Preservation and Maintenance of Negative Intrathoracic Pressure during Circulatory Collapse

Use of Capnography for Monitoring Pressure Status

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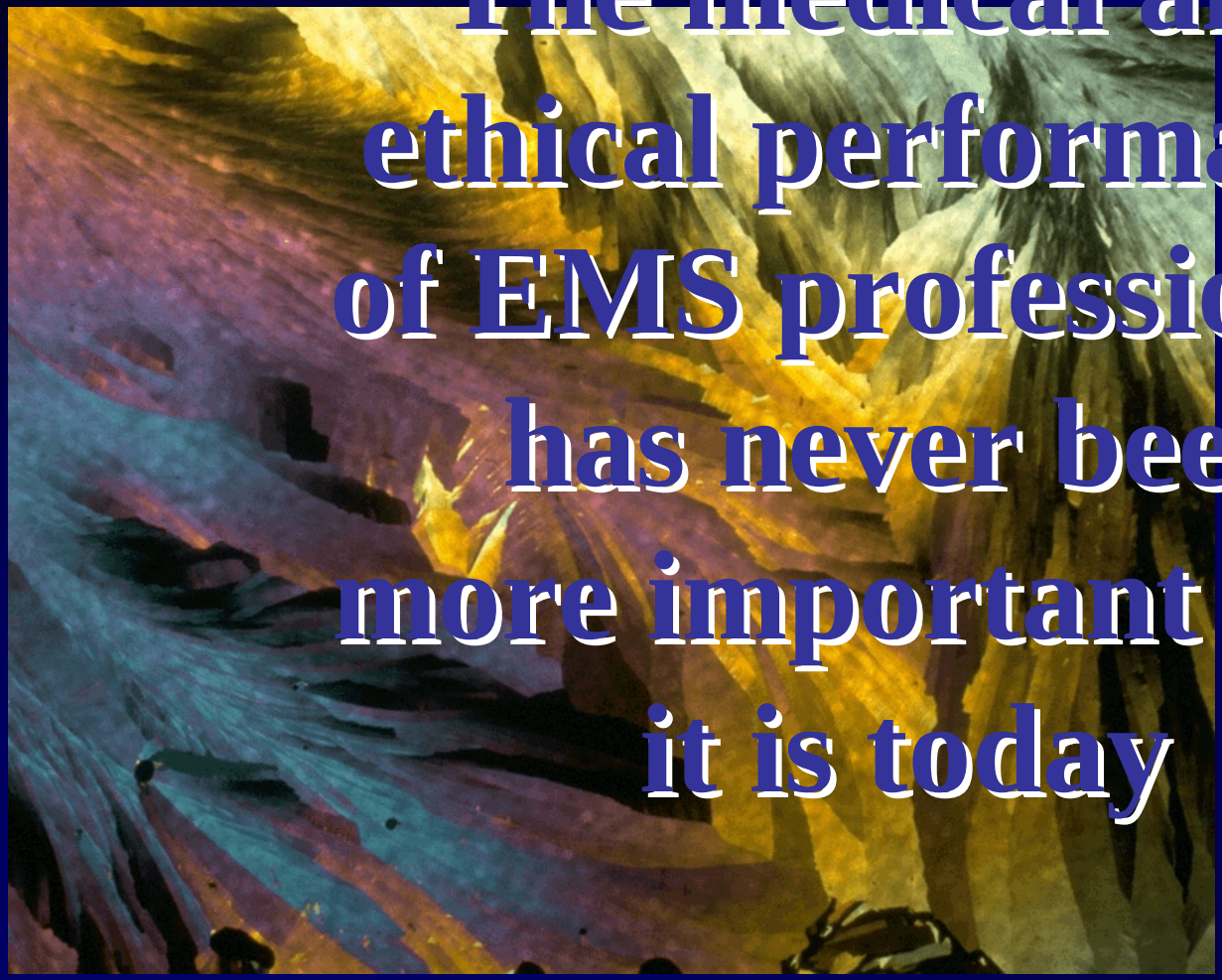
www.utsw.ws



The medical and ethical performance of EMS professionals has never been more important than it is today

The emerging of a profession:

The End of the Beginning

The End of the Beginning

- **Innocence is over**
- **You are COMPLETELY accountable for what you do**
- **Becoming a professional requires you to always be able to explain your actions**
- **EMS is ONLY and ALWAYS about patient care**

As we assess patients,
we must quickly determine
fundamental parameters
of their respiratory
and circulatory status.

How do we do it?

Standardized Patient Examinations!

Makes Sense Out of Chaos!!

Primary Survey

From Basic Trauma Life Support,1983

Scene/Mechanism/# of Patients
LOC/Airway/Cspine
Respiratory Rate and Labor
Pulses, Rate and Quality, Neck and Wrist
Skin CMT/CRT
Neck appearance, NVD, Trachea
Chest appearance
Breath sounds present and equal, percussion
Brief exam of abd, pelvis, LE, UE, Back

Conclusions:

- Medics learn as adult learners do (rote memorization works poorly)
- Medics must be allowed more practice time in stations, avoid long lectures
- Periodic quality assurance and retraining on patient assessment is vital
- Assuming that all experienced paramedics will retain material from intense training periods is wrong
- Tempus fugit

“Tweaking” the Process

- The Third Survey (MGA ~ 1994)
- Annual Skills Reviews (MGA ~ 1995)
- Improved assessment measures for performance including improving patient care report document and procedure notes

Third Survey

Level of Consciousness

Airway

Breathing

Circulation

Any other pertinent positive or negative following initial resuscitation

Understanding Resuscitation Requirements

We MUST maintain Normal Physiology

Statement of Concern:

What we DO to unstable patients during resuscitation is often BAD physiology

Understanding the body by regions

Positive pressure

Negative pressure

Positive pressure

The negative pressure inside the thorax “pulls” blood back from the positive pressure areas.

Positive pressure

Negative pressure

Positive pressure

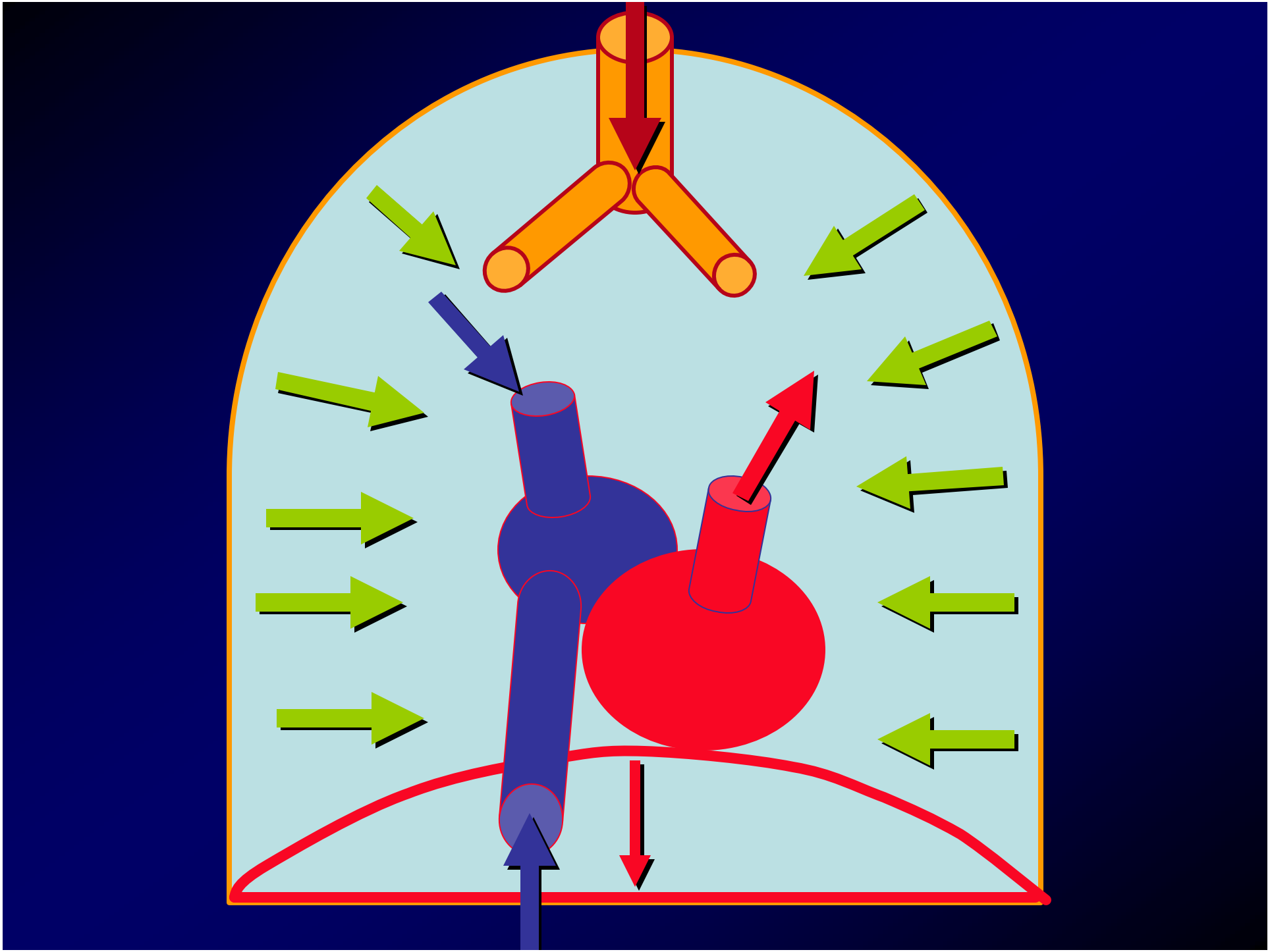
Maintaining the “negativity” of the pressure inside of the thorax is one of the most vital areas of understanding resuscitation

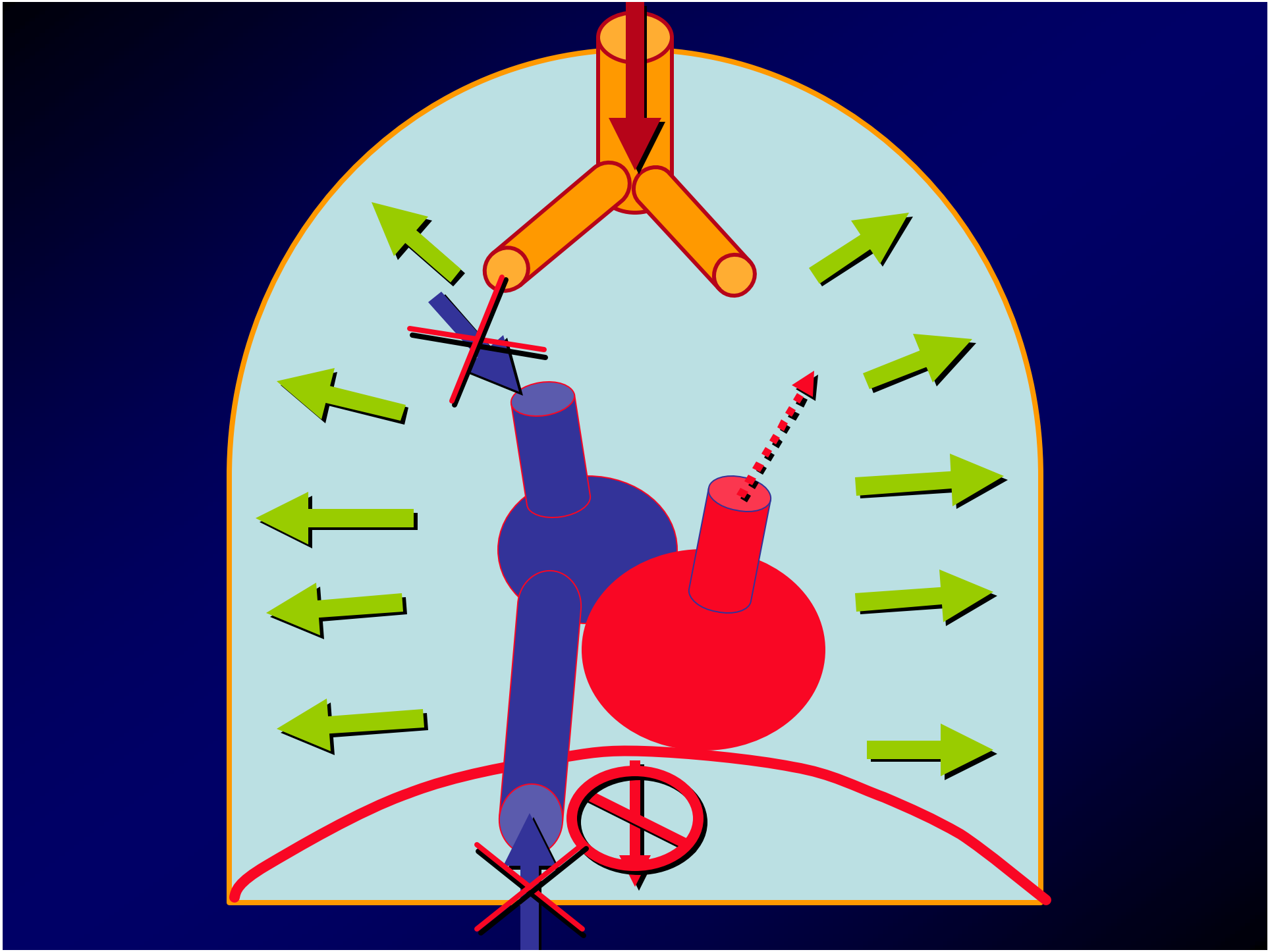
Negative pressure

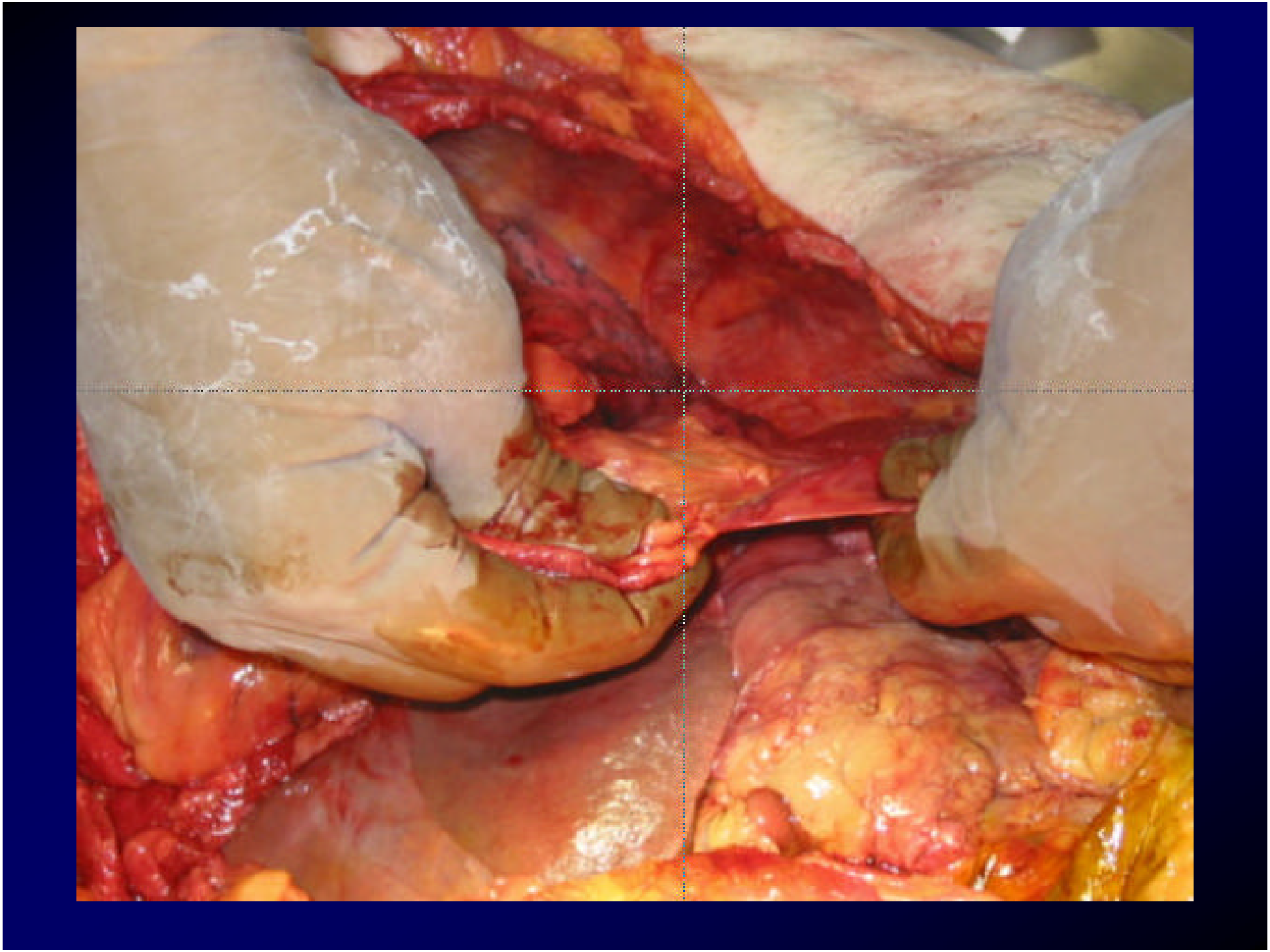
…and!!!

<u>Maintaining negative pressure is one of the LEAST understood requirements</u>!!

Negative pressure







How Does Blood Get Back from My Big Toe?

Does the heart PUMP it around?

Nope…

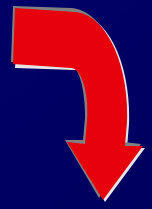
The heart sucks blood back on the intake stroke

Only through MAINTAINING the negative intake stroke can the pumping action (cardiac output) be preserved

Blood pressure =

Cardiac output x Volume
x Peripheral resistance

Blood pressure =



A heart thing &
a volume thing &
a blood vessel thing…ALWAYS!

What does a low blood pressure mean?

Either...

Or a combination of any of these

…from BTLS, editions 2, 3, 4, and 5

Fowler, Pepe et al

Signs of Shock

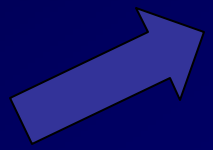
Early

- Weak, thirsty, lightheaded
- Pale, then sweaty
- Tachycardia
- Tachypnea
- Diminished urinary output

Late

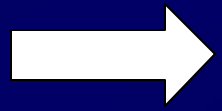
- Hypotension
- Altered LOC
- Cardiac arrest
- Death

