



DETERMINING TERMINATING DETERMINANTS: WHAT'S A REASONABLE DURATION OF CARDIAC ARREST EFFORTS?

SCOTT T. YOUNGQUIST, MD, MS, FACEP, FAEMS, FAHA
ASSOCIATE PROFESSOR OF EMERGENCY MEDICINE
MEDICAL DIRECTOR, SALT LAKE CITY FIRE DEPARTMENT, 911 DISPATCH

@ScottYoungquist

DISCLOSURES

None

HEALTH

When Not To Quit: Man Revived After 96 Minutes

August 22, 2011 · 12:01 AM ET

Heard on [Morning Edition](#)

GRETCHEN CUDA-KROEN

Last January, a Minnesota man's heart stopped beating for an amazing 96 minutes. Emergency room doctors thought he was dead. But first responders who gave CPR on the scene decided not to give up, in part because of technology that allowed them to see their efforts were working.

It's called capnography, and it measures how much carbon dioxide is being expelled with each breath. This information helps doctors and emergency medical



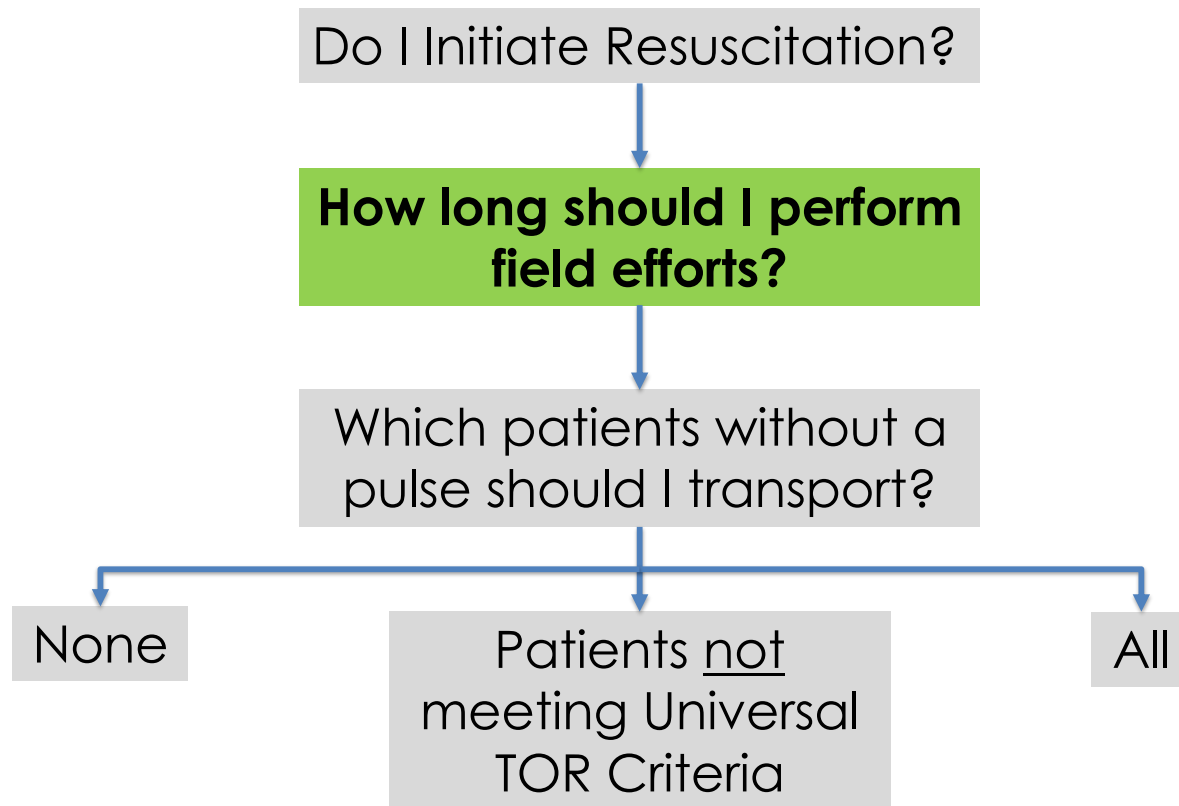
**Derek M. Nusbaum, MD
Scott T. Bassett, MD
Igor D. Gregoric, MD
Biswajit Kar, MD**

