SHOCK

…and the Trauma Victim

JP Pretorius
Department of Surgery & SICU
Steve Biko Academic Hospital.

Classification of Shock

- **Cardiogenic -** Myopathic Arrythmic Mechanical
- **Hypovolaemic -** Haemorrhagic Non-haemorrhagic Traumatic
- **Distributive -** Septic Neurogenic Adrenal crisis Anaphylactic
- **Obstructive -** Massive Pulmonary embolism
  Cardiac tamponade
  Tension pneumothorax
  Constrictive pericarditis

Classification of Shock

	Cardiac output	Filling pressures	Vascular resistance	SvO2 SvcO2
Cardiogenic	↓	↑	↑	↓
Hypovolaemic	↓	↓	↑	↓
Distributive	↑ or N	↓ or N	↓	↑ or N
Obstructive	↓	↑	↑	↓

Pathophysiology

The Basic Pathophysiologic Problem

⇩

inadequate / reduced oxygen delivery (DO_2)
inadequate / reduced oxygen consumption (VO_2)

Results in

⇩

tissue hypoxia
limitation of body metabolism
cumulative oxygen debts

Leads to

⇩

disturbed organ function (= multi organ failure)
compromised survival

Pathophysiology

Reasons For Limitation of Oxygen Consumption (VO_2)

- reduced / low blood flow
- reduced oxygen supply
- reduced tissue perfusion

Produced By

- trauma
- severe surgical operations
- anaesthetic agents
- sepsis
- metabolic disorders

Results In

- development of shock syndromes
- reduced survival rate

Essential Components for the Diagnosis of Shock

Quantitative criteria

↓ BP: <90 mm Hg systolic BP, or a fall of 30–40 mm Hg from previously recorded levels

Evidence of low perfusion

↓ Cerebral blood flow → obtundation/restlessness
↓ Renal blood flow → oliguria
↓ Peripheral blood flow → cool mottled periphery (except in septic shock)

Case Report – Mr B. Sethole

- 22 year old man
- Sustained GSW in peripheral town
- Taken to local hospital
- Patient in shock 90/60
- ? Definition of shock
- Hemothorax diagnosed
- ICD placed – drained 2 litres blood

Case Report – Mr B. Sethole

- Resuscitation started
- 500 ml Voluven
- 1 litre saline
- ? Fluid resuscitation in hypovolemic traumatic shock
- Referral to cardio – thoracic and general surgery departments
- ?Transfer procedures

Questions arise:

- How much to give ?
- What to give ?
- Where does the fluid go (end up) ?
- What are the consequences or results ?

Interesting Conundrum……

In fluid resuscitation:

- **Too little is no good**

BUT…..

- **Too much is no good either**

Adverse outcomes may be associated with inadequate or excessive fluid administration.

Inadequate Fluid Administration:

- Reduced effective circulating volume
- Divert blood flow toward vital organs (brain & heart)
- Vasoconstriction in skin, gut, kidneys
- Result in activation of the inflammatory response syndrome
- Lead to organ dysfunction.

Excessive fluid administration:

- Excess intravascular fluid -> increased venous pressure -> leakage into interstitial space.
- Pulmonary and peripheral edema compromise tissue oxygenation
- Impaired GIT functional tolerance of enteral nutrition
- Increased potential for bacterial translocation
- Development of MODS

How should fluid be administered?

CURRENT OPINION:

- **PAST:**

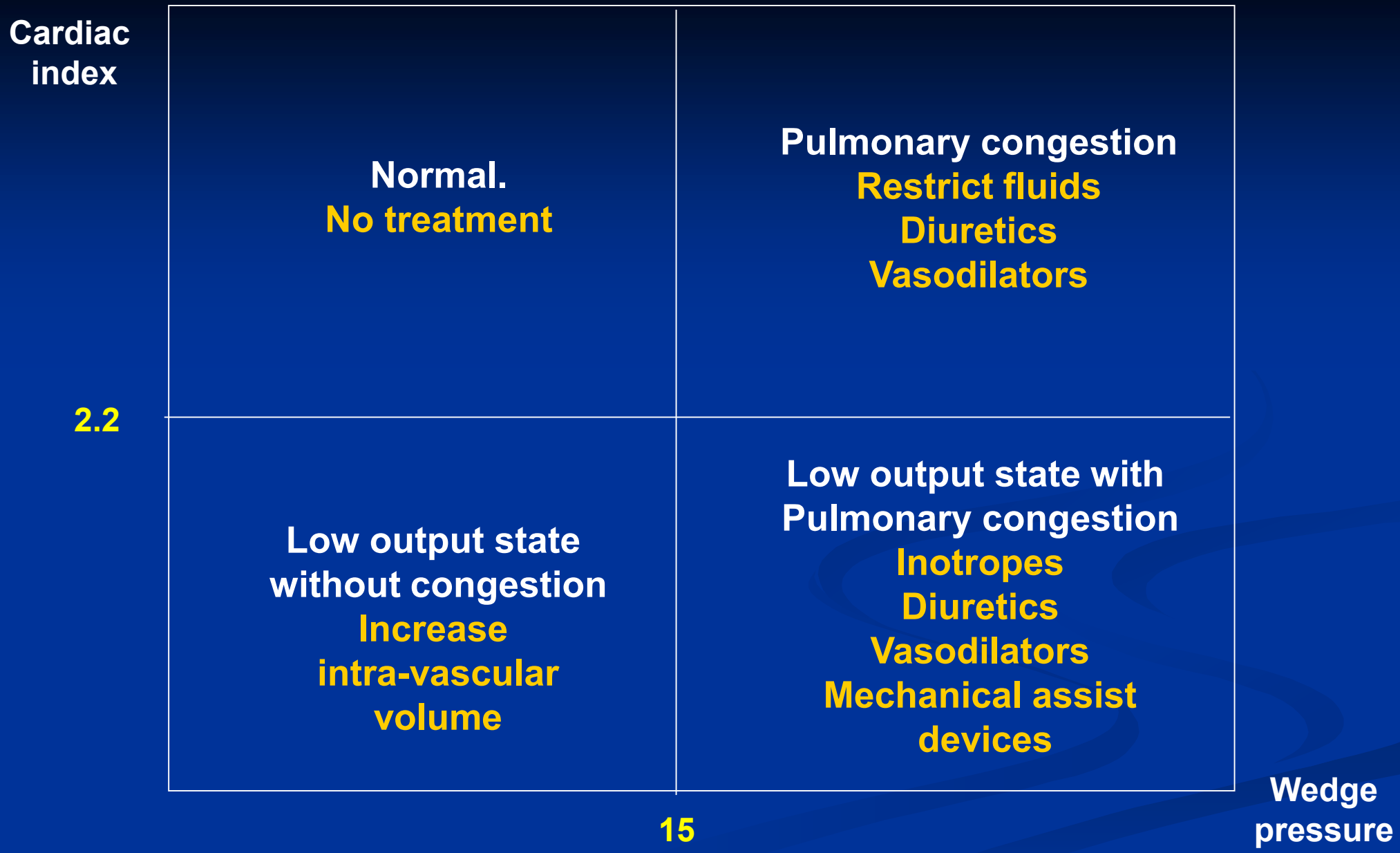
  Fluids were administered without adequate monitoring to guide dosage (volume) and this might have resulted in adverse outcomes relating to either inadequate or excess fluid administration.

- **FUTURE:**

  Strategies of fluid administration by titration of dosage (volume) to rational physiological endpoints by using appropriate monitoring can improve clinical outcome.

- **Adverse outcomes may be associated with inadequate OR excessive fluid administration.**

Grocott et al Anesth Analg 2005: 100: 1093-106



Therapeutic modalities indicated for various subsets of patients

How should fluid be administered?

CURRENT OPINION:

- **There is evidence supporting the hypothesis that improving tissue perfusion may result in reduced inflammatory activation and hence, organ dysfunction.**

- **Conversely, excessive administration of fluid may result in adverse effects:**
  - **Increased pressure in the venous circulation results in loss of fluid into the interstitial space**
  - **Pulmonary and peripheral edema develop compromising local and/or systemic tissue oxygenation**

How should fluid be administered?

