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Instrumente Structurale
2007-2013



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UNIVERSITATEA DE MEDICINĂ ȘI
FARMACIE "CAROL DAVILA"
BUCUREȘTI

AD-COR Program inovativ de formare in domeniul cardiologiei pediatrice POSDRU/179/3.2/S/152012

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MODUL TEORETIC

The Effects of Cardiopulmonary Bypass in Paediatric Cardiac Surgery

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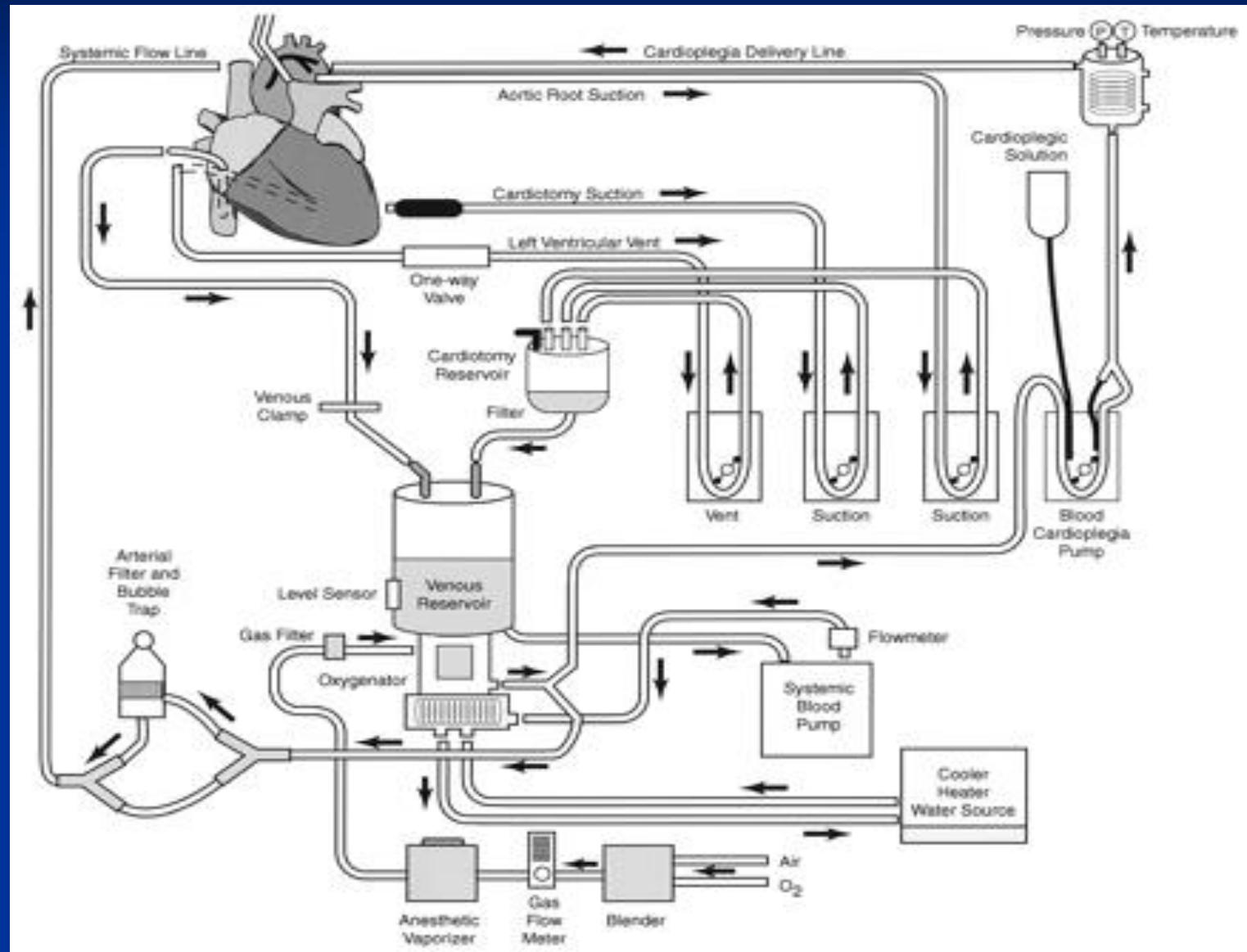
The Effects of Cardiopulmonary Bypass in Paediatric Cardiac Surgery

