Impact of Pre-hospital and Emergency Care on Cardiac Arrest Outcomes

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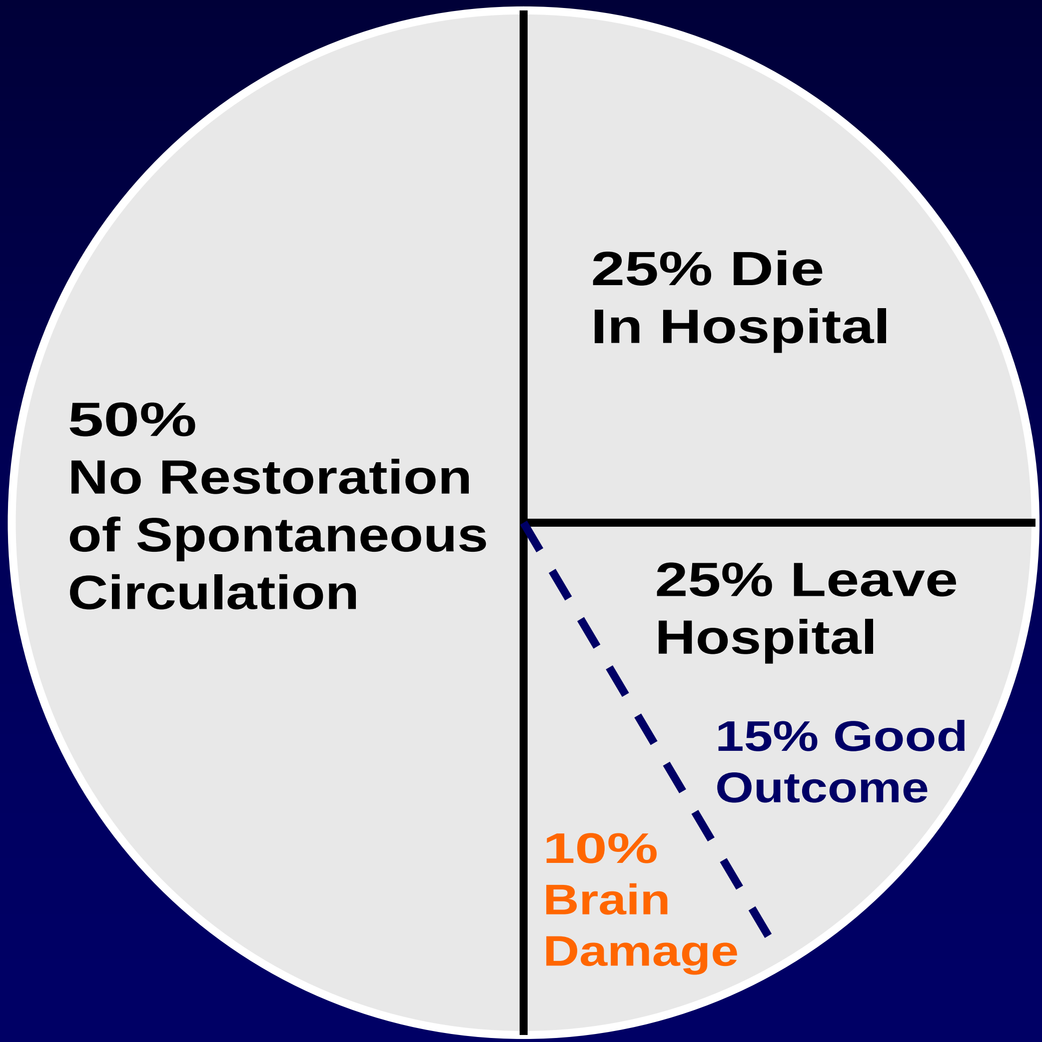
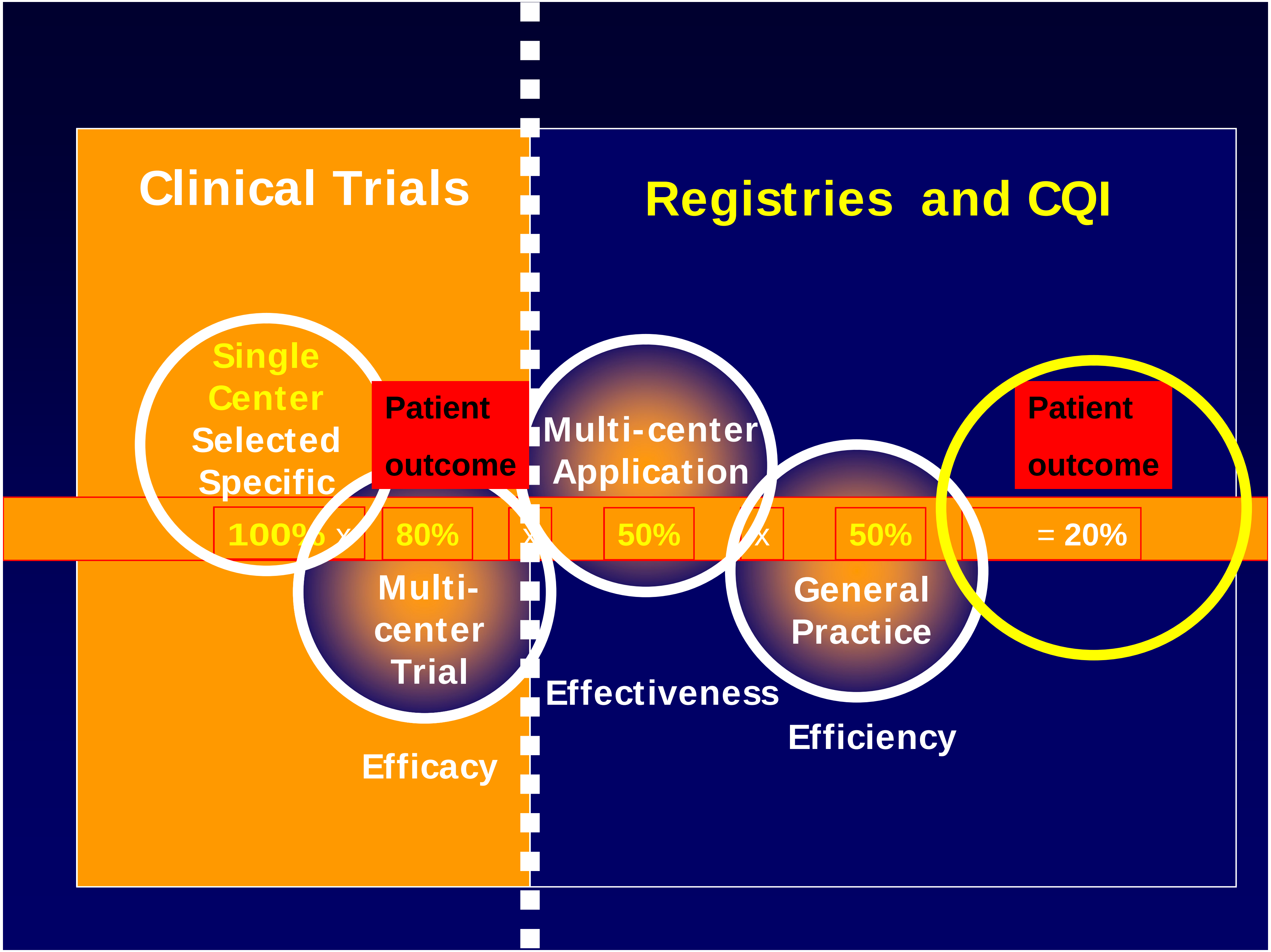
Potential Conflicts of Interest

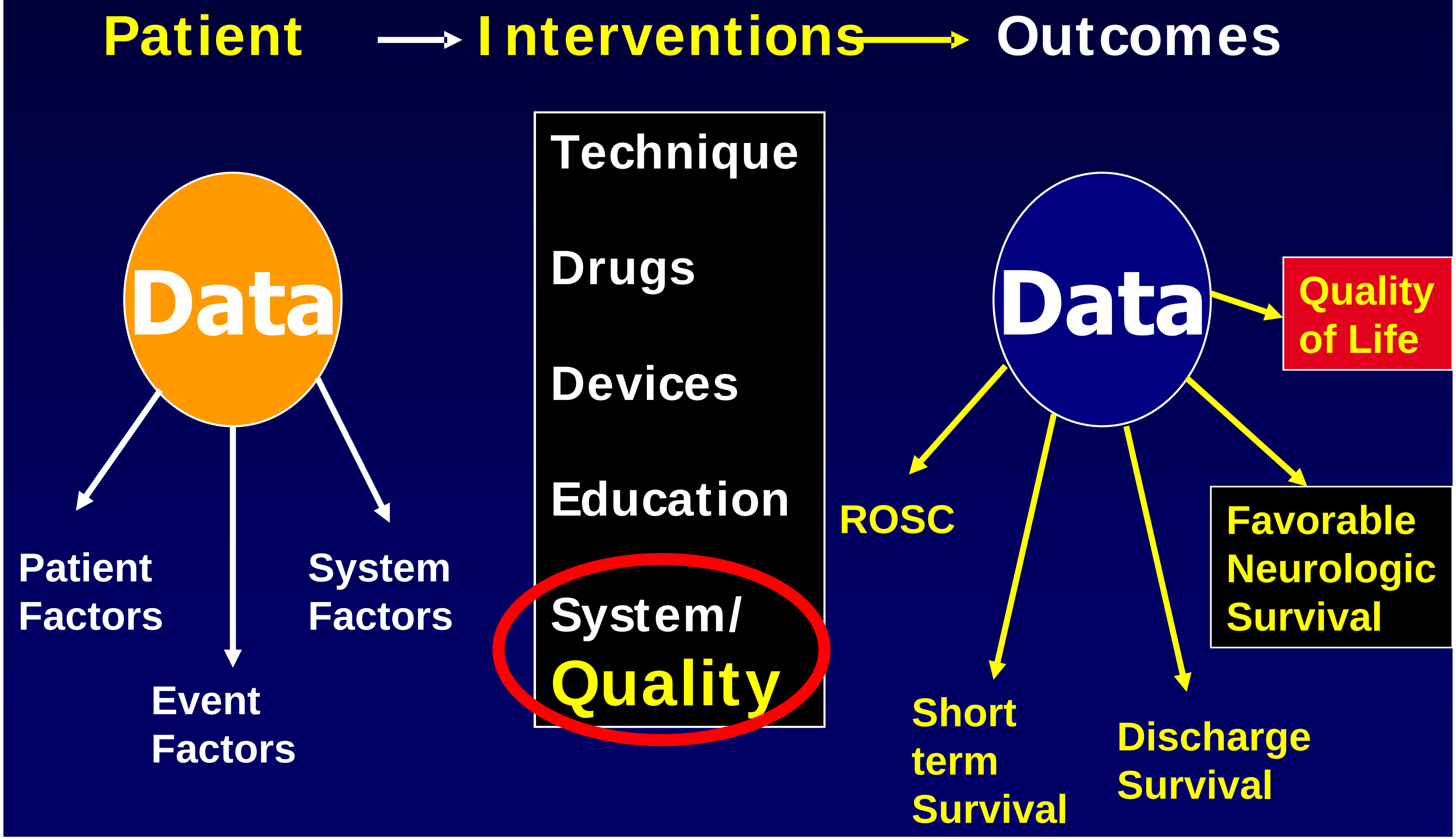
- **Employment:** **University of Pennsylvania**
- **Research Grants:**
  - **NIH/NICHD** **(Cardiac Arrest, Glucose Control)**
  - **AHRQ** **(Simulation Education)**
  - **Laerdal Foundation** **(Simulation and Resuscitation)**
  - **Medical Education Technology, Inc** **(Simulation)**
- **Science Advisory Board** **(Volunteer)**
  - **AHA National Registry of CPR**
  - **Pediatric ALI and Sepsis Investigators**
  - **World Federation of Pediatric and ICU Societies**

PRESENT PREHOSPITAL Cardiac arrest outcomes

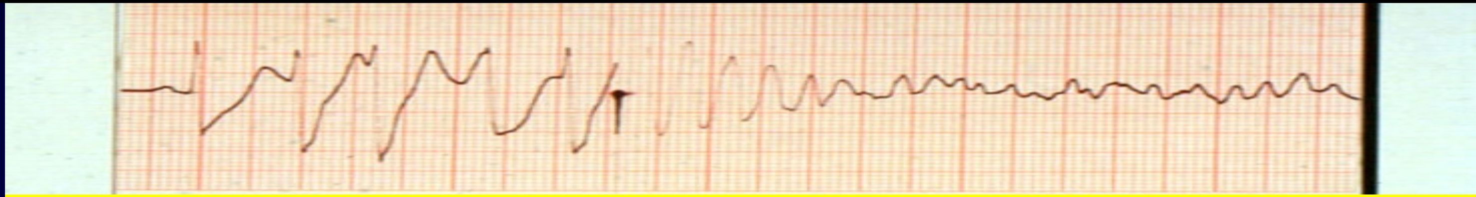



Clinical Trials
Registries and CQI
Single Center Selected Specific
Patient outcome
Multi-center Application
Patient outcome
100% x
80%
x
50%
x
50%
= 20%
Multi-center Trial
General Practice
Effectiveness
Efficiency
Efficacy