CURRENT OPINION:

- There is evidence that intestinal oedema is associated with:
  - Impaired GIT function tolerance for enteral nutrition
  - An increased potential for bacterial translocation
  - Development of multiple organ dysfunction syndrome
- The balance between inadequate fluid resuscitation and decreased tissue perfusion and excess fluid with edema formation will vary for specific types of surgery
- The degree of injury and the time exposed to stress must play an important role in the patient's response to treatment and edema resulting from resuscitative efforts

Grocott et al Anesth Analg 2005: 100: 1093-106

How should fluid be administered?

CURRENT OPINION:

- **It is therefore important to distinguish between different types of surgery, patients' conditions, and factors contributing to hypovolaemia to balance the risk of tissue hypoperfusion and of pulmonary and peripheral edema.**
- **Endpoints should:**
  - **Result in avoidance of under use of fluid therapy resulting in covert hypovolaemia with inadequate tissue perfusion**
  - **Result in prevention of administration of excess fluid to avoid pulmonary and peripheral edema**

Grocott et al Anesth Analg 2005: 100: 1093-106

04:00 – 07:00

- On arrival BP 126/68 Pulse 102
- ICD in situ
- GSW – entrance T5 Left posterior axillary line
  - exit T6 Left mid clavicular line
- ? Surgical assessment of this scenario
- ? Pre – op investigation and preparation

04:00 – 07:00

09.2.2009 03:24
Serial number : 7147
Instrument ID : E4 RESUS 2
Operator :
40329055

1

Last Name
Pat. ID

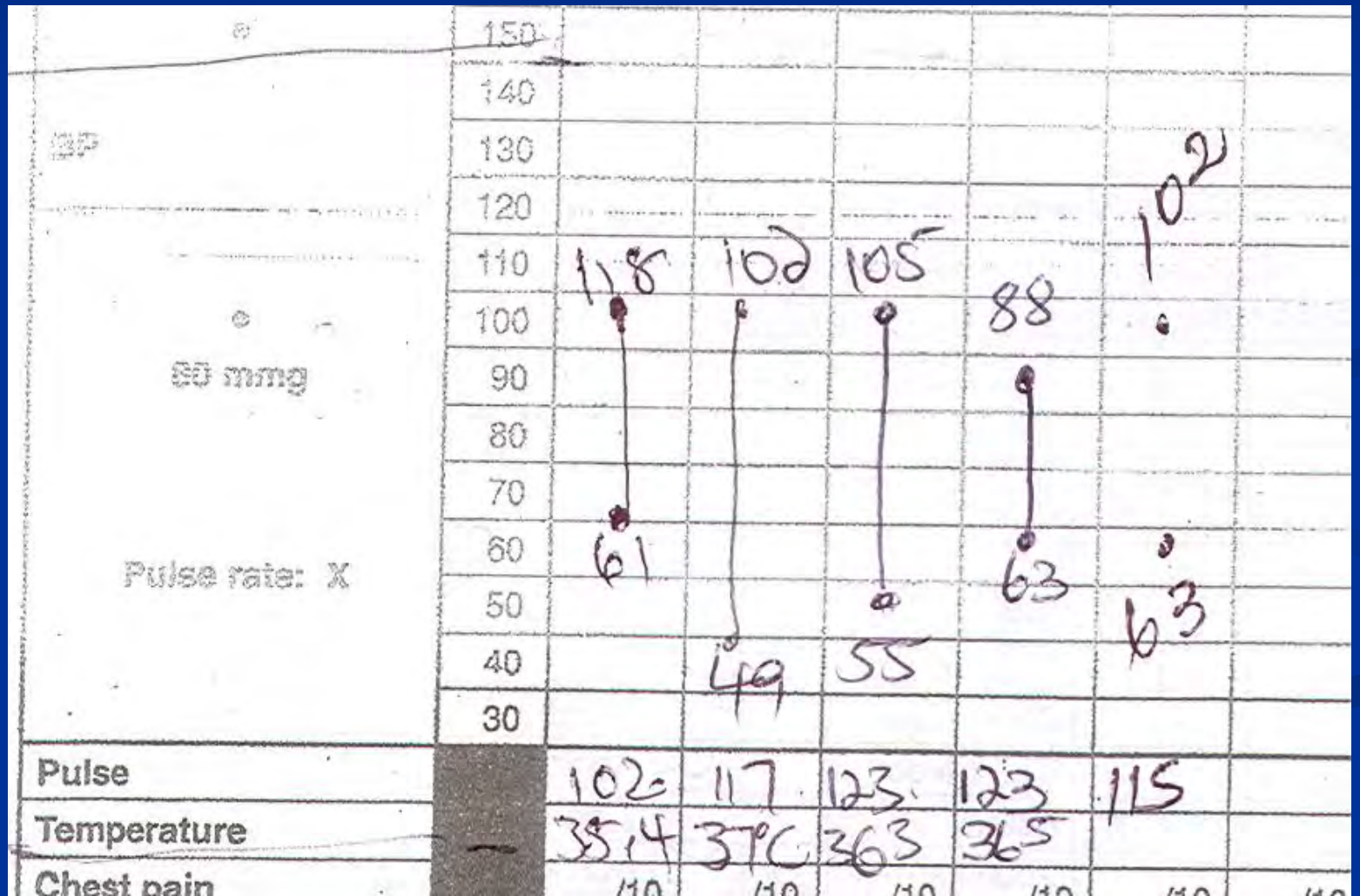
FIO_2	0.21	
Temperature	37.0 °C	
Blood type	Unknown	
pH	7.431	[7.350 - 7.450]
PO_2	89.4 mmHg	[80.0 - 100.0]
PCO_2	29.5 mmHg (-)	[35.0 - 45.0]
pH^t	7.431	
PO_2^t	89.4 mmHg	
PCO_2^t	29.5 mmHg	
K^+	5.03 mmol/L (+)	[3.50 - 4.50]
Na^+	139.0 mmol/L	[135.0 - 148.0]
Ca^{2+}	1.123 mmol/L	[1.120 - 1.320]
Cl^-	Not calibrated	[98.0 - 107.0]
tHb	10.7 g/dL (-)	[11.5 - 17.4]
Hct	32.6 % (-)	[35.0 - 50.0]
COHb	2.7 % (+)	[0.5 - 2.5]
MetHb	1.0 %	[0.4 - 1.5]
SO_2	97.1 %	[75.0 - 99.0]
$AaDO_2$	Invalid blood type	
P/F ratio	425.6 mmHg	
Qs/Qt	Missing data	
Glu	7.3 mmol/L (+)	[3.3 - 6.1]
Lac	Not calibrated	[0.4 - 2.2]
BE	-4.2 mmol/L	
$cHCO_{3\ st}^-$	21.0 mmol/L	

04:00 – 07:00

- Equal good air entry bilaterally
- Still bleeding from ICD – 400ml
- ? Interpretation
- Gastric contents in ICD
- Abdomen – board - like rigidity
- X – ray confirmed: both lungs expanded
- ? Antibiotic therapy

07:00 – 12:00

- Patient received – 1 litre ringers lactate
  - 1 litre colloid (2 units Haemacell)
  - 1 litre saline



