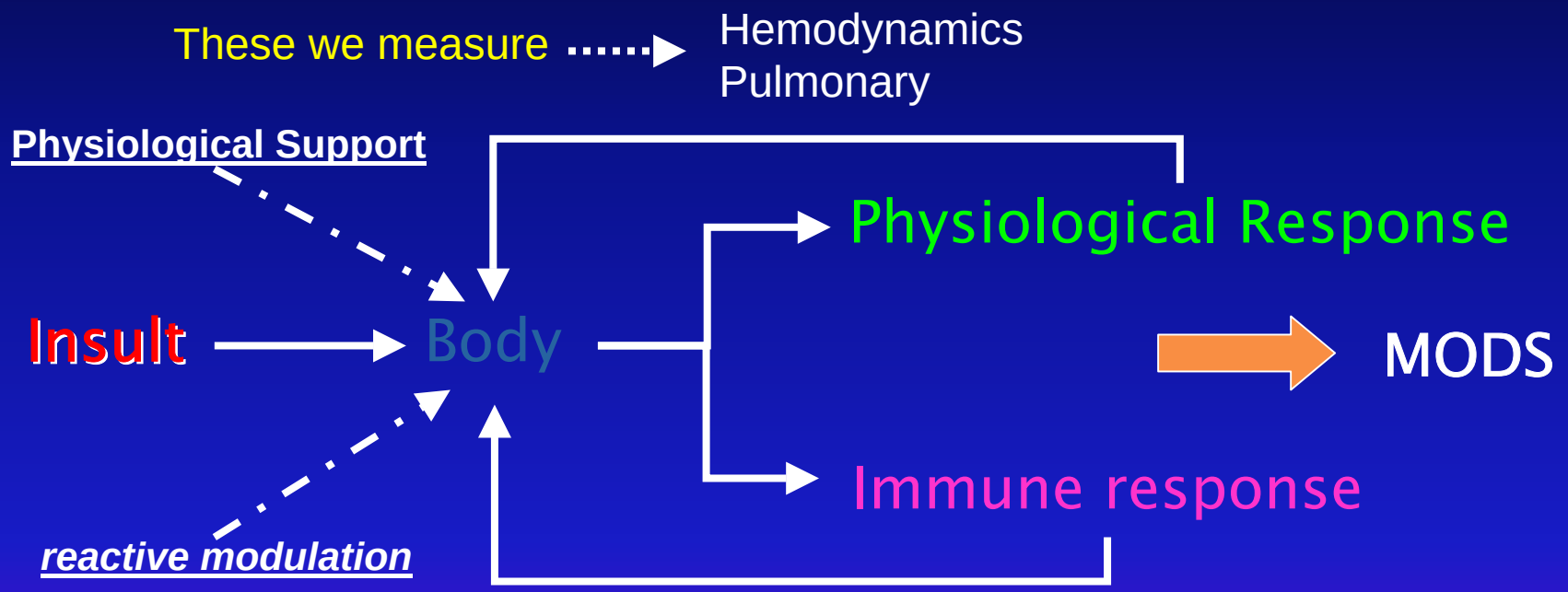
SpO_2

and Pneumothorax detection in field

Elio CARCHIETTI

Trauma Is Not Physiology



THORACIC TRAUMA PATHOPHYSIOLOGY

Hypoxia

- hypovolemia – loss of Hb
- ventilation/perfusion mismatch
- intrathoracic pressure changes