A Case of Survival after Cardiac Arrest and 3½ Hours of Resuscitation

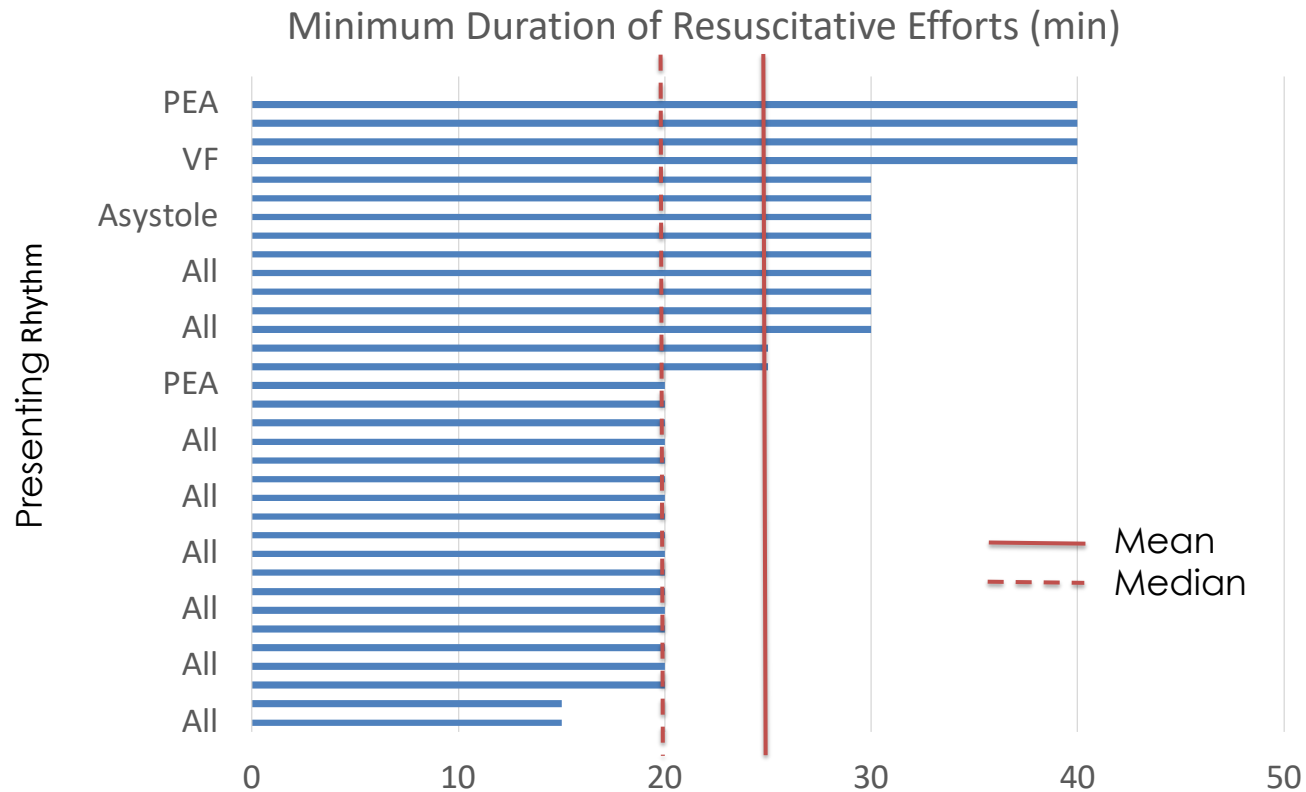
Although survival rates after cardiac arrest remain low, new techniques are improving patients' outcomes. We present the case of a 40-year-old man who survived a cardiac arrest that lasted approximately 3½ hours. Resuscitation was performed with strict adherence to American Heart Association/American College of Cardiology Advanced Cardiac Life Support guidelines until bedside extracorporeal membrane oxygenation could be placed. A hypothermia protocol was initiated immediately afterwards. The patient had a full neurologic recovery and was bridged from dual ventricular assist devices to a total artificial heart. On hospital day 160, he underwent orthotopic heart and cadaveric kidney transplantation. On day 179, he was discharged from the hospital in ambulatory condition.

To our knowledge, this is the only reported case in which a patient survived with good neurologic outcomes after a resuscitation that lasted as long as 3½ hours. Documented cases of resuscitation with good recovery after prolonged arrest give hope for improved overall outcomes in the future. (Tex Heart Inst J 2014;41(2):222-6)

FIELD DECISION-POINTS



MAJOR METRO EMS SYSTEMS IN THE UNITED STATES



Source: Correspondence with Eagles Consortium of U.S. Medical Directors, 2017



Source: The Knife and Gun Club by Eugene Richards



Prehospital Emergency Care

Volume 5, Issue 1, January–March 2001, Pages 79-87



Special Contributions

Resuscitation in the out-of-hospital setting: Medical futility criteria for on-scene pronouncement of death ☆ ☆ ☆

Presented at the Turtle Creek Conference II, Dallas, Texas, March 2000.

Paul E. Pepe MD, MPH, Robert A. Swor DO, Joseph P. Ornato MD, Edward M. Racht MD, Donald
M. Blanton MD, John K. Griswell MD, Thomas Blackwell MD, James Dunford MD

⊕ **Show more**

Special Contributions

Resuscitation in the out-of-hospital setting: Me futility criteria for on-scene pronouncement of death ☆ ☆ ☆

Presented at the Turtle Creek Conference II, Dallas, Texas, March 2000.

Paul E. Pepe MD, MPH, Robert A. Swor DO, Joseph P. Ornato MD, Edward M. Ra
M. Blanton MD, John K. Griswell MD, Thomas Blackwell MD, James Dunford MD

[Show more](#)

JOIN US FOR THE MOST EXCITING CONFERENCE IN
EMS!!!!

"EMS STATE OF THE SCIENCE:
A BALE OF TURTLES 2000"



STATE OF THE LITERATURE

1. Observational
2. Reporting of time to ROSC at which <1% of patients survive
3. Prone to prognostication bias

EARLY IDENTIFICATION OF NON-SURVIVORS IN 6 MIN?