07:00- 12:00

- 4 Units blood ordered - not yet given
- ? Blood component therapy in trauma

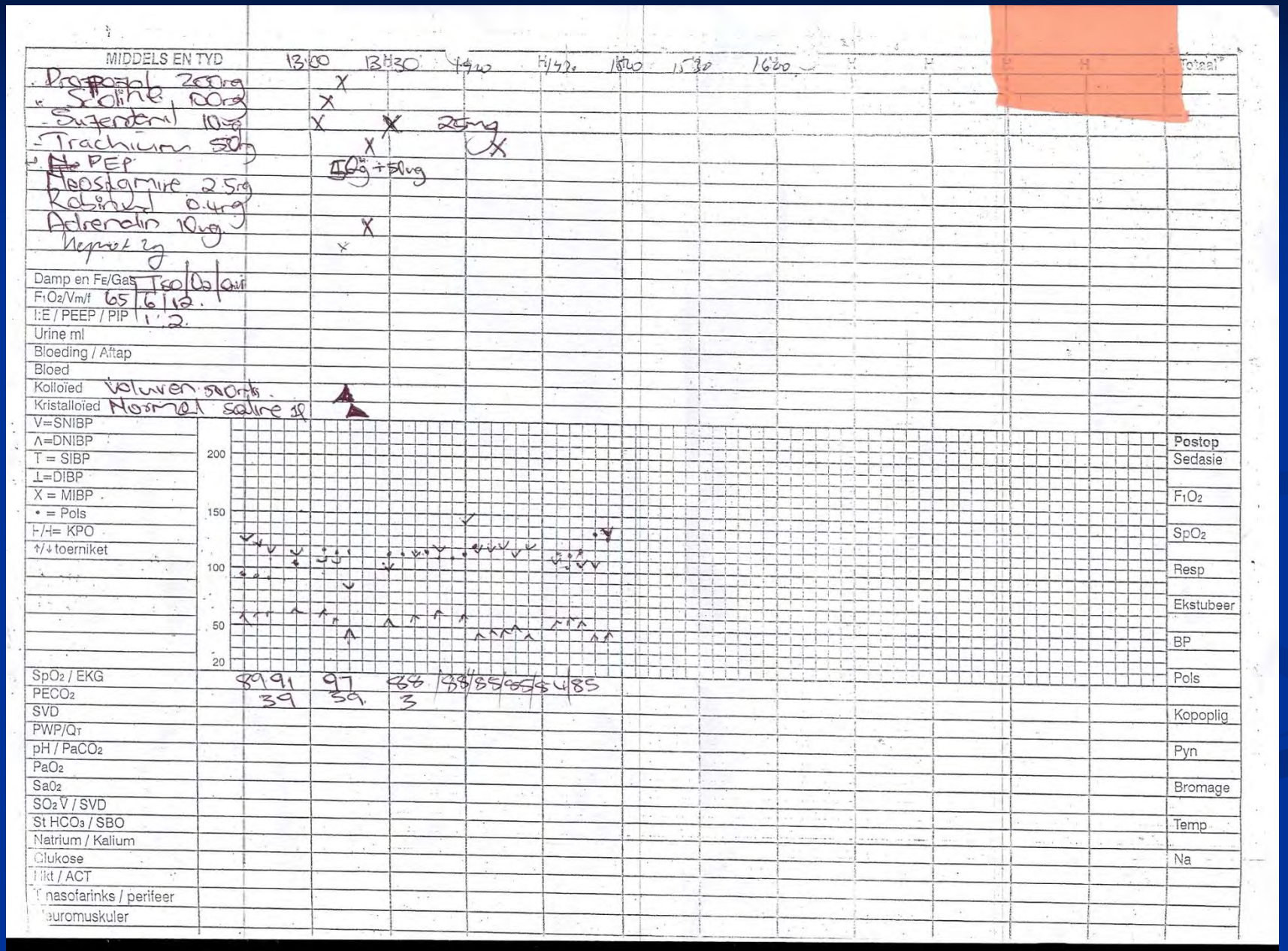
Theatre

- Penetrating injury of L diaphragm
- Tangential injury of stomach
- Splenic injury
- Gastric content in chest
- Broncho-pleural fistula
- ? Operative objectives

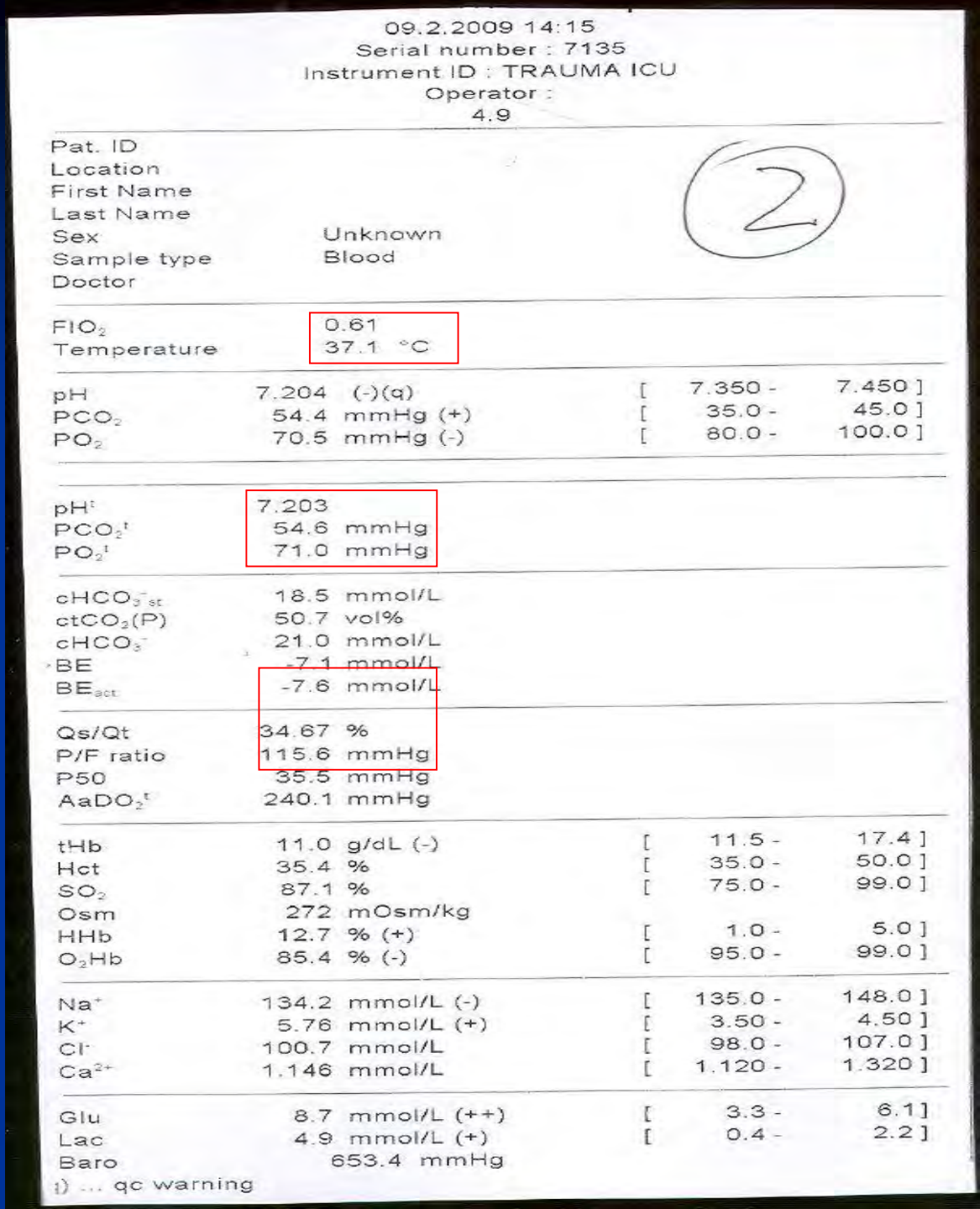
Theatre

- Chest rinsed out
- New ICD placed
- Cardio thoracic surgeon in theatre – advised conservative treatment for broncho – pleural fistula
- Splenectomy done
- Stomach repaired
- Abdomen rinsed