Pediatric Cardiac Arrest Process and Outcomes



Three Phases of Adult VF Cardiac Arrest

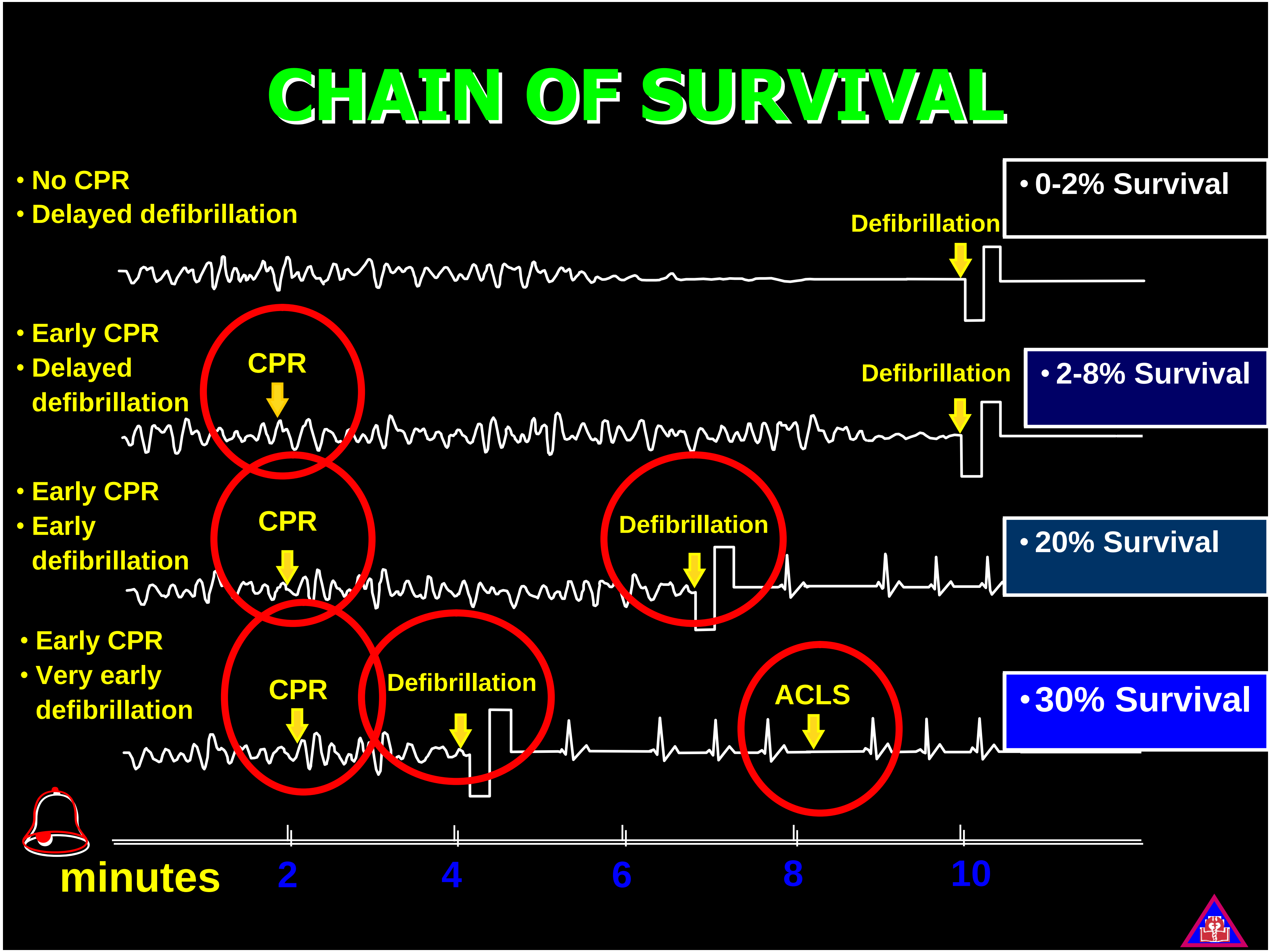


Electrical Phase (Early Defibrillation Critical)

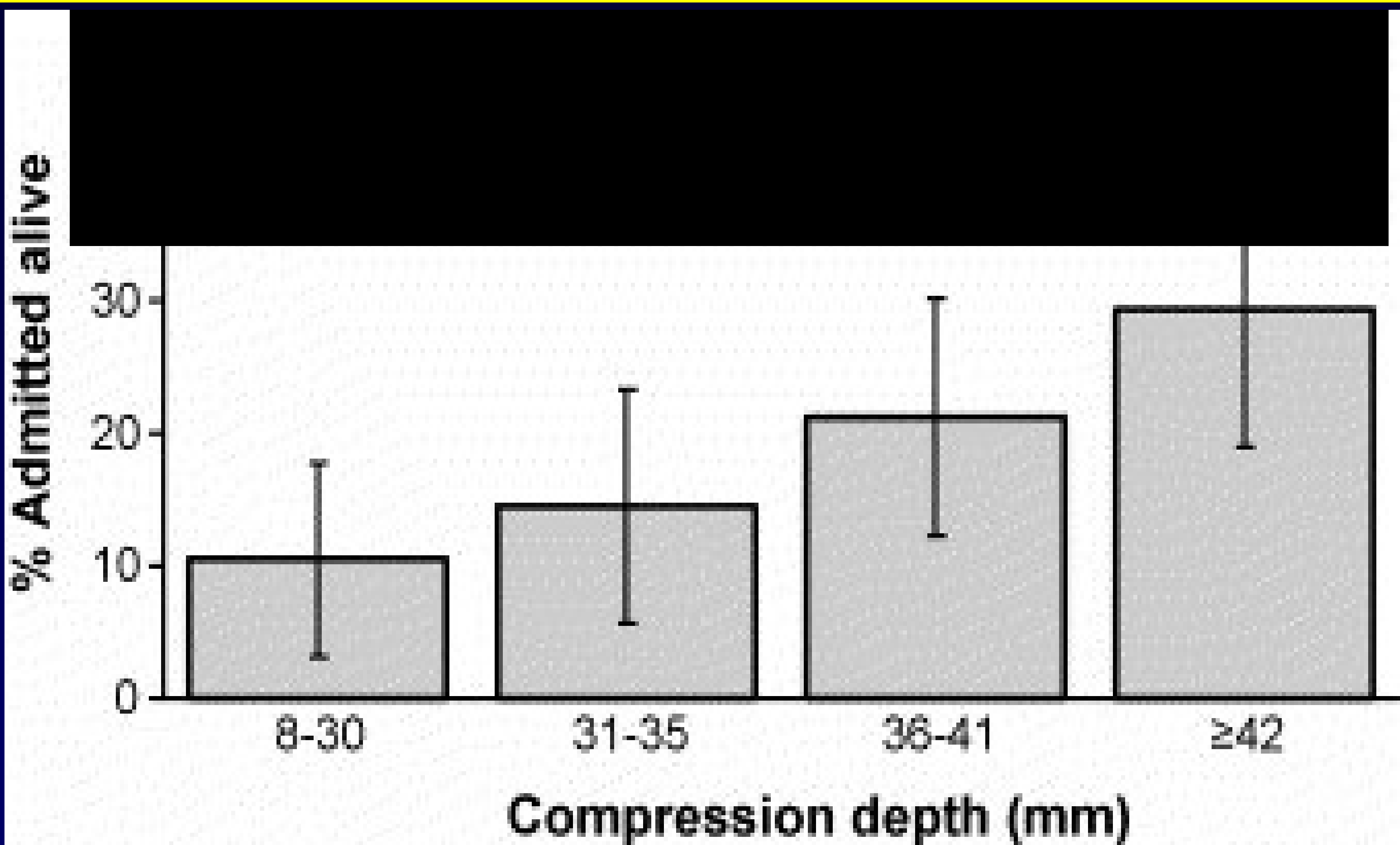
Hemodynamic Phase (Perfusion Critical)

Metabolic Phase (Newer Modalities Needed)

Becker et al. JAMA 2002;288:303

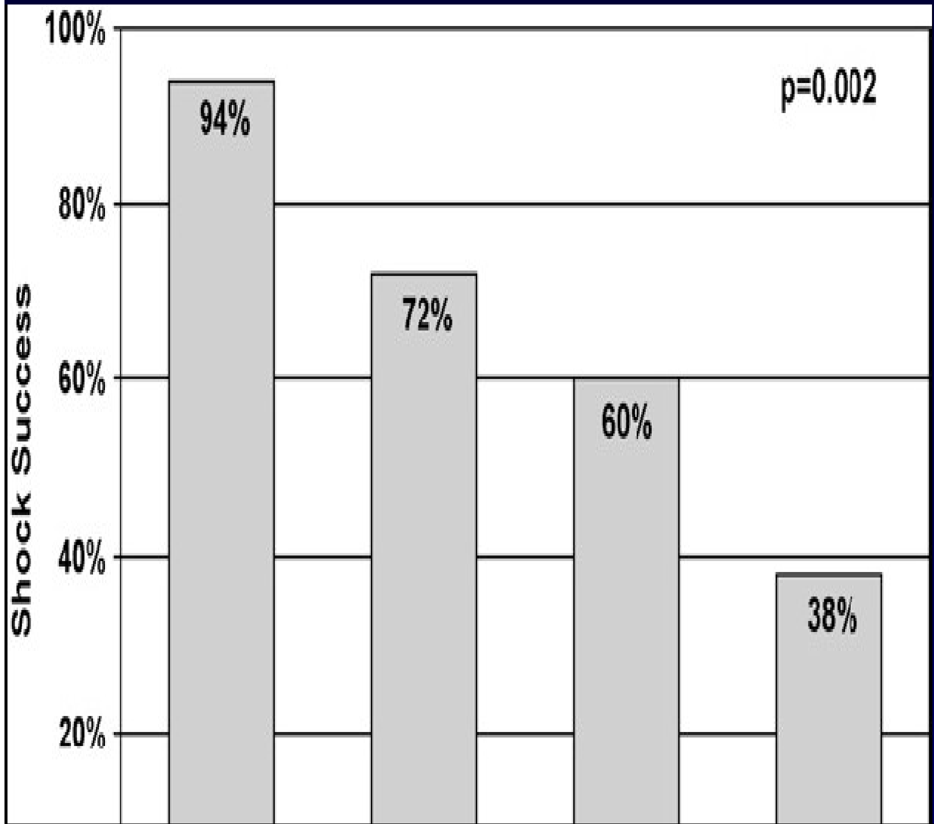

CHAIN OF SURVIVAL
• No CPR
• Delayed defibrillation
Defibrillation
• 0-2% Survival
• Early CPR
• Delayed defibrillation
CPR
Defibrillation
• 2-8% Survival
• Early CPR
• Early defibrillation
CPR
Defibrillation
• 20% Survival
• Early CPR
• Very early defibrillation
CPR
Defibrillation
ACLS
• 30% Survival
minutes
2
4
6
8
10

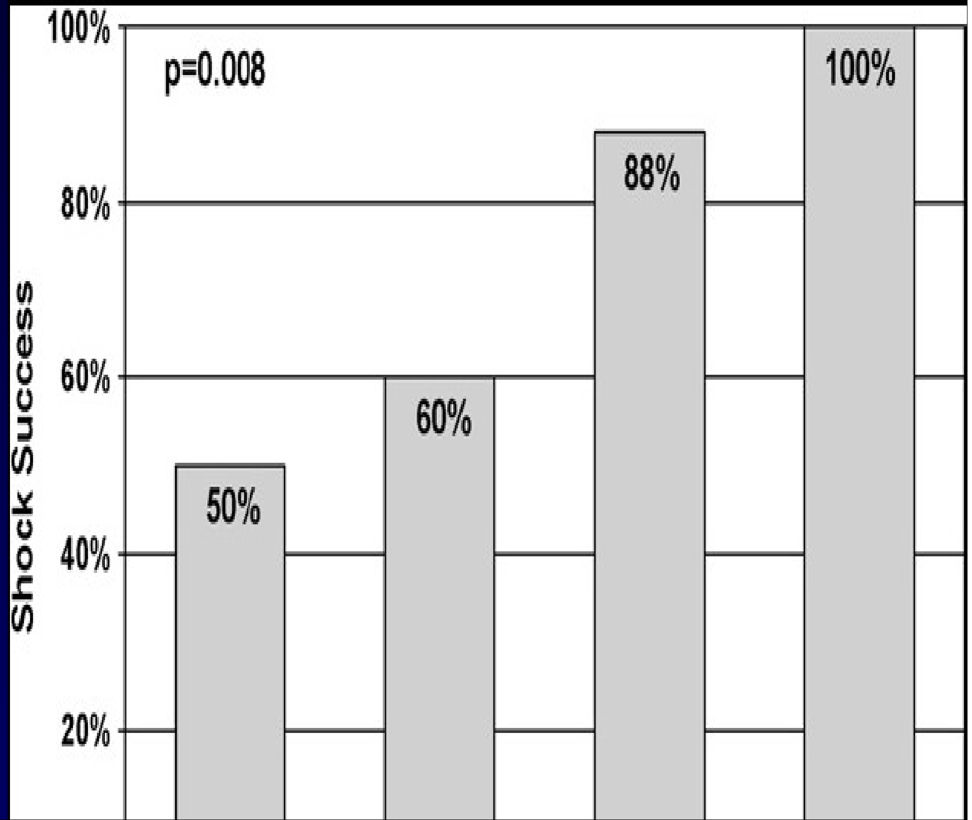
Quality CPR Improves Short Term Survival



