
Reflections on
Cardiopulmonary
Resuscitation
Ruminations upon a
half century of progress


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Objectives for Today's Talk

- *Some physiology basics*
- *History of CPR*
- *The ROC Trial*
- *ILCOR 2010*
- *Thoughts for the future*

- Airway Obstruction
- Apnea
- Cardiac Arrest
- Massive External Bleeding

We are talking today about the sickest patients that you will ever have

Cardiac arrest is a rapid and virtually inexorable movement toward death

To understand the progress of the field, there are THREE "physiological fives" that you must remember

Five liters of blood in the vascular system in the average-sized adult

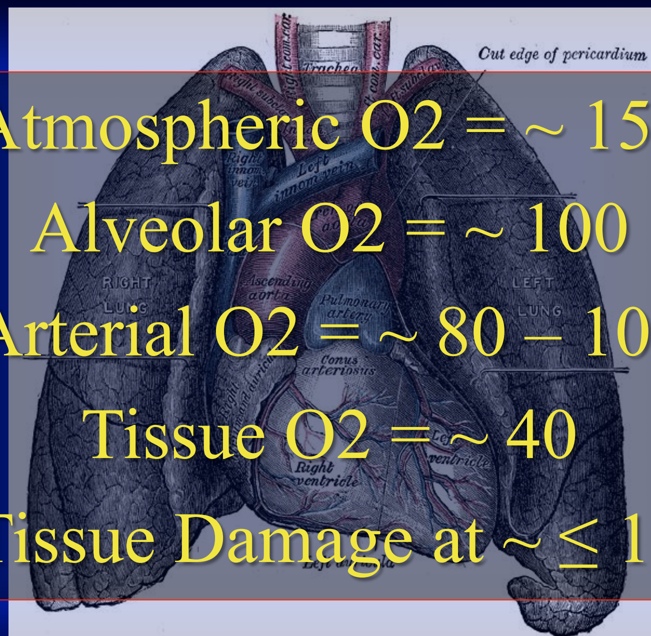
Five liters per minute
of cardiac output
in the resting state in
the average sized adult

Five liters per minute
of ventilation
in the resting state in
the average sized adult
(REMEMBER:
<u>This is NEGATIVE PRESSURE)</u>

FACE IT!!!
5's are
EVERYWHERE
in medicine

Circulation meets Ventilation

- BP = CO x PVR
- Our negative pressure inhalations enhance venous return and BP



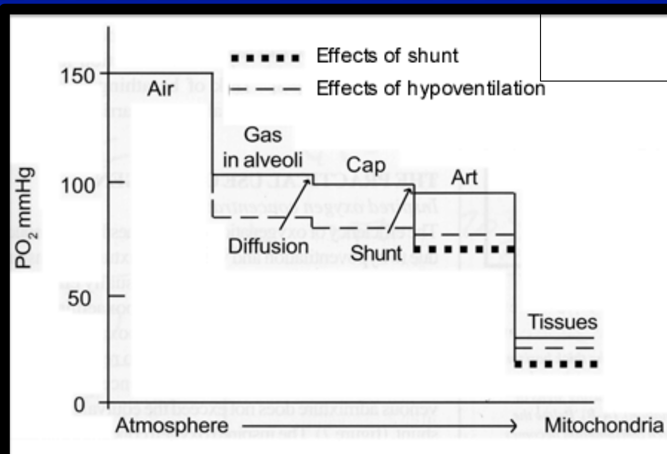
Atmospheric O2 = ~ 150

Alveolar O2 = ~ 100

Arterial O2 = ~ 80 – 100

Tissue O2 = ~ 40

Tissue Damage at ~ ≤ 10



Oxygen Delivery to Tissues (DO_2)

$DO_2 = CaO_2 \times CI \times 10$

(normally 550-650 cc/min/m^2
or around a liter per minute or so)

Fick Equation

- Gives "consumed oxygen"
- $VO_2 = 1.38 (Hb)(CO)(SaO_2 - SvO_2)/10$

(normally 240-290 cc/min)

Oxygen Consumption

- VO_2/DO_2 is normally 0.22-0.27 (0.25)
- ***Rising VO_2/DO_2 ratio is a sign of inadequate tissue oxygenation)***

$$Sat_VO_2 = Sat_aO_2 - \frac{VO_2\ (ml/min)}{O_2\ (L/min)} * \frac{1}{Hb\ (gr/L) * 1.39}$$

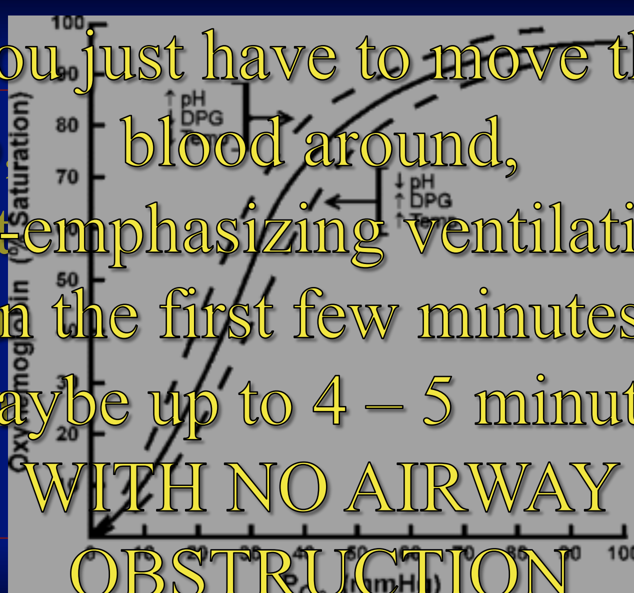
↓

$$Sat_VO_2 = Lung - \frac{Metabolism}{Hemodynamics} * \frac{1}{Anemia}$$

20 cc O_2 /100 cc Blood

5000 cc / 100 cc = 50

20 cc x 50 = ***1000 cc***



You just have to move the blood around, de-emphasizing ventilation in the first few minutes, maybe up to 4 – 5 minutes WITH NO AIRWAY OBSTRUCTION

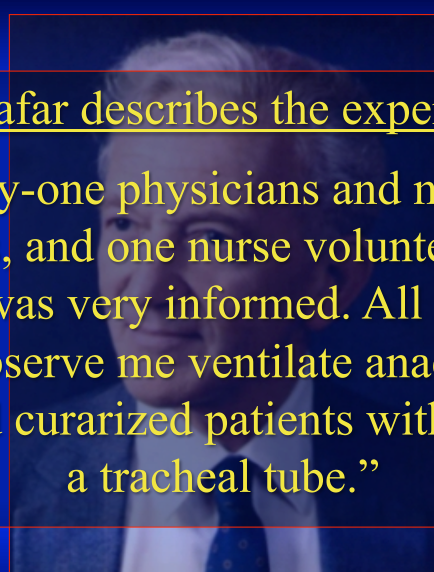
Coronary Perfusion

- Driven by aortic diastolic pressure
- Drops precipitously with the loss of cardiac output

Looking Backward

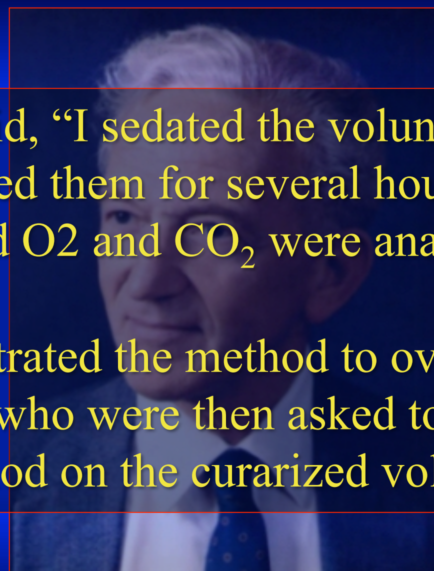
It was in 1954 when James Elam in New York first demonstrated experimentally that "exhaled air ventilation" worked, later partnering with Peter Safar and many national organizations to popularize the technique. His book "Rescue Breathing" was published in 1959.

Safar set out on a series of experiments using chemically paralysed individuals to show that the ventilation technique could maintain adequate oxygenation



Peter Safar describes the experiments:

"Thirty-one physicians and medical students, and one nurse volunteered . . . Consent was very informed. All volunteers had to observe me ventilate anaesthetised and curarized patients without a tracheal tube."



Safar said, "I sedated the volunteers and paralysed them for several hours each. Blood O2 and CO_2 were analysed.

I demonstrated the method to over 100 lay persons who were then asked to perform the method on the curarized volunteers."

Safar discussed in his memoirs that he so very much believed in the principle of mouth to mouth ventilation that the first person that he sedated, paralyzed, and ventilated in this study was his wife

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We MIGHT have trouble getting that study through an IRB today!

Peter Safar wrote the book "*ABC of Resuscitation*" in 1957.

