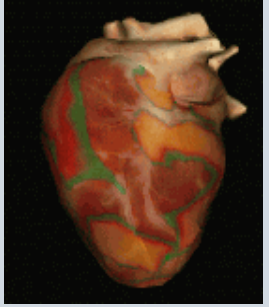
Lessons Learned From Cardiac Resuscitation Research: What Matters at the Bedside?

JILL LEY, MS, RN, CNS, FAAN
CLINICAL NURSE SPECIALIST SURGICAL SERVICES
CALIFORNIA PACIFIC MEDICAL CENTER
CLINICAL PROFESSOR, UCSF

Learning Outcomes

- Identify evidence based methods of optimizing perfusion and return of spontaneous circulation during in-hospital cardiac arrest
- Discuss the role of communication and teamwork in improving the clinical response to in-hospital cardiac arrest in patients undergoing cardiac intervention or cardiac surgery



U.S. Cardiac Arrest Mortality

- Adult cardiac arrests annually
  - OHCA = 347,000 with survival to hosp discharge 10.6%
  - IHCA = 209,000 with d/c survival 24.8%
- Pediatric cardiac arrests annually
  - OHCA = 7,000 with d/c survival 13.2%
  - IHCA = 2,340 with d/c survival 45%
- Post-cardiac surgery arrests annually
  - 2500-5000 with survival ranging from 40-80%
  - High potential for reversible causes and recovery

AHA 2015 Heart & Stroke Statistics

Emergency Cardiovascular Care (ECC) Scientific Review Process

- International Liaison Committee on Resuscitation (ILCOR) established in 1992 to achieve international standardization based on evidence
- Seven task forces (BLS, ACLS, PALS, etc) review questions based on new research
- PICO format – Population, Intervention, Comparator, Outcome
- 2015 CoSTR document – Consensus on Science with Treatment Recommendations

Kleinman ME, et al. Circulation 2018;137:e1-e19.

2015 CoSTR

- Notable for a limited number of recommendations
- Very few updates or changes made
- Largely continues current practices despite existing data that is often weak

"Confidence in effect estimates is so low that the panel feels a recommendation to *change current practice* is too speculative."

Kleinman ME, et al. Circulation 2018;137:e1-e19.

What Matters – Good BLS

- ACLS success depends on early recognition, good BLS, and timely defibrillation/AED use
- ACLS interventions that *interfere with* high quality CPR may ultimately decrease return of spontaneous circulation (ROSC), (e.g., advanced airway or central line)
- Post-resuscitation care *following ROSC* offers important opportunities to improve survival:
  - Coronary angiography and PCI for comatose STEMI pts
  - Targeted temperature management to 32-36^{o} C

Self-Assessment Question #1

To improve the quality of CPR you should:

1. Compress as fast as you can
2. Compress as deep as you can
3. Limit interruptions during compressions
4. All of the above

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High Quality CPR

- CPR quality affected by ***both*** **rate and interruptions**
- Compression fraction = portion of total CPR time when compressions are performed; goal > 60%
- Optimize by:
  - Increasing rate of compressions (up to 120/min)
  - Reducing interruptions (frequency and duration)
  - Upper limits for both added in 2015

American Heart Association. H I G H L I G H T S of the 2015 American Heart Association Guidelines Update for CPR and ECC. www.heart.org/cpr accessed April 27, 2018

High Quality CPR

Sequence of Interventions Remains C-A-B

DO	DON'T
Compress at rate of 100-120/min	Compress < 100 or > than 120 times/min
Compress to depth of 2 inches	Compress < 2" (5cm) or > 2.4" (6cm)
Allow full chest recoil	Lean on the chest between compressions
Minimize pauses in compressions	Interrupt compressions for > 10 seconds
Ventilate 2:30 ratio delivered over 1 sec and causing chest to rise	Provide excessive ventilation in depth or number

American Heart Association. H I G H L I G H T S of the 2015 American Heart Association Guidelines Update for CPR and ECC. www.heart.org/cpr accessed April 27, 2018

Self-Assessment Question #2

To improve the likelihood of successful defibrillation for VF/pVT in witnessed IHCA you should:

1. Defibrillate as soon as feasible once the rhythm is established
2. Optimize use of hands-free pads
3. Train non-code team members to defibrillate
4. All of the above

Self-Assessment Question #2

To improve the likelihood of successful defibrillation for VF/pVT in witnessed IHCA you should:

1. Defibrillate as soon as feasible once the rhythm is established
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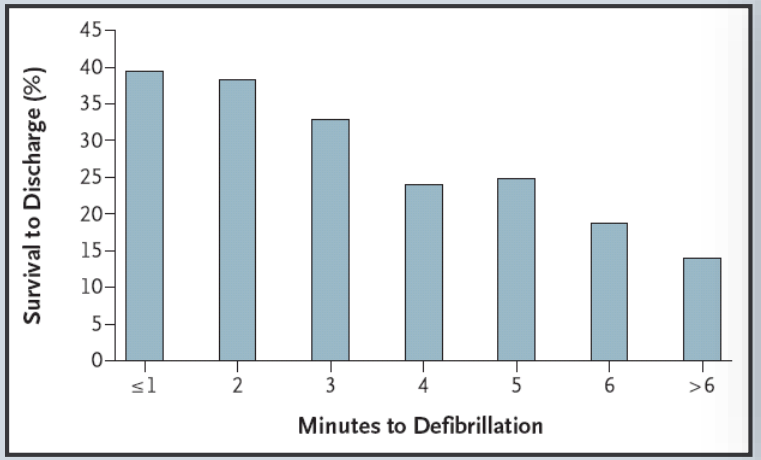
3. Train non-code team members to defibrillate
4. All of the above

What Matters – Prompt Defibrillation

- Early defibrillation is critical to survival
  - Guidelines recommend defibrillation within 2 minutes
  - Defibrillation time exceeds 2 min in 30% of US inpatients
  - Survival rates are 17% lower when defibrillation time exceeds 2 min (22.2% vs 39.3%).

