Emergency Ventilatory Management of the Critically Ill and Injured:

Elemental or Detrimental?

Presented at EMS Today

March 20, 2005

That Brings Us to Today's Sacred Cow…

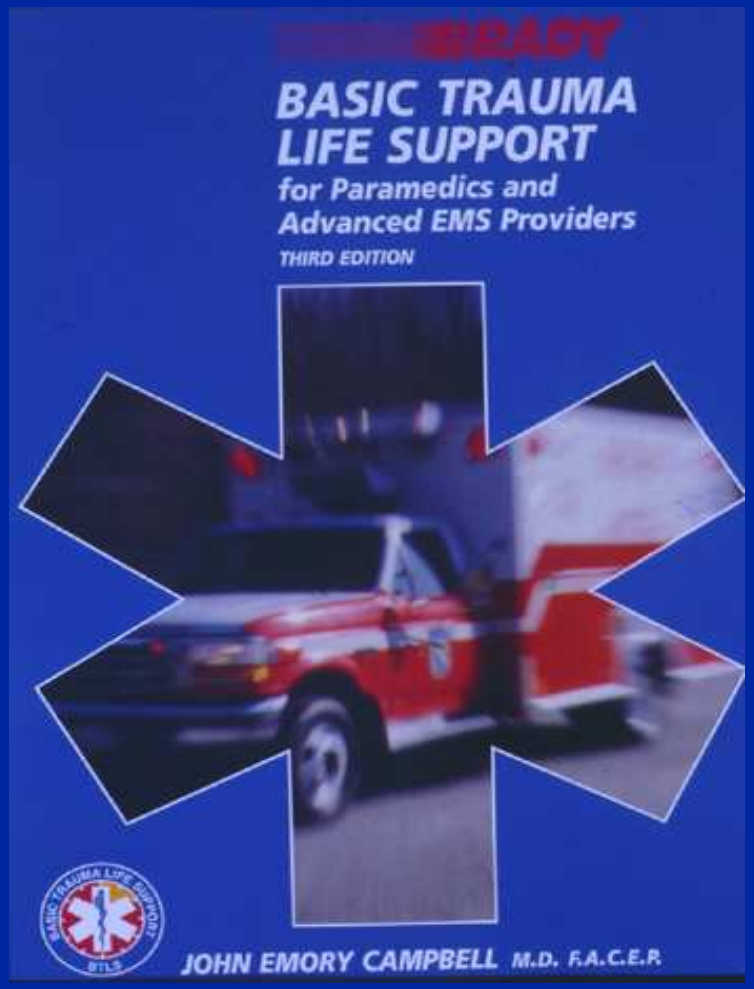
the A-B-C's!

What About the "B" Part?

Assisted Breathing with PPV

Is It Really Necessary ?

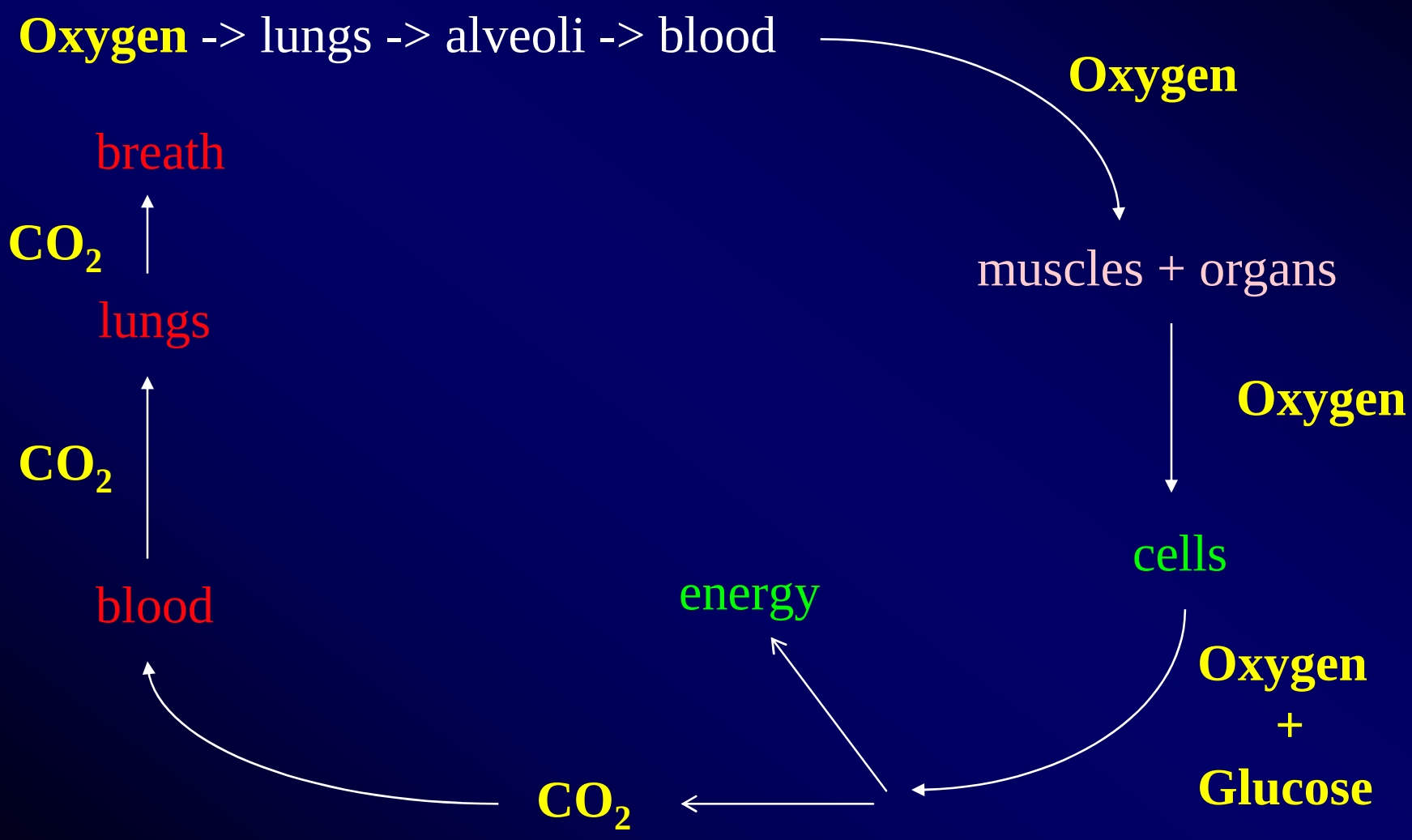
Q: What are the Typical Teachings & Current National Protocol Standards?



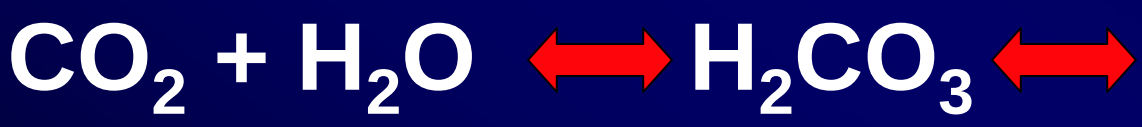
A: 10-15 ml/kg Tidal Volume & 15-20 breaths/min Respiratory Rate

Why Do We Ventilate?

Oxygen and CO_2



Carbon dioxide physiology



Carbon dioxide physiology

- 0.03% concentration in air
- Resting adult produces 2.5 mg/kg/min
- In a 70 kg adult, that is about

  175 mg per minute, or about

  4% of a teaspoonful

Carbon dioxide physiology

- **Transported in blood**
  - 60-70% bicarbonate ion after conversion in RBCs using carbonic anhydrase
  - 20-30% bound to proteins (e.g., Hb)
  - 5-10% in physical solution (PCO_2)
- **Cleared by alveolar ventilation**