Kramer-Johansen et. al., Resuscitation 2006

Quality CPR Improves Shock Success





[redacted]

Pre-existing conditions are different in Child vs Adult

	CHILD	ADULT
Respiratory Insufficiency	**58% ***	40%
Shock	**36% ***	27%
MI	2%	**35% ***
Diabetes	1%	**28% ***
Renal Failure	12%	**31% ***

Nadkarni et al. JAMA 2006

Event Characteristics are different in Child vs Adult

	CHILD	ADULT
Location in ICU	65% *	45%
Witnessed or monitored	95% *	88%
Witnessed & monitored	83% *	66%
Mechanical Ventilation	57% *	26%
Vasopressors	38% *	27%
Arterial Catheter	29% *	8%
Duration of CPR	25 [12,45]*	18 [10,29]

Nadkarni et al. JAMA 2006

Initial VF/VT rhythm is good

	Initial VF/ VT vs Sub VF/ VT
ROSC (> 20 min)	70% vs. 35% OR 2.8 (1.5 - 5.4)
Survival to Hospital Discharge	35% vs. 11% OR 2.9 (1.2 - 5.8)
Survival with Favorable Neurologic Outcome	33% vs. 8% OR 2.6 (1.2 - 5.8)

Samson et al. NEJM 2006

Subsequent VF/ VT rhythm is bad

	No VF/ VT vs Sub VF/ VT
ROSC (> 20 min)	51% vs 35% OR 2.1 (1.3 - 3.4)
Survival to Hospital Discharge	27% vs 11% OR 3.8 (1.8-7.6)
Survival with Favorable Neurologic Outcome	24% vs 8% OR 3.8 (1.9 - 7.7)

Samson et al. NEJM 2006

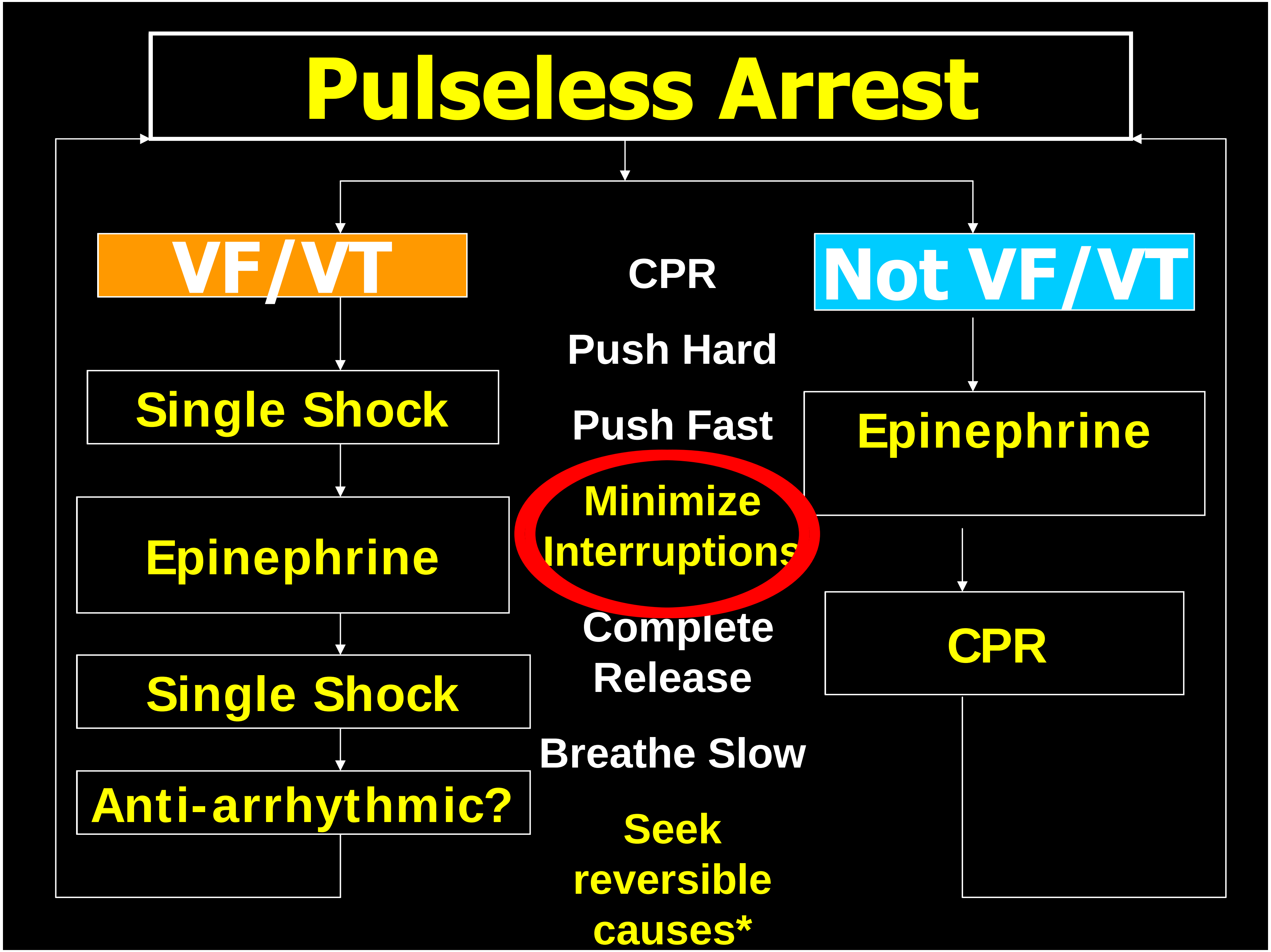
Pediatric Cardiac Arrest: Facts

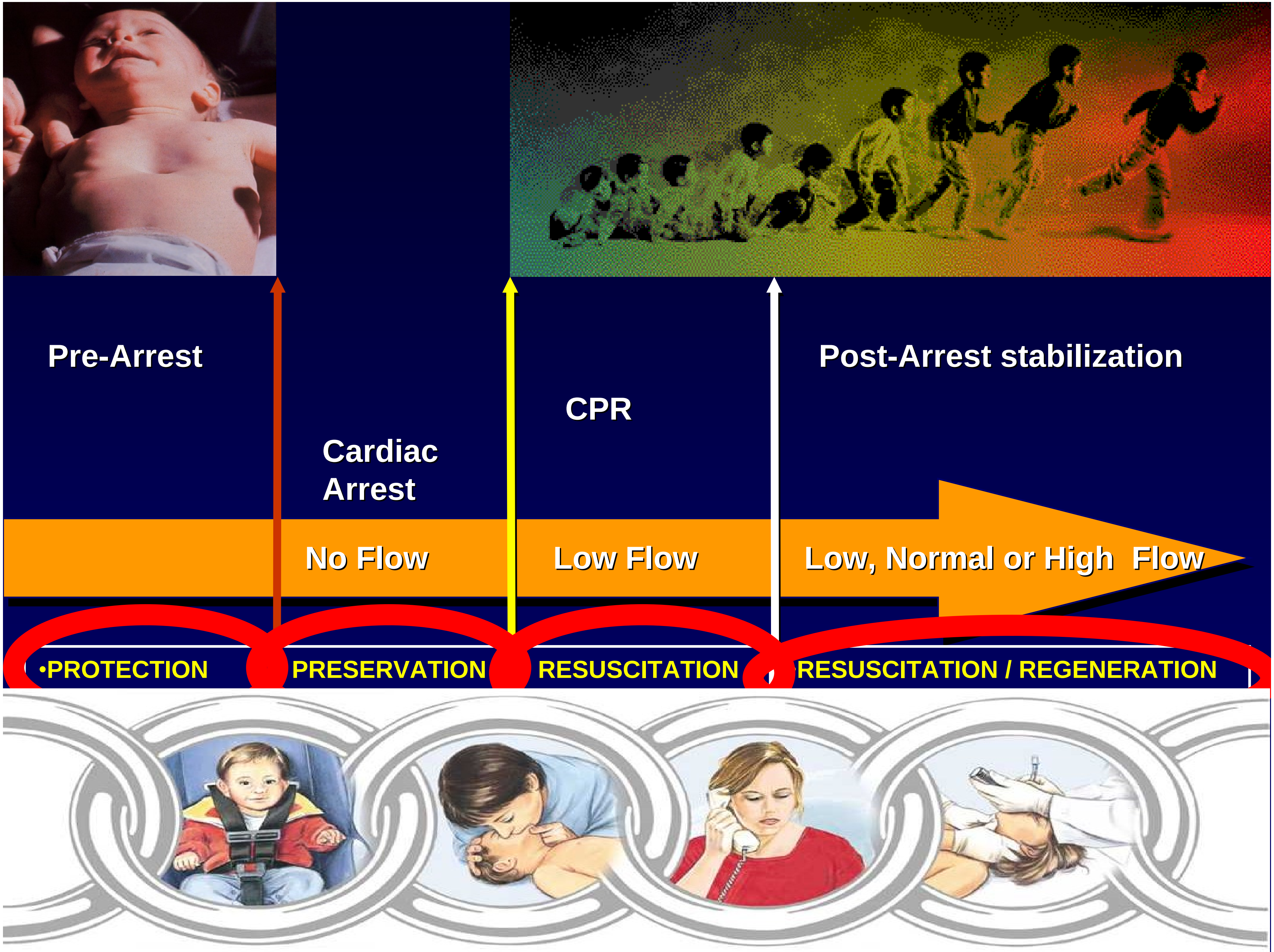
- ➔ **Out-of-hospital Pediatric Cardiac Arrest:**
  - ◆ **Respiratory Etiology**
  - ◆ **Rarely witnessed, monitored or shockable initial rhythms**

Donoghue et al. AEM 2005

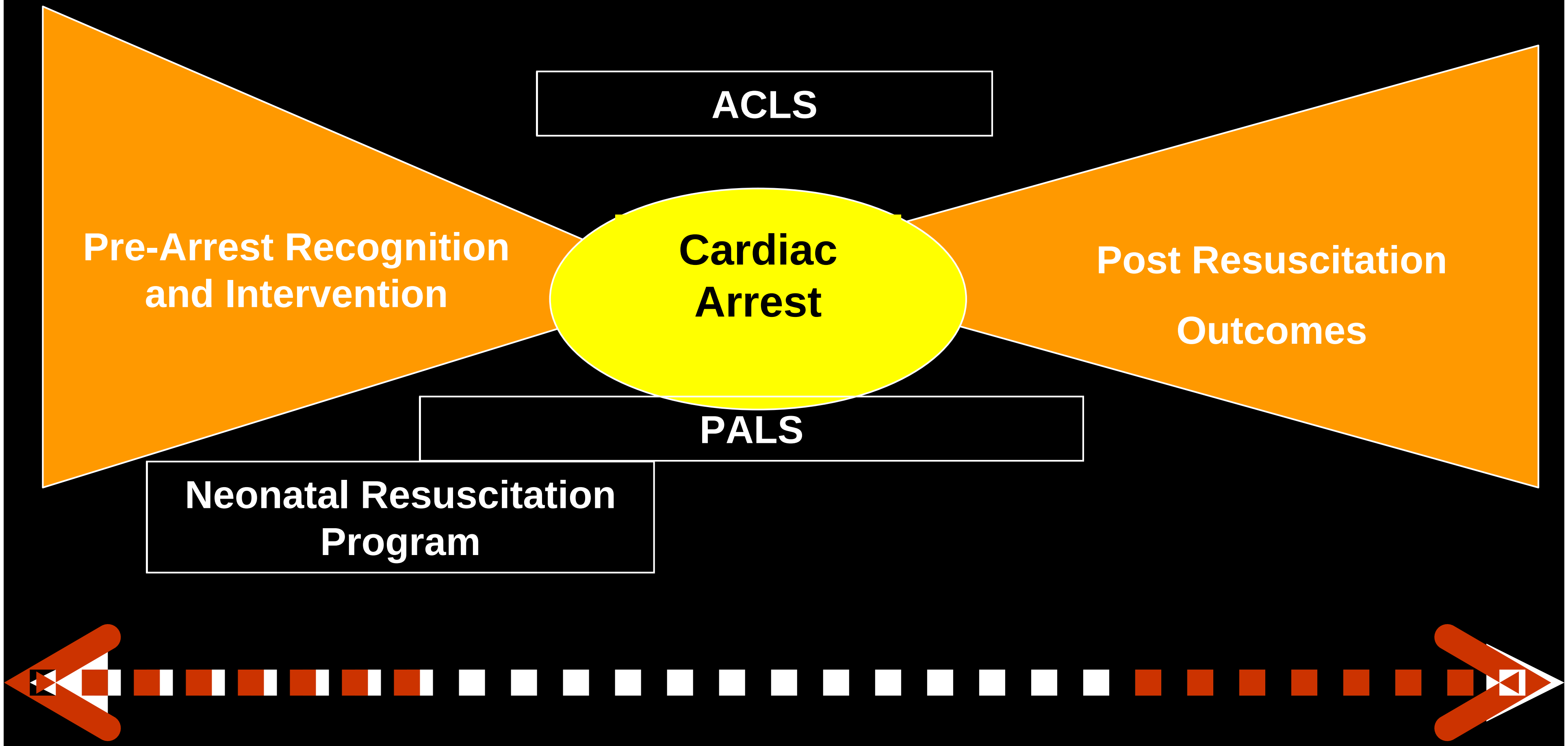
- ➔ **In-Hospital Pediatric Cardiac Arrest**
  - ◆ **Combined Respiratory/Cardiac Etiology**
  - ◆ **Complex, critically ill patients**
  - ◆ **Commonly witnessed, monitored and common shockable rhythms (14-27%)**

Nadkarni et al. JAMA 2006


Pulseless Arrest
VF/VT
Single Shock
Epinephrine
Single Shock
Anti-arrhythmic?
CPR
Push Hard
Push Fast
Minimize Interruptions
Complete Release
Breathe Slow
Seek reversible causes*
Not VF/VT
Epinephrine
CPR


Pre-Arrest
Cardiac Arrest
CPR
Post-Arrest stabilization
No Flow
Low Flow
Low, Normal or High Flow
•PROTECTION
PRESERVATION
RESUSCITATION
RESUSCITATION / REGENERATION

The "Bow Tie" Concept



What is Fact vs what is Fiction?…..