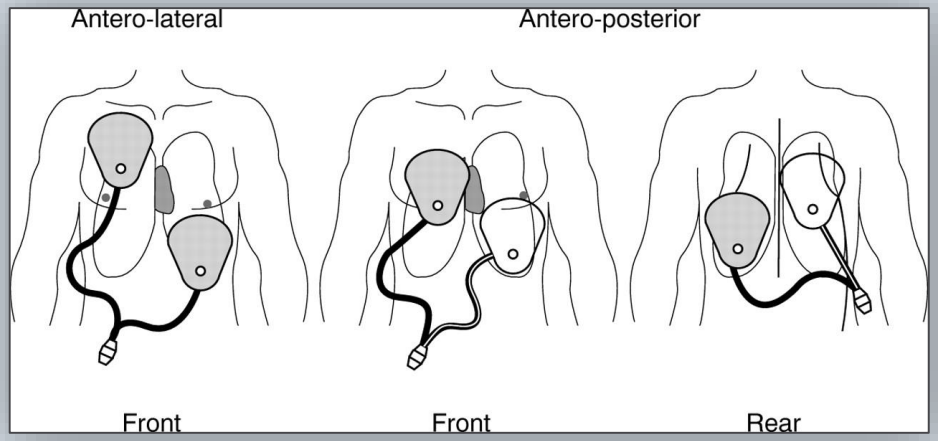


End Point	≤2 Minutes to Defibrillation (N = 4744)	>2 Minutes to Defibrillation (N = 2045)
Survival outcomes — no./total no. (%)		
Return of spontaneous circulation	3165/4744 (66.7)	1003/2045 (49.0)
Survival to 24 hr	2607/4744 (55.0)	765/2045 (37.4)
Survival to discharge	1863/4744 (39.3)	455/2045 (22.2)
Neurologic outcomes — no./total no. (%)‡		
No major disability	931/1549 (60.1)	197/381 (51.7)
Moderate disability	437/1549 (28.2)	134/381 (35.2)
Severe disability	152/1549 (9.8)	36/381 (9.4)
Coma or vegetative state	29/1549 (1.9)	14/381 (3.7)

Chan PS, et al. *NEJM* 2008;358(1):9-17

What Matters – Prompt Defibrillation

- Defibrillator connected, readily available, standardized
- Optimize use of hands free defibrillator pads
- Non-code team members can defibrillate



☑ For pulseless VT/VF, if defibrillator available

Post-op, Routine, CONTINUOUS starting Today at 0815 Until Specified
What is the nursing communication order: For pulseless VT/VF, if defibrillator available
For pulseless VT/VF, if defibrillator available, certified RN to provide 3 stacked shocks at 200J with biphasic defibrillator prior to initiating CPR. Fine VF should be considered if rhythm appears to be asystole, Sign & Hold

Single Versus Stacked Shocks

- 172 VA hospitals – GWTG Registry 2004-2012
- **P**opulation: adults with VF/pVT (n=2733)
- **I**ntervention: defibrillation
- **C**omparator: rapid sequence shocks vs deferred 2nd shock
- **O**utcome: ROSC, survival to 24hr, survival to discharge

Table 2 | Survival and neurologic outcomes by time interval between defibrillation attempts

	No (%) with second defibrillation attempt		Risk ratio (95% CI)
Outcome	**Early**	**Deferred**	**Unadjusted**
Survival outcomes			
Return of spontaneous circulation	1008/1612 (62.5)	643/1121 (57.4)	0.92 (0.86 to 0.98)
Survival to 24 hours	701/1606 (43.6)	430/1121 (38.4)	0.88 (0.80 to 0.96)
Survival to discharge	495/1605 (30.8)	277/1121 (24.7)	0.80 (0.71 to 0.91)
Neurologic outcome (survivors only)			
No major disability	306/443 (69.1)	152/236 (64.4)	0.93 (0.83 to 1.04)

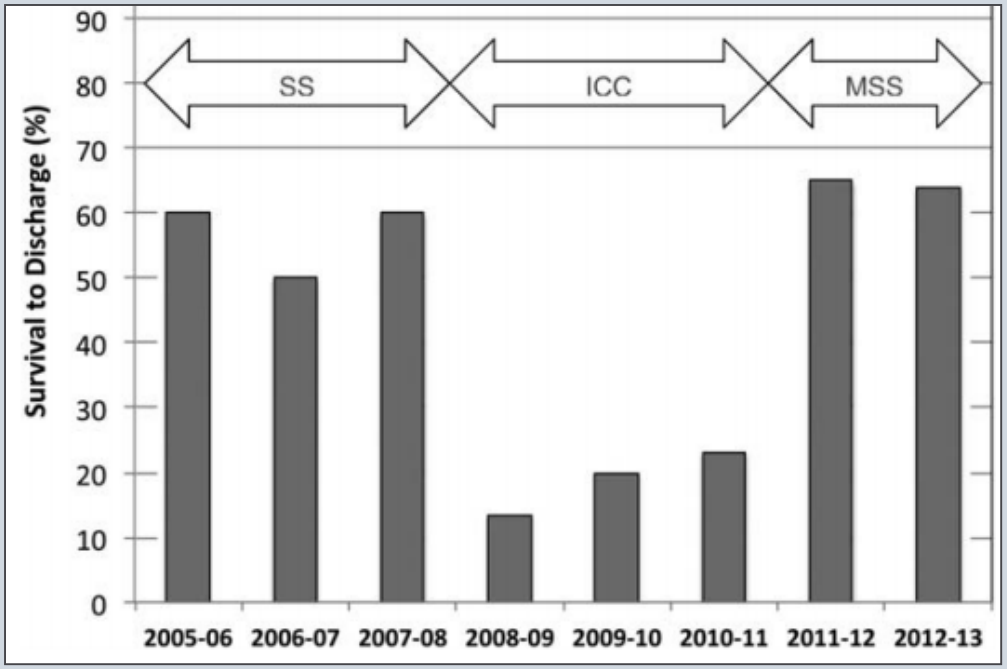
Deferred second defibrillation attempt *was NOT* associated with increased survival

Bradley SM, Liu W, Chan PS, et al. BMJ 2016; 353:i1653. doi:10.1136/bmj.i1653

Single Versus Stacked Shocks

- Single center review of 3 resuscitation protocols 2005-2013
- **P**opulation: adults with VF/pVT (n=102)
- **I**ntervention: defibrillation
- **C**omparator: single shock/CPR vs 120j-150j-200j shocks/CPR
- **O**utcome: survival to hospital discharge

"Survival was significantly lower during the initial chest compression (ICC) period as compared to stacked shocks (SS) and modified stacked shock (MSS) periods ($p<0.01$)"



Davis D, et al. J Hosp Med 2016;11(4):264-268

Shock Protocol For Witnessed VF/pVT IHCA

- Two recent studies support use of a 3-shock strategy
- Society of Thoracic Surgeons' recommend 3 sequential shocks after cardiac surgical arrest
- European guidelines recommend 3 sequential attempts "where immediate defibrillation is available" since 2010
- *This is currently not recommended in the AHA guideline*

Soar J, et al. ERC Guidelines for Resuscitation. Cardiac arrest in special circumstances. *Resuscitation* 2010; 81:1400-1433.