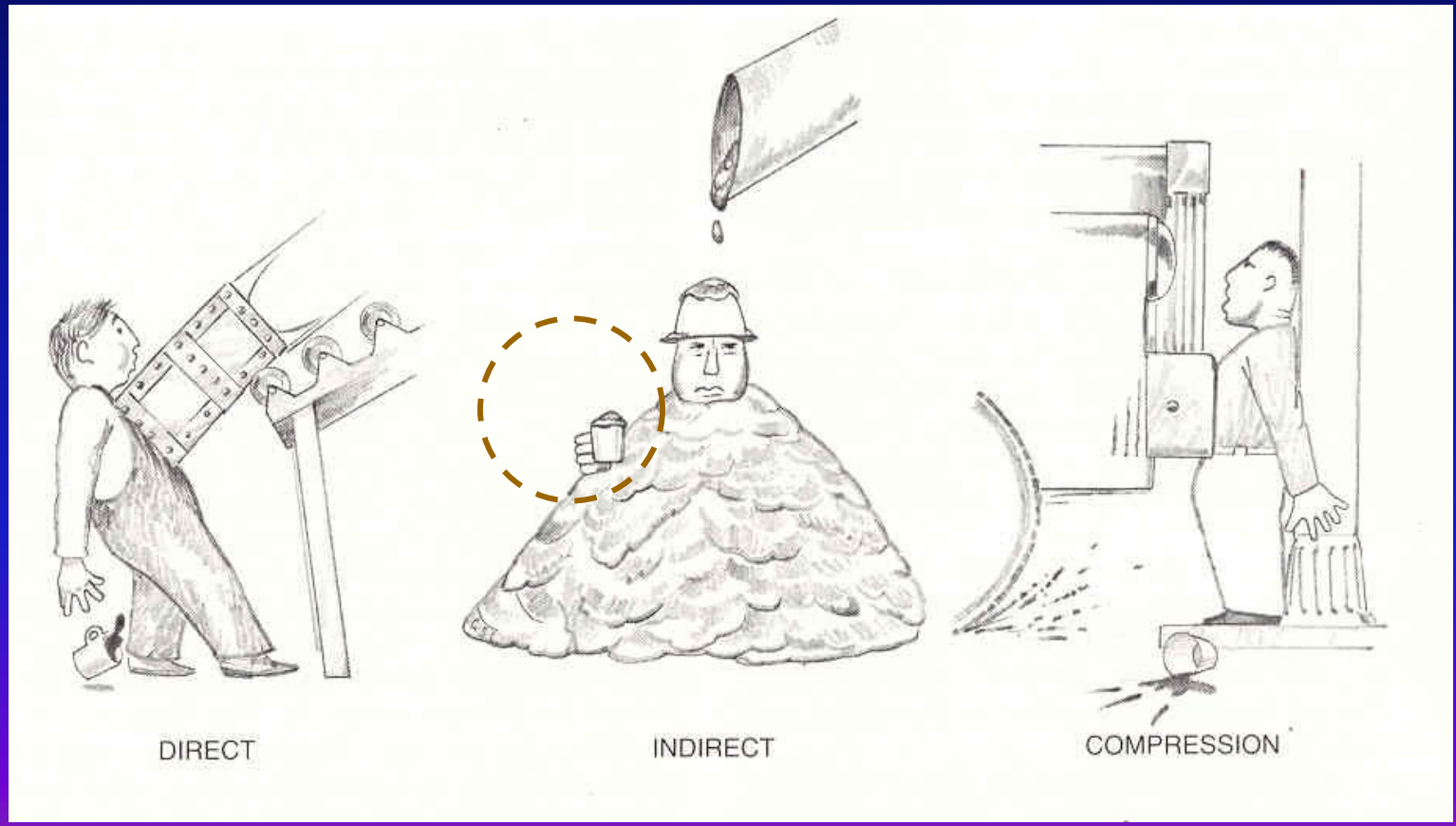
Hypercarbia

- ventilation/perfusion mismatch
- intrathoracic pressure changes

Acidosis

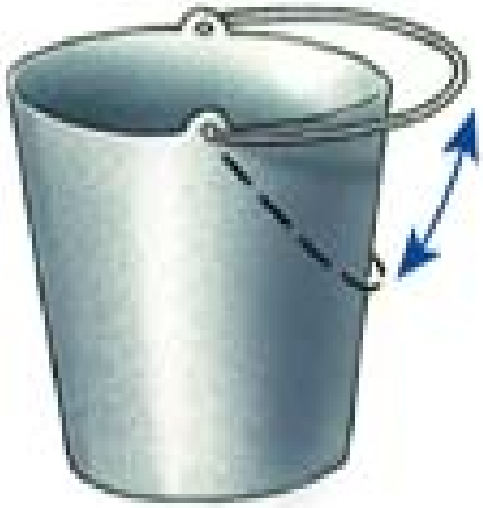
- hypoventilation
- hypercarbia
- hypoperfusion