In the U.S., it was first promoted as a technique for the public to learn in the 1970s

The first person saved with this technique was recalled by Jude:

"She was rather an obese female who … went into cardiac arrest as a result of flurothane anesthetic. This woman had no blood pressure, no pulse, and ordinarily we would have opened up her chest. Instead, since we weren't in the operating room, we applied external cardiac massage. Her blood pressure and pulse came back at once. We didn't have to open her chest. They went ahead and did the operation on her, and she recovered completely."

The formalized system of chest compression was really an accidental discovery made by William Kouwenhoven, Guy Knickerbocker, and James Jude at Johns Hopkins University

They were studying defibrillation in dogs when they noticed that by forcefully applying the paddles to the chest of the dog, they could achieve a pulse in the femoral artery

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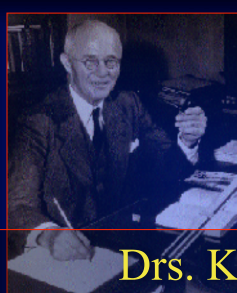
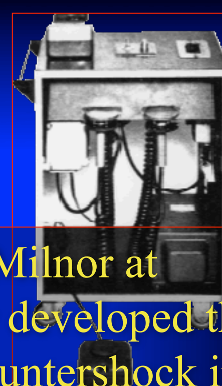
With this information,
they were ready for human trials

The formal connection of chest compression with mouth-to-mouth ventilation to create CPR as it is practiced today occurred when Safar, Jude, and Kouwenhoven presented their findings at the annual Maryland Medical Society meeting on September 16, 1960, in Ocean City

In the opening remarks the moderator said, "Our purpose today is to bring to you, then, this new idea."

It was so new that it was still without a name





Drs. Kouwenhoven and Milnor at The Johns Hopkins University developed the first defibrillator for use in countershock in humans in the early ‘50’s

The first device weighed 200 pounds, was on rollers, and delivered current via paddles placed at the suprasternal notch and at the apex

In 1960, a patient arrived in the emergency room at 1 a.m. complaining of indigestion, and in the midst of undressing for his exam, suddenly collapsed in ventricular fibrillation

The admitting resident, Dr. Gottleib (Bud) Friesinger, was familiar with the defibrillator located in a laboratory on the Hospital's 11th floor, having assisted in the early research

Dr. Friesinger commented,

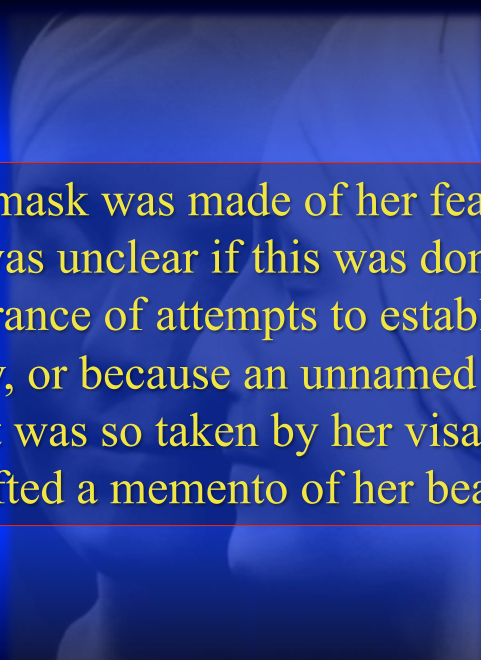
"*He was quite a dramatic Saturday morning Grand Rounds presentation.*"


Together Elam and Safar
helped develop the Resusci Anne
Mannequin which was produced
and distributed by
Laerdal of Norway

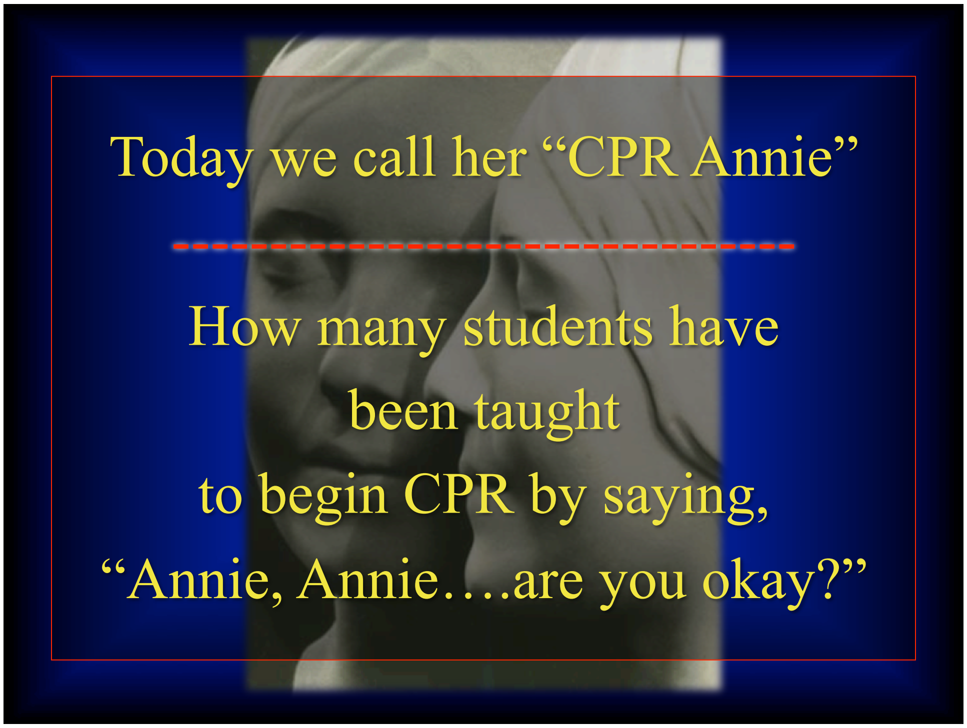

Asmund Laerdal

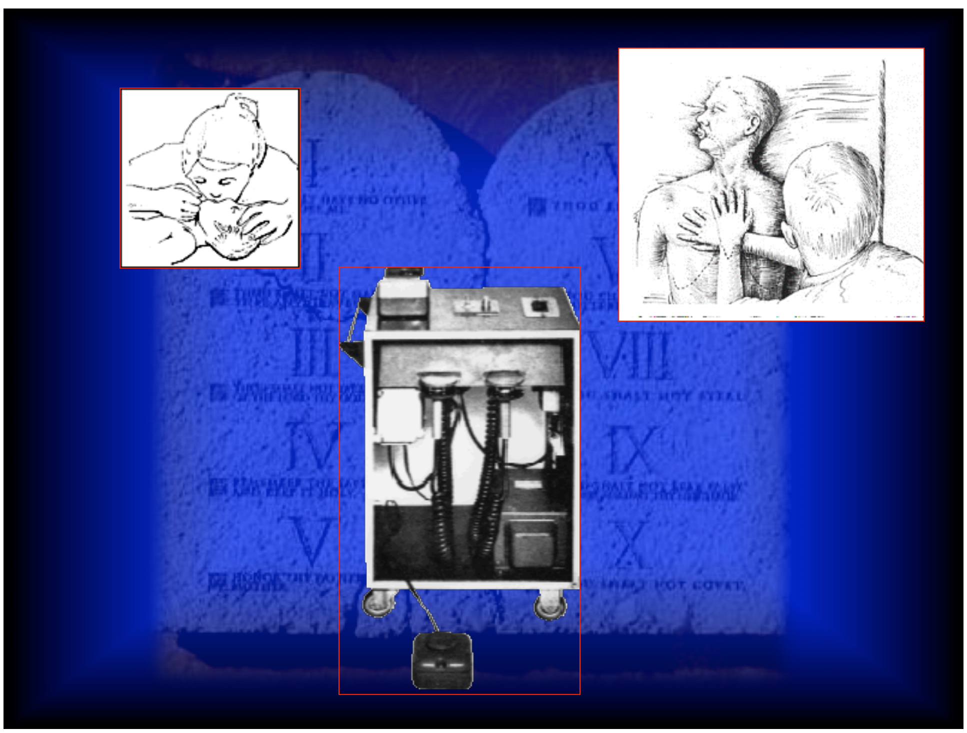
Where did Laerdal find the face for his mannequin?

Legend has it that there was an unknown girl, entered in the books of the Parks morgue in Paris as "ecadavre feminin inconnu", (unknown female cadaver) before her remains were disposed of in an unmarked pauper's grave.



A death mask was made of her features, but it was unclear if this was done in furtherance of attempts to establish her identity, or because an unnamed morgue attendant was so taken by her visage that he crafted a memento of her beauty.