What Medications Matter

WHAT'S IN, WHAT'S OUT . . .

KISS . . . SIMPLIFY

Self-Assessment Question #3

Which of the following medications are recommended for shock refractory VF/pVT *in adults*:

1. Amiodarone and Epinephrine
2. Amiodarone and Lidocaine
3. Epinephrine and Lidocaine
4. None of the above

Self-Assessment Question #3

Which of the following medications are recommended for shock refractory VF/pVT *in adults*:

1. Amiodarone and Epinephrine
2. Amiodarone and Lidocaine
3. Epinephrine and Lidocaine
4. None of the above

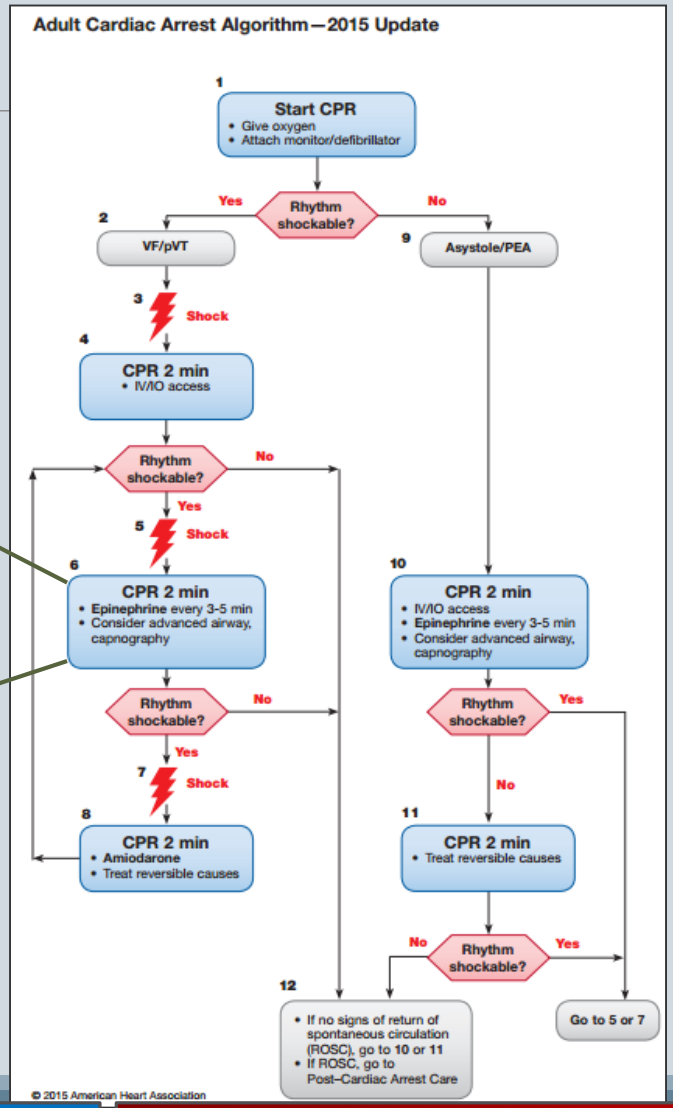
Bye Bye Vasopressin

Vasopressors for Resuscitation: Vasopressin

2015 (Updated): Vasopressin in combination with epinephrine offers no advantage as a substitute for standard-dose epinephrine in cardiac arrest.

CPR 2 min

- **Epinephrine** every 3-5 min
- Consider advanced airway, capnography



American Heart Association. H I G H L I G H T S of the 2015 American Heart Association Guidelines Update for CPR and ECC. www.heart.org/cpr accessed April 27, 2018

Lidocaine: ACLS vs PALS

Post–Cardiac Arrest Drug Therapy: Lidocaine

2015 (New): There is inadequate evidence to support the routine use of lidocaine after cardiac arrest. However, the initiation or continuation of lidocaine may be considered immediately after ROSC from cardiac arrest due to VF/pVT.