Alveoli: The Place Where Gas Exchange Happens

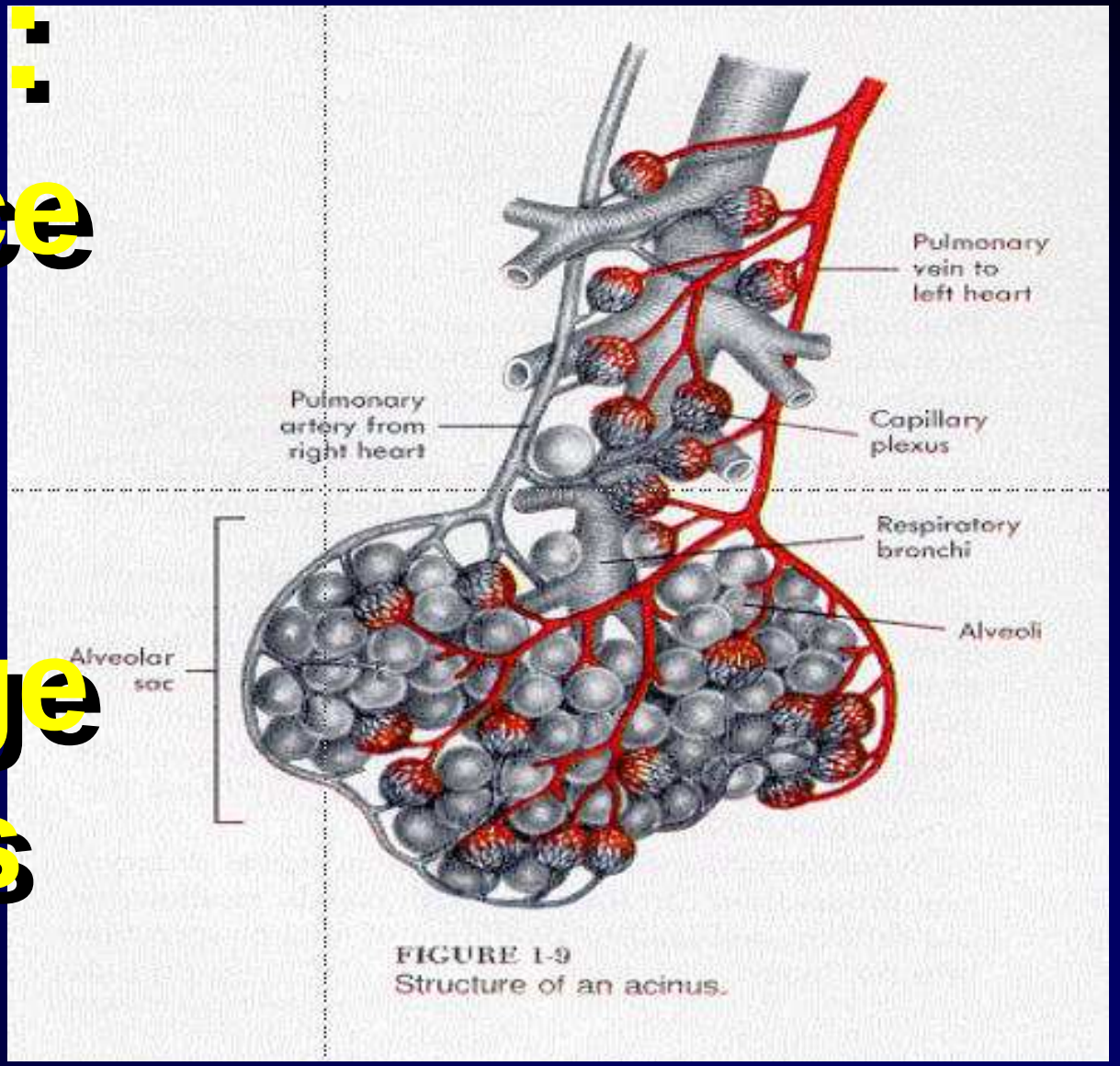


FIGURE 1-9
Structure of an acinus.

Oxygenation *vs.* Ventilation

Saturating Red Cells

vs.

Clearing CO_2

Oxygenation

Air Movement

and

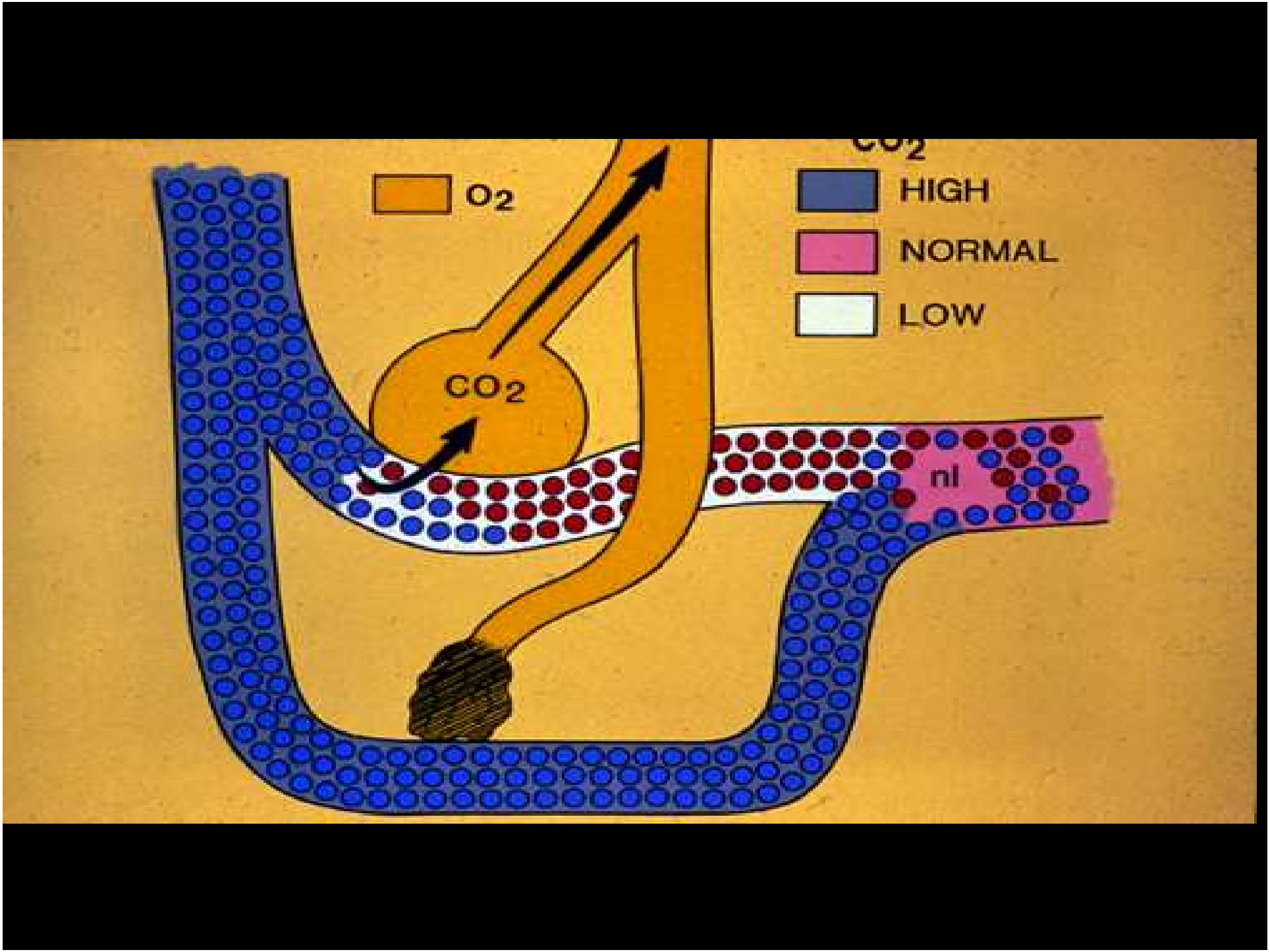
Blood Flow

THUS! Cyanosis…

An Air Movement Problem

or

A Circulation Problem



What's an Adequate Tidal Volume?

IT DEPENDS ON THE CLINICAL SITUATION!!

10 ml *per kg*

(Intubated, No PEEP, No Diffuse Lung Injury)

Ventilation

Tidal Volume

x

RR

“Ventilation” MEANS RATE!!

How Fast Should You Breathe Them?

Need to Ventilate

- CO_2 Production

(depends upon O_2 Consumption & Venous Return)

High Ventilatory Demand...

