Running the Perfect Code

Michael Winters, MD
@critcareguys

June 25, 1987

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> 500,000

5-10%

Running the Perfect Code

Michael Winters, MD
@critcareguys

The Perfect Code

- Team Leadership
- Hemodynamic-Directed Resuscitation
- High-Quality CPR
- Early Defibrillation
- Medications
- Novel Therapies
- Post-Arrest Care

The Perfect Code

- Team Leadership
- High-Quality CPR
- Early Defibrillation
- Medications?

The Perfect Code

- Team Leadership
- High-Quality CPR
- Early Defibrillation
- Medications?

Deficits in leadership can cost lives!

Cardiac Arrest

- Poor team management
  - ✓ Poor performance of CPR
  - ✓ Decreased ROSC
  - ✓ Decreased survival

Effects of team coordination during cardiopulmonary resuscitation: A systematic review of the literature

Ezequiel Fernandez Castelao[a,*], Sebastian G. Russo[b], Martin Riethmüller[a], Margarete Boos[a]

- Systematic review - 63 papers

1. Leadership
2. Planning
3. Communication

Castelao EF, et al. J Crit Care 2013

Effects of team coordination during cardiopulmonary resuscitation: A systematic review of the literature

Ezequiel Fernandez Castelao[a,*], Sebastian G. Russo[b], Martin Riethmüller[a], Margarete Boos[a]

- Systematic review - 63 papers

1. Leadership

✓ Establish ROSC faster

Castelao EF, et al. J Crit Care 2013

Effects of team coordination during cardiopulmonary resuscitation: A systematic review of the literature

Ezequiel Fernandez Castelao[a,*], Sebastian G. Russo[b], Martin Riethmüller[a], Margarete Boos[a]

- Systematic review - 63 papers

2. Planning - role assignment, task distribution

✓ Reduced hands-off time

✓ Prevention of interruption

✓ Faster treatment completion

Castelao EF, et al. J Crit Care 2013

Effects of team coordination during cardiopulmonary resuscitation: A systematic review of the literature

Ezequiel Fernandez Castelao[a,*], Sebastian G. Russo[b], Martin Riethmüller[a], Margarete Boos[a]

- Systematic review - 63 papers

3. Communication

✓ Accuracy of team leader communications linked to errors

Castelao EF, et al. J Crit Care 2013

Errors in the management of cardiac arrests: An observational study of patient safety incidents in England☆

Sukhmeet S. Panesar[a], Agnieszka M. Ignatowicz[b], Liam J. Donaldson[c,*]

- Observational study
- Incident reports to national system
- Understand types of errors during CA that lead to death

Panesar SS, et al. Resuscitation 2014

Errors in the management of cardiac arrests: An observational study of patient safety incidents in England☆

Sukhmeet S. Panesar[a], Agnieszka M. Ignatowicz[b], Liam J. Donaldson[c,*]

- Results

1. Poor application of knowledge / skills (37%)
2. Equipment deficits (37%)
3. Miscommunication (13%)

Panesar SS, et al. Resuscitation 2014

Errors in the management of cardiac arrests: An observational study of patient safety incidents in England☆

Sukhmeet S. Panesar[a], Agnieszka M. Ignatowicz[b], Liam J. Donaldson[c,*]

- Results

1. Poor application of knowledge / skills (37%)

✓ Indecisiveness by senior clinician

✓ Inexperience of junior physicians

✓ Lack of urgency in life-saving decisions

Panesar SS, et al. Resuscitation 2014

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Team Leader
  - ✓ Ensure delivery of adequate compressions
  - ✓ Minimize interruptions
  - ✓ Avoid excessive ventilation

Kleinman ME, et al. Circulation 2015

The Perfect Code

- Take Charge!
  - ✓ Direct all components of resuscitation
  - ✓ Assign tasks
  - ✓ Communicate clearly
  - ✓ Be decisive

Deficits in leadership can cost lives!

The Perfect Code

- Team Leadership
- Hemodynamic-Directed Resuscitation
- High-Quality CPR
- Early Defibrillation
- Medications?