American Heart Association

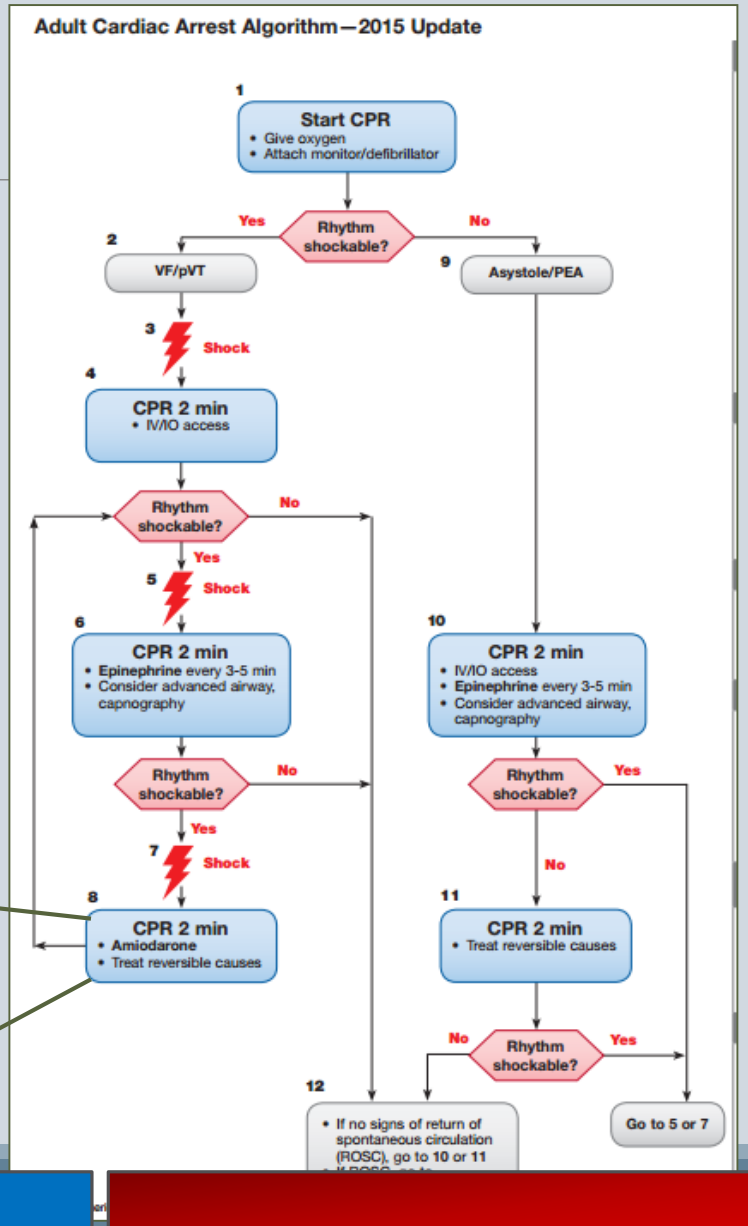
PALS

CPR 2 min
- **Amiodarone** or **lidocaine**
- Treat reversible causes

American Heart Association

ACLS

CPR 2 min
- **Amiodarone**
- Treat reversible causes



Lidocaine vs Amiodarone for Refractory VF/pVT

- The Amiodarone, Lidocaine, or Placebo Study (ALPS)
- **P**opulation: multicenter RCT for *adults* with VF/pVT OHCA (n=3026)
- **I**ntervention: medication following at least one failed shock
- **C**omparator: type of medication administered
- **O**utcome: neuro recovery and survival to hospital discharge

Table 3. Outcomes According to Trial Group in the Per-Protocol Population.*

Outcome	Amiodarone (N=974)	Lidocaine (N=993)	Placebo (N=1059)
Primary outcome: survival to discharge — no./total no. (%)†	237/970 (24.4)	233/985 (23.7)	222/1056 (21.0)
Secondary outcome: modified Rankin score ≤3 — no./total no. (%)‡	182/967 (18.8)	172/984 (17.5)	175/1055 (16.6)

No significant difference between groups

Kudenchuk PJ, Brown SP, Daya M, et al. NEJM.org, April 4, 2016 DOI: 10.1056/NEJMoa1514204.

Lidocine vs Amiodarone for Refractory VF/pVT

- Retrospective review of GWTG hospitals from 2000-2008
- **P**opulation: *patients age <18* with VF/pVT during IHCA (n=889)
- **I**ntervention: medication following at least one failed shock
- **C**omparator: type of medication administered
- **O**utcome: ROSC, survival at 24 hrs and to hospital discharge

Treatment group	ROSC	24 h survival	Survival to DC
Initial pVT/VF (N = 514)	328 (64%)	244 (47%)	148 (29%)
Amiodarone (*N* = 56)	30 (54%)	23 (41%)	14 (25%)
Lidocaine (*N* = 135)	94 (70%)	72 (53%)	43 (32%)
None (*N* = 267)	169 (64%)	60 (25%)	73 (27%)
Both (*N* = 56)	35 (63%)	26 (46%)	18 (32%)

Lidocaine associated with improved ROSC, 24-hr survival but not survival to discharge. No improvement seen w/Amiodarone

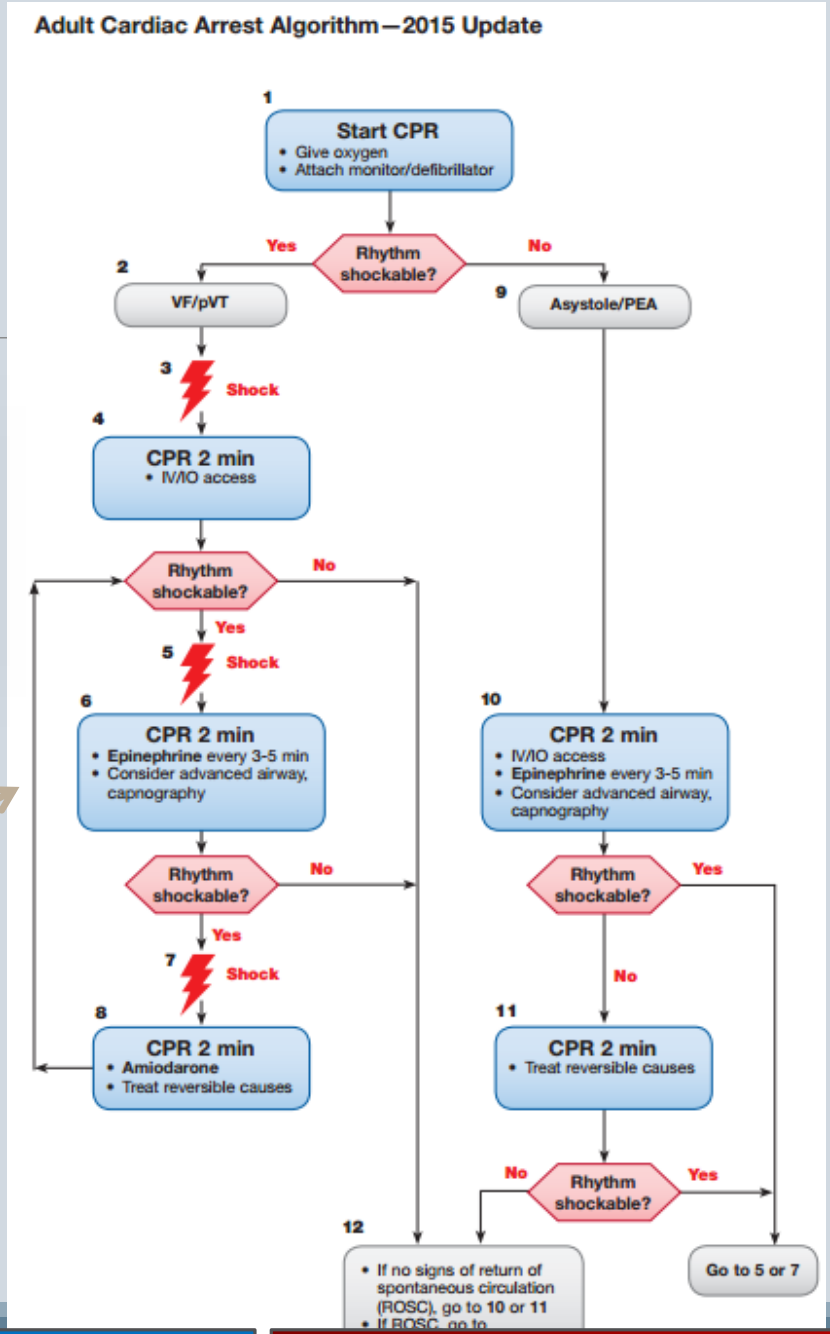
Valdes SO, et al. Resuscitation 2014;85(3):381-386

