You should do 5 things

1. Enable systems of response in your community, supporting rapid community notification & public safety response, hands-only CPR, & public-access AEDs.
2. Perform chest compressions - high quality with limited interruptions.
3. Apply defibrillation ASAP for pulseless VT & VF via public-access AED or multifunction device.
4. Provide appropriate airway & administer bolus-dose medications, as appropriate, without interruption in chest compression or defibrillation.
5. Deliver comprehensive post-resuscitation care.

Disclosures
Brady & Slovis
NONE


The History of Resuscitation

The Bellows Method
Middle Ages
The Flagellation Method

The Fumigation Method
1700
The Purgation Method

The Inversion Method
1775
The Baroni Roll Method

The Russian "Snow Packing" Method
1825
The Trotting Horse Method

1840
The Rocking Method

1930
The Rocking Method

Pre-Arrival Care
Recognition of Arrest
Call for Help
Chest Compressions
Automatic External Defibrillator

What’s all the fuss about this “pre-arrival” provider care?
Why not just take them to the hospital ASAP?

Survival in Cardiac Arrest
Time to Therapy is Key

Cardiac Arrest
Quality of care for EMS-managed cardiac arrest

<table>
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<tr>
<th>Issue</th>
<th>Total</th>
<th>Adult</th>
<th>Pediatric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bystander CPR (%)</td>
<td>40.8</td>
<td>40.4</td>
<td>53.9</td>
</tr>
<tr>
<td>AED before EMS (%)</td>
<td>2.1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>Pulseless VT / VF (%)</td>
<td>23</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Time to First EMS Shock (min)</td>
<td>8.9</td>
<td>8.9</td>
<td>0</td>
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<tr>
<td>Chest Compression Fraction</td>
<td>0.75</td>
<td>0.75</td>
<td>0.80</td>
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<tr>
<td>Compression Depth (mm)</td>
<td>39.5</td>
<td>39.6</td>
<td>35.9</td>
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<tr>
<td>Preshock Pause Duration (min)</td>
<td>18.5</td>
<td>18.5</td>
<td>NA</td>
</tr>
<tr>
<td>Number of Events (2013)</td>
<td>359,400</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>9.5%</td>
<td>--</td>
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</table>

Survival in Cardiac Arrest
Time to Therapy is Key

Resuscitation Outcomes Consortium Cardiac Epistry
What makes a difference…

- Early intervention…by anyone
- Chest compressions
- Defibrillation…for pVT & VF
- Particularly in cardiogenic events
- Lay Provider……EMS……EM……Hospital

Pre-Arrival Care

Dispatcher Instructions

- 911 provides instructions for CPR
- Only after event identified, location confirmed, & units dispatched
- 37,924 events
- Instructions CPR from 31% to 56%

- Public – any CPR increased neuro-intact survival
- Private – only CPR instruction group increased neuro-intact survival

Community Notification

Crowd Sourcing

- Smartphone-based technology
- Operated by 911 centers
- Intent – reduce time to lay interventions
- Largely endorsed by public safety agencies

Community Notification

Crowd Sourcing

- Survey asking about appropriateness of community notification – PulsePoint
- North America – 2415 participants
- 96+% Approved of concept
  – 98% Canadians / 96% US
- Would download app
  – 84% Canadians / 55% US
- Would want such a response if a victim
  – 95% Canadians / 94% US
Bystander CPR

- Compressions vs ventilations vs both
  - Compression-only similar ...or superior
  - Some form is highly important
- Outcome improved
  - Survival rate
  - Neurologic status

Early CPR Increases Survival

<table>
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<tr>
<th>Study</th>
<th>Survival</th>
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<tr>
<td>None 2.5%, CPR 4.3%, OR 1.72</td>
<td>CPR 10-15%</td>
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<tr>
<td>None 2.5%, CPR 4.3%, OR 1.72</td>
<td>None 2.2%, CPR 5.2%</td>
</tr>
<tr>
<td>None 2.5%, CPR 4.3%, OR 1.72</td>
<td>OR 5.0 – 5.4</td>
</tr>
<tr>
<td>None 2.5%, CPR 4.3%, OR 1.72</td>
<td>None 3.8%, CPR 7.1%, OR 1.78</td>
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</tbody>
</table>