World's first successful cryonics awakening!

CORPSE FROZEN FOR 97 YEARS BROUGHT BACK TO LIFE!

ALIVE AND WELL! Clara Valston went into a deep freeze after she died in 1902.

Docs put her on ice back when Teddy Roosevelt was President

PHOTO © NORTH AMERICAN PRESS PIX

PROVIDENCE, R.I. — Doctors have revived a corpse that was frozen solid since 1902 — and restored the woman to perfect health!

By BEATRICE DEXTER
Weekly World News

That's the word from sources in a government research facility who report that the woman, 55 at the time she died of pneumonia, was successfully thawed and treated with antibiotics.

The woman lived in this city during the Victorian era. She was an eccentric who paid to have

vances could restore her to life. Refrigeration had been perfected since a few years after its invention in 1834.

"Her name was Clara Valston and she was a well-known resident of Rhode Island in the late 1800s," said one U.S. government scientist who asked that we not use his name.

"When she was revived, she has suffered no ill-effects at all from her 97 years as a frozen corpse."

The secret project involving Mrs. Valston has attracted a number of top scientists including a nationally known neurologist, a biochemist and two pulmonary specialists.

Since the woman regained her health, she has been undergoing intensive interviews with historians and psychologists.

The CIA is believed to have hidden Mrs. Valston in a rural area in the Northeast, where she is

from a long state of suspended

plications," the government

Farmer uses mouth-to-beak resuscitation to bring her frozen chicken back to life!

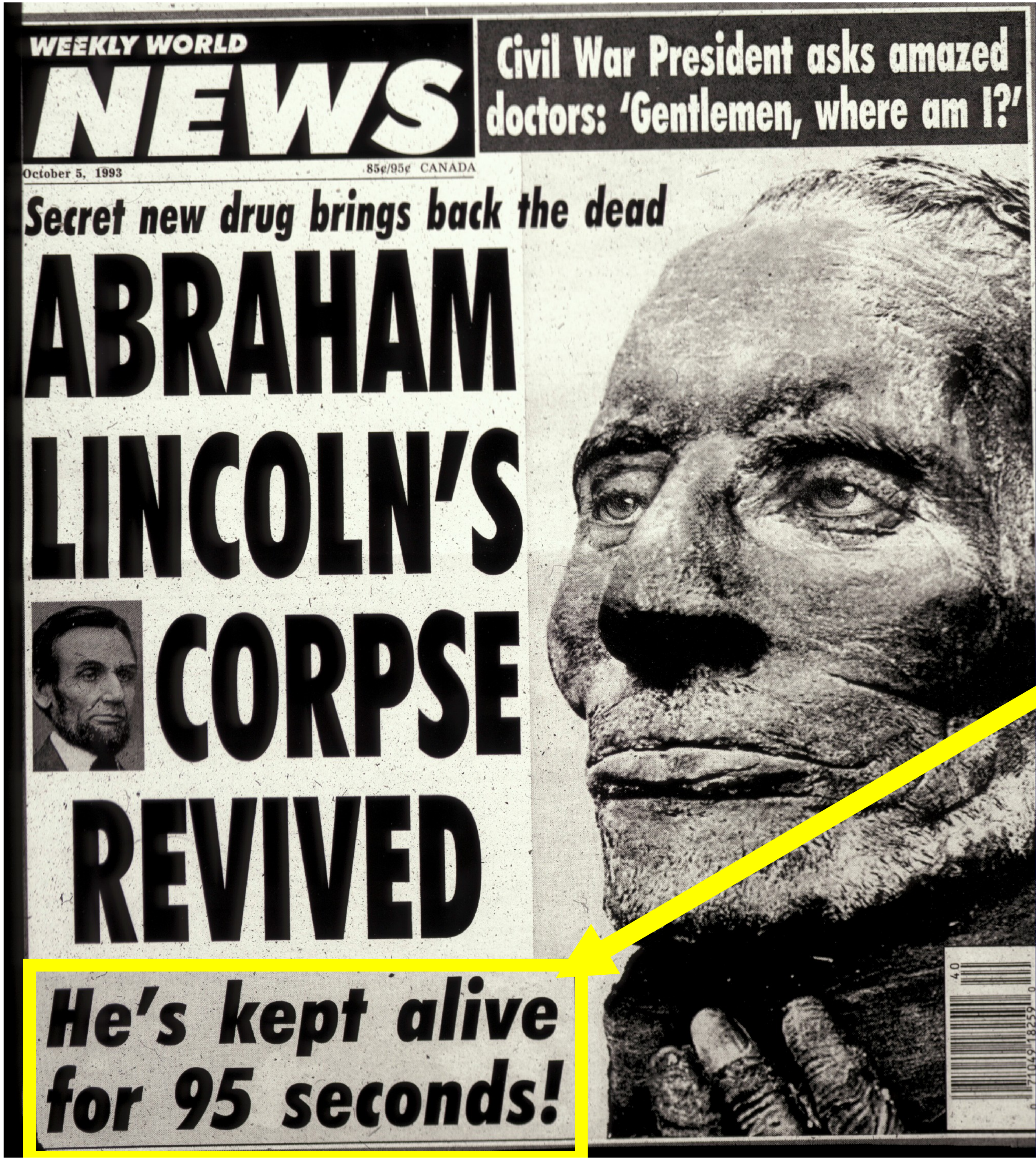
HARPSWELL, Maine — Farmer Janet Bonney found a hen frozen solid under her front porch — and revived her with heat treatments and mouth-to-beak resuscitation!

The born-again bird is up and running around again in

water bottle next to the chicken to thaw her enough for burial. A few minutes later she felt the bird's heartbeat and saw her feathered chest rise and fall. The excited farmer gave the frozen bird a few thumps on her chest and some mouth-to-beak resuscitation — and incredibly the chicken got on her feet and clucked!

The lucky bird has been named Valerie and is now a pet.

Fact: Interventions that seem to work in animals do NOT always translate to improved clinical outcomes…

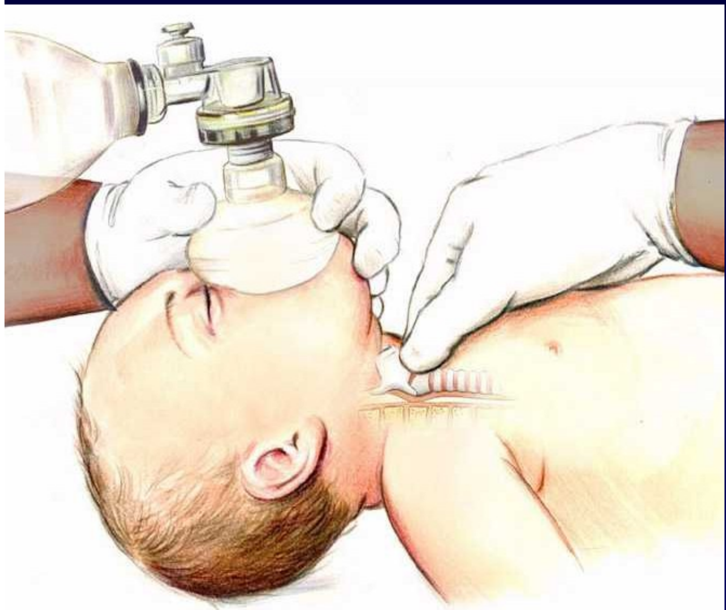


What is the relevant endpoint for resuscitation outcome?

How do we change?

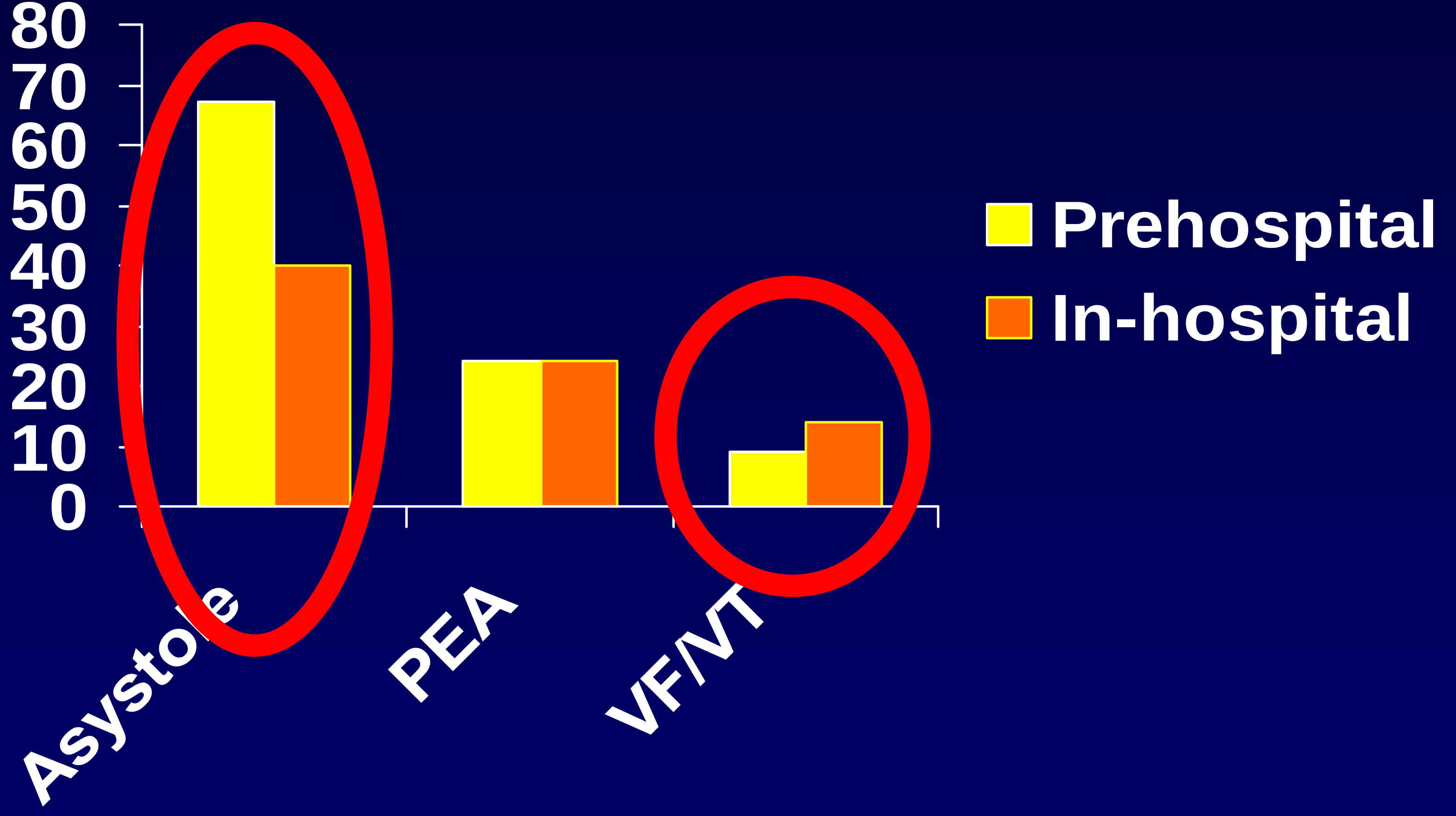
Basis for Decision	Measure	Device	Unit of measure
<u>EVIDENCE</u>	Randomized Controlled Trial	Meta-analysis	Odds Ratio
Eloquence	Smoothness of Tongue	Keynote speech	"Kissoon" unit
Vehemence	Loudness of voice	Audiometer	Decibels
Confidence	Bravado	Sweat test	No sweat