Shock



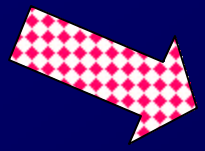
Cardiogenic

- Rapid pulse
- Distended neck veins
- Cyanosis



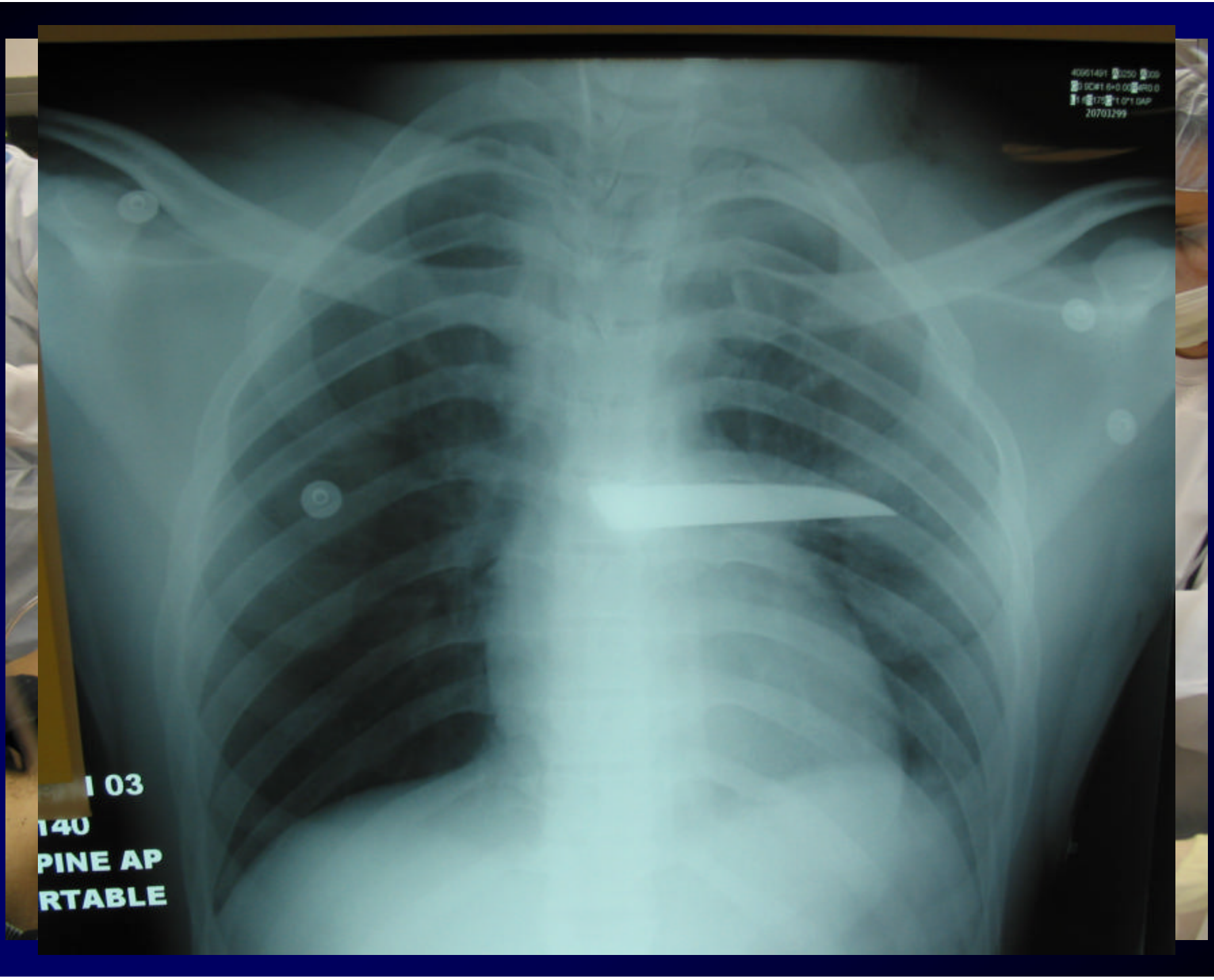
Volume Loss

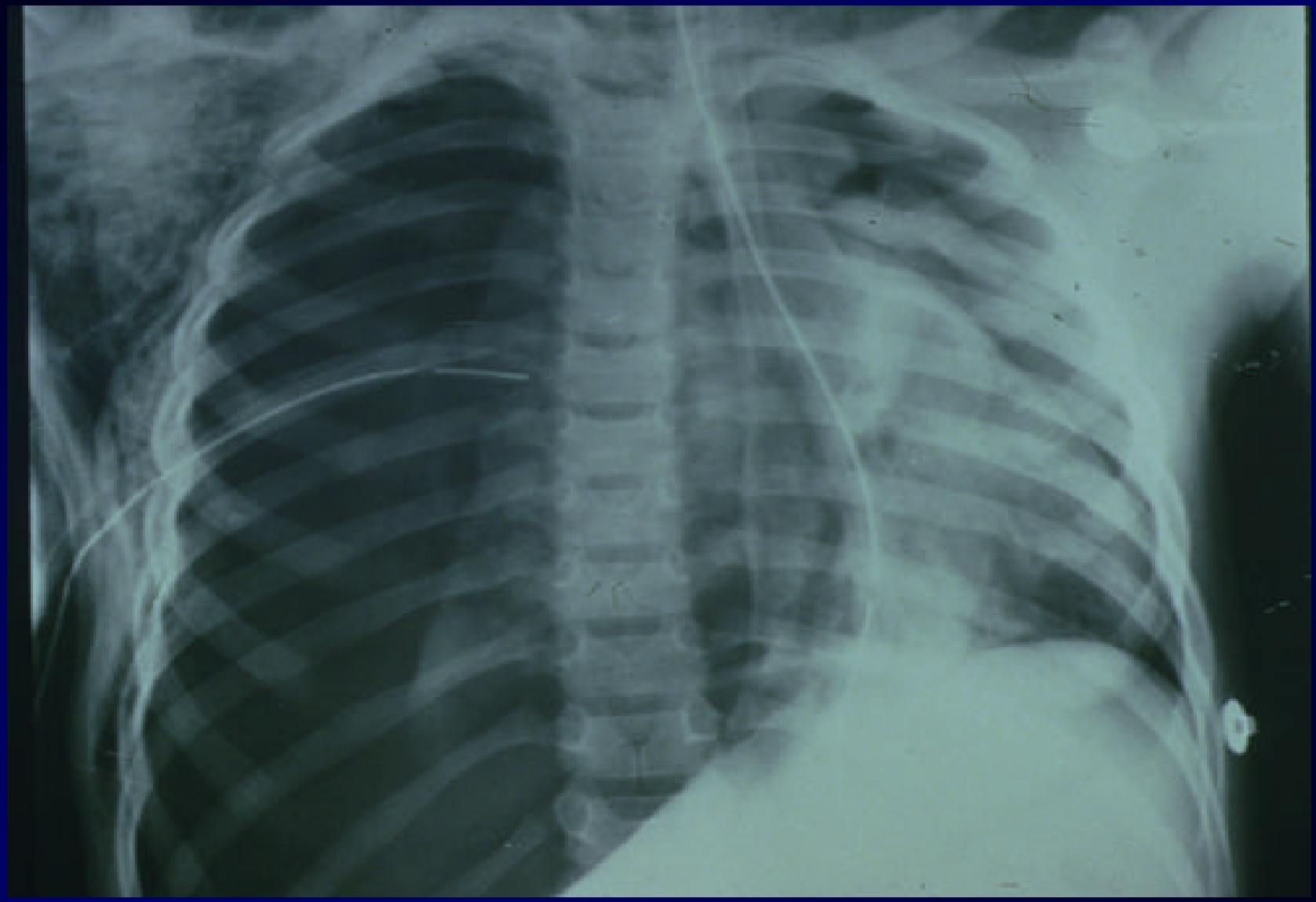
- Rapid pulse
- Flat neck veins
- Pale



Vasodilatory

- Variable pulse
- Flat neck veins
- Pale or pink


I 03
140
PINE AP
RTABLE



What is the problem with shock?

Oxygen deprivation to the tissues
below an absolute level of about 10 mmHg
at the tissue level,
causing cell membrane damage,
ion depolarization,
and calcium shifts with cell death.

Rationale for Fluid Resuscitation

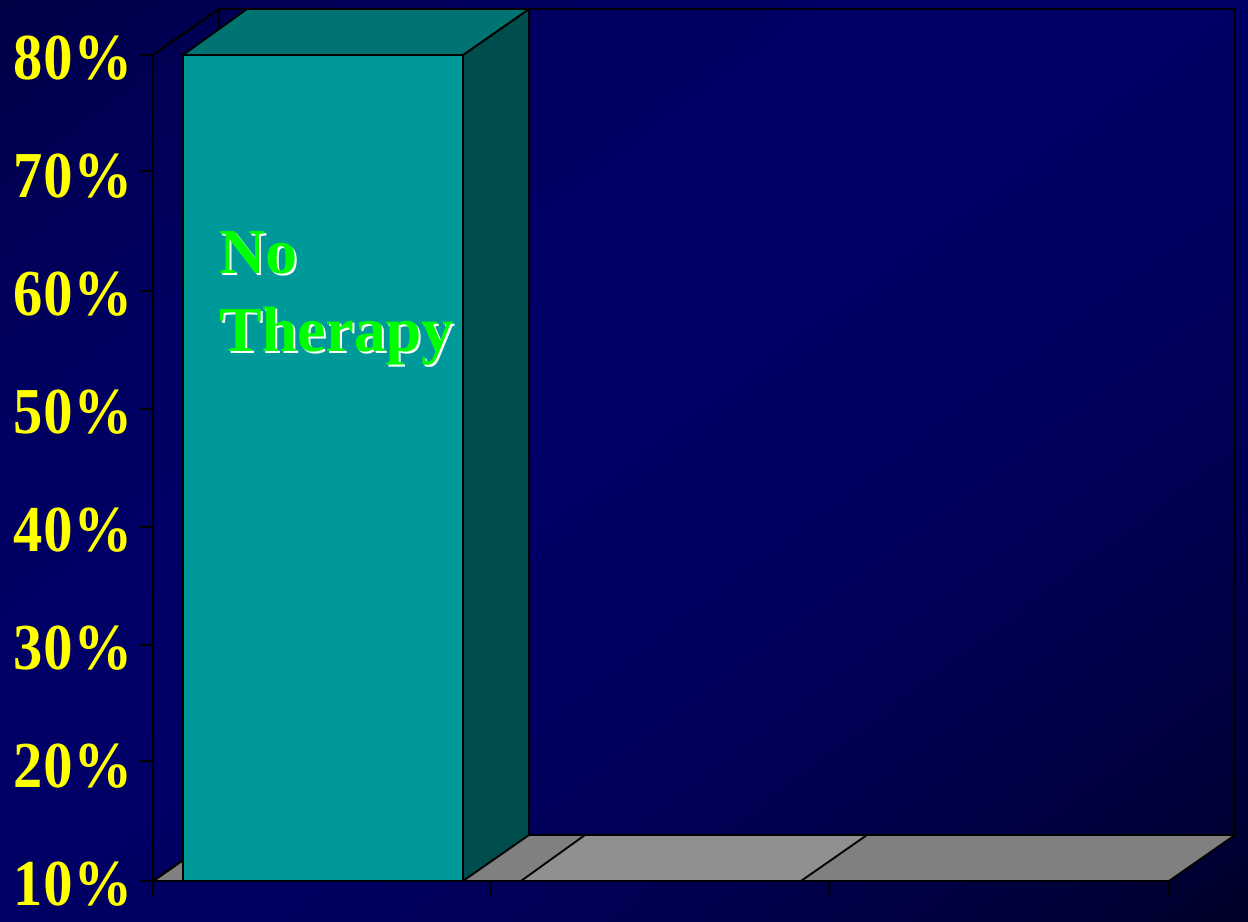
Series of Canine Experiments in 1950s and 1960s...

Shed 60 -70% blood volume =

80% Mortality Rate

Mortality Rate in Animals

with 60 -70% of their Blood Volume Shed



ASSUMPTION

Elevating Blood Pressure is Always a Good Thing

Maybe Not...

Bill Bickell and Paul Pepe

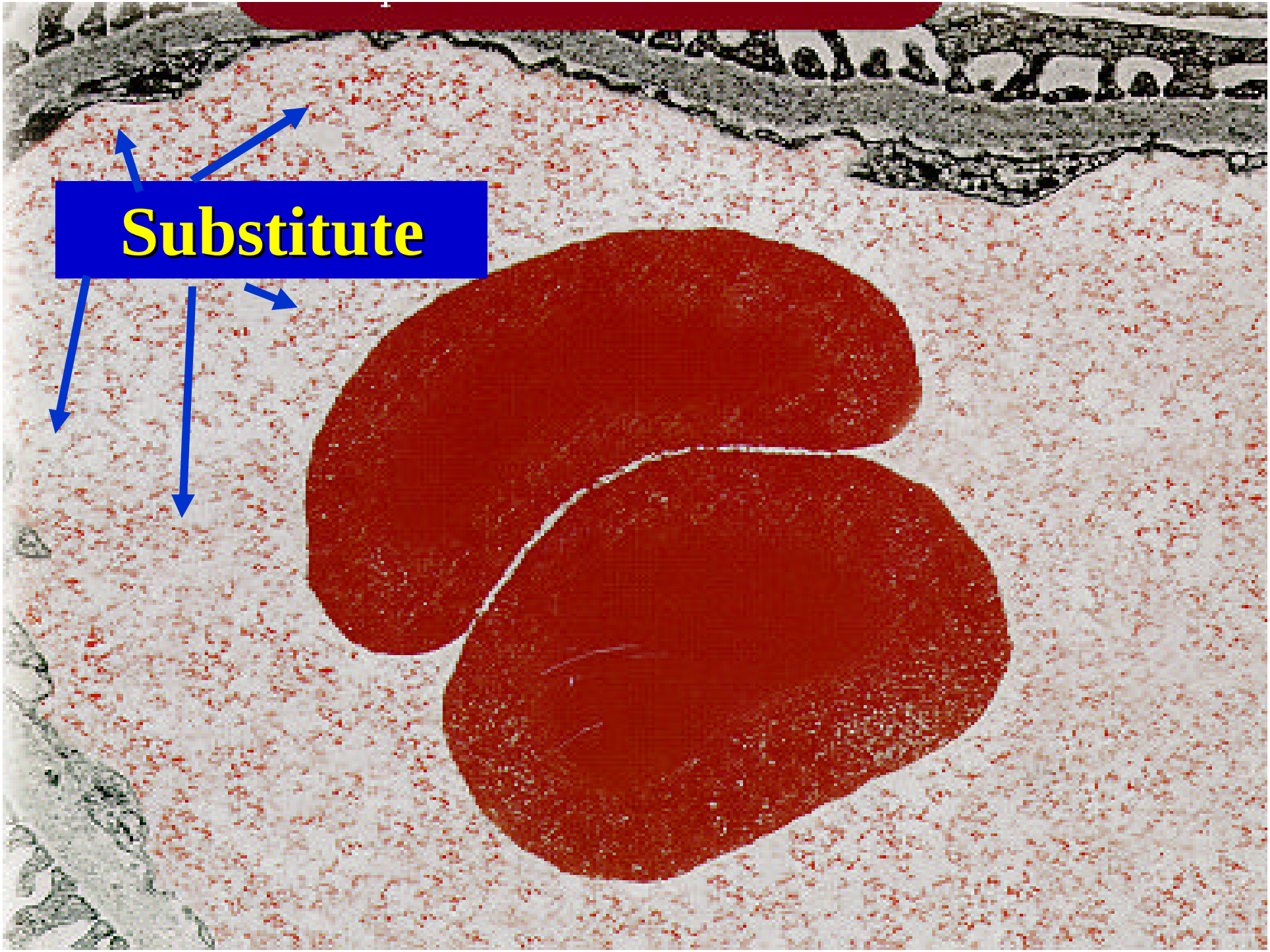
1990's -- New Series of Animal Experiments

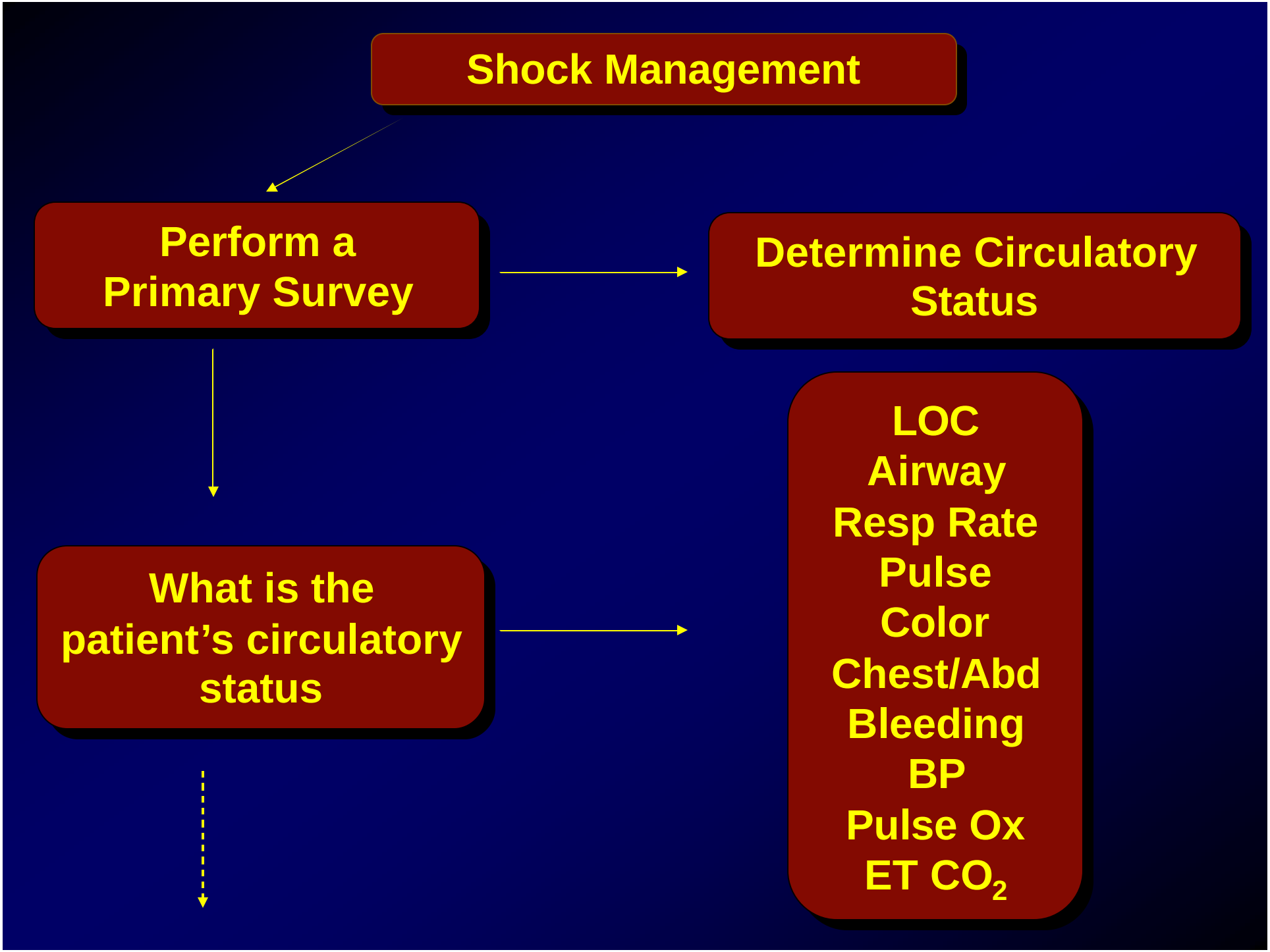
(uncontrolled hemorrhage in rats, dogs, pigs, sheep)

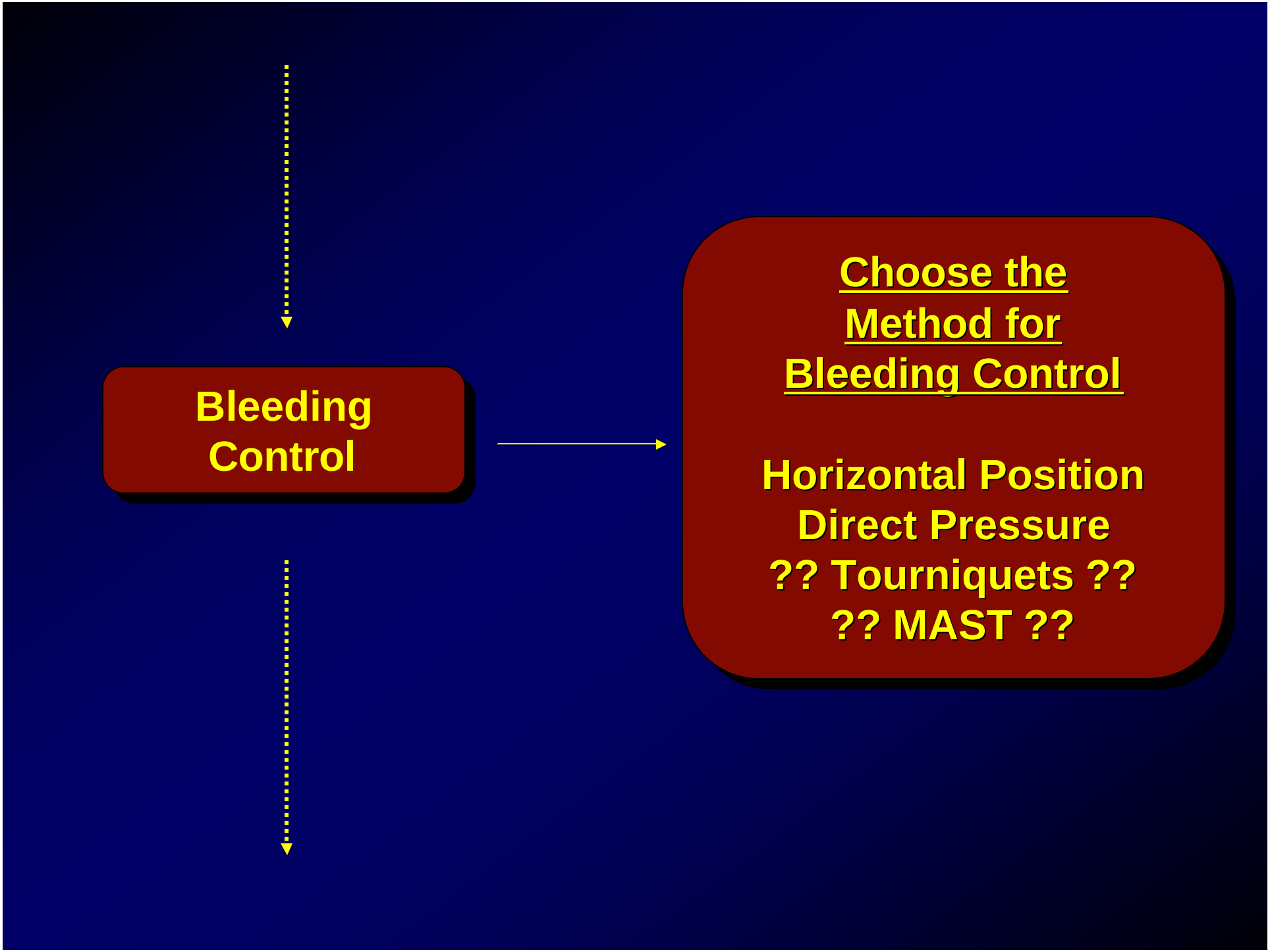
BP < 40 mmHg May Be a Hypotension Threshold

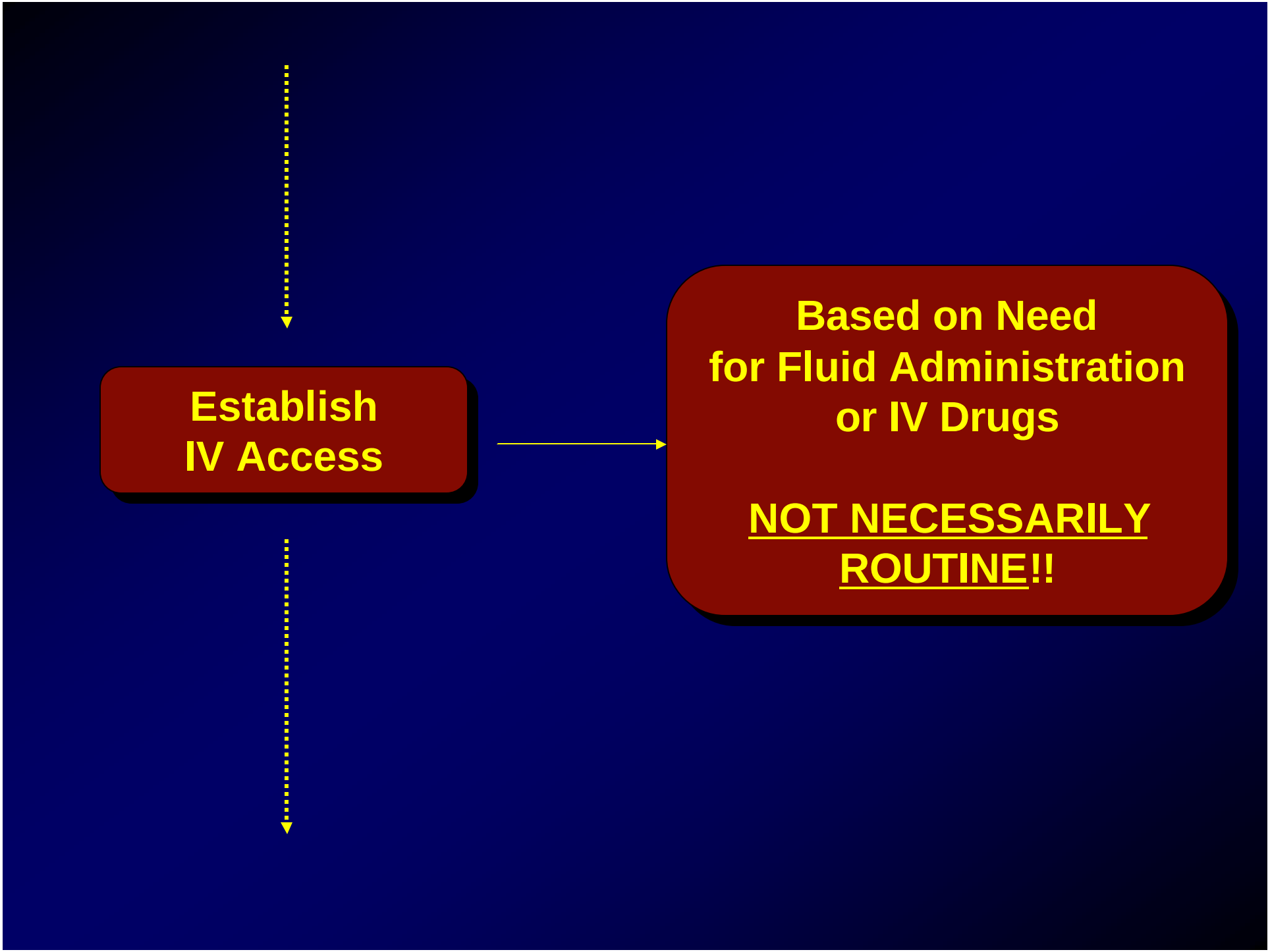
THUS!!!