Epinephrine for Cardiac Arrest

Drug Therapy

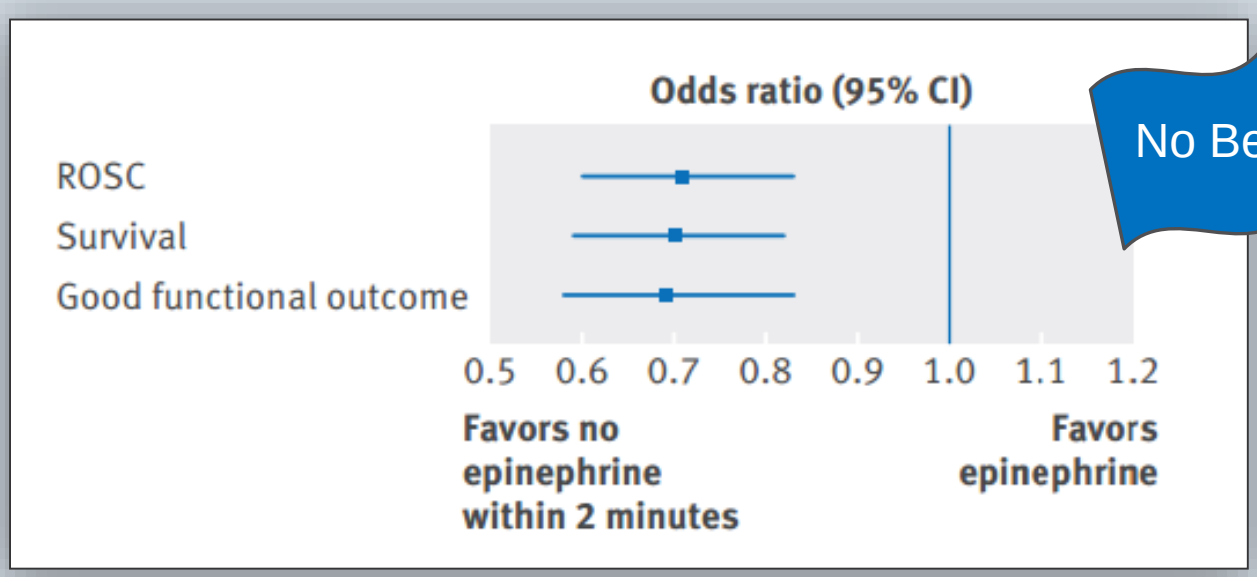
- **Epinephrine IV/IO dose:**
  1 mg every 3-5 minutes

ACLS & PALS Epinephrine recommended after *2nd failed shock*



Epinephrine for **Shockable** Rhythms

- Multicenter RCT evaluating outcomes when epi given ≤ 2 minutes of first defibrillation failure
- 2978 patients matched using propensity scores
- Epinephrine was associated with worse outcomes

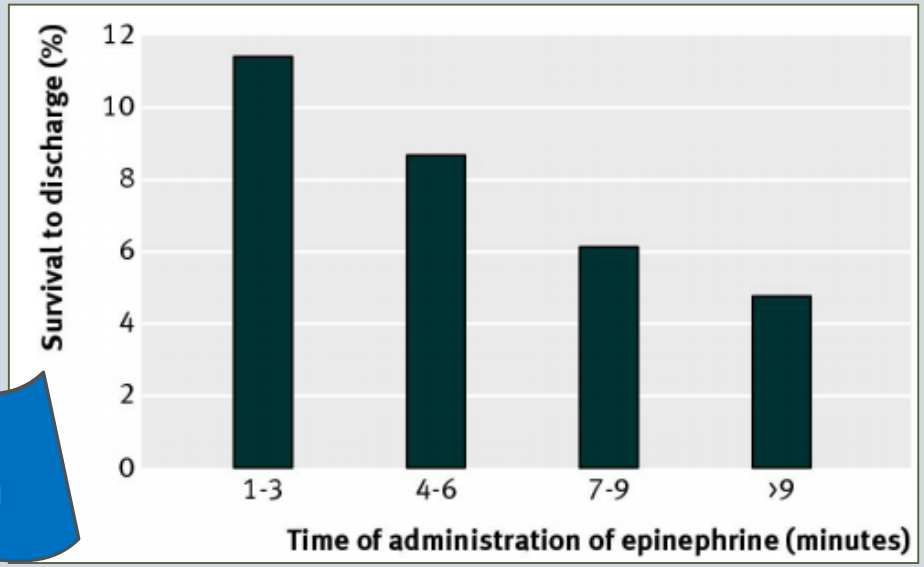


No Benefit

Andersen LW, Kurth T, Chase M, et al. BMJ 2016;353:i1577 doi:10.1136/bmj.i1577

Epinephrine for **Non-Shockable** Rhythms ADULTS

- Improved survival in 3 OHCA trials* (2 large RCT) when epinephrine was given within 9-10 minutes of CPR
- Improved neurologically intact survival in 1 IHCA trial† (n=25,095) with e*arly initiation* of epinephrine



