SNS COLLEGE OF ALLIED HEALTH SCIENCES
SNS Kalvi Nagar, Coimbatore - 35
Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIOPULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME: CPB and Perfusion Technology

TOPIC : Adequacy of Perfusion

Case Study

Mr. Ram, was posted to the Operation theatre for the elective surgery on Mitral Valve for Repair. The patient preparation was done and circuit was assembled and pump was started. The ACC done after 5 minutes and administration of Cardioplegia was done to arrest the heart.

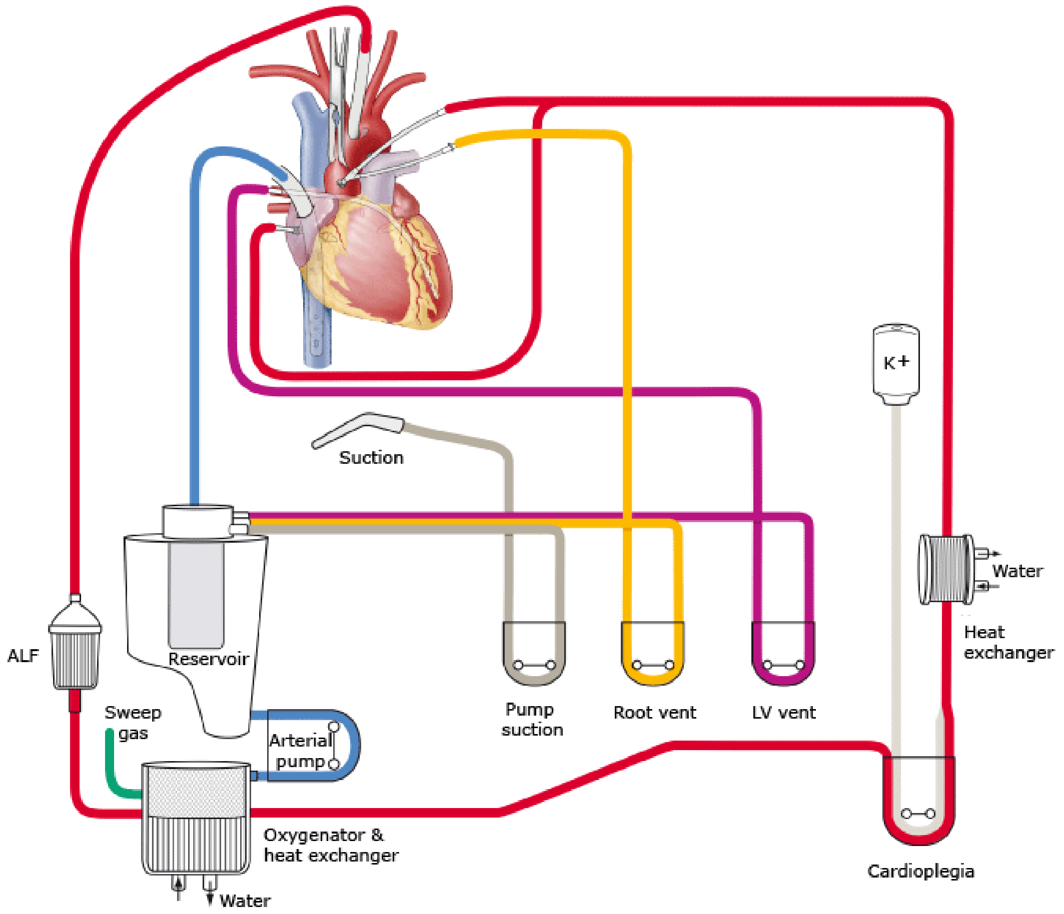
As a perfusionist, What are the parameters should you need to monitor for adequate perfusion to the patient throughout surgery.

Introduction

- Cardiopulmonary bypass has been used since 1953.
- We have seen that there is a significant morbidity and mortality associated with CPB.
- we must adapt our perfusion techniques to meet the patient's age and pathological condition.

Perfusionist measures

- **Flows** - Tissue perfusion
- **Pressures -** Viscosity , Vascular compliance
- **Hematocrit -** Oxygen carrying capacity
- **Gas exchange -** Optimal PaO2S, Optimal PaCO2S



Arterial flow rates

- **Computation -** By body weight (kg), By body surface area (meter square)
- **Body Weight -** Adults 30-70 ml/kg
- **Body Surface Area**
- At 37 degree C, 2.2 L/m was recommended by Kirklin
- Increased lactate formation is seen with flow rates < 1.6 L/m

BSA Calculation

Mosteller Formula

$$BSA\ (m^2) = \sqrt{\frac{[\text{height (cm)} \times \text{weight (kg)}]}{3600}}$$

Arterial flow rates

- It is apparent that CPB flow rates were based on unanesthetized human values – that is 2.4 – 3.2 L/m 2/min.