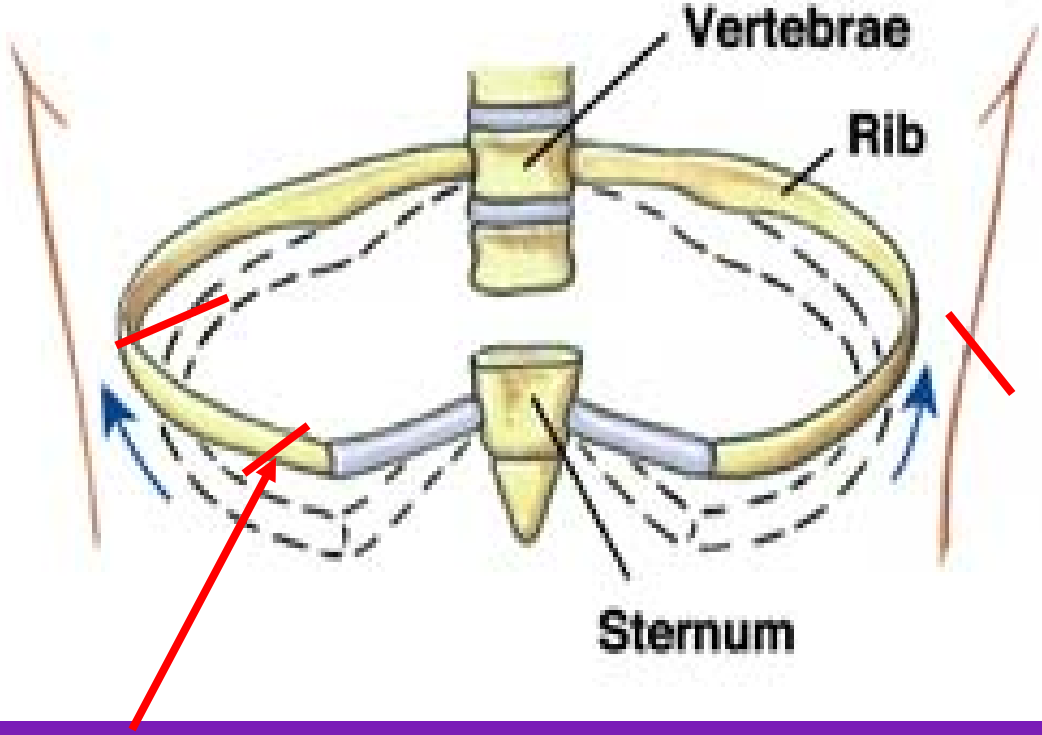
Blunt Chest Trauma



Intercostals

"Bucket handle" motion increases lateral dimension of rib cage





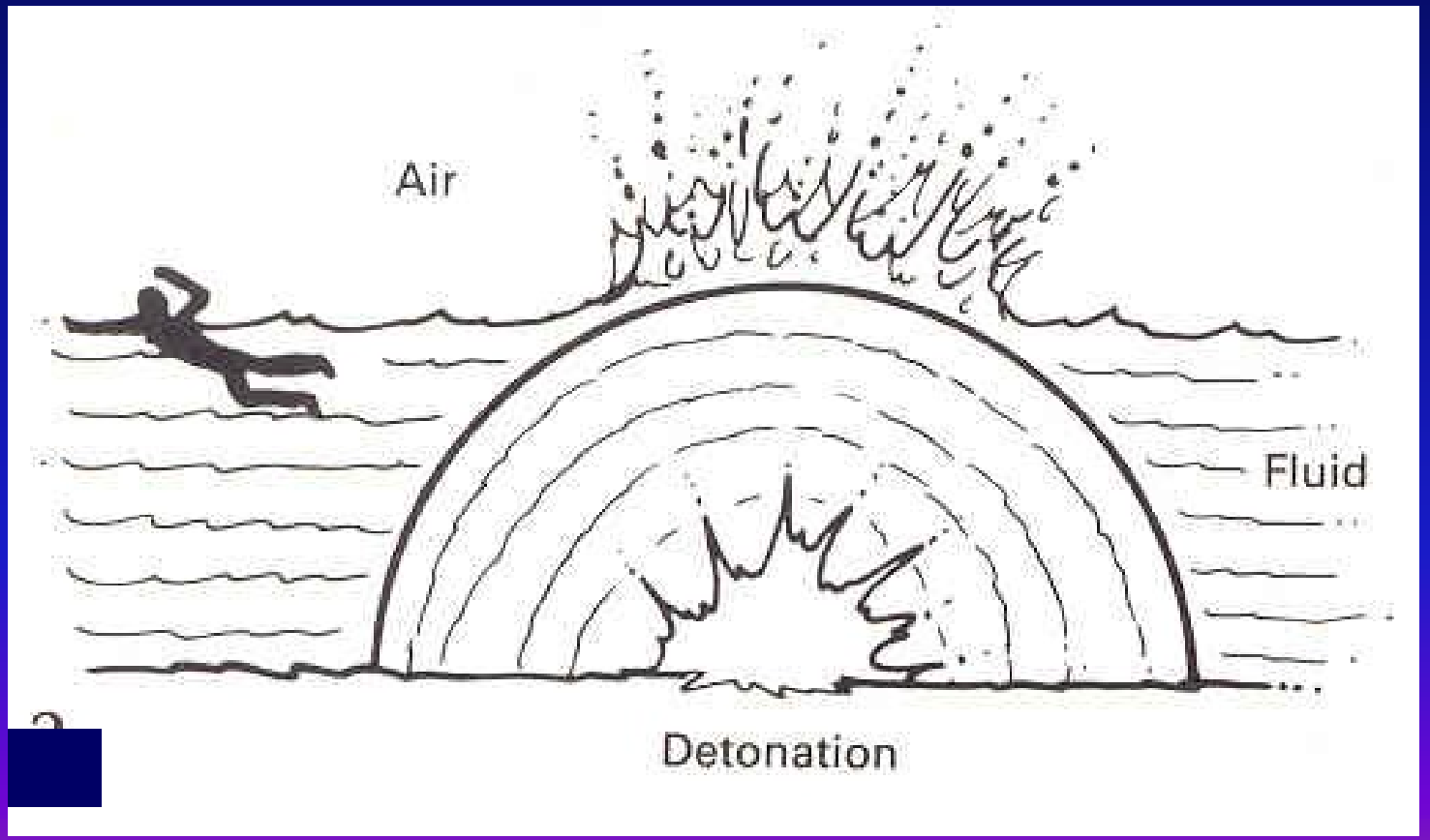
Pathophysiology

- Spalling effect
- Inertial effect
- Implosion effect

Spalling Effect

- Shearing or bursting at gas-liquid interface

‘Spalling’ At Gas-Tissue Interface



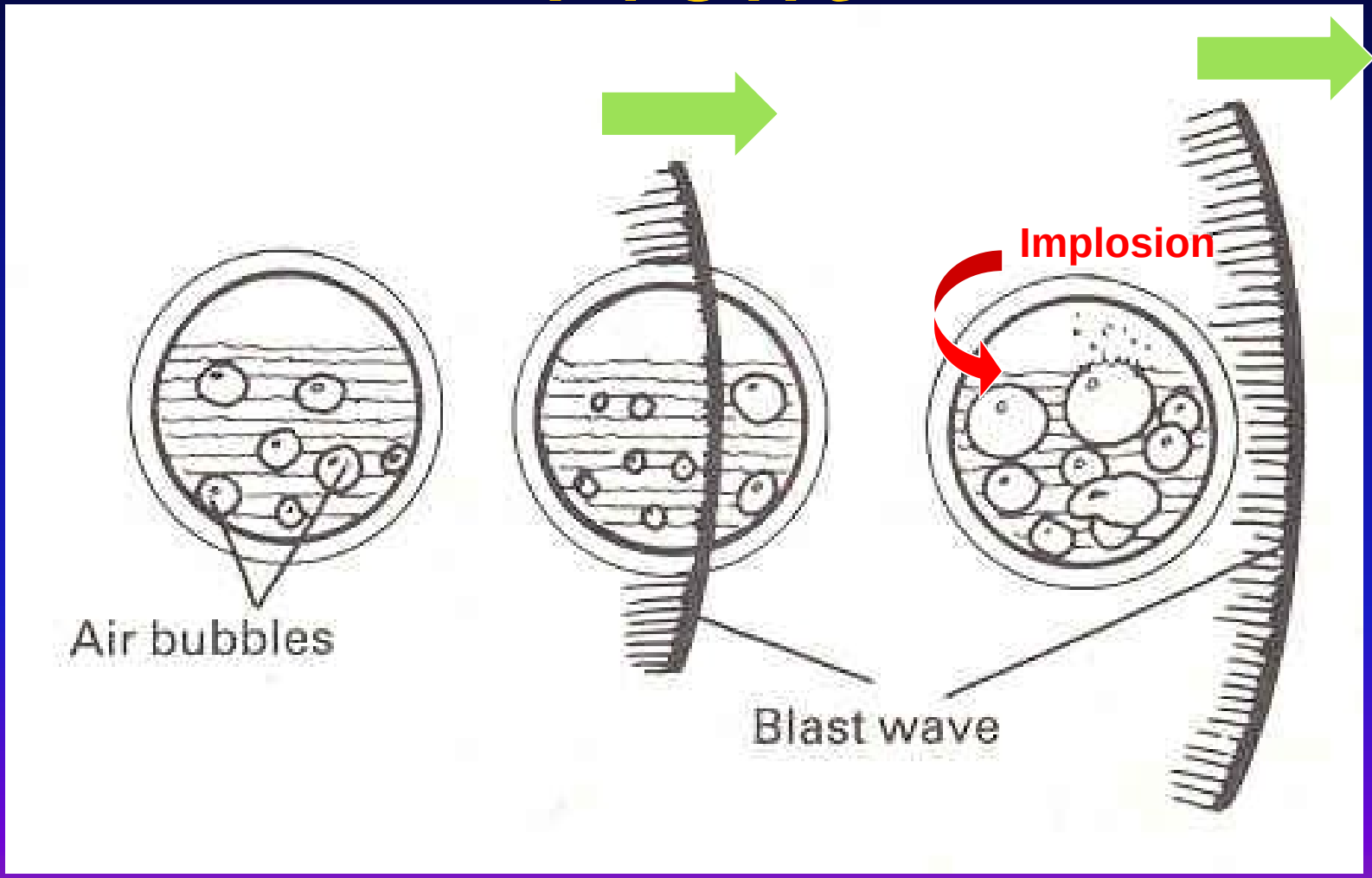
Inertial Effects

- Low density alveolar tissue is stripped from heavier hilar structures as they accelerate or decelerate at different rates.

Implosion Effects

- Rebound expansion or over expansion of gas bubbles after a pressure wave passes.
- There is a vacuum or negative pressure wave after the initial explosion has caused a high positive pressure wave.

Passing Shock Wave Front



Time Line of Events