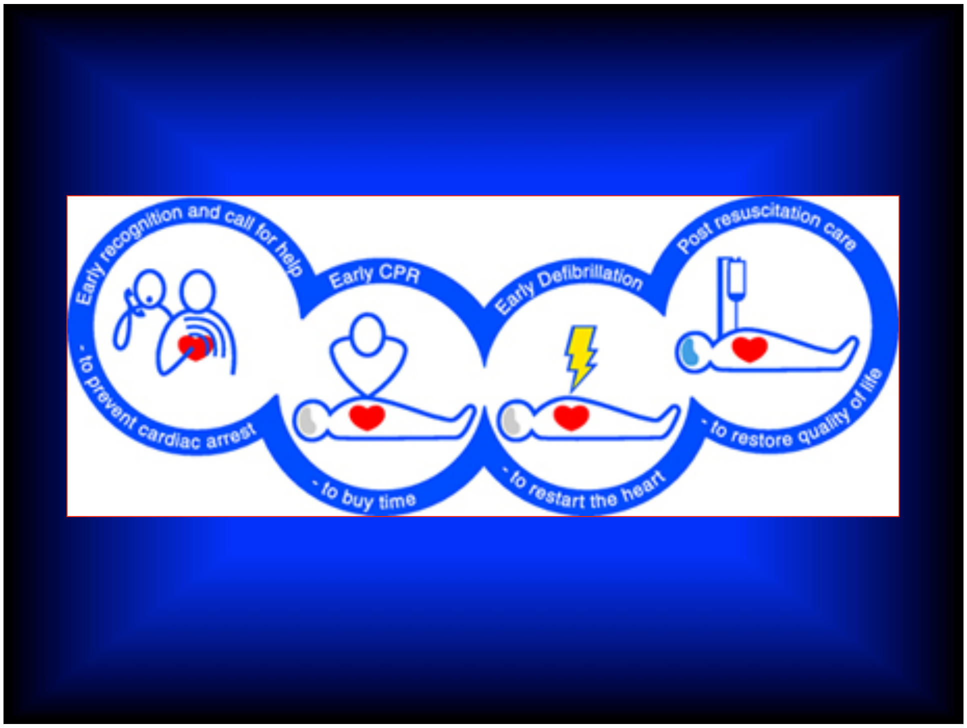

Today we call her "CPR Annie"
How many students have
been taught
to begin CPR by saying,
"Annie, Annie….are you okay?"

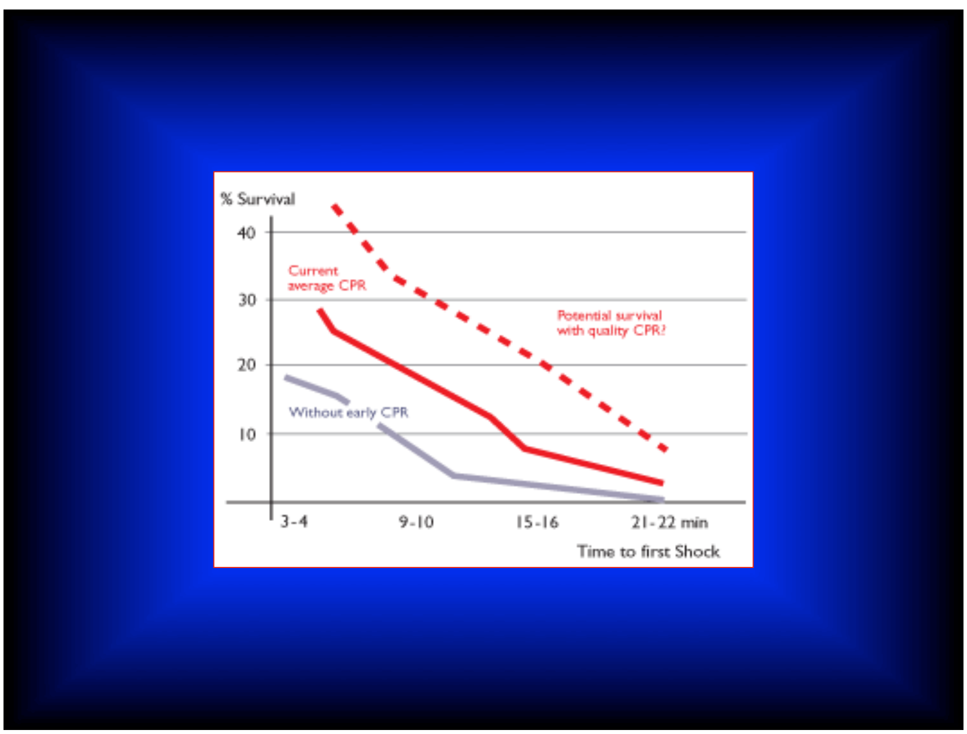


They named it
Cardiopulmonary Resuscitation

They did NOT name it
Pulmonocardiac Resuscitation

This is a principal take-home message of this presentation


Early recognition and call for help
- to prevent cardiac arrest
Early CPR
- to buy time
Early Defibrillation
- to restart the heart
Post resuscitation care
- to restore quality of life


% Survival
40
30
20
10
Current average CPR
Potential survival with quality CPR?
Without early CPR
3-4
9-10
15-16
21-22 min
Time to first Shock

50 years of evolving needs and solutions

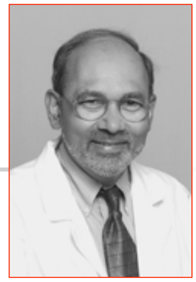
1960 — The need for a lifelike training aid for mouth-to-mouth ventilation, and to make rescuers willing to blow into a "dead" person, led Asmund S. Laerdal, together with Dr. Bjorn Lind and Dr.Peter Safar to develop Resusci-Anne.

1970 — The first AHA/JAMA Guidelines for CPR in 1974 recommended that full CPR be taught also to lay people. Recording Resusci Anne allowed "training to perfection", reporting quality of CPR on a paper strip.

1980 — In the 1980's the American Heart Association set a criteria of 90% correct performance to obtain CPR certification: SkillMeter Resusci Anne was developed to meet the need for quantitative real-time CPR measurement and feedback.

1990 — In the 1990's there was much focus on sufficient hands-on practice. Little Anne was introduced (1995) as a supplemental trainer to meet the need for a lower student to manikin ratio.

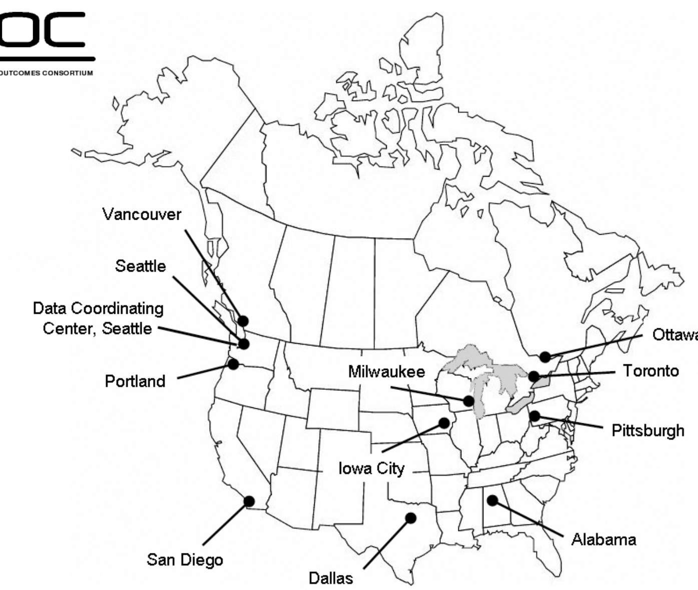
2000 — In the 2000's growing concern about patient safety and costefficiency caused increased focus on patient simulation and self-directed learning. Also, research demonstrated that the quality of CPR delivered by even health care professionals was poor and that CPR measurement and feedback helped improve performance.



ROC: Past, Present, and Future

AHAMED IDRIS, MD
PROFESSOR AND DIRECTOR
DFW CENTER FOR RESUSCITATION RESEARCH

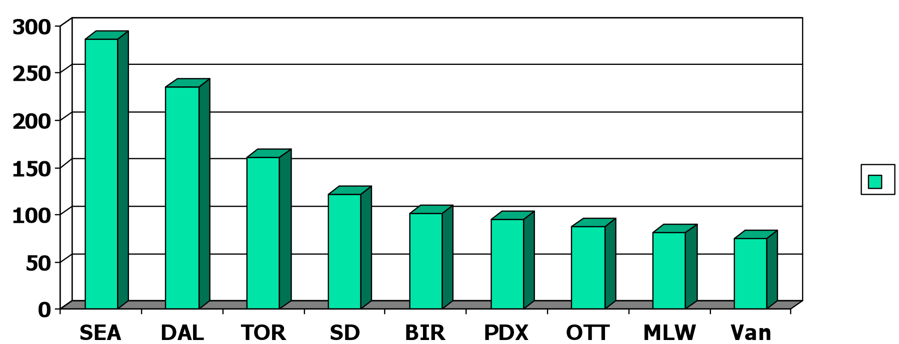
ROC
RESUSCITATION OUTCOMES CONSORTIUM



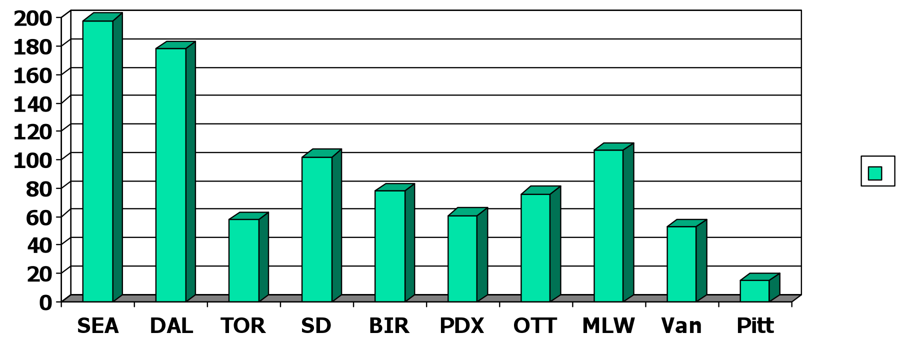
Completed Studies

- Epistry:
  - Cardiac arrest: ~ 85,000
  - Trauma: ~ 14,000
- Hypertonic Resuscitation for Severe Trauma
- ROC PRIMED - Prehospital Resuscitation IMpedance valve and Early vs Delayed analysis (**ROC PRIMED)** Trial