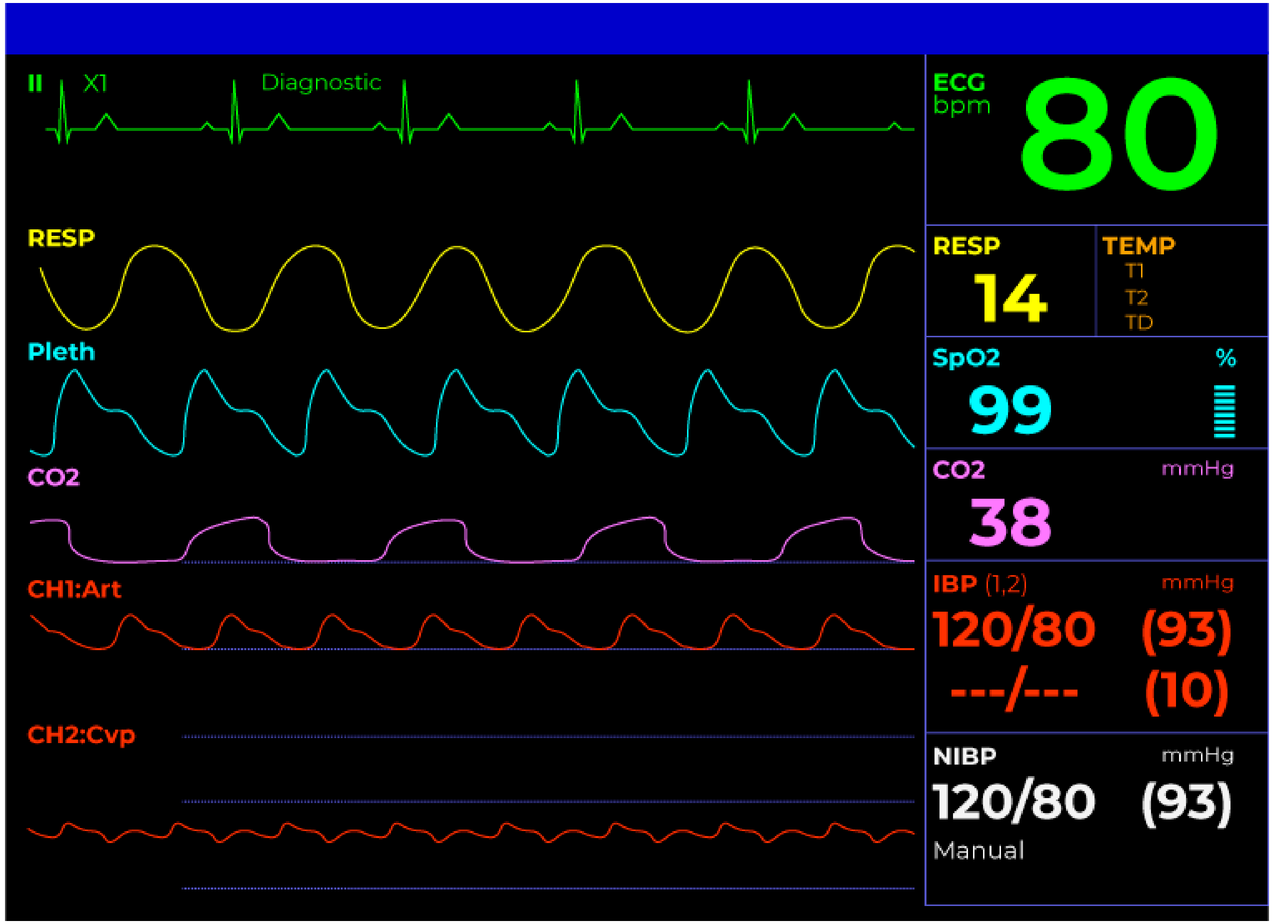
- It is logical that under flow anaesthesia that CBP flow rates could be markedly reduced.

- Historically in the 1950’s was established as the standard flow rate of **2.4 L/m2/min.**

- Currently, the standard of practice is 2.0 – 2.4 L/m2/min.

Arterial Flow Rates - Issues

- Oxygen delivery (Hgb/Hct)
- Patient’s oxygen consumption (VO2)
- Patient temperature
- Level of anaesthesia
- Pressures
- **Perfusion of critical organs:** Heart, Kidneys, Brain
- Blood trauma
- Third spacing



Oxygen Consumption is related to Age

Infants	VO
• 1 -3 weeks old	7.6 ml O2/kg/min
• 2 months	9.0 ml O2/kg/min
• Adults	4.0 ml O2/kg/min 250 ml O2/min (100-130 ml O2/min/m2)