Anaesthetic



Bloodgas after theatre



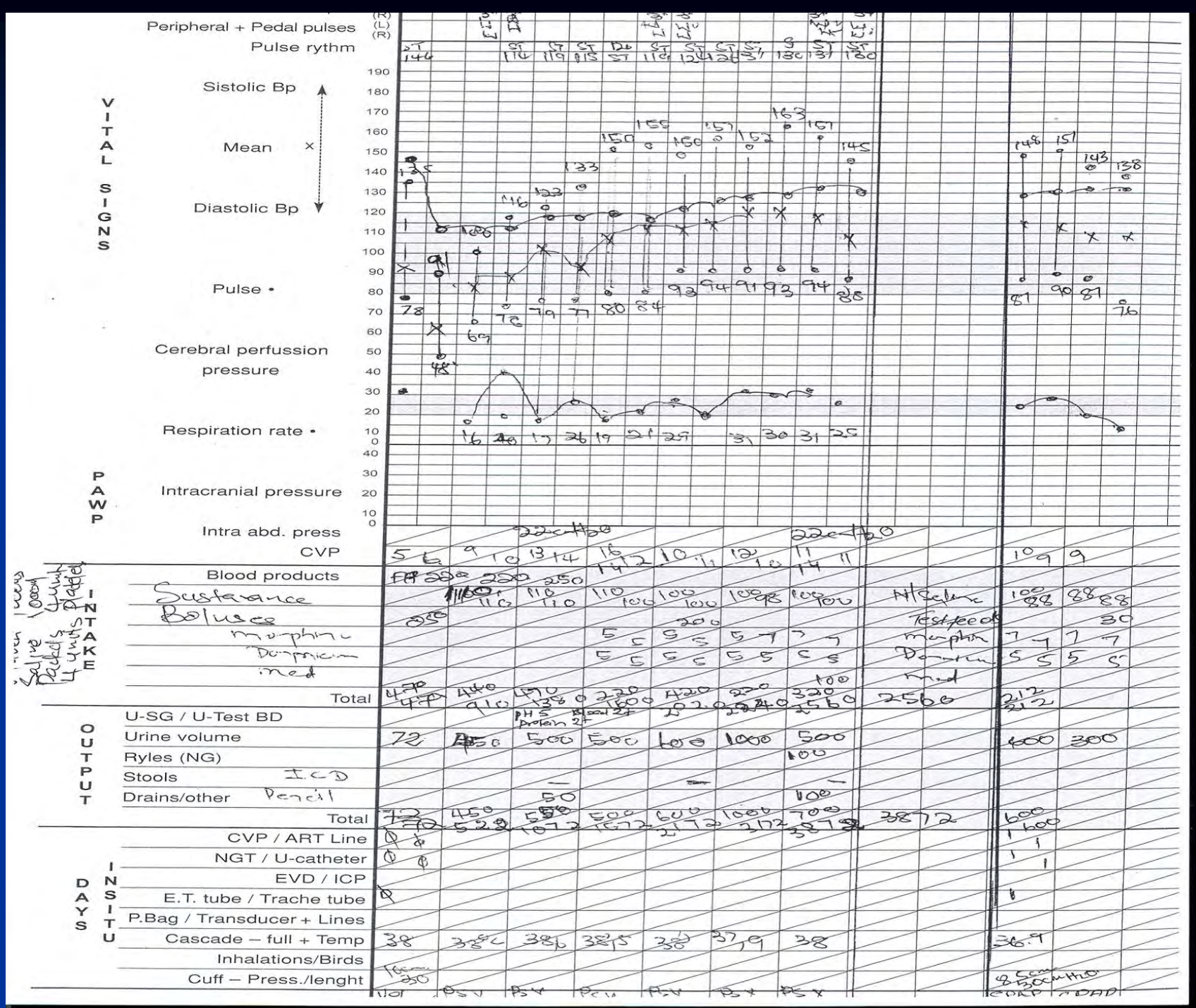
09.2.2009 14:15
Serial number : 7135
Instrument ID : TRAUMA ICU
Operator :
4.9

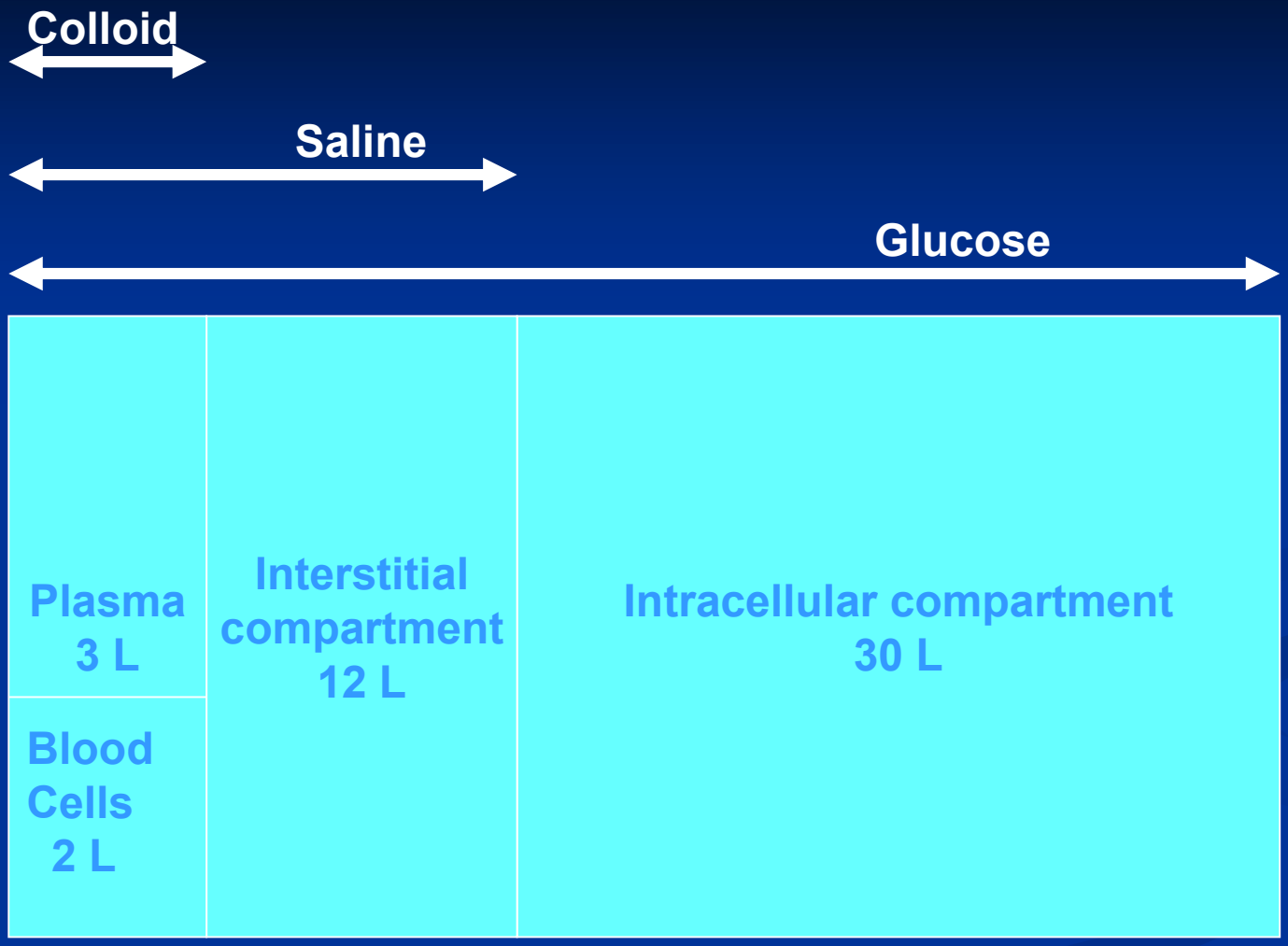
2

Pat. ID			
Location			
First Name			
Last Name			
Sex	Unknown		
Sample type	Blood		
Doctor			
FIO_2	0.61		
Temperature	37.1 °C		
pH	7.204 (-)(q)	[7.350 -	7.450]
PCO_2	54.4 mmHg (+)	[35.0 -	45.0]
PO_2	70.5 mmHg (-)	[80.0 -	100.0]
pH^t	7.203		
PCO_2^t	54.6 mmHg		
PO_2^t	71.0 mmHg		
$cHCO_3^-{}_{st}$	18.5 mmol/L		
$ctCO_2(P)$	50.7 vol%		
$cHCO_3^-$	21.0 mmol/L		
BE	-7.1 mmol/L		
BE_{act}	-7.6 mmol/L		
Qs/Qt	34.67 %		
P/F ratio	115.6 mmHg		
P50	35.5 mmHg		
$AaDO_2^t$	240.1 mmHg		
tHb	11.0 g/dL (-)	[11.5 -	17.4]
Hct	35.4 %	[35.0 -	50.0]
SO_2	87.1 %	[75.0 -	99.0]
Osm	272 mOsm/kg		
HHb	12.7 % (+)	[1.0 -	5.0]
O_2Hb	85.4 % (-)	[95.0 -	99.0]
Na^+	134.2 mmol/L (-)	[135.0 -	148.0]
K^+	5.76 mmol/L (+)	[3.50 -	4.50]
Cl^-	100.7 mmol/L	[98.0 -	107.0]
Ca^{2+}	1.146 mmol/L	[1.120 -	1.320]
Glu	8.7 mmol/L (++)	[3.3 -	6.1]
Lac	4.9 mmol/L (+)	[0.4 -	2.2]
Baro	653.4 mmHg		