HS TBI Enrollment



HS Shock Enrollment



Hypertonic Resuscitation

- 2,300 patients
- TBI and Shock studies completed
- No difference between groups for primary outcome
- Increased blood pressure in HS group
- May have resulted in later transfusion and surgery
- Higher early mortality, same at 30 days

Table 4. Incidence and Outcome of EMS-Treated Out-of-Hospital Cardiac Arrest[a]

	Alabama (n = 267)	Dallas (n = 1265)	Iowa (n = 565)	Milwaukee (n = 801)	Ottawa (n = 1836)	Pittsburgh (n = 575)	Portland (n = 793)	Seattle (n = 1170)	Toronto (n = 2992)	Vancouver (n = 1634)	Overall (n = 11 898)
Adjusted incidence rate per 100 000	40.3	82.9	51.3	86.7	45.1	51.1	47.0	74.4	57.0	52.8	56.0
Adjusted mortality rate per 100 000	36.9	77.2	44.4	78.0	42.3	47.1	41.0	62.3	53.6	46.9	50.9
Case-fatality rate, %	91.7	92.6	86.9	90.1	93.5	92.3	86.8	83.5	93.8	88.5	90.7
Survival to discharge, %	3.0	4.5	11.0	9.7	5.3	7.0	10.6	16.3	5.5	9.7	7.9
Vital status data missing, %	5.3	2.9	2.1	0.1	1.2	0.7	2.5	0.2	0.7	1.7	1.4

Abbreviation: EMS, emergency medical services.
[a] All rates were unequal across sites at $P < .001$.

ROC PRIMED: Cardiac Arrest

- The largest cardiac arrest resuscitation trial in history

Delaying Defibrillation to Give Basic Cardiopulmonary Resuscitation to Patients With Out-of-Hospital Ventricular Fibrillation
A Randomized Trial

Lars Wik, MD, PhD
Trond Boye Hansen
Frode Fylling
Thorbjørn Steen, MD
Per Vaagenes, MD, PhD
Bjørn H. Auestad, PhD
Petter Andreas Steen, MD, PhD

Context Defibrillation as soon as possible is standard treatment for patients with ventricular fibrillation. A nonrandomized study indicates that after a few minutes of ventricular fibrillation, delaying defibrillation to give cardiopulmonary resuscitation (CPR) first might improve the outcome.

Objective To determine the effects of CPR before defibrillation on outcome in patients with ventricular fibrillation and with response times either up to or longer than 5 minutes.

Design, Setting, and Patients Randomized trial of 200 patients with out-of-hospital ventricular fibrillation in Oslo, Norway, between June 1998 and May 2001. Patients received either standard care with immediate defibrillation (n=96) or CPR first with 3 minutes of basic CPR by ambulance personnel prior to defibrillation (n=104). If initial defibrillation was unsuccessful, the standard group received 1 minute of CPR before additional defibrillation attempts compared with 3 minutes in the CPR first group.

Main Outcome Measure Primary end point was survival to hospital discharge. Secondary end points were hospital admission with return of spontaneous circulation (ROSC), 1-year survival, and neurological outcome. A prespecified analysis examined subgroups with response times either up to or longer than 5 minutes.

Results In the standard group, 14 (15%) of 96 patients survived to hospital discharge vs 23 (22%) of 104 in the CPR first group (*P*=.17). There were no differences in ROSC rates between the standard group (56% [58/104]) and the CPR first group (46% [44/96]; *P*=.16); or in 1-year survival (20% [21/104] and 15% [14/96], respectively; *P*=.30). In subgroup analysis for patients with ambulance response times of either up to 5 minutes or shorter, there were no differences in any outcome variables between the CPR first group (n=40) and the standard group (n=41). For patients with response intervals of longer than 5 minutes, more patients achieved ROSC in the CPR first group (58% [37/64]) compared with the standard group (38% [21/55]; odds ratio [OR], 2.22; 95% confidence interval [CI], 1.06-4.63; *P*=.04); survival to hospital discharge (22% [14/64] vs 4% [2/55]; OR, 7.42; 95% CI, 1.61-34.3; *P*=.006); and 1-year survival (20% [13/64] vs 4% [2/55]; OR, 6.76; 95% CI, 1.42-31.4; *P*=.01). Thirty-three (89%) of 37 patients who survived to hospital discharge had no or minor reductions in neurological status with no difference between the groups.

Conclusions Compared with standard care for ventricular fibrillation, CPR first prior to defibrillation offered no advantage in improving outcomes for this entire study population or for patients with ambulance response times shorter than 5 minutes. However, the patients with ventricular fibrillation and ambulance response intervals longer than 5 minutes had better outcomes with CPR first before defibrillation was attempted. These results require confirmation in additional randomized trials.

JAMA. 2003;289:1389-1395 www.jama.com

EARLY DEFIBRILLATION IS CRITICAL for survival from ventricular fibrillation. The survival rate decreases by 3% to 4% or 6% to 10% per minute depending on whether basic cardiopulmonary resuscitation (CPR) is performed.[1,2] Another major factor known to influence survival in patients with ventricular fibrillation is whether CPR is performed prior to when a defibrillator is available.[1] It has been assumed that the blood flow generated by CPR decreases the rate of deterioration of the heart and brain cells,[3] but is insufficient to improve the state of the tissues. If tissue perfusion could be improved, withholding defibrillation for a short period while administering CPR might improve the results for patients with depleted myocardial levels of high-energy phosphates,[3] severe acidosis,[4] and a ventricular fibrillation frequency spectrum indicating a low chance of defibrillation success.[5,6]

In an experimental study, defibrillation was more successful following basic CPR and high-dose epinephrine than immediate defibrillation in dogs with

Conclusions:

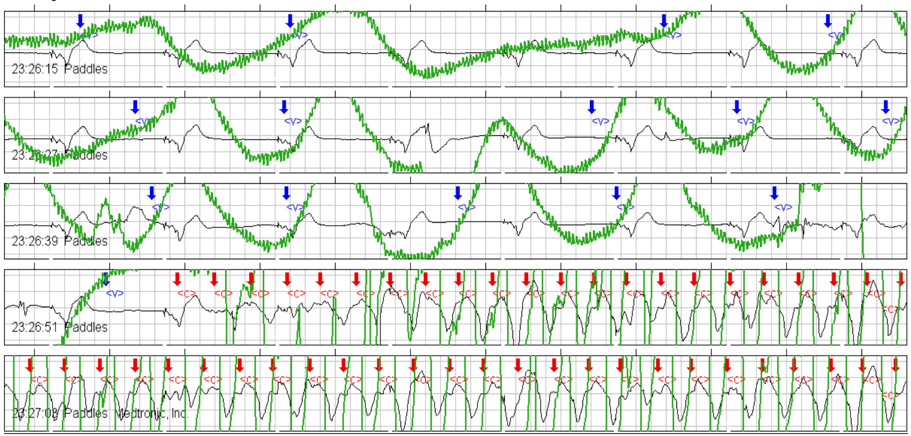
For patients with response intervals of longer than 5 minutes, more patients achieved ROSC in the CPR first group [illegible] than in the [illegible] group (38% [21/55]; odds ratio [OR], 2.22; 95% confidence interval [illegible] P [illegible] survival to hospital discharge (22% [14/64] vs 4% [2/55]; OR, 7.42; 95% CI, 1.61-34.3; P [illegible] and [illegible] (20% [13/64] vs 4% [2/55]; OR, 6.76; 95% CI, 1.42-31.4; P = .01). Thirty-three [illegible] of 37 patients who survived to hospital discharge had no or minor reductions in neurological status with no difference between the groups.

1-year survival 20% [13/64] vs 4% [2/55]; OR, 6.76; 95% CI, 1.42-31.4; P = .01!!!!