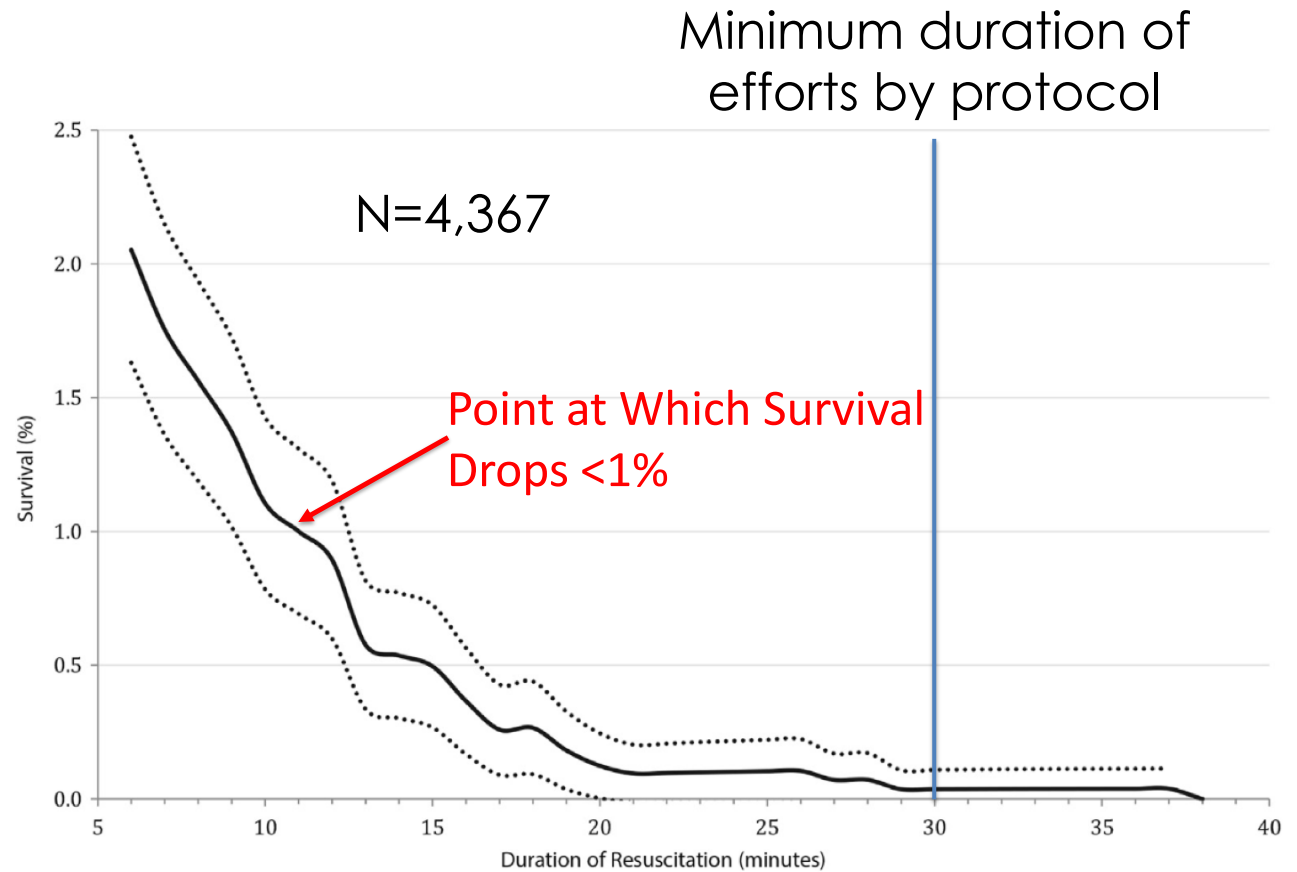
Universal Termination of Resuscitation Criteria

1. Not EMS Witnessed
2. No Shocks Delivered
3. No ROSC



Morrison LJ, Visentin LM, Kiss A, Theriault R, et al. Validation of a Rule for Termination of Resuscitation in Out-of-Hospital Cardiac Arrest. NEJM 2006;355:478-87.

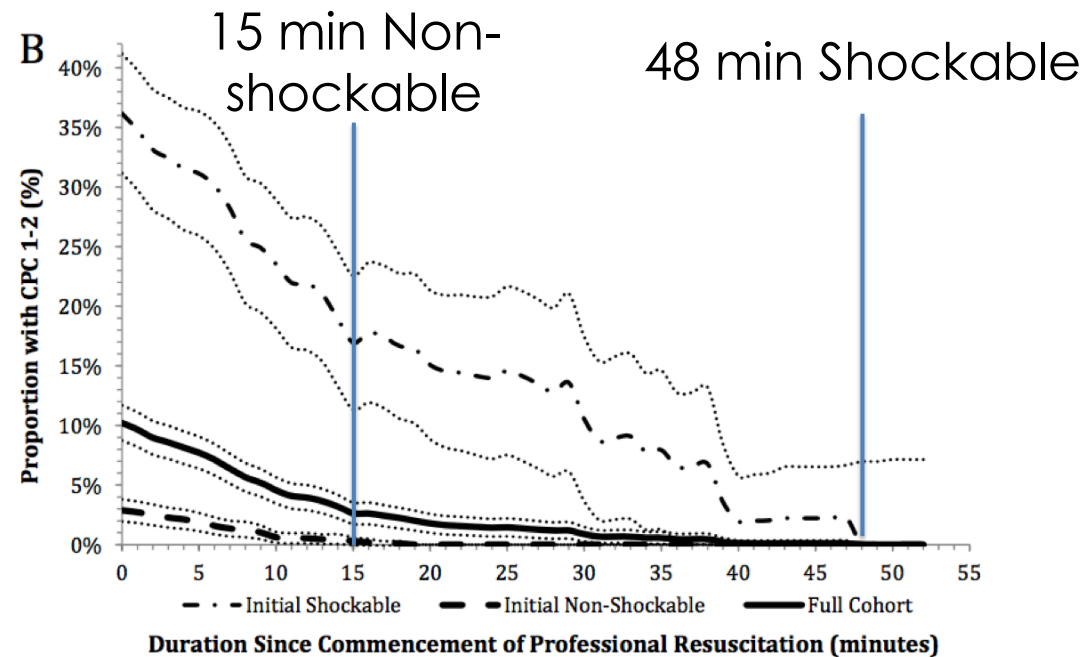
Performance of Universal TOR in British Columbia



Grunau B, Taylor J, Scheuermeyer FX, Stenstrom R, et al. External Validation of the Universal Termination of Resuscitation Rule for Out-of-Hospital Cardiac Arrest in British Columbia. *Ann Emerg Med* 2017;70:374-381.

