Science Behind the 2015 Cardiopulmonary Resuscitation Guidelines

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Objectives

- Discuss the science behind the latest AHA Guidelines in Resuscitation, including
  - CPR technique and sequencing
  - Method of ventilation during resuscitation
  - Whether ACLS drugs are of value during resuscitation
  - Prehospital use of therapeutic hypothermia

Public Health Burden of Cardiac Arrest

Heart Disease and Stroke Statistics 2015 Update
A Report from the American Heart Association
Mozzaffarian D et al. Circulation. 2015; 131:e29-e322

	# Cardiac Arrests/yr	Survival rate	Mortality rate	# deaths/yr in USA
Out-of-hospital	326,200	5.6%	94.4%	308,259
In-hospital	209,000	25.5%	74.5%	155,705
Total				463,964

Equivalent loss of life

- 4 Boeing 747 aircraft crashing & killing everyone on board each day of the year!

Basic Life Support Sequence

Step	Lay Rescuer Not Trained	Lay Rescuer Trained
1	Ensure scene safety.	Ensure scene safety.
2	Check for response.	Check for response.
3	Shout for nearby help. Phone or ask someone to phone 9-1-1 (the phone or caller with the phone remains at the victim's side, with the phone on speaker).	Shout for nearby help and activate the emergency response system (9-1-1, emergency response). If someone responds, ensure that the phone is at the side of the victim if at all possible.
4	Follow the dispatcher's instructions.	Check for no breathing or only gasping; if none, begin CPR with compressions.
5	Look for no breathing or only gasping, at the direction of the dispatcher.	Answer the dispatcher's questions, and follow the dispatcher's instructions.
6	Follow the dispatcher's instructions.	Send the second person to retrieve an AED, if one is available.

Basic Life Support Sequence

Dispatch CPR instructions

Step	Lay Rescuer Not Trained	Lay Rescuer Trained
1	Ensure scene safety.	Ensure scene safety.
2	Check for response.	Check for response.
3	Shout for nearby help. Phone or ask someone to phone 9-1-1 (the phone or caller with the phone remains at the victim's side, with the phone on speaker).	Shout for nearby help and activate the emergency response system (9-1-1, emergency response). If someone responds, ensure that the phone is at the side of the victim if at all possible.
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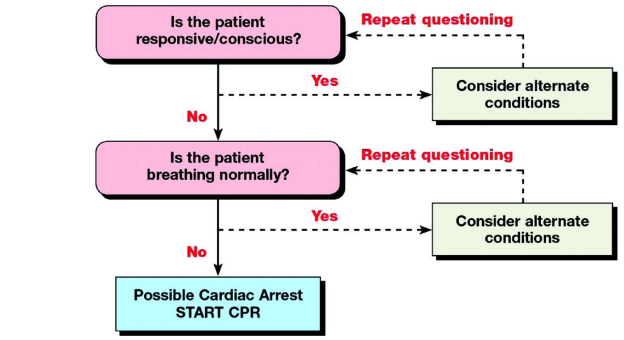
Dispatch CPR: Arrest Identification

Lerner EB et al. Circulation. 2012;125:648-655



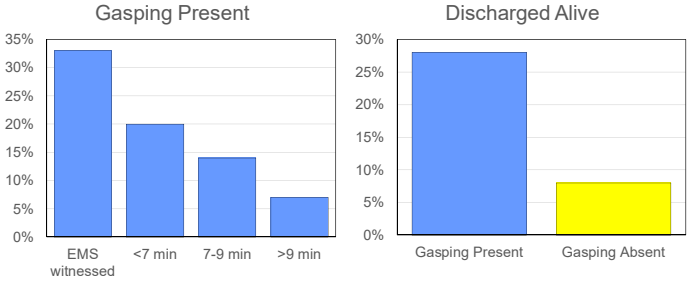
American Heart Association.

Agonal ("gasping") respirations

Gasping in cardiac arrest

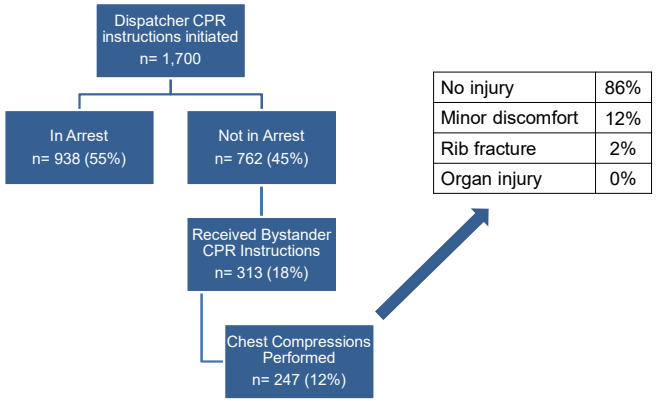
Bobrow et al. Circulation 2008; 118:2550-4

- 1,218 adult out-of-hospital cardiac arrest patients in Phoenix, AZ



Dispatcher-Assisted CPR Risks for Patients Not in Cardiac Arrest (King County, WA)

White L et al. Circulation 2010; 121:91-7



No injury	86%
Minor discomfort	12%
Rib fracture	2%
Organ injury	0%

Basic Life Support Sequence

Dispatch "hands-only" CPR

Step	Lay Rescuer Not Trained	Lay Rescuer Trained
1	Ensure scene safety.	Ensure scene safety.
2	Check for response.	Check for response.
3	Shout for nearby help. Phone or ask someone to phone 9-1-1 (the phone or caller with the phone remains at the victim's side, with the phone on speaker).	Shout for nearby help and activate the emergency response system (9-1-1, emergency response). If someone responds, ensure that the phone is at the side of the victim if at all possible.
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Attitudes of AHA BLS instructors regarding MTM ventilation

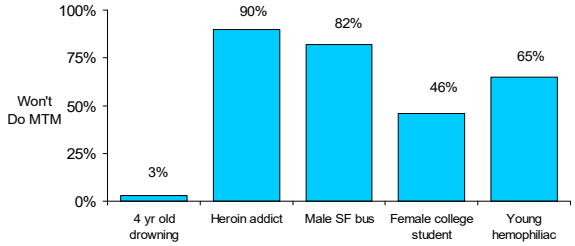
Ornato JP et al. Ann Emerg Med 1989; 19:151-6