Cardiopulmonary Bypass in Pediatric Cardiac Surgery

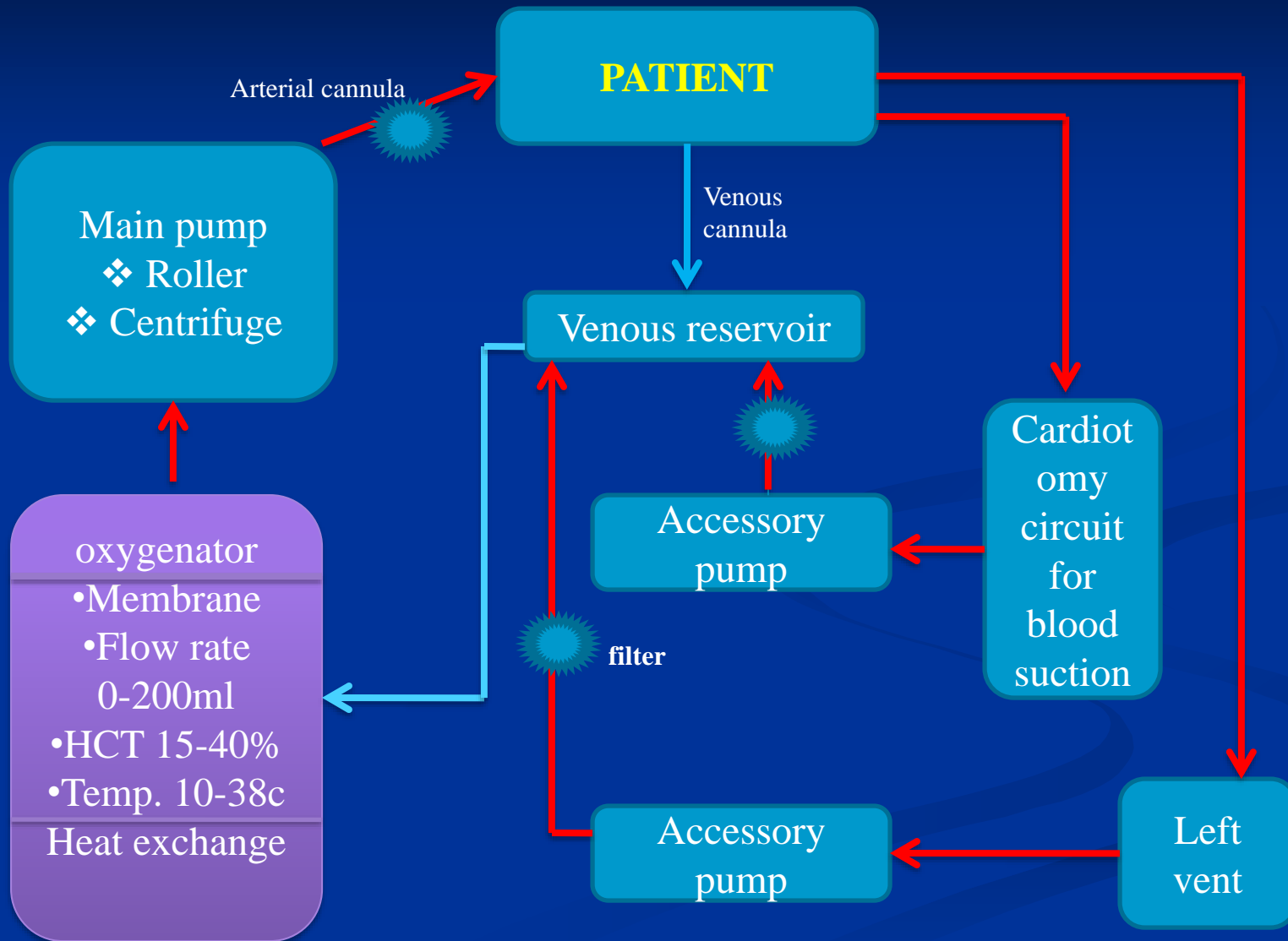
Rational for use of cardiopulmonary bypass in cardiac surgery