CPP

- Survival dependent upon restoring myocardial blood flow
- CPP is the driving force
- CPP = Aortic DBP - RAP

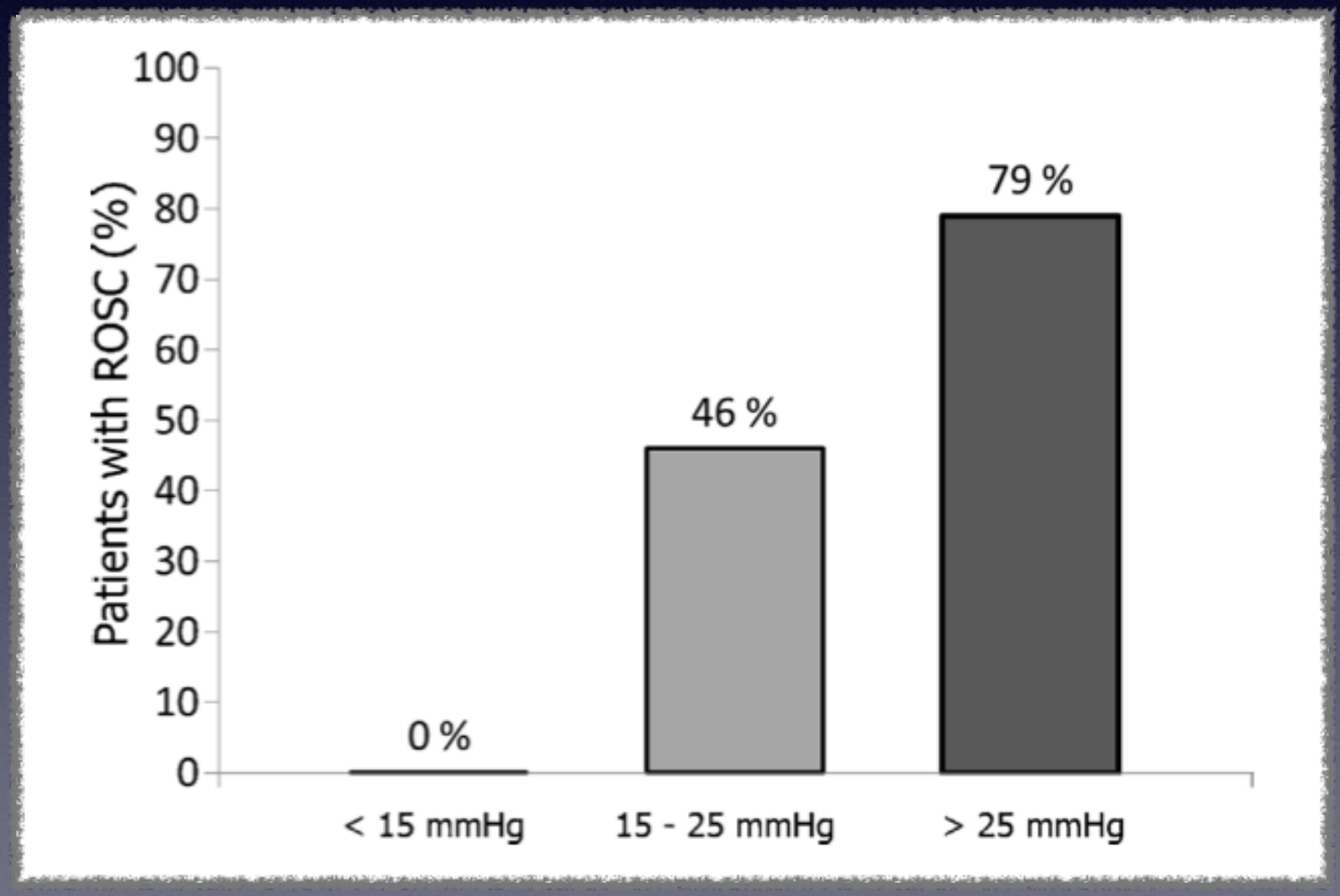
Sutton RM, et al. Resuscitation 2014

CPP

- *Kern KB, et al. Resuscitation 1988*
  - Animal data
  - Failure to obtain a CPP of 20 mm Hg predicted poor survival

CPP

- *Paradis NA, et al. JAMA 1990*



Systematic review and meta-analysis of hemodynamic-directed feedback during cardiopulmonary resuscitation in cardiac arrest☆