- Interstitial haemorrhage
- 1-2 h interstitial oedema

SpO_2 Monitoring

- Normal PaO2 is 80-100 mmHg
  - Normally
    - 80-100 mm Hg corresponds to 95-100% SpO2
    - 60 mm Hg corresponds to 90% SpO2
    - 40 mm Hg corresponds to 75% SpO2

Interactive Oxyhemoglobin Dissociation Curve

Severinghaus

1. standard:
T.37°C; pH 7.4; $PaCO_2$ 40 mmHg

2. ipoventilation
T 37°C; pH 7.35; PaCO2 50 mmHg

3. iperventilation
T 37 °C; pH 7.4; $PaCO_2$ 35mmHg

SpO_2	1 PaO_2	$2PaO_2$	$3PaO_2$
90	**57.64**	**60.61**	**54.11**
91	59.86	62.94	56.19
92	62.45	69.40	58.62
93	65.58	72.87	61.56
94	69.46	77.19	65.20
95	**74.53**	**82.82**	**69.96**
96	81.56	90.63	76.56
97	91.44	101.6	85.83

- **Pulse oximetry measures oxygenation not ventilation**
  - Pulse oximetry does NOT indicate the removal of carbon dioxide from the blood!

SpO_2 and the inspired oxygen concentration.

- Assuming a normal oxyhemoglobin dissociation curve,

if

SpO_2=90% (PaO_2=60mmHg), and normal A-a oxygen gradient =15, the alveolar oxygen tension = 75 mmHg (90-15=75)

At barometric pressure = 760mmHg,
water vapor pressure = 47 mmHg,
alveolar air equation as shown in:

$$PAO_2=(O_2 - Wp) \times FiO_2 - 1.25^* \times PACO_2$$
$$PAO_2 = (760-47) \times 0.21 - 1.25 \times PACO_2$$

Assuming $PAO_2 = 75$,
$$PACO_2 = 713 \times 0.21 - 75/1.25 = \underline{59.7 \text{ mmHg}}.$$

***respiratory quotient**

In case of hypoventilation, with FiO_2=0.21, the SpO_2=90% will be reached at a $PaCO_2$ of about 60mmHg.

Oxygen Saturation

Percentage of hemoglobin saturated with oxygen

- Normal SpO2 is 95-98%
- Suspect cellular perfusion compromise if less than 95% SpO2

