT

*Aim:* We studied resuscitation process metrics in patients with out-of-hospital cardiac arrest enrolled in a randomized trial comparing one protocol designed to best use a mechanical CPR device, with another based on the 2005 European Resuscitation Council guidelines for manual CPR.
*Methods:* We analyzed clinical data, ECG signals, and transthoracic impedance signals for a subset of the patients in the LUCAS in Cardiac Arrest (LINC) trial, including 124 patients randomized to mechanical and 82 to manual CPR. Chest compression fraction (CCF) was defined as the fraction of time during cardiac arrest that chest compressions were administered.
*Results:* Patients in the mechanical CPR group had a higher CCF than those in the manual CPR group [0.84 (0.78, 0.91) vs. 0.79 (0.70, 0.86), $p < 0.001$]. The median duration of their pauses for defibrillation was also shorter [0 s (0, 6.0) vs. 10.0 s (7.0, 14.3), $p < 0.001$]. Compressions were interrupted for a median of 36.0 s to apply the compression device. There was no difference between groups in duration of the longest pause in compressions [32.5 s vs. 26.0 s, $p = 0.24$], number of compressions received per minute [86.5 vs. 88.3, $p = 0.47$], defibrillation success rate [73.2% vs. 81.0%, $p = 0.15$], or refibrillation rate [74% vs. 77%, $p = 0.79$].
*Conclusions:* A protocol using mechanical chest compression devices reduced interruptions in chest compressions, and enabled defibrillation during ongoing compressions, without adversely affecting other resuscitation process metrics. Future emphasis on optimizing device deployment may be beneficial.
© 2015 Elsevier Ireland Ltd. All rights reserved.

## 1. Introduction

Out-of-hospital cardiac arrest (OHCA) remains a leading cause of death in developed countries.[1] Optimizing the cardiopulmonary resuscitation (CPR) provided to victims of OHCA helps improve their chances of survival.[2] The quality of chest compressions administered may be particularly important. Both the 2010 American Heart Association (AHA) and European Resuscitation Council guidelines advise that CPR should be performed at a recommended rate and depth.[2,3] Furthermore, the guidelines advise a change in rescuer every 2 min, each change corresponding with the end of a CPR cycle.[2,3] In practice, fatigue and human error can prevent adherence to these guidelines, especially in longer resuscitations; compressions are often too shallow, are given at incorrect rates, and are interrupted for frequent and lengthy pauses.[4–6]

Mechanical chest compression devices may enable process improvements that help address these shortcomings. These devices are designed to deliver compressions of consistent rate and depth, eliminate fatigue as a factor, and provide an opportunity to reduce the frequency and length of pauses in compressions.[7,8] Manikin studies with mechanical chest compression devices have demonstrated improvements in CPR quality,[7–11] but clinical evidence is limited.[12] When introducing any new device into clinical care, it is important to verify that intended process improvements are realized in actual use. For example, placing a mechanical CPR device on a patient adds hands-off time; however, this action may pay off by ultimately increasing the cumulative chest compression fraction (CCF).

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.02.028.

* Corresponding author.
*E-mail address:* alex.esibov@physio-control.com (A. Esibov).

http://dx.doi.org/10.1016/j.resuscitation.2015.02.028
0300-9572/© 2015 Elsevier Ireland Ltd. All rights reserved.

## Esibov et al. (2015)

- Analysis of LINC trial data.
- Looked at patients for whom CODE-STAT data was available.
  - Continuous EKG
  - Impedance measure