But Also:

in very low flow states

Oxygen Consumption

Becomes Dependent on

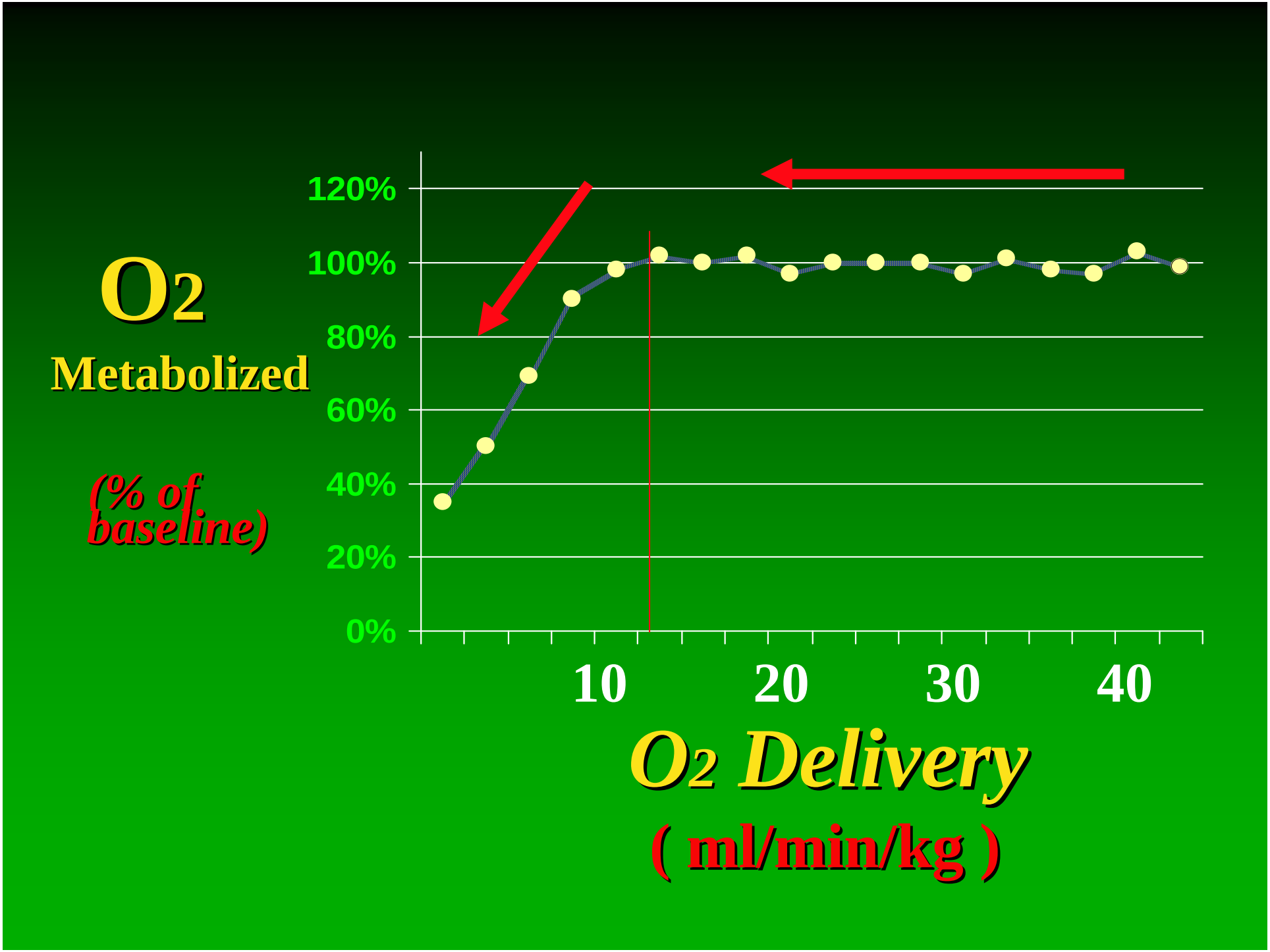
Oxygen Delivery...

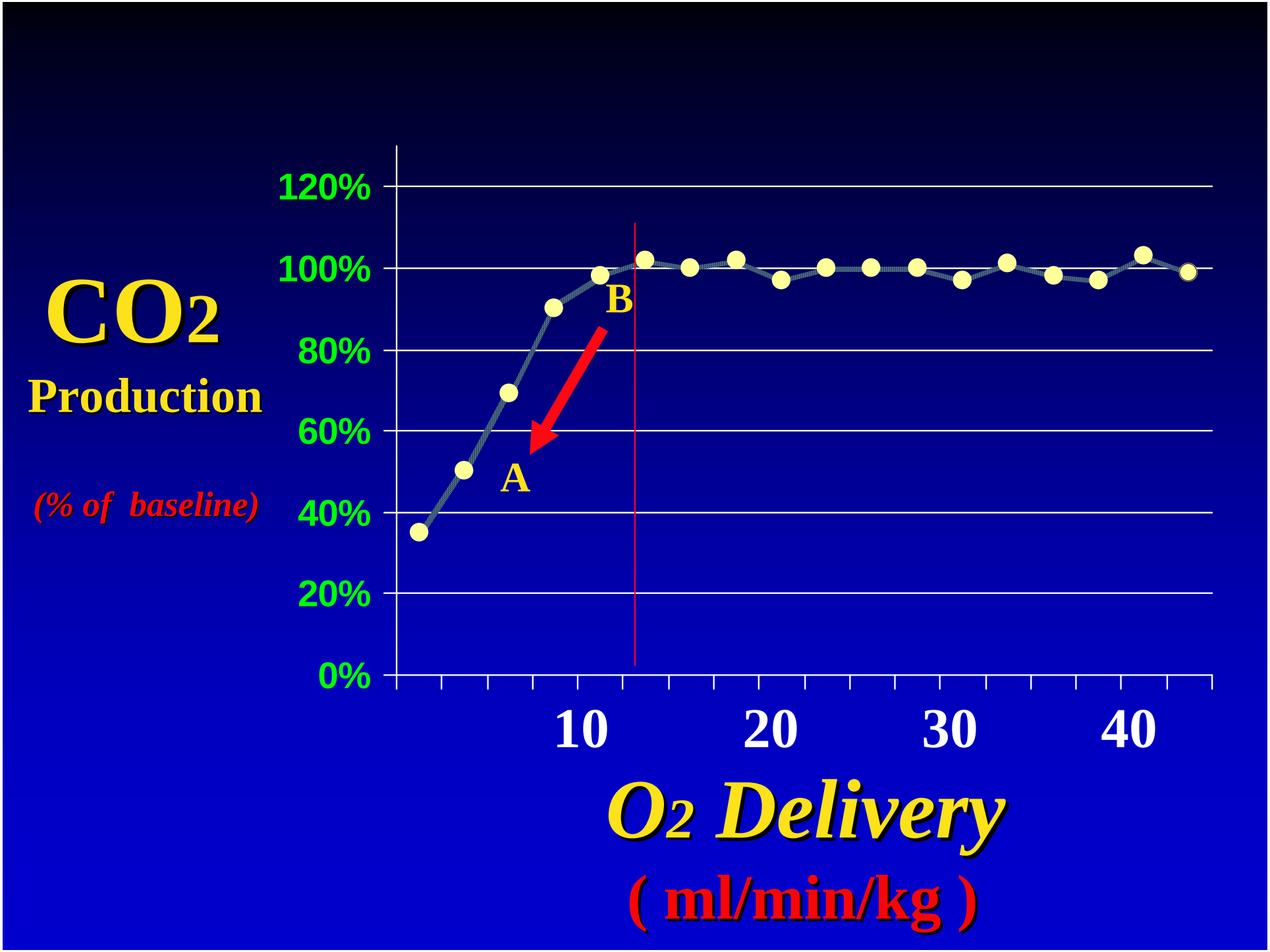
For Example, CPR Cases...

Cardiac Arrest

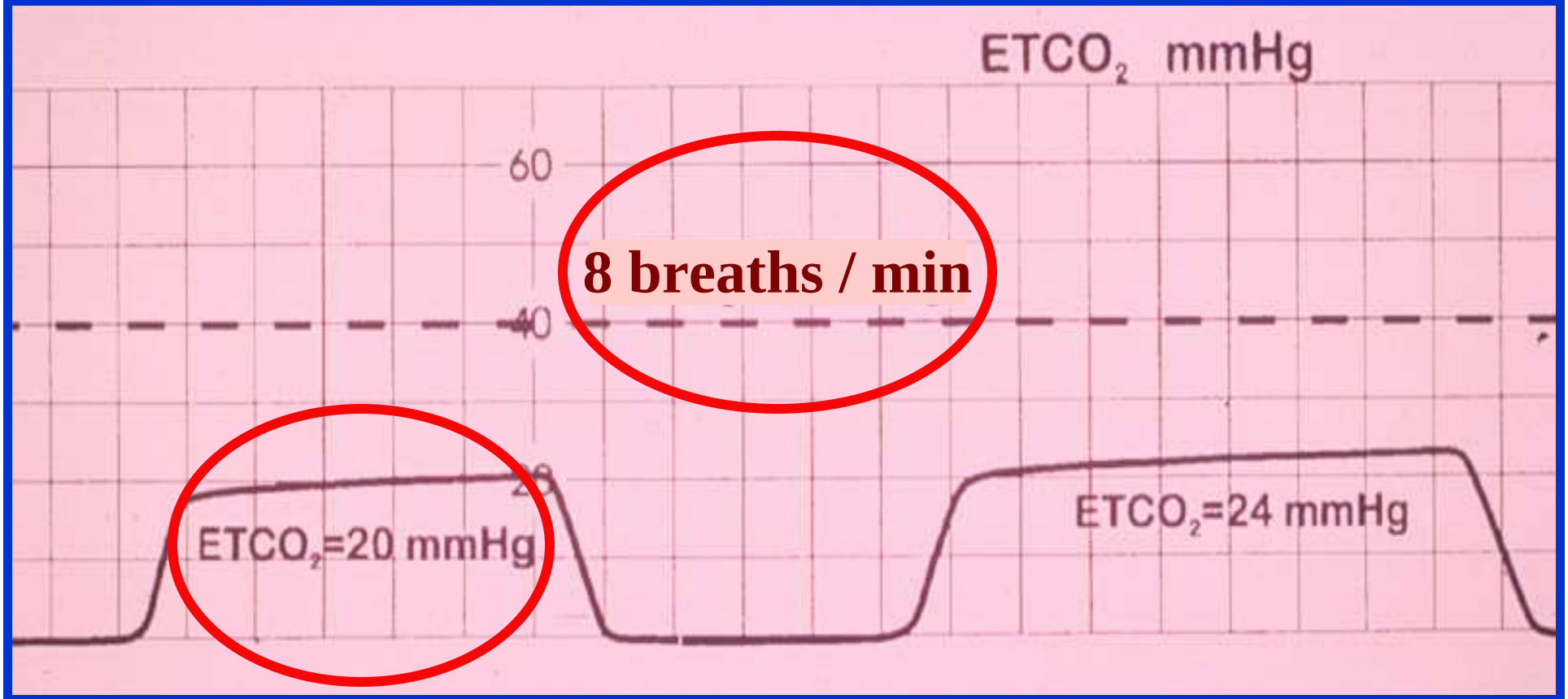
- Little O_2 Delivery & Consumption
- Little CO_2 Production & Venous Return