* However these values are unanaesthetised patients

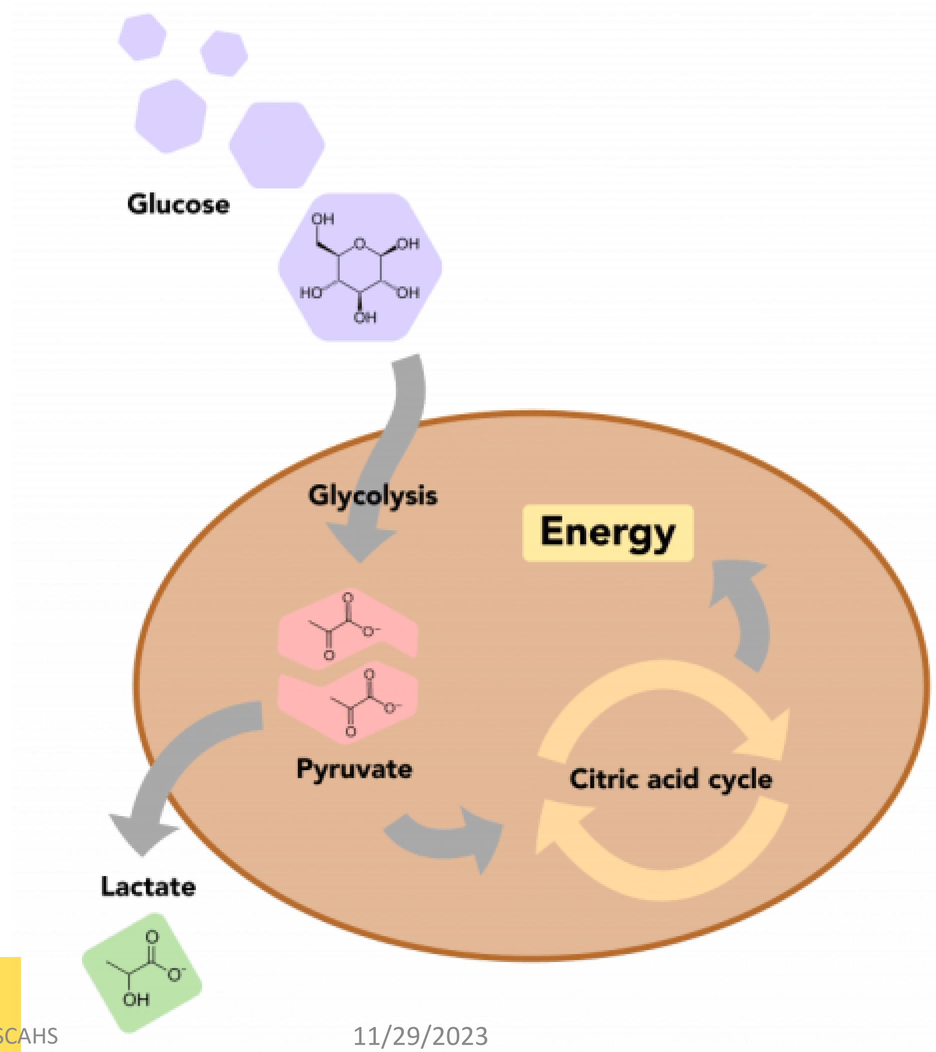
Oxygen Consumption (VO2) : Anaesthesia and Temperature

Condition	(VO2)
• 37ºC Unanaesthetised	= 4 ml/kg/min
• 37ºC Anesthetized	= 2-3 ml/kg/min
• 28ºC Anesthetized*	= 1-2 ml/kg/min

- Patient oxygen consumption decreases 7% per 1ºC.

Adequacy of arterial flow rate

- Mixed Venous Oxygen Tension (PvO2) – normal values **35 – 45mm Hg**
- Mixed Venous Oxygen Saturation (SvO2) – normal values **65 – 75%**
- Lactates – normal values **0.5 – 1 mmol/L**
- ΔPCO2
- Arterial pressures

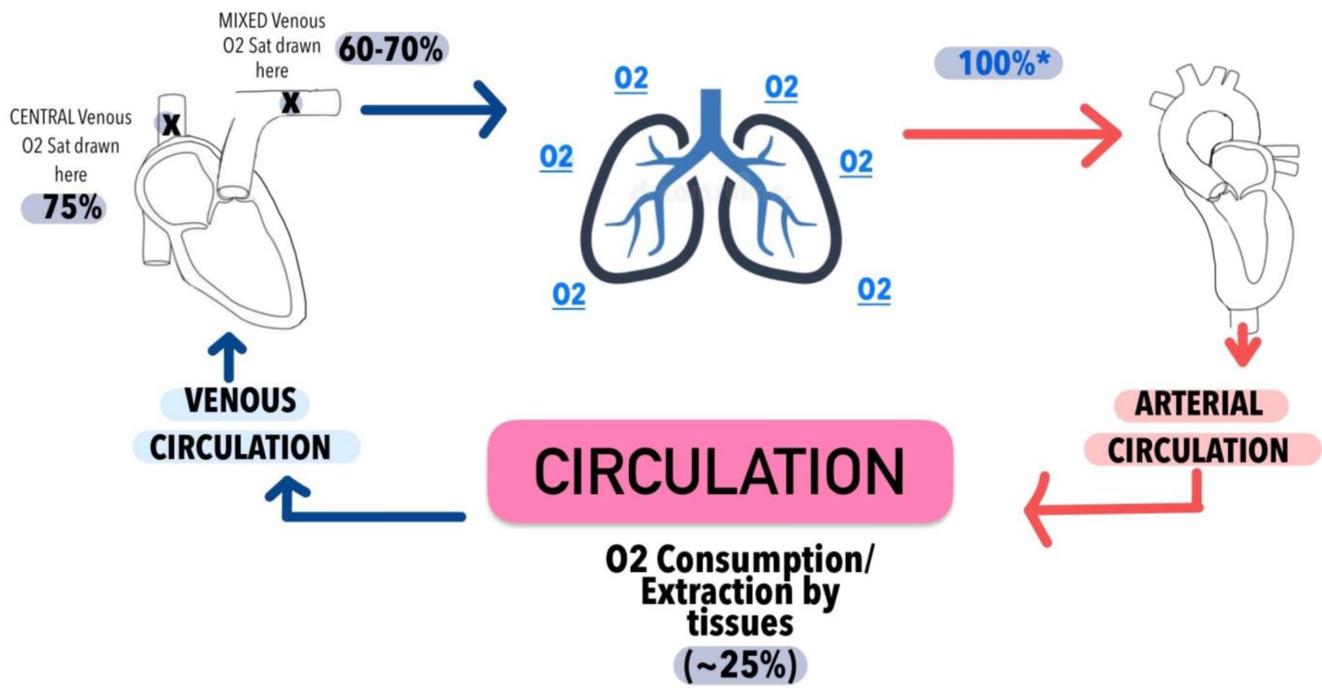


Venous Saturation (SvO2)