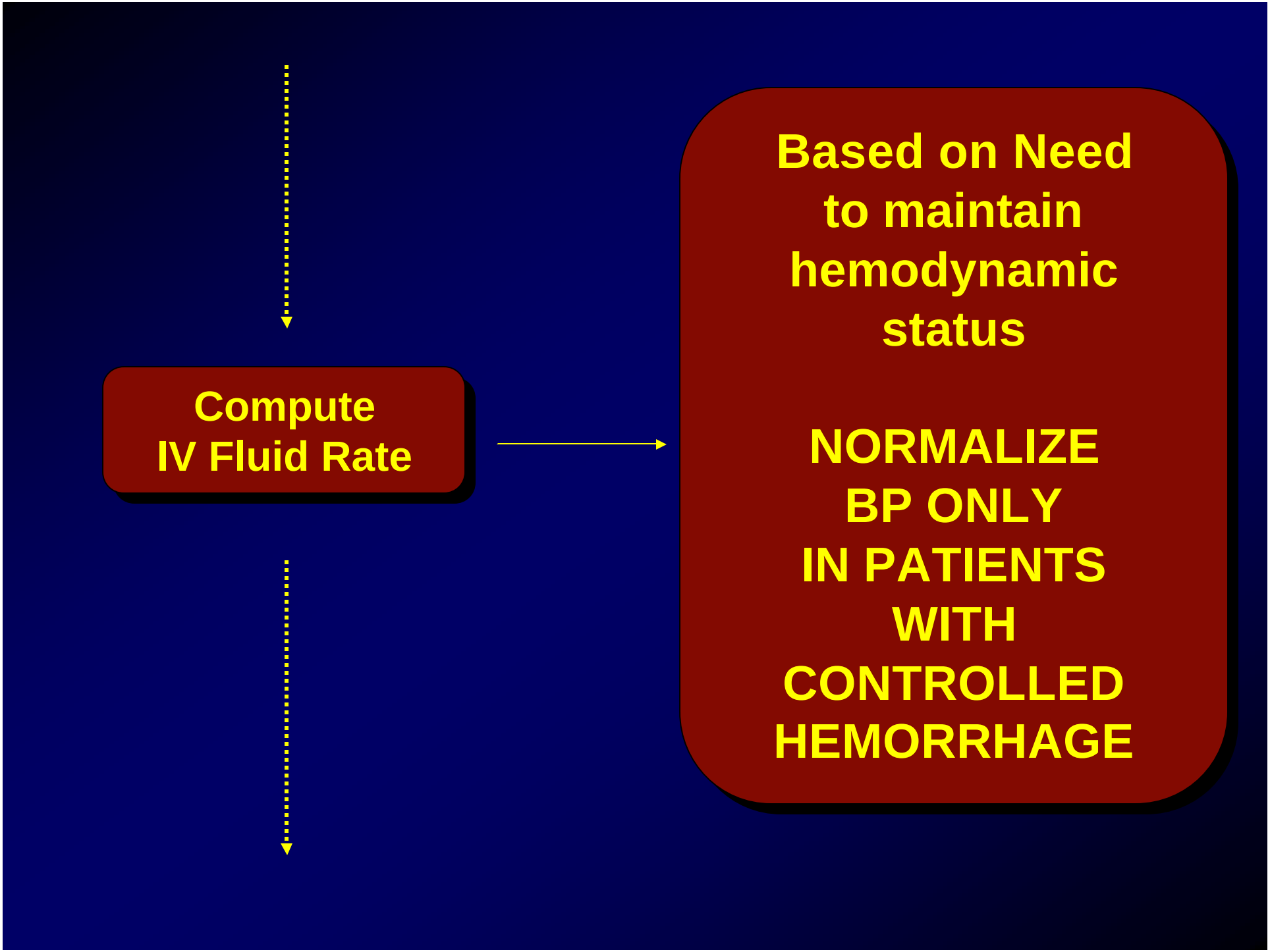
Providing a base level of
a few CC's of oxygen per 100 cc of blood
(far less than normally carried in
arterial blood – 15 to 20 cc's/100 cc blood)
may prevent cellular injury and death

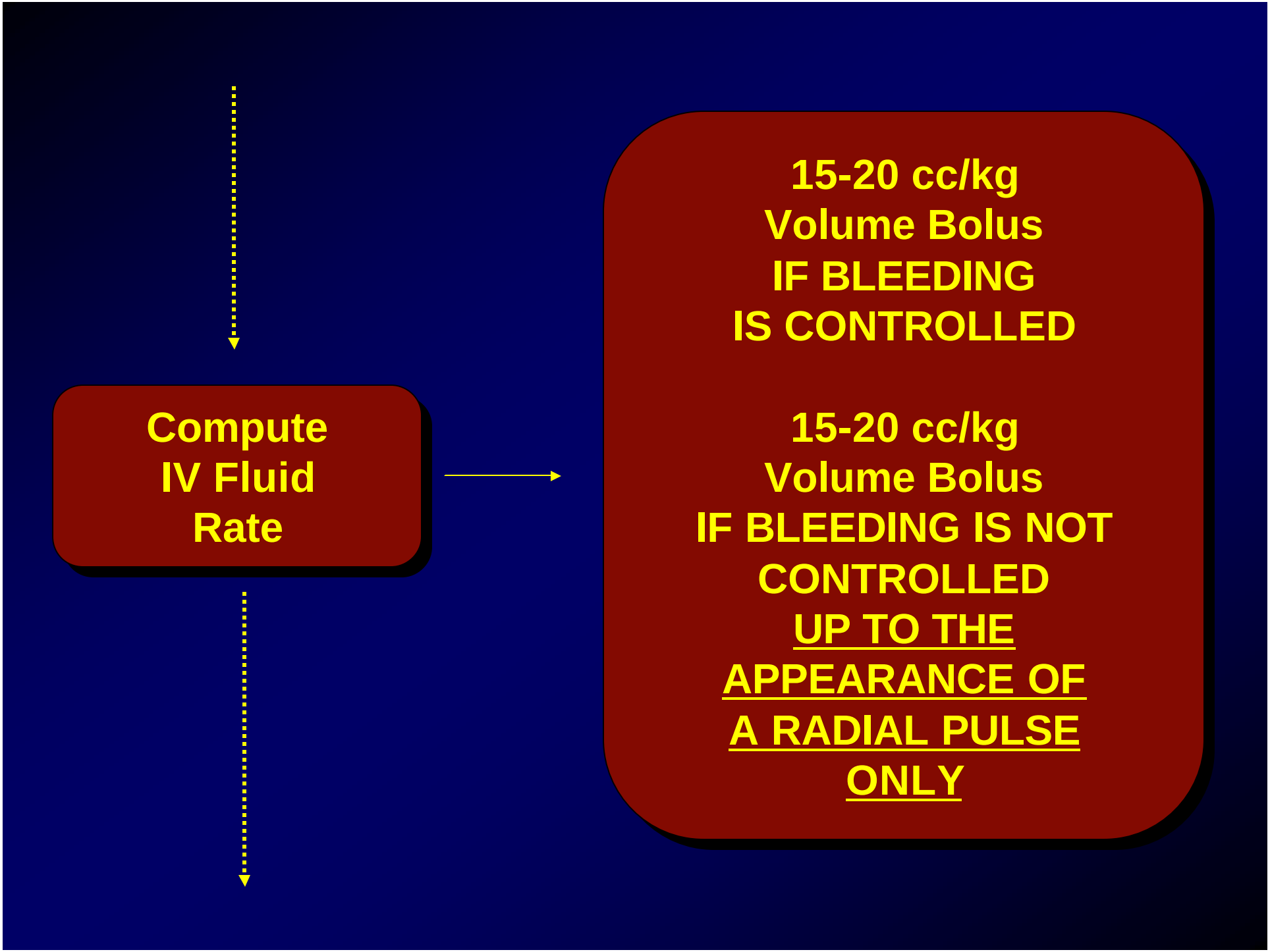

Substitute

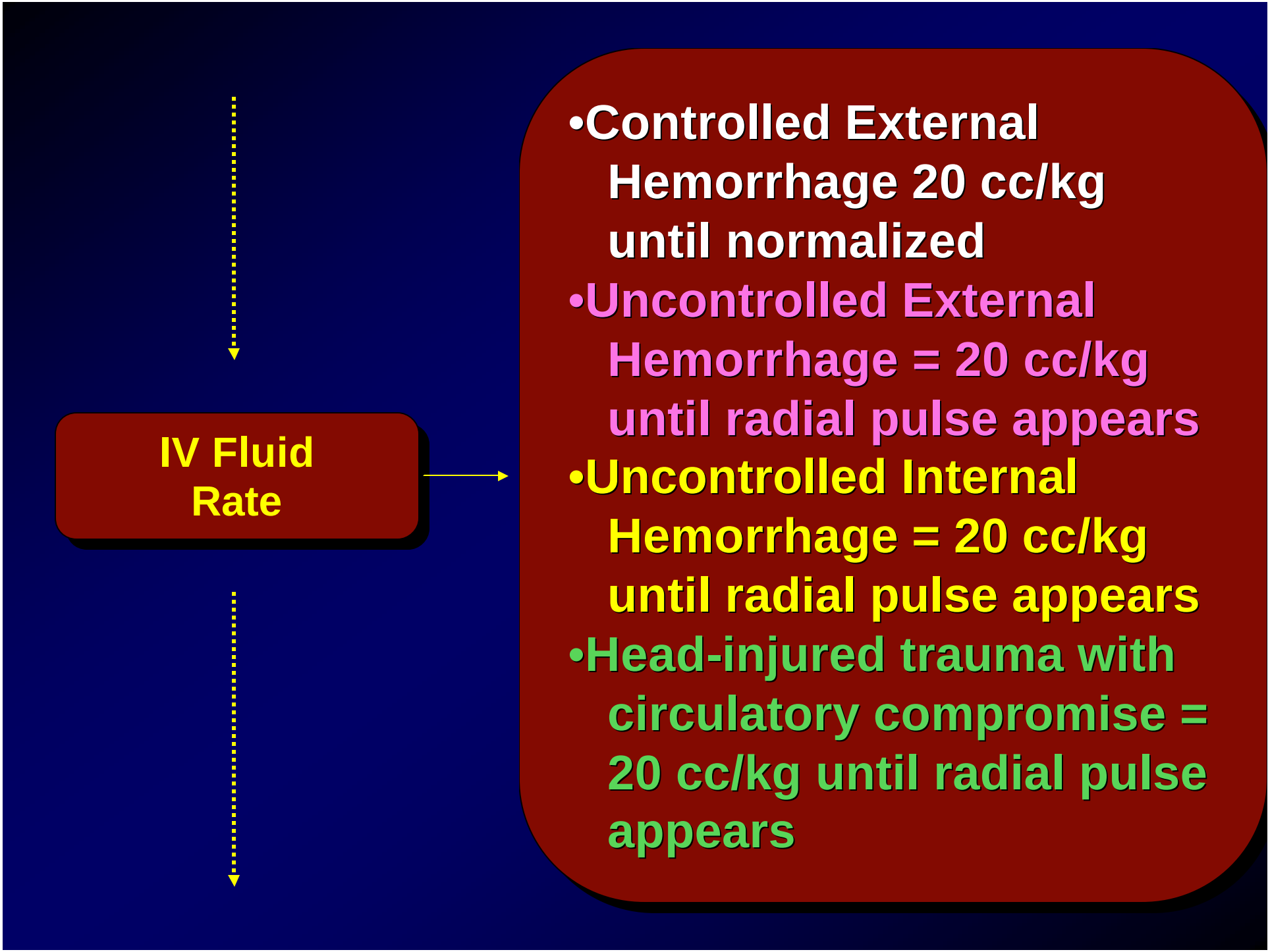

Shock Management
Perform a Primary Survey
Determine Circulatory Status
What is the patient's circulatory status
LOC
Airway
Resp Rate
Pulse
Color
Chest/Abd
Bleeding
BP
Pulse Ox
ET CO_2

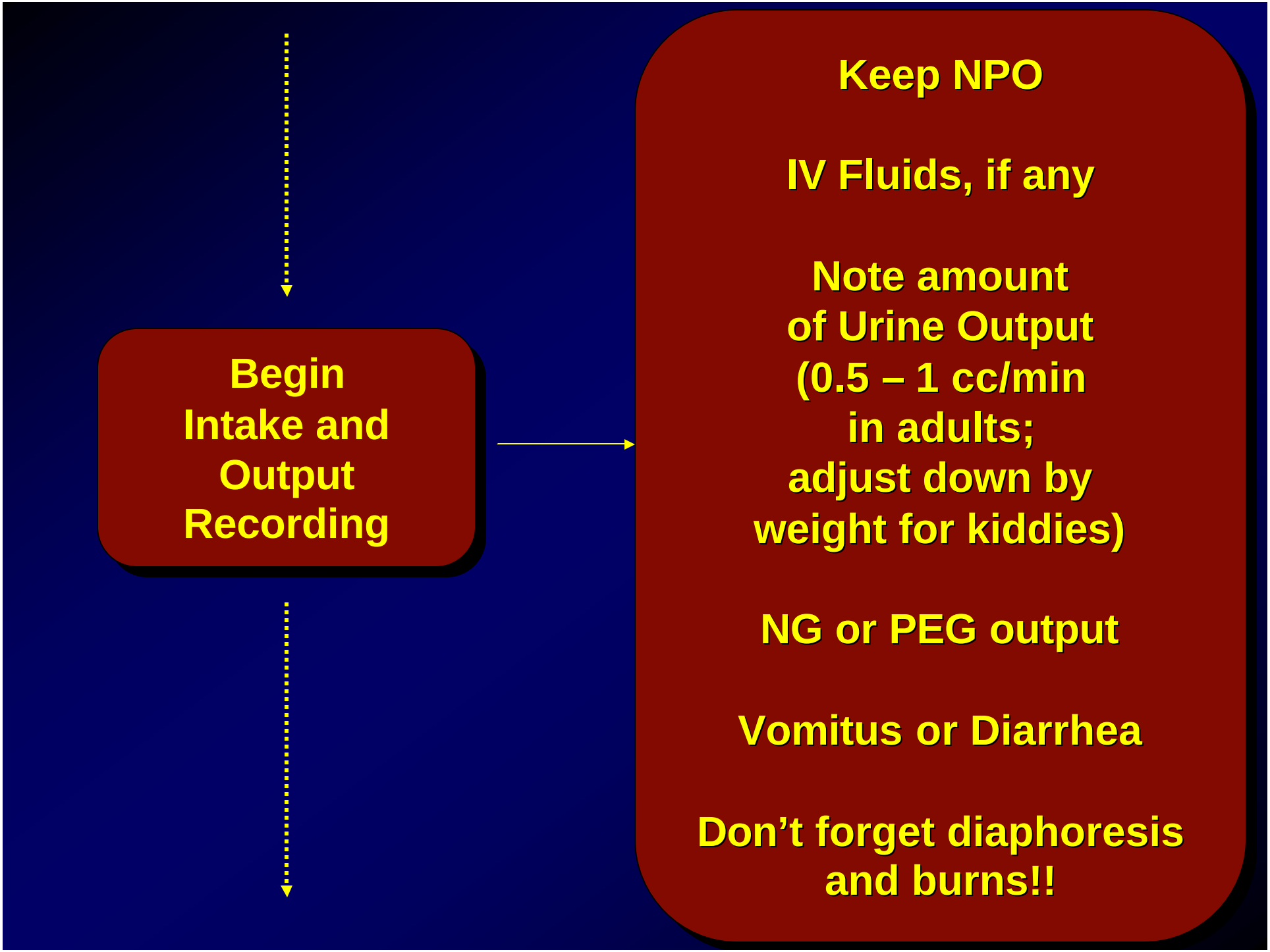

Bleeding Control
Choose the Method for Bleeding Control
Horizontal Position
Direct Pressure
?? Tourniquets ??
?? MAST ??

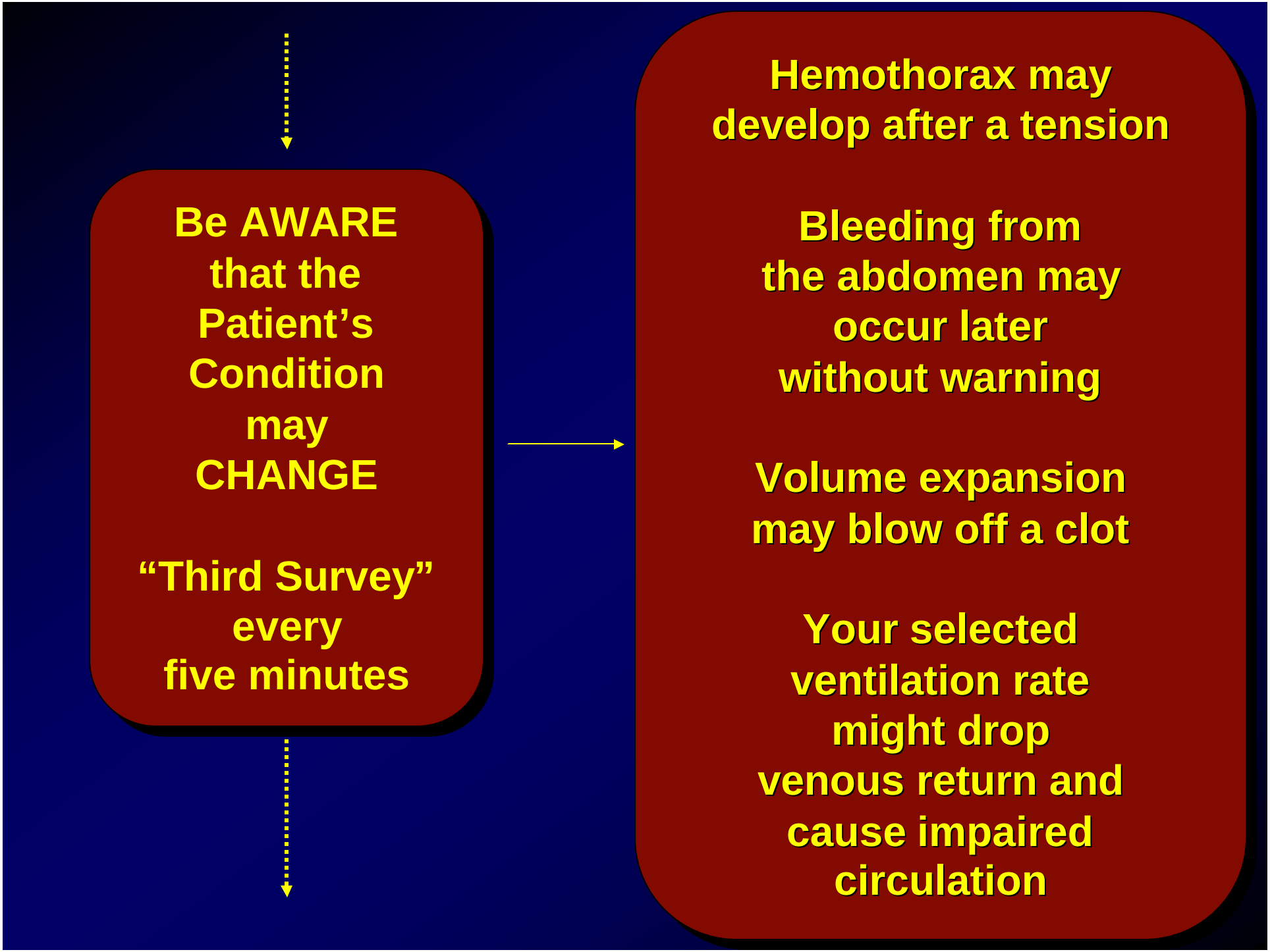

Establish
IV Access
Based on Need
for Fluid Administration
or IV Drugs
NOT NECESSARILY
ROUTINE!!


Compute
IV Fluid Rate
Based on Need
to maintain
hemodynamic
status
NORMALIZE
BP ONLY
IN PATIENTS
WITH
CONTROLLED
HEMORRHAGE


Compute
IV Fluid
Rate
15-20 cc/kg
Volume Bolus
IF BLEEDING
IS CONTROLLED
15-20 cc/kg
Volume Bolus
IF BLEEDING IS NOT
CONTROLLED
UP TO THE
APPEARANCE OF
A RADIAL PULSE
ONLY


IV Fluid Rate
•Controlled External Hemorrhage 20 cc/kg until normalized
•Uncontrolled External Hemorrhage = 20 cc/kg until radial pulse appears
•Uncontrolled Internal Hemorrhage = 20 cc/kg until radial pulse appears
•Head-injured trauma with circulatory compromise = 20 cc/kg until radial pulse appears


Begin Intake and Output Recording
Keep NPO
IV Fluids, if any
Note amount of Urine Output (0.5 – 1 cc/min in adults; adjust down by weight for kiddies)
NG or PEG output
Vomitus or Diarrhea
Don’t forget diaphoresis and burns!!


Be AWARE
that the
Patient's
Condition
may
CHANGE
"Third Survey"
every
five minutes
Hemothorax may
develop after a tension
Bleeding from
the abdomen may
occur later
without warning
Volume expansion
may blow off a clot
Your selected
ventilation rate
might drop
venous return and
cause impaired
circulation

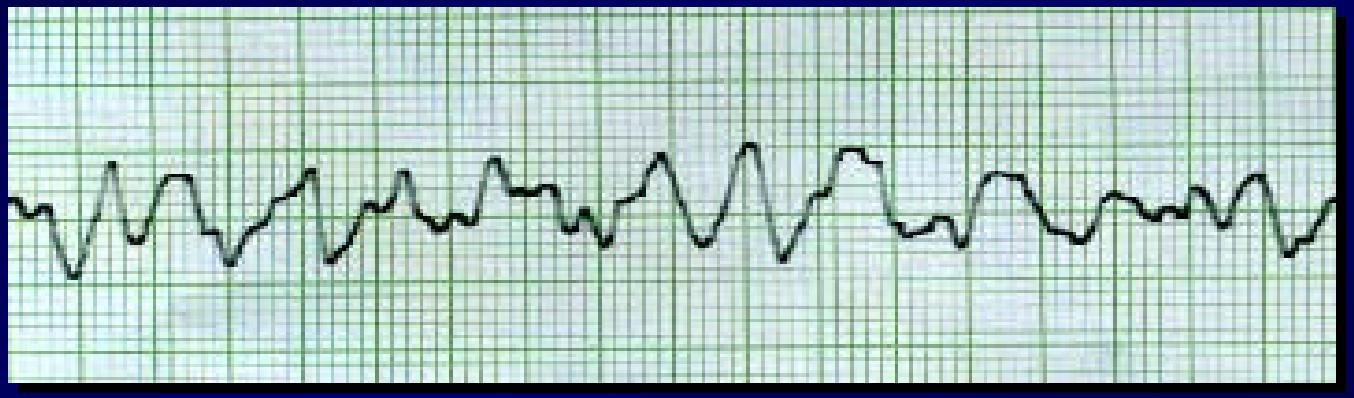
Determine need for HBOC!