Automatic External Defibrillator

- Easy & safe
- Reduce time to defibrillation
- Used with CPR
- Can be life saving
- Obviously...only impact “shockable rhythm” presentations

Public Access Defibrillation

Early Studies

- Airports, gambling casinos, & general community
- Greatly reduced time to 1st shock
- Improved outcome

Study | Survival
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>EMS 6%, Bystander 50%, Bystander AED 2.72 OR</td>
<td>EMS 31%, First Responder 42%, Bystander 70%</td>
</tr>
<tr>
<td>EMS 31%, Bystander 45%, Bystander AED 1.62 OR</td>
<td>EMS 31%, Bystander 45%, Bystander AED 1.62 OR</td>
</tr>
<tr>
<td>None 9%, Bystander 38%, Bystander AED 1.75 OR</td>
<td>None 47%, Bystander 64%</td>
</tr>
</tbody>
</table>
Public Access AEDs...Less Frequently Used

AEDs are used infrequently by lay providers

Public Access Defibrillation

- Bystander-witnessed, VF arrests, 2005-2013
- PAD use increased, from 1% to 17%
- 30 day survival with intact neuro status
  - 18% no PAD
  - 39% PAD
  - Neuro-intact survivors increased from 6 (2005) to 201 (2013)

Public Access Defibrillation

- Systematic review of 41 studies
  - 18 non-dispatched lay provider
  - 3 dispatched lay provider
  - 20 dispatched first responder
- Survival to D/C
  - Overall median -- 40%
  - Non-dispatched lay provider – 53%
  - Dispatched lay provider – limited data
  - Dispatched first responder – 29%

Public Access Defibrillation

- Western Sweden, 2008-2015
- Shockable rhythm & AED applied prior to EMS
- PAD use increased from 5% (2008) to 20% (2015)
- OR for 30-day survival for PAD vs dispatched AED, 2.45 (1.02-5.95)

Drone AED

- Delivery of AED
- 911 center launch
- Rapid delivery – ~5 min (well developed system)
- AED used by lay provider
- Investigational in northern Europe

Pre-arrival Care & Duration of Resuscitation

Impact of Bystander Intervention

- Bystander intervention – CPR +/- AED
  - Improves neuro-intact survival AND
  - Mitigates impact of longer EMS response times
- Bystander intervention – CPR +/- AED
  - “...30-day survival more than doubled...despite long ambulance response time.” Circulation 2016; 134:2095
  - “…risk of brain damage was significantly lower...” NEJM 2017:376:1737
  - “…with longer ambulance response times, the increase in mortality and worsening neurologic outcome appear to be mitigated...” AJEM 2017;35:1049
Pre-arrival Care & Duration of Resuscitation
Impact of Bystander Intervention

Take Homes

- Basic has significant impact
- Interventions...CPR & AED
- Enhance early care
  - Dispatcher instructions
  - Crowd sourcing
  - Drone AEDs
- As EPs...
  - Support programs in prehospital world
  - Extrapolate to ED care (compressions, defibrillator, etc)

Traumatic Cardiac Arrest
EMS Management

- 2 registries - ROC & PROPHET - #2300
- Blunt & penetrating trauma – CPR
- 6.3% survival to D/C – most survivors + vitals on EMS arrival

- “...no ALS procedures were associated with increased odds of survival”

The “Code” Meds

None of the meds ever work!
Giving any of them is a big waste of time!! So why do YOU do it?

Antiarrhythmic for VF/pVT

- Amiodarone may be considered
- Lidocaine may be considered as alternative
- Magnesium not recommended

“No antiarrhythmic as yet been shown to increase survival or neurologic outcome after cardiac arrest due to VF/pVT”
Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

3,026 pts., 10 ROC sites
Randomized, double blind, placebo controlled
VF/pVT, s/p 1 or more shocks, s/p epi
Only adult, medical VF/pVT OOH

What is the best antiarrhythmic for shock resistant VF/pVT: Amiodarone vs Lidocaine vs Placebo?