- SVO2 is the percentage of oxygen bound to hemoglobin in blood returning to the right side of the heart. This reflects the amount of oxygen “left over” after the tissues remove what they need.

- **Venous saturation (SvO2)** are useful and easy markers to measure but may NOT always related to adequate tissue perfusion.

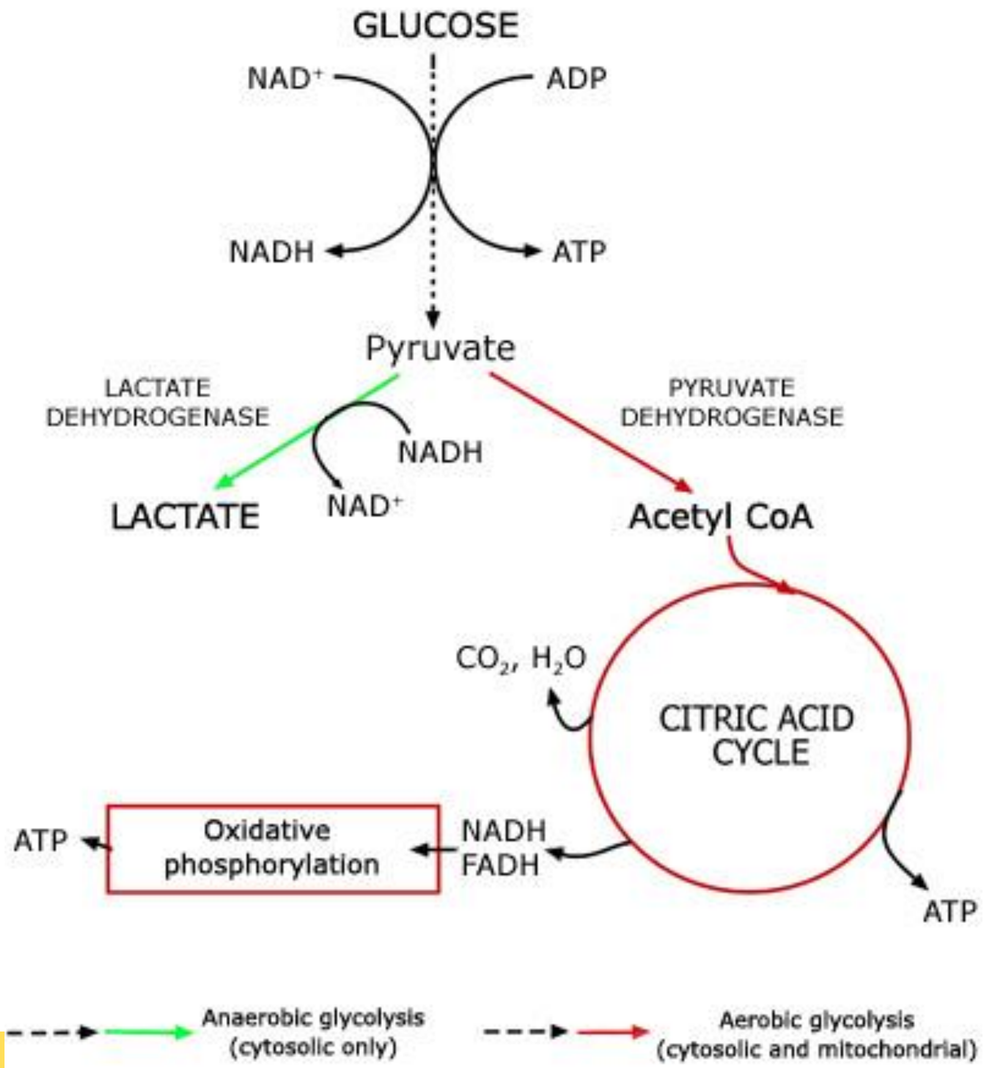
- SVO2 will mimic a vascular shunt , so it shows an increase value



Lactate

- Lactate is an organic molecule produced by tissues and muscles.

- In anaerobic respiration Pyruvate is metabolized by Enzyme lactate dehydro- -genase into lactate.