- Decreasing CO_2 especially in setting of Hypotension
- Pale Patient
- Altered Mental Status
- Any severe hemorrhage
- Arrhythmia development
- "PROTECTION FROM ANOXIC DAMAGE"

Current Ventilation Concepts in Critical Care

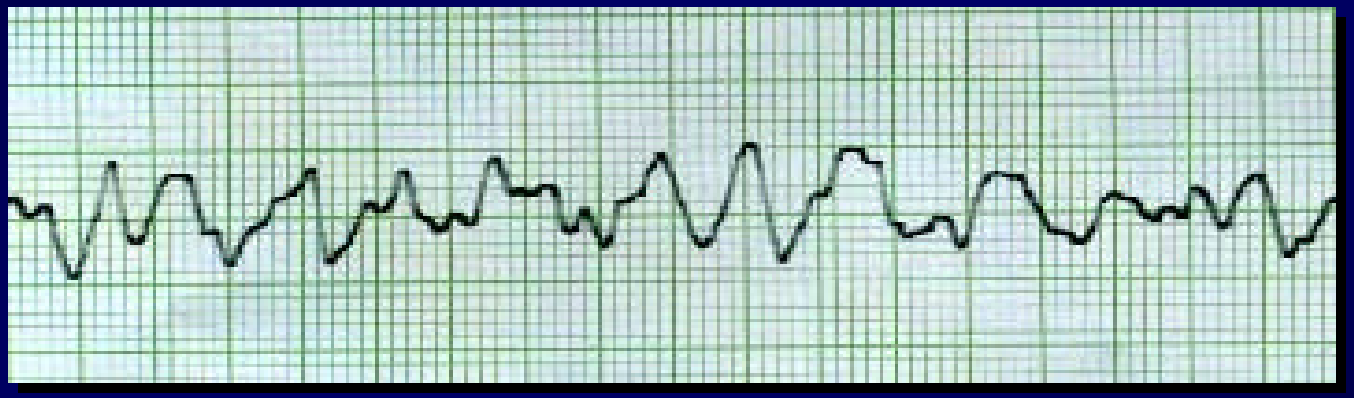
Cardiac Arrest

A 55 year old man
is found down in Cardiac Arrest
by his wife. EMS is called.
Citizen CPR is being done



He was well until this happened.
He has no medical problems
and takes no medications.

After defibrillation the patient remains in VF



He does not improve after administration of CPR, epinephrine, or amiodarone,

What do you do??

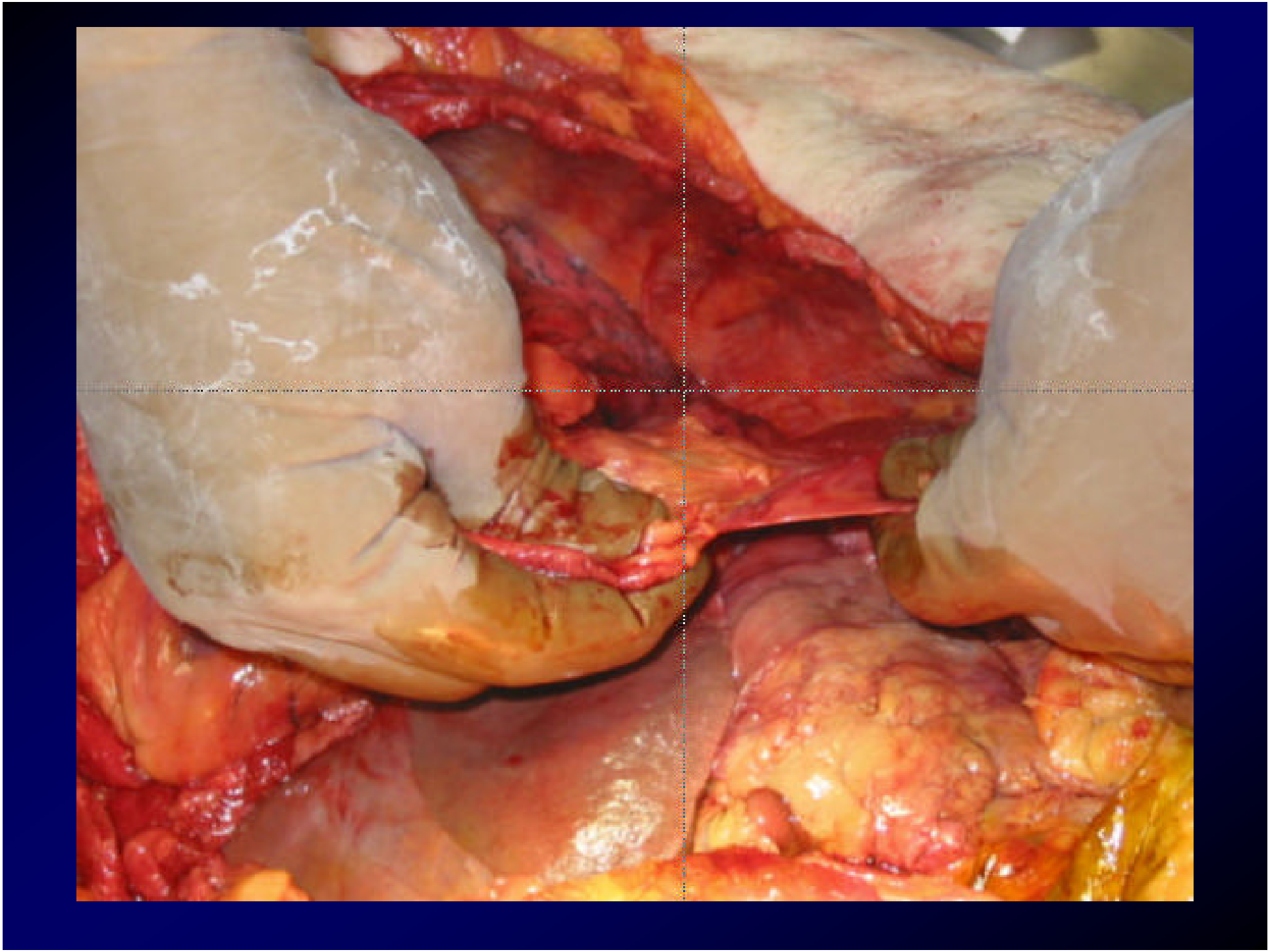
Our normal breathing

is

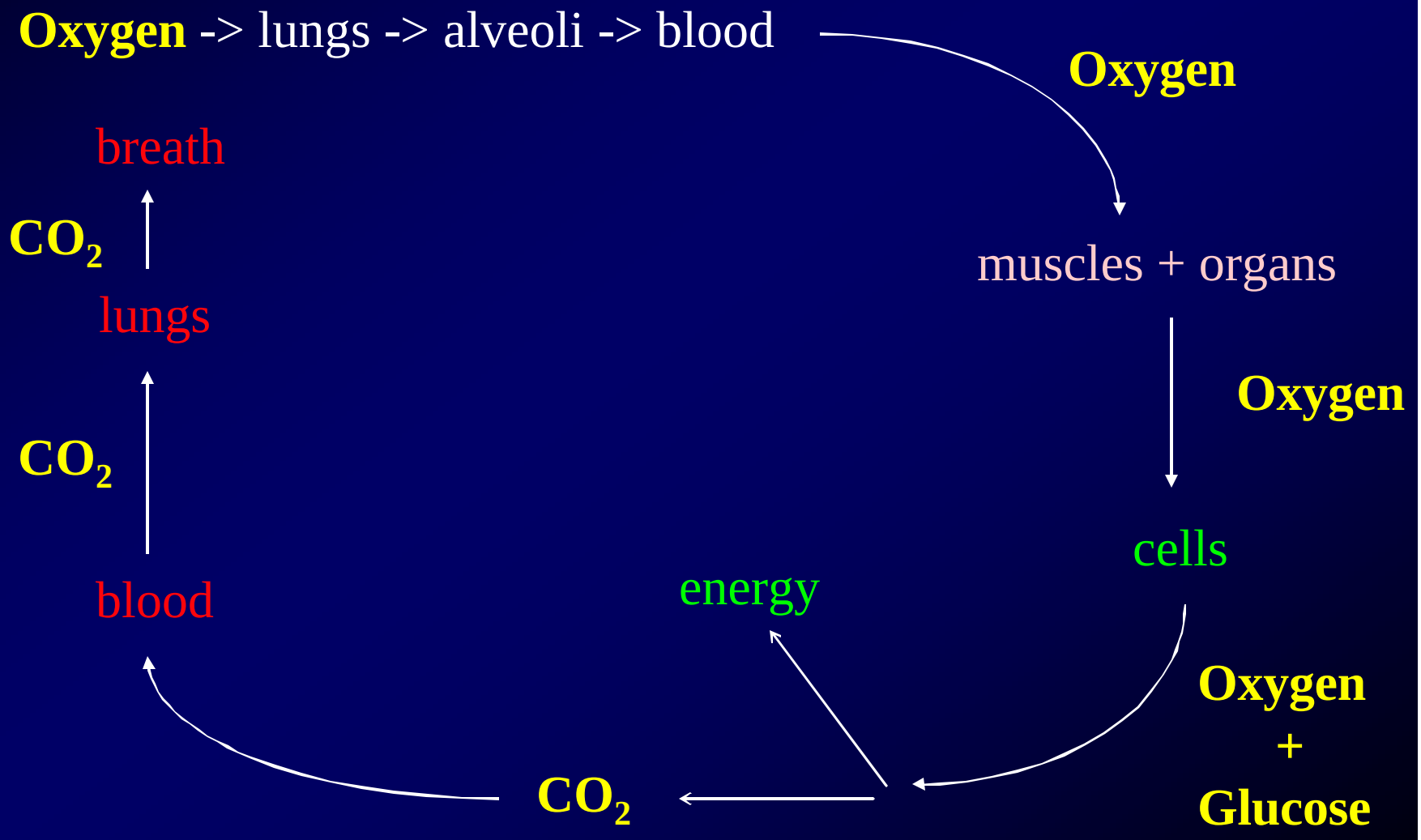
NEGATIVE PRESSURE

breathing!

Negative pressure breaths improve venous return to the heart and increase cardiac output



Physiology


Oxygen -> lungs -> alveoli -> blood
Oxygen
muscles + organs
Oxygen
cells
Oxygen
+
Glucose
energy
CO_2
blood
CO_2
lungs
breath

Alveoli:
The Place Where Gas Exchange Happens

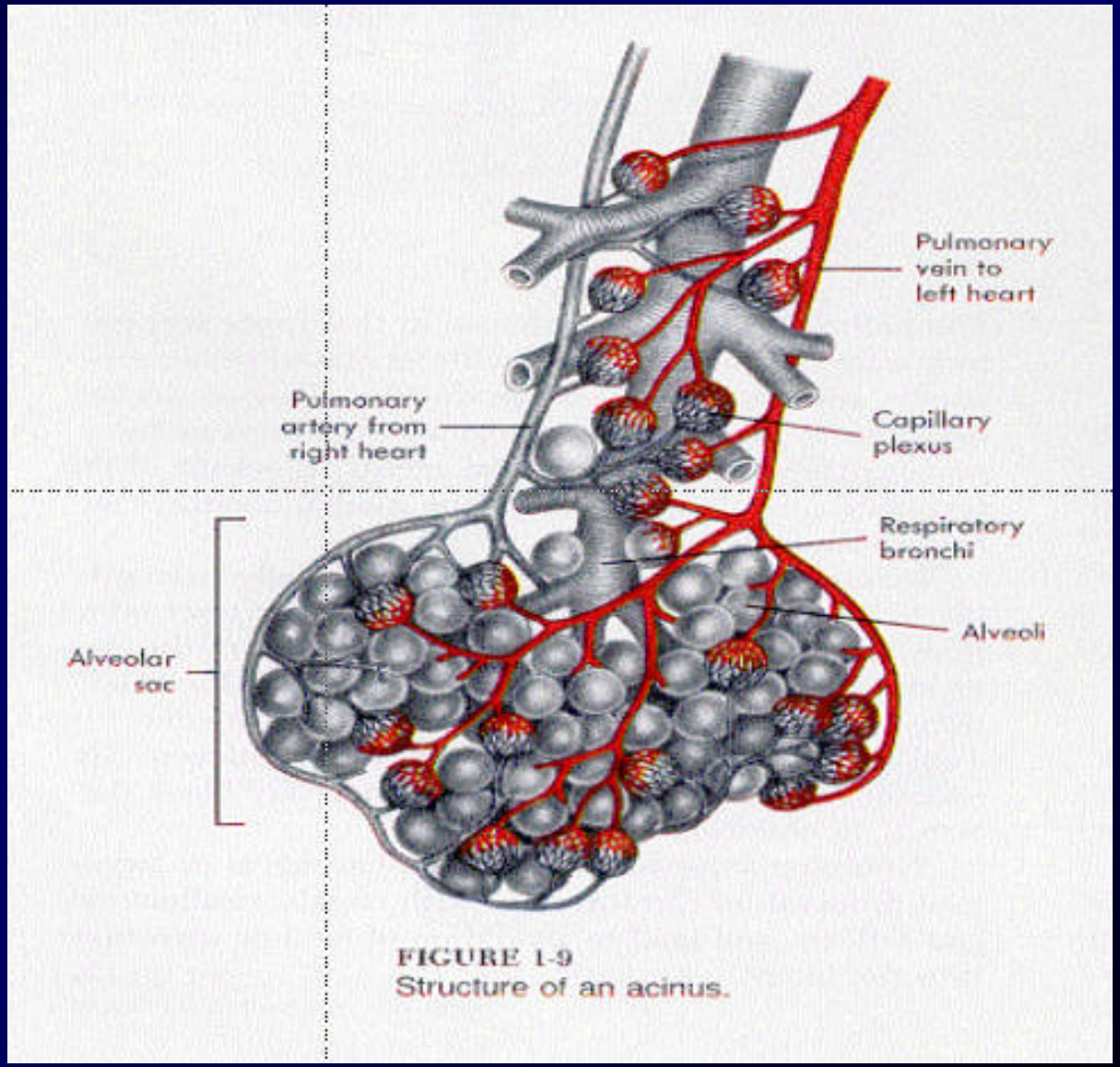
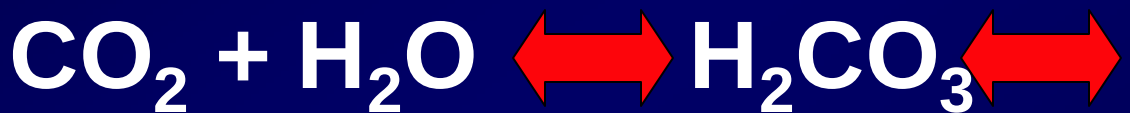
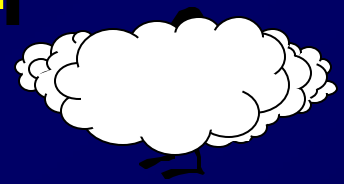


FIGURE 1-9
Structure of an acinus.

Carbon dioxide physiology



What is Carbon Dioxide?



- **Capnos comes from the Greek word for "smoke"**
  - smoke from the fire of metabolism
  - a natural waste product of cellular activity
- **CO_2 is a compound molecule**
  - 2 elements of oxygen and 1 element of carbon
  - colorless and heavier than air
  - green plants clean up after our exhaled CO_2

Carbon dioxide physiology

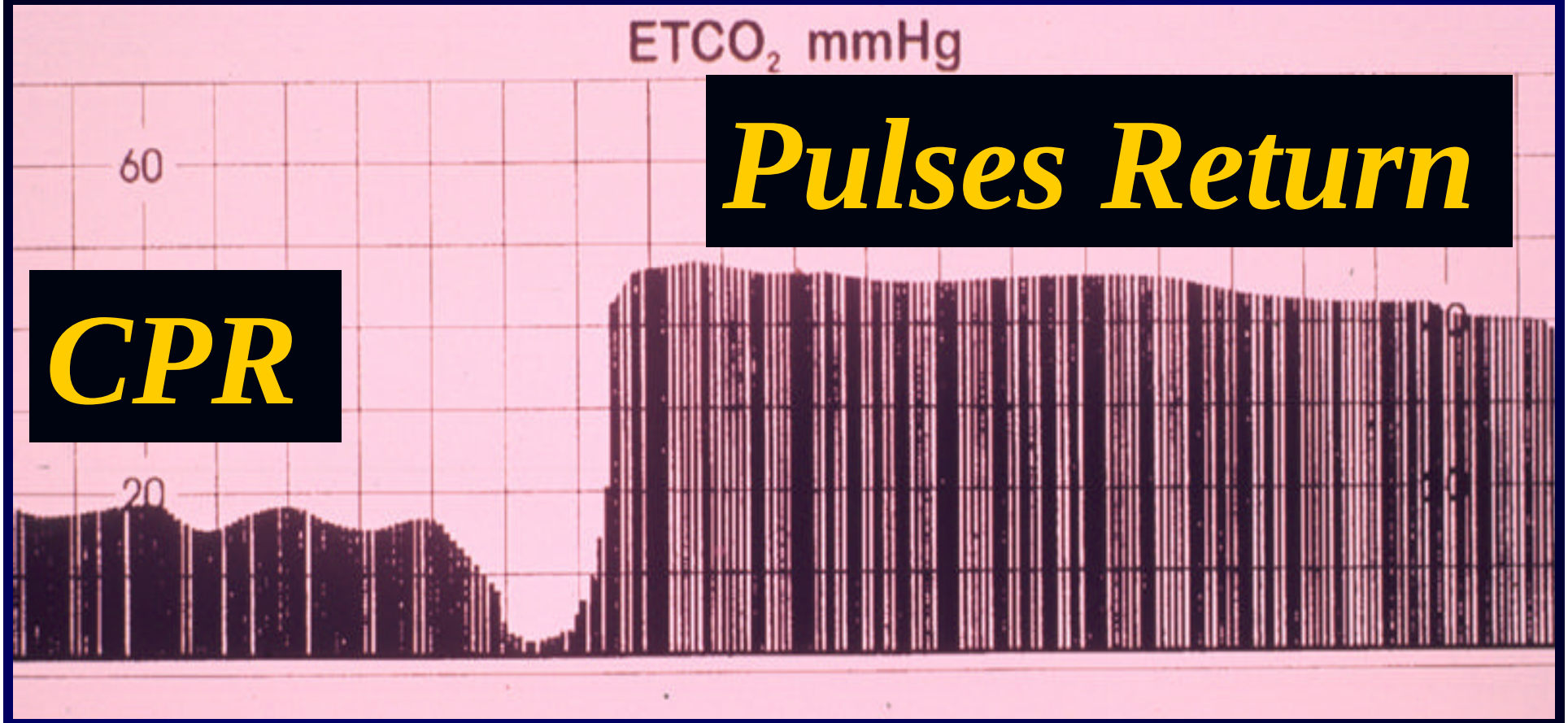
- 0.03% concentration in air
- Resting adult produces 2.5 mg/kg/min, or about 185 mg in a guy my size

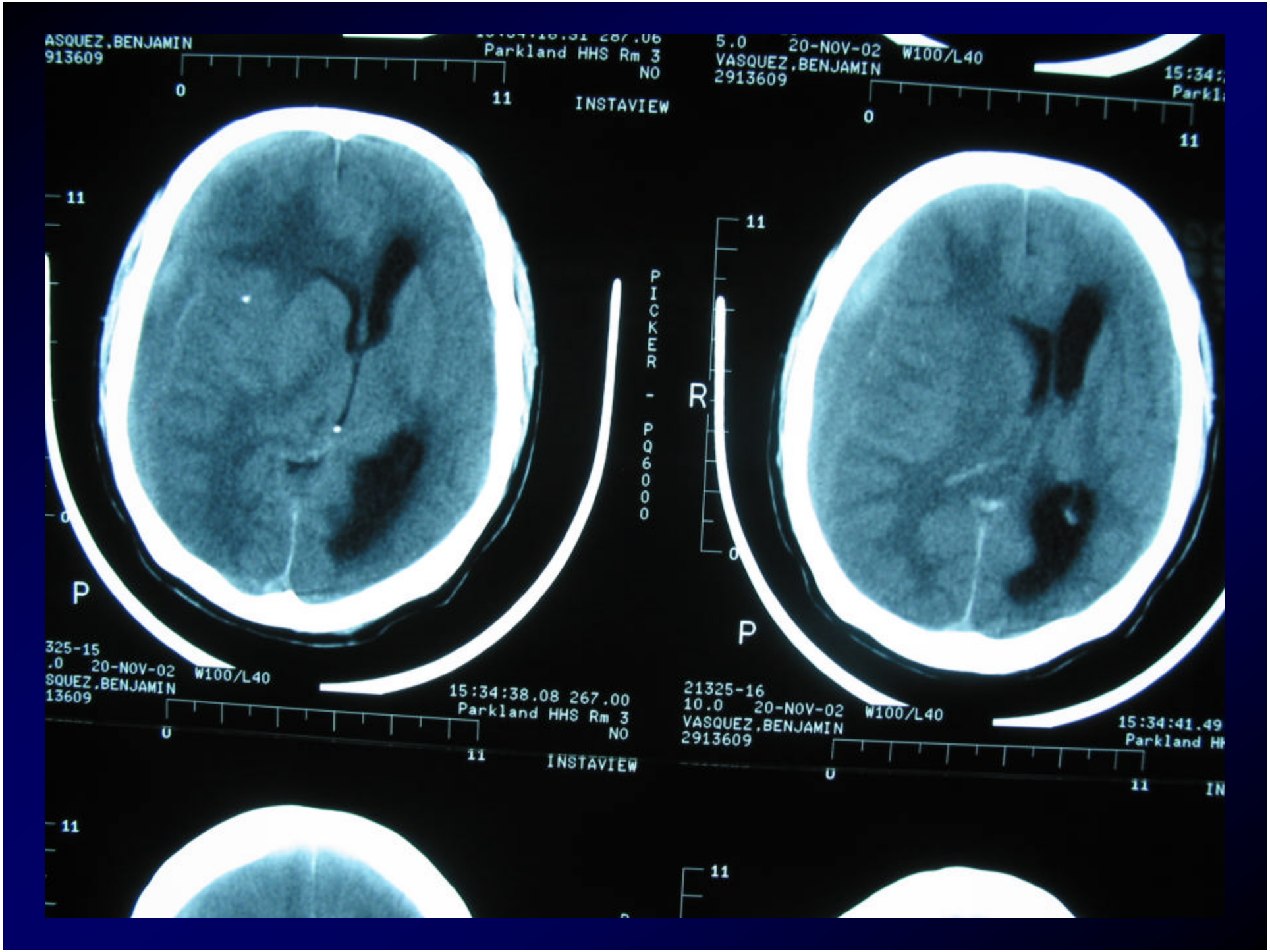
(okay, okay…195 mg…4% of a teaspoonful)