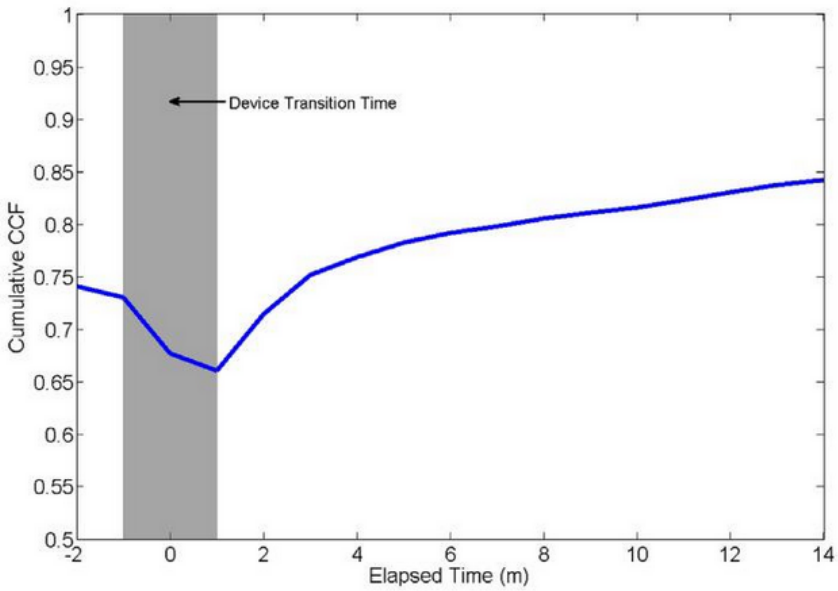


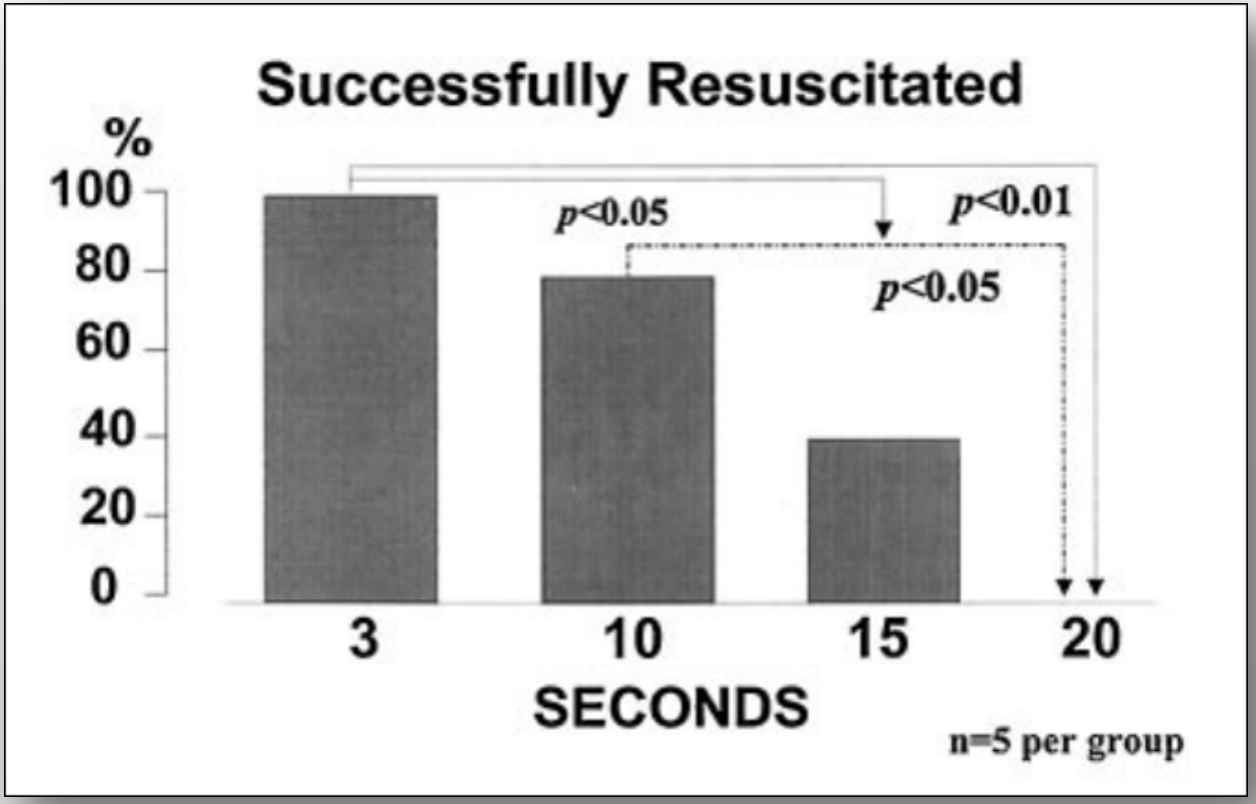

**Fig. 2.** Cumulative CCF over time in a subset of the mechanical CPR group. In the mechanical CPR group, all records that captured device application time were used to plot cumulative CCF over time. Each record fitting this description was time-aligned to capture device application anywhere between minutes −1 and 1 (since application time varied in duration). For each minute, the average CCF for that minute and all previous minutes across all cases is averaged and plotted.

## Esibov et al. (2015)

- Analysis of LINC trial data.
- Looked at patients for whom CODE-STAT data was available.
  - Continuous EKG
  - Impedance measure
- "The mechanical device did NOT reduce the duration of the single longest pause."
- "In many of the mechanical CPR cases the longest pause was the interruption for device application."

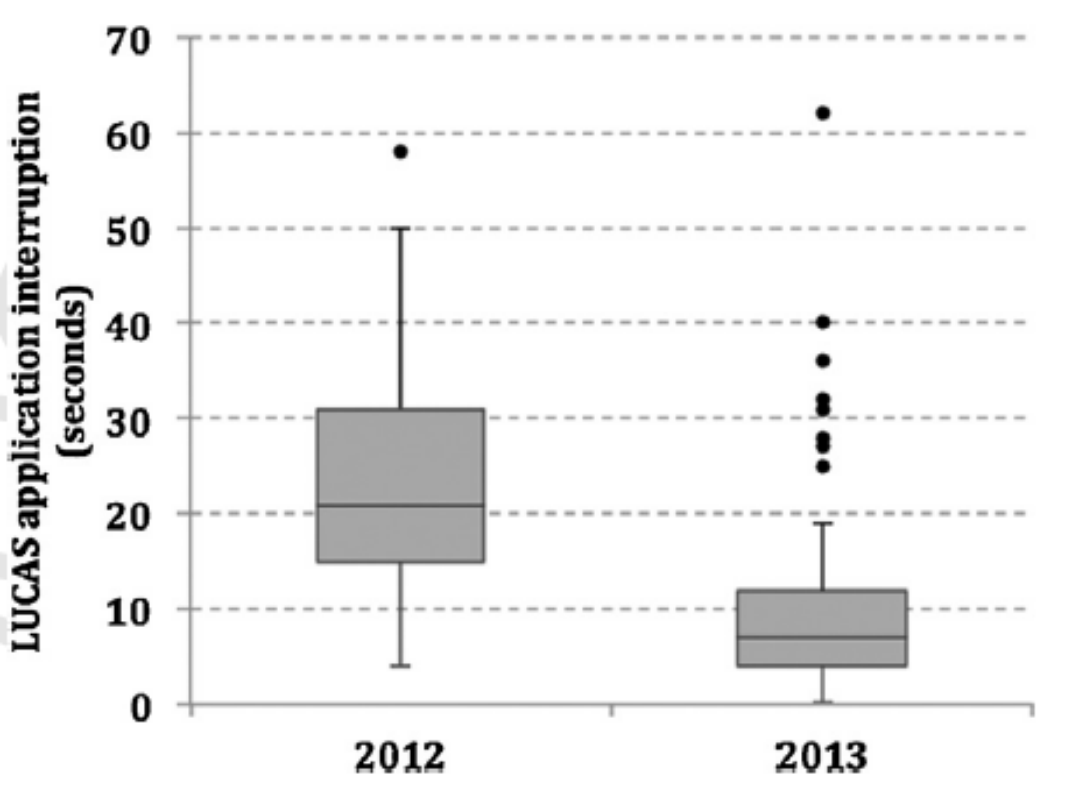
# The Way Forward?

- Reduce the duration of chest compression interruptions when applying a mechanical CPR device.



# The Way Forward?

- Reduce the duration of chest compression interruptions when applying a mechanical CPR device.



# The Way Forward?

- Delay the application of mechanical CPR?
  - Esibov et al. (2015):
    - "For patients likely to respond quickly, before device use can counteract the device application time, it may be better to delay device application; patients with witnessed, ventricular fibrillation arrest may be good examples of this."
  - Perkins et al. (2014):
    - "Deployment of [mechanical CPR] before first shock is likely to have led to a delay in the time to first shock, which might in itself reduce survival."
- Delay transport?

# THE RESUSCITATION FAIRY

# Why Do We Transport Dead People?

You've shocked the patient twice and given one round of drugs but no ROSC?

Quick! Place the patient on a backboard and drive to the hospital so the resuscitation fairy can save the patient!