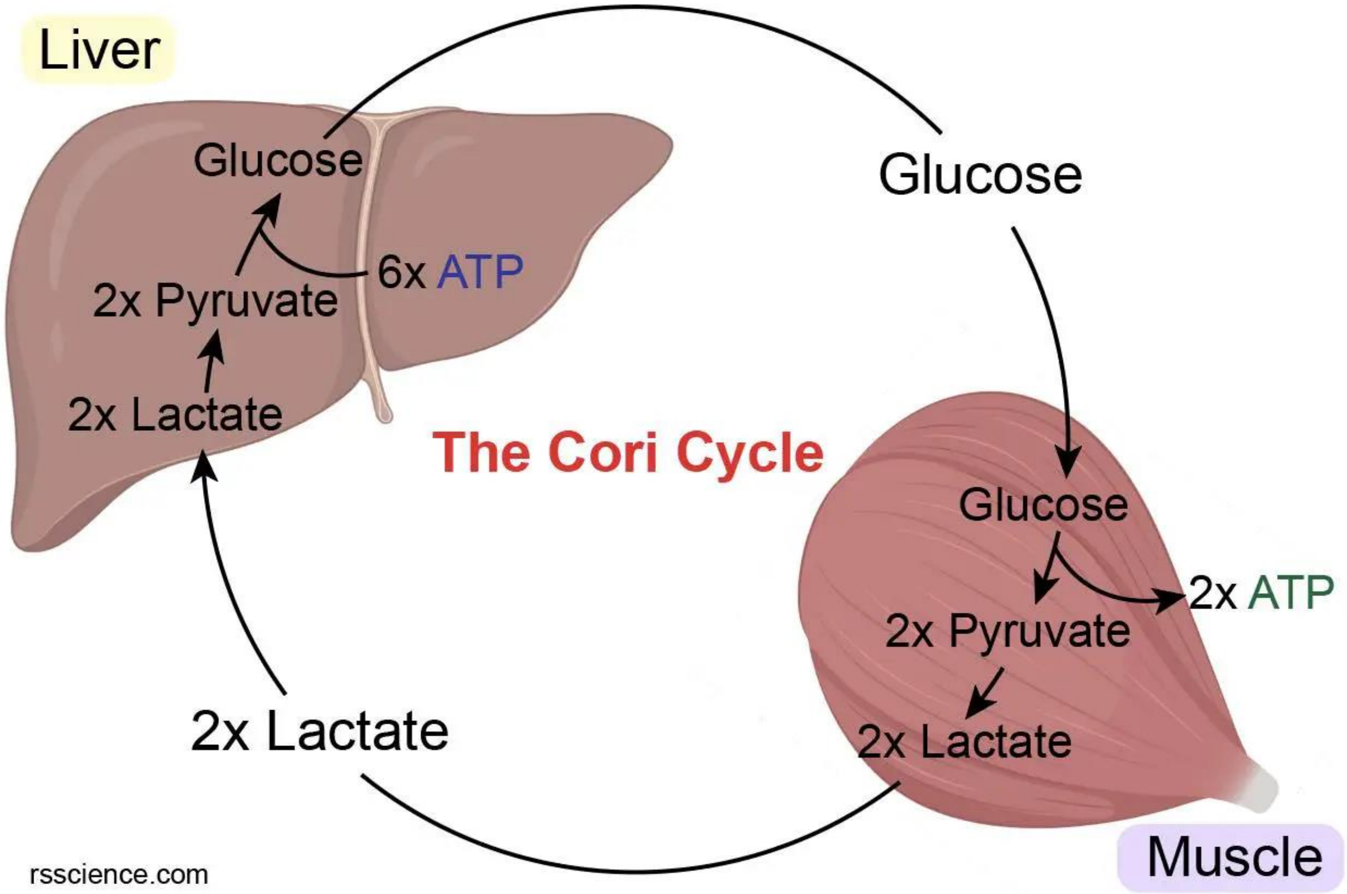


lactate

- Lactate leaves the cells and enters into blood stream and transports to the liver.

- From liver it oxidized back into pyruvate and then converted into glucose via cori cycle.

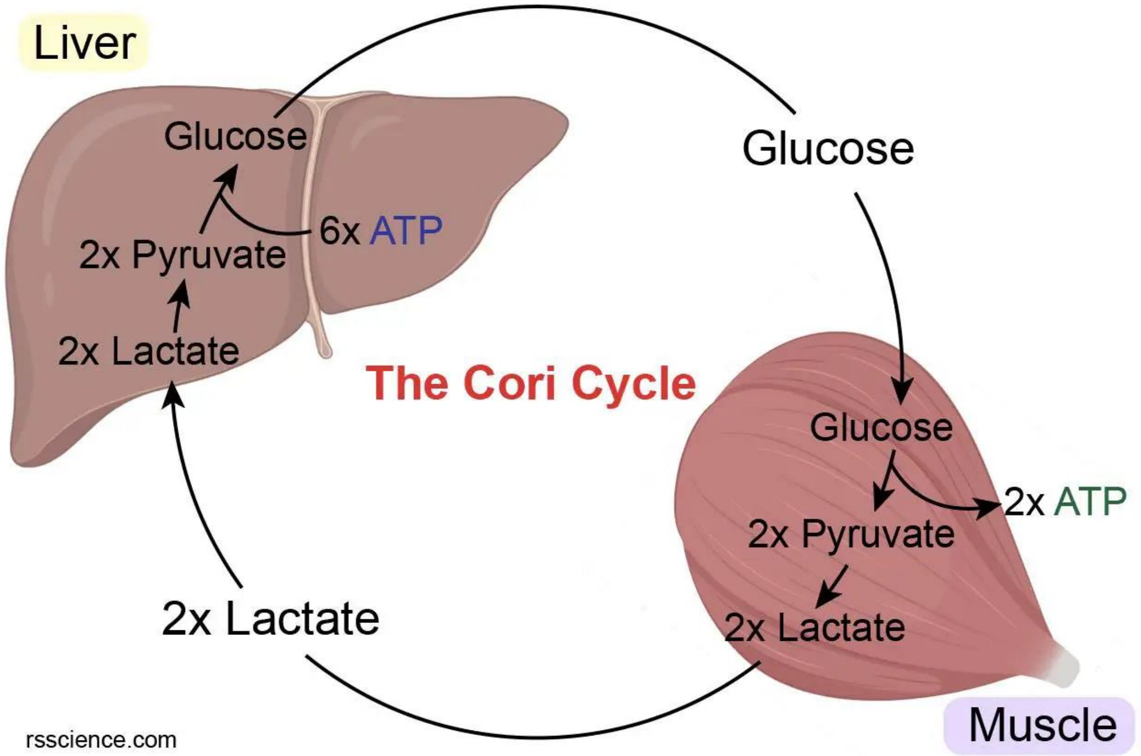
- Lactate is cleared from blood and to a lesser extend by the kidneys and skeletal muscles.