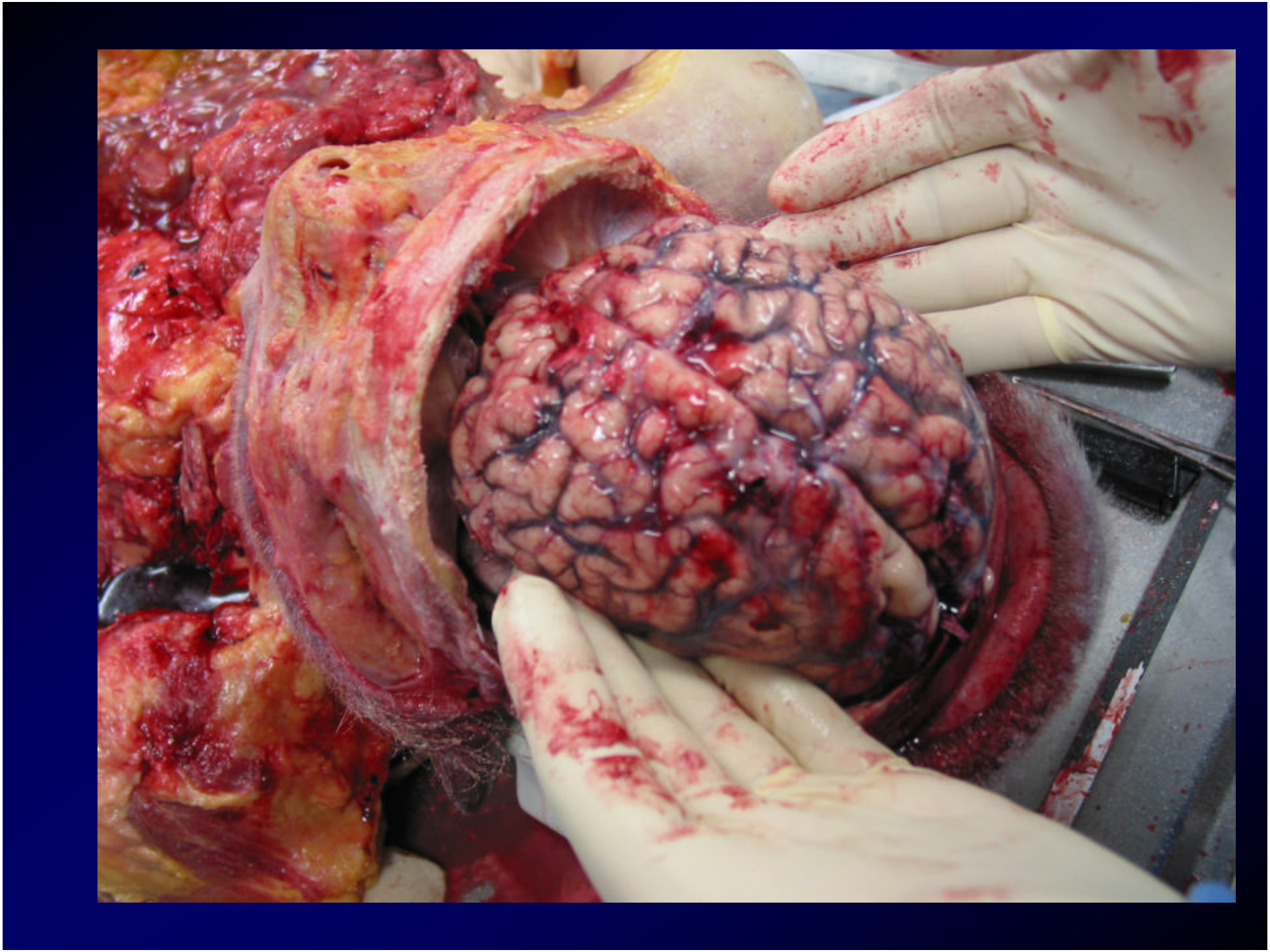
AVOID OVERVENTILATION!

Only ventilate as fast as the amount of CO_2 being produced

Bagging too fast RAISES intrathoracic pressure, drops venous return, and reduces cardiac output


ETCO2 mmHg
60
20
Pulses Return
CPR


ASQUEZ,BENJAMIN
913609
Parkland HHS Rm 3
NO
INSTAVIEW
0
11
11
PICKER - PQ6000
P
325-15
.0 20-NOV-02 W100/L40
SQUEZ,BENJAMIN
13609
15:34:38.08 267.00
Parkland HHS Rm 3
NO
INSTAVIEW
5.0 20-NOV-02 W100/L40
VASQUEZ,BENJAMIN
2913609
R
P
21325-16
10.0 20-NOV-02 W100/L40
VASQUEZ,BENJAMIN
2913609
15:34:41.49
Parkland



CAT Scans in The Field?

Well, not any time soon,
Though in Odessa, Texas
One of the first studies
On field ultrasound machines
Is now being conducted!

Rates greater than 8 per minute by ET tube in patients with circulatory collapse

MAY

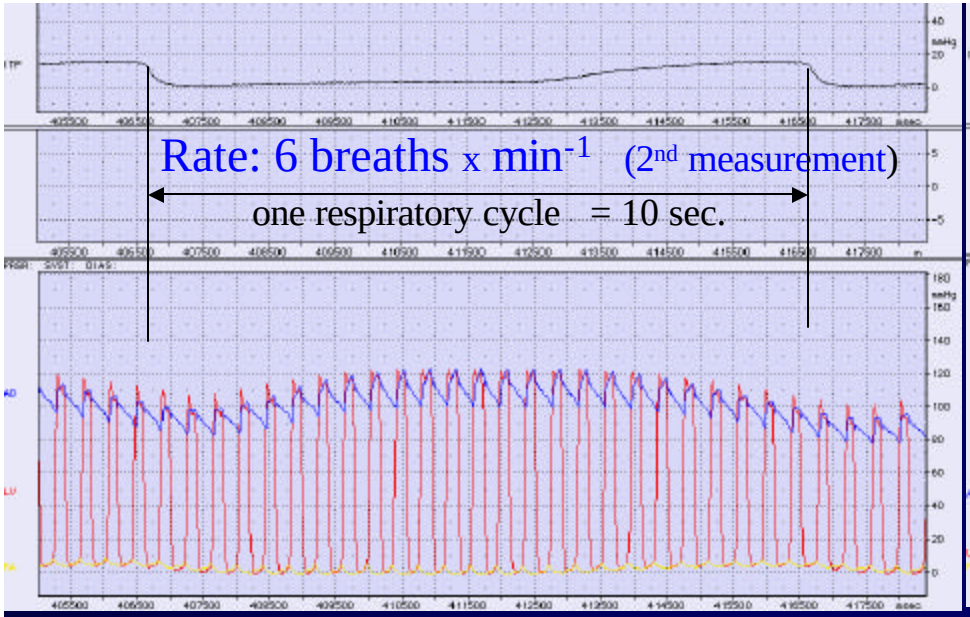
drop blood pressure…or worse!

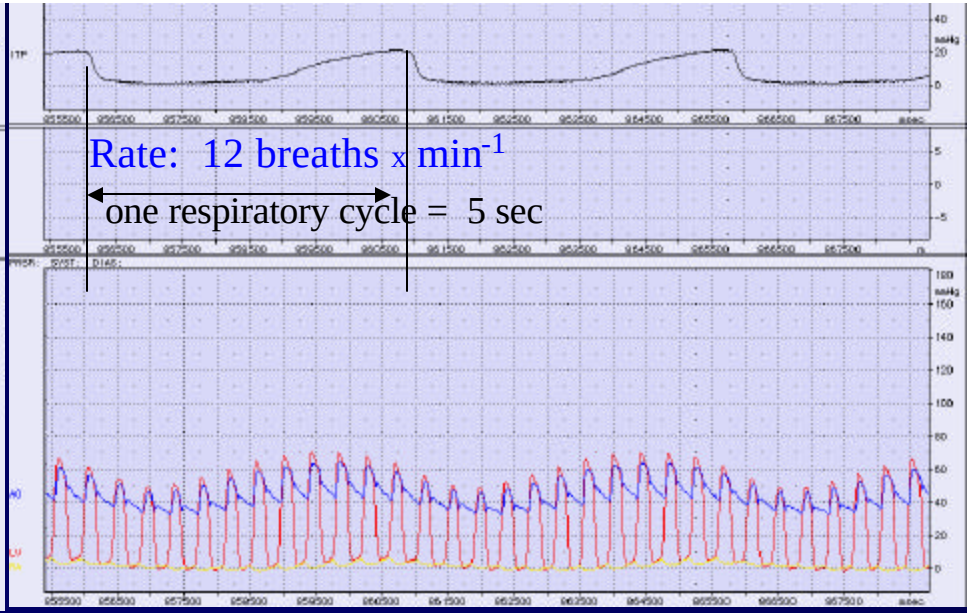
Previous and Ongoing Studies by Pepe et al

A swine model was cannulated and nearly exsanguinated

Hyperventilation was induced

Pepe showed that coronary perfusion pressures DROPPED dramatically during overventilation





RR = 6 / min

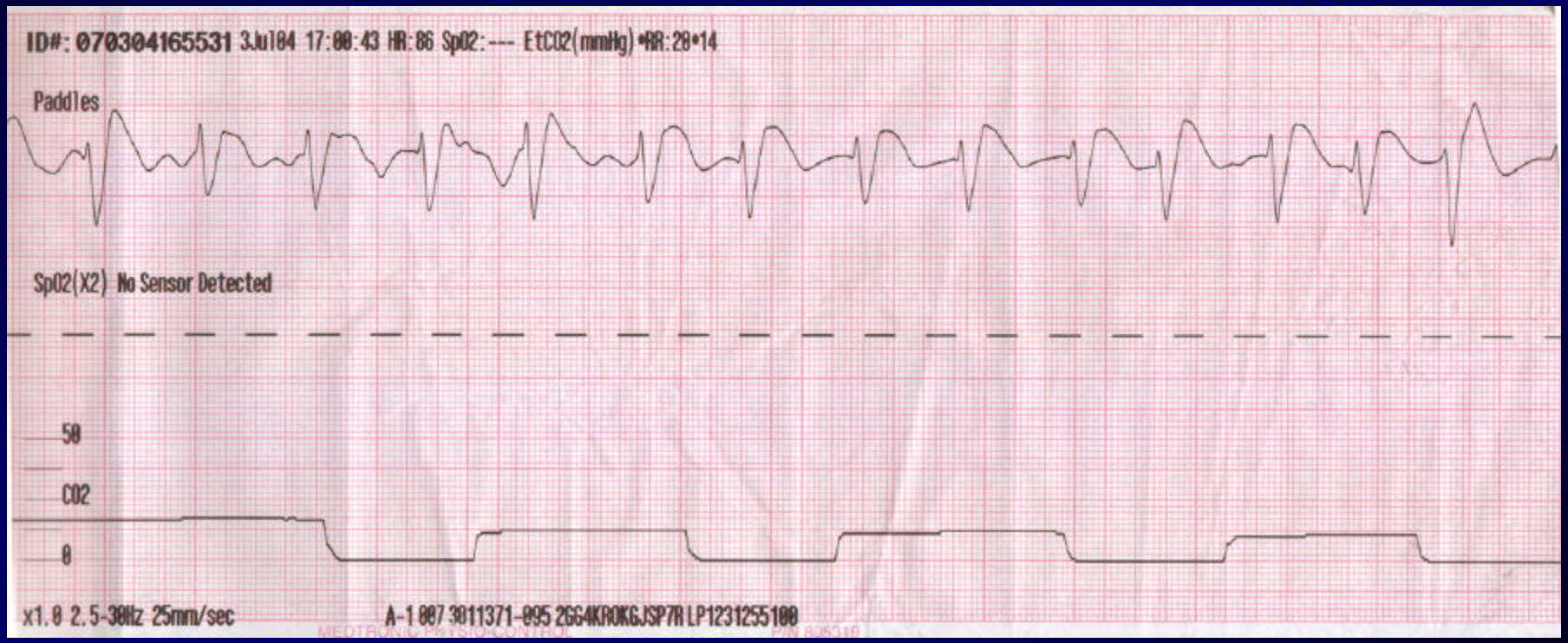
RR = 12 / min

Time-Averaged Coronary Perfusion Pressure

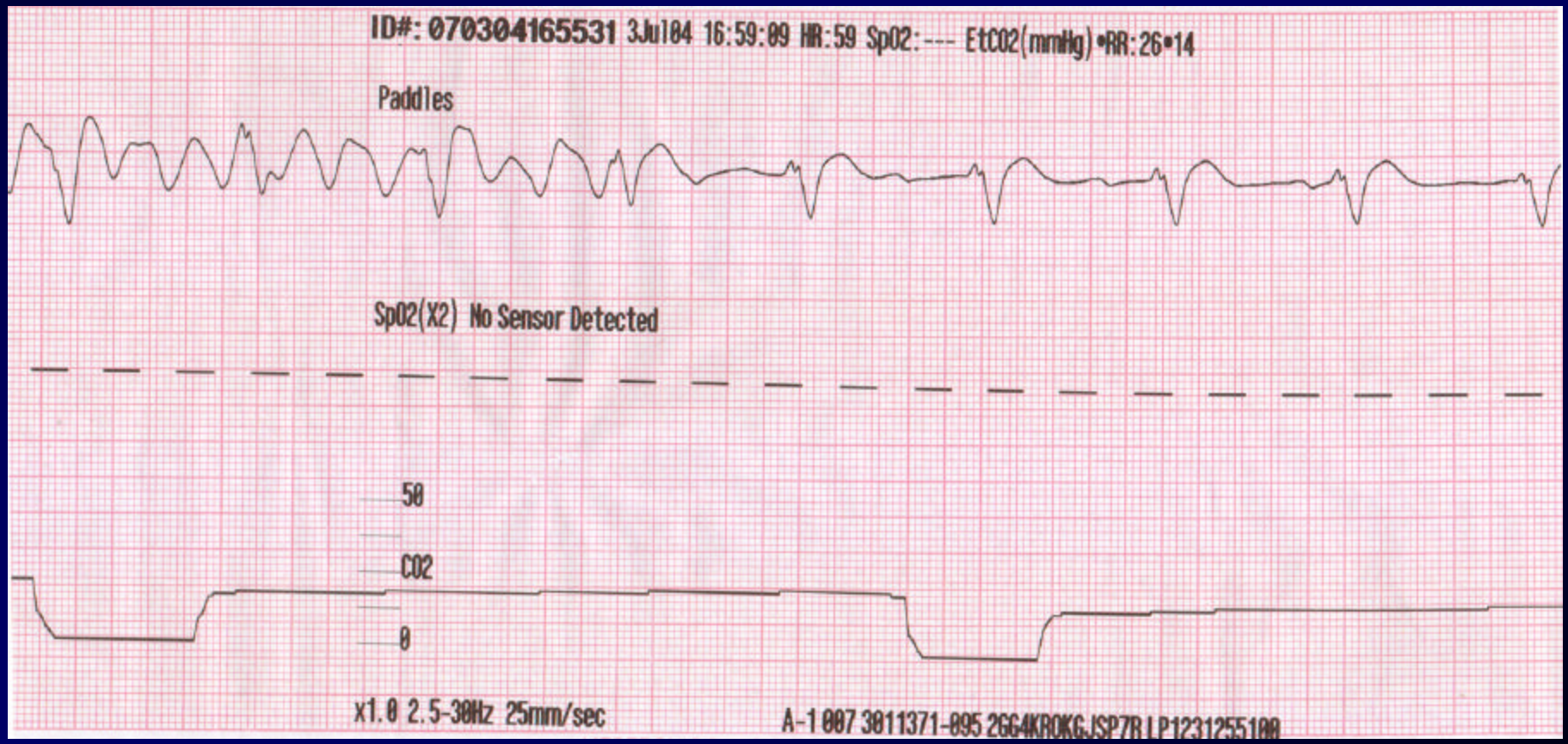
= *Area Under the Curve* *(in Pink)*

Aufderheide found, medics routinely overventilate patients even when specifically trained to avoid overzealous ventilation

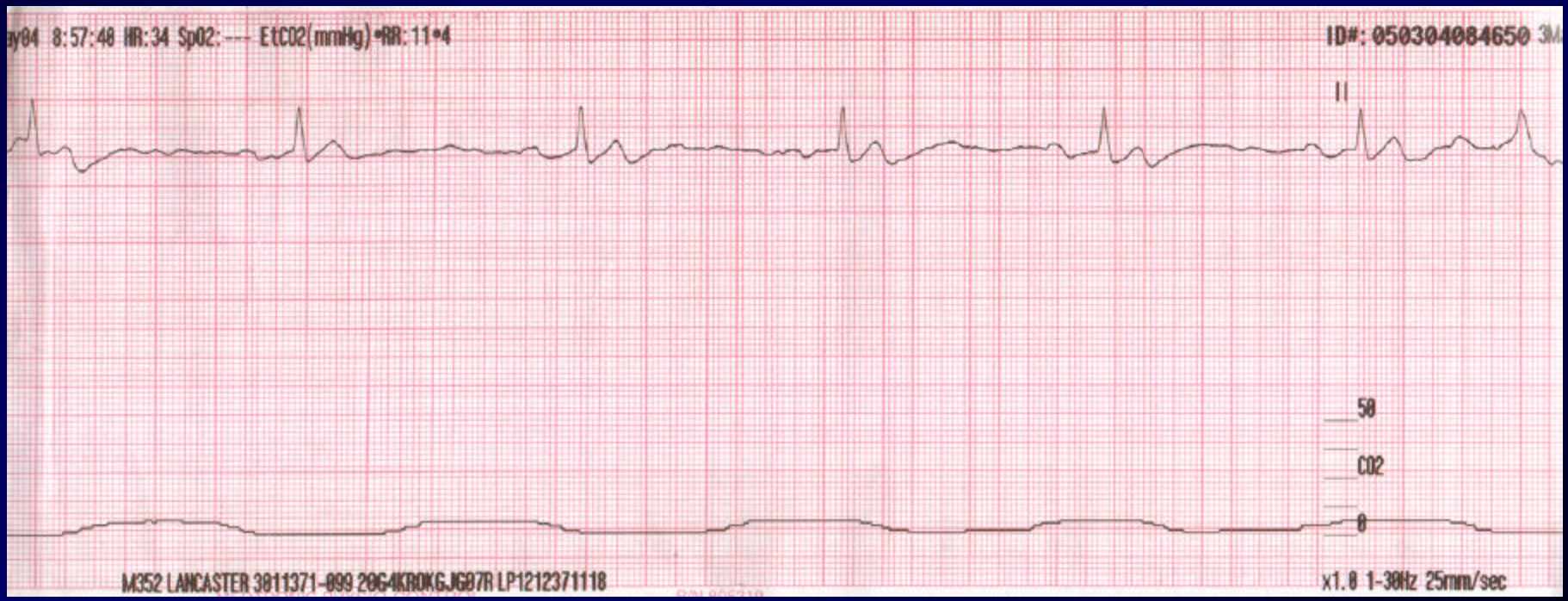
Patient in PEA being Overventilated at Rate of 30 and CO_2 of about 15



Same Patient in PEA at Rate of 10 and CO_2 increased to 25



Patient in Severe Sinus Brady Being Overventilated at a rate of 40 and a CO2 of 8



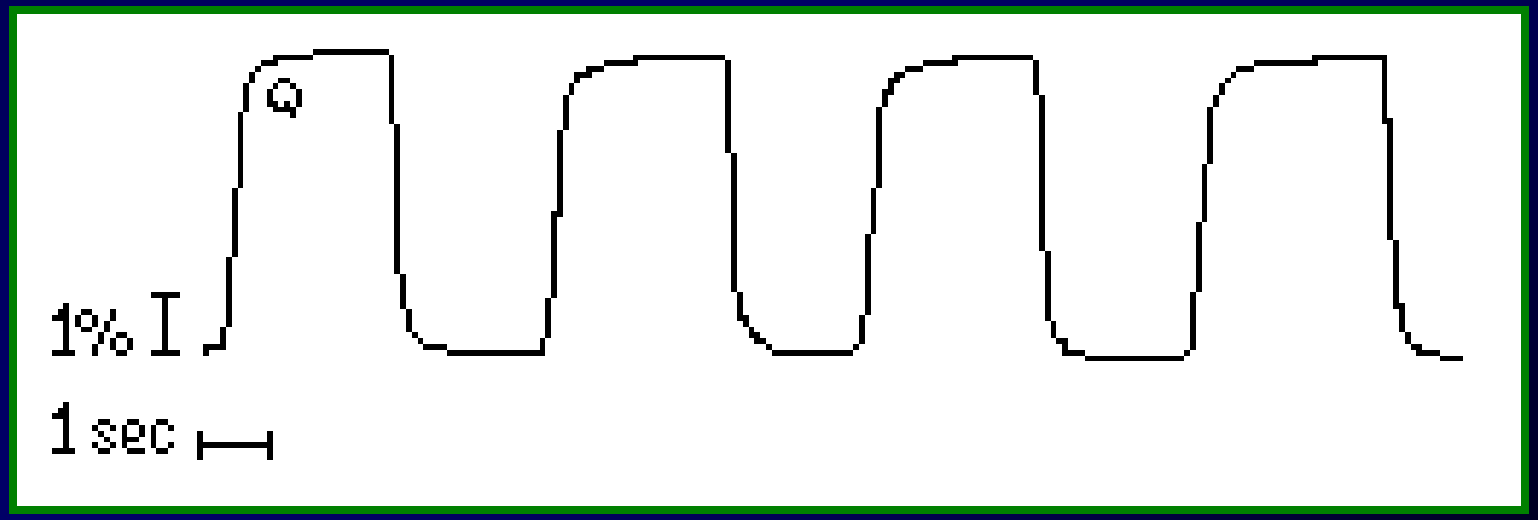
CONCLUSIONS:

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.

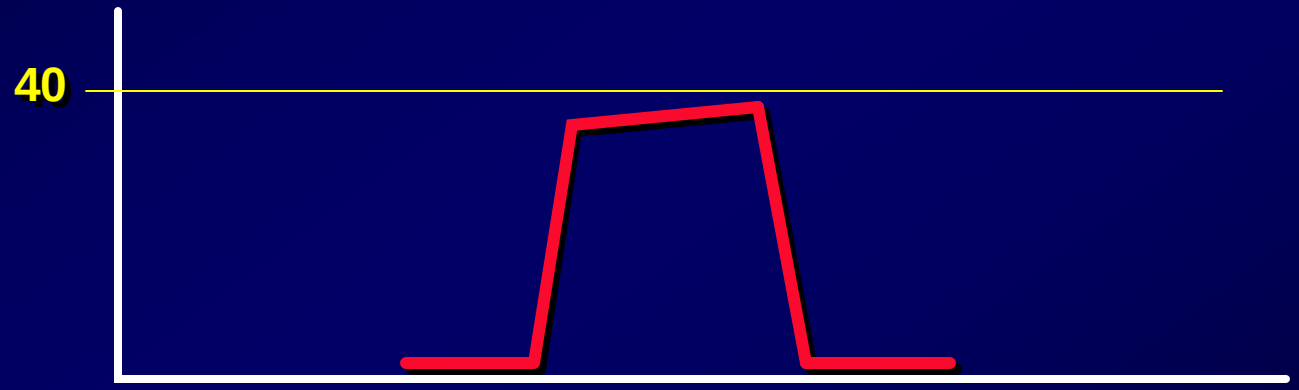
A one hand squeeze at a rate of one every eight seconds is ALL the ventilation that a patient in circulatory collapse needs!