- ** Provides clear surgical field for cardiac manipulations during open heart surgery
- ** Provides enough flow to maintain sufficient tissue perfusion

Components of Cardiopulmonary Bypass

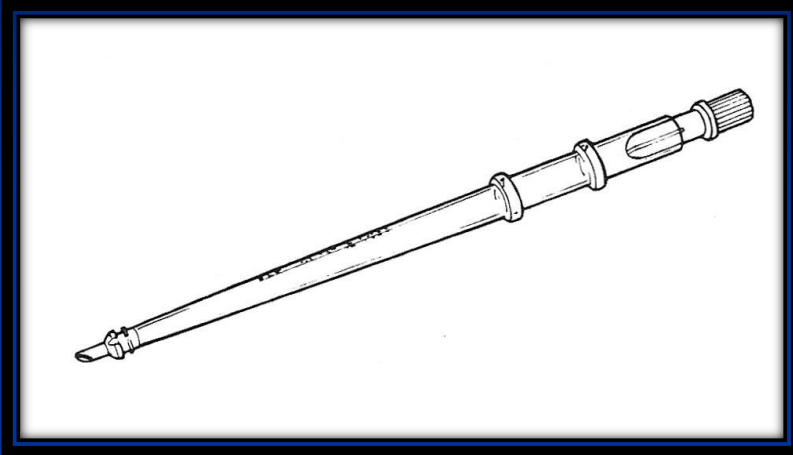


Cardiopulmonary Bypass Circuit

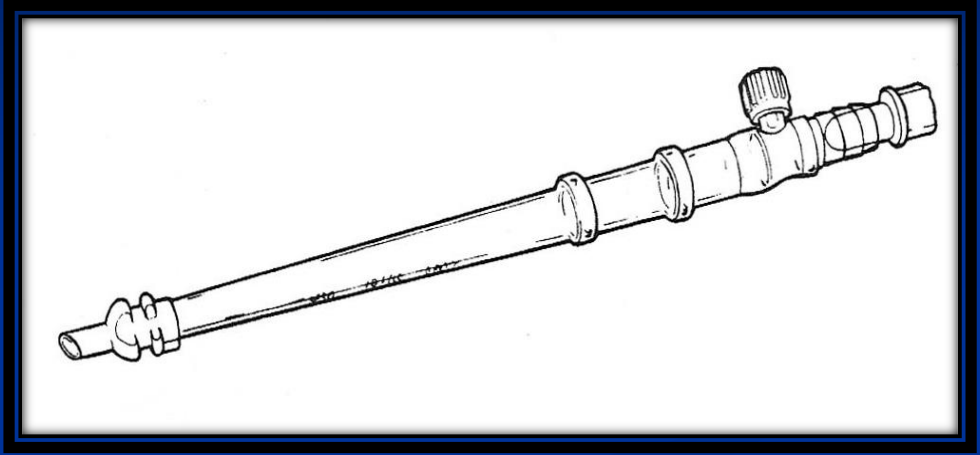


Arterial cannulae

Pediatric straight tip with 1/4 inch connection site

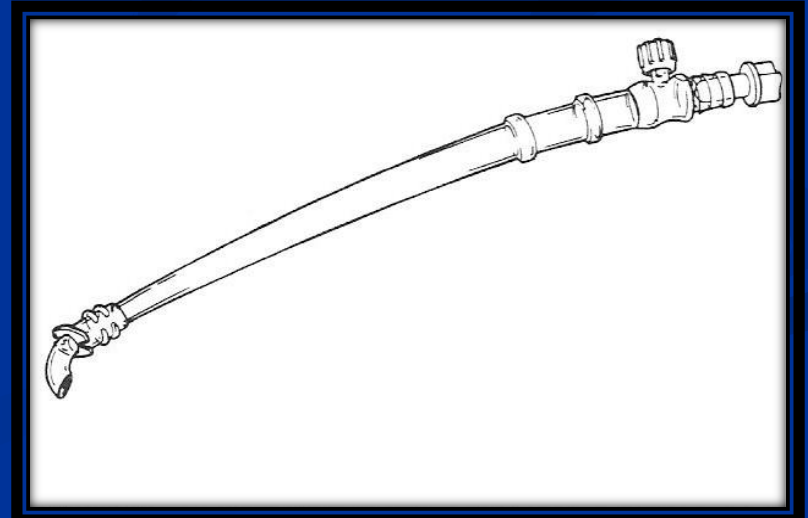
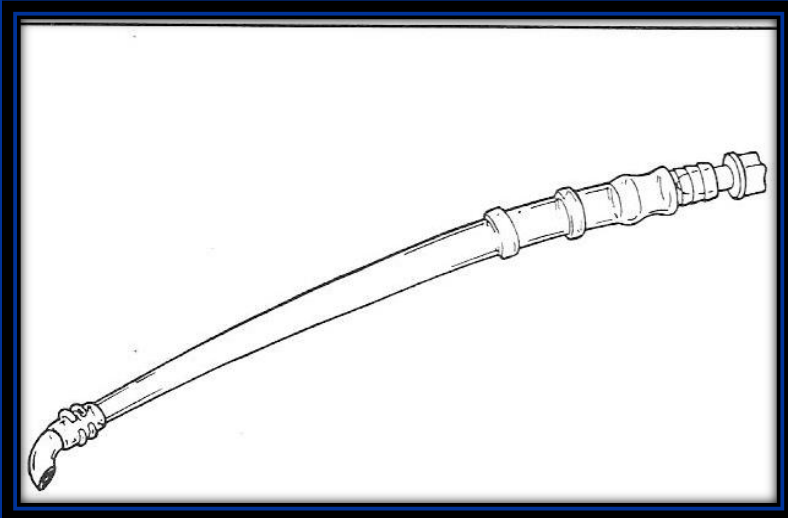