- Meta-analysis
- Examine evidence on use of physiologic monitoring to guide CPR

Chopra AS, et al. Resuscitation. 2016

Systematic review and meta-analysis of hemodynamic-directed feedback during cardiopulmonary resuscitation in cardiac arrest☆

- 6 Studies - ROSC
  - ✓ Hemodynamic-directed group: 73.3%
  - ✓ Control group: 63.3%

Chopra AS, et al. Resuscitation. 2016

Systematic review and meta-analysis of hemodynamic-directed feedback during cardiopulmonary resuscitation in cardiac arrest☆

- 6 Studies - Survival
  - ✓ Hemodynamic-directed group: 94.6%
  - ✓ Control group: 34.3%

Chopra AS, et al. Resuscitation. 2016

CPP

- Currently NO prospective human trials
- Optimal CPP target unknown

Cardiopulmonary Resuscitation Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital

A Consensus Statement From the American Heart Association

Endorsed by the American College of Emergency Physicians and the Society of Critical Care Medicine

✓ Target CPP > 20 mm Hg

Meaney PA, et al. Circulation 2013

Cardiopulmonary Resuscitation Quality:
Improving Cardiac Resuscitation Outcomes
Both Inside and Outside the Hospital

A Consensus Statement From the American Heart Association

Endorsed by the American College of Emergency Physicians and the Society of Critical Care Medicine

1. Arterial line + central venous line
   - Target CPP > 20 mm Hg

Meaney PA, et al. Circulation 2013

Cardiopulmonary Resuscitation Quality:
Improving Cardiac Resuscitation Outcomes
Both Inside and Outside the Hospital

A Consensus Statement From the American Heart Association

Endorsed by the American College of Emergency Physicians and the Society of Critical Care Medicine

2. Arterial line

- Target DBP > 25 mm Hg

Meaney PA, et al. Circulation 2013

Cardiopulmonary Resuscitation Quality:
Improving Cardiac Resuscitation Outcomes
Both Inside and Outside the Hospital

A Consensus Statement From the American Heart Association

Endorsed by the American College of Emergency Physicians and the Society of Critical Care Medicine

3. Capnography

- Target $ETCO_2$ > 20 mm Hg

Meaney PA, et al. Circulation 2013

Part 7: Adult Advanced Cardiovascular Life Support
2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Mark S. Link, Chair; Lauren C. Berkow; Peter J. Kudenchuk; Henry R. Halperin; Erik P. Hess;

✓ "Reasonable to use physiologic parameters ($ETCO_2$, arterial diastolic pressure, arterial pressure monitoring) to monitor and optimize CPR quality, guide vasopressor use, and detect ROSC"

Link MS, et al. Circulation 2015

The Perfect Code

- Target CPP > 20 mm Hg
  - ✓ $ETCO_2$
  - ✓ Arterial line for DBP

The Perfect Code

- Team Leadership
- High-Quality CPR
- Early Defibrillation
- Medications

High-Quality CPR

- Providers
  - ✓ Too slow
  - ✓ Too shallow
  - ✓ Do not allow for complete recoil

Meaney PA, et al. Circulation 2013

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Rate
- Depth
- Chest recoil
- Leaning
- Chest compression fraction

Kleinman ME, et al. Circulation 2015

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Rate: 100 - 120/min
- Depth
- Chest recoil
- Leaning
- Chest compression fraction

Kleinman ME, et al. Circulation 2015

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Rate: 100 - 120/min
- Depth: 5-6 cm (2-2.4 inches)
- Chest recoil
- Leaning
- Chest compression fraction

Kleinman ME, et al. Circulation 2015

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Rate: 100 - 120/min
- Depth: 5-6 cm (2-2.4 inches)
- Allow full chest recoil
  - ✓ Creates relative negative intrathoracic pressure
  - ✓ Promotes venous return

Kleinman ME, et al. Circulation 2015

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Rate: 100 - 120/min
- Depth: 5-6 cm (2-2.4 inches)
- Allow full chest recoil
- Avoid leaning
  - ✓ Increases RAP, decreases CPP
  - ✓ Decreases myocardial blood flow