Benefit Seen

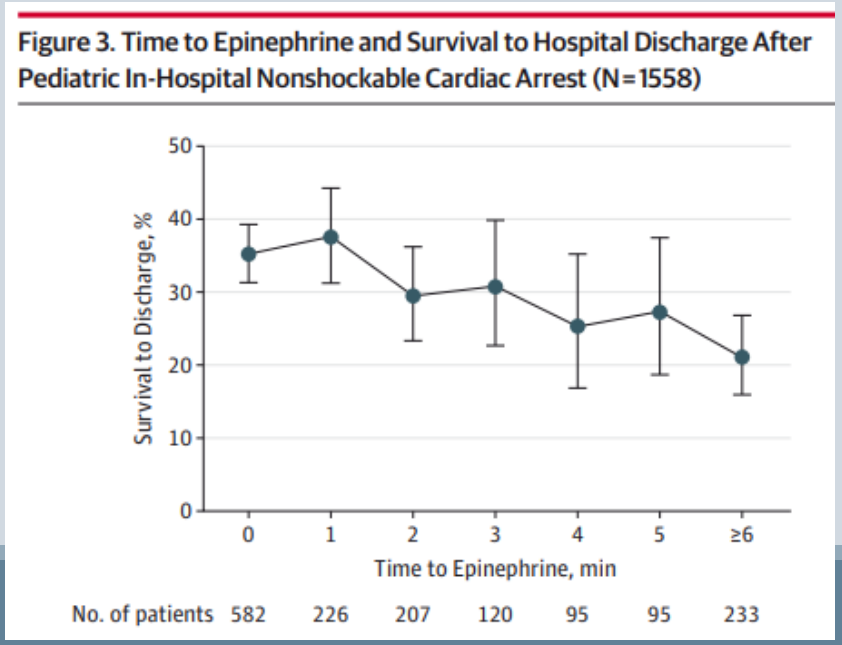
† Donnino MW, et al *BMJ.* 2014;348:g3028

* Goto Y, et al. *Crit Care.* 2013;17:R188. Nakahara S, et al. *Acad Emerg Med.* 2012;19:782-792. Koscik C, et al. *Resuscitation.* 2013;84:915-920.

Epinephrine for **Non-Shockable** Rhythms CHILDREN

- Retrospective review of GWTG hospitals from 2000-2014
- **P**opulation: *patients age <18* with non-shockable IHCA (n=1558)
- **I**ntervention: epinephrine administered following arrest
- **C**omparator: time to epi administration
- **O**utcome: ROSC, survival at 24 hrs and to hospital discharge

Delay in administration of epinephrine was associated with *decreased* chance of ROSC, survival, or favorable neurological recovery



Epinephrine Data Demonstrating Positive Outcomes

SHOCKABLE	Adult	Pediatric
ROSC	Yes/No	Yes/No
Survival to discharge	No	No
Favorable neuro recovery	No	No

NONSHOCKABLE		
Neurologically intact survival	Yes	Yes
High dose epinephrine	Harm	Harm

Airway - What Matters?

- Either bag-mask, supraglottic airway, or advanced airways are acceptable for initial management, based on rescuer skills
- Some evidence that intubation < 15 min *worsens* outcomes
- $ETCO_2$ remains a Class 1 recommendation to confirm intubation; use for prognostication *with other factors*

2015 Recommendations—Updated

Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an ETT (Class I, LOE C-LD).

American Heart Association. H I G H L I G H T S of the 2015 American Heart Association Guidelines Update for CPR and ECC. www.heart.org/cpr accessed April 27, 2018

Self-Assessment Question #4

During CPR you note the end-tidal CO_2 abruptly changed from 15 to 35 mmHg, which *most likely* indicates:

1. The person performing CPR is tired
2. The patient has expired
3. Epinephrine should be administered
4. Return of spontaneous circulation has occurred

Self-Assessment Question #4

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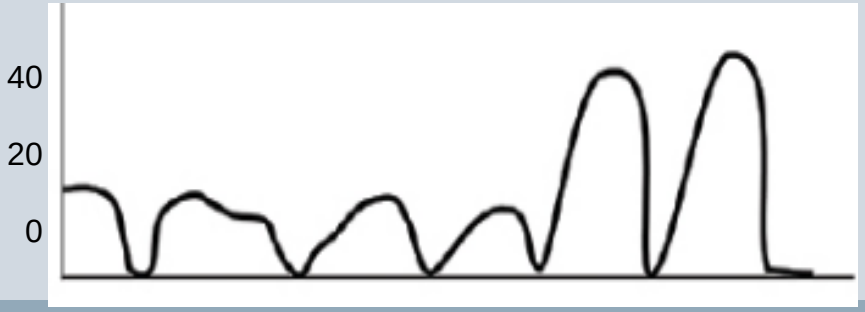
4. Return of spontaneous circulation has occurred