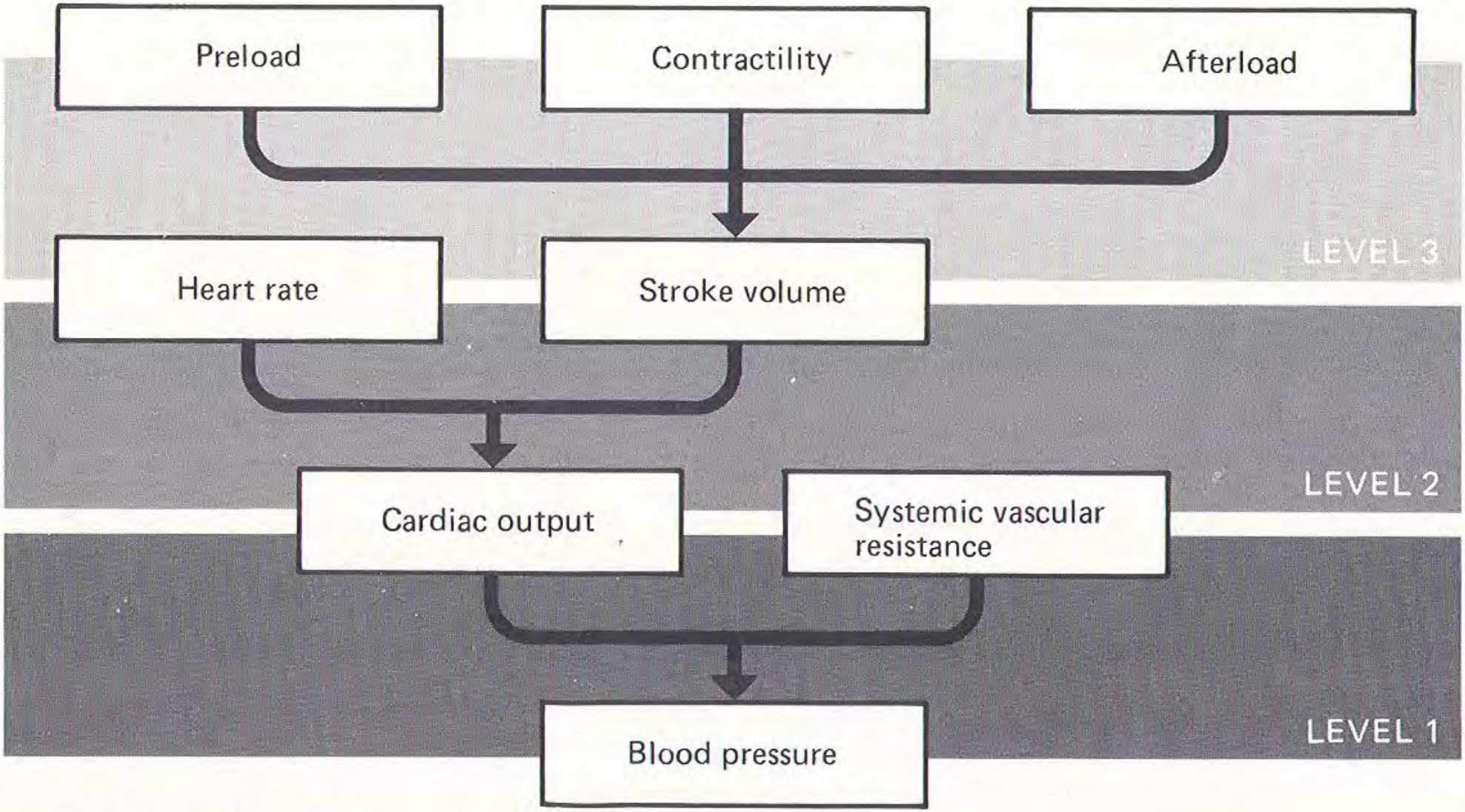
t) ... qc warning

ICU


Peripheral + Pedal pulses (R) (L) (R)
Pulse rythm
VITAL SIGNS
Sistolic Bp
Mean
Diastolic Bp
Pulse
Cerebral perfussion pressure
Respiration rate
PAWP
Intracranial pressure
Intra abd. press
CVP
INTAKE
Blood products
Substance
Bolus
morphine
Dompicum
med
Total
OUTPUT
U-SG / U-Test BD
Urine volume
Ryles (NG)
Stools
Drains/other
Total
DAYS INSITU
CVP / ART Line
NGT / U-catheter
EVD / ICP
E.T. tube / Trache tube
P.Bag / Transducer + Lines
Cascade – full + Temp
Inhalations/Birds
Cuff – Press./lenght

