ABC’s or CAB’s: What’s New in the Resuscitation Guidelines . . . And What Was Left Out

Jill Ley, MS, RN, CNS, FAAN
Clinical Nurse Specialist Surgical Services, CPMC
Clinical Professor, UCSF
Learning Outcomes

• Review key recommendations from The American Heart Association’s 2015 ECC update
• Discuss emergency management strategies that promote optimal outcomes after in-hospital cardiac arrest
Cardiac Arrest Mortality

- 326,200 out of hospital (OHCA) arrests/year
  - Survival to discharge in 10.6%
  - Good neurologic recovery in 8.3%
- 209,000 in hospital (IHCA) arrests/year
  - Survival to discharge in 24%
- 2500-5000 post-cardiac surgery arrests/year
  - High potential for reversible causes and recovery
  - Wide variation in survival; 40-80%

AHA 2015 Heart & Stroke Statistics
Important AHA 2015 Updates

• Focus on compression fraction
  o Rate 100-120 per minute
  o Compression depth 5-6 cm

• Capnography recommendations

• Medication updates
  o Vasopressin removed
  o Lidocaine not *routinely* recommended
  o Epinephrine for shockable vs non-shockable rhythms
  o Naloxone added for suspected opiate overdose

• Did NOT address cardiac surgery resuscitation

Compressions & 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 (↑ to 120)
  - Reducing interruptions (frequency and duration)
  - Upper limits for both added in 2015

Compressions & High Quality CPR

Sequence of Interventions Remains C-A-B

Table 1  BLS Dos and Don’ts of Adult High-Quality CPR

<table>
<thead>
<tr>
<th>Rescuers Should</th>
<th>Rescuers Should Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform chest compressions at a rate of 100-120/min</td>
<td>Compress at a rate slower than 100/min or faster than 120/min</td>
</tr>
<tr>
<td>Compress to a depth of at least 2 inches (5 cm)</td>
<td>Compress to a depth of less than 2 inches (5 cm) or greater than 2.4 inches (6 cm)</td>
</tr>
<tr>
<td>Allow full recoil after each compression</td>
<td>Lean on the chest between compressions</td>
</tr>
<tr>
<td>Minimize pauses in compressions</td>
<td>Interrupt compressions for greater than 10 seconds</td>
</tr>
<tr>
<td>Ventilate adequately (2 breaths after 30 compressions, each breath delivered over 1 second, each causing chest rise)</td>
<td>Provide excessive ventilation (ie, too many breaths or breaths with excessive force)</td>
</tr>
</tbody>
</table>

Self-Assessment Question #1

During CPR you note the end-tidal CO2 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 #1

During CPR you note the end-tidal CO2 abruptly changed from 15 to 35 mmHg, which most likely indicates:

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Capnography

- Provides valuable information about patient response during arrest
- Strategies should offer continuous monitoring without interrupting compressions
- 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).

2015 Recommendations—New
In intubated patients, failure to achieve an ETCO$_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts, but it should not be used in isolation (Class IIb, LOE C-LD).
Capnography & CPR Quality

- Eliminate pulse checks!
  - Palpation for a pulse is an *insensitive indicator* of organ perfusion with very poor inter-rater reliability
- ETCO$_2$ to assess perfusion & response to therapy:
  - Assess CPR adequacy; ETCO$_2$ goal 12-15 mmHg
  - ETCO$_2$ < 10 mmHg *may be* poor quality CPR
  - ETCO$_2$ spike to 35-40 mmHg confirms ROSC
Electrical Therapy for VF

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

Reduce Time to Defibrillation!

- Defibrillator readily available and standardized
- Optimize use of hands free defibrillator pads
- Non-code team members can defibrillate
2016 Studies Favor Stacked Shocks

- Multicenter review: adults with IHCA from VF (n=2733)
  - Rapid sequence shocks superior to deferred 2nd shock
    - ROSC in 62.5% vs 57.4% (Risk Ratio 0.92)
    - Survival to discharge in 30.8% vs 24.7% (RR 0.80)
  

- Single center review of 3 historical resus protocols
  - 3 SS vs single shock & 2 min CPR vs 3 SS (120j-150j-200j)
  - Worst survival with single shock
  - Highest survival after resuming 3 SS

"Our data suggest that in cases of monitored VF/VT arrest, expeditious defibrillation with use of stacked shocks is associated with a higher rate of ROSC and survival to hospital discharge."