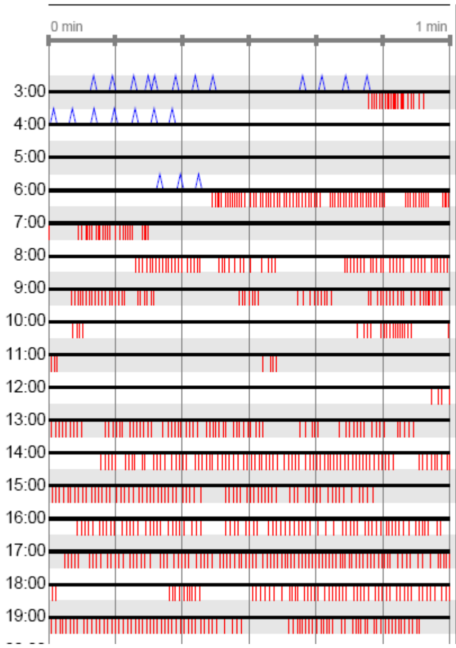
ROC PRIMED: Cardiac Arrest

- We completed the study
- Enrolled >11,000 patients
  - No difference between ITD groups overall
  - No difference analyze early vs later

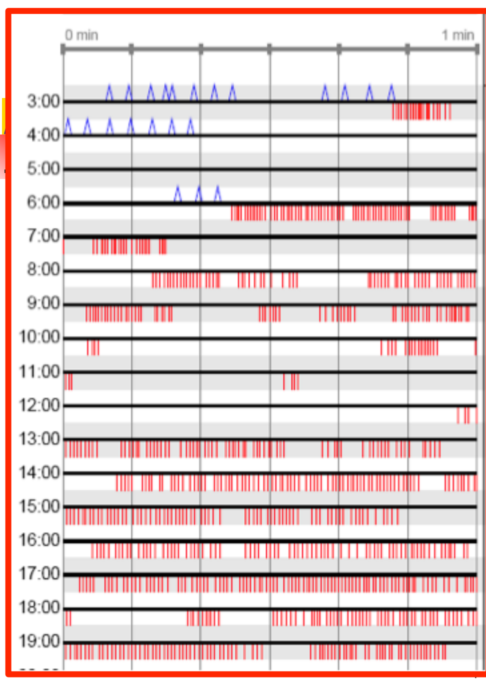
Ambulance Monitors Record CPR

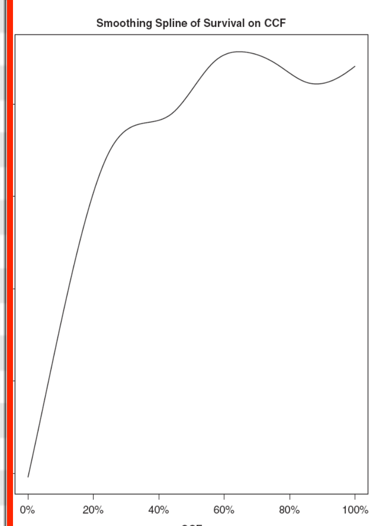


Medtronic LP12



Time	CPR Ratio, %	Prompt. CPR Ratio, %	Compr. Ratio, %	Prompt. Compr. Ratio, %	Compr. Rate	Compr. /min	Vent. Rate	Vent. /min
3:00	15	--	15	--	163	22	--	12
4:00	--	--	--	--	--	--	--	7
5:00	--	--	--	--	--	--	--	--
6:00	59	--	56	--	145	73	3	3
7:00	27	--	21	--	167	26	--	--
8:00	63	--	63	--	119	60	--	--
9:00	80	--	60	--	123	62	--	--
10:00	33	--	20	--	130	21	--	--
11:00	9	--	9	--	92	7	--	--
12:00	4	--	4	--	--	4	--	--
13:00	93	--	77	--	108	69	--	--
14:00	87	--	82	--	108	81	--	--
15:00	83	--	78	--	107	69	--	--
16:00	93	--	88	--	100	74	--	--
17:00	100	--	96	--	107	94	--	--
18:00	74	--	62	--	107	58	--	--
19:00	94	--	84	--	106	83	--	--





3. Smoothing spline representing the incremental proba-
survival corresponding to a linear increase in chest
ssion fraction.

Changes Resulting from Increased Monitoring of CPR Quality Since 2006

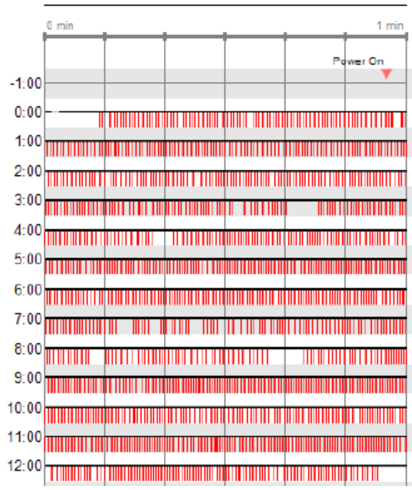
- Changed CPR protocol:
  - Do Not Move the patient!
  - Start chest compression immediately!
- Minimize interruptions in chest compressions
- Don't intubate for first 5 minutes
- Continue CPR for at least 10 minutes before attempting to move the patient

Increased Monitoring for ROC Cardiac Arrest Trials

- Interruptions in CPR
- First responding Firefighters not starting CPR
- AEDs/Defibs not being carried into the scene:
  - Unconscious, seizure, respiratory problem

CPR 2009

CPR QUIK-VIEW

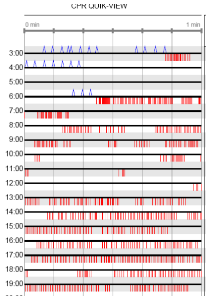


Interval Statistics

Time	CPR Ratio, %	Prompt. CPR Ratio, %	Compr. Ratio, %	Prompt. Compr. Ratio, %	Compr. Rate	Compr. /min	Vent. Rate	Vent. /min
-1:00	--	--	--	--	--	--	--	--
0:00	86	--	86	--	120	101	--	--
1:00	100	--	100	--	118	112	--	--
2:00	100	--	100	--	117	111	--	--
3:00	100	--	93	--	122	104	--	--
4:00	100	--	96	--	127	113	--	--
5:00	100	--	100	--	138	130	--	--
6:00	100	--	100	--	138	133	--	--
7:00	100	--	100	--	108	93	--	--
8:00	100	--	92	--	110	92	--	--
9:00	100	--	100	--	143	136	--	--
10:00	100	--	100	--	138	124	--	--
11:00	100	--	100	--	147	141	--	--
12:00	94	--	94	--	146	118	--	--

2006

CPR QUIK-VIEW



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7:00	27	--	21	--	167	26	--	--
8:00	63	--	63	--	119	60	--	--
9:00	80	--	60	--	123	62	--	--
10:00	33	--	20	--	130	21	--	--
11:00	9	--	9	--	92	7	--	--
12:00	4	--	4	--	--	4	--	--
13:00	93	--	77	--	108	69	--	--
14:00	87	--	82	--	108	81	--	--
15:00	83	--	78	--	107	69	--	--
16:00	93	--	88	--	100	74	--	--
17:00	100	--	96	--	107	94	--	--
18:00	74	--	62	--	107	58	--	--
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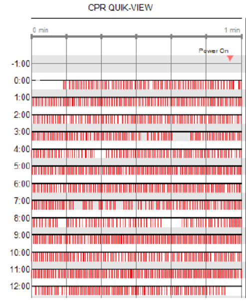
2009

CPR QUIK-VIEW



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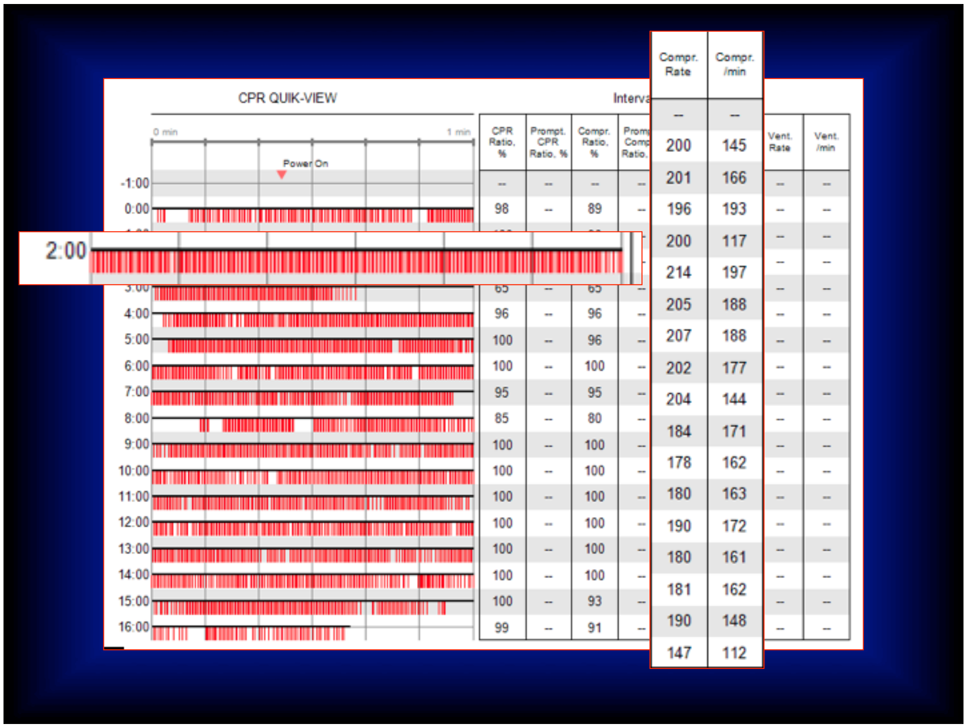
0:00	86	--	86	--	120	101	--	--
1:00	100	--	100	--	118	112	--	--
2:00	100	--	100	--	117	111	--	--
3:00	100	--	93	--	122	104	--	--
4:00	100	--	96	--	127	113	--	--
5:00	100	--	100	--	138	130	--	--
6:00	100	--	100	--	138	133	--	--
7:00	100	--	100	--	108	93	--	--
8:00	100	--	92	--	110	92	--	--
9:00	100	--	100	--	143	136	--	--
10:00	100	--	100	--	138	124	--	--
11:00	100	--	100	--	147	141	--	--
12:00	94	--	94	--	146	118	--	--