PROSPECTIVE OBSERVATIONAL STUDY
HEMS FVG-UDINE 2002-2004

55 CONSECUTIVE PATIENTS rTS 9.6 + - 2.7

PNX 91.5% HAEMOTHORAX 5.1%

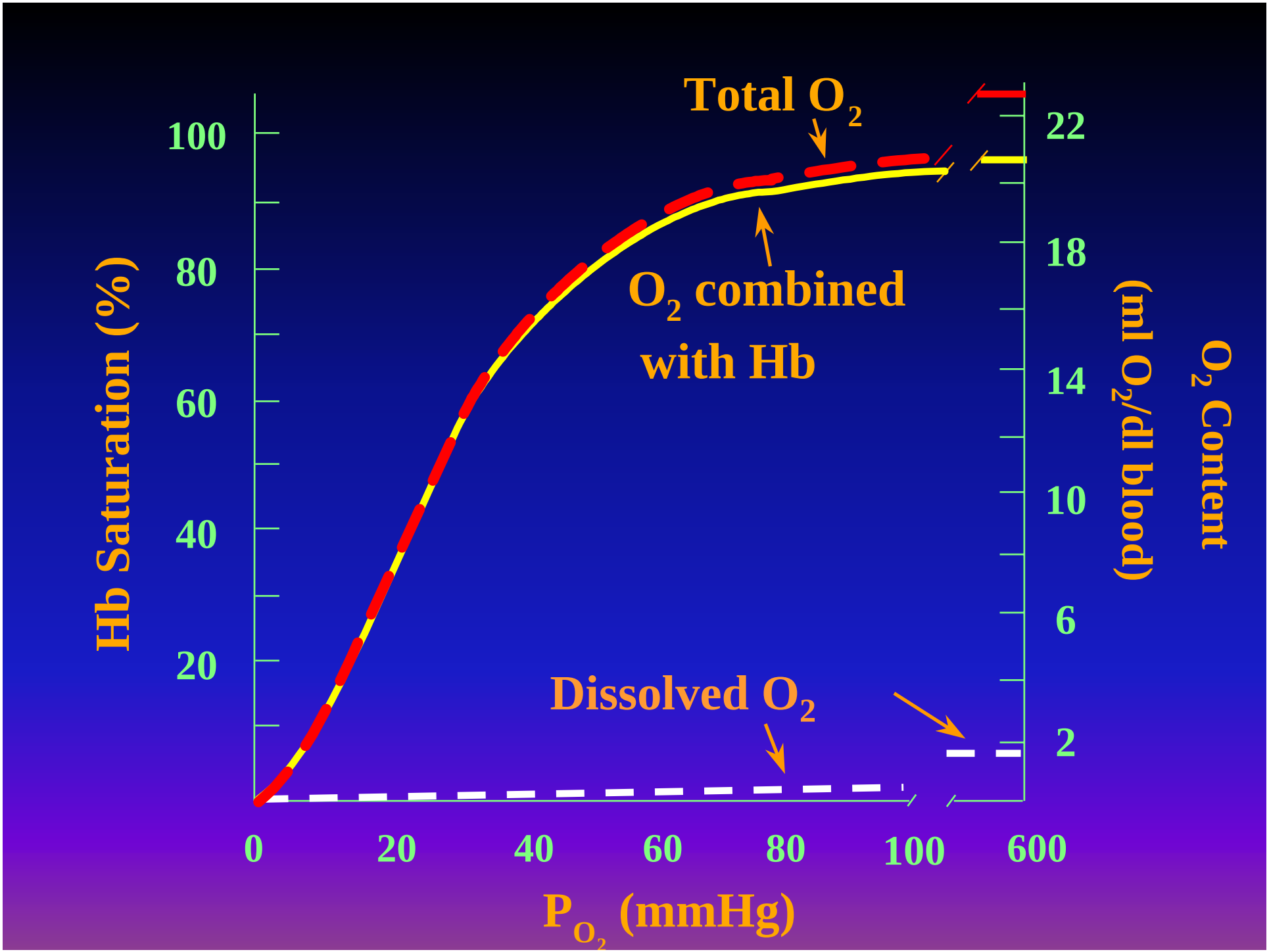
Spo_2 in the field	=< 70%	7.5%	
	=< 80%	28.3%	
	< 90%	11.9%	77.4%
	=< 95%	29.7%	
	> 95%	22.6%	