5,823 AHA BLS Instructors

87% healthcare, 11% lay, 2% public safety workers

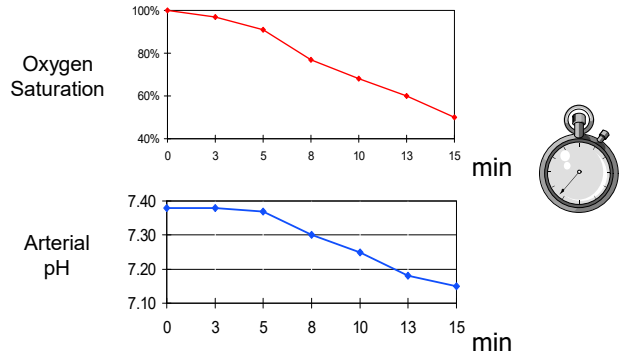
40% hesitated to perform MTM in last year

40% witnessed a colleague hesitating



Chest Compression without Ventilation

Chandra et al. Circulation 1994; 90:3070-5

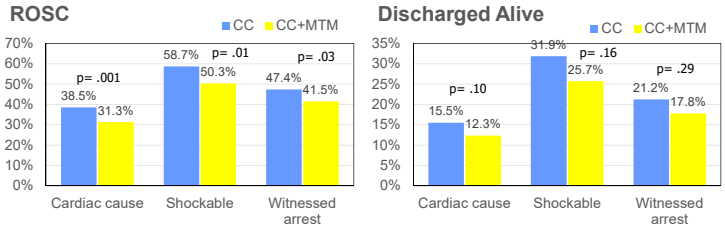


Dispatcher-Assisted Resuscitation Trial (DART)

Rea TD et al. N Engl J Med 2010; 363:423-33

Wander PL, Fahrenbruch CE, Rea TD. Resuscitation 2014; 85;1594-8

- 1,941 adult out-of-hospital cardiac arrests in King County, WA
- Randomized to dispatch instructions for CC+MTM vs CC alone ("hands-only CPR")

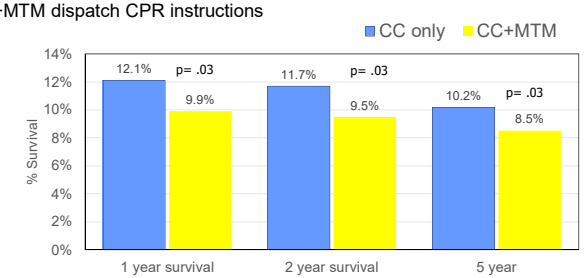


Dispatch CPR: CC vs. CC+MTM

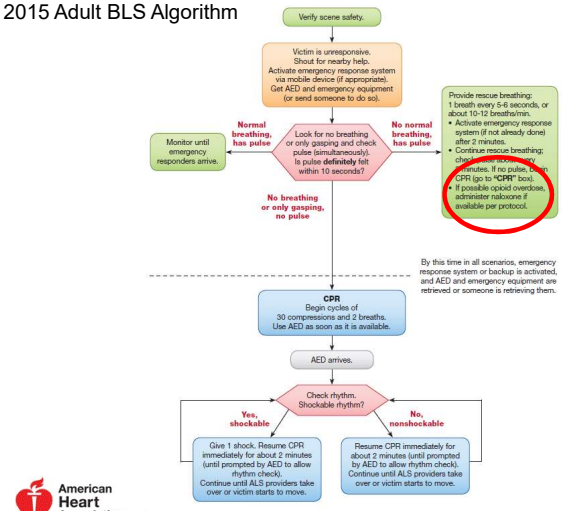
Dumas et al. Circulation. 2013;127:435-441

- 2,496 adult out-of-hospital cardiac arrest patients
- Combined 2 randomized trials (Seattle, Sweden)
- 911 callers randomized to CC only vs. CC+MTM dispatch CPR instructions

AHA: Dispatchers should provide CC-only CPR instructions to laypersons



2015 Adult BLS Algorithm



American Heart Association.

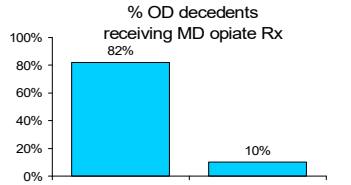
Kleinman ME et al. Circulation. 2015;132:S414-S434

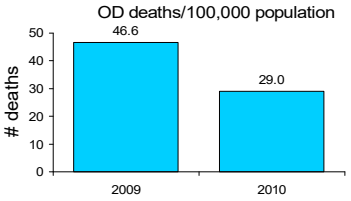
Community-based overdose prevention in rural North Carolina: Project Lazarus

Albert S et al. Pain Med 2011; 12:S77-S85

- Community activation and coalition building
- Monitoring and surveillance data
- Education directed at prevention of overdoses by reducing MD opiate prescriptions
- Use of rescue medication for reversing overdoses by community members
- Evaluating project components

2014 – FDA approved naloxone autoinjector (EVZIO®) use by lay rescuers & healthcare providers





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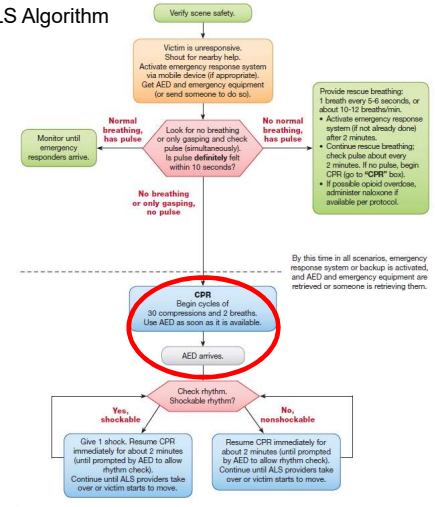


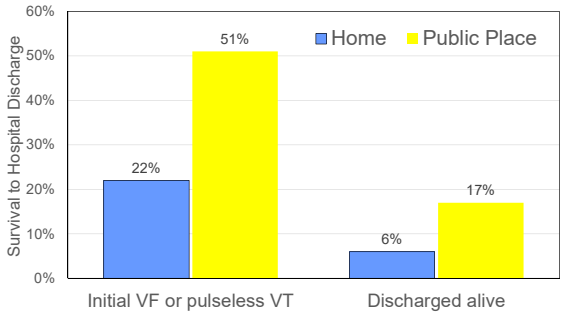
American Heart Association.