SHOULD DURATION OF EFFORTS BE BASED ON PRESENTING RHYTHM?

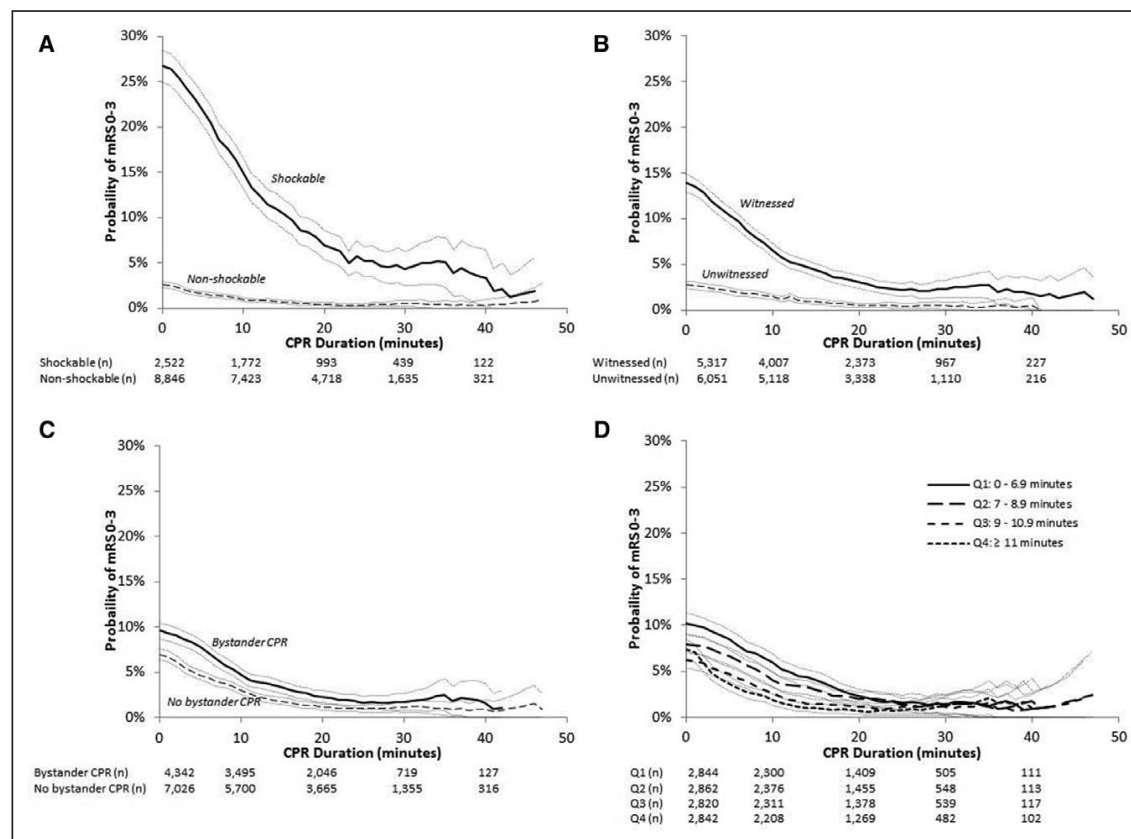
Vancouver, BC
N=1,617



Grunau B, Reynolds JC, Scheurmeyer FX, Stenstrom R, et al. Comparing the prognosis of those with initial shockable and non-shockable rhythms with increasing durations of CPR: Informing minimum durations of Resuscitation. Resuscitation 2016;101:50-56.

SHOCKABLE, WITNESSED, BYSTANDER CPR EXTEND THERAPEUTIC WINDOW

ROC-PRIMED
N=11,368



Reynolds JC, Grunau B, Rittenberger JC, Sawyer KN, et al. Association between duration of resuscitation and favorable outcome after out-of-hospital cardiac arrest: implications for prolonging or terminating resuscitation. *Circulation* 2016;134:2084-2094.