# Cardiac Arrest Survival Is Rare Without Prehospital Return of Spontaneous Circulation

David A. Wampler, PhD, LP, Lindsey Collett, EMT-P, Craig A. Manifold, DO, Christopher Velasquez, EMT-P, Jason T. McMullan, MD

Abstract

**Background.** Emergency medical services (EMS) are crucial in the management of out-of-hospital cardiac arrest (OHCA). Despite accepted termination-of-resuscitation criteria, many patients are transported to the hospital without achieving field return of spontaneous circulation (ROSC). **Objective.** We examine field ROSC influence on OHCA survival to hospital discharge in two large urban EMS systems. **Methods.** A retrospective analysis of prospectively collected data was conducted. Data collection is a component of San Antonio Fire Department's comprehensive quality assurance/quality improvement program and Cincinnati Fire Department's participation in the Cardiac Arrest Registry to Enhance Survival (CARES) project. Attempted resuscitations of medical OHCA and cardiac OHCA for San Antonio and Cincinnati, respectively, from 2008 to 2010 were analyzed by city and in aggregate. **Results.** A total of 2,483 resuscitation attempts were evaluated. Age and gender distributions were similar between cities, but ethnic profiles differed. Cincinnati had 17% ($p = 0.002$) more patients with an initial shockable rhythm and was more likely to initiate transport before field ROSC. Overall survival to hospital discharge was 165 of 2,483 (6.6%). More than one-third (894 of 2,483, 36%) achieved field ROSC. Survival with field ROSC was 17.2% (154 of 894) and without field ROSC was 0.69% (11 of 1,589). Of the 11 survivors transported prior to field ROSC, nine received defibrillation by EMS. No asystolic patient survived to hospital discharge without field ROSC. **Conclusion.** Survival to hospital discharge after OHCA is rare without field ROSC. Resuscitation efforts should focus on achieving field ROSC. Transport should be reserved for patients with field ROSC or a shockable rhythm. **Key words:** cardiac arrest; survival; prehospital; emergency medical services

PREHOSPITAL EMERGENCY CARE 2012;16:451–455

## Introduction

The European Resuscitation Council and the American Heart Association have invested tremendous study and resources in an effort to improve the poor survivability of out-of-hospital cardiac arrest (OHCA). The rapid return of spontaneous circulation (ROSC) is paramount, and must be followed by intervention to reverse the cause of the arrest. Survival from OHCA is highly time-sensitive and requires aggressive intervention by both the lay public and health care professionals.[1,2]

Emergency medical services (EMS) are typically the initial medical professionals to intervene and are tasked with the primary goals of establishing ROSC, providing the appropriate postresuscitative care, and transporting the patient to an appropriate postresuscitation care facility.[3] Despite the existence of prehospital termination-of-resuscitation (TOR) protocols,[4] EMS systems have variable practices in the disposition of OHCA patients who fail to achieve ROSC.[5,6] In October 2011, the National Association of EMS Physicians released a position statement indicating that EMS systems should consider TOR of any patient suffering OHCA if the patient exhibits unwitnessed arrest, no shockable rhythm, and no field ROSC.[7]

This study aimed to determine rates of survival to hospital discharge in patients transported to the hospital without achieving ROSC in the field in two distinctly different large urban EMS systems.

## Methods

This was a retrospective analysis of prospectively collected data of OHCA patients in two large ethnically diverse cities in the United States over three years (2008–2010). Prehospital care was dictated by local

Received January 27, 2012, from the Department of Emergency Health Sciences, University of Texas Health Science Center at San Antonio (DAW, CAM, CV), San Antonio, Texas; the San Antonio Fire Department (DAW, CAM, CV), San Antonio, Texas; the Department of Emergency Medicine, University of Cincinnati (LC, JTM), Cincinnati, Ohio; and the Cincinnati Fire Department (LC, JTM), Cincinnati, Ohio. Revision received April 16, 2012; accepted for publication April 22, 2012.

Presented in part as an abstract at the American College of Emergency Physicians Research Forum, San Francisco, California, October 2011.

The authors wish to acknowledge the daily lifesaving efforts of the firefighters, EMTs, and paramedics of the San Antonio and Cincinnati Fire Departments. Funding was provided, in part, by the San Antonio Office of the Medical Director. The CARES data registry is a collaborative effort with the Centers for Disease Control and Prevention, the American Heart Association, and emergency medical services and hospitals across the United States.

All authors report no conflict of interest.

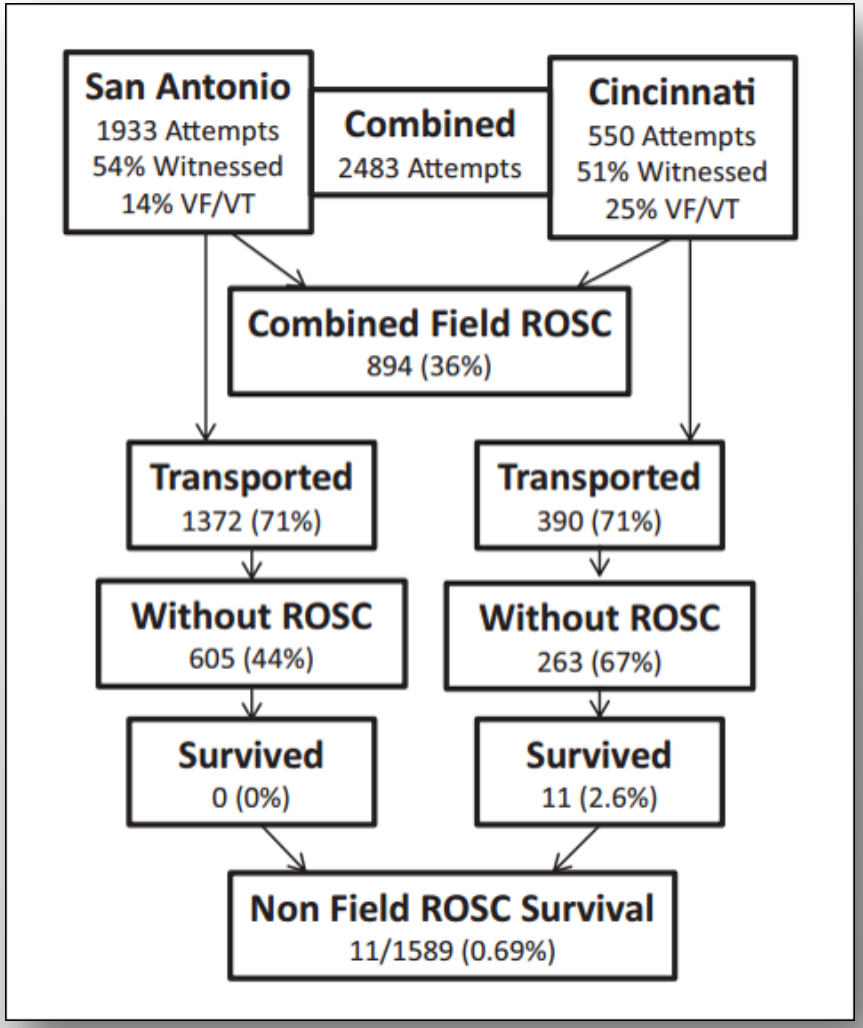
Address correspondence and reprint requests to: David Wampler, PhD, LP, UTHSCSA, Department of Emergency Health Sciences, 4201 Medical Drive, Suite 120, San Antonio TX 78229. E-mail: wamplerd@uthscsa.edu