...Little Need to Ventilate

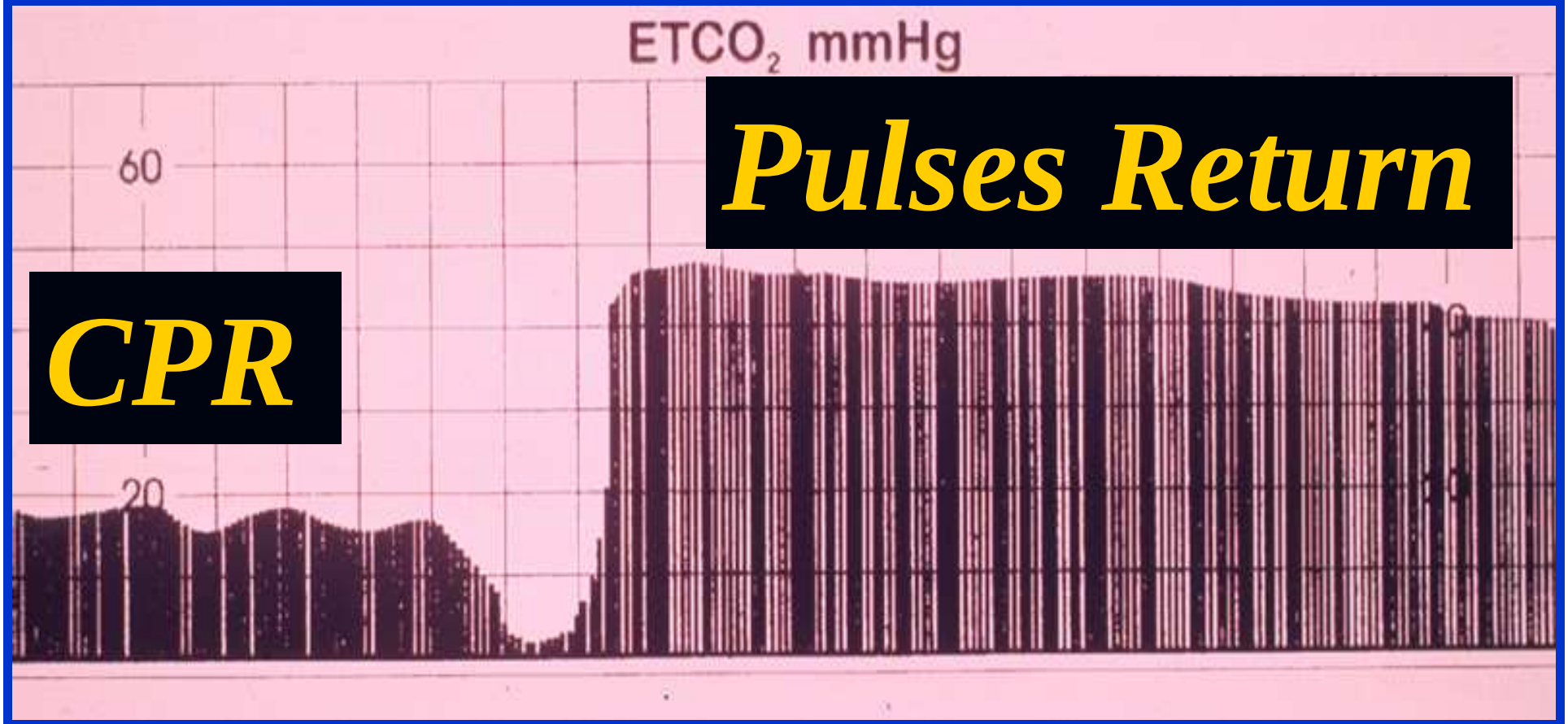




Cardiac Arrest….



…Little CO_2 Excretion



Take Home…

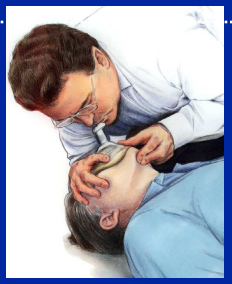
Ventilation Should Match Perfusion…

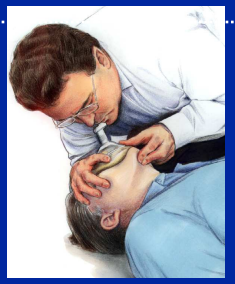
The "CPR Dilemma"

Chest Compressions & *Coronary Perfusion Pressure*

5:1 Ratio

20 mmHg





40 mmHg

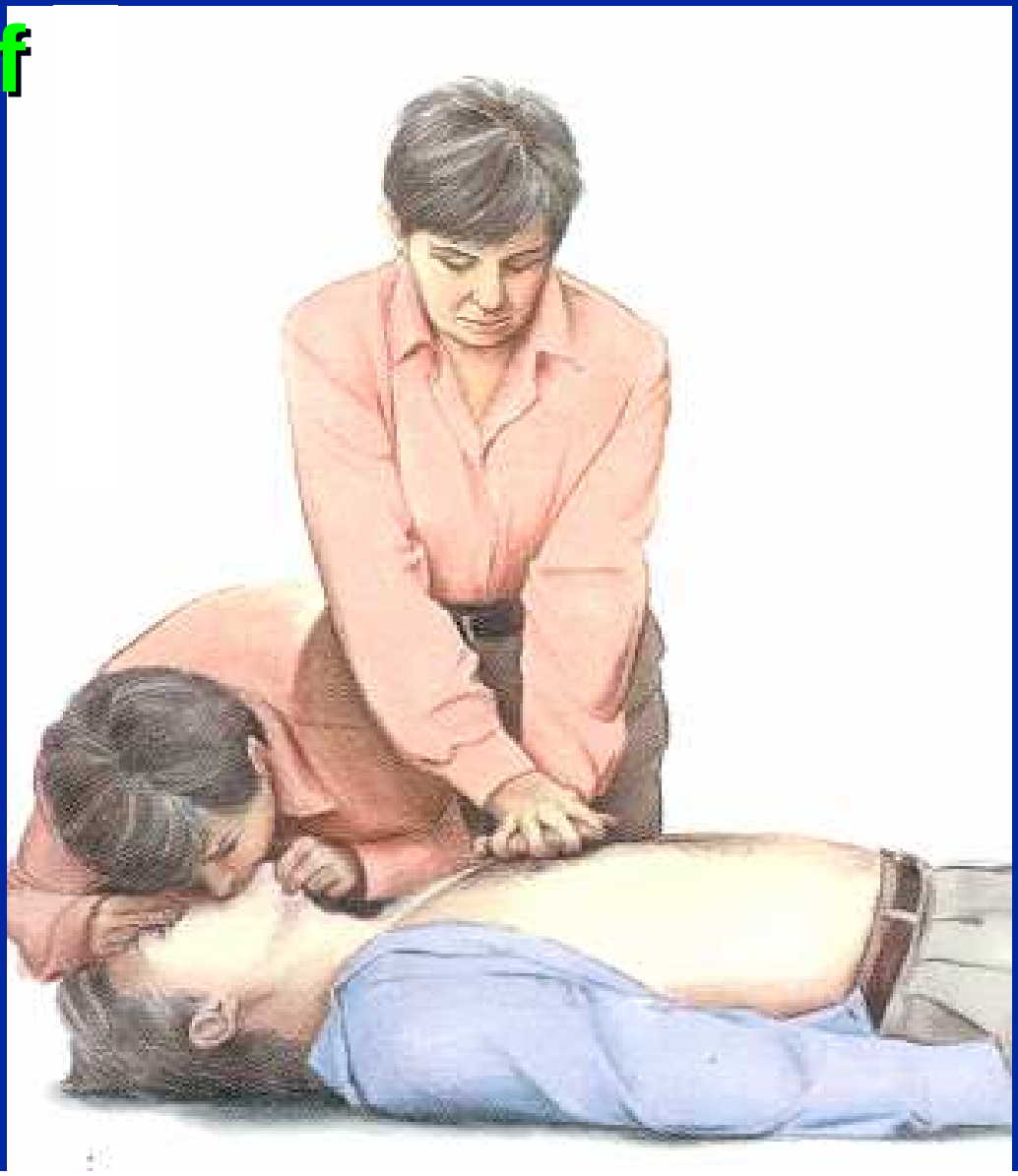
15:2 Ratio

20 mmHg

“Reality” CPR

In Video Study of Lay Individuals Recently Taught 15:2 CPR ….