Non vented

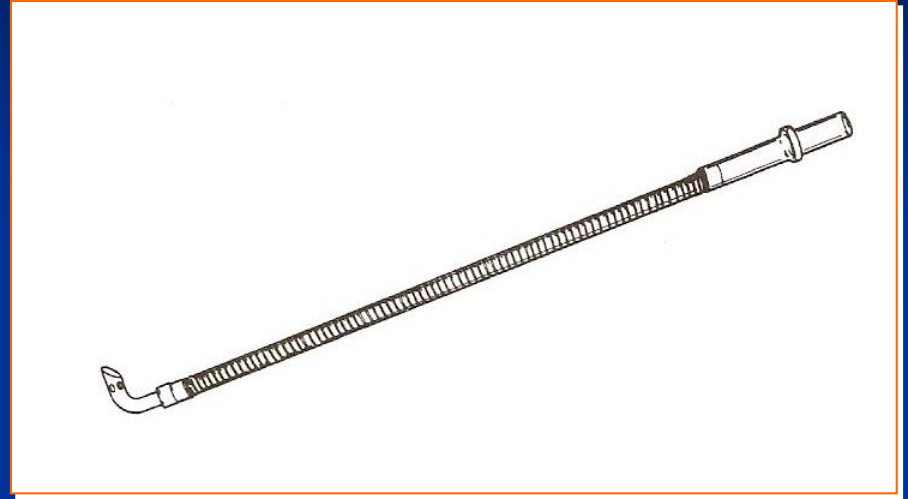
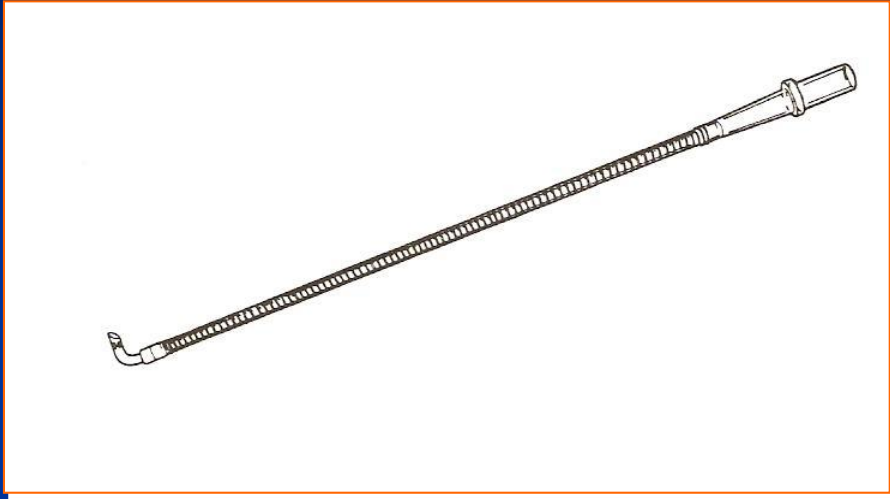


vented

Curved tip cannulae



Venous Cannulae