Kleinman ME et al. Circulation. 2015;132:S414-S434

Cardiac arrests in public vs. non-public places

Weisfeldt ML et al. N Engl J Med 2011; 364:313-21

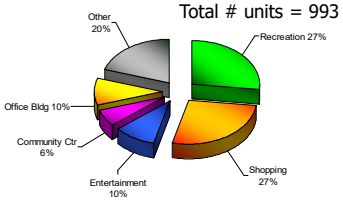
- 12,930 out-of-hospital cardiac arrests in Resuscitation Outcomes Consortium (ROC) database

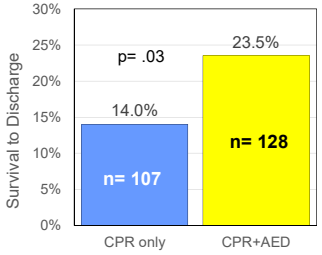


Public Access Defibrillation (PAD) trial

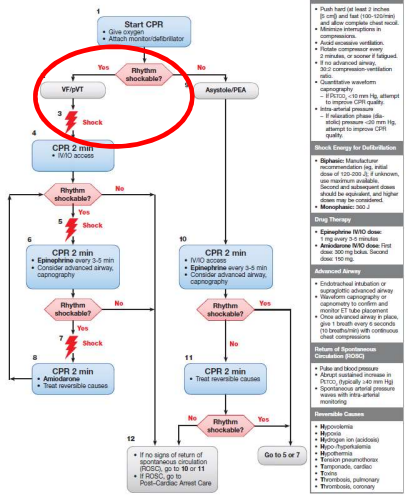
Hallstrom A, Ornato JP, et al. NEJM 2004 Aug 12;351(7):637-46

- Prospective, randomized, controlled clinical trial
- Trained 23,000 lay persons in 23 cities
- Deployed 1,500 AEDs
- Compared two lay volunteer-based cardiac arrest response systems





2015 Adult ALS Algorithm

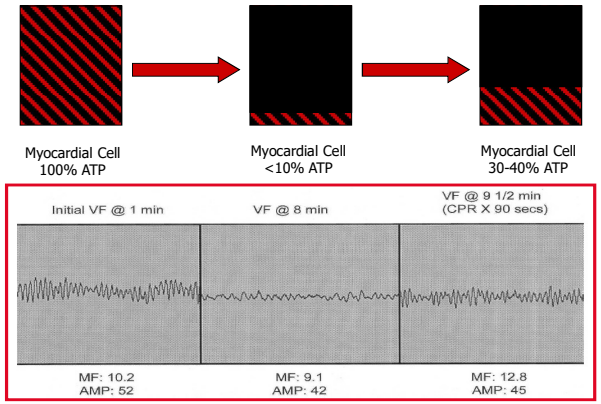


American Heart Association.

Link MS et al. Circulation. 2015;132:S444-S464

Theoretical importance of myocardial ATP

How long do you need to "prime the pump"

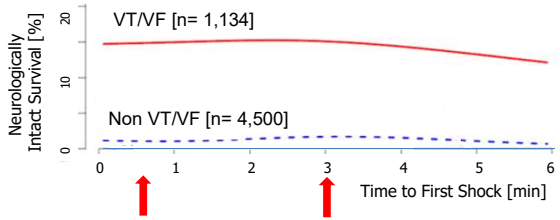


ROC- PRIMED Trial

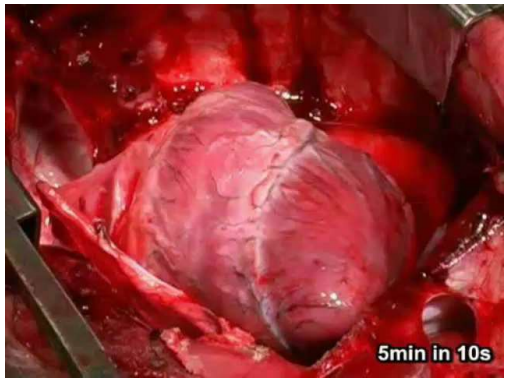
Stiell et al. NEJM 2011; 365:787-97

- Resuscitation Outcomes Consortium (ROC) prospective, prehospital, randomized clinical trial
- Analyze/shock VF early (30s CPR) vs. later (3 min CPR)

AHA: brief CPR until DF/AED ready to use



RV dilates rapidly after pauses in chest compression



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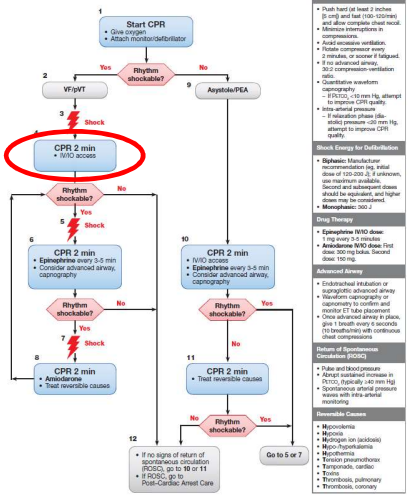


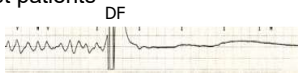
American Heart Association.