Impact of ROC on Dallas Outcomes

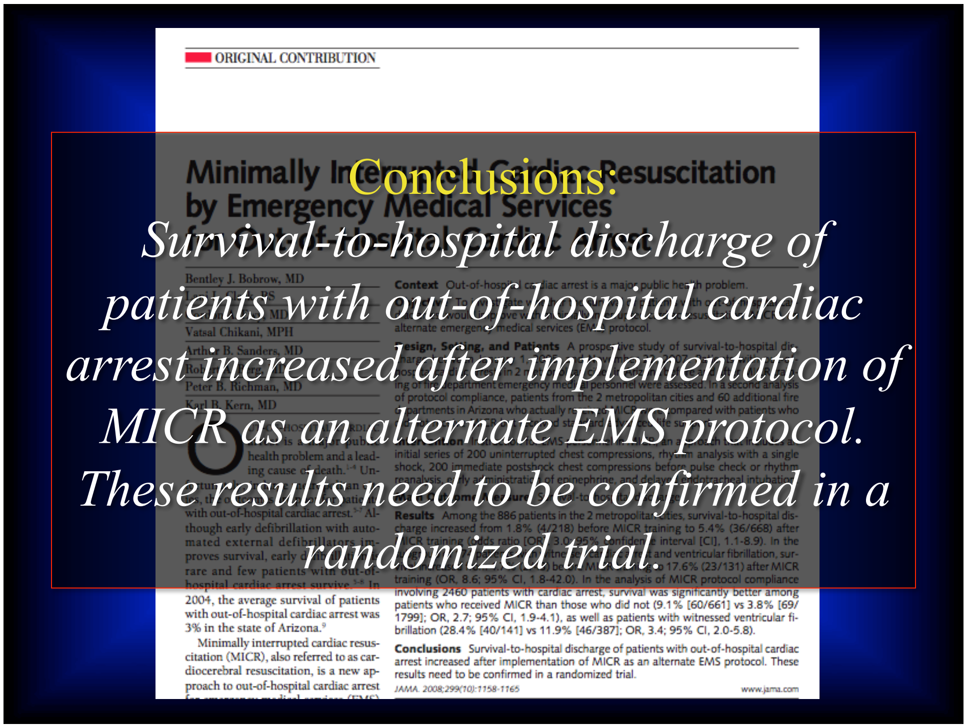
	Survival-to-Hospital Discharge		
	2006	*2009*	*Relative Percent Increase*
Dallas	**3.9%**	**6.0%**	**54%**
Irving	**7.0%**	**11%**	**57%**
Carrollton	**4.2%**	**15.8%**	**376%**
Mesquite	**3.0%**	**6.0%**	**100%**

ROC Present

- Epistry continues
- PROPHET: Trauma registry Jan 2010
- Publications
  - 35 published
  - 25 being written
  - Numerous studies in progress

Continue to Collect Information About CPR/Cardiac Arrest

- Continue excellent basic life support
- Continue to download all CPR files
- Continue to fill out CPR form
- BioTel OLMC will continue to call engine crews
- Will make another set of training videos
- Another round of training
  - Analyze early = witnessed cardiac arrest protocol
  - Analyze later = unwitnessed CA protocol
- Engine crews continue to record information about CPR


ORIGINAL CONTRIBUTION
Conclusions:
Survival-to-hospital discharge of patients with out-of-hospital cardiac arrest increased after implementation of MICR as an alternate EMS protocol. These results need to be confirmed in a randomized trial.
Conclusions Survival-to-hospital discharge of patients with out-of-hospital cardiac arrest increased after implementation of MICR as an alternate EMS protocol. These results need to be confirmed in a randomized trial.
JAMA. 2008;299(10):1158-1165
www.jama.com


Looking Ahead

International Liaison Committee on Resuscitation

International Liaison Committee on Resuscitation
ILCOR

A Belgian Nonprofit Association

ILCOR Members

- American Heart Association
- European Resuscitation Council
- Heart and Stroke Foundation of Canada
- Australian and New Zealand Committee on Resuscitation
- Resuscitation Councils of South Africa
- Inter American Heart Foundation
- Resuscitation Council of Asia

ILCOR's Activities

- Meets twice annually
- First joint guidelines with AHA in 2000
- International Consensus on CPR and ECC Science in 2005
- Evidence-based consensus conference in February, 2010
- Will publish findings in October, 2010

Worksheets 2010

To view the ILCOR worksheets, select one of the disciplines and click on the link. Readers are cautioned that the information contained in each worksheet is preliminary and does not represent any task force or resuscitation council recommendation.

- Acute Coronary Syndrome (ACS)
- Advanced Life Support (ALS)
- Basic Life Support (BLS)
- Education, Implementation and Teams (EIT)
- Neonatal Life Support (NRP)
- Pediatric Life Support (Peds)

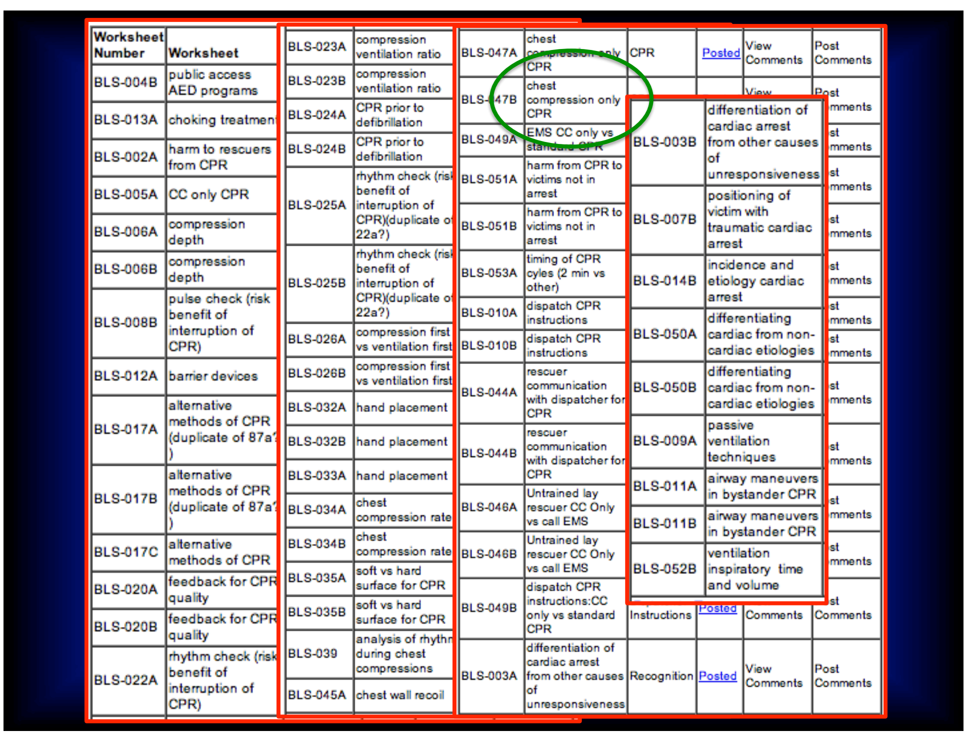
Basic Life Support Worksheets

ILCOR invites you to track the evidence evaluation worksheets with the opportunity to view and offer comments.

Worksheets will be viewable when they are posted and hyperlinked. Until they are posted the status will remain listed and not hyperlinked as indicated by pending in the status column.

If you have any questions please contact eccscience@heart.org

AED Choking CPR Dispatcher Instructions Recognition Ventilation



WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

Worksheet author(s)

Date Submitted for review: 12 September 2009

Clinical question.