doi: 10.3109/10903127.2012.695435



## Wampler et al. (2014)

- "Transportation of OHCA victims is NOT a benign process."
- "Aggressive treatment of the OHCA victim in the field before transport, compared with rapid transportation, is associated with improved outcomes."




Wampler et al. (2014)

- "Transportation of OHCA victims is NOT a benign process."
- "Aggressive treatment of the OHCA victim in the field before transport, compared with rapid transportation, is associated with improved outcomes."
- Survival to hospital discharge in patients transported to the hospital without achieving ROSC in the field … is very low."

# The Way Forward?

- Apply Termination of Resuscitation (TOR) guidelines.
  - Unwitnessed
  - Non-shockable rhythm
  - No ROSC
  - "Prolonged downtime"
- How long should we attempt resuscitation if no ROSC?
  - Wake County study: 90% of neurologically intact survivors had ROSC at 40 minutes.
  - What does your protocol say?
- How will advancements in ECMO change this calculus?
  - Extracorporeal membrane oxygenation
  - Limited success for OHCA.

# ALS RESPONSE TIMES

# Do ALS Response Times Matter?

ELSEVIER

The Journal of Emergency Medicine, Vol. 23, No. 1, pp. 43–48, 2002
Copyright © 2002 Elsevier Science Inc.
Printed in the USA. All rights reserved
0736-4679/02 $–see front matter

PII S1736-4679(02)00460-2

***Selected Topics: Prehospital Care***

# EIGHT MINUTES OR LESS: DOES THE AMBULANCE RESPONSE TIME GUIDELINE IMPACT TRAUMA PATIENT OUTCOME?

Peter T. Pons, MD, FACEP, and Vincent J. Markovchick, MD, FACEP

Department of Emergency Medicine and Denver Paramedic Division, Denver Health Medical Center, Denver, Colorado
*Correspondence Address:* Peter T. Pons, MD, 777 Bannock Street, Denver, CO 80204

☐ **Abstract—Emergency Medical Services (EMS) agencies are increasingly being held to an ambulance response time (RT) criterion of responding to a medical emergency within 8 min for at least 90% of calls. This recommendation resulted from one study of outcome after nontraumatic cardiac arrest and has never been studied for any other emergency. This retrospective study evaluates the effect of exceeding the 8 min RT guideline on patient survival for victims of traumatic injury treated by an urban paramedic ambulance EMS system and transported to a single Level I trauma center. Of 3576 patients identified by the hospital trauma registry, 3490 (97.6%) had complete records available. Patients were grouped according to ambulance RT: ≤ 8 min ($n$ = 2450) or > 8 min ($n$ = 1040). After controlling for other significant predictors, there was no difference in survival after traumatic injury when the 8 min ambulance RT criteria was exceeded (mortality odds ratio 0.81, 95% CI 0.43–1.52). There was also no significant difference in survival when patients were stratified by injury severity score group. Exceeding the ambulance industry response time criterion of 8 min does not affect patient survival after traumatic injury.** © 2002 Elsevier Science Inc.

☐ **Keywords—ambulance response time; EMS; trauma**

## INTRODUCTION

The response times of ambulances from the time of initial call for medical assistance until arrival at the scene have been receiving increasing attention by the ambulance industry and governmental agencies (1,2). The promulgation of guidelines for ambulance response times, now often described and utilized as standards, resulted in large part from one study that concluded that victims of non-traumatic cardiac arrest have a better outcome if basic life support (BLS) cardiopulmonary resuscitation (CPR) is initiated within 4 min of the onset of cardiac arrest and advanced life support (primarily defibrillation) is provided within 8 min (3). Using this single disease as a basis, the ambulance industry has generalized the results and suggested that emergent (red light and siren) ambulance responses meet a response time criterion of 8 min or less in at least 90% of responses. The presumption, based upon the medical cardiac arrest model, is that patient care and outcome in all other cases will be better if ambulance response time is shorter. Over the past 5 to 10 years, specific response time criteria have been developed and implemented in some states or included in contracts to provide emergency medical services (EMS) to a community as a measure of performance and quality of service. In some instances, penalties are assessed for failure to meet the specified target times (2).

The medical literature, with the exception of the above mentioned study, has devoted little attention specifically to ambulance response time and its potential effect on patient care and outcome. Numerous studies, most commonly trauma-related, have reported ambu-

**Selected Topics: Prehospital Care** is coordinated by *Peter T. Pons*, MD, of Denver Health Medical Center, Denver, Colorado

RECEIVED: 18 May 2001; FINAL SUBMISSION RECEIVED: 11 December 2001;
ACCEPTED: 19 February 2002



## Pons & Markovchick (2002)

- "This study demonstrates that ambulance response time does not have any effect on survival for patients who sustain significant trauma requiring admission to a trauma center."
- ALS 911 transport service.
- Trauma patients transported to a Level I trauma center.
- 8-minute ALS response time goal.