Right angle metal tip cannulae

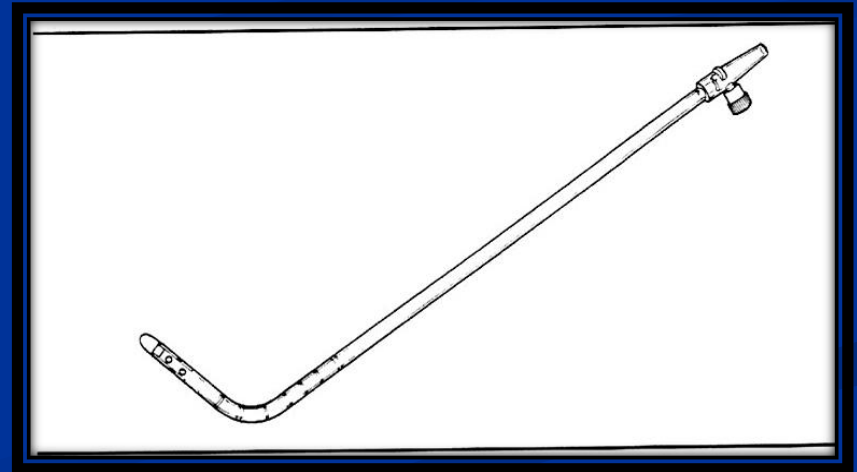
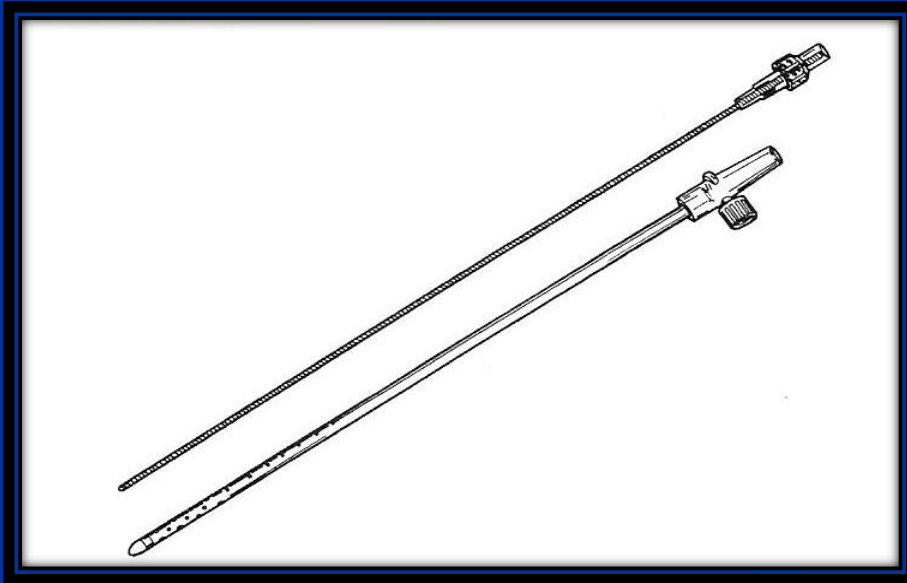
Thus, canulation for cardiopulmonary bypass should provide:

- Adequate flow.
- Unobstructed drainage.
- Perfusion and drainage of all organs.
- Unobstructed field.

Venting:

Left ventricular venting is necessary in infants and neonates because of their greater bronchial collateral flow (up to 30% of neonatal circulating blood volume may be held within suction system) .

Pediatric Left Heart Catheter



What Intensivists should know about pediatric CPB

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graph TD; A[What Intensivists should know about pediatric CPB] --- B[Physiology of CPB]; A --- C[Conduct of CPB]; A --- D[Pathophysiologic effect of CPB]; A --- E[Strategies Optimizing CPB];
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Physiology of
CPB

Conduct of CPB

Pathophysiologic
effect of CPB

Strategies
Optimizing CPB

Physiology Of Cardiopulmonary Bypass

PRIMING :

NEONATES : Large prime/ blood volume ratio
> 200 – 300 % of blood volume

PEDIATRIC : Total prime volume 500 – 1200 ml

Priming Should Be A Balanced Electrolyte Solution

Constituents Of Prime For Pediatric Extracorporeal Circuit

Plasmalyte – A Or Normosmol-R (PH 7.4)	400-1200 MI
Red packed cells or fresh whole blood	0-600Ml
Mannitol 15%	1g/Kg
Albumin 25%	50Ml
NaHCO ₃	25mmol/Kg
CaCL ₂	30mg/Kg
Heparin	2U/ml Prime
Total volume	700-1200 ml

Hemodilution:

- ❑ Due to priming volume
- ❑ Priming volume depends on size of venous reservoir , oxygenator and tubing
- ❑ Degree of hemodilution (predicted HCT on bypass) is a matter of prime volume , patient blood volume and HCT
- ❑ HCT below $< 20-25\%$ on bypass consider addition of blood to bypass circuit

N.B:

$$P_{HCT} = \frac{Pt_{BV} \times Pt_{HCT}}{Pt_{BV} + Prime_{BV}}$$

PHCT= Predicted Pump HCT

PT. BV = Patient Calculated Blood Volume

PT.HCT = Patient HCT

PRIME BV = Total Priming Volume

The Amount Of Blood Required To Be Added To The Prime Is Calculated As :

$$\text{Prime RBC Volume} = \left[(\text{On Bypass HCT}) \times (\text{Pt.BV} + \text{Prime BV}) \right] - (\text{Pt. RBC Volume})$$

Effect Of Hemodilution

- ↓ systemic vascular resistance → improve blood flow through microcirculation in presence of hypothermia
- Loss of oncotic activity → ↑ tissue oedema
- Hemodilution of coagulation factors
- Exaggerates release of stress hormones, complement and white cell and platelet activation