Kleinman ME, et al. Circulation 2015

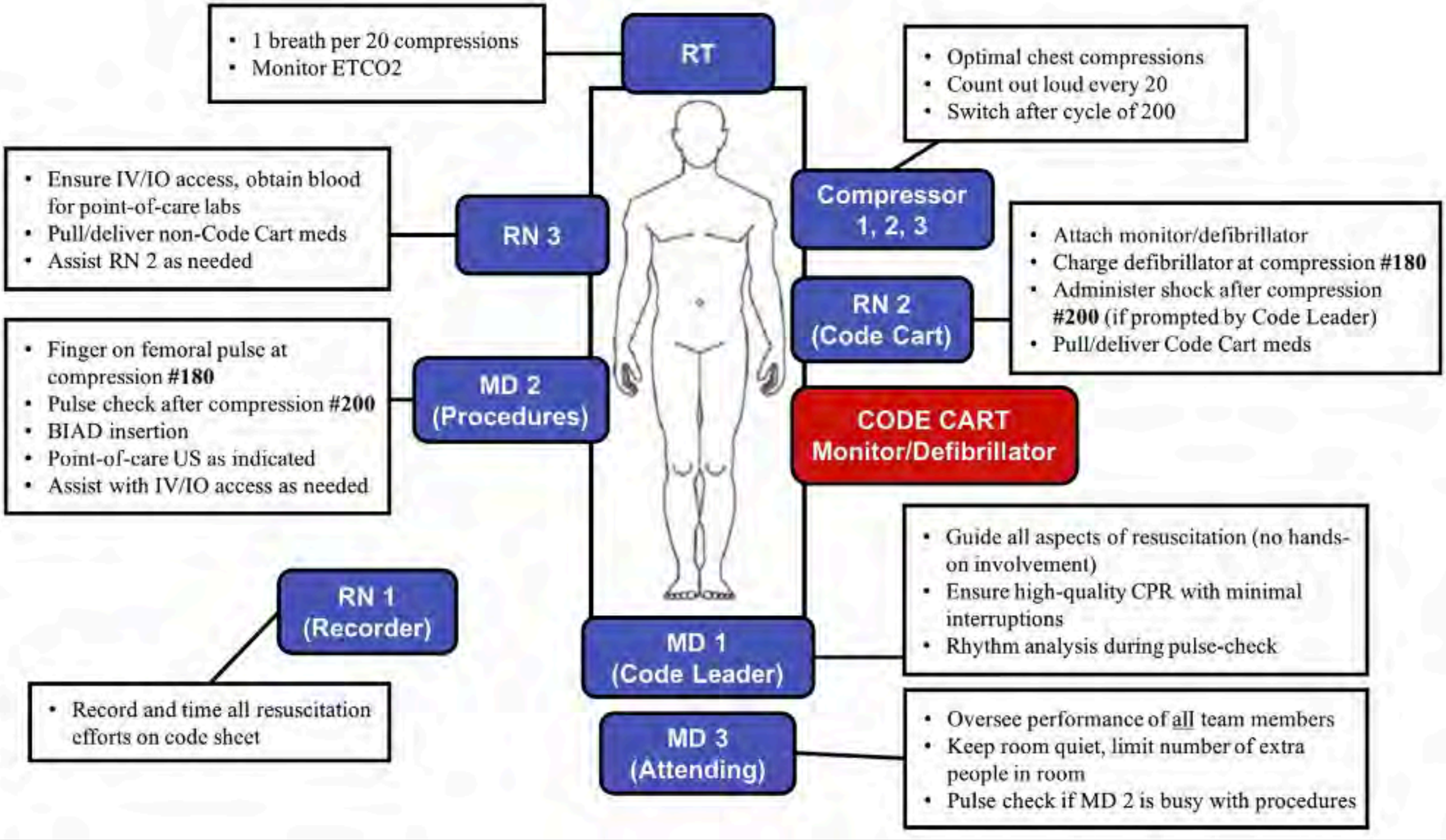
Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- Rate: 100 - 120/min
- Depth: 5-6 cm (2-2.4 inches)
- Allow full chest recoil
- Avoid leaning
- Chest compression fraction: > 60%

Kleinman ME, et al. Circulation 2015


GEICO
GEICO
GEICO



Johnson B, et al. J Emerg Med. 2018

Comparison of team-focused CPR vs standard CPR in resuscitation from out-of-hospital cardiac arrest: Results from a statewide quality improvement initiative☆

- Retrospective cohort
- North Carolina EMS Agencies - CARES
- Determine whether TF-CPR improves survival with good neurologic outcome compared with standard CPR