…Took 15-16 Seconds to Deliver the 2 Breaths



Is There Evidence That We Can Breathe Less Often?

Sanders, *et al*

- **15:2 (e.g., *standard CPR*)**
- **50:5 (e.g., *Great Britain*)**
- **CC (*chest compressions* only)**
- **4 min CC only; *then* 100:2**

Porcine model of four different CPR techniques
Annals of Emergency Medicine, Dec. 2002, pp 553-62

Neurological Outcomes...

- **4 min CC only; *then* 100:2**

  --Did Significantly Better than

  15:2 (e.g., standard CPR)

- **CC (chest compression only)**

  --Did Much Worse

Annals of Emergency Medicine, Dec. 2002, pp 553-62

Neurological Outcomes...

- **CONCLUSION: In this experimental model of bystander CPR, the group receiving compressions only for 4 minutes followed by a compression-ventilation ratio of 100:2 achieved better neurologic outcome than the group receiving standard CPR and CC-CPR. Consideration of alternative chest compression-ventilation ratios might be appropriate.**

Annals of Emergency Medicine, Dec. 2002, pp 553-62

Sources of Ventilation:

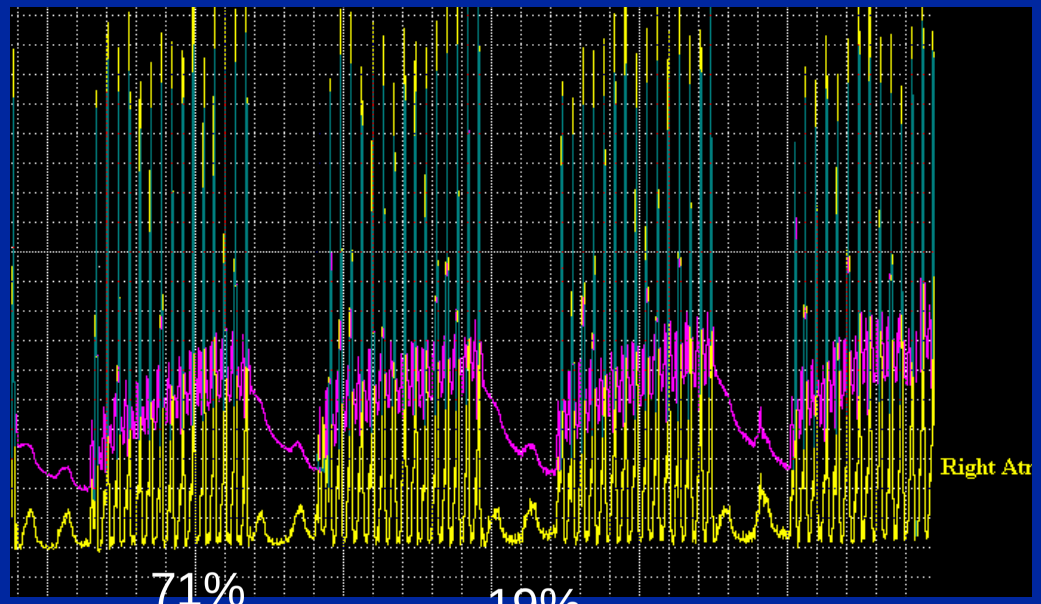
- Active Positive Pressure
- Chest Compressions
- Gasping (Agonal Breaths)

Stopping to Breathe...

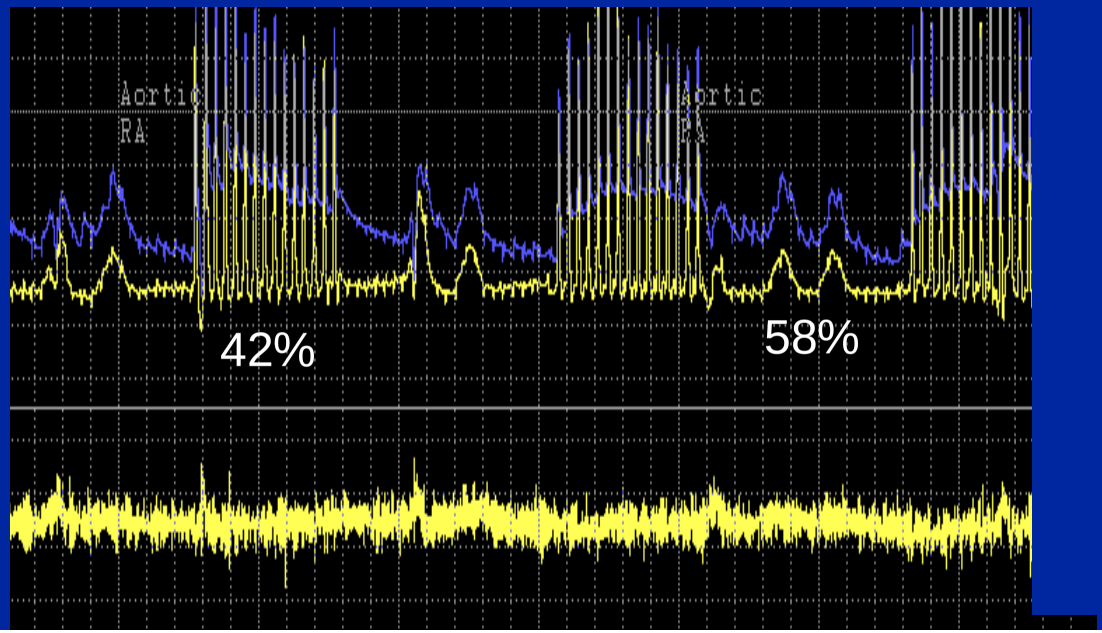
...Interrupts

Chest Compressions

Ideal CPR



Real CPR



Normal Breathing…

- **Generates Negative Intra-thoracic Pressure**
- **Pulls Lungs Open in a Specific Architecture**
- **Enhances Venous Return and Cardiac Preload**

Assisted Breathing with PPV

PPV…

- **Generates Positive Intrathoracic Pressure**
- **Pushes Lungs Open in a Maldistributive Manner**
- **Diminishes Venous Return and Cardiac Preload**