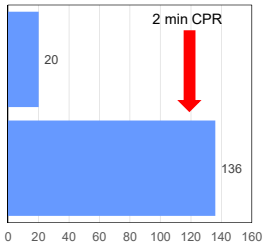
Link MS et al. Circulation. 2015;132:S444-S464

Duration of pulselessness after DF shocks

Pierce AE et al. Resuscitation 2015; 89:162-8

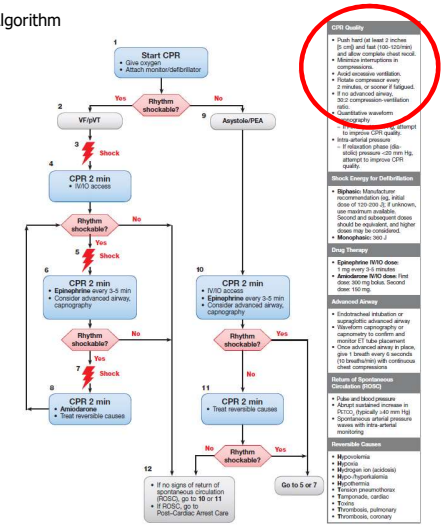
- Resuscitation Outcomes Consortium (ROC) Epistry data
- 176 out-of-hospital cardiac arrest patients
- 376 DF attempts
  - Asystole initial post-DF rhythm in 55%





AHA: Resume CPR x 2 min after DF before checking rhythm/pulse

2015 Adult ALS Algorithm



American Heart Association

Link MS et al. Circulation. 2015;132:S444-S464

CPR technique

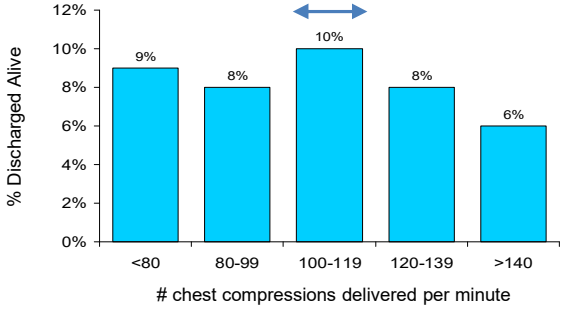
- Rate
- Downstroke force & depth
- Upstroke relaxation
- Chest compression fraction (CCF)
- Pauses
- Compression:ventilation sequence

CPR chest compression rate

Idris, et al. Critical Care Med 2015;43(4):840-848

- 10,371 out-of-hospital arrests
- Resuscitation Outcomes Consortium

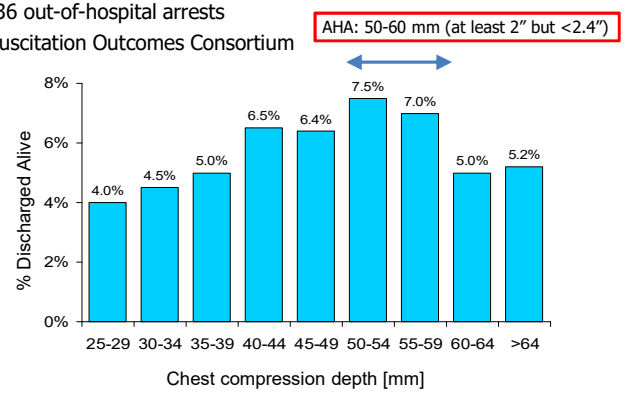
AHA: 100-120 compressions/min



CPR chest compression depth

Stiell IG et al. Circulation 2014; 130:1962-70

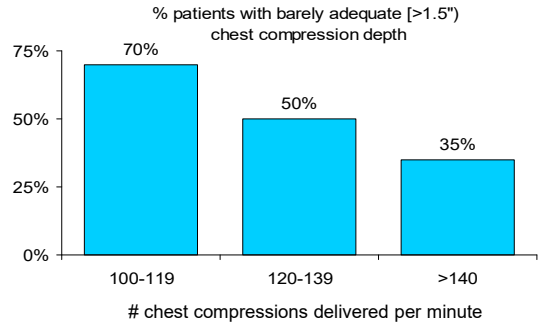
- 9,136 out-of-hospital arrests
- Resuscitation Outcomes Consortium



Inverse relationship between chest compression rate and compression depth

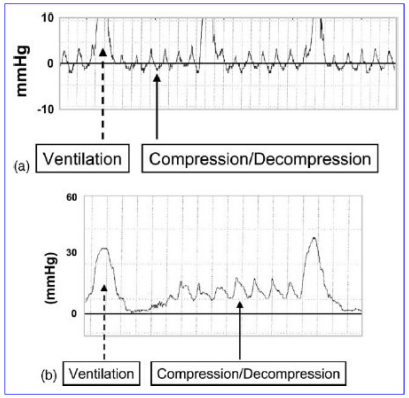
Idris, et al. Critical Care Med 2015;43(4):840-848

- 10,371 out-of-hospital arrests
- Resuscitation Outcomes Consortium



Incomplete chest wall decompression during CPR by EMS personnel

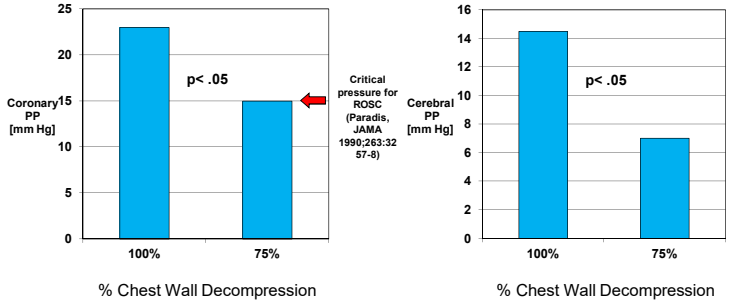
Aufderheide et al. Resuscitation 64 (2005) 353–362



Effect of incomplete chest wall decompression on coronary and cerebral perfusion pressures during CPR in swine

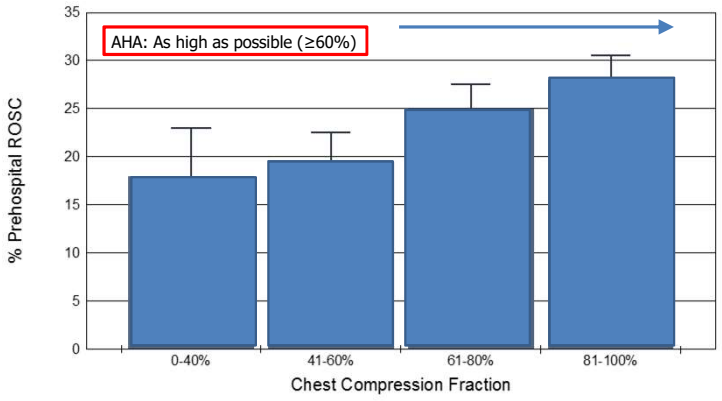
Yannopoulos D et al. Resuscitation 2005;64:363-72