lactate

- Elevated blood **lactate levels** associated with **metabolic acidosis** are common among critically ill patients with systemic hypo perfusion and tissue hypoxia.

- This occurs because of imbalance between tissue oxygen supply and demand.



A-V PCO2 Gradient (ΔPCO2)

- Partial Pressure of carbon dioxide reflects the amount of carbon dioxide gas dissolved in the blood.

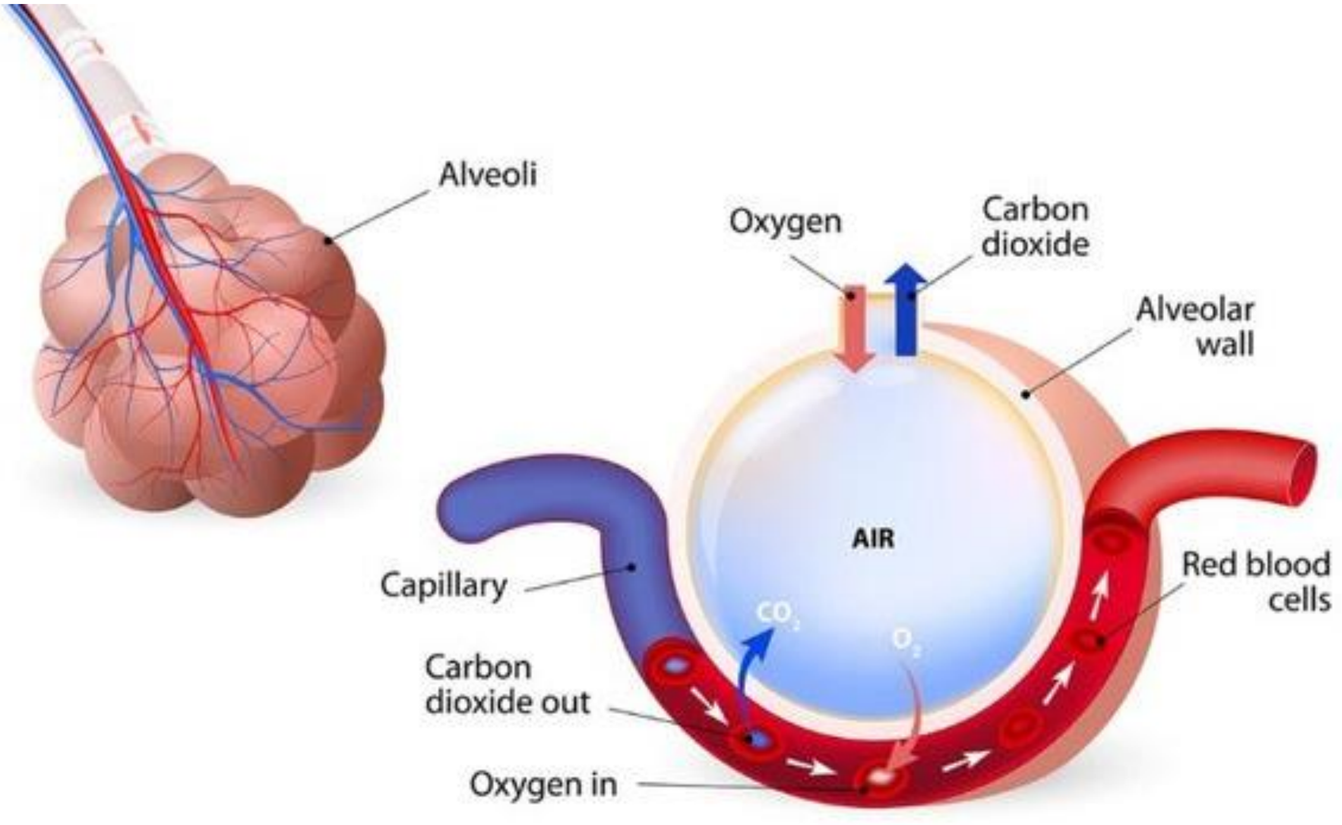
- $\Delta PCO2 = PvCO2 - PaCO2$

- The ΔPCO2 is an index to identify the critical oxygen delivery point (VO2/DO2).