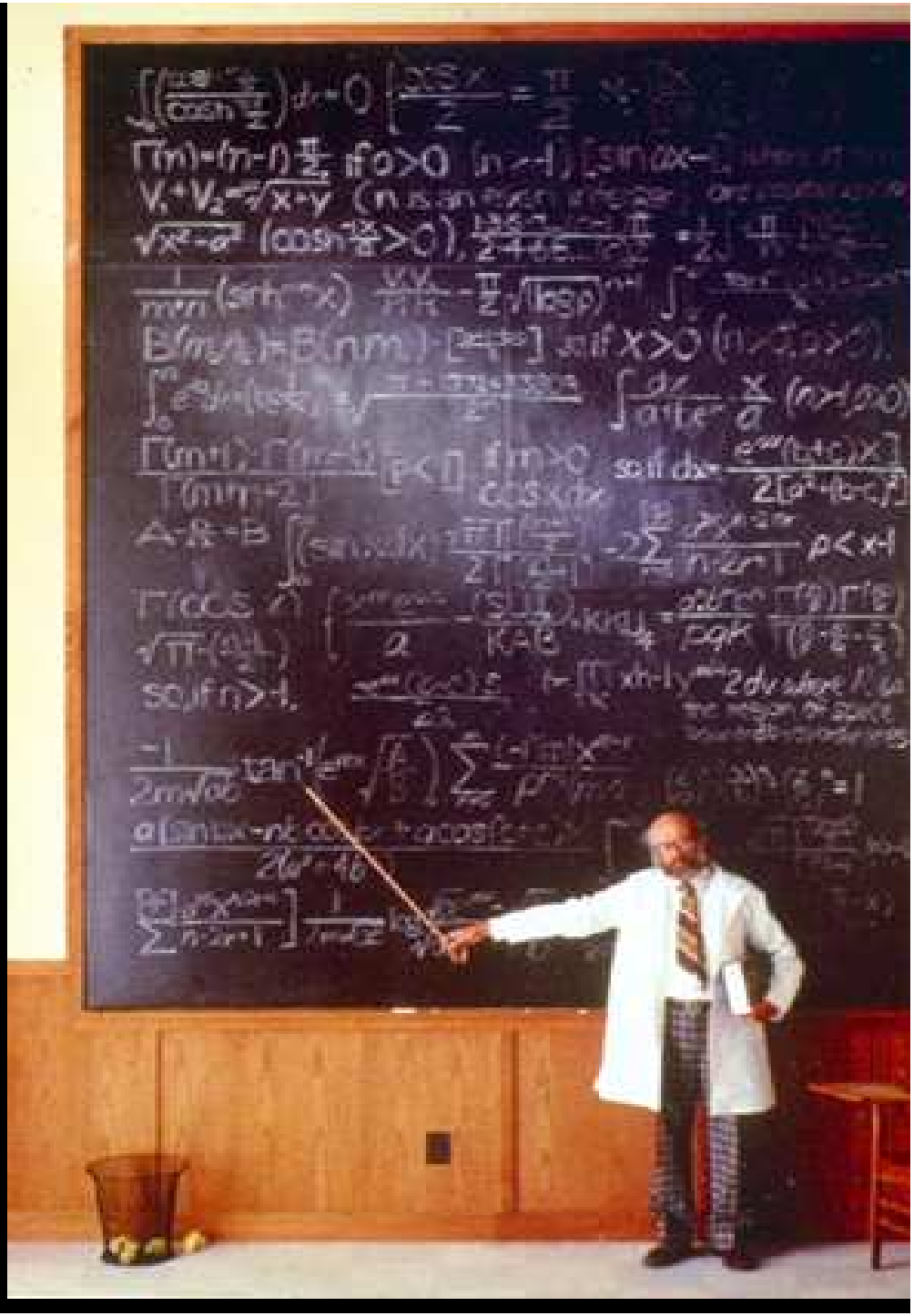
PPV Cardiovascular Effects

Worsened By...

- **Obstructive Lung Disease**
- **Hypovolemia**
- **Circulatory Compromise**

So Let's Study It !!

It's Not **Rocket Science !!**



The New England Journal of Medicine

Established in 1812 as THE NEW ENGLAND JOURNAL OF MEDICINE AND SURGERY

VOLUME 342 MAY 25, 2000 NUMBER 21

THIS WEEK IN THE *JOURNAL* 1545

ORIGINAL ARTICLES

Cardiopulmonary Resuscitation by Chest Compression Alone or with Mouth-to-Mouth Ventilation 1546
A. HALLSTROM, L. COBB, E. JOHNSON, AND M. COPASS

Dexamethasone Alone or in Combination with Ondansetron for the Prevention of Delayed Nausea and Vomiting Induced by Chemotherapy 1554

CASE RECORDS OF THE MASSACHUSETTS GENERAL HOSPITAL

A 53-Year-Old Woman with Swelling of the Right Breast and Bilateral Lymphadenopathy 1590
E.A. PILLEMER AND N.L. HARRIS

EDITORIAL

Cardiopulmonary Resuscitation — Strengthening the Links in the Chain of Survival 1599
G.A. EWY

Dispatch Assisted CPR Instructions

Compressions Alone

vs

Standard ABC's

Survival...