# Lack of Association Between Prehospital Response Times and Patient Outcomes

Thomas H. Blackwell, MD, Jeffrey A. Kline, MD, J. Jeffrey Willis, MD, G. Monroe Hicks

Abstract

**Background.** Limited data exist that examine the relationship between prehospital response times (RTs) and improved patient outcomes. **Objective.** We tested the hypothesis that patient outcomes do not differ substantially based on an explicitly chosen advanced life support (ALS) RT upper limit of 10 minutes 59 seconds (10:59 minutes). **Methods.** This case–control retrospective study was conducted in a metropolitan county with a population of 750,000 for the calendar year 2004. The emergency medical services (EMS) system is a single-tiered, ALS paramedic service that includes basic life support (BLS) first responders. The 90% fractile RT specification required by contractual agreement is 10:59 minutes or less for emergency, life-threatening (Priority 1) calls. Cases (study patients), defined as Priority 1 transports with RTs exceeding 10:59 minutes, were compared with controls, which comprised a random sample of Priority 1 calls with RTs of 10:59 minutes or less. Prehospital run reports and hospital outcomes were evaluated using explicit criteria by one observer for the primary outcome of in-hospital death and secondary outcomes of critical interventions performed in the field. We tested the hypothesis of equivalence using the 95% confidence intervals (CIs) for difference in proportions with $\alpha = 0.05$ and $\beta = 0.2$ to show $\Delta = \pm 5\%$. **Results.** Of the 3,270 emergency transports in 2004, we identified 373 study patients (RT >10:59 min) and a random sample of 373 controls (RT ≤10:59 min). Survival to hospital discharge was 80% (76% to 84%) for study patients vs. 82% (77% to 85%) for controls, yielding a 95% CI for the difference of –6 to +4%. ALS procedures were performed in 47.7% (95% CI: 43% to 53%) of study patients vs. 45.4% (40% to 51%) of controls (95% difference in proportions –10 to +5%). The most frequently performed procedures were administration of nitroglycerine and endotracheal intubation. **Conclusions.** Compared with patients who wait 10:59 minutes or less for ALS response, Priority 1 patients who wait longer than 10:59 minutes could experience between a 6% increase and a 4% decrease in mortality, and do not have an increase in critical procedures performed in the field. Our data are most consistent with the inference that neither the mortality nor the frequency of critical procedural interventions varies substantially based on this prespecified ALS RT. **Key words:** emergency medical services; reaction time; outcome assessment (health care); ambulances; prehospital.

PREHOSPITAL EMERGENCY CARE 2009;13:444–450

## Introduction

The provision of optimal emergency medical services (EMS) care in the prehospital environment requires integration of multiple operational and clinical components undertaken by many persons from different sites. Call taking and dispatching, scene response, on-scene patient care, triage and hospital destination decisions, continuing care during transport, and transfer to definitive care are all factors subject to online and off-line medical direction. Ambulance response time represents a high-profile target for potential process improvement. It remains self-evident that response time represents an important performance indicator, but taken alone, it does not completely predict outcome of disease severity or mortality. While prior research has evaluated the effectiveness of response time by various levels of care provision, there are limited studies that have examined the relationship between prehospital response times and patient outcome.[1–4] The purpose of this study was to examine the EMS response times, clinical care provided, and patient outcome for high-acuity 9-1-1 calls that occurred in an urban metropolitan jurisdiction to determine whether the current response time specifications set for the community are safe. As such, this report concerns the relationship between the duration of time defined by the period measured between a call received at the 9-1-1 dispatch center, arrival of an ambulance at the scene, and outcome of the patient. We further tested the hypothesis that patient outcomes do not differ substantially based on an explicitly chosen advanced life support (ALS) response time specification.

## Methods

We studied a cohort of EMS-transported patients. The data for this report were obtained by structured, secondary review of explicitly recorded data from EMS transports conducted in an urban setting between

Received December 18, 2008, from the Department of Emergency Medicine, Carolinas Medical Center (THB, JAK, JJW), Charlotte, North Carolina; and the Mecklenburg EMS Agency (THB, GMH), Charlotte, North Carolina. Revision received February 18, 2008; accepted for publication February 20, 2009.

Presented at the National Association of EMS Physicians annual meeting, Naples, Florida, January 2007.

The authors have no relevant disclosures.

Address correspondence and reprint requests to: Thomas Blackwell, MD, The Center for Prehospital Medicine, Department of Emergency Medicine, Carolinas Medical Center, P.O. Box 32861, Charlotte, NC 28232-2861. e-mail: tom.blackwell@carolinashealthcare.org

doi: 10.1080/10903120902935363



RIGHTSL

## Blackwell et al. (2009)

- "The results of this study showed no evidence of increased mortality or increased requirement for critical procedures during transport for Priority 1 patients in association with an ALS response time exceeding 10:59 minutes."
- ALS 911 transport service.
- Priority 1: Emergency, life threatening.
- 11-minute ALS response time goal.

CLINICAL PRACTICE

# Response Time Effectiveness: Comparison of Response Time and Survival in an Urban Emergency Medical Services System

THOMAS H. BLACKWELL, MD, JAY S. KAUFMAN, PHD

***Abstract.*** Emergency medical services (EMS) administrators seek methods to enhance system performance. One component scrutinized is the response time (RT) interval between call receipt and arrival on scene. While reducing RTs may improve survival, this remains speculative and unreported. **Objective:** To determine the effect of current RTs on survival in an urban EMS system. **Methods:** The study was conducted in a metropolitan county (population 620,000). The EMS system is a single-tier, paramedic service and provides all service requests. The 90% fractile RT specifications required for county compliance include 10:59 minutes for emergency life-threatening calls (priority I) and 12:59 minutes for emergency non-life-threatening calls (priority II). All emergency responses resulting in a priority I or priority II transport to a Level 1 trauma center emergency department over a six-month period were evaluated to determine the relation between specified and arbitrarily assigned RTs and survival. **Results:** Five thousand, four hundred twenty-four transports were reviewed. Of these, 71 patients did not survive (1.31%; 95% CI = 1.04% to 1.67%). No significant difference in median RTs between survivors (6.4 min) and nonsurvivors (6.8 min) was noted ($p = 0.10$). Further, there was no significant difference between observed and expected deaths ($p = 0.14$). However, mortality risk was 1.58% for patients whose RT exceeded 5 minutes, and 0.51% for those whose RT was under 5 minutes ($p = 0.002$). The mortality risk curve was generally flat over RT intervals exceeding 5 minutes. **Conclusions:** In this observational study, emergency calls where RTs were less than 5 minutes were associated with improved survival when compared with calls where RTs exceeded 5 minutes. While variables other than time may be associated with this improved survival, there is little evidence in these data to suggest that changing this system's response time specifications to times less than current, but greater than 5 minutes, would have any beneficial effect on survival. **Key words:** prehospital; emergency medical services; response time; effectiveness; standards. ACADEMIC EMERGENCY MEDICINE 2002; 9:288–295