- The critical oxygen delivery point is when consumption (VO2) is dependent on delivery (DO2)

A-V PCO2 Gradient (ΔPCO2)

Since CO2 is 20 x more soluble in aqueous solutions than O2, it is logical that ΔPCO2 may serve as an excellent measurement of adequacy of perfusion.



ΔPCO2

- ΔPCO2 is a valuable parameter for determining the adequacy of CPB to a given metabolic condition.
- Δ PCO2 can help to detect changes in oxygen demand (e.g., the metabolic changes that accompany temperature changes, flow rates and drug administration).
- Δ PCO2, together with SvO2, can help to assess the adequacy of DO2 to global oxygen demand and thus may help to assess perfusion adequacy.

Arterial pressure

The arterial pressures are a very important determinant of adequacy of perfusion during cardiopulmonary bypass.

Factors affecting Arterial Pressure

- Vascular tone
- Anaesthetic agents
- Hemodilution (Hgb/Hct)
- Prime composition (viscosity)
- Temperature
- Pathological conditions (diabetes)
- Anatomic features
  - Bronchial blood flow
  - Patent ductus arteriosus

Vascular resistance

- Poiseuille's Law **Q = flow rate (cm3/s, ml/s)**

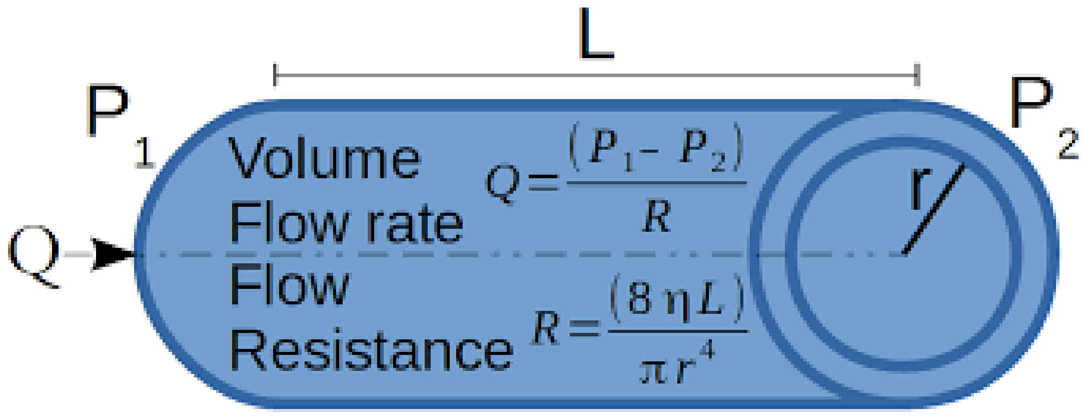
P = pressure difference (dyn/cm2)

r = radius of the vessel (cm)

h **= coefficient of blood viscosity (dyn-s/cm2)**

L = length of vessel (cm)

- Q = ∏ ΔPr4/ 8 ŋ l



Therefore:

- Vascular resistance is related to:
  - vascular tone
  - blood viscosity (HCT) at a given flow rate.

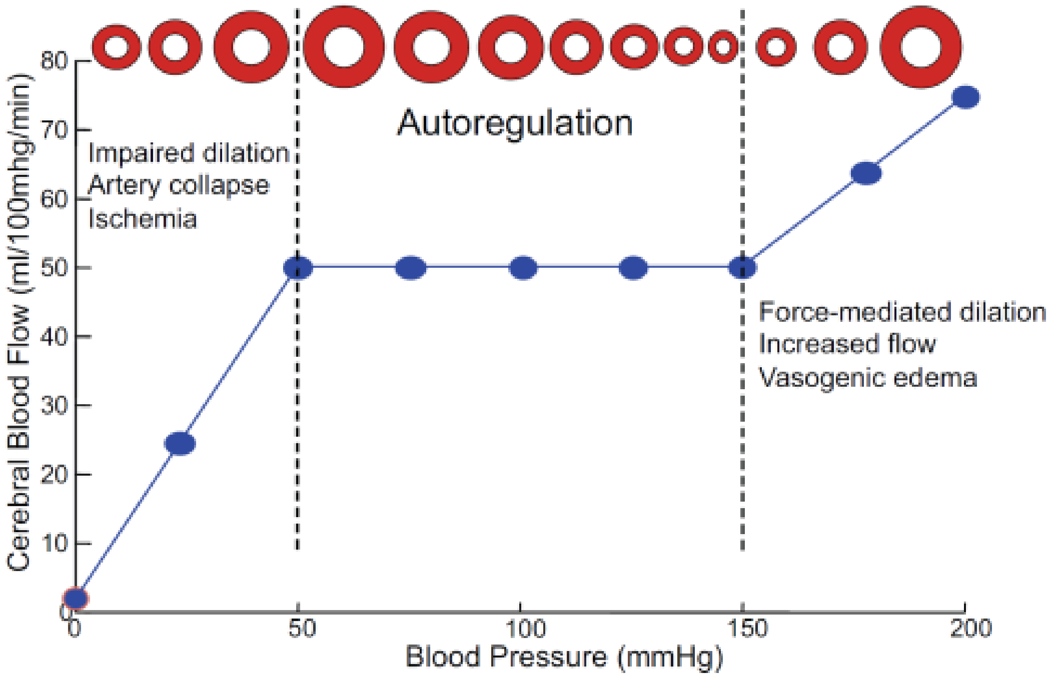
Vascular resistance

- **Autoregulation of vascular resistance.**
- Different organs display varying degrees of autoregulatory behaviour.
- The renal, cerebral, and coronary circulations show excellent autoregulation.
- The skeletal muscle and splanchnic circulations show moderate autoregulation.
- The cutaneous circulation shows little or no autoregulatory capacity.