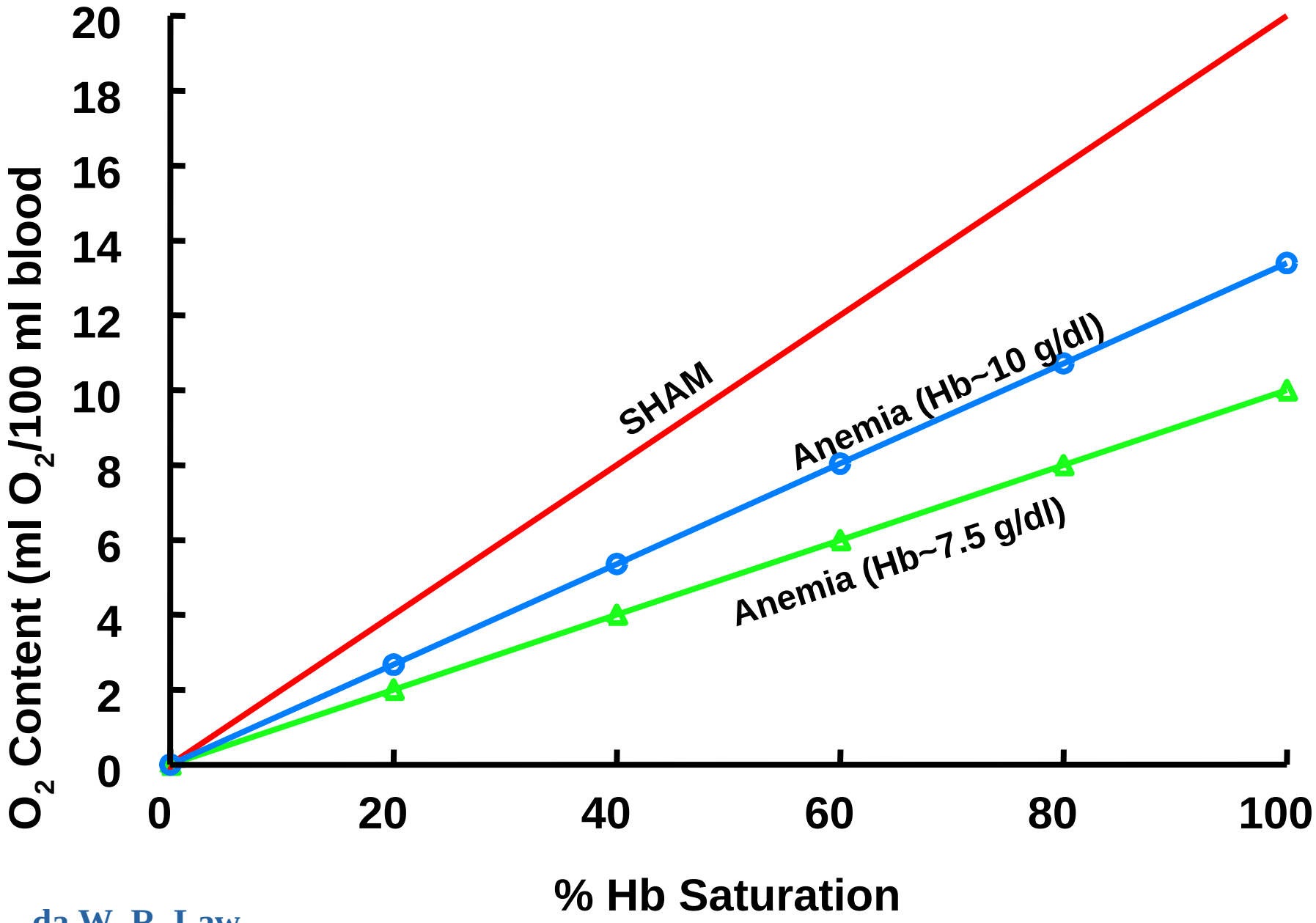
PA sist.<90 mmHg e SpO_2 =<90% nel 32% dei pazienti.