Challenges: Etiology based approach



Prehospital vs. In-Hospital

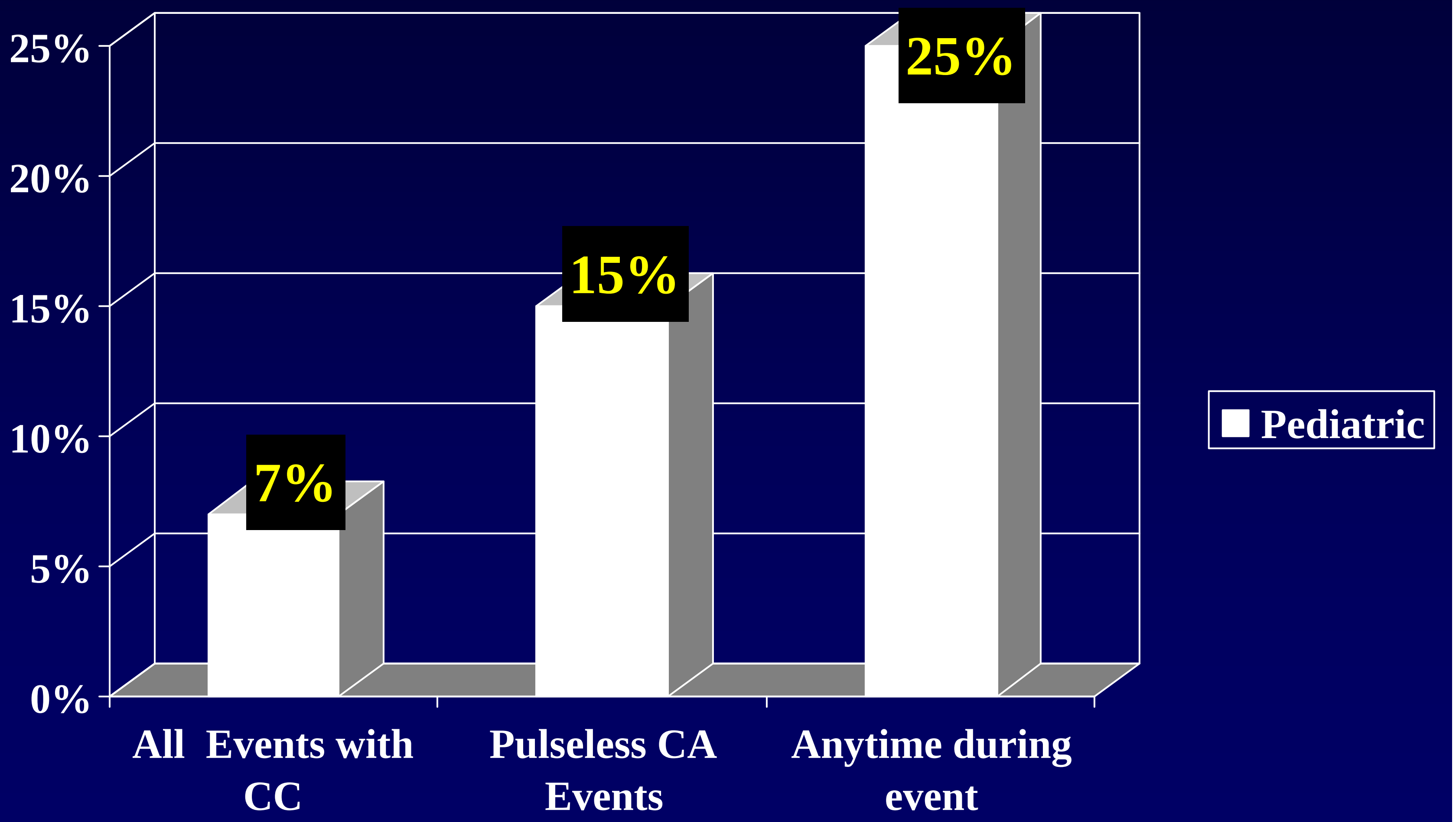
Pediatric First Documented Cardiac Arrest Rhythm



Nadkarni et al. JAMA 2006 and Young et al. Pediatrics 2004

AHA National Registry of CPR:

Shockable Rhythms in Hospitalized Children < 18 years



Samson et al NEJM 2006

Nadkarni et al JAMA 2006

Quality of Cardiopulmonary Resuscitation During In-Hospital Cardiac Arrest

Benjamin S. Abella, MD, MPhil
Jason P. Alvarado, BA
Helge Myklebust, BEng
Dana P. Edelson, MD
Anne Barry, RN, MBA
Nicholas O'Hearn, RN, MSN
Terry L. Vanden Hoek, MD
Lance B. Becker, MD

Context The survival benefit of well-performed cardiopulmonary resuscitation (CPR) is well-documented, but little objective data exist regarding actual CPR quality during cardiac arrest. Recent studies have challenged the notion that CPR is uniformly performed according to established international guidelines.

Objectives To measure multiple parameters of in-hospital CPR quality and to determine compliance with published American Heart Association and international guidelines.

Design and Setting A prospective observational study of 67 patients who experienced in-hospital cardiac arrest at the University of Chicago Hospitals, Chicago, Ill, between December 11, 2002, and April 5, 2004. Using a monitor/defibrillator with

In-hospital:

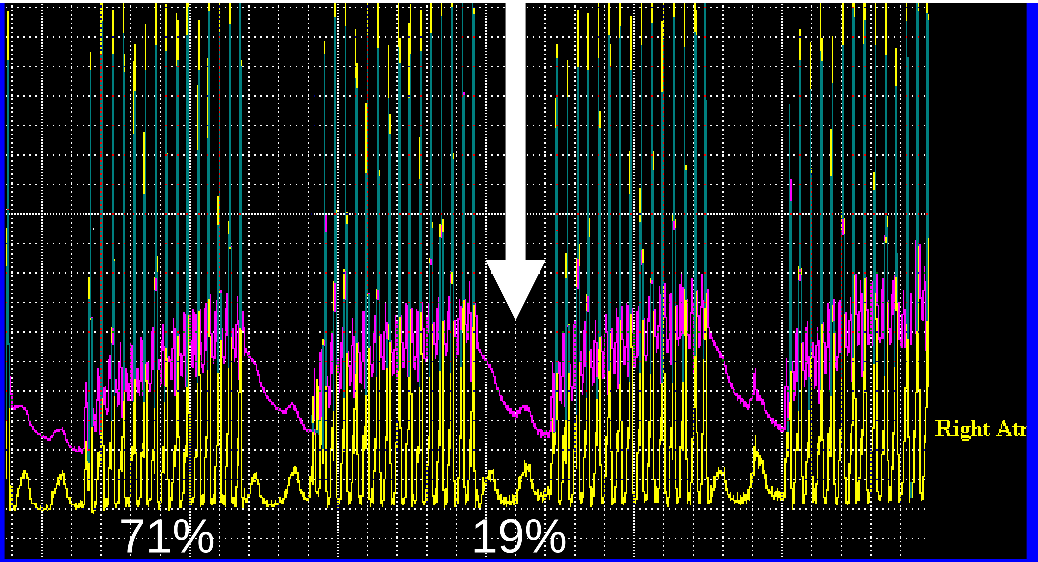
CPR was inconsistent and often did not meet published guideline recommendations… Too few compressions, too many ventilations, too many pauses.

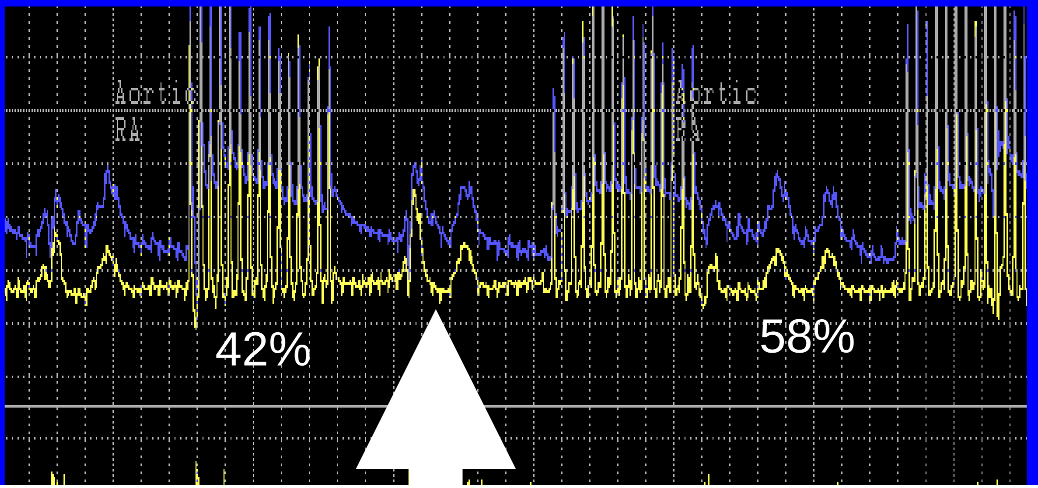
formed,[9] but the parameters of CPR in actual practice are not routinely measured, nor is the quality known.

high-quality CPR suggests the need for rescuer feedback and monitoring of CPR quality during resuscitation efforts.

JAMA. 2005;293:305-310 www.jama.com

What we SAY we do...

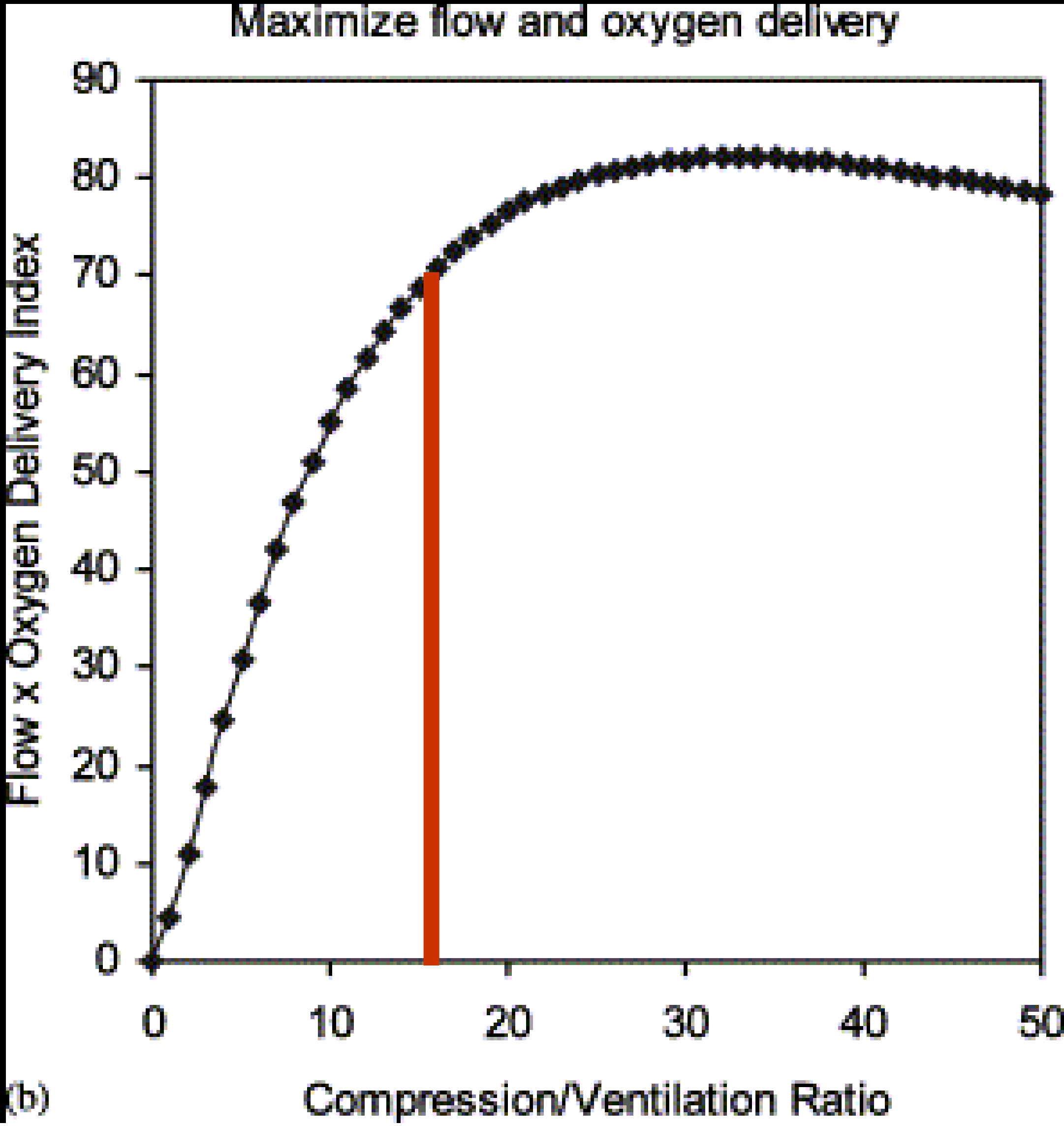




What we REALLY do...!