EMERGENCY medical services (EMS) administrators and managers continually seek innovative methods to enhance system performance. Like any service, multiple elements comprise an emergency medical response system, each with inherent qualities that may be reviewed, analyzed, and improved if deficient. One component commonly scrutinized by administrators, elected officials, and the public, and one potentially affecting patient care, is the response time interval between call receipt and arrival of medical care on the scene. Various times and response intervals intrinsic to EMS systems have been previously described.[1–3] Further, the Utstein criteria for cardiac arrest data were proposed in an attempt to report uniform data collection with reference to clinical and time criteria.[4] Despite these attempts for achieving consistent data reporting, definitions continue to vary between systems depending on design, performance specifications, or data collection limitations. Such designs may limit the ability to adequately scrutinize response times and to make comparisons between EMS systems.

Intuitively, reducing the response time would potentially decrease morbidity and improve survival for many categories of illness and injury. The benefit associated with a standardized, quantitative time reduction, however, remains speculative.

From the Center for Prehospital Medicine (THB), Departments of Emergency Medicine (THB), Epidemiology (JSK), and Statistics (JSK), Carolinas Medical Center, and Mecklenburg EMS Agency (THB), Charlotte, NC. Dr. Kaufman is currently in the Department of Epidemiology, UNC School of Public Health, Chapel Hill, NC.
Received June 1, 2001; revisions received August 27, 2001, and November 6, 2001; accepted November 15, 2001.
Presented at the National Association of EMS Physicians annual meeting, Laguna, CA, January 2000.
Address for correspondence and reprints: Thomas H. Blackwell, MD, Department of Emergency Medicine, Carolinas Medical Center, P.O. Box 32861, Charlotte, NC 28232-2861. Fax: 704-355-7047; e-mail: tom.blackwell@carolinashealthcare.org
*A related commentary appears on page 320.*

## Blackwell & Kaufman (2002)

- "There was no statistically significant difference for times between 5 and 10 minutes, and no evidence to suggest any dose–response trend in this region of the data."
- "There was some apparent evidence for a survival benefit associated only with response times less than 5 minutes."
- ALS 911 transport service.
- Priority 1 & Priority 2 patients

# Paramedic Response Time: Does It Affect Patient Survival?

Peter T. Pons, MD, Jason S. Haukoos, MD, MS, Whitney Bludworth, MD, Thomas Cribley, EMT-P, Kathryn A. Pons, RN, Vincent J. Markovchick, MD

## Abstract

**Objectives:** One marker of quality emergency medical services care is measured by meeting an 8-minute response time guideline. This guideline was based on results of paramedic response times for nontraumatic cardiac arrest patients and has not been studied in unselected patients. The objective of this study was to evaluate the effect of paramedic response time on survival to hospital discharge in unselected patients in a large urban setting while controlling for a number of potentially important confounders, including level of illness severity. **Methods:** This was a retrospective cohort study performed in an urban 911-based ambulance service system. Patients transported by paramedics to a single urban county teaching hospital from January 1, 1998, to December 31, 1998, were included. Data collected included patient demographics; paramedic response, scene, and transport times; the nature of the medical complaint; and whether the patient survived to hospital discharge. Multivariable logistic regression models were developed using response time as the primary independent variable and survival to hospital discharge as the dependent variable. Covariates included scene time, transport time, age, gender, and level of illness severity. **Results:** Of 34,111 calls involving emergency response, 11,078 patients (32%) were transported to the study institution and 10,382 (94%) had response time data available. Of these, 9,559 patients (92%) had data available to categorize them into groups based on their level of illness severity and were thus included in the study. A survival benefit was identified for response times ≤4 minutes (odds ratio [OR], 0.70; 95% confidence interval [CI] = 0.52 to 0.95). No survival benefit was identified when response time was modeled as a continuous variable (OR, 1.01; 95% CI = 0.98 to 1.04) or when dichotomized at 8 minutes (OR, 1.06; 95% CI = 0.80 to 1.42). **Conclusions:** A paramedic response time within 8 minutes was not associated with improved survival to hospital discharge after controlling for several important confounders, including level of illness severity. However, a survival benefit was identified when the response time was within 4 minutes for patients with intermediate or high risk of mortality. Adherence to the 8-minute response time guideline in most patients who access out-of-hospital emergency services is not supported by these results.
**Key words:** advanced life support; ambulance response; emergency medical services; paramedic ambulance; response time; response time guideline; survival. ACADEMIC EMERGENCY MEDICINE 2005; 12:594–600.

Paramedic response time to the scene of a call for emergency medical assistance has become a benchmark measure of the quality of the service provided by emergency medical services (EMS) agencies.[1,2] A suggested target response time of ≤8 minutes for at least 90% of emergent responses has evolved into a guideline that has been incorporated into operating agreements for many EMS providers.[3]