- n=9 instrumented swine
- 6 minutes untreated VF → standard CPR* x 3 min → CPR with 75% recoil (residual 1.2 cm sternal compression @ end decompression) x 1 min → standard CPR* x 1 min → defib x 3 → ACLS

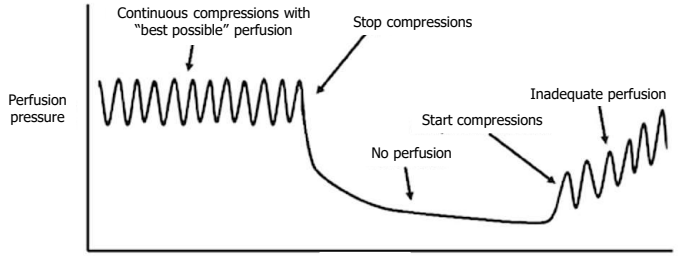


Chest compression fraction vs. ROSC

Vaillancourt et al. Resuscitation 2011; 82:1501-7



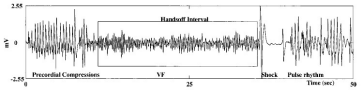
Effect of stopping chest compressions on brain & heart perfusion pressure

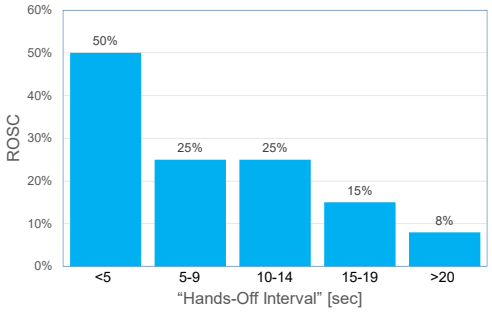


"Hands-Off" Interval vs. DF Success

Eftestol T et al. Circulation 2002; 105:2270-3

- 156 OOH cardiac arrest patients
- 868 DF attempts on coarse VF

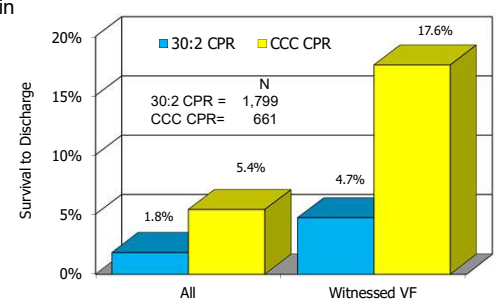




Continuous chest compression

Bobrow et al. JAMA 2008; 299:1158-65

- 62 EMS agencies in Arizona
- 75% of state population
- 200 CCs first
- Rhythm check
- Single DF
- 200 CCs post-DF
- Early epinephrine
- Delayed intubation



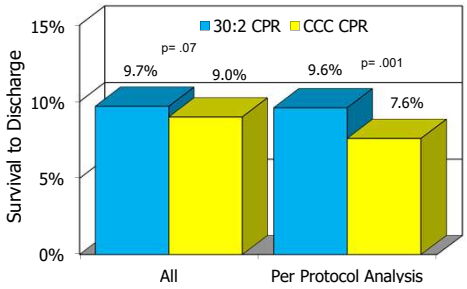
- Possible "Hawthorne effect"? *Peberdy MA, Ornato JP: JAMA editorial 2008; 299:1188-90*

Continuous chest compression (CCC) vs. 30:2 CPR Trial

Nichol et al. N Engl J Med 2015; 373

- Resuscitation Outcomes Consortium (ROC) randomized, out-of-hospital clinical trial
- 23,711 patients
- 350 EMS agencies
- Chest compression fraction
  - CCC= 90%
  - 30:2= 82%

AHA: Compression:Ventilation= 30:2



Hemodynamic effects of ventilation

	Spontaneous ventilation	Positive pressure ventilation
Intrathoracic pressure	↓	↑
Venous return	↑	↓
Cardiac output	↑	↓

Carr DT, Essex HE. Am Heart J 1946; 31:53-73
Cournand A, et al. Am J Physiol 1948; 152:162-74
Morgan BC et al. Anesthesiology 1969; 30:297-305
Prewitt RM, Wood LDH. Am J Physiol 1979; 236:534-44
Marini JJ et al. J Appl Physiol 1981; 51:1367-74

Ventilation rate during out-of-hospital CPR

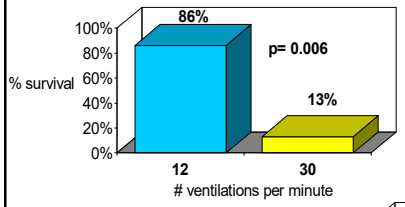
Aufderheide et al. Circulation 2004; 109:1960-5

- 13 out-of-hospital cardiac arrest patients
- Professional Milwaukee Fire/EMS rescuers
- Ventilation rate measured during CPR

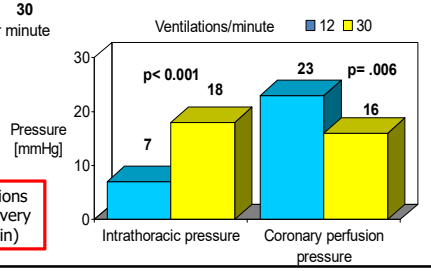
Average ventilation rate = 30 ± 3 per minute (range 15-49)

Hyperventilation during CPR

Aufderheide et al. Circulation 2004; 109:1960-5

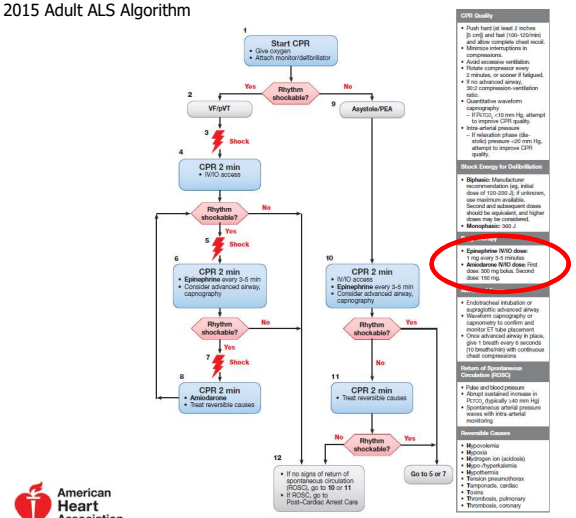


- 27 domestic pigs in cardiac arrest
- 100% oxygen ventilation
- Ventilation rate vs. survival