In rescuers performing CPR on adult or paediatric patients (P), does compression only CPR (I) when compared with traditional CPR (C) result in an increase in adverse outcomes (e.g. fatigue) (O)?

Search strategy (including electronic databases searched).

Medline (PubMed, Ovid, SCOPUS)
Embase.
Follow-up of quoted references

Cardiopulmonary resuscitation OR CPR AND fatigue
Cardiopulmonary resuscitation OR CPR AND quality
Chest compression AND fatigue
Chest compression AND quality
Chest compression AND continuous

- **State inclusion and exclusion criteria.**

Chest compressions given mechanically or using feedback devices excluded.

- **Number of articles/sources meeting criteria for further review:**

465 papers met the above criteria; 25 papers were reviewed; 7 papers were considered relevant to the question

Updated search 17 August 2009 - Search terms as above – articles since July 2007 (date of initial search)

211additional papers met the above criteria; 4 papers were considered relevant to the question

Evidence Supporting Clinical Question

Good					Hightower, 1995 E
Fair					Huseyin, 2002 E Ashton, 2002 E Odegaard, 2007 E (key article) Trowbridge, 2009, 6 E
Poor					Ochoa, 1998 E
	1	**2**	**3**	**4**	**5**
	Level of evidence				

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Animal studies

(key article icon) denotes key article

Evidence Neutral to Clinical question

Good					
Fair				Sugerman, 2009, 981 E	Heidenreich, 2006 E Lucia, 1999 E
Poor					Riera, 2007, 108 E Manders, 2009, 1015 E
	1	**2**	**3**	**4**	**5**
	Level of evidence				

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Animal studies

Evidence Opposing Clinical Question

Good					
Fair					
Poor					
	1	**2**	**3**	**4**	**5**
	Level of evidence				

REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

A single in-hospital, human study was found that measured quality of CPR during actual cardiac arrest procedures by healthcare professionals (LOE 4: Sugerman, 2009, 981). A sensing device with feedback to the rescuer was used to measure depth and rate of continuous chest compression for 3min. After 90sec, there was a significant fall in mean depth of compression, although this was not considered clinically significant. A weakness of the study was the presence of the feedback device which may have helped to encourage the rescuers to maintain adequate compression.

A single, manikin, study was found that directly compared the quality of continuous chest compression (CCC) with 30:2 CPR(LOE 5 Odegaard, 2007, 335). Travellers at Oslo Airport were invited to volunteer, then randomised to perform 5 min of 15:2, 30:2, or continuous chest compression. Quality of compression was measured as depth and rate. The mean depth of compression during CCC was reduced significantly with time (p=0.01), and the mean depth (30mm ± 8mm) was significantly less than that for 30:2 (45±8; p=<0.05). There was no significant difference in rates of compression.

Five manikin studies were found that measured the effect of time (3-18 min) on the quality of CCC without comparison with CPR. Four of these (LOE 5: Ashton, 2002, 151; Hightower, 1995, 300; Huseyin, 2002, 57; Ochoa, 1998, 149) demonstrated a time-related deterioration in quality of chest compression. In each, compression depth was included as part of 'correct/adequate' compressions, but without specific data as to the actual depths of compression achieved. The aim of the fifth study (LOE 5: Lucia, 1999, 158) was to evaluate the effect of physical fitness on performance of CC. No values for compression depth are reported, but 'the mean values fell within standard accepted limits (38 to 51 mm)…'

Two LOE 5 manikin studies (Lucia, 1999, 158; Riera, 2007, 108) were found that demonstrated that performing chest compressions increases heart rate and oxygen consumption in healthcare professionals. Three LOE 5 studies (Odegaard 2007, 335; Trowbridge, 2009, 6; Lucia, 1999, 158) showed that some rescuers are unable to complete 5min (laypeople), 5-6min (laypeople) or 18min (healthcare professionals) continuous chest compression respectively because of physical exhaustion.

One manikin study (LOE 5: Heidenreich, 2006, 1020) compared 9-minutes of CCC with 15:2 CPR. The mean number of 'adequate compressions' were greater for CCC than 15:2 for the first 2 minutes, no longer different by the third minute, and less by the ninth minute.

A single, manikin, healthcare professional, LOE 5 study (Manders, 2009, 1015) compared the number of effective (depth >38mm) compressions over 8 min, changing rescuer every 1 minute with changing every 2 min. Fatigue was reported more frequently with 2-min periods of compression, but total effective compressions were similar.

Conclusion

DISCLAIMER: Potential possible wording for a Consensus on Science Statement. Final wording will differ due to other input and discussion.

CONSENSUS ON SCIENCE:

Citation List

Ashton A, McCluskey A, Gwinnutt CL, A.M. Keenan AM. Effect of rescuer fatigue on performance of continuous external chest compressions over 3 min. Resuscitation 2002; 55: 151-155.

Guidelines for the performance of cardiopulmonary resuscitation (CPR) have been revised recently and now advocate that chest compressions are performed without interruption for 3 min in patients during asystole and pulseless electrical activity. The aim of the present study was to determine if rescuer fatigue occurs during 3 min of chest compressions and if so, the effects on the rate and quality of compressions. Forty subjects competent in basic life support (BLS) were studied. They performed continuous chest compressions on a Laerdal SkillmeterTM Resusci-Anne† manikin for two consecutive periods of 3 min separated by 30 s. The total number of compressions attempted was well maintained at approximately 100 min_1 throughout the period of study. However, the number of satisfactory chest compressions performed decreased progressively during resuscitation (PB 0.001) as follows: first min, 82 min_1; second, 68 min_1; third, 52 min_1; fourth, 70 min_1; fifth, 44 min_1; sixth, 27 min_1. We observed significant correlations between the number of satisfactory compressions performed and both height and weight of the rescuer. Female subjects achieved significantly fewer satisfactory compressions compared with males (P_ 0.03). Seven subjects (five female, two male) were unable to complete the second 3-min period because of exhaustion. We conclude that rescuer fatigue adversely affects the quality of chest compressions when performed without interruption over a 3-min period and that this effect may be greater in females due to their smaller stature. Consideration should be given to rotating the rescuer performing chest compressions after 1 min intervals.

Level 5 (manikin). Fair. Supporting.
Continuous chest compressions only. 2 x 3-min periods. Deterioration in depth/quality of compression over each 3-min period.

Heidenreich JW, Berg, RA, Higdon TA, Ewy GA, Kern KB, Sanders AB. Rescuer Fatigue: Standard versus Continuous Chest-Compression Cardiopulmonary Resuscitation. Academic Emerg Med 2006; 13: 1020-1026.

Objectives: Continuous chest-compression cardiopulmonary resuscitation (CCC-CPR) has been advocated as an alternative to standard CPR (STD-CPR). Studies have shown that CCC-CPR delivers substantially more chest compressions per minute and is easier to remember and perform than STD-CPR. One concern regarding CCC-CPR is that the rescuer may fatigue and be unable to maintain adequate compression rate or depth throughout an average emergency medical services response time. The specific aim of this study was to compare the effects of fatigue on the performance of CCC-CPR and STD-CPR on a manikin model. Methods: This was a prospective, randomized crossover study involving 53 medical students performing CCC-CPR and STD-CPR on a manikin model. Students were randomized to their initial CPR group and then performed the other type of CPR after a period of at least two days. Students were evaluated on their performance of 9 minutes of CPR for each method. The primary endpoint was the number of adequate chest compressions (at least 38 mm of compression depth) delivered per minute during each of the 9 minutes. The secondary endpoints were total compressions, compression rate, and the number of breaks taken for rest. The students' performance was evaluated on the basis of Skillreporter Resusci Anne (Laerdal, Wappingers Falls, NY) recordings. Primary and secondary endpoints were analyzed by using the generalized linear mixed model for counting data. Results: In the first 2 minutes, participants delivered significantly more adequate compressions per minute with CCC-CPR than STD-CPR, (47 vs. 32, p = 0.004 in the 1st minute and 39 vs. 29, p = 0.04 in the 2nd minute). For minutes 3 through 9, the differences in number of adequate compressions between groups were not significant. Evaluating the 9 minutes of CPR as a whole, there were significantly more adequate compressions in CCC-CPR vs. STD-CPR (p = 0.0003). Although the number of adequate compressions per minute declined over time in both groups, the rate of decline was significantly greater in CCC-CPR compared with STD-CPR (p = 0.0003). The mean number of total compressions delivered in the first minute was significantly greater with CCC-CPR than STD-CPR (105 per minute vs. 58 per minute, p < 0.001) and did notchange over 9 minutes in either group. There were no differences in compression rates or number of breaks between groups. Conclusions: CCC-CPR resulted in more adequate compressions per minute than STD-CPR for the first 2 minutes of CPR. However, the difference diminished after 3 minutes, presumably as a result of greater rescuer fatigue with CCC-CPR. Overall, CCC-CPR resulted in more total compressions per minute than STD-CPR during the entire 9 minutes of resuscitation.