SUMMARY OF RECENT STUDIES: OHCA

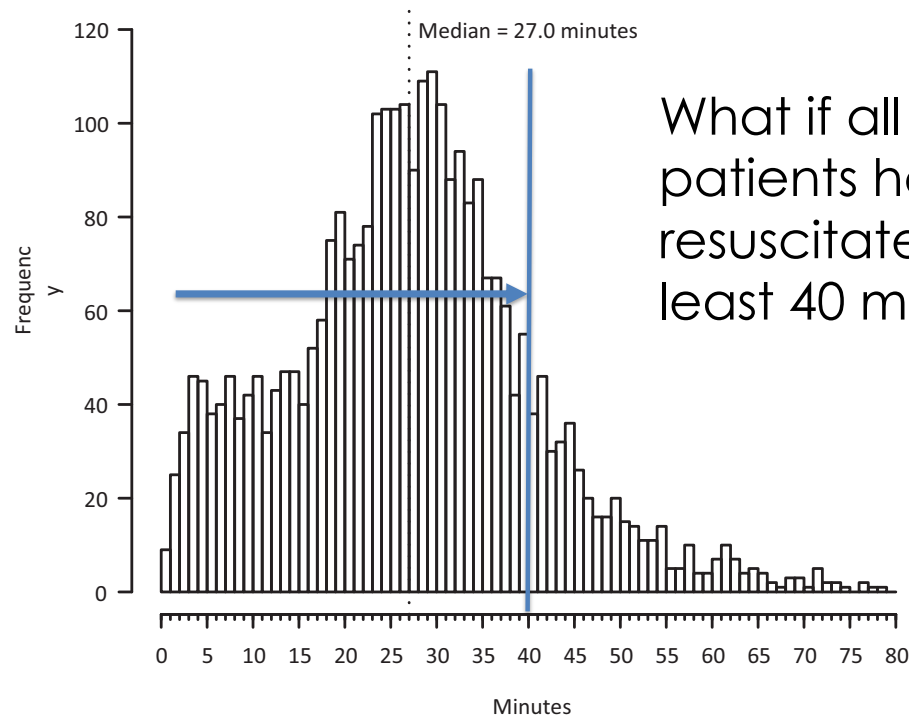
Author	Outcome	Presenting Rhythm	Time to 99% with ROSC (or likelihood)
Drennan IR, et al.*	Survival with Good Neuro	All	37
Grunau B, et al.†	Survival to Discharge	All	28
Grunau B, et al.†	Survival with Good Neuro	All	30
		Shockable	48
		Non-Shockable	15
Reynolds JC, et al.*	Survival with Good Neuro	All	37
Nagao K, et al.	Survival with Good Neuro	All (bystander witnessed)	40

*partially overlapping populations

†partially overlapping populations

WHAT IS THE BENEFIT OF EXTENDING FIELD EFFORTS?

British
Columbia
N=5,674
2007-2011



What if all these
patients had been
resuscitated for at
least 40 min?

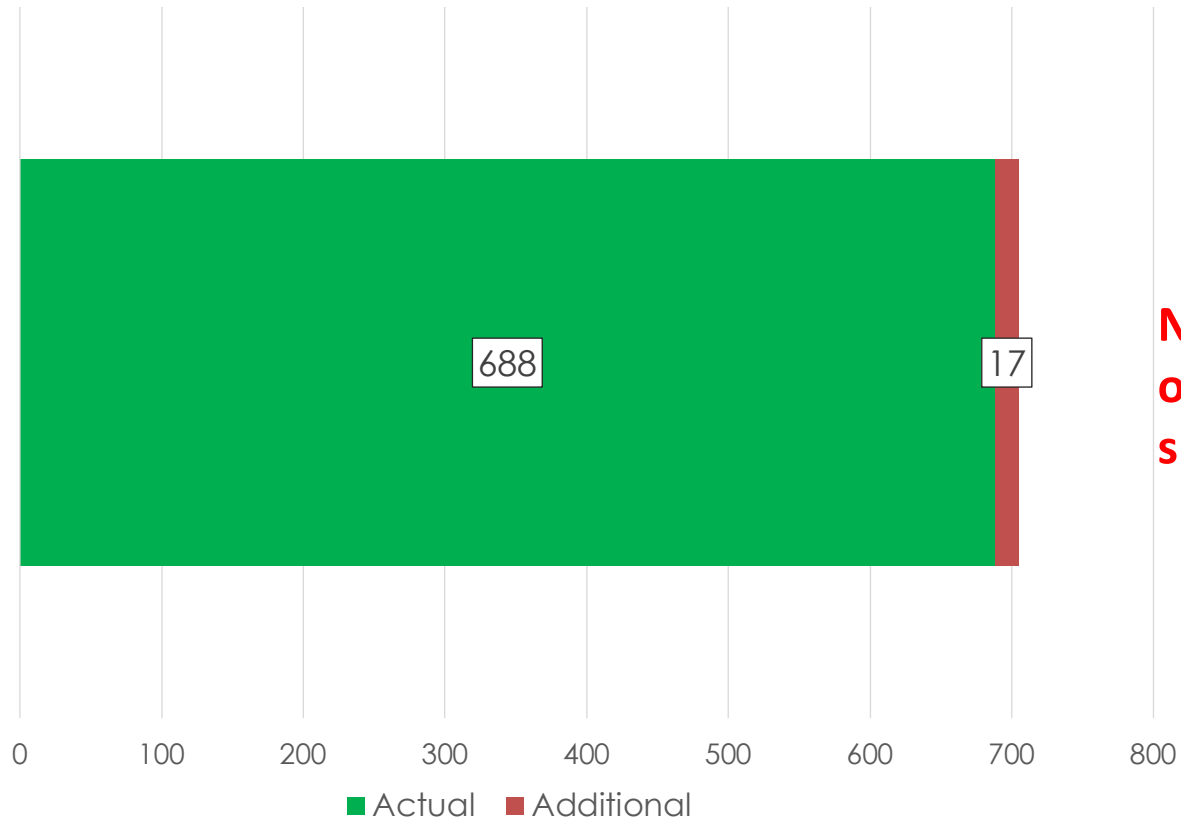
FIGURE 3. Histogram of durations until termination of resuscitation in 3041 patients who did not achieve return of spontaneous circulation.