Recommendations Regarding 3 Shock Protocol

- For refractory VF/pVT in witnessed IHCA, recent data support use of a 3-shock strategy
- STS recommends 3 sequential shocks after cardiac surgery
- Since 2010 European guidelines recommend 3 sequential attempts at defibrillation for witnessed VF/pVT arrest ‘where immediate defibrillation is available’
- This is currently not recommended in the AHA guideline

Medication Update

What’s in, what’s out . . .

KISS . . . simplify
Self-Assessment Question #2

Which of the following medications does the AHA recommend for a shockable rhythm:

1. Epinephrine and Amiodarone
2. Epinephrine and Lidocaine
3. Amiodarone and Lidocaine
4. None of the above
Self-Assessment Question #2

Which of the following medications does the AHA recommend for a shockable rhythm:

1. Epinephrine and Amiodarone
2. Epinephrine and Lidocaine
3. Amiodarone and Lidocaine
4. None of the above
Drugs for Cardiac Arrest

Drug Therapy

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

- **Amiodarone IV/IO dose:**
  First dose: 300 mg bolus. Second dose: 150 mg.

Epinephrine not recommended until after 2nd failed shock
Lidocaine Gone

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.

CPR 2 min
- Amiodarone
- Treat reversible causes
Why? The ALPS

• The Amiodarone, Lidocaine, or Placebo Study
• Multicenter RCT; 3026 pts randomly assigned to 1 of 3 treatment groups by EMS (out of hospital)
• Enrolled after at least one failed shock for VF/pVT
• Results: no significant difference in survival or neurologic recovery between the 3 groups


<table>
<thead>
<tr>
<th>Table 3. Outcomes According to Trial Group in the Per-Protocol Population.‡</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome</strong></td>
</tr>
<tr>
<td>Primary outcome: survival to discharge — no./total no. (%) †</td>
</tr>
<tr>
<td>Secondary outcome: modified Rankin score ≤3 — no./total no. (%) ‡</td>
</tr>
</tbody>
</table>
## Important Differences if Witnessed

### Table S2. Survival to Discharge in A Priori Subgroups in the Per-Protocol Population

<table>
<thead>
<tr>
<th>Witnessed status</th>
<th>Amiodarone</th>
<th>Lidocaine</th>
<th>Placebo</th>
<th>Amiodarone vs Placebo Difference (95% CI)</th>
<th>Lidocaine vs Placebo Difference (95% CI)</th>
<th>Amiodarone vs Lidocaine Difference (95% CI)</th>
<th>P for Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMS witnessed, n (%)</td>
<td>22 (38.6%)</td>
<td>10 (23.3%)</td>
<td>9 (16.7%)</td>
<td>21.9% (5.8%, 38.0%)</td>
<td>6.6% (-9.5%, 22.7%)</td>
<td>15.3% (-2.6%, 33.2%)</td>
<td>0.01</td>
</tr>
<tr>
<td>[N=57;43;54]</td>
<td></td>
<td></td>
<td></td>
<td>P=0.01</td>
<td>P=0.42</td>
<td>P=0.09</td>
<td></td>
</tr>
<tr>
<td>Bystander witnessed, n (%)</td>
<td>171 (27.7%)</td>
<td>176 (27.8%)</td>
<td>155 (22.7%)</td>
<td>5.0% (0.3%, 9.7%)</td>
<td>5.2% (0.5%, 9.9%)</td>
<td>-0.1% (-5.1%, 4.9%)</td>
<td>0.04</td>
</tr>
<tr>
<td>[N=618;632;684]</td>
<td></td>
<td></td>
<td></td>
<td>P=0.03</td>
<td>P=0.97</td>
<td>P=0.97</td>
<td></td>
</tr>
<tr>
<td>Unwitnessed, n (%)</td>
<td>41 (15.1%)</td>
<td>45 (16.0%)</td>
<td>48 (16.8%)</td>
<td>-1.7% (-7.8%, 4.4%)</td>
<td>-0.8 (-6.9%, 5.3%)</td>
<td>-0.9% (-6.9%, 5.1%)</td>
<td>0.58</td>
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<tr>
<td>[N=271;282;286]</td>
<td></td>
<td></td>
<td></td>
<td>P=0.80</td>
<td>P=0.77</td>
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</table>

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.