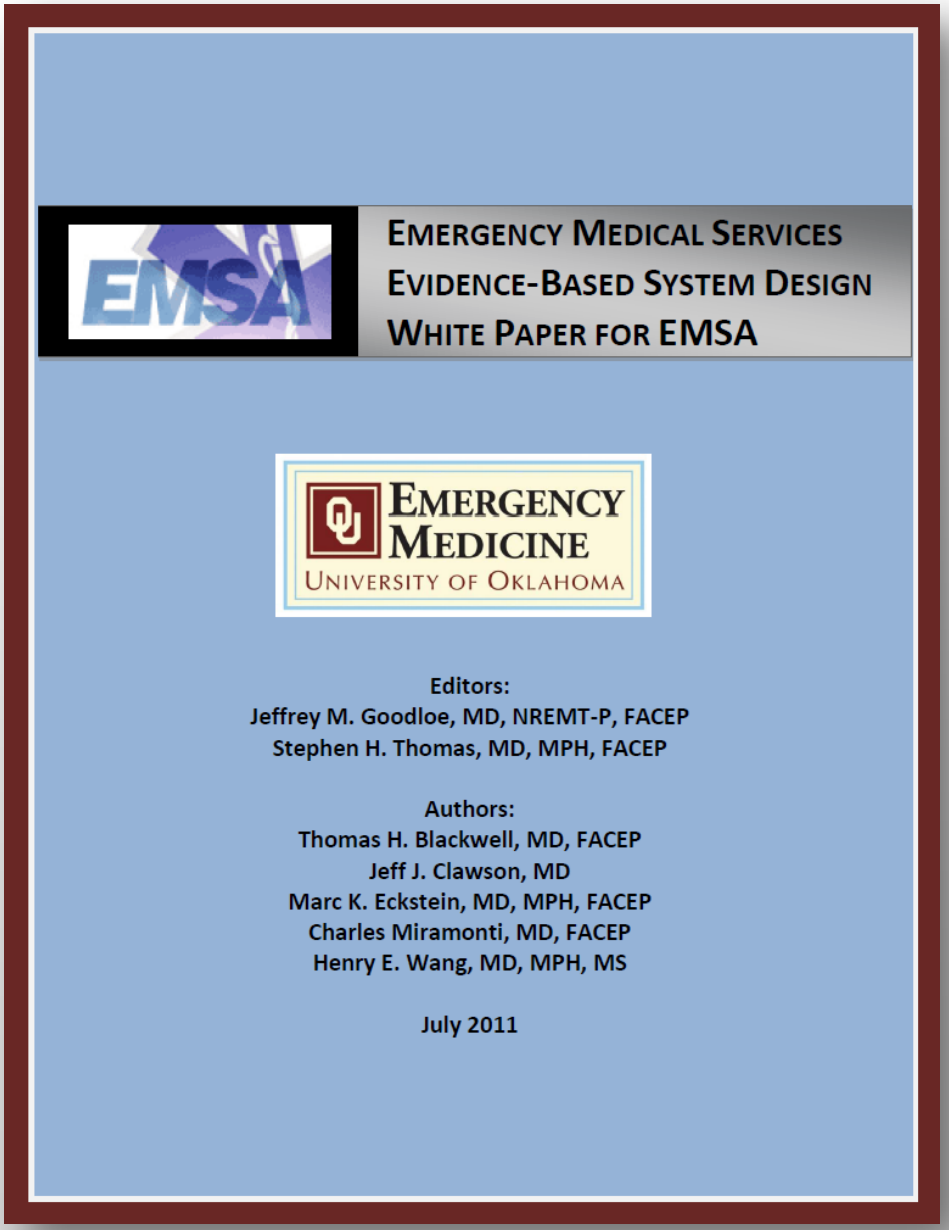
This response time guideline has its origin in an article published in 1979 that evaluated patient outcomes after out-of-hospital nontraumatic cardiac arrest.[4] The investigators reported that survival decreased significantly if basic life support and advanced life support were initiated in >4 minutes and >8 minutes, respectively. They therefore suggested these times as recommended guidelines for the emergency response of basic and advanced life support providers. Although that study reported exclusively on outcomes from cardiac arrest, the response time guidelines were subsequently generalized to all emergent responses and to any type of illness or injury.

Since the publication of that initial report, much work has been done to evaluate which interventions provided by basic or advanced life support providers positively affect patient outcomes after nontraumatic cardiac arrest. This resulted in the recognition that an important determinant of survival is the time

From the Department of Emergency Medicine, Denver Health Medical Center (PTP, JSH, WB, KAP, VJM), Denver, CO; Department of Preventive Medicine and Biometrics, University of Colorado Health Sciences Center (JSH), Denver, CO; Denver Paramedic Division, Denver Health and Hospital Authority (WB), Denver, CO; and Department of Emergency Medicine, South Austin Hospital (TC), Austin, TX.
Received November 22, 2004; revision received January 3, 2005; accepted February 1, 2005.
Presented in part at the SAEM western regional meeting, Oakland, CA, April 2004.
Address for correspondence and reprints: Peter T. Pons, MD, Department of Emergency Medicine, Denver Health Medical Center, 777 Bannock Street, Mail Code 0108, Denver, CO 80204. Fax: 303-436-7541; e-mail: peter.pons@dhha.org.
doi:10.1197/j.aem.2005.02.013

## Pons et al. (2005)

- "There was no effect on patient survival to hospital discharge."
- "There does appear to be a survival advantage for [cardiac arrest] patients in instances where paramedics respond within 4 minutes."
- ALS 911 transport service.
- All transported patients; stratified into high, intermediate, and low risk groups.



EMERGENCY MEDICAL SERVICES
EVIDENCE-BASED SYSTEM DESIGN
WHITE PAPER FOR EMSA

EMERGENCY MEDICINE
UNIVERSITY OF OKLAHOMA

Editors:
Jeffrey M. Goodloe, MD, NREMT-P, FACEP
Stephen H. Thomas, MD, MPH, FACEP

Authors:
Thomas H. Blackwell, MD, FACEP
Jeff J. Clawson, MD
Marc K. Eckstein, MD, MPH, FACEP
Charles Miramonti, MD, FACEP
Henry E. Wang, MD, MPH, MS

July 2011

## Blackwell (2011)

- "Decreasing EMS system response times is laudable on any first contemplation, but careful analysis yields realizations that the costs are great, the benefits suspect, and the perceptions substantial."
- NFPA 1710 response time standard based on CPR within 4 minutes (BLS) and defibrillation within 8 minutes (ALS).
- CPR and defibrillation now provided by first responders!

# The Way Forward?

- Focus on patient outcomes.
  - Response time is a process measure, not an outcome measure
  - Response times reflect reliability, not effectiveness
- Focus on evidence-based interventions.
  - Regardless of whether delivered by ALS or BLS
    - Epinephrine for allergic reaction
    - CPR and AED for cardiac arrest
    - Tourniquets for bleeding control

# CONCLUSION

# Does ALS Improve Patient Care?

- The "therapeutic range" for ALS is narrow.
  - Too much does not benefit patients
    - Skill dilution and reduced exposure to critical patients
- The benefit of any ALS is even in question.
  - OPALS Study: Benefit limited to respiratory patients
  - Sanghavi et al. (2015): Higher likelihood of survival for cardiac arrest patients transported by BLS than those transported by ALS
  - Sanghavi et al. (2015): ALS associated with substantially higher mortality than BLS for several acute medical emergencies