Pearson DA, et al. Resuscitation 2016

Comparison of team-focused CPR vs standard CPR in resuscitation from out-of-hospital cardiac arrest: Results from a statewide quality improvement initiative☆

- 14,129 Patients - Survival to Hospital DC
  - ✓ TF-CPR: 11.5%
  - ✓ Standard CPR: 7.3%

Pearson DA, et al. Resuscitation 2016

Comparison of team-focused CPR vs standard CPR in resuscitation from out-of-hospital cardiac arrest: Results from a statewide quality improvement initiative☆

- 14,129 Patients - Good Neuro Outcome
  - ✓ TF-CPR: 8.3%
  - ✓ Standard CPR: 4.8%

Pearson DA, et al. Resuscitation 2016

High-Quality CPR

- Minimize Interruptions
  - ✓ Airway
  - ✓ Peri-shock pauses
  - ✓ Pulse Checks - ETCO2
  - ✓ Ultrasound

Clinical paper

Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions☆

- Prospective cohort
- Single, tertiary, academic ED
- Determine impact of POCUS during CPR on duration of pulse checks

Huis in't Veld, et al. Resuscitation 2017

Clinical paper

Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions☆

- Patients
  - ✓ Adults ≥18 years of age
  - ✓ Cardiac arrest in ED or field
  - ✓ Placed into video-taped resuscitation rooms

Huis in't Veld, et al. Resuscitation 2017

Clinical paper

Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions☆

- Primary Outcome
  - ✓ Duration of pulse checks with POCUS

Huis in't Veld, et al. Resuscitation 2017

Clinical paper

Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions☆

- Results
  - ✓ 23 patients
  - ✓ 123 total pulse checks
  - ✓ Duration of pulse checks w/o POCUS: 13 secs

Huis in't Veld, et al. Resuscitation 2017

Clinical paper

Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions☆

- Results
  - ✓ 23 patients
  - ✓ 123 total pulse checks
  - ✓ Duration of pulse checks w/o POCUS: 13 secs
  - ✓ Duration of pulse checks w/ POCUS: 21 secs

Huis in't Veld, et al. Resuscitation 2017

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- Prospective, cohort study
- Single center, urban ED
- Evaluate if POCUS use in cardiac arrest is associated with CPR pause duration

Clattenburg EJ, et al. Resuscitation 2018

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- Patients
  - ✓ All patients presenting to ED in CA or experiencing CA in the ED
  - ✓ Excluded: trauma, patients with ROSC prior to ED arrival, and no video recording

Clattenburg EJ, et al. Resuscitation 2018

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- Primary Outcome
  - ✓ Difference in CPR duration when POCUS was and was not performed

Clattenburg EJ, et al. Resuscitation 2018

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- Results
  - ✓ 107 cardiac arrest
  - ✓ 24 had video recordings
  - ✓ Mean CPR pauses with POCUS: 19.3 seconds
  - ✓ Mean CPR pauses without POCUS: 14.2 seconds

Clattenburg EJ, et al. Resuscitation 2018

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- Results
  - ✓ 107 cardiac arrest
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Clattenburg EJ, et al. Resuscitation 2018

The Perfect Code

- Team-Focused CPR
  - ✓ Improves survival with good neurologic outcome in OHCA

The Perfect Code

- Team Leadership
- High-Quality CPR
- Early Defibrillation
- Medications?

The Perfect Code

- Team Leadership
- High-Quality CPR
- Early Defibrillation
- Medications?

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Multicenter, randomized, double-blind, placebo-controlled trial

- 5 National Health Service EMS services in UK

- Determine whether epinephrine is beneficial or harmful in OHCA

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Patients
  - ✓ Adults with OHCA
  - ✓ ALS provided by trial-trained paramedics

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Randomization & Treatment
  - ✓ Given epi or saline if initial attempts at resus (CPR, defibrillation) unsuccessful
  - ✓ Single dose every 3 to 5 minutes
  - ✓ Continued until ROSC, resus discontinued, or care transferred to hospital clinicians

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Primary Outcome
  - ✓ 30-day survival

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- 8014 Patients
  - ✓ Epi group: 4015 patients
  - ✓ Placebo group: 3999 patients
  - ✓ 20% had shockable rhythm
  - ✓ Mostly medical arrests
  - ✓ 59% received bystander CPR