AHA: 30:2 compressions:ventilations
BVM: 1 breath over 1 sec every 10 sec (10 breaths/min)

2015 Adult ALS Algorithm



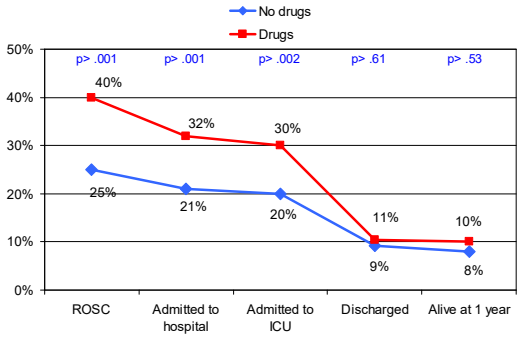
American Heart Association.

Link MS et al. Circulation. 2015;132:S444-S464

ACLS meds vs. no ACLS drugs in Oslo

Olasveengen TM et al. JAMA 2009; 301:2222-9

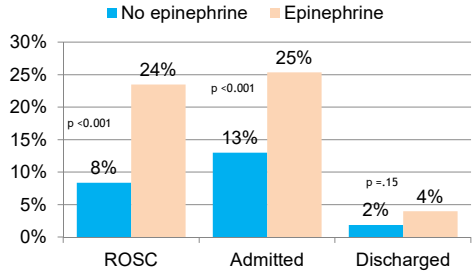
- 851 OOH-CA cases
- Randomized to ACLS with vs. without drugs
- EMS response time interval= 10 min
- Initial VF= 33%
- Byst witn= 65%
- Byst CPR= 63%
- MD on unit= 37%



Prehospital randomized trial of no epi vs. epi

Jacobs I et al. Resuscitation 2011;82(9):1138-43

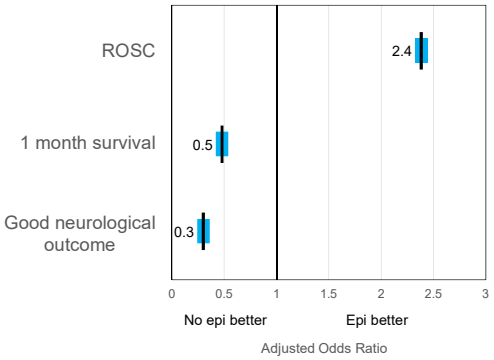
- 534 prehospital cardiac arrest pts
- Randomized to no epi vs. epi
- Perth, Australia



Prehospital epinephrine use & survival in Japan

Hagihara A et al. JAMA 2012; 307:1161-8

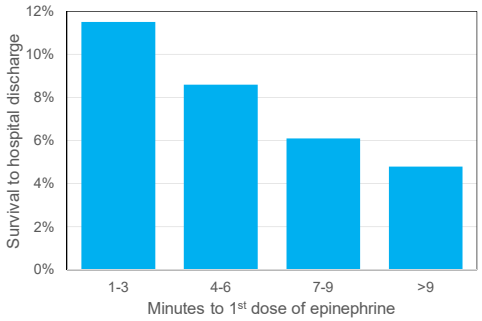
- 417,188 OOH-CA cases
- EMS skills:
  - CPR
  - AED
  - IV
  - Give epi 1 mg q4min x 3
- Epinephrine vs. no epinephrine by EMS
- 3.7% of patients received epinephrine



Time to administration of epinephrine after in-hospital arrest

Donnino et al. Brit Med J 2014; 348:

- 25,095 adults with in-hospital cardiac arrest
- 570 US hospitals in AHA GWTG-R database
- Median time to 1st epinephrine dose was 3 min

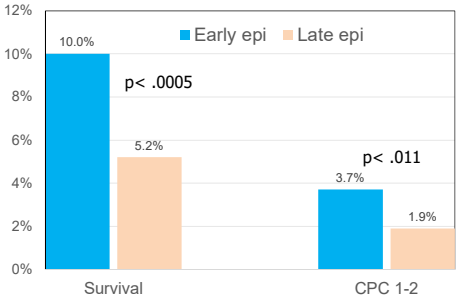


Time to administration of epinephrine after out-of-hospital arrest in Japan

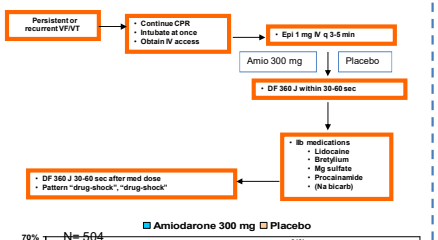
Nakahara et al. Acad Emerg Med 2012; 19:782-92

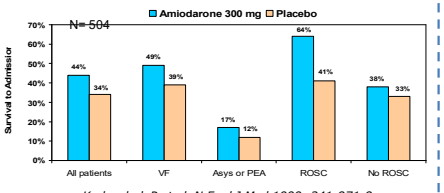
- 49,165 adults in the Japan national registry of out-of-hospital cardiac arrest
- Early epi= <10 min from EMS start of CPR to 1st epinephrine dose

AHA: Epinephrine 1mg every 3-5 min



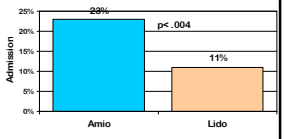
Amiodarone vs. lidocaine OOH-CA





Kudenchuk P et al. N Engl J Med 1999; 341:871-8

- N= 348
- Amio vs. Lido
- Toronto EMS
- 911-1st DF = 12±7 min
- 911-drug = 25±8 min