- Amiodarone vs Placebo: 3.2% (p=0.08)
- Amiodarone vs Lidocaine: 0.7% (p=0.70)
- Lidocaine vs Placebo: 2.6% (p=0.16)
- Amiodarone vs Placebo Modified Rankin ≤ 3: 2.2% (p=0.19)
- Amiodarone vs Lidocaine Modified Rankin ≤ 3: 1.3% (p=0.44)

What do all studies combined tell us about Amiodarone vs Lidocaine in VF/pVT?
- 7 studies: 3 RCTs, 4 non-RCTs
- 3,877 pts in RCTs and 700 in non-RCTs
- Includes 2016 NEJM trial
- Admission and Discharged Alive evaluated

Results
Amiodarone vs Placebo: ↑trend for hospital discharge with Amio (p=0.08)
No difference in favorable neuro outcomes

Lidocaine vs Placebo: No significant difference at discharge

Amiodarone vs Lidocaine: No difference in hospital discharge (p=0.81)

At the present time, there is no clear benefit of Amiodarone vs Lidocaine
Late in VF it's not clear either drug is beneficial
Do not always use pre-hospital data for in-ED and in-hospital arrests

**Corey, so there is limited to no benefit for med administration.**

*Is there anything other than amiodarone or lidocaine for refractory VF?*

---

**Refractory VF**

- Switching pad locations
- Beta blockers
- Double sequential defibrillation
- ECMO/ECLS *(discussed later...)*

---

**Refractory VF/pVT**

Change Pad Location

Ant-Lat ↔ Ant-Post

---

**Authors Note in Letter to Editor**

- 5% absolute improvement of Amiodarone over placebo (p ≤ 0.04) if arrest witnessed (1934 pts)

- 21.9% absolute increase Amiodarone vs placebo if EMS witnessed and gave drugs near immediately (p < 0.01 for 154 pts)

---

**Beta Blockers**

- Use not addressed during VF/pVT
- “Inadequate evidence” to support post CPR use
- May be considered
- Not enough evidence to be for or against lidocaine or beta blockers s/p VF/pVT
Is Esmolol effective in refractory VF/VT?
• Retrospective ED study
• All EMS to ED arrivals
• All s/p 3 shocks, 3 doses Epi, 300mg Amio
• Compares Esmolol vs no Esmolol

I now always consider beta blockers in VF

Is double sequential defibrillation (DSD) beneficial in refractory VF/pVT?
• 45 patients treated with DSD
• Retrospective observational study
• London Ambulance Service
• Compared to 175 who got standard defibrillation
• Only patients with ≥ 6 shocks compared
Double Sequential Defibrillation

- Not a randomized trial
- Many pts got up to 10 shocks pre DSD
- The role of Double Sequential Defibrillation is not yet clarified and needs a randomized larger trial

Dual Sequential Defibrillation

- Zoll M and/or Physio-Control LP 15s
- Two DSDs: 1 Zoll & 1 LP @ 560 J synched
- Two DSDs with 2 LPS at combined 720 J
- All 4 DSDs done A-P
- One LP found to become nonfunctional

“LIFEPAK defibrillators comply with standards which require defibrillators to withstand defibrillation shocks from a second defibrillator connected to a patient. This testing does not include delivering simultaneous/sequential or overlapping 360 J defibrillation shocks from two LIFEPAK defibrillators. There are no design and/or safety standards for use of external defibrillators to perform double sequential defibrillation. We cannot guarantee the reliability of functionality of devices subject to this off-label use. Product warranty cannot legally cover damage to LIFEPAK defibrillators which occurs as a result of performing an off-label use”

Treating VF pVT

- Either Lidocaine or Amiodarone, not ready to drop antiarrhythmics completely in VF/pVT
- They work if given immediately
- Consider Beta Blockers in shock resistant refractory VF
- Consider moving pads
- Consider double sequential defibrillation

Corey, anything new on epi?
Should we still use it?
Epinephrine Use

Standard dose epinephrine (1 mg Q 3-5 min) may be reasonable for patients with cardiac arrest (class 11b)

• Early administration may improve ROSC and neurologic outcomes – later administration may decrease both

Does Epinephrine use have true benefits in CPR?