Anemia

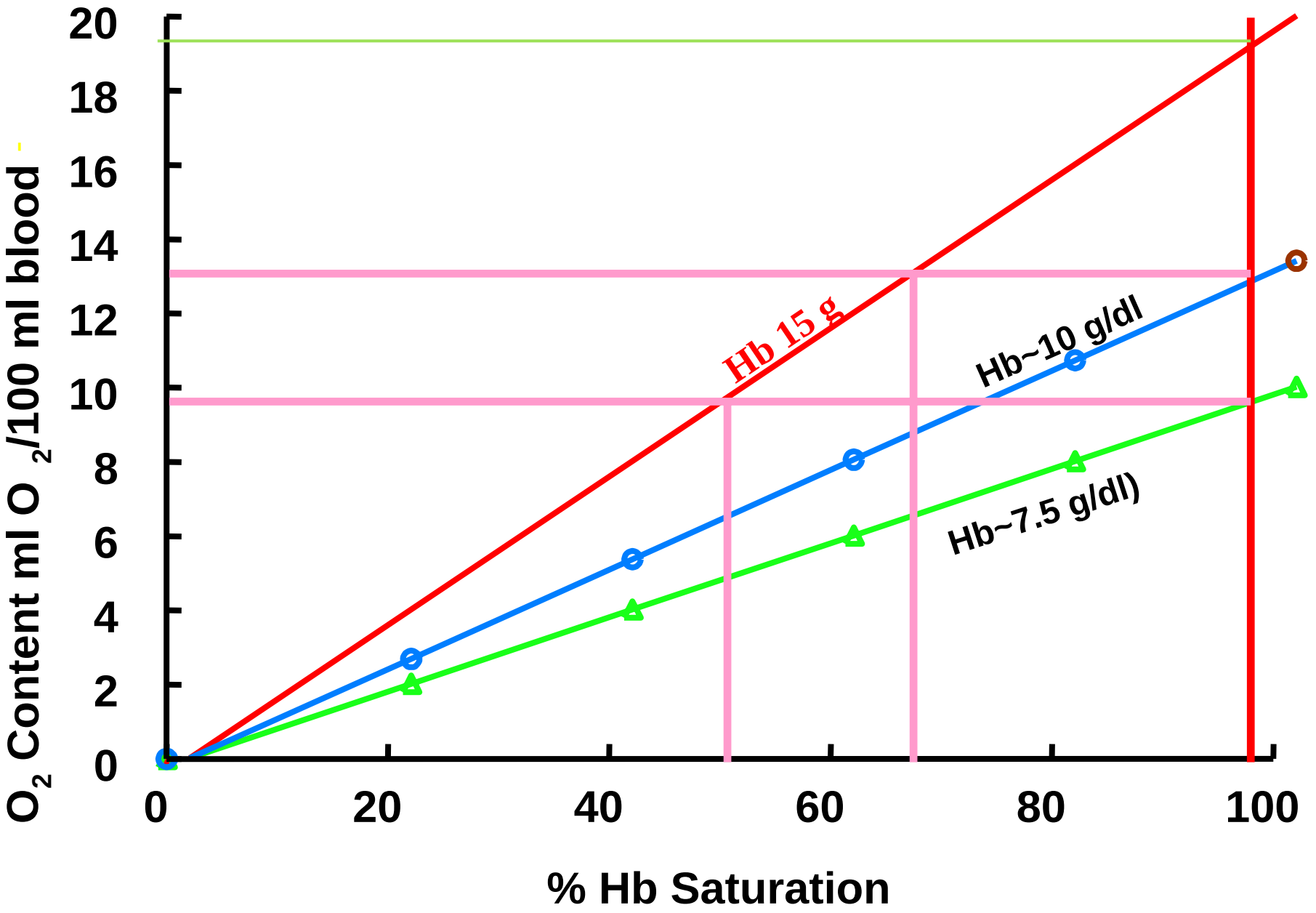
- Normal value of hemoglobin 11-18 g/dl
- Values as low as 5 g/dl may result in 100% SpO2

Anemic patients require high levels of oxygen to compensate for low oxygen carrying capacities!


Total O_2
O_2 combined with Hb
Dissolved O_2
Hb Saturation (%)
100
80
60
40
20
22
18
14
10
6
2
O_2 Content (ml O_2/dl blood)
0
20
40
60
80
100
600
P_{O_2} (mmHg)


20
18
16
14
12
10
8
6
4
2
0
O_2 Content (ml O_2/100 ml blood
0
20
40
60
80
100
% Hb Saturation
SHAM
Anemia (Hb~10 g/dl)
Anemia (Hb~7.5 g/dl)

da W. R. Law


20
18
16
14
12
10
8
6
4
2
0
O_2 Content ml O_2/100 ml blood
0
20
40
60
80
100
% Hb Saturation
Hb 15 g
Hb~10 g/dl
Hb~7.5 g/dl)

Early Symptoms and Signs of tension pnx in awake patients

Universal findings : respiratory distress

Common findings (>50% of cases):

- **ipsilateral decresed air entry**

Inconsistent findings (<25% of cases):

- **Low SpO_2**
- **Hypotension**

Leigh-Smith, Harris Emerg.Med.J. 2005;22:8-16

- **Any amount of supplemental oxygen will completely invalidate the use of the pulse oximeter as a monitor of ventilation.**

Ayas N., Bergstrom L.R.,Schwab T.R., Narr B.J.

Mayo Clinic Proceedings. 1998

Problem

Inadequate Information Compromises Quality of Care