Grunau B, Puyat J, Wong H, Scheurmeyer FX, et al. Gains of Continuing Resuscitation in Refractory Out-of-Hospital Cardiac Arrest: A Model-Based Analysis to Identify Deaths Due to Intra-Arrest Prognostication. *Prehospital Emergency Care* 2017;Early Online 1-10

British
Columbia
N=5,674
2007-2011

Survivors

Estimated Gain in Survivors from Extending Resuscitation to 40 min



**NNT of 500 for
one additional
survivor**

Grunau B, Puyat J, Wong H, Scheurmeyer FX, et al. Gains of Continuing Resuscitation in Refractory Out-of-Hospital Cardiac Arrest: A Model-Based Analysis to Identify Deaths Due to Intra-Arrest Prognostication. Prehospital Emergency Care 2017;Early Online 1-10

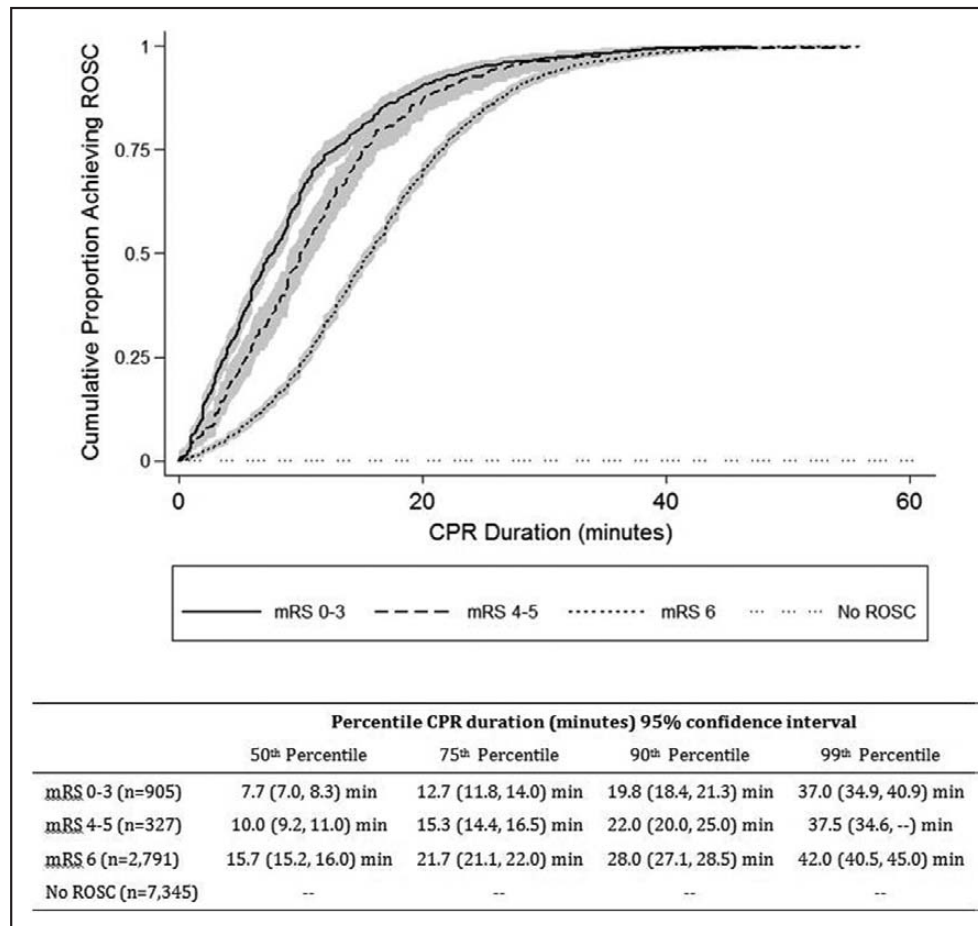


Source: The Knife and Gun Club by Eugene Richards



DURATION OF RESUSCITATION INVERSELY IS ASSOCIATED WITH NEURO OUTCOME

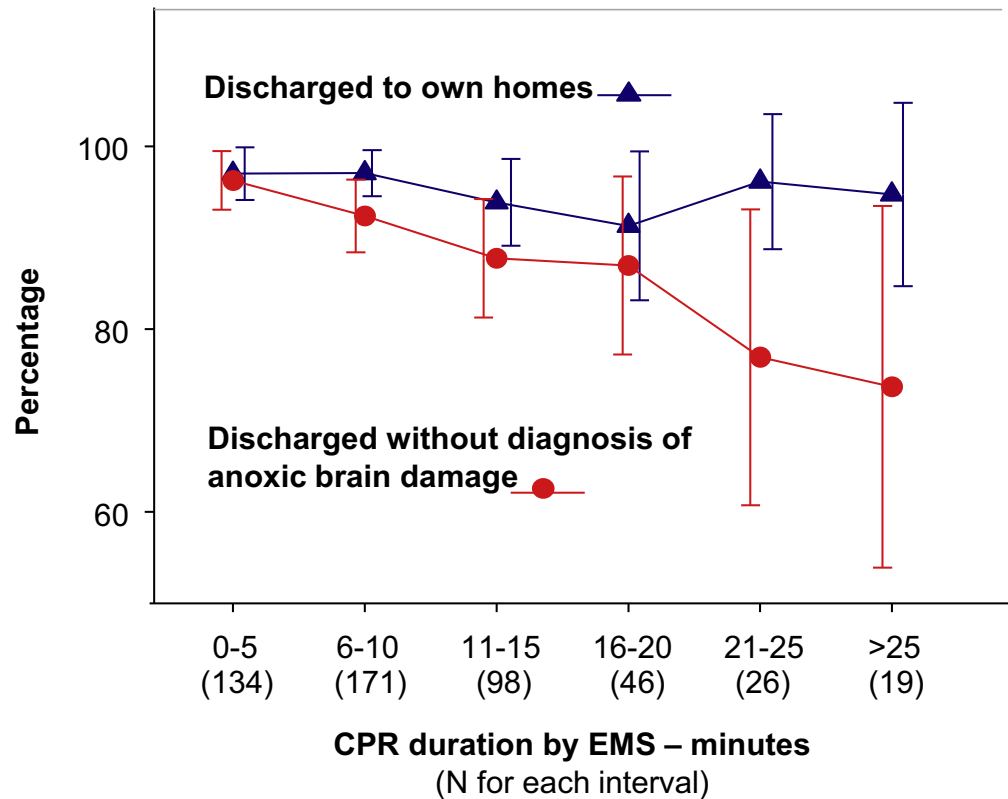
ROC-PRIMED
N=11,368



Reynolds JC, Grunau B, Rittenberger JC, Sawyer KN, et al. Association between duration of resuscitation and favorable outcome after out-of-hospital cardiac arrest: implications for prolonging or terminating resuscitation. *Circulation* 2016;134:2084-2094.

DURATION OF RESUSCITATION INVERSELY IS ASSOCIATED WITH NEURO OUTCOME

Denmark
N=1,316



Rajan S, Folke F, Kragholm K, Malta Hansen C, et al. Prolonged cardiopulmonary resuscitation and outcomes after out-of-hospital cardiac arrest. *Resuscitation* 2016;105:45-51.

POTENTIAL
CONS OF
INCREASING
DURATION OF
FIELD EFFORTS

Increase in number of non-neurologically intact survivors

Increase time out of service and man hours
(~96 man-hours/life saved)