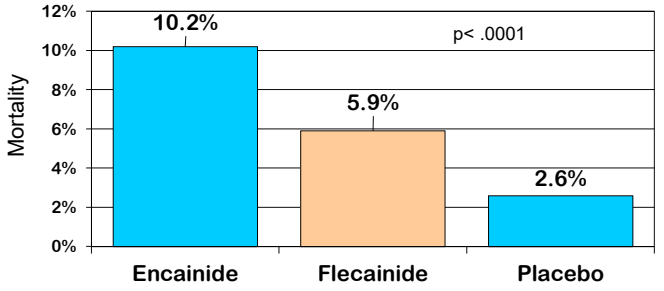


Dorian P et al. N Engl J Med. 2002 Mar 21;346(12):884-90

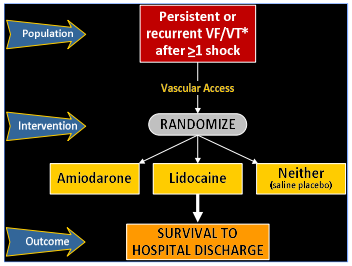
Cardiac Arrhythmia Suppression Trial (CAST)

Echt DS et al. N Engl J Med 1991;324(12):781-8

- 1,498 post-MI patients with ventricular arrhythmias
- Randomized to one of 2 anti-arrhythmic drugs vs. placebo

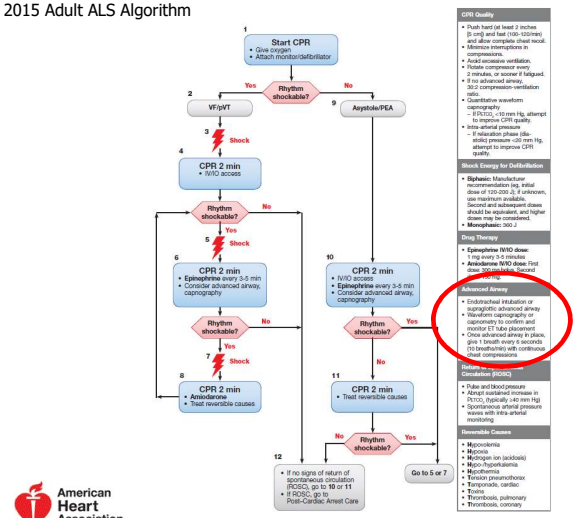


ROC Amiodarone vs. Lidocaine vs. Placebo Study *(ALPS)*



SYRINGE #	AMIODARONE KIT	LIDOCAINE KIT	PLACEBO KIT
1	Amiodarone 150 mg (3 cc)	Lidocaine 60 mg (3 cc)	Placebo (3 cc)
2	Amiodarone 150 mg (3 cc)	Lidocaine 60 mg (3 cc)	Placebo (3 cc)
3	Amiodarone 150 mg (3 cc)	Lidocaine 60 mg (3 cc)	Placebo (3 cc)

2015 Adult ALS Algorithm



American Heart Association.

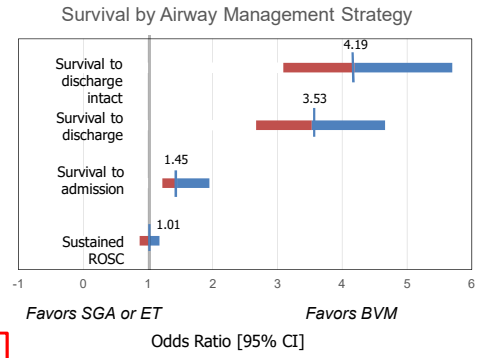
Link MS et al. Circulation. 2015;132:S444-S464

Prehospital airway management in cardiac arrest - CARES

McMullan J et al. Resuscitation 2014; 85:617-22

- 10,691 out-of-hospital cardiac arrests in the CARES registry
- Frequency of use
  - ET= 5,591 (52%)
  - SGA= 3,110 (30%)
  - BVM= 1,929 (18%)
- Survival to DC intact
  - ET= 5.4%
  - SGA= 6.7%
  - BVM= 18.6%
- BVM pts more likely to be:
  - VF or VT initially
  - EMS witnessed
  - Bystander AED
- Propensity matched, adjusted for confounders

AHA: Either a BVM or advanced airway



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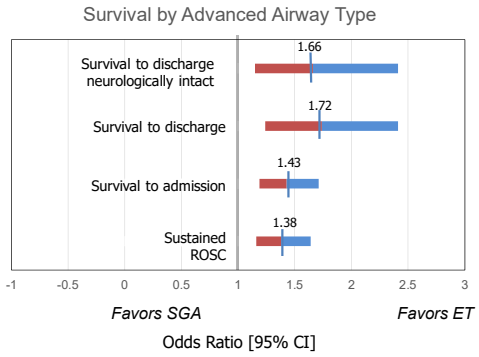
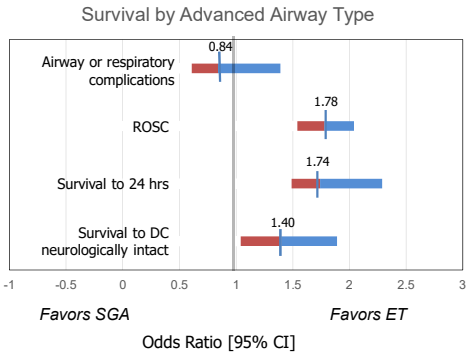


ET intubation vs. supraglottic airway in cardiac arrest - ROC

Wang HE et al. Resuscitation 2012; 83:1061-6

- 10,455 adult out-of-hospital cardiac arrest in Resuscitation Outcomes Consortium (ROC) registry
- Not a randomized trial
- Frequency of use
  - ET= 8,487 (81%)
  - SGA= 1,968 (19%)
- Survival to DC intact
  - ET= 4.7%
  - SGA= 3.9%

AHA: Either an ET or SGA



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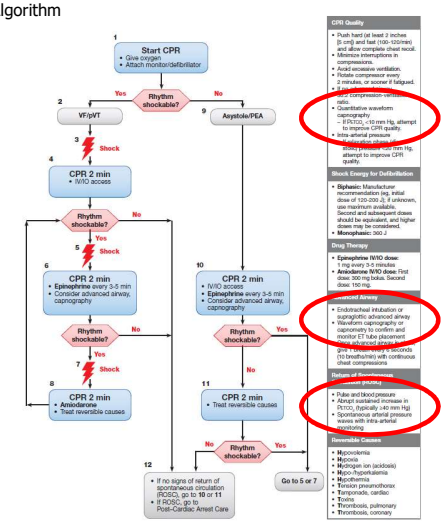
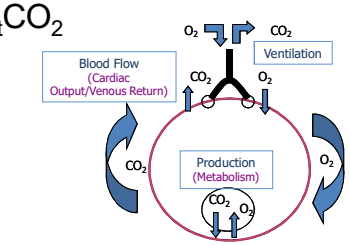