Maximal O2 Delivery

Lay Rescuer



Babbs, Kern 2002

Mathematical Modeling Compression : Ventilation Ratios

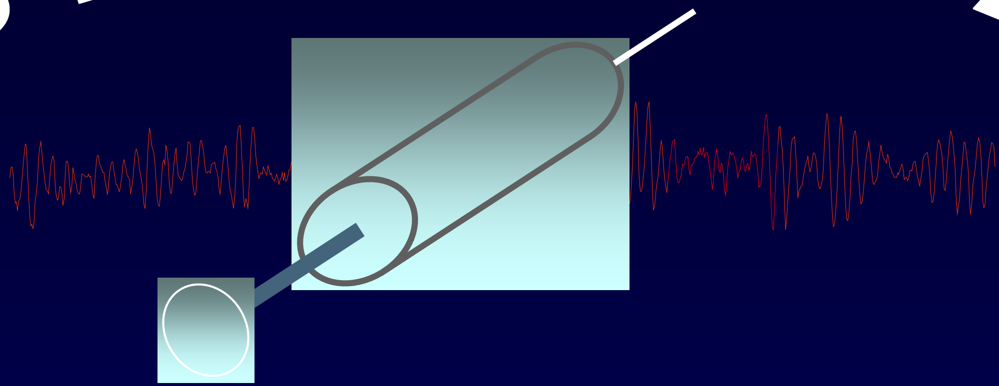
Children

- “Optimal CPR” (best systemic oxygen delivery)
- Optimal C-V ratio for:

	lay rescuers	professional
10 kg	~ 12:2	~ 12:2
20 kg	~ 24:2	~ 15:2
40 kg	~ 30:2	~ 20:2

Babbs C, Nadkarni V Resuscitation 2004

Drugs in Cardiac Arrest



Vasopressors

Adrenergic

Adrenaline
Methoxamine
Phenylephrine
Norepinephrine
Dopamine
~~Isoproterenol~~
~~Orciprenaline~~
~~Dobutamine~~

Non-Adrenergic

Angiotensin II
Endothelin-1
Vasopressin

Antiarrhythmics

Lidocaine
Amiodarone

Others

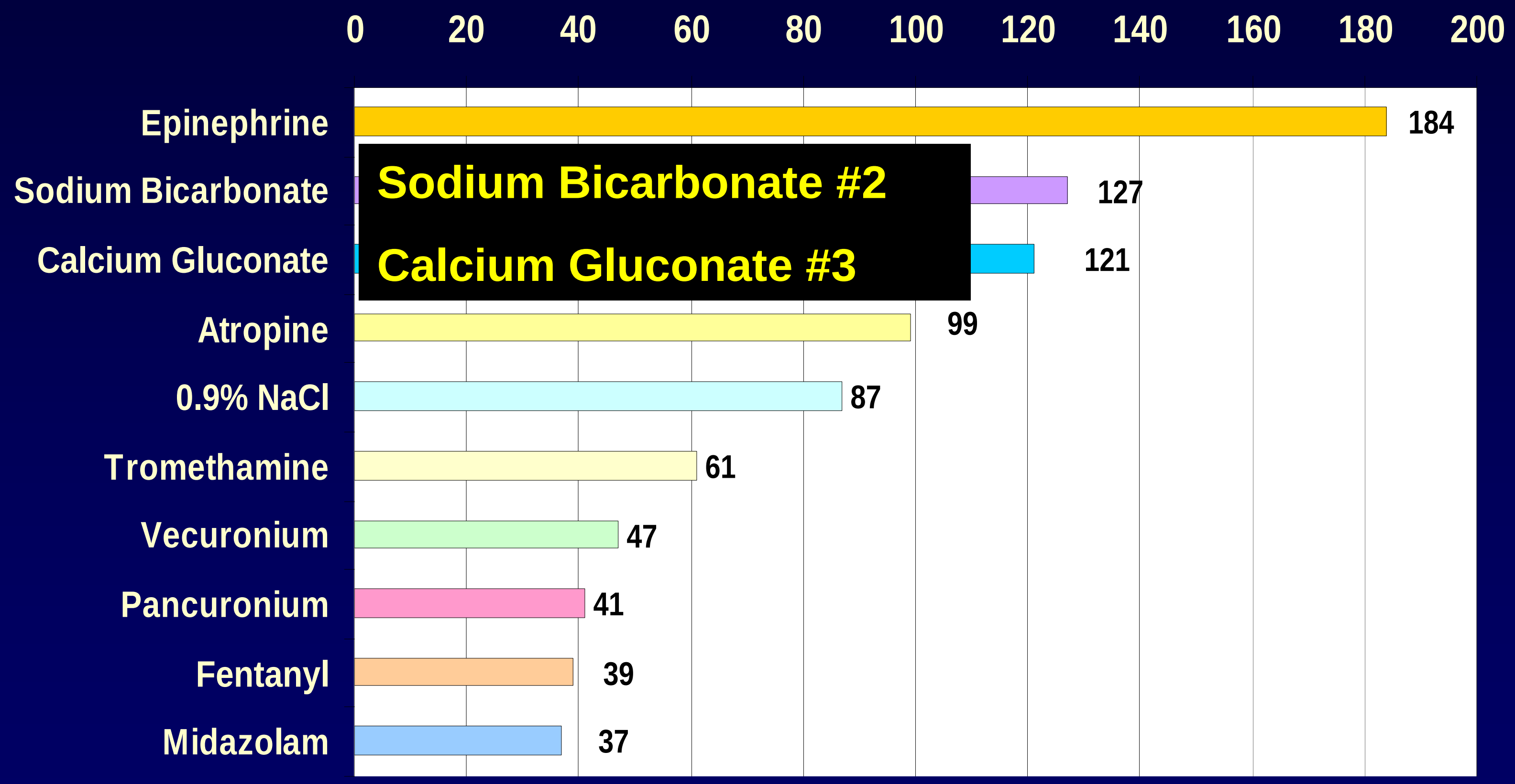
Theophylline
Atropine

Buffer

$NaHCO_3$
TRIS
Na_2CO_3
Carbicarb
Tribonate

Thrombolysis? B-Blockers? Short-acting vasoconstrictors? Chemical defibrillation? Chemical Hibernation?

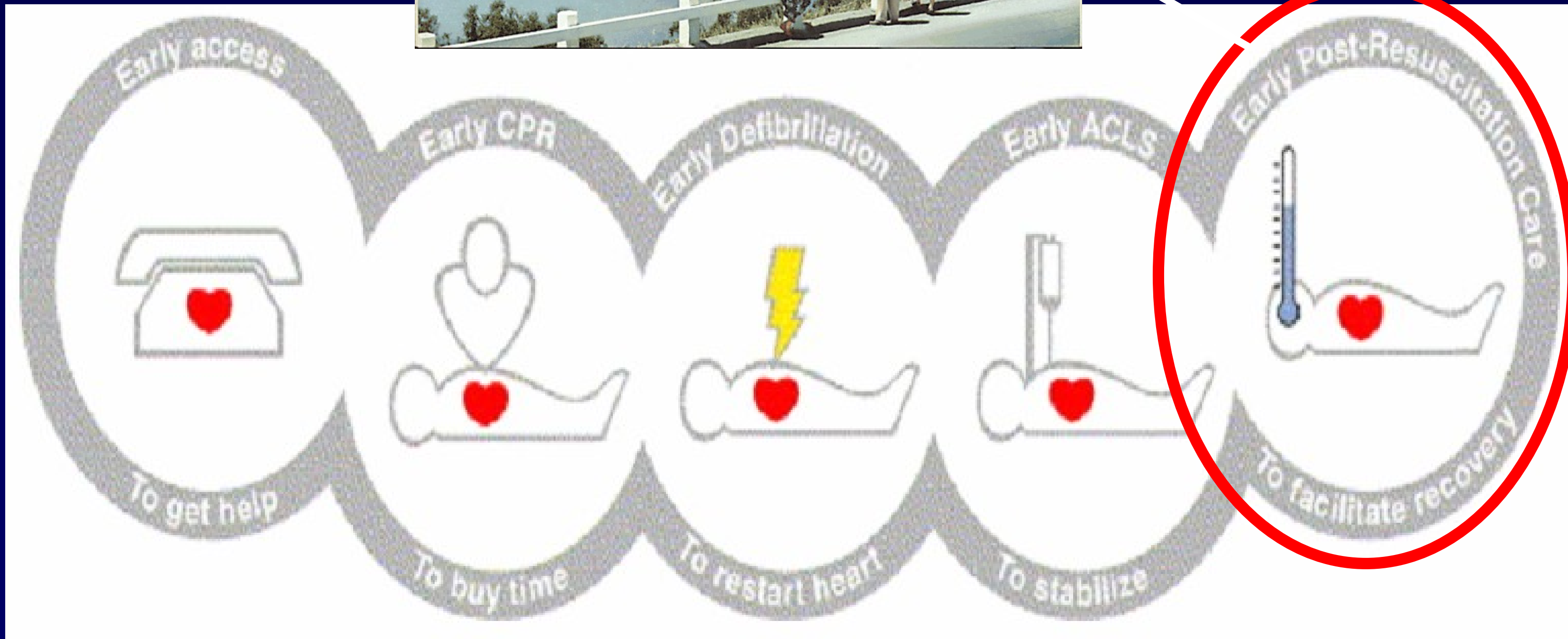
10 Most Frequently Administered Medications from the CHOP pediatric code cart



Roberts KR et al. Crit Care Med 2005: A

Improving the post cardiac arrest link in the chain of survival

Post-resuscitation care

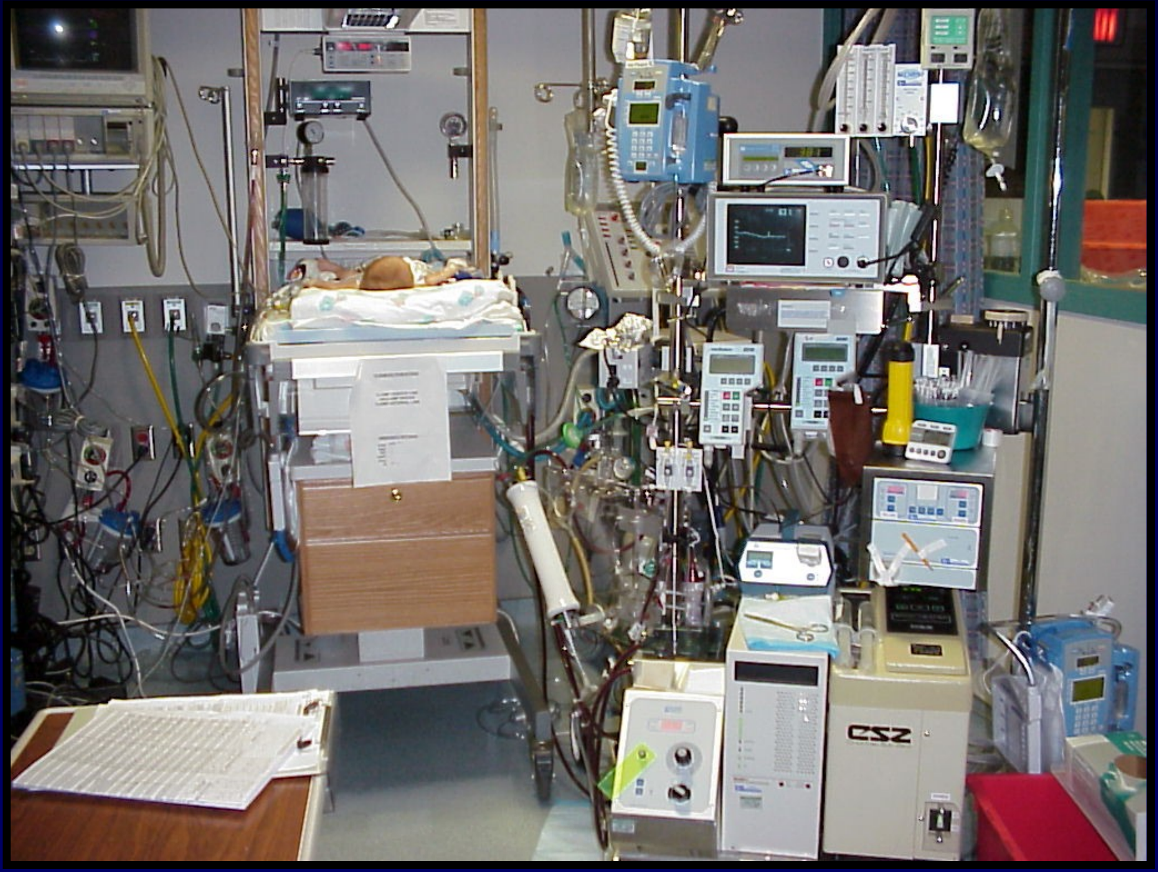


Infant undergoing Selective Hypothermia with a cooling cap

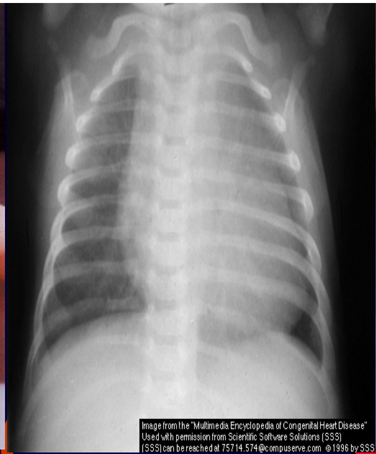
Courtesy: Dr. David Durand, Children's Hospital Oakland

Infant undergoing Total Body Cooling with a Cooling Blanket

Mechanical Support – during or After CPR



Morris M, Wernovsky G et al. CCM 2004, Morris M, Nadkarni V et al, PCCM 2004, deMos et al CCM 2006



Pre-Load	Contractility	Afterload	Heart rate and rhythm
Check the plumbing Physiology? Fluid bolus? Diuretics?	**Check the function** Contraction? Relaxation? R/o tamponade?	**Check the circuits** Systemic? Pulmonary? Shunt fxn? Pressors? Dilators?	**Check the rate and rhythm** Too fast? Too slow? Atrial kick? Pacer fxn?