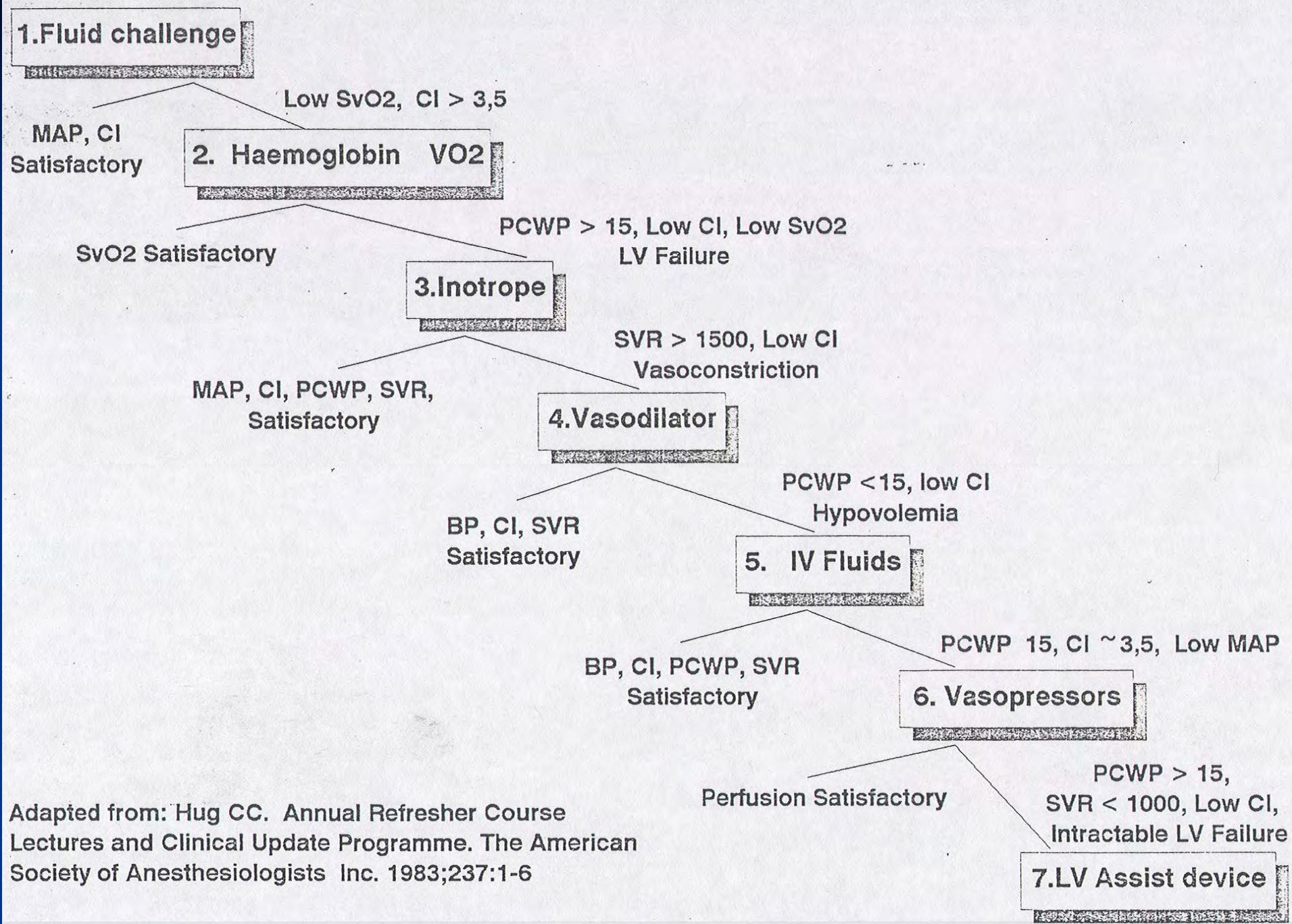


Model for volumes of distribution of isotonic colloid, saline and glucose solutions in a 75kg patient.



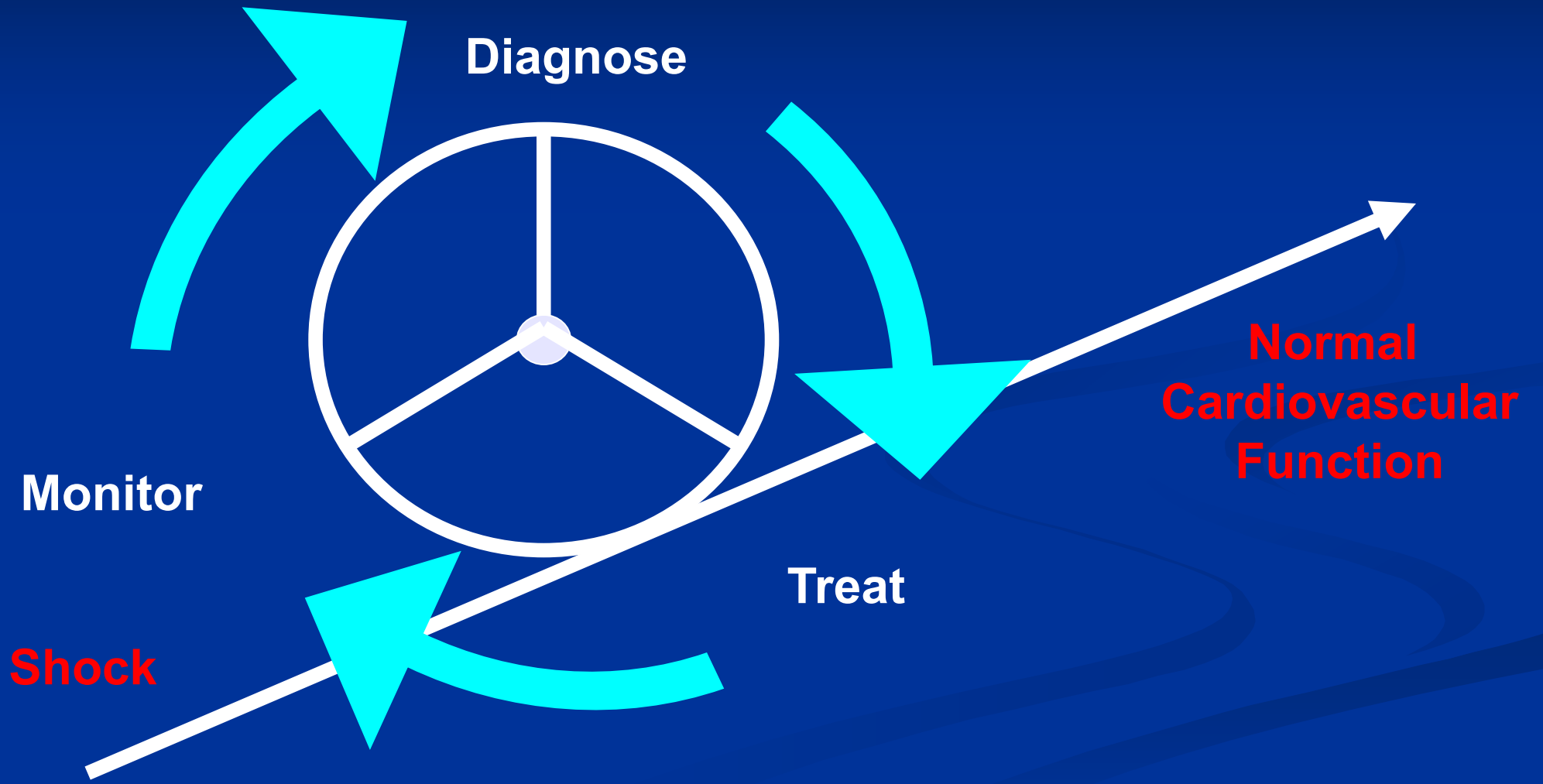
Regulation of blood pressure.

GENERAL APPROACH FOR MANAGEMENT OF LOW PERFUSION STATES



Adapted from: Hug CC. Annual Refresher Course Lectures and Clinical Update Programme. The American Society of Anesthesiologists Inc. 1983;237:1-6

The wheel of successful Haemodynamic Resuscitation



Monitoring

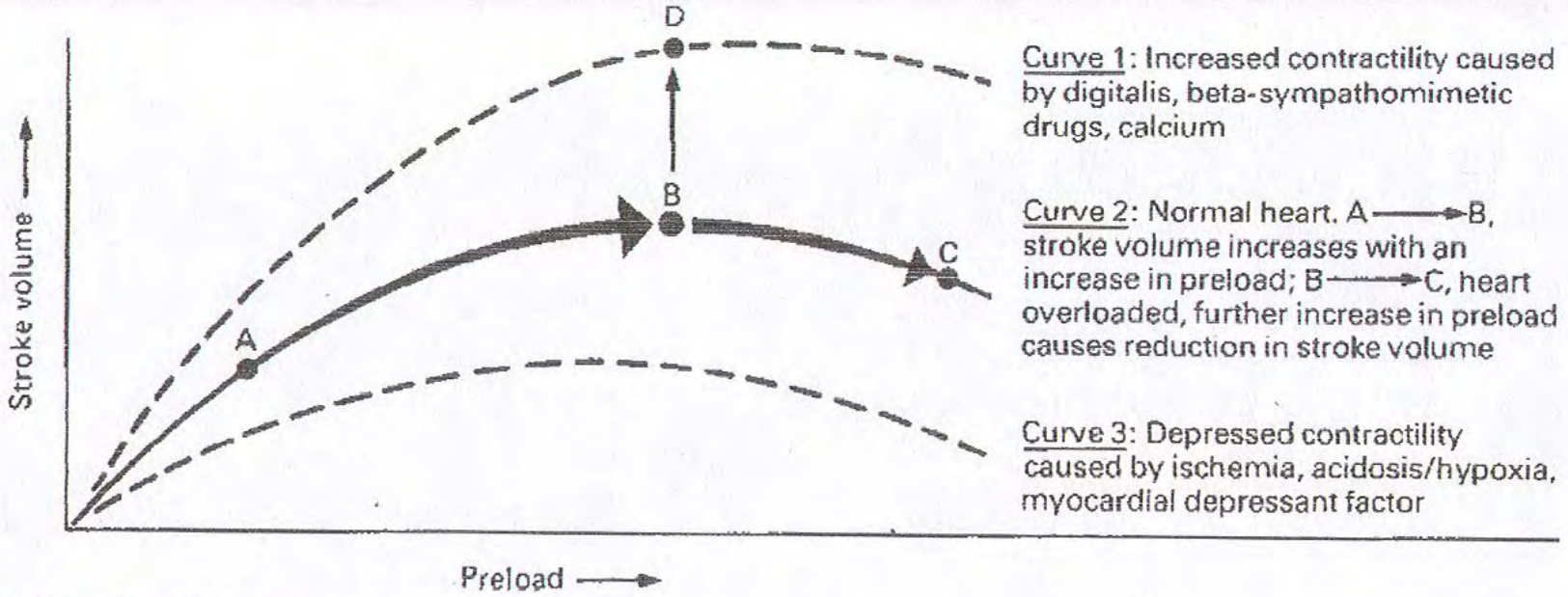


Figure 5.2. The Frank-Starling curve and contractility.