Breathing the patient faster than that may reduce venous return, worsen shock, and kill the patient!

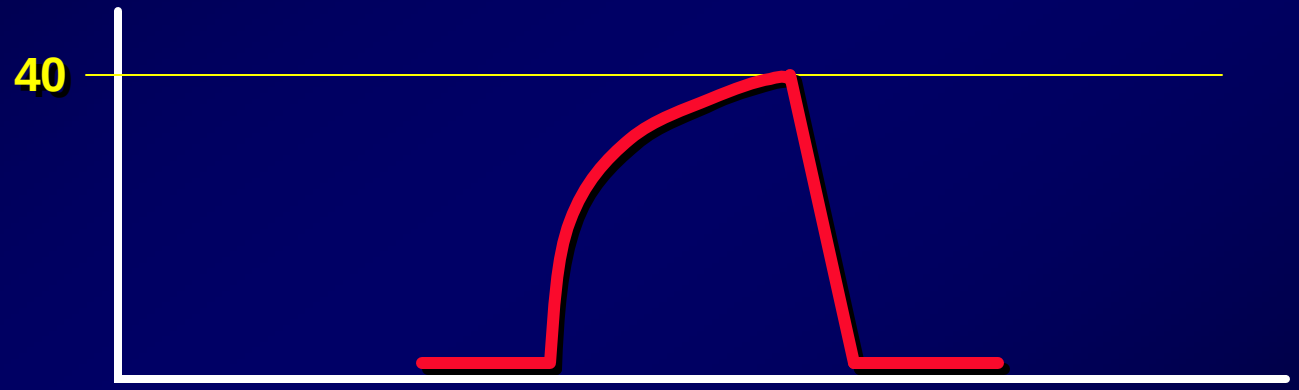
Let capnography guide you!



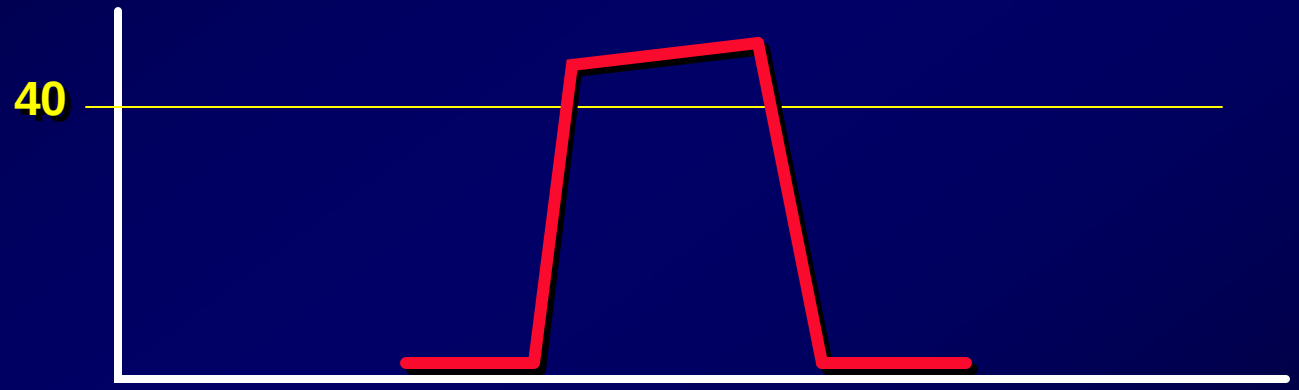
Normal Capnography Wave

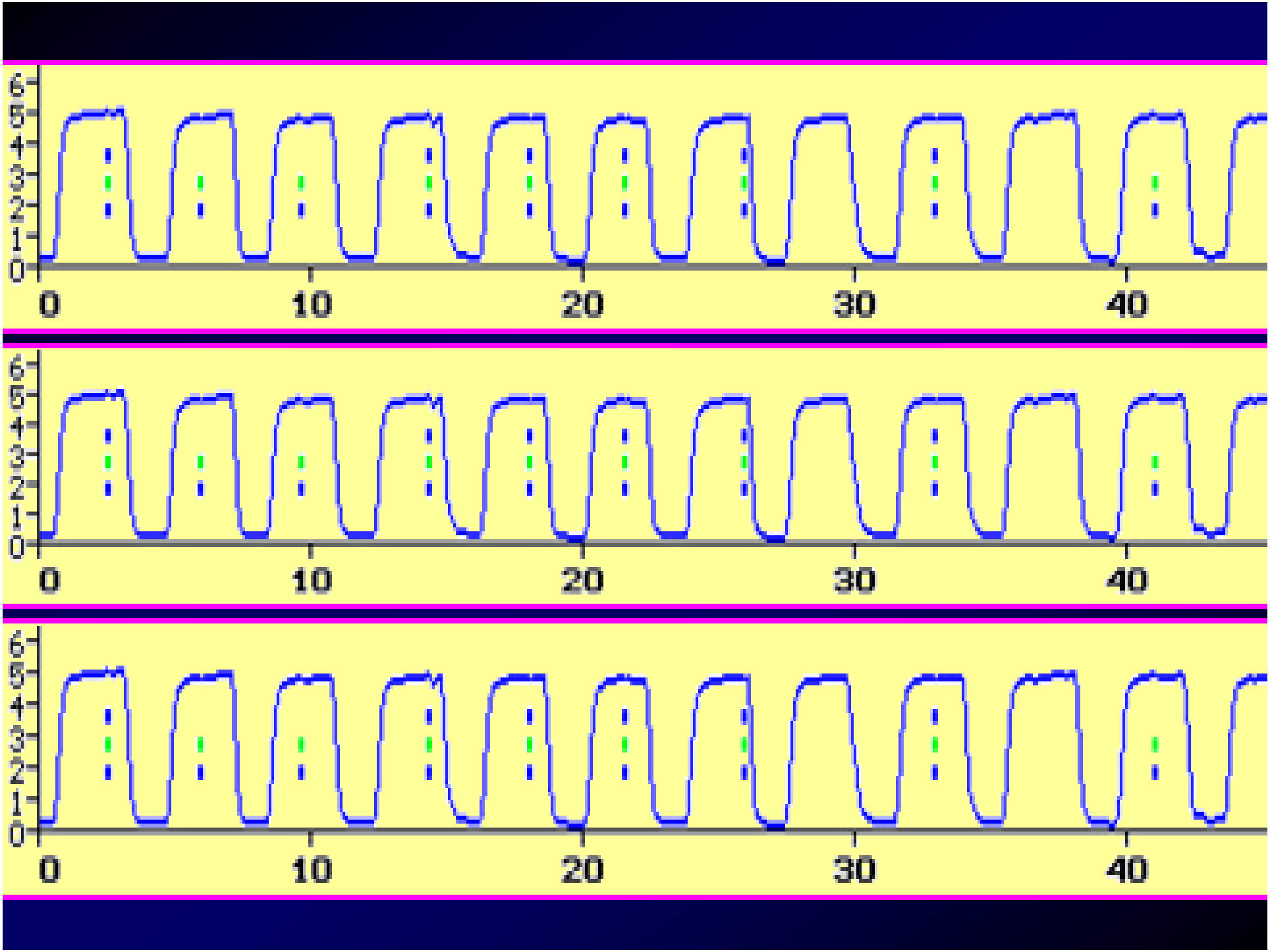


Capnography Wave with Obstructive Component?



Capnography Wave with Restrictive Component?




0
1
2
3
4
5
6
0
10
20
30
40
0
1
2
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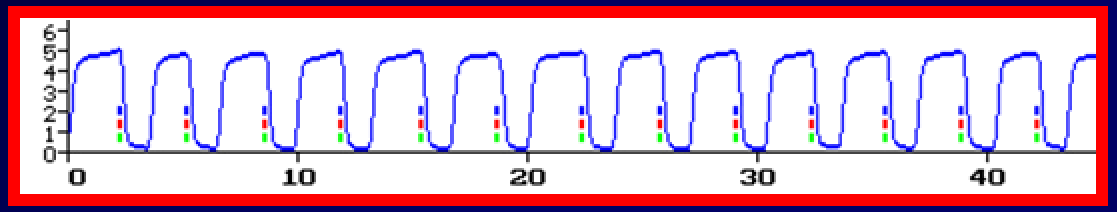
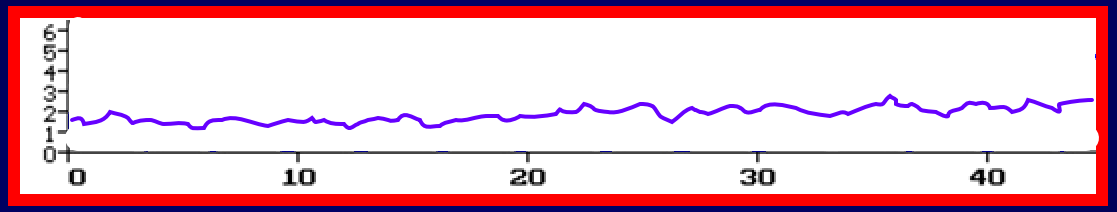
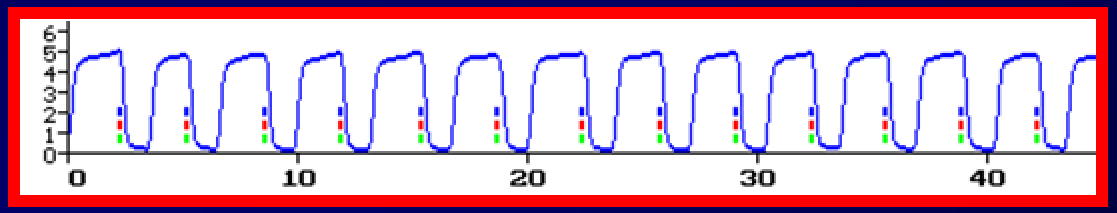
10
20
30
40
0
1
2
3
4
5
6
0
10
20
30
40

What Happened in Block 2?







The endotracheal tube became dislodged!

Ann Emerg Med 2001 Jan;37(1):32-7

Misplaced endotracheal tubes by paramedics in an urban emergency medical services system.

Katz SH, Falk JL
Department of Emergency Medicine, JFK Medical Center, Atlantis, FL, USA.

- **A total of 108 intubated patients were studied**
- **On arrival in the ED, 25% (27/108) of patients were found to have improperly placed endotracheal tubes. Of the misplaced tubes, 67% (18/27) were found to be in the esophagus, whereas in 33% (9/27), the tip of the tube was found to be in the hypopharynx, above the vocal cords.**
- **Of the patients with misplaced tubes noted in the hypopharynx, 33% (3/9) died while in the ED. For the patients found to have tubes in the hypopharynx, 56% (5/9) had evidence of ETCO(2) on ED arrival.**
- **For the patients found to have esophageal tube placement on ED arrival, 56% (10/18) died in the ED.**

CONCLUSION: The incidence of out-of-hospital, unrecognized, misplaced endotracheal tubes in our community is excessively high and may be reflective of the incidence occurring in other communities. Data from other communities are needed to clarify the scope of this alarming issue.

DOUGLAS COUNTY FIRE / EMS
PRE-HOSPITAL AIRWAY MANAGEMENT FORM

Patient's Name:_____ **Age:**_____ **Case #** _____ **Date:** ___/___/____

Check all appropriate items: **Intubating Medic's Name (Print):** _____ **Medic Number:** _____

Care prior to EMS arrival	Arrival Of EMS: Status of Pt's Airway/Ventilation	Indication(s) for ETT	Indications for ETT continued:
☐ CPR ☐ Mouth-to-Mouth ☐ BVM ☐ Oral/Nasal Airway ☐ Manual Maneuvers ☐ ET/Combitube Placed	☐ Airway not open on arrival ☐ Open,-Pt Ventilating Well ☐ Open, not Ventilating Well ☐ Open, in Respiratory Arrest ☐ Foreign Body Obstruction ☐ Vomitus/Blood in Airway ☐ Facial/Tracheal Trauma	☐ Asthma ☐ Apnea ☐ Cardiac Arrest ☐ Head Injury ☐ Hypoxia	☐ Prophylactic ☐ Major Trauma ☐ Low Tidal Volume/ Respiratory Rate ☐ Other_____ _____

Type of Intubation (ETT)	Verification Check #1 (ETT)	Verification Check #2	Verification Check #3
☐ Oro-tracheal ☐ Nasal ☐ Digital	☐ Direct Visualization **(ET seen through vocal cords)** ☐ ET Over Arytenoids ☐ Unable to Visualize	**Esophageal Air Aspiration** ☐ Aspirated 60cc's or more of air ☐ Unable to Aspirate 60cc of air	**Breath Sounds** ☐ B/S Present 5 area check ☐ B/S Right __Left__ only ☐ B/S Absent

Verification Check #4	Verification Check # 5	ETT Placement	Combitube Placement
Epigastric Sounds ☐ Absent epigastric sounds ☐ Epigastric sounds present ☐ Unable to determine	**Pulse Ox Reading** **Pre ETT:** _____% **Post ETT:** _____% **Capnometry** **Pre-ETT: Yellow___ Purple___** **Post-ETT: Yellow___Purple___**	**YES** **NO** ☐ Gag Reflex Present ☐ ☐ Suction Needed ☐ ☐ Stylet Used? ☐ ☐ Jaw Flexible? ☐ **# of Attempts** _____ **ETT Size** _____ **Type of Blade** _____	**(First Responder or EMS)** ☐ Combitube **NOT** Attempted ☐ Combitube **WAS** Attempted **Number Of Attempts** _____ **Lung Sounds? Yes ☐ NO☐** **Chest Rise? Yes ☐ NO☐**

PLACEMENT SECURED BY: ☐ **ETT HOLDER** ☐ **C-COLLAR** ☐ **OTHER**_____

PHYSICIAN OR RESPIRATORY THERAPIST STATEMENT

TO THE PHYSICIAN OR RESPIRATORY THERAPIST ACCEPTING CARE OF THIS PATIENT, PLEASE FILL OUT THIS SECTION AS PART OF OUR QUALITY IMPROVEMENT PROGRAM:

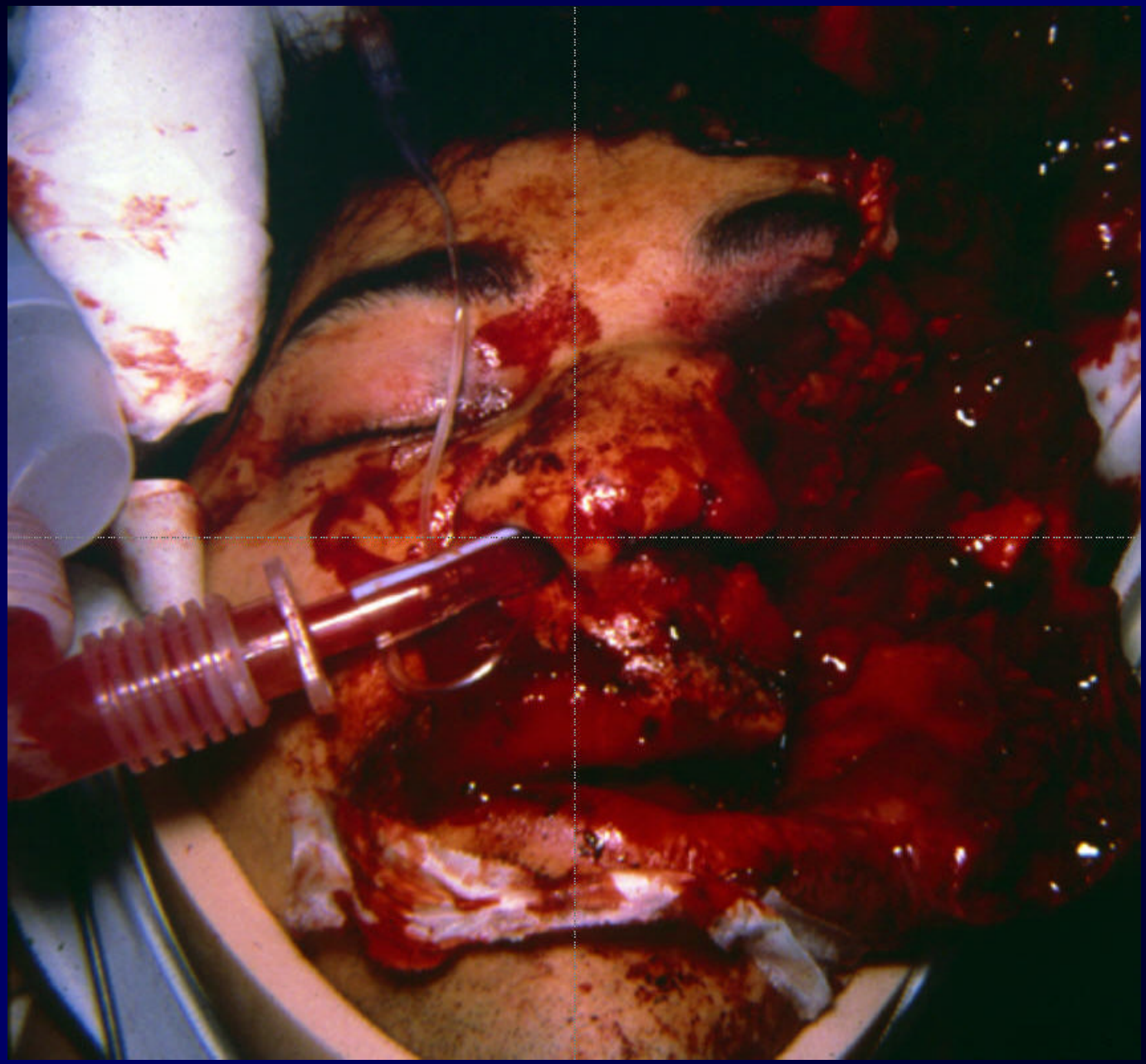
ETT Position upon Arrival in your ER: ☐ Trachea ☐ Esophagus **RECEIVING HOSPITAL:** _____
Combitube Position upon Arrival in your ER: ☐ Trachea ☐ Esophagus
Method of Verification: ☐ Direct Visualization ☐ Breath Sounds