ECMO for Refractory Cardiac Arrest

In-Hosp Cardiac Arrest

CPR + ALS x 10 minutes

CPR + ALS

Anti-Coagulate?

??Cold Perfusate

Endpoint?

ECMO circuit clear prime

Cannulate Neck V-A

ECMO team notified

ECMO:

Induced Hypothermia

Controlled blood flow titrated to SvO2

Standard Sedation/Monitoring

Normalize glucose, Blood Pressure, pCO2

Follow markers of Organ injury/function

Brain

- Cerebral perfusion
- Sedation
- Control of seizures
- Temperature control
- Glucose control

Gap between Training and Implementation

CHALLENGES NOTED DURING SIMULATIONS	% of Centers
Child Weight Estimates	34%
IO preparation	69%
IV Fluid Bolus	89%
Order Glucose bolus	97%

Difficulty with 25/44 (57%) C-Spine Stabilization Tasks

Simulation of C-Spine Stabilization in 35 North Carolina Emergency Departments

Hunt E et al. Pediatrics 2006

Implementing the guidelines: training and practice

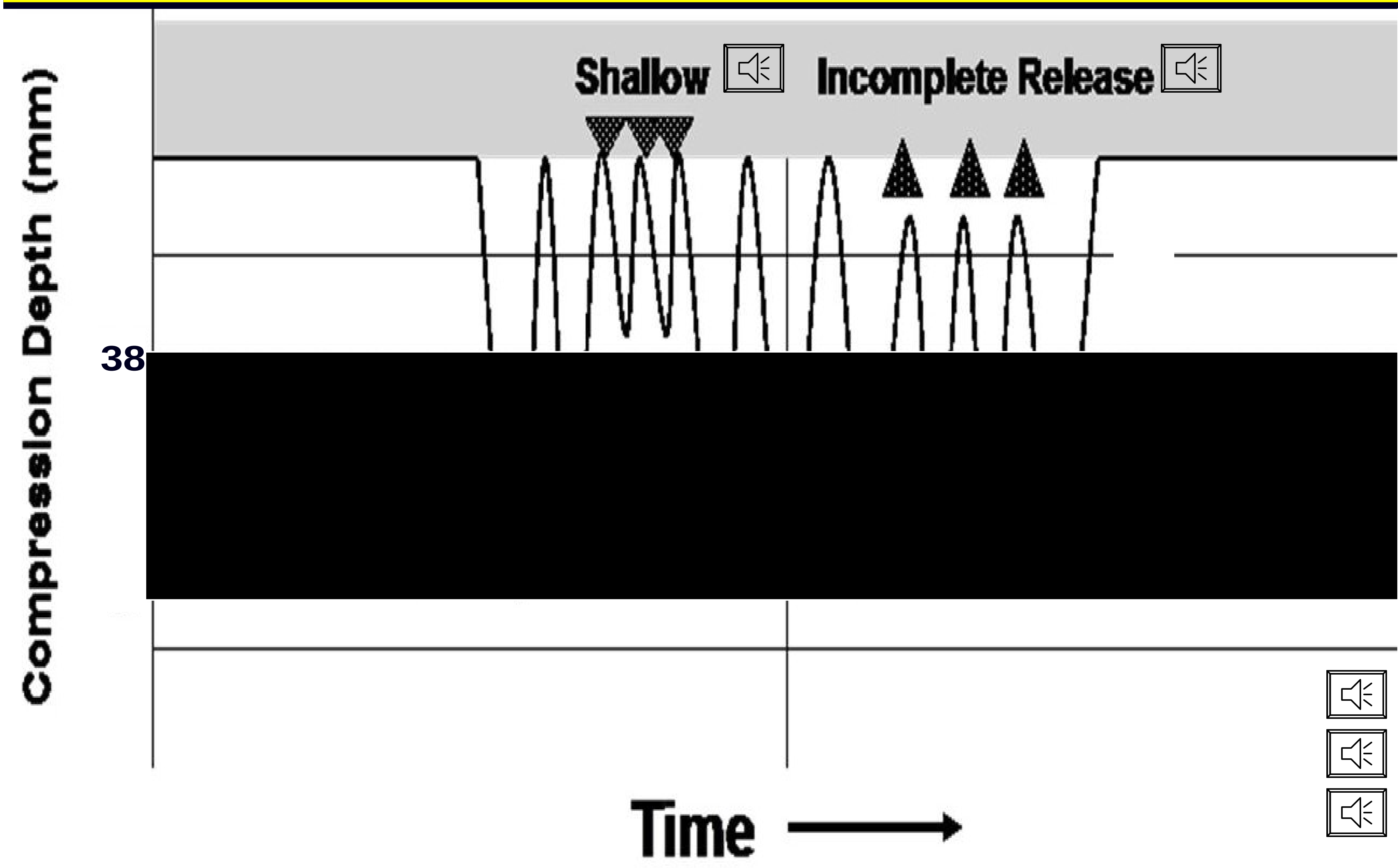
Team Training…building competence to Excellence!

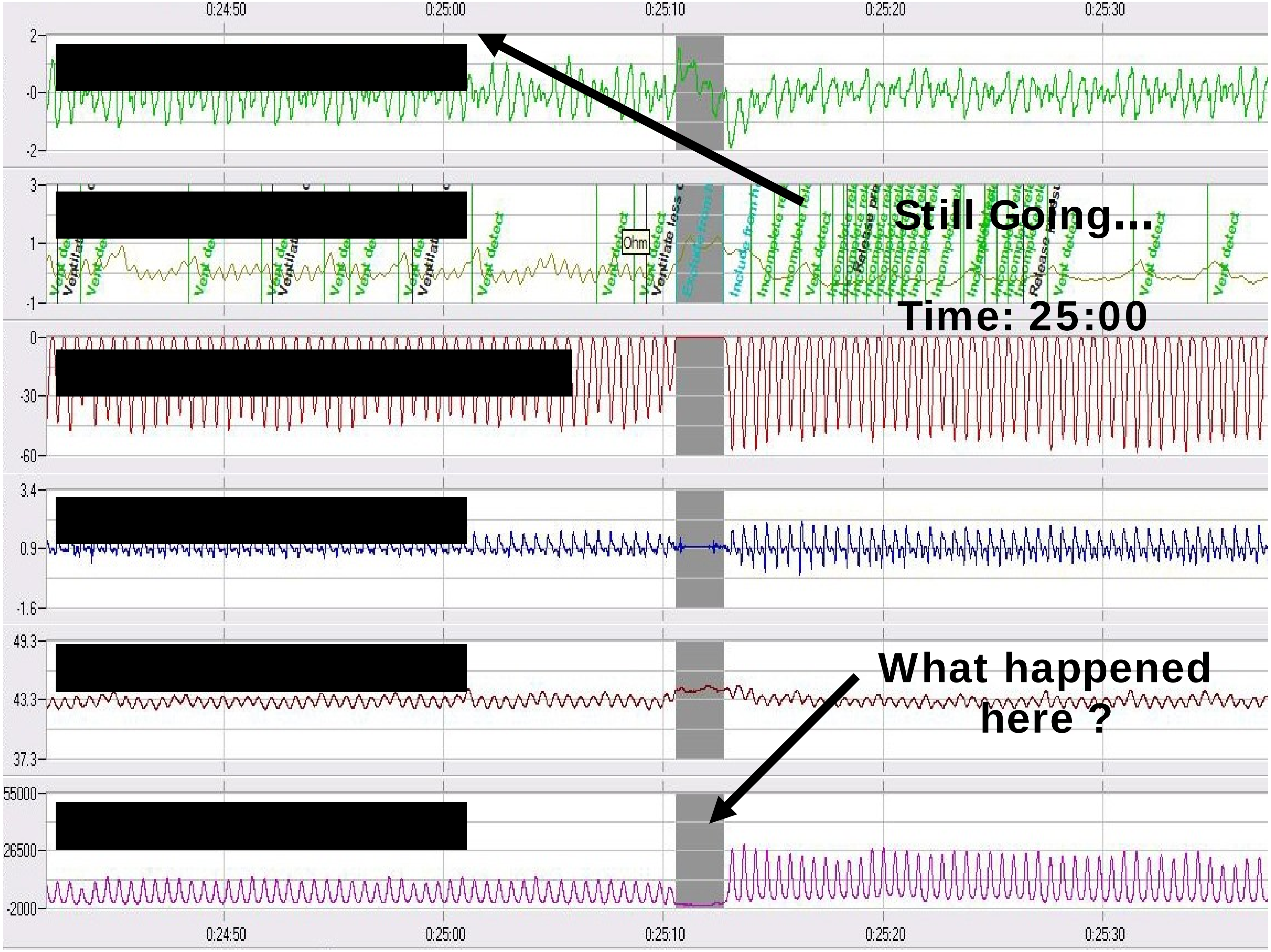
"Just-in-time….Just-in-place"

Improving CPR Techniques

- Mechanisms to evaluate and "see-through" artifacts to allow near continuous chest compressions

Audio Feedback




0:24:50
0:25:00
0:25:10
0:25:20
0:25:30
[redacted]
Still Going…
Time: 25:00
Ohm
Vent detect
Ventilate loss
Incomplete
Release
What happened here ?
2
-0-
-2
3
1
-1
0
-30
-60
3.4
0.9
-1.6
49.3
43.3
37.3
55000
26500
-2000

Chest Compression (CC) Quantitative Data: n=10

Total Time	134.32 min
Total CC Delivered	13,136
Chest Compression Rate	113 ± 13.4 CC/min
Chest Compression Count	98 ± 7.1 CC/min
No Flow Time	10.33 ± 0.9 min
No Flow Fraction	7.7 ± 5.4 %
Percent Incomplete Release	13.6 ± 9.5 %
Percent Adequate Depth	86.8 ± 16.1 %

Chest Compression (CC)
Quantitative Data: n=10

PEDIATRIC		In-Hospital Adult*
Chest Compression Rate / No Flow Fraction	7.7 %	24 %
Chest Compression Count / Percent Adequate Depth	86.8 %	62 %
No Flow Fraction	7.7 %	48 %
Percent Adequate Depth	86.8 %	38 %

*Abella, JAMA 2005
*Wik, JAMA 2005

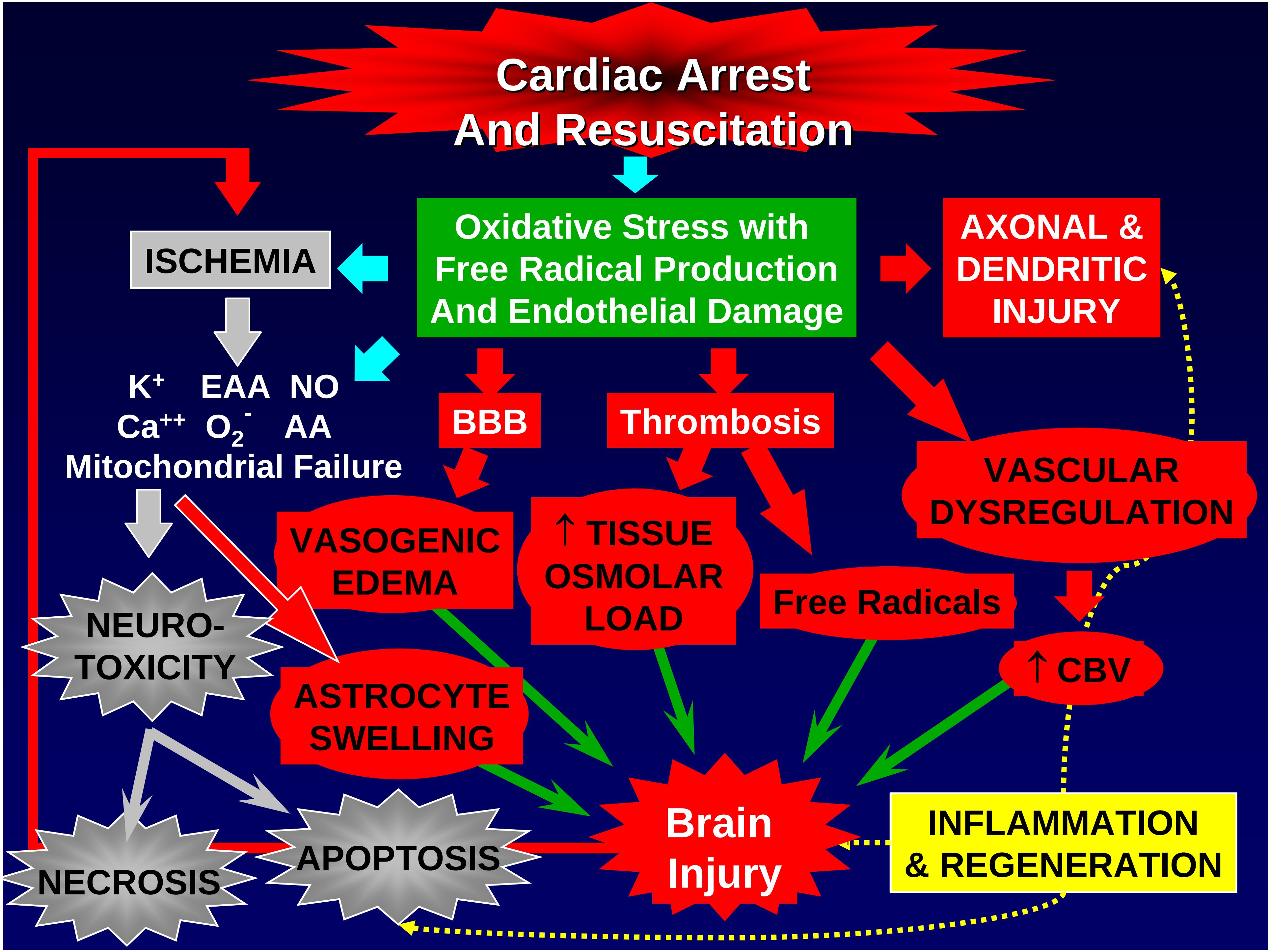
Summary/Conclusions

For Out of Hospital Cardiac Arrest:

- Push hard, push fast, complete release, Minimize interruptions, Do NOT over-ventilate

For In-Hospital Cardiac Arrest:

- Etiology specific response will improve outcome
  - ➔Respond before arrest (Rapid Response)
  - ➔Emphasize Quality of CPR
  - ➔Use adjuncts and monitor effects/feedback
- Advanced techniques have merit but are not proven



Cardiac Arrest
And Resuscitation
Oxidative Stress with
Free Radical Production
And Endothelial Damage
ISCHEMIA
AXONAL &
DENDRITIC
INJURY
K^+ EAA NO
Ca^{++} O_2^- AA
Mitochondrial Failure
BBB
Thrombosis
VASCULAR
DYSREGULATION
VASOGENIC
EDEMA
↑ TISSUE
OSMOLAR
LOAD
Free Radicals
NEURO-
TOXICITY
↑ CBV
ASTROCYTE
SWELLING
Brain
Injury
INFLAMMATION
& REGENERATION
NECROSIS
APOPTOSIS

Guideline Principles

- Early Detection and Intervention
  - Universal monitoring
  - METS
  - Automated Directive Feedback (Prompts)
- Improved Circulation
  - Less interruption (C:V ratio, Fewer shocks)
  - Less Ventilation (titrated to blood flow and microcirculation)
  - Adjuncts (circumferential, thoracic pump)
- Real-time Corrective feedback based upon the patient's metabolic status

On the Horizon

- Metabolic therapies
  - Therapeutic hypothermia
  - Chemical hibernation
- Post-resuscitative care
  - Blood Pressure, Temperature, Glucose, Ventilation, Thrombolysis, myocardial support, rapid mechanical support
- Better Predictors
  - Imaging, Neurophysiology and biomarkers
- Genomics and proteomics
  - Hibernation / Regeneration / Transplantation

Training and Preparedness

- Home therapies
  - Smart AEDs in the home, video links, “smoke alarm and fire extinguisher” mentality
- Short and simple training
  - School, Work, Driver’s License
- Just-in time support and training
  - 111, flashes, physiologic feedback, incorporation into everyday life (ATM, stadium, groceries)

Pre-Arrest

Cardiac Arrest

CPR

Post-Arrest stabilization

No Flow

Low Flow

Low, Normal or High Flow

•PROTECTION

PRESERVATION

RESUSCITATION

RESUSCITATION /REGENERATION

- Rapid Recognition
- Call 9-1-1
- METs

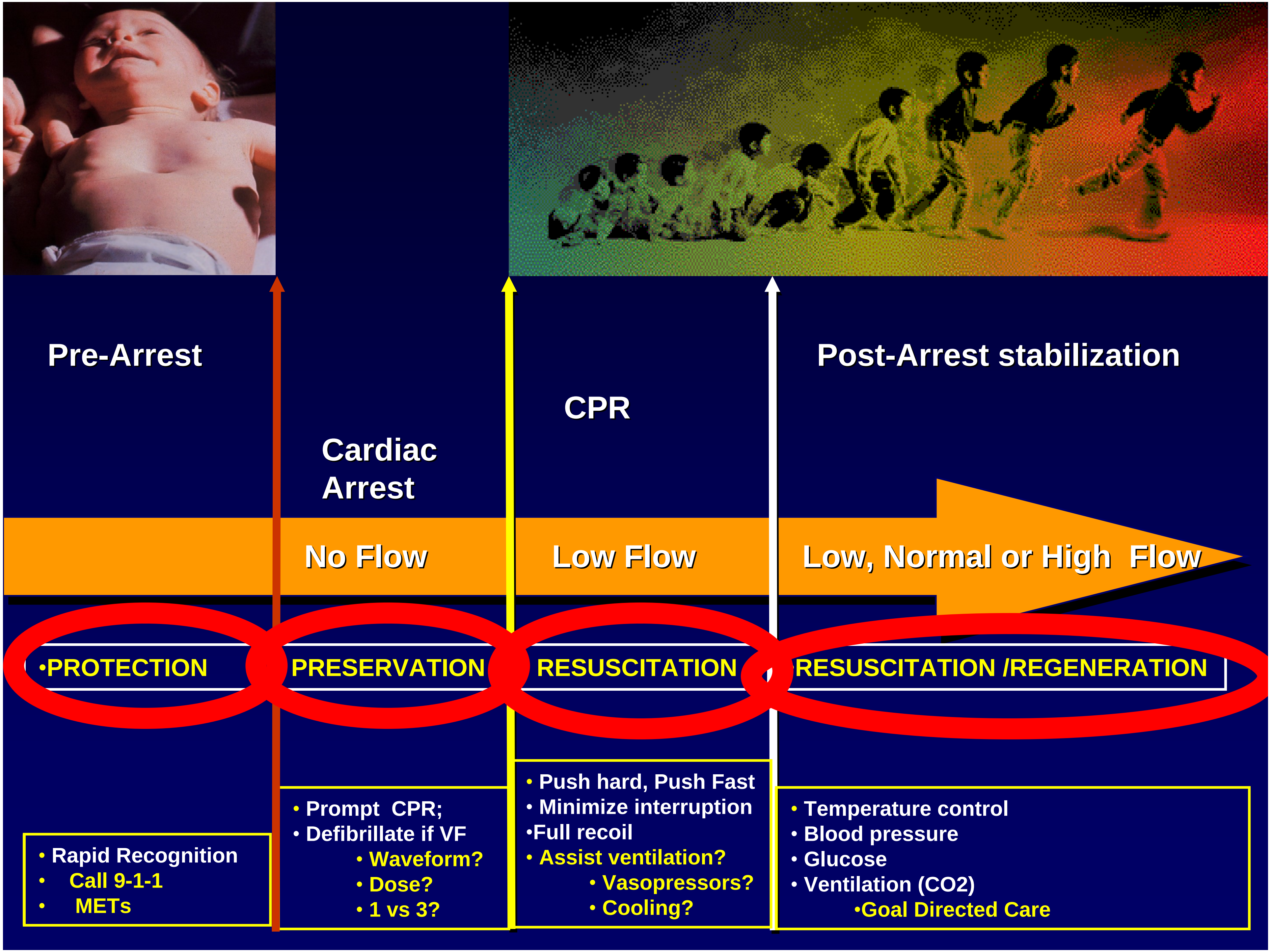
- Prompt CPR;
- Defibrillate if VF
  - Waveform?
  - Dose?
  - 1 vs 3?

- Push hard, Push Fast
- Minimize interruption
- Full recoil
- Assist ventilation?
  - Vasopressors?
  - Cooling?

- Temperature control
- Blood pressure
- Glucose
- Ventilation (CO2)
  - Goal Directed Care

We are going to have to look deeper to discover evidence that lies beneath the surface…

Next planned revision of AHA Guidelines: 2010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• Defibrillate if VF
• Waveform?
• Dose?
• 1 vs 3?
• Push hard, Push Fast
• Minimize interruption
•Full recoil
• Assist ventilation?
• Vasopressors?
• Cooling?
• Temperature control
• Blood pressure
• Glucose
• Ventilation (CO2)
•Goal Directed Care

Quality of CPR

CPR

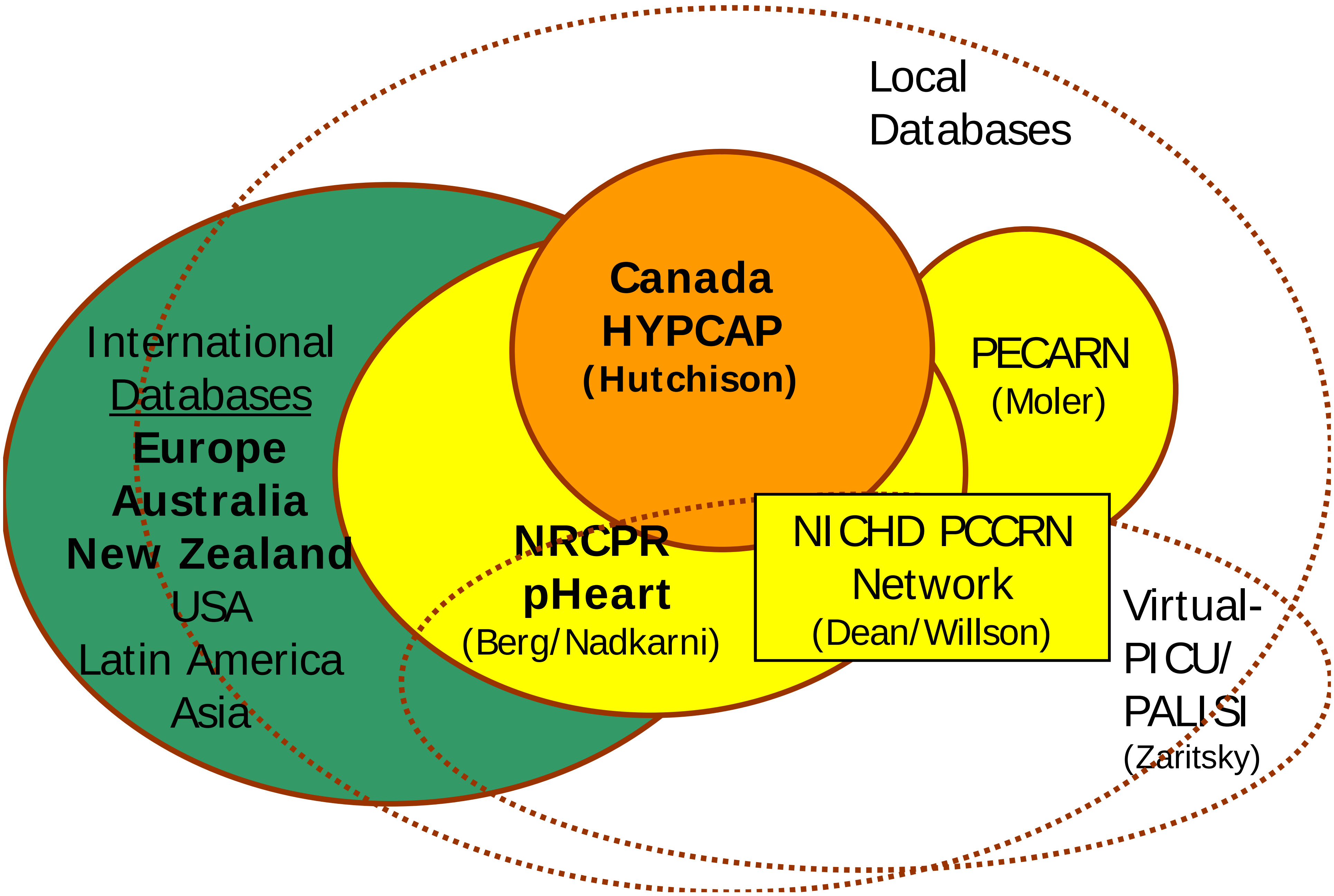
Push Hard

Push Fast

Allow full chest recoil

Minimize Interruptions

Don’t Overventilate


Local
Databases
International
Databases
Europe
Australia
New Zealand
USA
Latin America
Asia
Canada
HYPCAP
(Hutchison)
PECARN
(Moler)
NRCPR
pHeart
(Berg/Nadkarni)
NICHD PCCRN
Network
(Dean/Willson)
Virtual-
PICU/
PALISI
(Zaritsky)