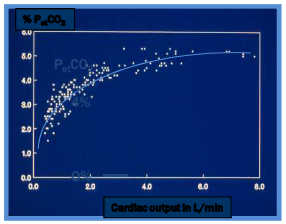
American Heart Association

Link MS et al. Circulation. 2015;132:S444-S464

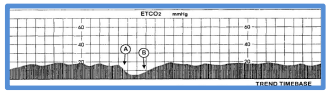
Effect of blood flow on $P_{et}CO_2$

- Cardiac arrest/CPR
- Shock
- Massive PE

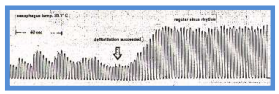




Ornato JP, Garnett AR, Glauser FL. Ann Emerg Med 1990; 19:1104-6



Ward KR, Yealy DM. Acad Emerg Med 1998; 5:637-46



Garnett AR, Ornato JP, Gonzalez ER et al. JAMA 1987; 257:512-4

Temperature Management After Cardiac Arrest: An AHA/ILCOR Advisory Statement

Donnino MW et. al. Resuscitation; Oct 5, 2015

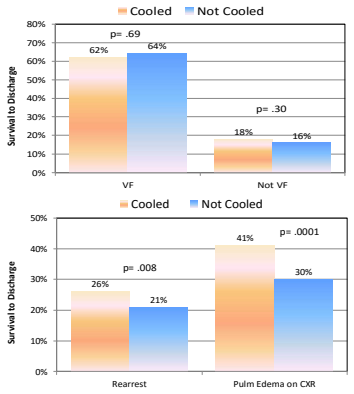
"The Task Force recommends against routine use of prehospital cooling with rapid infusion of large volumes of cold intravenous fluid immediately after ROSC … Other cooling strategies and cooling during cardiopulmonary resuscitation in the prehospital setting have not been studied adequately, and further research in this area is needed."

Randomized Trial of Prehospital Induction of Hypothermia in OOH-CA with Rapid Infusion of 4ºC Saline

Kim et. al. JAMA 2014; 311:45-52

- N= 1,359
- Median times from 911 call to ROSC = 25-30 min

Mean temp change NS vs control
- VF= -1.1 ºC
- Non-VF= -1.2 ºC



Possible reasons why starting TH in the field post-ROSC did not improve measured outcomes compared to starting TH in the ED

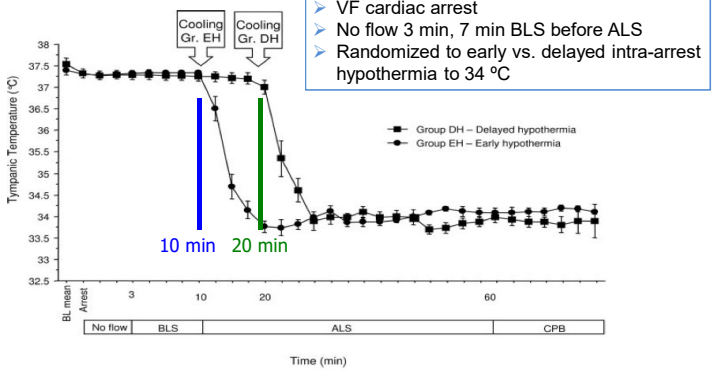
Initial temperature [ºC] in field

Study	Field Cooling	Hospital Cooling	p
Kim et. al. Circulation 2007;115:3064-3070	35.8 ± 1.0	35.5 ± 1.2	0.14
Bernard et. al. Circulation 2010; 122:737-42	35.9 ± 1.0	35.8 ± 0.8	0.63
Kim et. al. JAMA 2014; 311:45-52 (supplement eTable 1) – VF patients	36.1 [95%CI= 36.0-36.2]	36.0 [95%CI= 35.9-36.1]	0.63
Kim et. al. JAMA 2014; 311:45-52 (supplement eTable 1) – nonVF patients	36.0 [95%CI= 35.9-36.1]	35.9 [95%CI= 35.8-36.0]	0.09

Intra-arrest hypothermia

Nozari et al. Circulation, 2006; 113: 2690-96

- 17 dogs
- VF cardiac arrest
- No flow 3 min, 7 min BLS before ALS
- Randomized to early vs. delayed intra-arrest hypothermia to 34 ºC



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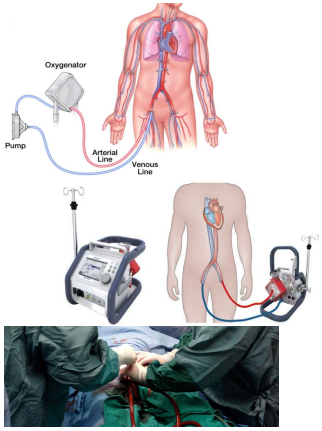
	Early Hypothermia	Delayed Hypothermia
OPC-1 (normal)	OOOO	O
OPC-2 (mildly impaired)	O	
OPC-3 (moderately impaired	O	
OPC-4 (severely impaired)	O	
OPC-5 (death)	O	OOOOOOOO

Design of the Rapid Infusion of cold Normal SalinE by paramedics during CPR (RINSE trial)

Deasy C et al. BMC Emergency Medicine. 2011;11:17

- Australian pre-hospital randomized clinical trial
- During CPR, infuse up to 2L of 4°C saline rapidly IV
- Primary outcome: survival to d/c
- Secondary outcomes: ROSC, survival to admission, temp on ED arrival, 12 month quality of life in survivors

ExtraCorporeal Membrane Oxygenation (ECMO aka "eCPR")



- Available data is from case series and observational reports
- Ideal duration of CPR <45 minutes
- Indications
  - Recurrent/refractory VF arrest
  - Massive pulmonary embolism
- Survival 20-33%

AHA: eCPR may be considered…where it can be rapidly implemented…and there is a potentially reversible cause

Summary

- Discussed the science behind the latest AHA Guidelines in Resuscitation, including
  - CPR technique and sequencing
  - Method of ventilation during resuscitation
  - Whether ACLS drugs are of value during resuscitation
  - Prehospital use of therapeutic hypothermia