Compressions

Alone

14.7%

vs

Standard

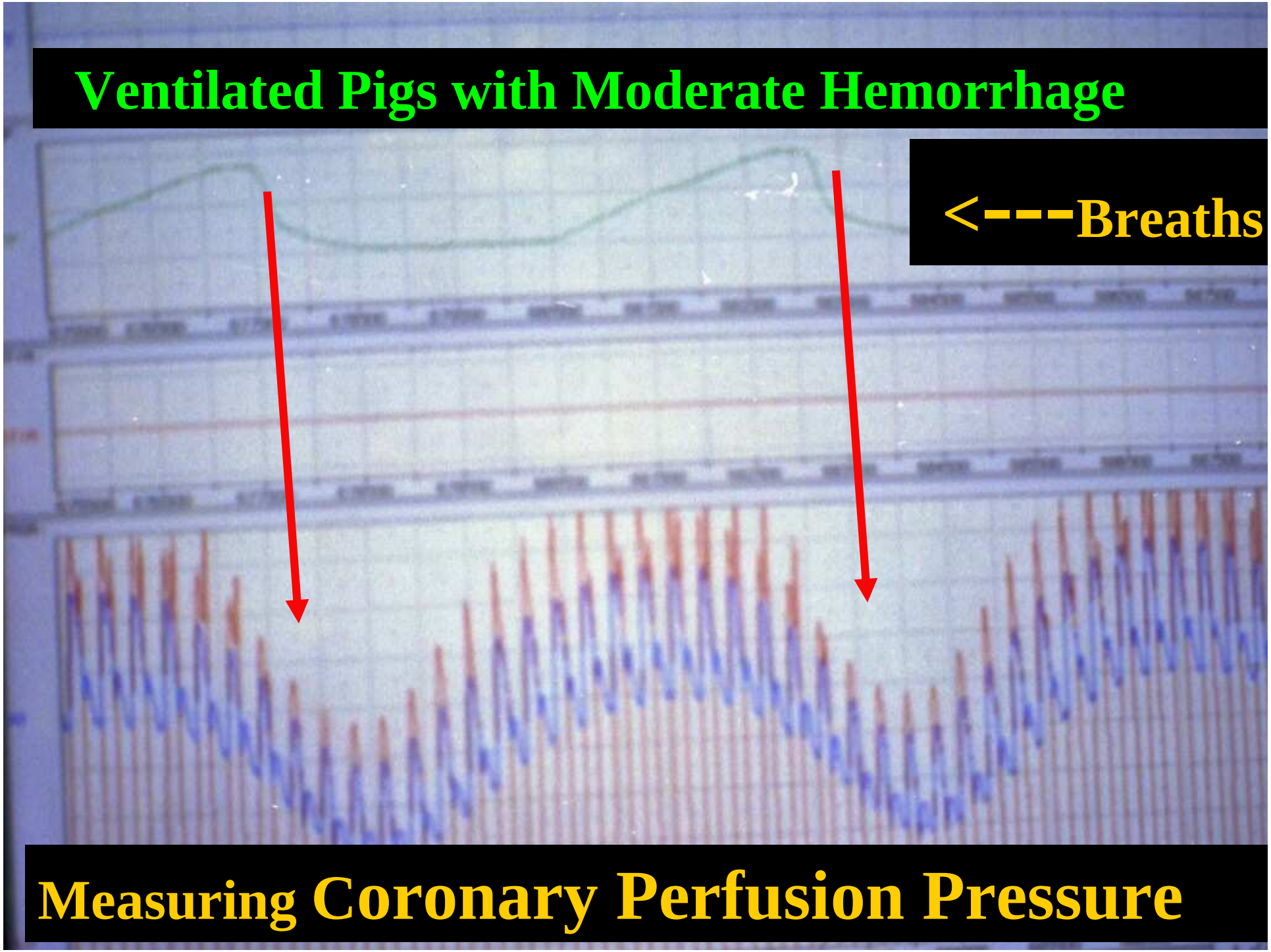
ABC's

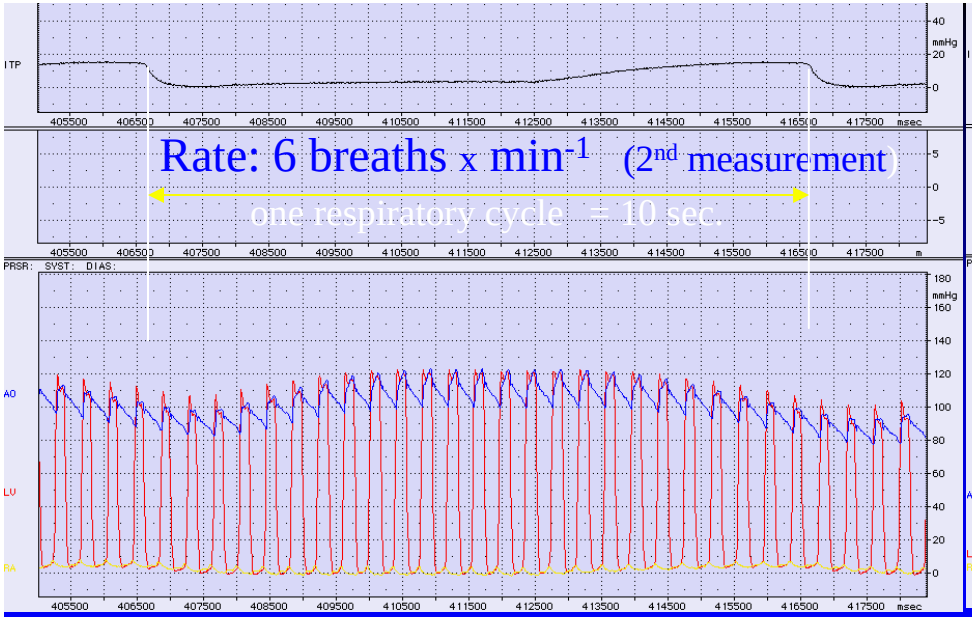
10.4%

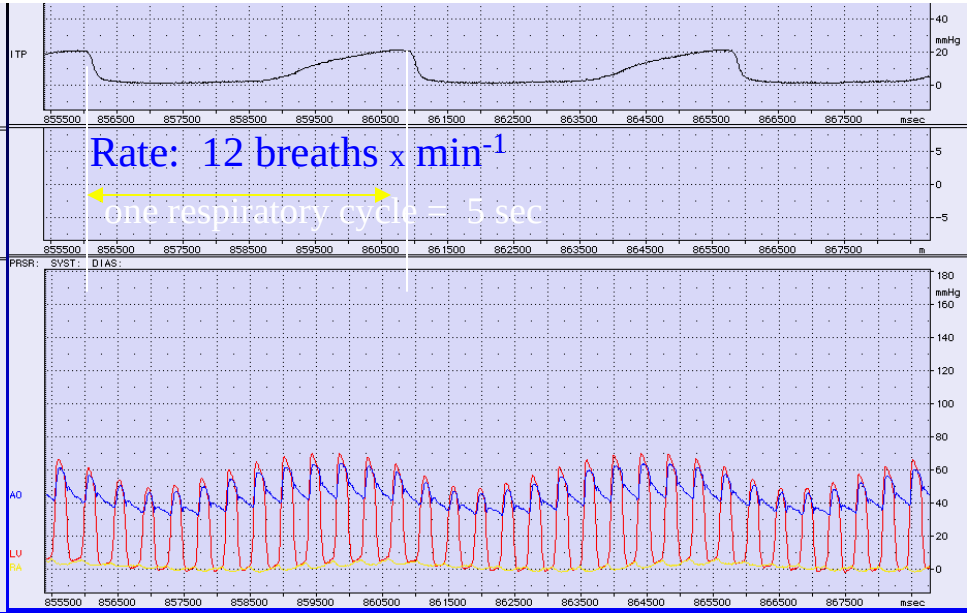
But Does This Apply to Children? Think Hypoxia!!

How About Hypovolemic Patients?

Depends!







RR = 6 / min

RR = 12 / min

Time-Averaged Coronary Perfusion Pressure

= *Area Under the Curve* *(in Pink)*

Hyperventilation-Induced Hypotension During Cardiopulmonary Resuscitation

Tom P. Aufderheide, MD; Gardar Sigurdsson, MD; Ronald G. Pirrallo, MD, MHSA; Demetris Yannopoulos, MD; Scott McKnite, BA; Chris von Briesen, BA, EMT; Christopher W. Sparks, EMT; Craig J. Conrad, RN; Terry A. Provo, BA, EMT-P; Keith G. Lurie, MD

Background—A clinical observational study revealed that rescuers consistently hyperventilated patients during out-of-hospital cardiopulmonary resuscitation (CPR). The objective of this study was to quantify the degree of excessive ventilation in humans and determine if comparable excessive ventilation rates during CPR in animals significantly decrease coronary perfusion pressure and survival.

Methods and Results—In humans, ventilation rate and duration during CPR was electronically recorded by professional rescuers. In 13 consecutive adults (average age, 63±5.8 years) receiving CPR (7 men), average ventilation rate was 30±3.2 per minute (range, 15 to 49). Average duration per breath was 1.0±0.07 per second. No patient survived. Hemodynamics were studied in 9 pigs in cardiac arrest ventilated in random order with 12, 20, or 30 breaths per minute. Survival rates were then studied in 3 groups of 7 pigs in cardiac arrest that were ventilated at 12 breaths per minute (100% O_2), 30 breaths per minute (100% O_2), or 30 breaths per minute (5% CO_2/95% O_2). In animals treated with 12, 20, and 30 breaths per minute, the mean intrathoracic pressure (mm Hg/min) and coronary perfusion pressure (mm Hg) were 7.1±0.7, 11.6±0.7, 17.5±1.0 ($P<0.0001$), and 23.4±1.0, 19.5±1.8, and 16.9±1.8 ($P=0.03$), respectively. Survival rates were 6/7, 1/7, and 1/7 with 12, 30, and 30+ CO_2 breaths per minute, respectively ($P=0.006$).

Conclusions—Professional rescuers were observed to excessively ventilate patients during out-of-hospital CPR. Subsequent animal studies demonstrated that similar excessive ventilation rates resulted in significantly increased intrathoracic pressure and markedly decreased coronary perfusion pressures and survival rates. **(*Circulation*. 2004;109: 1960-1965.)**

Aufderheide Study of Paramedics

- Averaged 37 ± 4 breaths/min
- Re-trained at 12 / min
- Averaged 22 ± 3 breaths/min

CONCLUSIONS:

Despite seemingly adequate training, professional rescuers consistently hyperventilated patients during out-of-hospital CPR.

And on the Road to the 22nd Century...

…Phrenic Nerve Pacemaker?

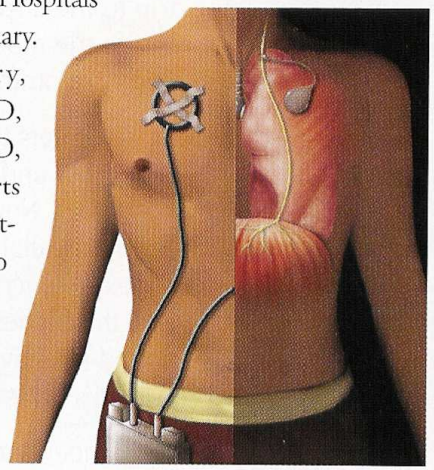
CLOSE-UP

Diaphragm Pacing Device Offers Ventilator Freedom

By Debra Yemenijian

For more than 20 years, researchers have sought ways to stimulate the nerves that control the diaphragm. Today, Christopher Reeve is reaping the benefits of their work after undergoing what the actor has called "a drastic and dangerous procedure."

Reeve underwent surgery for diaphragm pacing at the University Hospitals of Cleveland in February. During the surgery, Raymond Onders, MD, Anthony DiMarco, MD, and a team of experts implanted electrodes attached through wires to a small external battery pack that electrically stimulates Reeve's diaphragm muscle and phrenic nerves. The procedure carries some risk of damaging these nerves, which lead from the brain to the diaphragm.



When the diaphragm muscle is stimulated, it contracts, causing a vacuum-like effect

conditioning, that patient weaned off mechanical ventilation, and he has been independent of the ventilator for more than two years. This has allowed him to speak more normally, improved his sense of smell and increased his mobility.

Reeve's operation "yielded impressive results," Dr. Onders said.

Every year, 10,000 new cases of spinal cord injury are reported in the United States. About 1,000 of these patients require mechanical ventilation following injury. Some patients recover on their own, but others, like Reeve, may require lifelong ventilation.

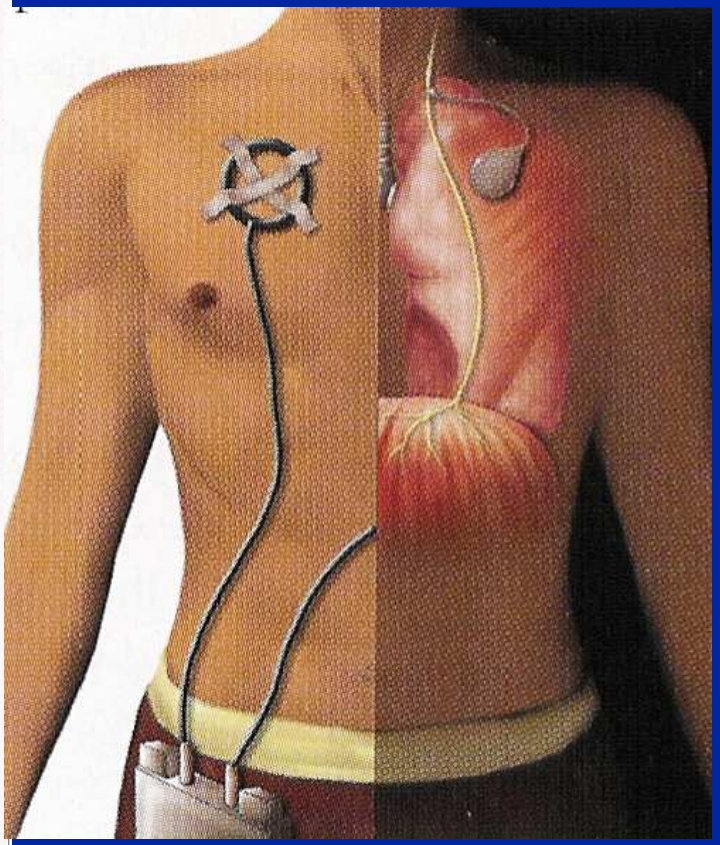
"The constant and high cost of care for ventilator-dependent patients not only exhausts most insurance policies but contributes to strain on families and caregivers," Reeve said in a press release.