Level 5 (manikin). Fair. Neutral.
Compared 9-minutes of continuous compressions with 15:2 CPR, not 30:2 The mean number of 'adequate compressions' were greater for continuous than 15:2 for the first 2 minutes, no longer different by the third minute, and less by the ninth minute. Although not compared with 30:2, showed initial good compression quality, deteriorating with time.

Sugerman NT, Edelson DP, Leary M, Weidman EK, Herzberg DL, Vanden Hoek TL, Becker LB, Abella BS. *Rescuer fatigue during actual in-hospital cardiopulmonary resuscitation with audiovisual feedback: A prospective multicenter study. Resuscitation 2009; 80: 981–984.*

Level 4. Fair. Neutral.

135 episodes of continuous chest compression by healthcare professionals during in-hospital cardiac arrest procedures were monitored. A sensing device with feedback to the rescuer was used to record depth and rate of compression for 3 min. After 90 sec, there was a significant fall in mean depth of compression, although this was not considered clinically significant. A weakness of the study was the presence of the feedback device which may have helped to encourage the rescuers to maintain adequate compression.

Looking Forward

Cardiac Arrest Guidelines 1

The ROC PRIMED Cardiac Arrest Trial found only two clinical treatments that improved survival from cardiac arrest:

1. Defibrillation of ventricular fibrillation saves lives.

2. A high percentage of cardiac compressions per minute saves lives.

Cardiac Arrest Guidelines 2

- Maintaining blood flow to the heart muscle at all possible moments during cardiac arrest is essential. Compressions are the only way to do that during cardiac arrest.
- In caring for a patient in cardiac arrest, it is appropriate to begin and maintain compressions, minimizing interruptions in compressions at all times.

Areas Anticipated to be Addressed and Stressed in the upcoming release of the new Guidelines

In No Particular Order #1

- Uninterrupted compressions while the patient is in cardiac arrest, avoiding distractions to compressors
- Don't compress too fast, and emphasize full recoil
- Deemphasizing early ventilations in arrest ***EXCEPT*** with an obstructed airway
- It is not AT ALL clear what the optimal airway is, and supraglottic airway is probably as good as ETI early on
- BVM is FINE during compressions
- Avoid over-ventilation
- Not at all clear if drugs help, indeed MAY be harmful

In No Particular Order #2

- Something made your patient die, and you will likely have to figure out what it was: CAD, PE, CHF, drugs, hemorrhage, TP, CT, electrolyte, acidosis, stroke, etc[5]
- Procainamide may be coming back – *Mattu, U.O.M.*
- Think therapeutic hypothermia, and keep the neurologist AWAY from your patient early on
- Avoid over-ventilation
- Monitor Capnography, allow mild hypercapnea

In No Particular Order #3

- Following ROSC, medics should perform a 12-lead ECG ASAP and transport pt. to a Resuscitation Center
- Consider TCP for unresponsive slow PEA
- There is no evidence to support the use of atropine in asystole or PEA, though there is no evidence of harm
- Think about using physiological parameters to guide vasopressor use in CPR: $ETCO_2$, CVO_2
- Cricoid pressure will likely be deemphasized
- No evidence in support of or against antiarrhythmics in the "post-arrest phase"

…and, oh, by the way…

- *We should re-order the "ABCs" to "CABs" as has been done for years in Europe, to stress the importance of chest compression*
- *Teach "Compressions only CPR" to the public over the phone during a cardiac arrest, with the exception of arrest caused by an obstructed airway*

Take Home Message 1:

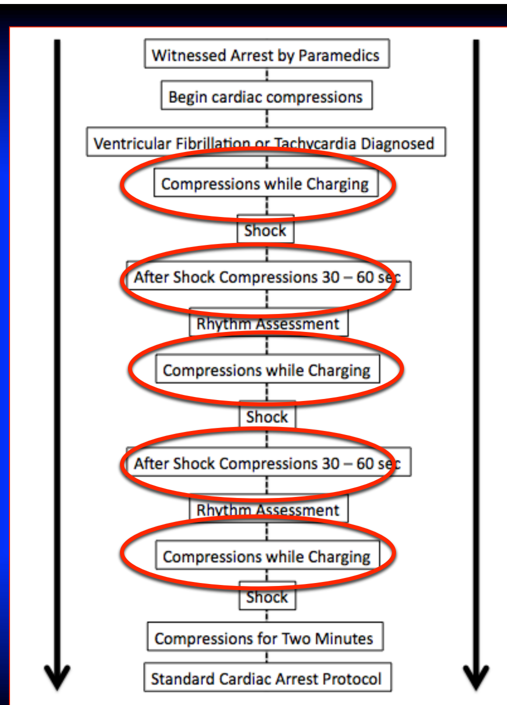
- GET ON THE CHEST
- STAY ON THE CHEST
- KEEP PUMPING UNTIL YOU STOP THE CODE

Take Home Message 2:

- If an airway obstruction caused the cardiac arrest, you MUST get the airway open

Take Home Message 3:

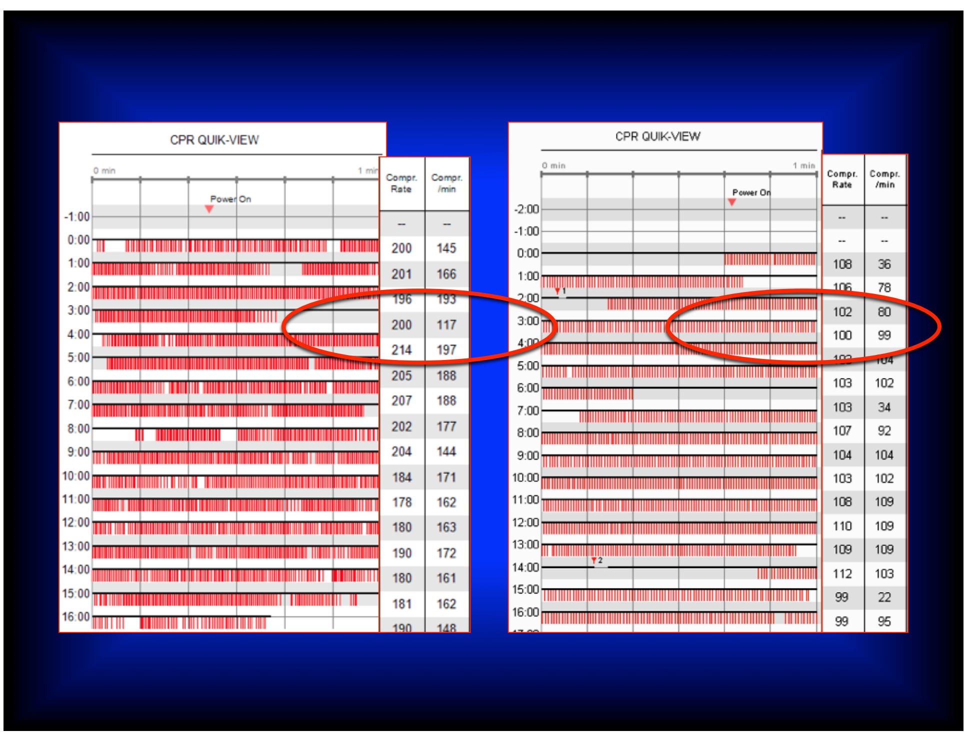
- The core management of cardiac arrest is the same for all rhythms



Take Home Message 4:

- In the non-airway obstruction arrest, ventilation is de-emphasized for several minutes
- Clawson's experience


2:00
Compr. Rate
Compr. /min
Bee Gees
190 148
147 112


CPR QUIK-VIEW
Power On
Compr. Rate
Compr. /min
-- --
200 145
201 166
196 193
200 117
214 197
205 188
207 188
202 177
204 144
184 171
178 162
180 163
190 172
180 161
181 162
CPR QUIK-VIEW
Power On
Compr. Rate
Compr. /min
-- --
-- --
108 36
106 78
102 80
100 99
103 102
103 34
107 92
104 104
103 102
108 109
110 109
109 109
112 103
99 22
99 95

Faster is NOT Better!!

We NEED to be Stressing *THREE THINGS*

- ✓ *Citizen "CR"*
- ✓ *Medic Uninterrupted Compressions*
- ✓ *Rate 100 - 120*

Slovis's Five Steps of Cardiac Arrest Management

1. *Pre-arrest - get the word out in the community about Compressions-Only CPR!*
2. *Get to cardiac arrest patients quickly - Too many EMS systems are wasting up to 3 minutes processing the 9-1-1 call.*
3. *Our first responders are indispensable partners in our chain-of-survival and need to be treated as equals.*
4. *Advanced responders need to know what works and utilize evidence-based techniques.*
5. *EMS needs to partner with our other emergency colleagues inside the hospital by using approaches such as therapeutic hypothermia and other best practices.*

Vision for the Future:

- That all that CAN be prepared, would be
- That all of us in clinical care sing as a well-rehearsed choir from **the same sheets of music**
- That research will light our paths as we maintain our commitment to the betterment of the human condition…