# It's Up To You To Prove That It Does!

Clinical Competency

Technical Proficiency

Continuing Education

Evidence-based Medicine

# Thank You!

mario.weber@m10.solutions
hilary.gates@alexandriava.gov

# BACKUP SLIDES

# Left Ventricular Hypertrophy

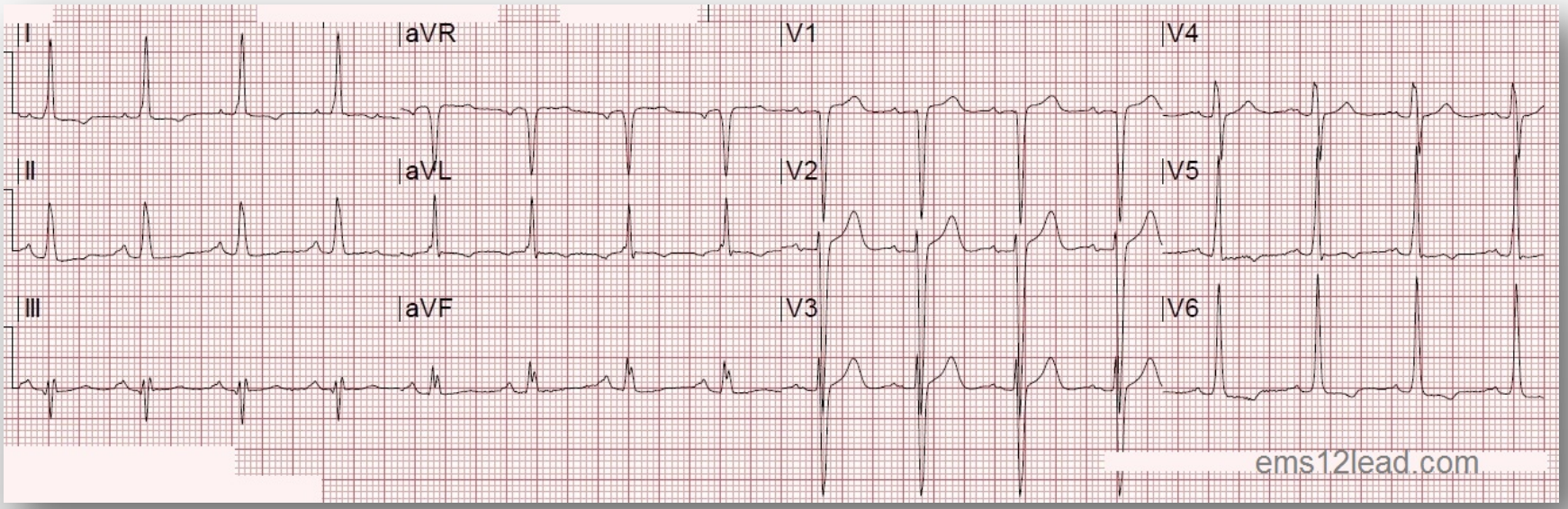
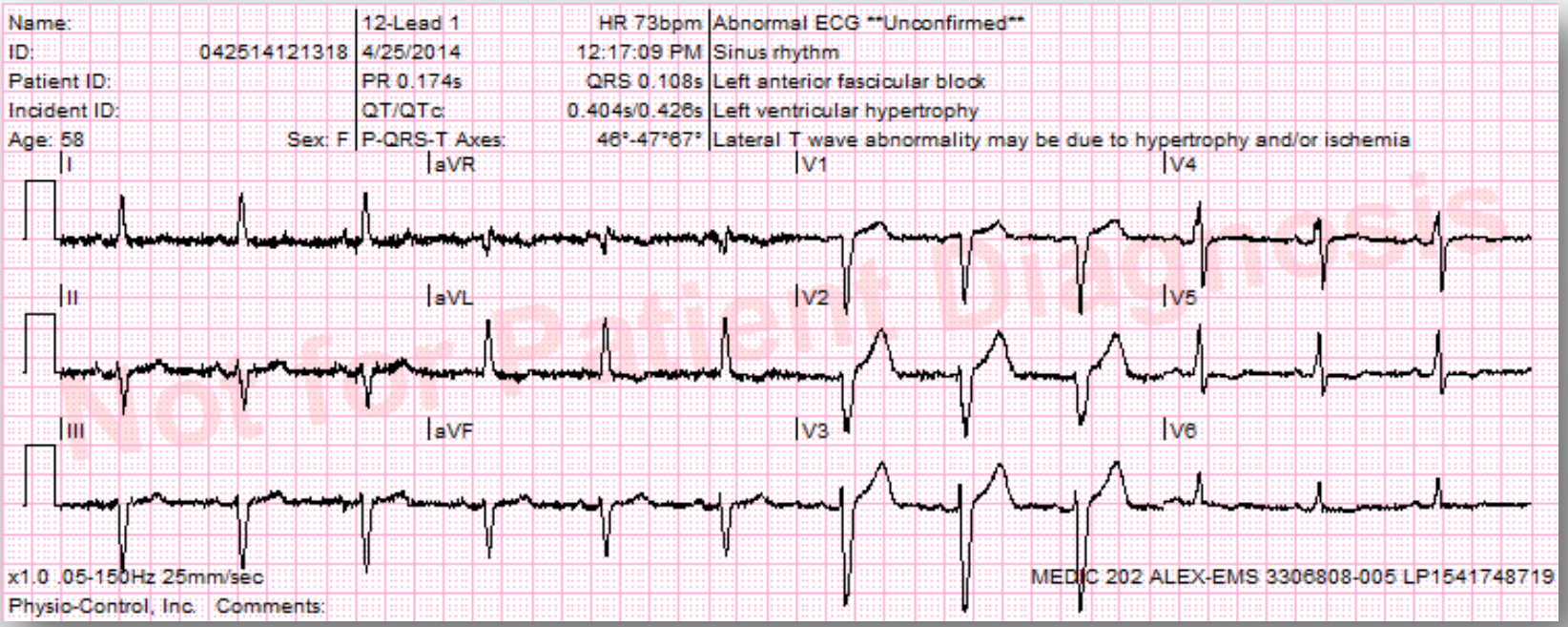
<u>Diagnostic Criteria</u>

- Increased R-wave amplitude in left-sided leads
  - I, aVL, and V4-V6
- Increased S-wave depth in right-sided leads
  - III, aVR, V1-V3
- LV “Strain” pattern
  - ST-segment depression and T-wave inversion in left-sided leads

# Left Ventricular Hypertrophy

- Left and Right-Sided Leads
- LV Strain on Left-Sided Leads

# Left Ventricular Hypertrophy



# Left Ventricular Hypertrophy