Monitoring

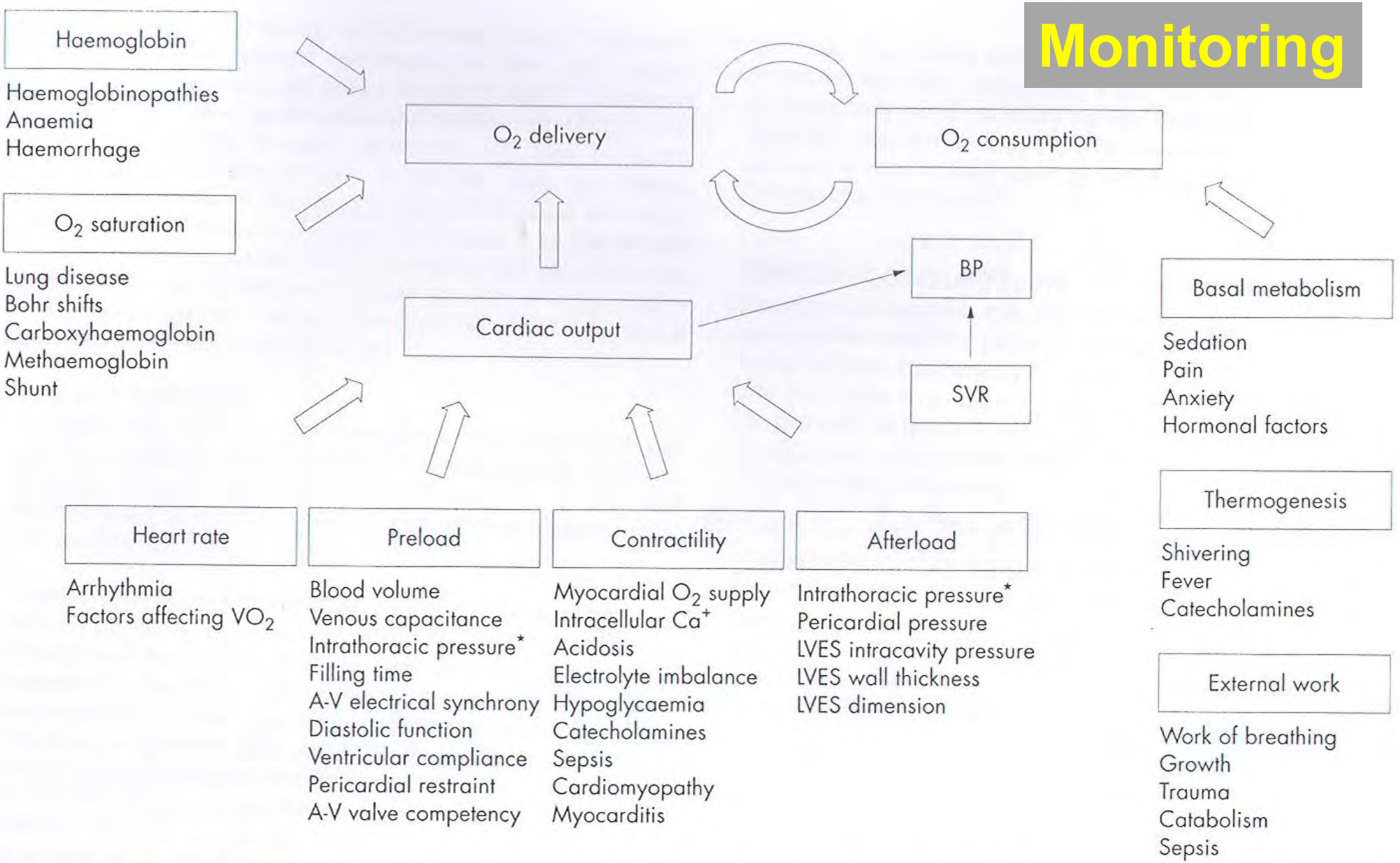


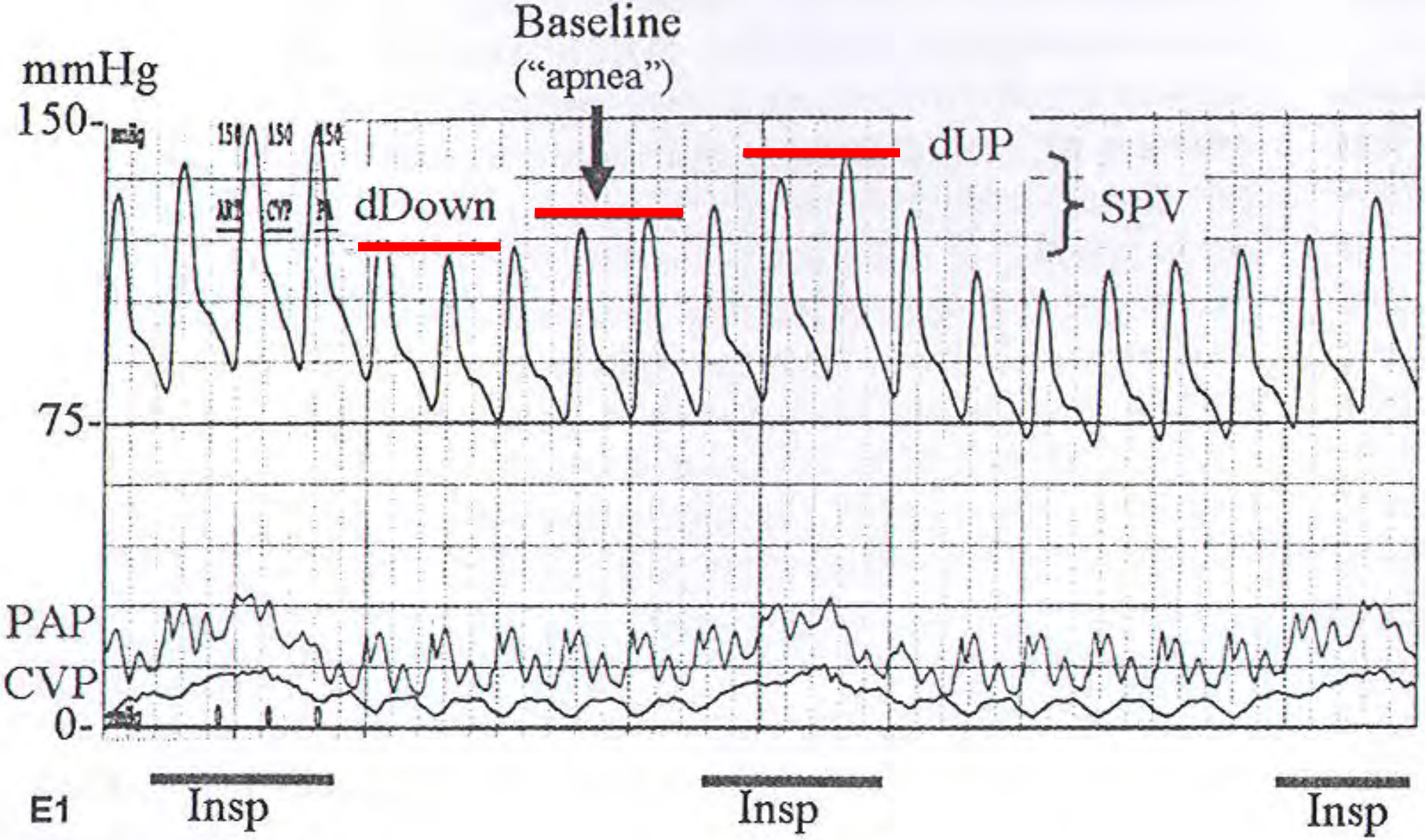
Figure 1 Factors affecting oxygen delivery and consumption. BP, systemic blood pressure; SVR, systemic vascular resistance; VO_2, oxygen consumption; A-V, atrioventricular; LVES, left ventricular end systolic. *Common intensive care scenarios augmenting intrathoracic pressure include mechanical ventilation, pneumothorax, pleural/pericardial fluid collections.