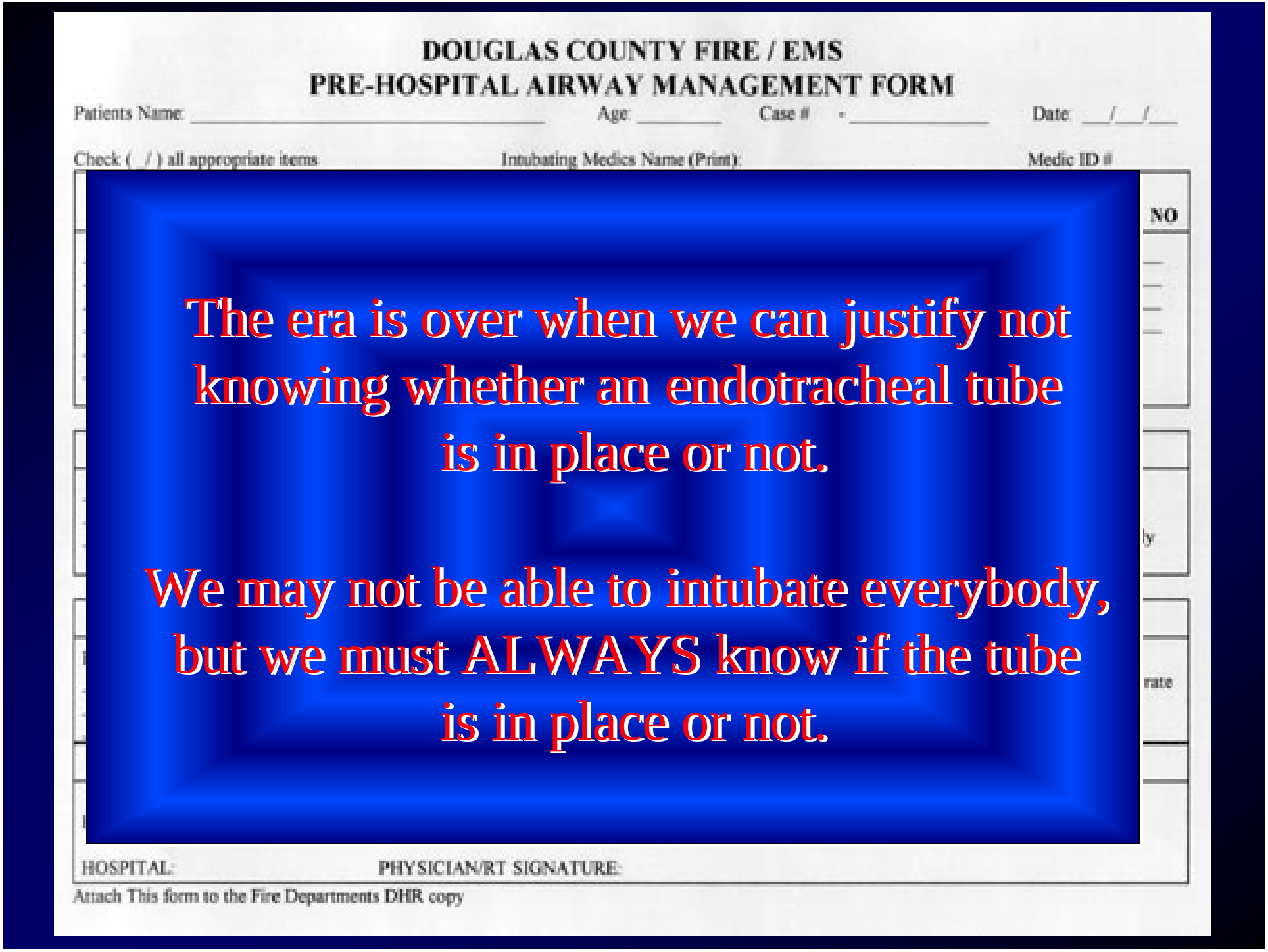
Comments: _____
_____

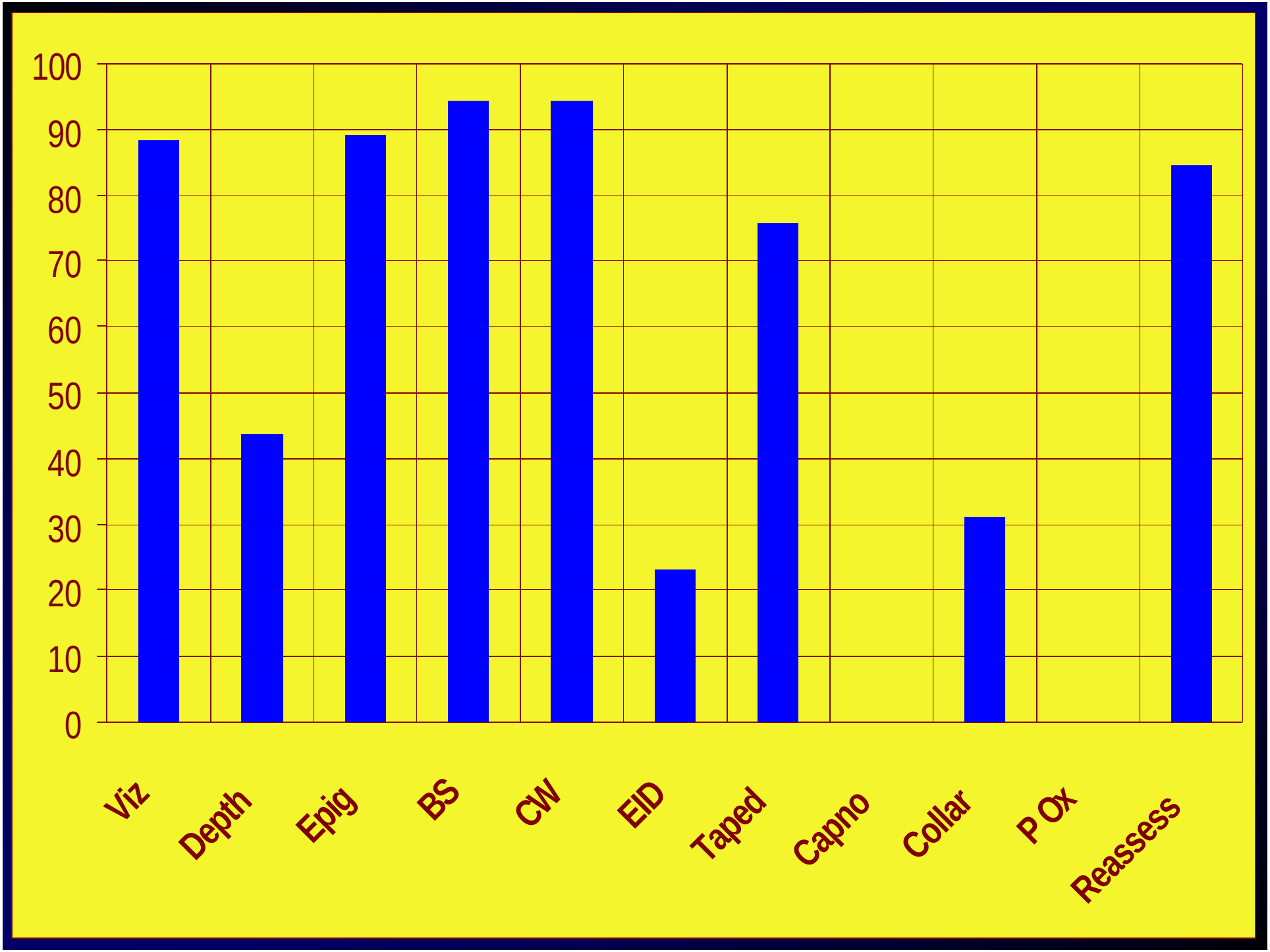
PHYSICIAN/RT SIGNATURE:_____ **DATE OF SIGNATURE:** _____

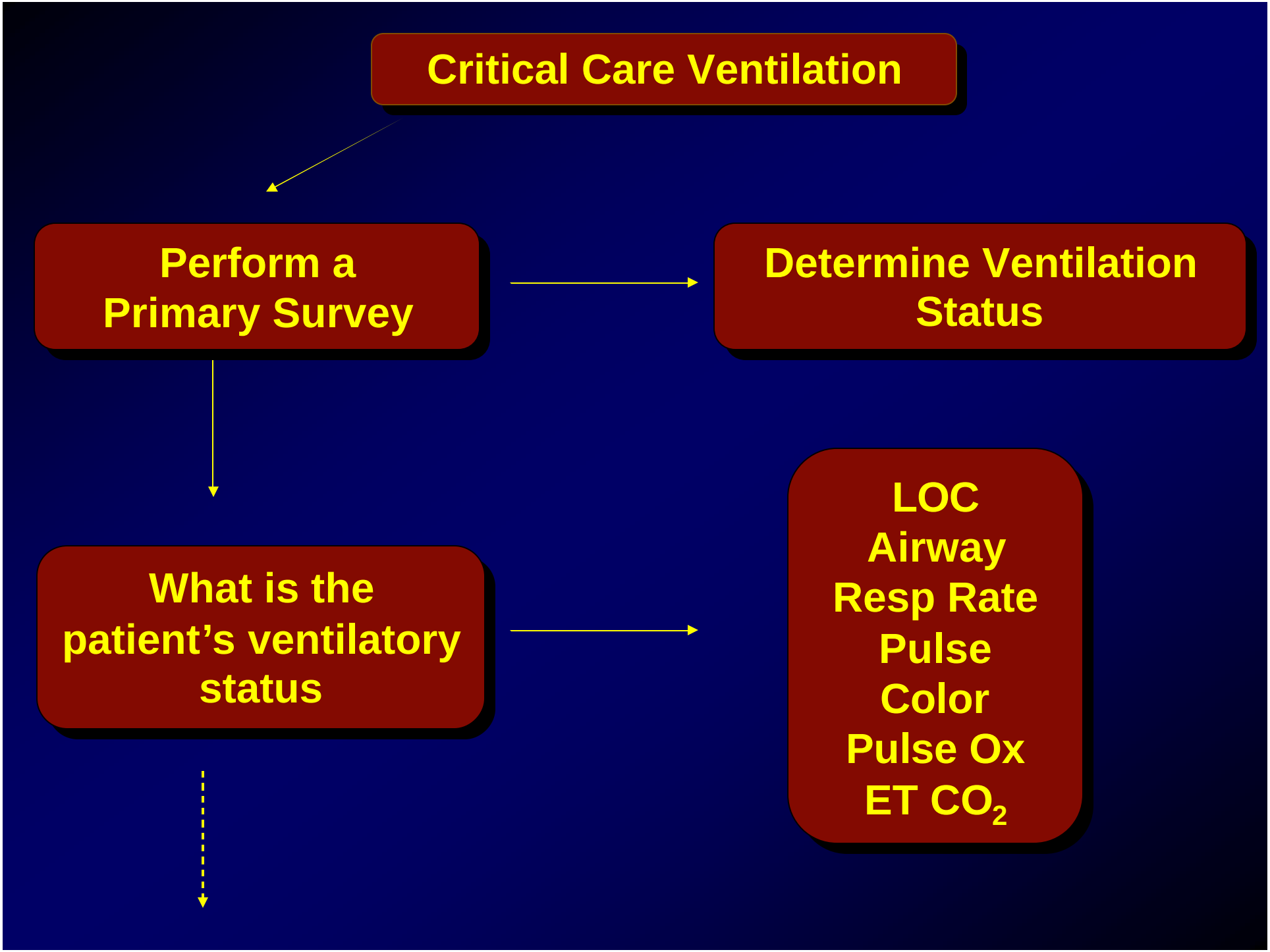
EMS MEDICAL DIRECTOR SIGNATURE:_____ **DATE OF SIGNATURE:**_____

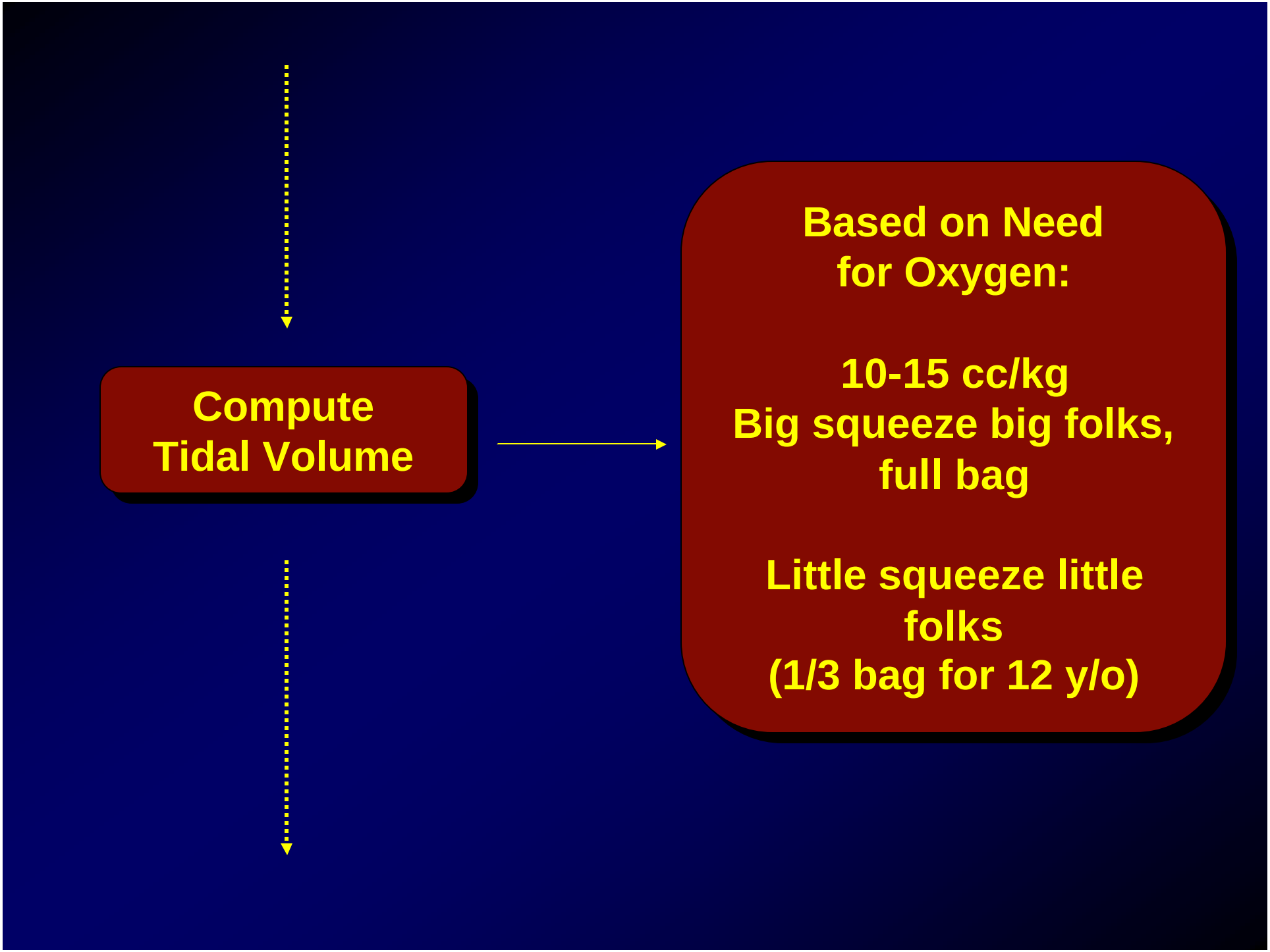
Please attach this form to the Douglas County Fire Department's copy of the DHR on this patient

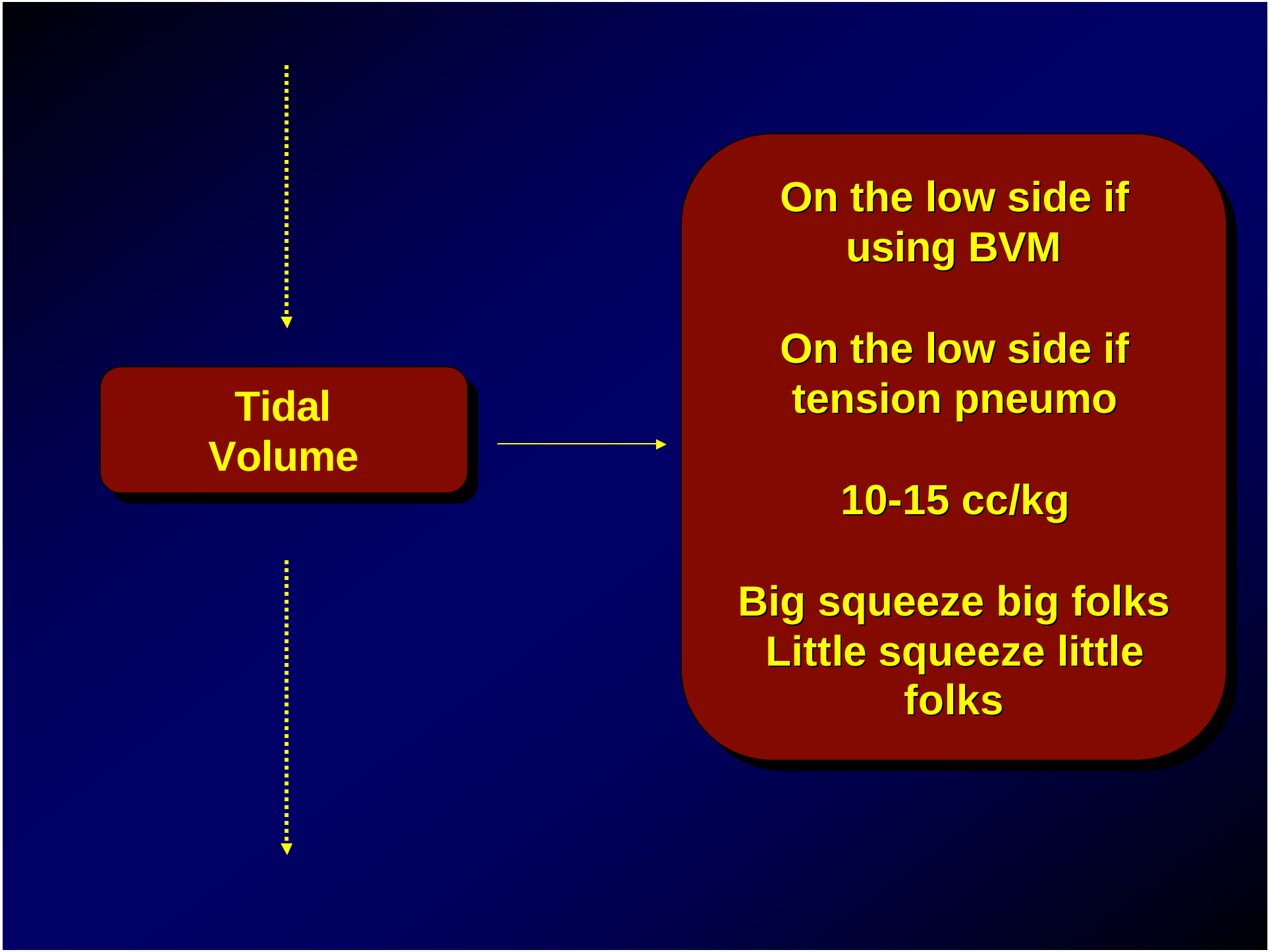


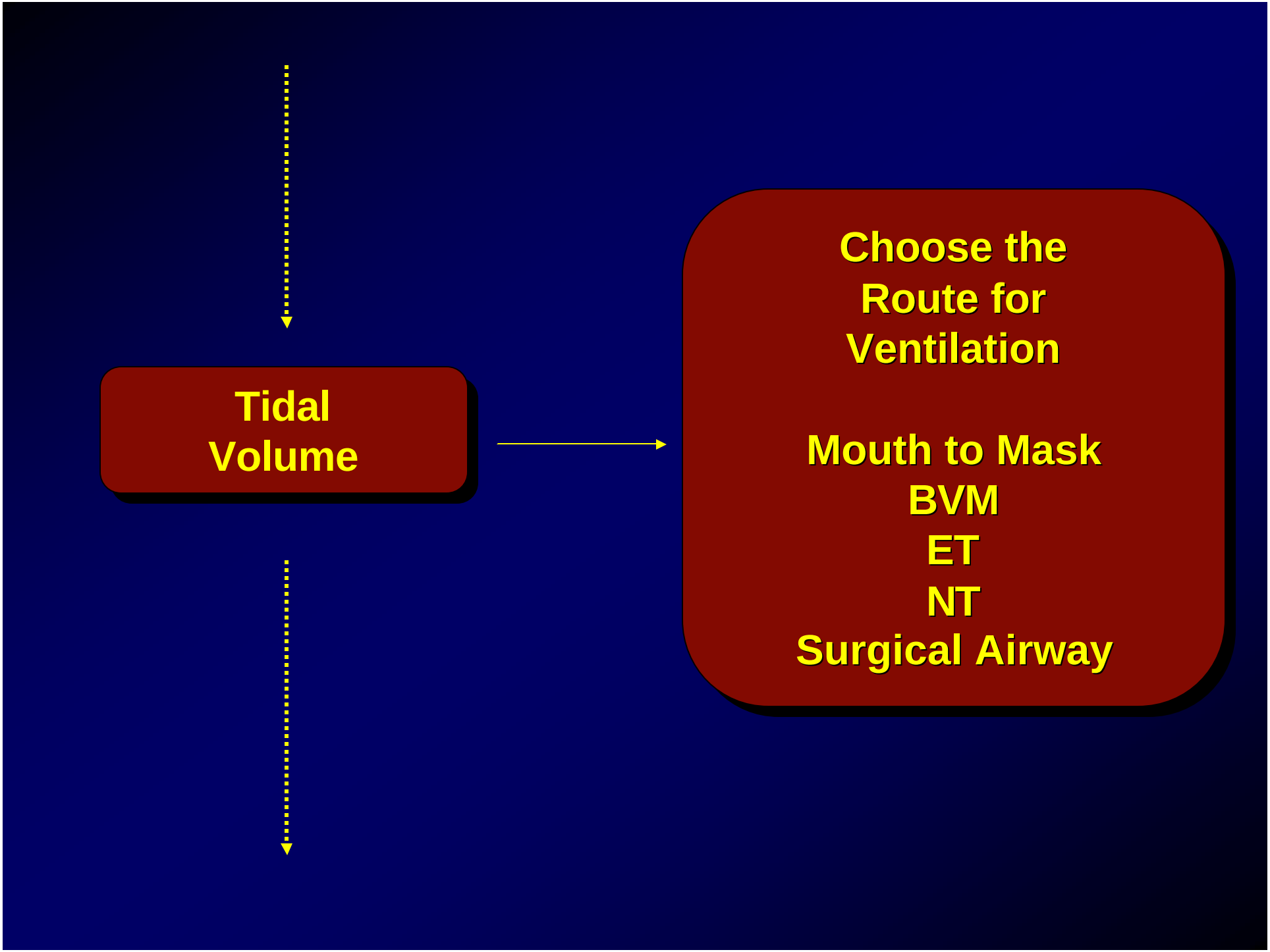

DOUGLAS COUNTY FIRE / EMS
PRE-HOSPITAL AIRWAY MANAGEMENT FORM
Patients Name:
Age:
Case #
Date
Check (/) all appropriate items
Intubating Medics Name (Print):
Medic ID #
NO
The era is over when we can justify not knowing whether an endotracheal tube is in place or not.
We may not be able to intubate everybody, but we must ALWAYS know if the tube is in place or not.
HOSPITAL:
PHYSICIAN/RT SIGNATURE:
Attach This form to the Fire Departments DHR copy

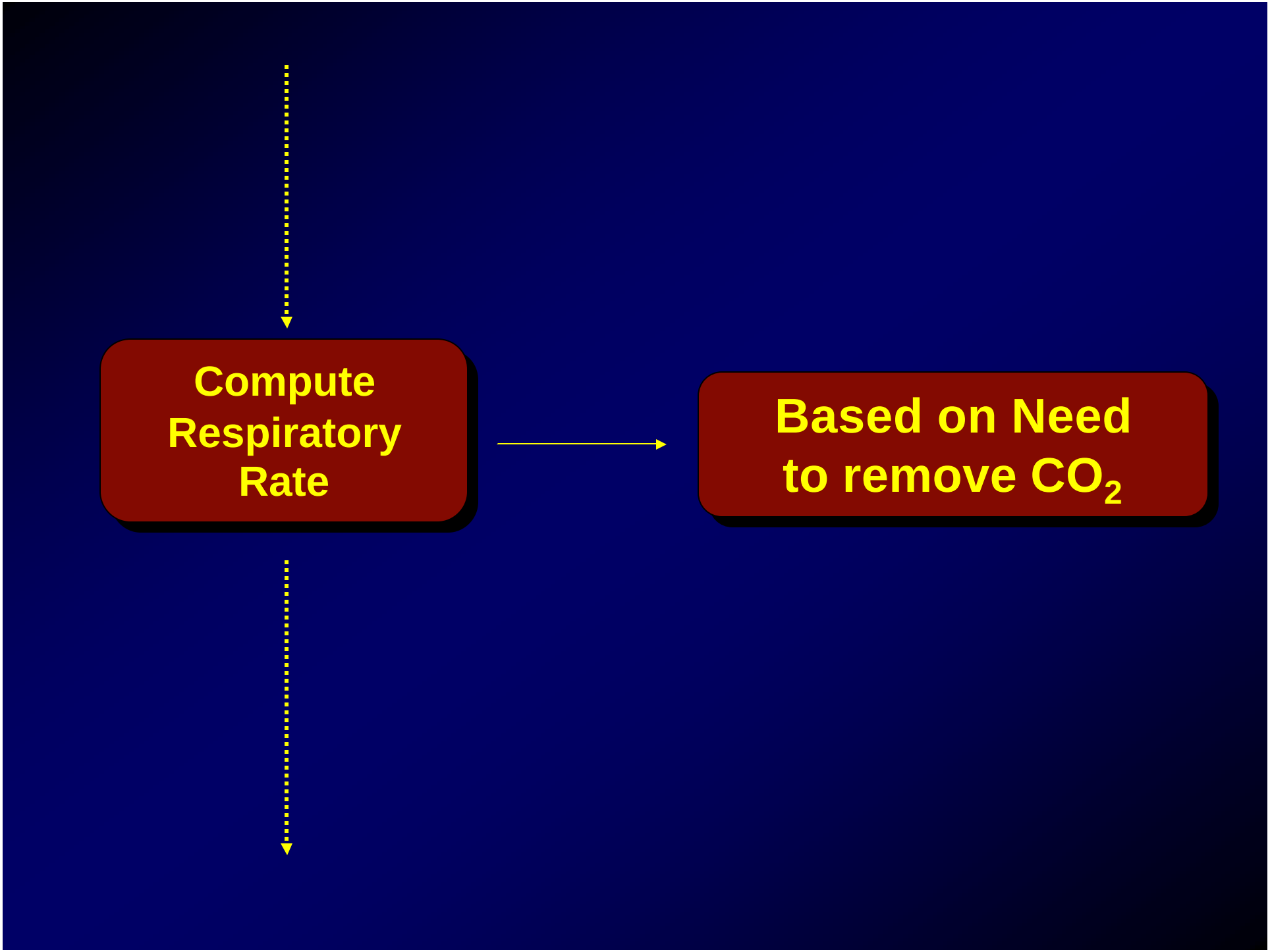

100
90
80
70
60
50
40
30
20
10
0
Viz
Depth
Epig
BS
CW
EID
Taped
Capno
Collar
P Ox
Reassess