• Meta analysis, 14 RCTs, 12,246 patients

Studies were:

• Epi vs placebo (1) n = 534
• Epi vs high does Epi (6) n = 6,174
• Epi vs Vasopression (1) n = 336
• Epi vs Epi + Vasopressin (6) n = 5,202

What is the role of epinephrine in cardiac arrest?

• Large double blind placebo controlled trial
• 8,014 pts, London EMS, adults ≥ 16 yo
• 4,015 pts, 1 mg epi Q 3-5 min
• 3,999 placebo receiving patients

The study evaluated 30 day outcomes and functional neurologic outcomes at discharge and at 3 months

Times and Dose

6.6 min Call to EMS arrival (median)
21.4 min Call to epinephrine or placebo
4.9 ± 2.5 mg Epinephrine dose (mean)
**ROSC and EMS Transport**

![Graph showing ROSC and EMS Transport](New Engl J Med 2018;379:711-21)

**30 Day Survival**

![Graph showing 30 Day Survival](New Engl J Med 2018;379:711-21)

**30 Day Neurologic Outcomes**

![Graph showing 30 Day Neurologic Outcomes](New Engl J Med 2018;379:711-21)

**Favorable Neurologic Outcome Rankin 0 - 2**

![Graph showing Favorable Neurologic Outcome Rankin 0 - 2](New Engl J Med 2018;379:711-21)

**Severe Neurologic Disability (30 d) Rankin 4, 5**

![Graph showing Severe Neurologic Disability (30 d) Rankin 4, 5](New Engl J Med 2018;379:711-21)
### Adjusted Analysis
**Paramedic Witnessed**

*New Engl J Med 2018;379:711-21*

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>OR (95% CI)</th>
<th>p-value (interaction)</th>
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<tbody>
<tr>
<td>Witness</td>
<td></td>
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</tr>
<tr>
<td>None</td>
<td>2.62 (1.15, 5.86)</td>
<td>0.02</td>
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<td>Responder</td>
<td>1.90 (0.95, 3.81)</td>
<td></td>
</tr>
<tr>
<td>Paramedic</td>
<td>1.46 (0.90, 2.32)</td>
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</tbody>
</table>

### Epinephrine in Cardiac Arrest
**Take Homes**

The role of epinephrine in cardiac arrest will continue to be debated

Epinephrine increases survival but does not increase the rate of neurologically intact survival

---

**Does giving epinephrine before 2nd shock help or hinder resuscitation?**

- 2,974 VF/pVT arrests, 1,510 with epi < 2 min
- Inpatient data from 300 GWTG-R hospitals
- Propensity matched cardiac arrest pts
- 51% of patients received epi before 2nd shock

---

**Epi Before vs After 2nd Shock**

*BMJ 2016;353:i377-87*

- **ROSC**: 67% vs 31%, p < 0.001
- **Survival**: 41% vs 25%
- **Good Neuro**: 41% vs 25%

Wait for second shock before giving Epi in VF!
Epinephrine in Cardiac Arrest

**Take Home**

- Epinephrine increases the number of neurologically devastated survivors
- Do not give epinephrine until after second shock in VF

---

Intubation is very important. Everyone in cardiac arrest should be intubated ASAP.

---

Airway Management

- Prior teaching...Focused on the “ABC’s”
  - Favored ETT...early & in all
- Alphabet no longer starts with "A"...The "CAB’s"
- If performed
  - properly...
  - without interruptions or delays...
- Cardiogenic vs non-cardiogenic events

---

Airway Management

- **Cardiogenic**
  - Cardiac-based event
  - Sudden with oxygen “reserve” & little acidosis
  - “Less early” airway
- **Non-cardiogenic**
  - Not initially cardiac...
  - Gradual with progressive hypoxia & acidosis
  - “Earlier” airway

---

Management

Basic vs Advanced Care

In both populations, advanced care had marginal positive impact on outcome...
Airway Management

- Randomized trial, multicenter – BVM vs ETI
- Adult OHCA - #2040: 1018 BVM & 1022 ETI
- Outcomes
  - Primary– neuro @ 28 days
  - Secondary– ROSC, survival ED arrival / 28 days, difficulty
- No difference in primary / secondary outcomes
  - “Among patients with OHCA, the use of BMV compared with ETI failed to demonstrate noninferiority or inferiority... requires further research.”