Endpoints

- Systolic (SPV) and Pulse Pressure Variation (PPV)
  - Useful during positive pressure ventilation to predict response to fluid challenge
  - Assessment of swing in arterial pressure with respiratory cycle (>5mm Hg decrease in SAP during one positive pressure mechanical breath, predicts positive response to colloid bolus)
  - Pulse pressure variation most reliable
  - Stroke volume variation (SSV >12%) readily available from the Vigeleo monitor, but dependent on quality of arterial pulse wave form.

"Fluid responsiveness"

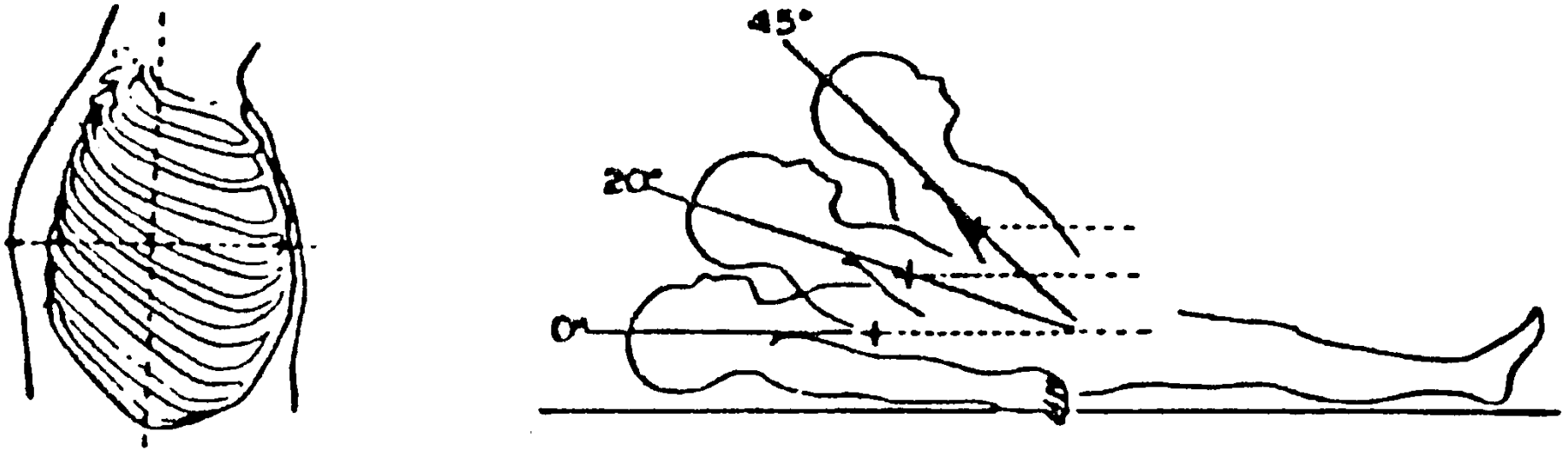
***Always….*consider volume, pressure and flow.**


Baseline
("apnea")
mmHg
150-
dDown
dUP
SPV
75-
PAP
CVP
0-
E1
Insp
Insp
Insp

Endpoints

- The Fluid Challenge
  - Observe the response of CVP or PAOP to a fluid challenge

  (A bolus of 200ml colloid over 15 min)
  - CVP stays the same or decreases: covert hypovolaemia
  - A sustained increase > 3mm Hg – at the limit of vascular compliance



The reference point for central hemodynamic measurements is the junction between a frontal plane of the body halfway between the anterior and posterior chest and a transverse plane passing through the fourth intercostal space at the sternum.

Endpoints

- The Fluid Challenge and Measurement of Blood Flow
  - Esophageal Doppler
  - Colloid bolusses
  - Maximizing stroke volume rather than targeting a specific figure
  - Avoids inappropriate excessive fluid infusion

Assessment of Volume Status

BOUILAIN T. CHEST 2002

Passive leg raising for 4 minutes identifies patients with hypovolemia

1. Change in radial artery pulse pressure correlate with changes in stroke volume during PLR.
   ($r = 0.77$; $p<0.001$)
2. Change in stroke volume correlate with fluid loading (300ml over 24hrs)
   ($r = 0.89$; $p<001$)
3. Change in radial artery pulse pressure with PLR correlate with change in stroke volume induced by fluid
   ($r = 0.84$; $p<0.001$)

Endpoints

- Intravascular pressure measurement
  - Static measurements of IV pressure does not avoid tissue under perfusion
  - Blood pressure measurements do not reflect blood flow
  - Hypovolaemia may be present despite normal pressures
  - Clearly, below a certain arterial pressure, especially the kidney and brain do not function normally
  - Maintain an individual's pre-op MAP
  - CVP if used thoughtfully according to basic physiological and measurement principles can provide a useful guide to cardiac preload, volume status and a change in cardiac output and blood pressure

Hemodynamic Management

- Arbitrary haemodynamic endpoints are difficult to substantiate
- But - MAP 70-80 mm Hg
  CI > 2.8 L/min/m2
  Systolic > 100
  SaO2 > 90%

Endpoints

- Tissue Perfusion
  - Very appealing as goal for resuscitation
  - A number of technologies tested perioperatively

    Gastrointestinal tonometry

    Laser Doppler flowmetry

    Microdialysis catheters

    Near-infrared spectroscopy

    Transcutaneous oxygen measurements

    Tissue pH monitors

Still experimental – hope for the future.

Gastric tonometer ? most promise

Perfusion Pressure

MAP – ICP = CPP

(but CPP does not represent cerebral blood flow)

MAP – IAP = APP

Compartment Syndrome Concept

- Head injuries
- Limb injuries
- Thoracic injuries
  - Tension pneumothorax
  - Pericardial tamponade
- Abdominal pathology
  - Acalculous cholesystitis
  - NOBS with nutrition
  - Acute renal failure

INDICATIONS FOR FLUID AND ELECTROLYTE THERAPY IN SURGICAL PATIENTS

TOTAL FLUID MANAGEMENT TFM	MAINTENANCE	RESUSCITATION	REPLACEMENT
1. Indication:	Daily requirements	Hypovolaemia	Abnormal or continuing losses.
2. Intention:	According to a formula based on body mass	"Aggressively" according to endpoints	Collect drainage for 4 hours, replace % during next 4 hours, while collecting again
3. Infusion rate:	Continuously per 24 hours = 24 equal doses	Bolus	Continuously according to losses.
4. Type of fluid:	Maintenance: Maintelyte 5%, Electrolyte No2 10% Sustenance 5%	Volume expander: Ringers Lactate (Modified), PlasmalyteB, Saline, Colloids	According to fluid lost; Rehydration, 5% Dextrose in water, 0,45% NaCl, 0,9% NaCl, Ringers Lactate
5. Monitor	Serum and urine electrolytes and osmol. Fluid balance chart.	Central haemodynamics, Urine flow, Stroke Volume Variation, SvO_2, Lactate, pH, BE	Serum and urine electrolytes and osmol

Conclusion

- Knowledge of available IV fluids
- The Crystalloid – Colloid controversy rages on
- Stay away from Saline based solutions
- Use physiologically balanced electrolyte solutions
- There is a time for crystalloids – but later in the disease process colloid and inotropes / vasopressors become more relevant
- Accurate dosing of fluid therapy depends on monitoring blood pressure AND flow.
- Also monitor LV stroke volume

IT IS TIME FOR MODERATION
AND "PRECISION" =
Deliberate about each and every fluid bolus!


Thank you for your attention