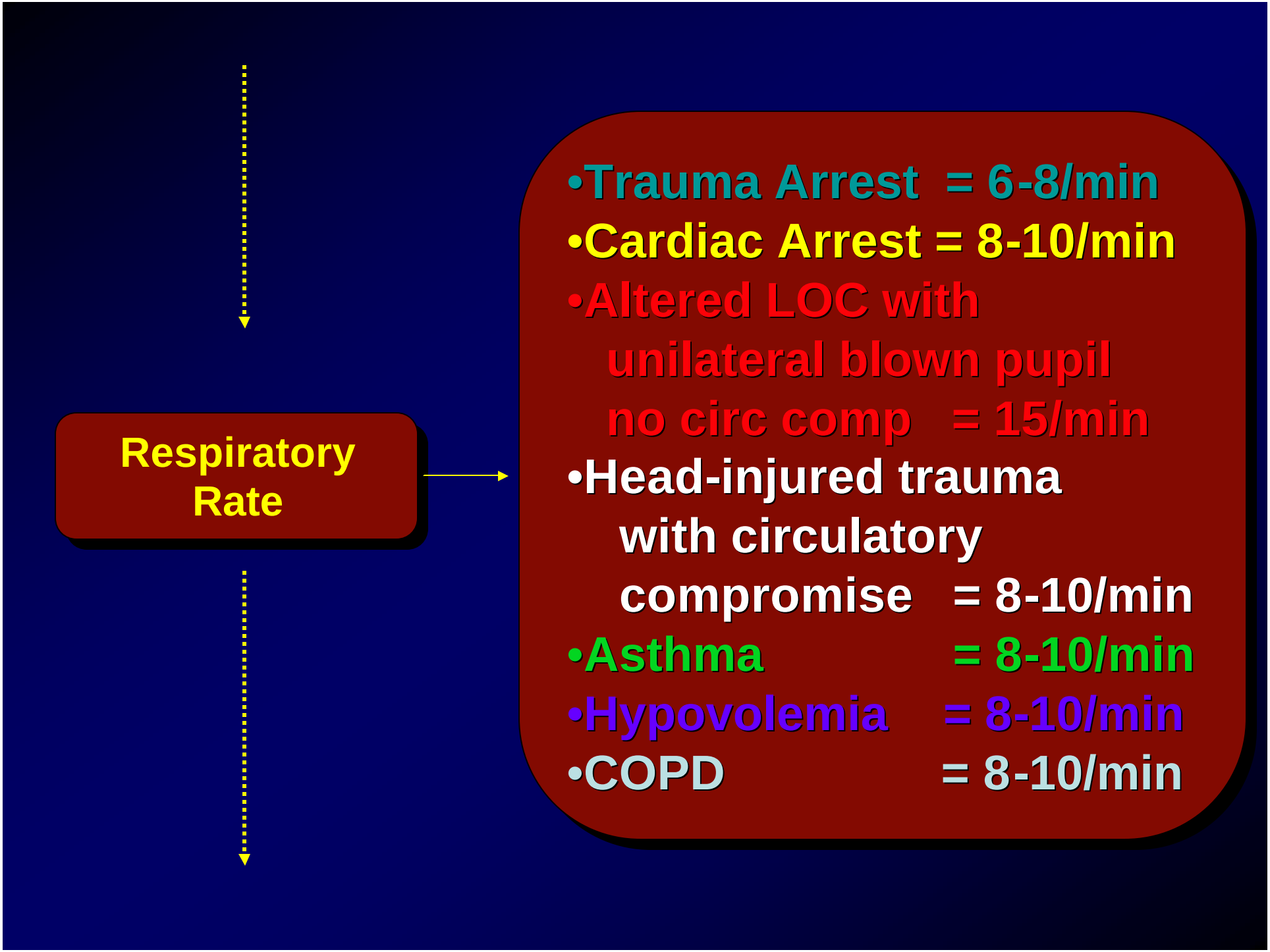

Critical Care Ventilation
Perform a Primary Survey
Determine Ventilation Status
What is the patient's ventilatory status
LOC
Airway
Resp Rate
Pulse
Color
Pulse Ox
ET CO_2


Compute
Tidal Volume
Based on Need
for Oxygen:
10-15 cc/kg
Big squeeze big folks,
full bag
Little squeeze little
folks
(1/3 bag for 12 y/o)


Tidal Volume
On the low side if using BVM
On the low side if tension pneumo
10-15 cc/kg
Big squeeze big folks
Little squeeze little folks


Tidal Volume
Choose the Route for Ventilation
Mouth to Mask
BVM
ET
NT
Surgical Airway


Compute Respiratory Rate
Based on Need to remove CO_2


Respiratory Rate
•Trauma Arrest = 6-8/min
•Cardiac Arrest = 8-10/min
•Altered LOC with unilateral blown pupil no circ comp = 15/min
•Head-injured trauma with circulatory compromise = 8-10/min
•Asthma = 8-10/min
•Hypovolemia = 8-10/min
•COPD = 8-10/min

Adjust Ventilation Rate

Based on Capnometry: Slow ventilation rate until you see yellow in the capnometry reading (or better, use waveform and slow ventilation until CO_2 crosses about 20 or greater)

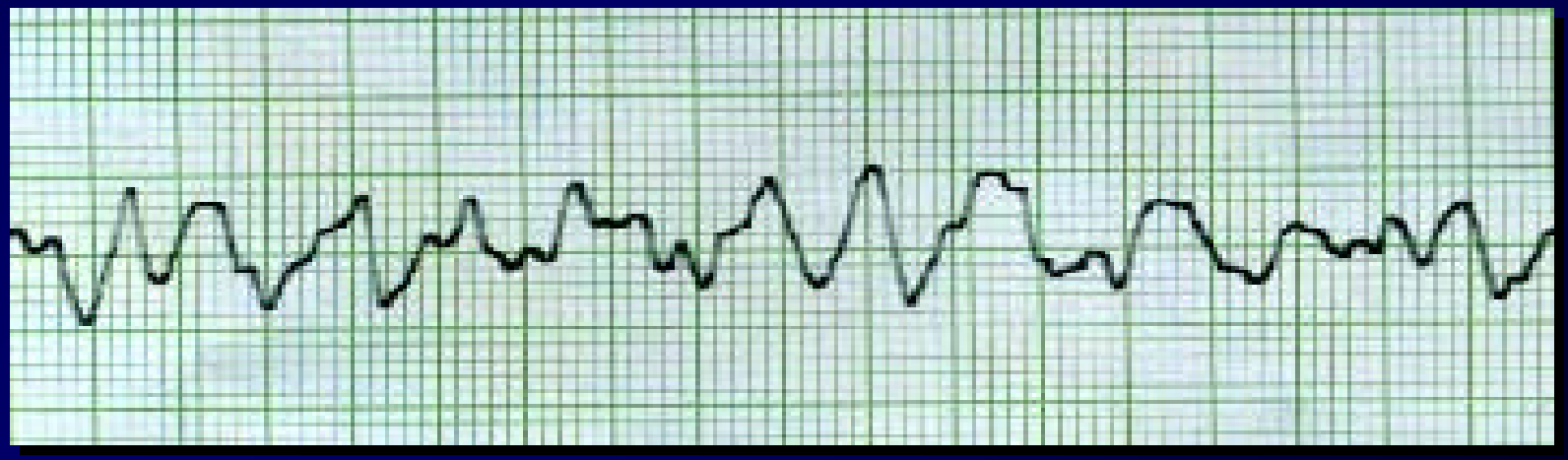
Capnometry

- A (purple) = < 4 mm Hg
- B (tan) = 4-15 mm Hg
- C (yellow) = > 15 mm Hg

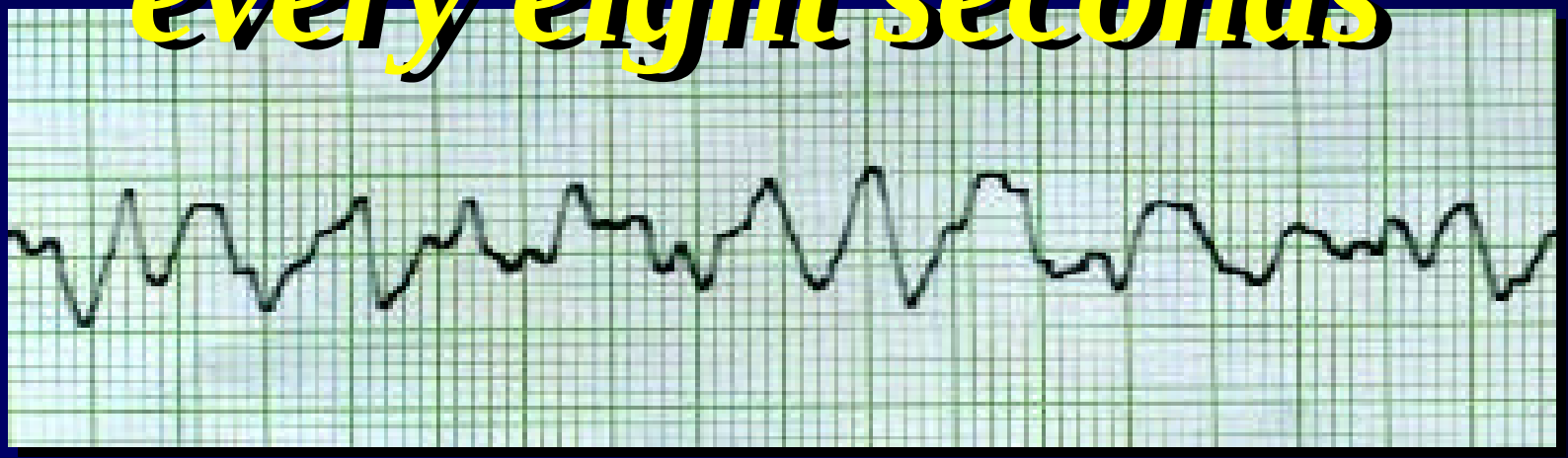
Wayne et al:

Showed that in cardiac arrest patients whose endtidal CO_2 was less than 10 mmHg, no one survived

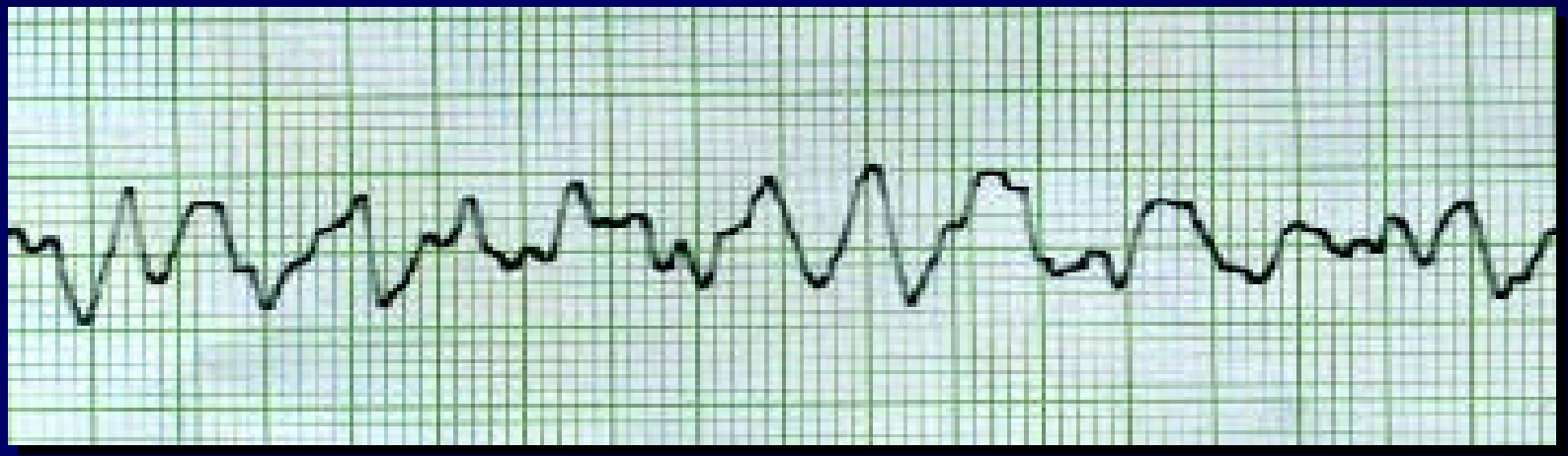
So, what do we do with this guy??



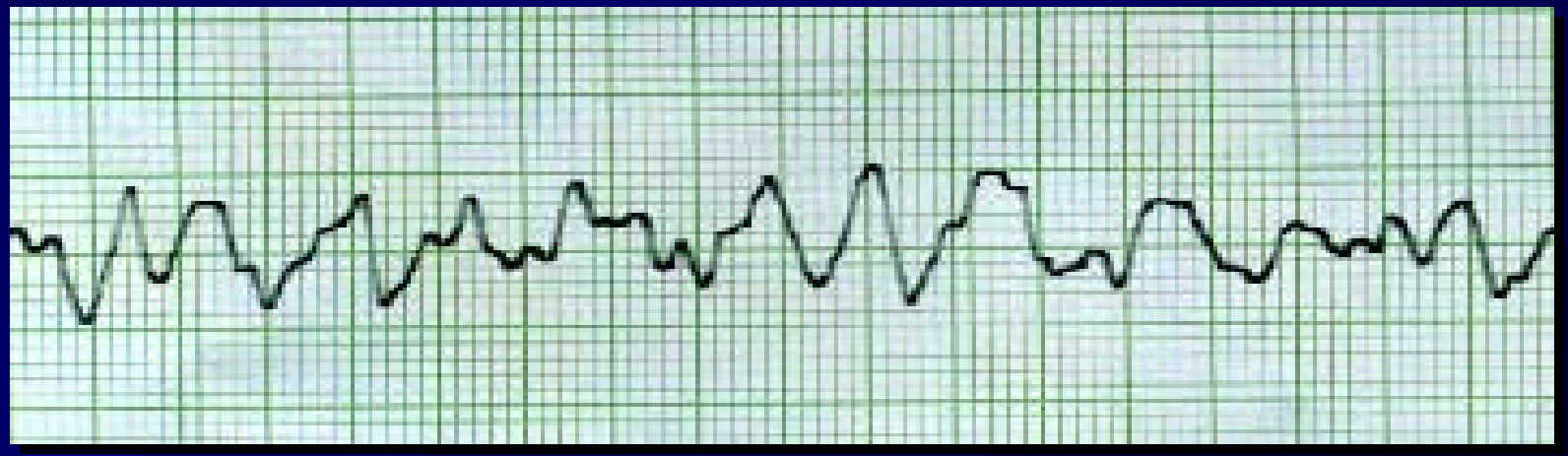
Make SURE that his ventilation rate is a one hand squeeze every eight seconds



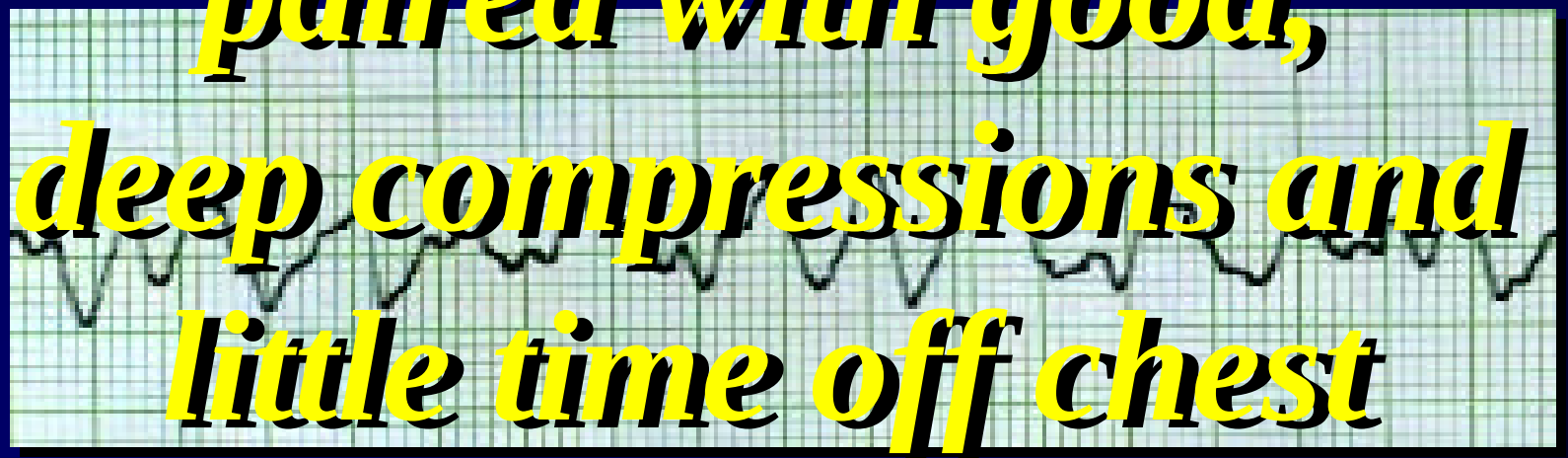
Evaluate capnography or capnometry five minutes later



Adjust the ventilation rate from there



Slow the ventilation rate down until exhaled CO2 rises above 20, paired with good, deep compressions and little time off chest



…and, if you do this…

AND YOU MUST…

you will likely be the only guy on the team who understands that this is now the standard

Major Trauma

Bubba was shot in the chest during an intellectual discussion about the value of certain goods and services where one individual did not feel that the goods rendered equaled the value transferred

He was well until this happened.
He has no medical problems
and takes no medications.

Enroute his capnography shows 40 on exhalation, and you begin O's, IV's, and rapid transport

Shortly thereafter, his CO2 drops to 20 and he is acting a little confused

What is happening?

He is going into circulatory collapse

What do you do?

Administer sufficient fluid to maintain radial ("permissive hypoperfusion")
Examine for the development of a tension

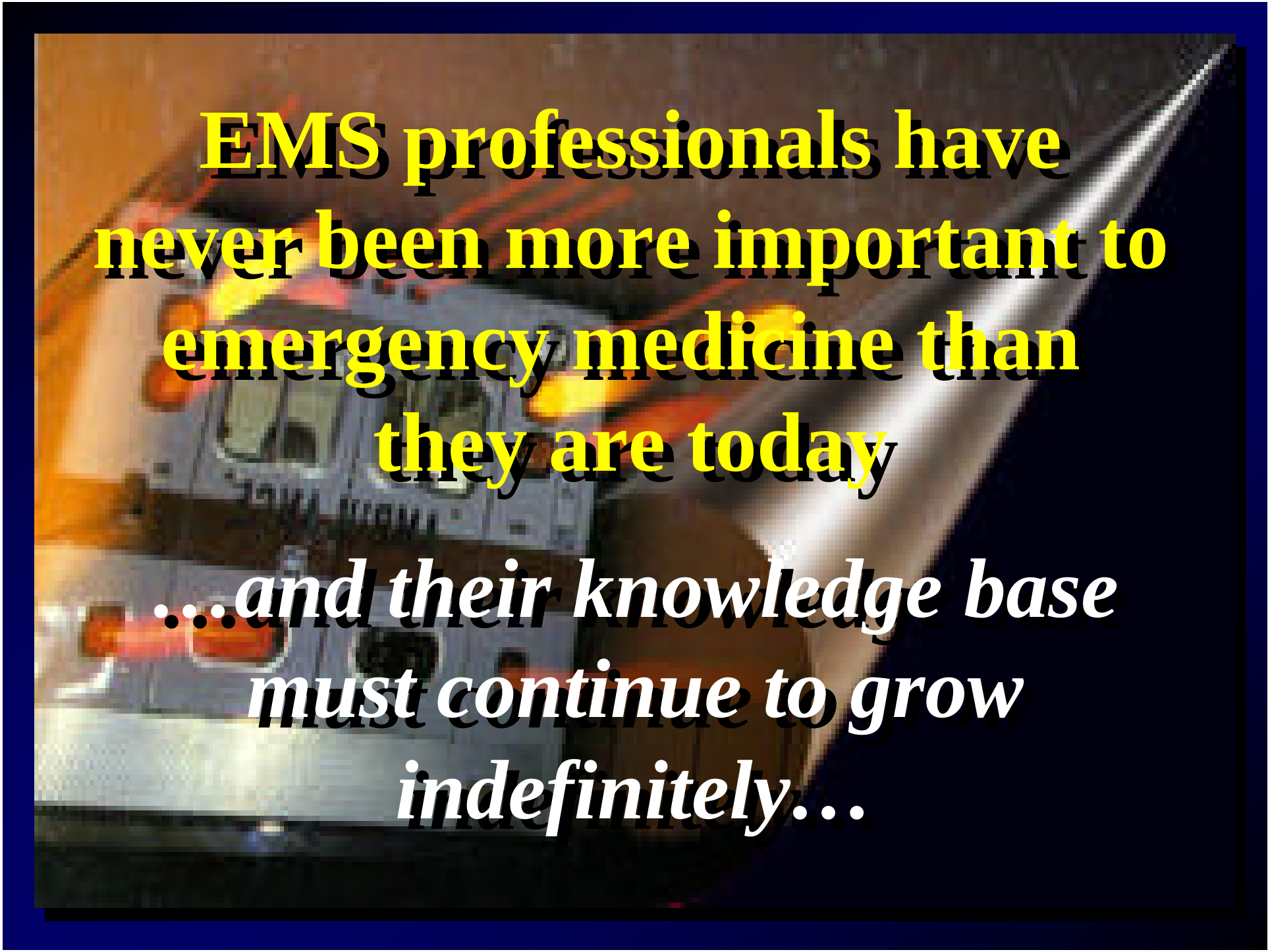
If you have to assist ventilation start with a one hand squeeze at a rate of eight and keep your eye on the Capnography Waveform

…and contact the trauma team…

…and drive fast…

…but not too fast…


Synthesis


EMS professionals have never been more important to emergency medicine than they are today
...and their knowledge base must continue to grow indefinitely…

BP = 88/55
P = 160
Resp = 36
TV = 800
Glu = 425
Hgb = 9

The Medics of the Near Future will be "Out of Hospital Intensivists"


51
503·532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www.utsw.ws


QUESTIONS
and
COMMENTS??