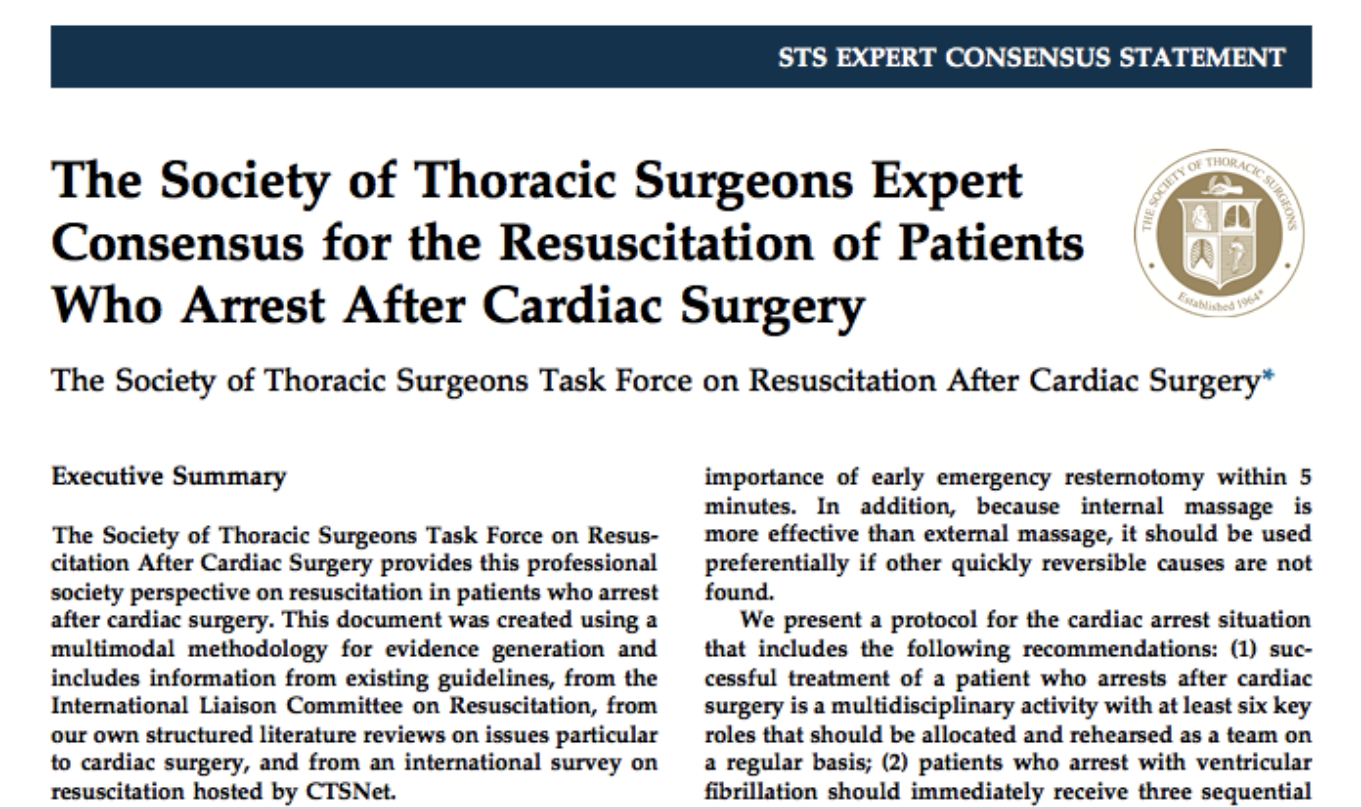
Capnography & CPR Quality

- Eliminate pulse checks!
  - Palpation for a pulse is an *insensitive indicator* of organ perfusion with very poor inter-rater reliability
- Use $ETCO_2$ to assess perfusion and response to therapy:
  - To assess CPR adequacy; $ETCO_2$ goal 12-15 mmHg
  - $ETCO_2$ < 10 mmHg *may indicate* poor quality CPR
  - $ETCO_2$ spike to 35-40 mmHg confirms ROSC



Resuscitation After Cardiac Surgery – What Matters?

A New National Standard of Care



STS EXPERT CONSENSUS STATEMENT

The Society of Thoracic Surgeons Expert Consensus for the Resuscitation of Patients Who Arrest After Cardiac Surgery

The Society of Thoracic Surgeons Task Force on Resuscitation After Cardiac Surgery*

Executive Summary

The Society of Thoracic Surgeons Task Force on Resuscitation After Cardiac Surgery provides this professional society perspective on resuscitation in patients who arrest after cardiac surgery. This document was created using a multimodal methodology for evidence generation and includes information from existing guidelines, from the International Liaison Committee on Resuscitation, from our own structured literature reviews on issues particular to cardiac surgery, and from an international survey on resuscitation hosted by CTSNet.

importance of early emergency resternotomy within 5 minutes. In addition, because internal massage is more effective than external massage, it should be used preferentially if other quickly reversible causes are not found.

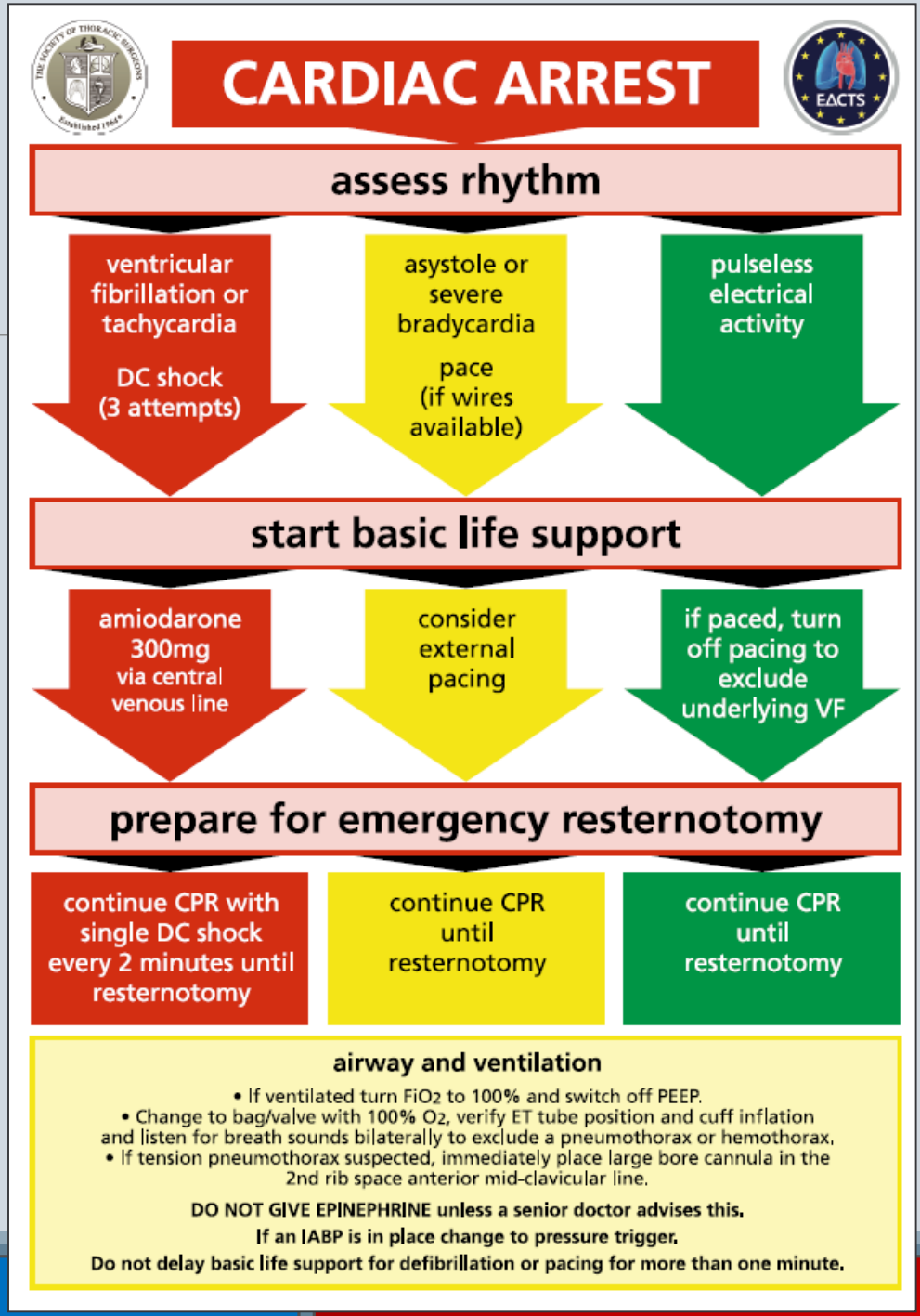
We present a protocol for the cardiac arrest situation that includes the following recommendations: (1) successful treatment of a patient who arrests after cardiac surgery is a multidisciplinary activity with at least six key roles that should be allocated and rehearsed as a team on a regular basis; (2) patients who arrest with ventricular fibrillation should immediately receive three sequential