Jabre et al. JAMA 2018;319:779

Carlson & Wang
Ann EM 2016;67:396

Ongoing trials
- UK Airway Management in Cardiac Arrest Patients trial study (www.isrctn.com)
- US Pragmatic Airway Resuscitation Trial (www.clinicaltrials.gov)

Compression Interruptions Due to Endotracheal Intubation

Interruptions are significant & negatively impact outcome

Airway Management

- Cardiogenic vs non-cardiogenic
  - AND
- Early vs “less early” airway intervention
- BVM vs invasive airway
- Avoid interruptions due to airway management
Post-Resuscitation Care

Post-resuscitation care should only include BP & airway management. The rest of those interventions really are not of value in most patients & should be done in the ICU.

2017 ACC/AHA Guidelines
PCI and Hypothermia

- Therapeutic hypothermia should be started ASAP for all comatose STEMI patients and out of hospital arrests due to VF or VT (1B)
- Immediate PCI is indicated in all STEMI arrest patients including those who are receiving therapeutic hypothermia (1B)

Hypothermia vs Normal Temp
Survival and Neuro Outcomes

- What temperature for Therapeutic Hypothermia?
- Compares 32º - 33º to 35º - 36º TH
- 939 patients in randomized trial
- 36 ICUs in Europe and Australia
- Evaluated: mortality & neuro outcome at 180d
- 80% VF/VT; 20% AS and PEA (12%/7%)
**Therapeutic Hypothermia**

**Take Homes**

- The future of deep TH is unclear
- Preventing Hyperthermia appears crucial
- Future studies will determine optimal TH temp
- Well done study, but likely not the final study
- $35^\circ - 36^\circ$ looks like the new $32^\circ - 34^\circ$

**Is ECMO really of value in patients with ongoing cardiac arrest?**

...who are the patients?  
...what are the system needs?

**There is no benefit to prehospital hypothermia regardless of cooling method, time to induce TH, continuation of TH in ED or initial arrest rhythm**

**Does ECMO have a role in CPR?**

**“E-CPR” “ECLS”**

- ECMO
- Mechanical CPR
- Therapeutic Hypothermia
- Immediate post ECMO PCI
- 24 hours of TH
Uses of ECMO and ECLS

- Respiratory failure – ARDS, H1N1, SARS
- Bridge to heart transplant
- Bridge to lung transplant
- Cardiogenic shock
- ECLS s/p cardiac arrest

Does ECMO improve post-arrest resuscitation outcomes – The CHEER trial

- Refractory VF x 30 minutes
- No known underlying severe disease
- CPR within 10 minutes of arrest
- Mechanical CPR available
- ECMO Team with 2 MDs present

E-CPR Results

- 26 patients (11 OHCA, 15 IHCA)
- ECMO within 56 minutes; 2 days on
- 96% ROSC

54% (14/26) survived to discharge with CPC score of 1 – full neurologic recovery

ECPR

- Shockable arrest rhythm or known precipitant
- Reversible cause of arrest
- Witnessed arrest with CPR
- Duration of pulselessness < 15-20 min or transient ROSC
- Absence of major life-limiting comorbidities

No ECPR

- Elderly or serious underlying diseases
- Irreversible neurologic insult
- Morbid obesity or arterial disease
- ECLS team not readily available
- Contraindications to LVAD, Heart Transplant
Does ECPR really improve survival s/p refractory VF/pVT arrest?

- 100 transported VF/pVT pts
- University of Minnesota in Minneapolis
- All pts 3 shocks without ROSC
- Amiodarone 300 mg IV
- EMS transport with LUCAS device

EMS — Cardiac Cath Lab in less than 30 minutes ECMO begun ASAP in CCL

Declared Dead on CCL Arrival

- ETCO$_2$ < 10 mm Hg
- PaO$_2$ < 50 mm Hg
- Lactate > 18 mmol/L
- EMS→CCL time > 90 min

Fate of 100 Refractory VF/pVT pts

- 92% good neuro CPC 1
- 83% CVICU Admit

ECPR Complications

- Mean time on ECMO 3.5 days
- All patients developed MOSF
- Anoxic CNS insult #1 cause of death
- ¼ of pts will have CPR trauma
- Requires team of intensivists, surgeons, cardiologists

Does ECPR really improve survival s/p refractory VF/pVT arrest?