These patients could benefit from lifelong breathing support, such as that offered by the diaphragm pacing device.

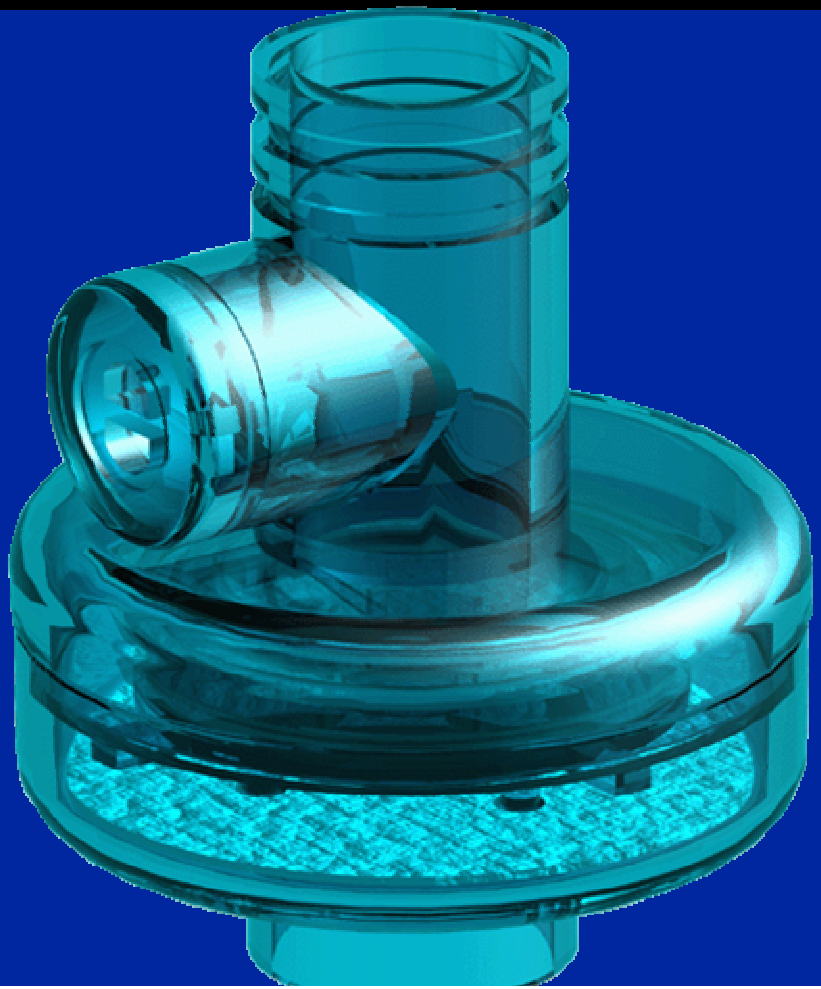
FURTHER DEVELOPMENT

Currently, this procedure is being conducted under a Food and Drug Administration protocol, with research funds covering the costs of the device and its implementation. The cost of the standard diaphragm pacing procedure and the device can exceed $100,000.

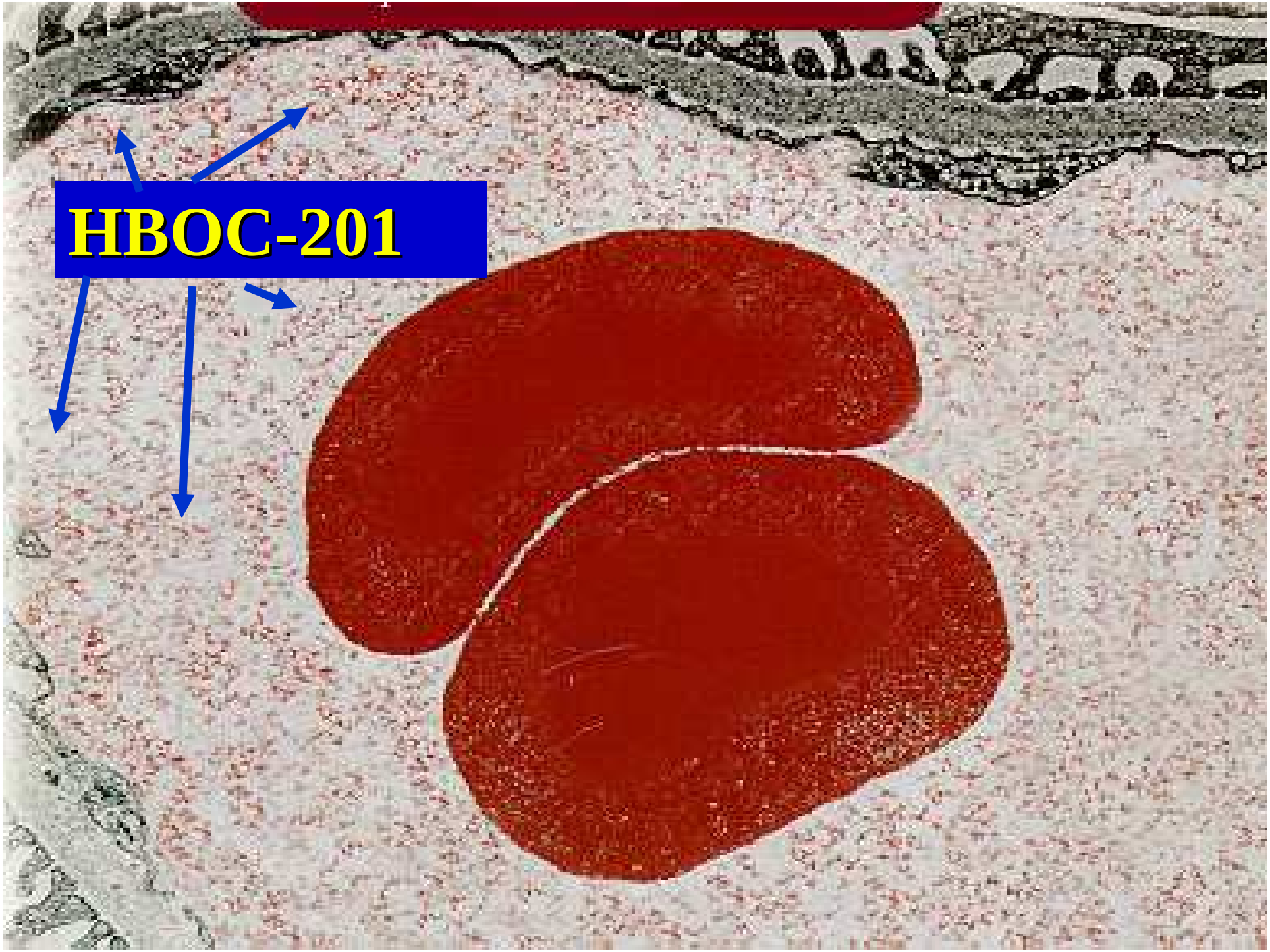
The investigational diaphragm pacing system Reeve uses received FDA approval to be tested in ventilator-dependent patients who have undamaged phrenic nerve function.



Inspiratory Impedance Threshold Valve



- 12 cm H_2O



Let's do a

Case Study

Case #1…

- **24 yo Male, Involved in MVC**
- **Altered MS**
- **PERLA (but sluggish), Thrashing**
- **80/60, HR 130, pale**

Case # 1…

- **Chest wall tender**
- **Diminished BS on Right, dull**
- **Tender abdomen**

Case # 1…

- **Sick or not sick?**
- **REAL SICK, or kinda sick?**

Remember!! Normal Breathing…

- **Generates Negative Intrathoracic Pressure**
- **Pulls Lungs Open in a Specific Architecture**
- **Enhances Venous Return and Cardiac Preload**

SO?????

How to assist ventilation on this guy??

Moribund Trauma Pt.

- Little O_2 Transport & Consumption
- Little CO_2 Production & Venous Return

Little Need to Ventilate

And There's a Key Problem...

Positive Pressure Breaths *Can Impair Cardiac Output...*

...in the Face of Severe Circulatory Compromise

Moribund Trauma Patient

- Adequate Tidal Volume
- Breath q 7 - 10 seconds

Thank you for your kind attention!!

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