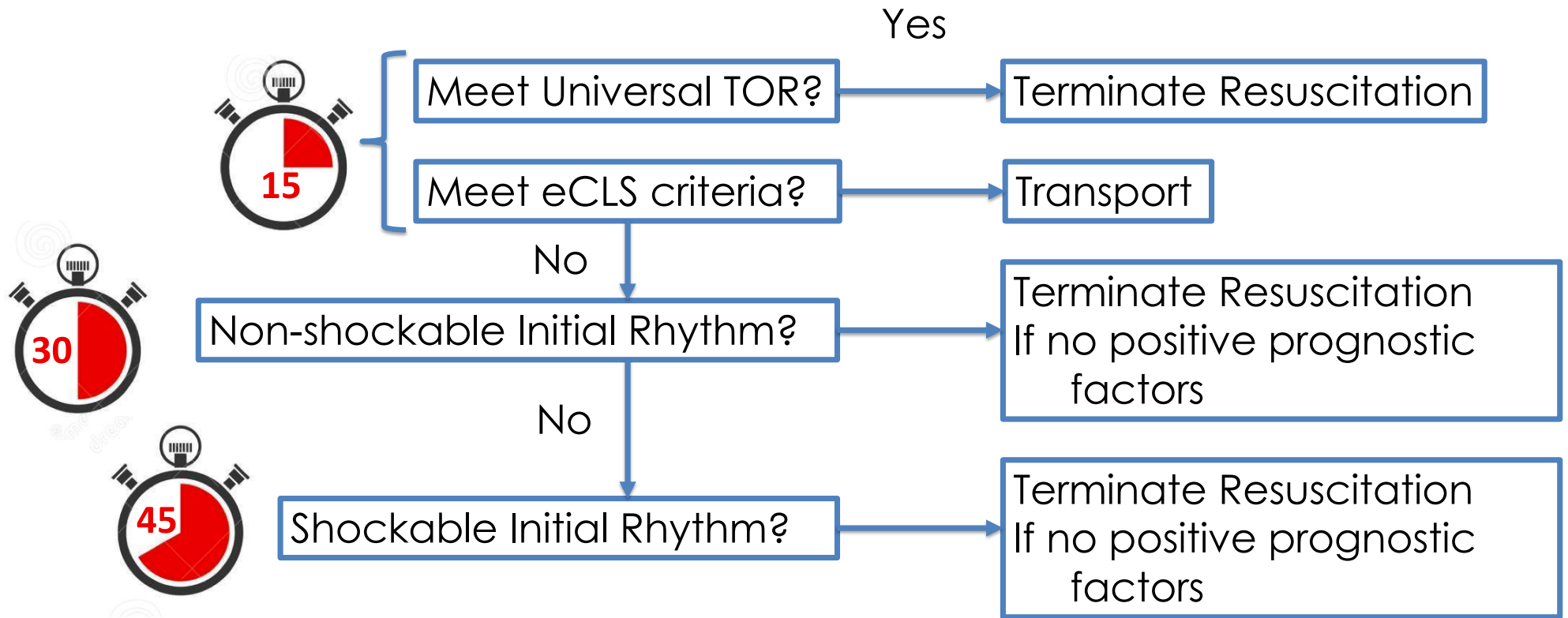
40
min





Source: The Knife and Gun Club by Eugene Richards

PROPOSED MINIMUM DURATIONS





The Role of EtCO₂ in TOR

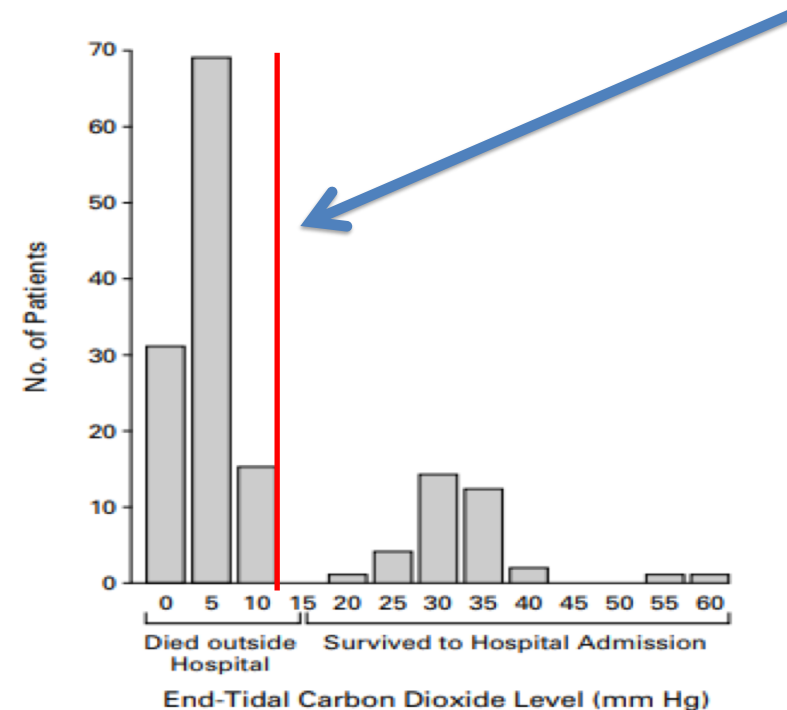
END-TIDAL CARBON DIOXIDE AND OUTCOME OF OUT-OF-HOSPITAL CARDIAC ARREST

ROBERT L. LEVINE, M.D., MARVIN A. WAYNE, M.D., AND CHARLES C. MILLER, PH.D.

- 150 consecutive PEA arrest patients
- At 20 minutes, if EtCO₂ <10 mmHg, no survival
 - 100% positive predictive value
 - 100% negative predictive value
 - 100% specificity

Conclusion: An end-tidal carbon dioxide level of 10 mm Hg or less measured 20 minutes after the initiation of advanced cardiac life support accurately predicts death in patients with cardiac arrest associated with electrical activity but no pulse. Cardiopulmonary resuscitation may reasonably be terminated in such patients. (N Engl J Med 1997;337:301-6.)