March 2017– *Ann Thorac Surg*

STS/EACTS Protocol vs ACLS

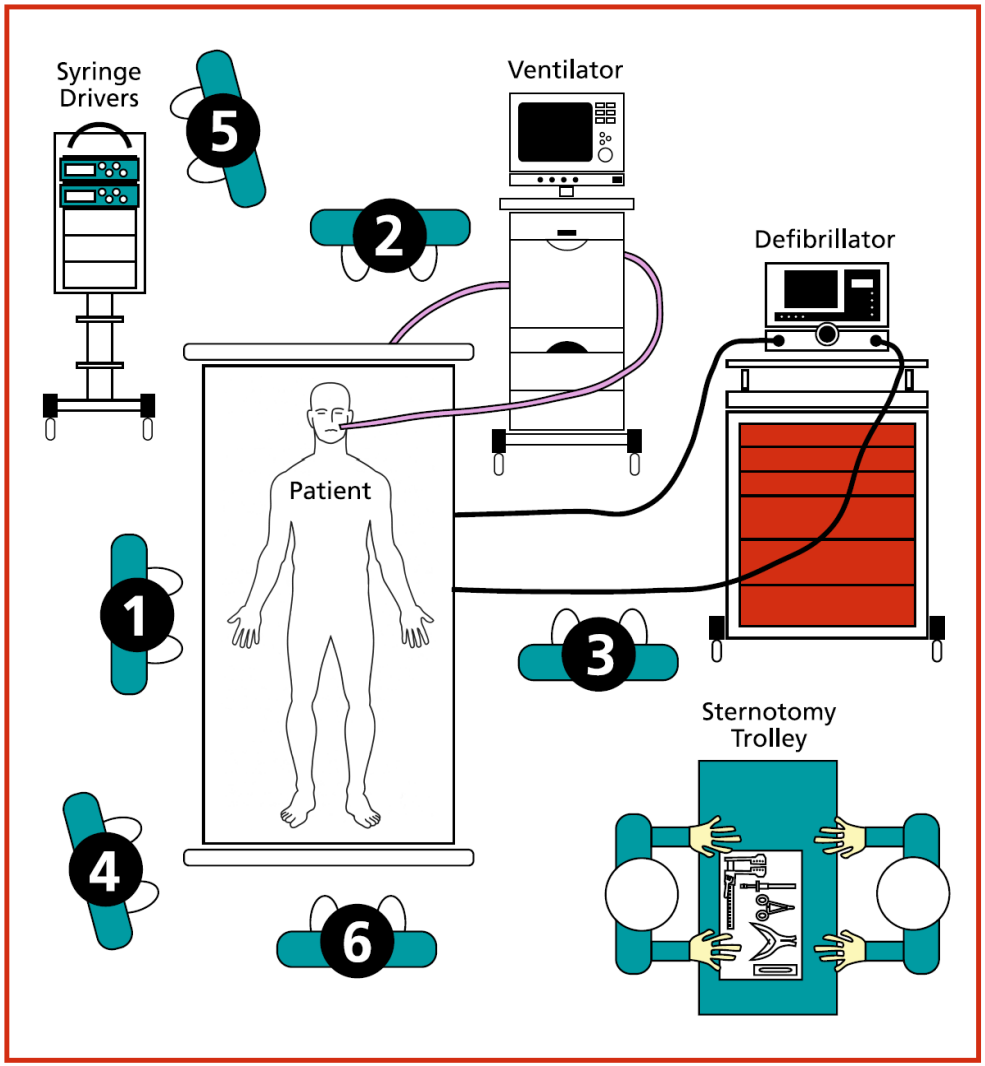
STS /EACTS Protocol	ACLS
For VF/pVT	
Defibrillation takes priority; may defer CPR for up to 1 minute	CPR should be performed immediately on all patients
3 successive shocks before CPR	CPR $\rightarrow$ 1 shock $\rightarrow$ CPR

The STS/EACTS Resuscitation Protocol



Role Functions in Postoperative Cardiac Arrest

Figure 3. Six key roles in the cardiac arrest



Six key roles in the cardiac arrest:

1. External cardiac massage
2. Airway and breathing
3. Defibrillation
4. Team leader
5. Drugs and syringe drivers
6. ICU co-ordinator

What Matters in Cardiac Arrest?

- Designation of specific roles for team members
- Clearly defined expectations by role
- Protocol implemented without waiting for orders
- TEAM-work!

CPR after TAVR

Complete Crush of a Balloon-expandable Bioprosthesis After Prolonged Cardiopulmonary Resuscitation

Tobias Spangenberg, Christian Frerker, Ralf Bader and Ulrich Schäfer

Circulation
Cardiovascular Interventions

To our knowledge, this is the first reported case of a deformed aortic valve prosthesis after cardiopulmonary resuscitation. Nevertheless, there have been reports on deformed pulmonary valves, coronary stents, or stentgrafts after chest compressions.[2–4] Thus, further investigations to increase the radial force or crush resistance of current and future TAVI devices are warranted, especially in view of endeavors to extend minimal invasive aortic valve replacement therapies to healthier patient populations.

Circ Cardiovasc Interv. 2013;6:e1-e2
doi: 10.1161/CIRCINTERVENTIONS.112.975904

Summary – What Matters?

- **Simplify** arrest management to what works:
  - High quality CPR saves lives; reduce interruptions
  - Team work and team training is where REAL advances lie
- **Shockable** rhythms
  - Early defibrillation saves lives; reduce delays
  - Post cardiac surgery – shock x 3 *before* CPR
  - Amiodarone is the *only* recommended ADULT antiarrhythmic
  - Epinephrine is *not associated* with survival benefit
- **Nonshockable** rhythms
  - Epinephrine may be of benefit, if given early
  - Use pacing following cardiac surgery

“Universal” ACLS Algorithm