Autoregulation

- At normothermic conditions in normal individuals, autoregulation is preserved at pressures between 50 – 150 mm Hg.

- Under profound hypothermia in normal individuals conditions autoregulation threshold may be as low as 30 mm Hg.



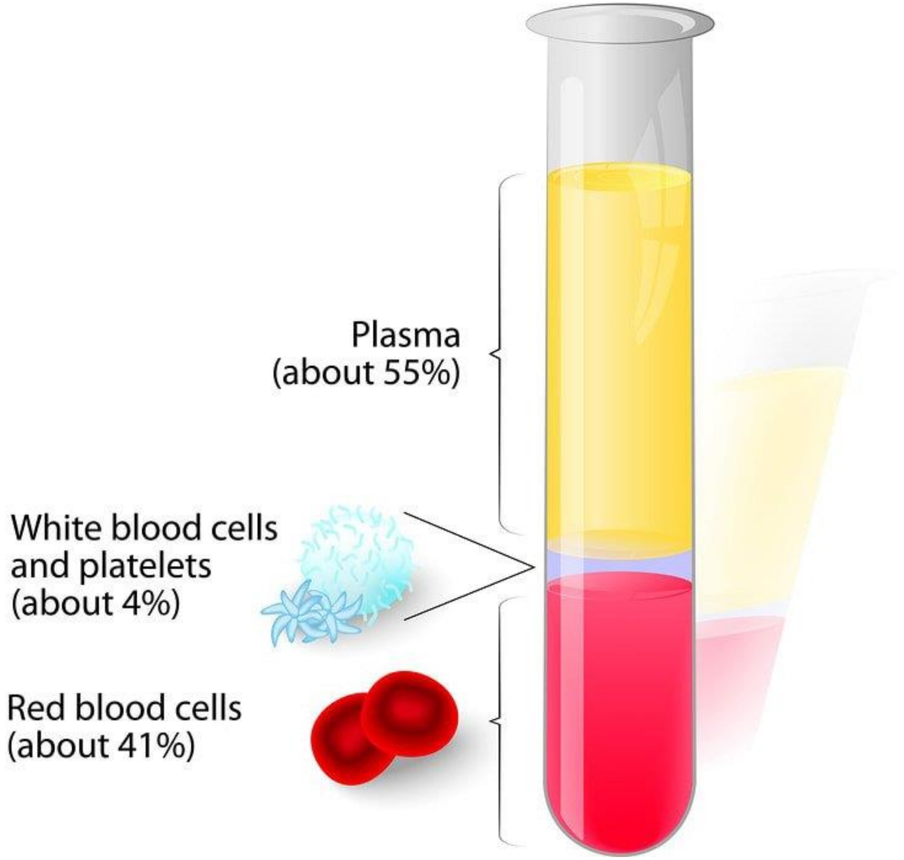
Autoregulation

- Autoregulation of blood flow for the heart, kidney, and brain can be uncoupled by vascular disease and diabetes.
- In the diabetic, cerebral artery perfusion flow is completely dependent upon perfusion pressures!
- Therefore, perfusion pressures need to be maintained at 65-80 mm Hg to provide adequate cerebral blood flow.
- ***Therefore, arterial pressures are coupled to arterial flows.***

Hematocrit

- The coupling between hematocrit and arterial flow rate has been established to provide adequate DO2.

- The optimal hematocrit is 27% however with a lower hematocrit the flow rate must be increased to provide adequate DO2 to meet the patient's VO2.



Oxygenation (PaO2)

- Oxygen content in the blood is mainly dependent upon the hematocrit and the percentage of saturation of the hemoglobin.

- Once the hemoglobin is 100% saturated, normally at a PO2 of 120 mm Hg.

- Increasing the PO2 provides minimal increases in oxygen content of the blood.

- PaCO2's have a marked effect on the pH, HCO3 -, hemoglobin saturation and most importantly cerebral circulation.

Assessment

- What is lactate and why it is important?
- What is the calculated flow rate?
- What is autoregulation?
- What are the parameters for monitoring adequacy of perfusion?

Conclusion

Flow rates

- 1.8 L/min/m2 adult
- 2.4 L/min/m2 in the pediatrics
- ?? In the aged

Hematocrit

- 24-28%, may be higher in the aged
- PaO2 >120 mm Hg

Pressures

- > 50 mm Hg except higher in the diabetic

CONCLUSION

- **Cerebral Function –** Electroencephalography
- **Blood flow viscosity -** Transcranial Doppler
- **Oxygen saturation** by near infrared spectroscopy
- **Renal function, Urine output**
- **Arterial blood gases** will monitor oxygenator function and measurement of mixed venous oxygen tension.

THANK YOU

References:

Principles of Perfusion – Sunit Ghosh

Cardiopulmonary Bypass – Glenn P. Gravelle