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**CPR 2 min**
- **Epinephrine** every 3-5 min
- Consider advanced airway, capnography

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The Rationale

• Important note ....
• Recommendation based on two new studies showing lack of clear benefit, not harm
• No benefit demonstrated for OHCA with VF/pVT
• Single study showed possible role for vasopressin in IHCA “bundle” combined with epi and steroids

Circulation 2015;132[suppl 2]:S444–S464. DOI: 10.1161/CIR.0000000000000261
Self-Assessment Question #3

Which of the following statements about Epinephrine is TRUE for a VF arrest:

1. Epinephrine is advocated AFTER the 2nd failed shock attempt and not before
2. Epinephrine significantly improves neurologic recovery after arrest
3. Epinephrine is equally effective in shockable vs non-shockable rhythms
4. None of the above
Self-Assessment Question #3

Which of the following statements about Epinephrine is TRUE for a VF arrest:

1. Epinephrine is advocated AFTER the 2\textsuperscript{nd} failed shock attempt and not before
2. Epinephrine significantly improves neurologic recovery after arrest
3. Epinephrine is equally effective in shockable vs non-shockable rhythms
4. None of the above
Epinephrine for **Shockable** Rhythms

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

Epinephrine for Non-Shockable Rhythms

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

† Donnino MW, et al BMJ. 2014;348:g3028
Summary of Epinephrine Data

- Controversy persists surrounding the optimal use of epinephrine for cardiac arrest
- Improved neurologically intact survival has not been demonstrated for VF/pVT but was recently reported for non-shockable rhythms
- For shockable rhythms
  - Use no earlier than 2\textsuperscript{nd} failed shock in standard dose
- For non-shockable rhythms
  - Consider early administration
The Opioid Epidemic

• 21.5 million Americans > age 12 have a substance abuse disorder – 1.9 million from prescription pain relievers.
• Drug overdose is now the leading cause of accidental death in the US.
  • 47,055 fatal OD in 2014: 18,893 from pain meds vs 10,574 from heroin
• Almost half a million adolescents use pain relievers and 168,000 were addicted to pain relievers in 2014.
• 48,000 women died of prescription drug overdose between 1999-2010.

First Responders

**Opioid Overdose Treatment**

2015 (New): Empiric administration of IM or IN naloxone to all unresponsive victims of possible opioid-associated life-threatening emergency may be reasonable as an adjunct to standard first aid and non-HCP BLS protocols.

- Impact on in-hospital arrest
  - Algorithms
  - Medication availability
Resuscitation After Cardiac Surgery
A New STS National Standard
We Know That . . .

Standard CPR is *ineffective* in:

- **CARDIAC TAMPONADE**
- **PROFOUND HYPOVOLEMIA / BLEEDING**
  - TENSION PNEUMOTHORAX

Without effective CPR - IRREVERSIBLE BRAIN DAMAGE occurs within 5 minutes

Performing a RAPID (< 5 min)

EMERGENCY RESTERNOTOMY is essential to survival
Self-Assessment Question #4

The STS protocol for resuscitation after cardiac surgery now endorses which of the following practices:

1. Perform CPR for only 1 minute prior to defibrillation
2. Defibrillate first, prior to starting CPR, if available within 1 minute of witnessed arrest
3. Administer high dose epinephrine (10 mg) for cardiac arrest with a shockable rhythm
4. Administer atropine for asystole/profound bradycardia
Self-Assessment Question #4

The STS protocol for resuscitation after cardiac surgery now endorses which of the following practices:

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The STS/EACTS Resuscitation Protocol

- 2003: Two UK surgeons initiate project: *J Dunning, A Levine*
- 2004: First UK course in Manchester, England
- 2009: EACTS Guideline for Resuscitation After Cardiac Surgery
  
- 2009: First US course in San Francisco, California
- 2010: International Liaison Committee on Resuscitation & European Resuscitation Council guidelines
  
- 2015: STS Resuscitation Task Force initiated
- 2017: Publication of STS Expert Consensus Statement
  
### STS/EACTS Protocol vs ACLS

<table>
<thead>
<tr>
<th>STS /EACTS Protocol</th>
<th>ACLS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For VF/pVT</strong></td>
<td></td>
</tr>
<tr>
<td>Defibrillation takes priority; may defer CPR for up to 1 minute</td>
<td>CPR should be performed immediately on all patients</td>
</tr>
<tr>
<td>3 successive shocks before CPR</td>
<td>CPR $\rightarrow$ 1 shock $\rightarrow$ CPR</td>
</tr>
</tbody>
</table>

- **Rapid resternotomy (<5 min) if no response to pacing/defibrillation**
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.

In gathering evidence for this consensus paper, searches were conducted using the MEDLINE keywords “cardiac surgery,” “resuscitation,” “guideline,” “thoracic surgery,” “cardiac arrest,” and “cardiac massage.” Weight was given to clinical studies in humans, although some case studies, mannequin simulations of potential protocols, and animal models were also considered.