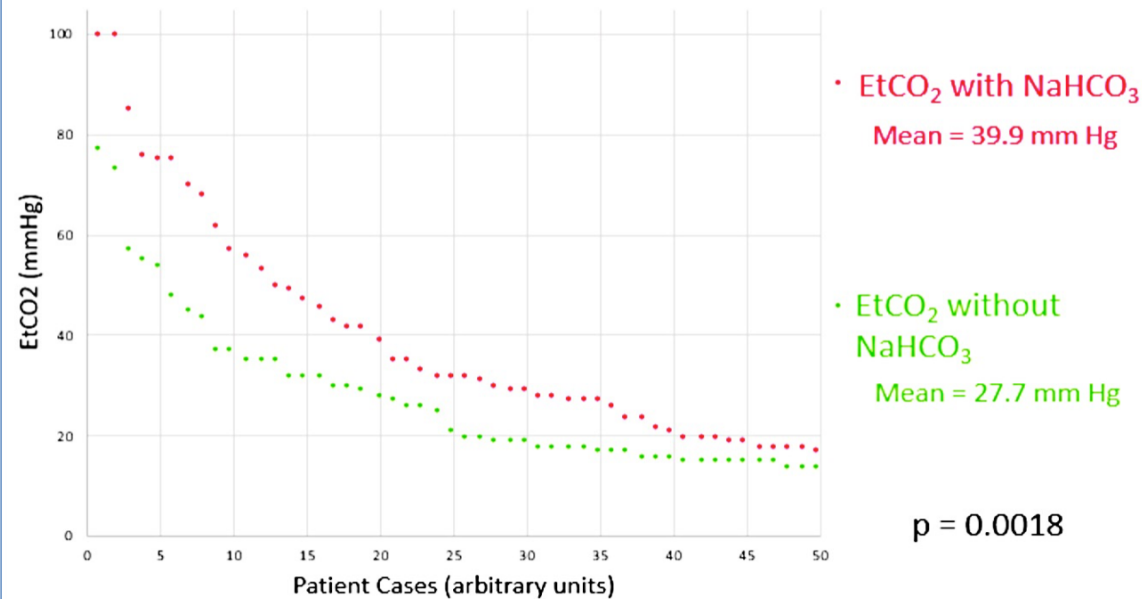
©1997, Massachusetts Medical Society.



Levine RL, Wayne MA, Miller CC. End-tidal carbon dioxide and outcome of out-of-hospital cardiac arrest. N Engl J Med. 1997 Jul 31;337(5):301-6.

Effect of Sodium Bicarbonate on EtCO₂

Figure 2. EtCO₂ in TOR cases with and without NaHCO₃ (2013-2016)
(50 highest EtCO₂ readings)



- Retrospective observational study
 - 93 received NaHCO₃ (EtCO₂ $\bar{x}$ =26)
 - 89 did not received NaHCO₃ (EtCO₂ $\bar{x}$ =19)
 - EtCO₂ significant difference (p=0.026)

Morshedi B, Joseph A, Fowler R. Effect of Sodium Bicarbonate Administration During Out-of-Hospital Cardiac Arrests on End-Tidal CO₂ Readings in Considering Termination of Resuscitation (abstract). Prehospital Emergency Care. 2018 Jan 2;22(1):101–50.



Where Do We Go Next?

- TOR criteria?
- Use of EtCO₂ in TOR?
- Is there an EtCO₂ threshold?
- Was NaHCO₃ used?