- 48% good neuro for Shock resistant VF/pVT
ECLS clearly improves in-hospital arrest outcomes if begun within 30-60 minutes of arrest

ECLS of variable benefit for out of hospital arrests unless transported rapidly to the CCL

Bill, this is my last question...
What are your thoughts on PCI post arrest?

Corey...send ‘em to the cath lab!
And this is why...

PCI after ROSC

PCI indicated STEMI on ECG?
• Los Angeles - Regional Registry Data
• OHCA with ROSC & STEMI
  – 422 patients over 3.5 years
  – 74% shockable rhythm
  – Time to PCI 94 +/- 37 min
• Outcome - Survival 62% with ~50% good neuro outcome

Am J Cardiol 2017;120:729–733

PCI after ROSC

PCI indicated if VT/VF & no STEMI on ECG?
• Systematic review & meta-analysis
• 11 articles involving 2,885 pts.
• Evaluated in CCL if no STEMI on ECG

PCI after ROSC

PCI indicated if VT/VF & no STEMI on ECG?
• Culprit lesion found...
  • ...in 71.9% if STEMI on ECG
  • ...in 32.2% if no STEMI on ECG
• PCI improves survival by a factor of 3.7 (CI 1.31-10.70)
  • ...regardless of STEMI or no STEMI on ECG
  • Survival increase by 30% in "no STEMI on ECG" patients

Resuscitation 2016;108:54-60
How common is intervenable coronary lesion with non-shockable rhythm?

- 1396 ROSC patients, 18 centers, retrospective
- 879 patients with asystole or PEA
- 141 underwent angiography
  - 69% with no STEMI
  - 25% had lesion with PCI

Shockable rhythm / no STEMI #269
- Multicenter (US) retrospective study with TH...comatose patients
- 45% CCL early with 66% survival, early CCL increased survival
- Conclusion – “In comatose survivors of cardiac arrest, early cardiac catheterization is associated with significantly decreased mortality.”

ROSC with CCL & TH #886
- Single center (Italy) retrospective review
- 24 comatose ACS patients - 16 surviving to D/C w/ good neuro status
- Conclusion – “PCI is feasible & associated with acceptable outcome in the majority of comatose survivors…”

Is Coma a Contra-indication to PCI?…NO
- Hollenberg, Resuscitation, 2014
- Angeletti, G Ital Cardiol, 2014

“…older patients with MI [and OHCA] did not have higher 1-year mortality or health care use rates compared with those MI survivors without OHCA. These findings … support efforts to improve initial survival rates of older patients with MI and OHCA.”

What is Long-term Outcome in Older Adults with ROSC & PCI?

Patients with multiple unfavorable resuscitation features
- Unwitnessed arrest
- Initial rhythm: Non-WF
- No bystander CPR
- >30 min to ROSC
- Ongoing CPR
- pH <7.2
- Lactate >7
- Age >85
- End stage renal disease
- Noncardiac causes (e.g., traumatic arrest)
Take Homes
PCI After ROSC

• Shockable rhythms…
  – STEMI greatest benefit
  – no STEMI also benefits
• Nonshockable, if cardiogenic…some benefit
• Coma NOT a contra-indication
• Can be performed with TTM
• Long-term outcome is favorable
• Largely retrospective data…
• Prospective trial in progress………………

In summary…
• Early care is vital…lay provider, EMS, & hospital
• The “code meds” – minor, not major, contribution
• Airway management – any benefit?
  – Shockable vs non-shockable rhythms
  – Early vs non early
  – Avoid interruptions…
• Post-ROSC care
  – Basic is key & mandatory
  – Advanced in certain patients – PCI, TTM & …………………ECMO

The bottom line you ask…
• One approach does not fit all
• Tailor your approach

That’s it…thanks!

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