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Results
  - ✓ Median time from call to EMS arrival: 6.6 min
  - ✓ Median time from arrival to agent admin: 13.8 min
  - ✓ Mean drug doses: 5
  - ✓ Pre-hospital ROSC: 36.3% vs. 11.7%

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- 30-day Survival
  - ✓ Epi group: 3.2%
  - ✓ Placebo group: 2.4%
  - ✓ p=0.02
  - ✓ NNT with Epi to prevent one death: 112

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Survival to DC with Favorable Neurologic Outcome
  - ✓ Epi group: 2.2%
  - ✓ Placebo group: 1.9%

Perkins GD, et al. NEJM. 2018

A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest

- Severe Neurologic Impairment
  - ✓ Epi group: 31%
  - ✓ Placebo group: 17.8%

Perkins GD, et al. NEJM. 2018

2019 American Heart Association Focused Update on Advanced Cardiovascular Life Support: Use of Advanced Airways, Vasopressors, and Extracorporeal Cardiopulmonary Resuscitation During Cardiac Arrest

"We recommend that epinephrine be administered to patients in cardiac arrest (Class 1; LOE B-R). Reasonable to administer 1 mg every 3 to 5 minutes"

Panchal, et al. Circulation. 2019

The Perfect Code

- Epinephrine in OHCA
  - ✓ Higher 30-day survival but no difference in favorable neurologic outcome
  - ✓ More severe neurologic impairment

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Prospective, double-blind, RCT
- 55 EMS agencies at 10 North American sites
- Compare effects of amiodarone, lidocaine, and placebo after OCHA

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Patients
  - ✓ 18 years or older
  - ✓ Nontraumatic OHCA
  - ✓ Shock-refractory VF or pulseless VT

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Treatment
  - ✓ Failure of 1 or more shocks, patients got vasopressor + study drug
  - ✓ If pVT or VF persisted, additional shock + another dose of drug
  - ✓ Open-label amio or lidocaine could be used in post-arrest care

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Primary outcome
  - ✓ Survival to hospital DC

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Results
  - ✓ 3,026 patients
    - Amiodarone: 974
    - Lidocaine: 993
    - Placebo: 1059

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Survival to Hospital DC
  - ✓ Amiodarone: 24.4%
  - ✓ Lidocaine: 23.7%
  - ✓ Placebo: 21%

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Neurologic Outcome
  - ✓ Amiodarone: 18.8%
  - ✓ Lidocaine: 17.5%
  - ✓ Placebo: 16.6%

Kudenchuk PJ, et al. NEJM 2016

Amiodarone, Lidocaine, or Placebo in Out-of-Hospital Cardiac Arrest

P.J. Kudenchuk, S.P. Brown, M. Daya, T. Rea, G. Nichol, L.J. Morrison, B. Leroux,

- Bystander Witnessed Arrest
  - ✓ Amiodarone: 27.7%
  - ✓ Lidocaine: 27.8%
  - ✓ Placebo: 22.7%

Kudenchuk PJ, et al. NEJM 2016

No definitive evidence that any vasopressor agent improves long-term survival

No definitive evidence that any antiarrhythmic agent improves long-term survival

Running the Perfect Code

Michael Winters, MD
@critcareguys

Team Leadership

- Take Charge!
  - ✓ Direct all components of resuscitation
  - ✓ Assign tasks
  - ✓ Communicate clearly
  - ✓ Be decisive

High-Quality CPR

- ✓ Rate: 100 - 120/min
- ✓ Depth: 5-6 cm (2-2.4 inches)
- ✓ Allow full chest recoil
- ✓ Avoid leaning
- ✓ Chest compression fraction: > 60%

High-Quality CPR

- Team-Focused CPR
  - ✓ Improves survival with good neurologic outcome in OHCA

High-Quality CPR

- Minimize Interruptions
  - ✓ Airway
  - ✓ Peri-shock pauses
  - ✓ Pulse Checks - ETCO2
  - ✓ Ultrasound

Medications

- Epinephrine in OHCA
  - ✓ Higher 30-day survival but no difference in favorable neurologic outcome
  - ✓ More severe neurologic impairment
- Antiarrhythmics
  - ✓ No definitive evidence that any agent improves long-term survival

Thank You!

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