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 attempts at defibrillation before external cardiac massage, and if this fails, emergency resternotomy should be performed; (3) patients with asystole or extreme bradycardia should undergo an attempt to pace if wires are available before external cardiac massage, then optionally external pacing followed by emergency resernotomy; and (4) pulseless electrical activity should receive prompt rest-
STS Protocol Implementation

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

For Postoperative Cardiac Surgical Arrest
Role Functions in Postop Arrest

# 1: Defib or pace, then start CPR
# 2: Airway, ↑O2 to 100%, no PEEP
# 3: External defibrillator - switch to internal defib; pacemaker
# 4: Run code, in charge of arrest
# 5: Amiodarone, stop other drips
# 6: Run unit, delegate resources
# 7 and #8: Prepare for re-entry
“Mini” Resternotomy Set

1. Scalpel
2. Wire cutter
3. Wire puller
4. Retractor
5. Suction tubing/yankauer
6. Optional: scissor, forceps
Protocol for Reopening

1. “Sterile OR personnel”
   - Apply large sterile drape over entire bed
   - Receive “mini” instrument set onto sterile field
   - Stand back when surgeon ready with scalpel

2. Scalpel used along prior incision down to wired sternum

3. Remove wires; cut/pull (side w/knot)

4. Insert closed chest retractor *carefully*
   - Crank retractor until sternum open widely
   - Assess for bleeding; ready with suction
   - Internal massage ≥ 1 min
   - Internal defibrillator paddles 20j x 3
Impact on Failure To Rescue

Ley SJ, Gaudiani VG, Egrie GE, Shaw RE, Brewster J. Poster presented at STS 51st Annual Meeting, January 2015, San Diego, CA

Implementation of ERC guideline

<table>
<thead>
<tr>
<th>Year</th>
<th>Arrest Rate</th>
<th>FTR Rate</th>
<th>Percent %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>5/161</td>
<td>5/5</td>
<td>100</td>
</tr>
<tr>
<td>2007</td>
<td>11/280</td>
<td>4/11</td>
<td>40</td>
</tr>
<tr>
<td>2008</td>
<td>10/235</td>
<td>6/10</td>
<td>30</td>
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<td>2009</td>
<td>5/224</td>
<td>5/5</td>
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<td>2010</td>
<td>6/227</td>
<td>3/6</td>
<td>25</td>
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<td>2011</td>
<td>6/235</td>
<td>3/6</td>
<td>25</td>
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<tr>
<td>2012</td>
<td>7/211</td>
<td>1/7</td>
<td>15</td>
</tr>
<tr>
<td>2013</td>
<td>7/234</td>
<td>2/7</td>
<td>15</td>
</tr>
</tbody>
</table>

Benchmark: 60%

Legend:
- FTR Rate
- Arrest Rate
Potential Cath Lab Emergencies

- **Procedure related**
  - Vessel dissection
  - Pneumothorax
  - Tamponade

- **Rhythm related**
  - Brady arrhythmias/tachyarrhythmias

- **Hypotension/ST changes**
  - Preload/volume e.g. femoral blood loss
  - Pump - problem e.g. Ischemia, dissection, stunning
  - Afterload e.g. drug reaction or GTN
  - Tamponade e.g. cardiac and pneumothorax
  - Co -morbidities e.g. CVA, DM

- **Drug Related**
  - Sedation- airway compromise, respiratory depression
  - Anaphylaxis
  - Drug errors
  - Hypotension (i.e. secondary to NTG)
CPR after TAVR

Complete Crush of a Balloon-expandable Bioprosthesis After Prolonged Cardiopulmonary Resuscitation
Tobias Spangenberg, Christian Frerker, Ralf Bader and Ulrich Schäfer

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.\textsuperscript{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.

\textit{Circ Cardiovasc Interv}. 2013;6:e1-e2
doi: 10.1161/CIRCINTERVENTIONS.112.975904
Cardiac Catheterization Lab: Response to Emergencies

Cath Lab Team – What is Your Immediate Response to These Complications?

Does the room/equipment configuration lend itself to emergency resuscitation?

Does your team train for / rehearse these emergencies?
Personnel Positioning

1. Massage/Defib
2. Airway
3. Team Leader
4. Drugs
5. Resource Manager
6. Scrub Nurse
7. Runners
Personnel Positioning
Summary

- **Shockable** rhythms
  - Early defibrillation saves lives - shock without delay
  - Consider stacked shocks for witnessed IHCA
  - Amiodarone is the only recommended antiarrhythmic
  - Epinephrine has no survival benefit
- **Nonshockable** rhythms
  - Epinephrine may be of benefit, if given early
- New protocol recommended *post-cardiac surgery*

- **Simplify** arrest management to what works:
  - High quality CPR saves lives
  - Capnography is our best monitor for ETT placement and ongoing response