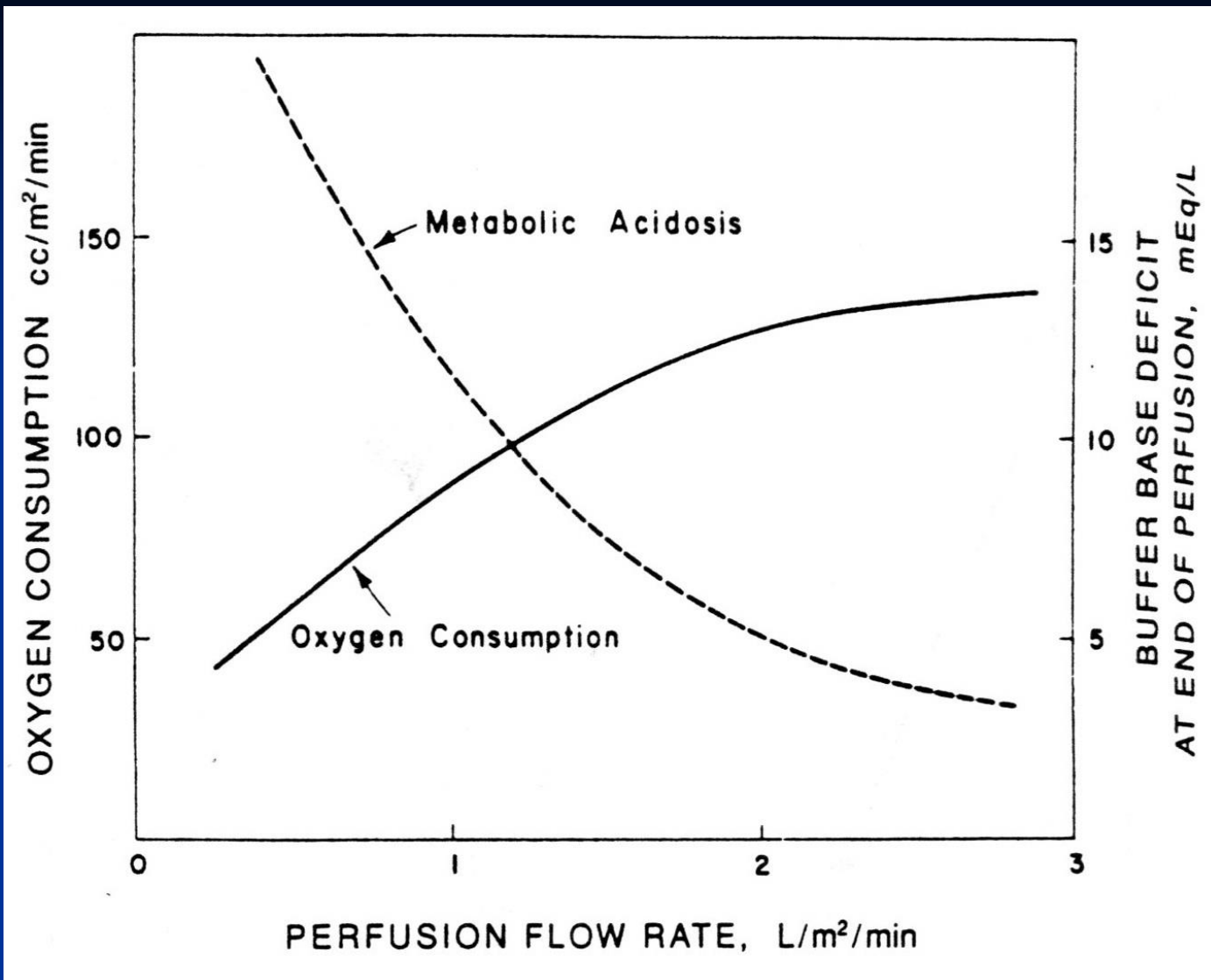
Pump Flow Rate

Pump Flow Rate

Based on body weight and maintenance efficient organ perfusion

- *Venous saturation**
- *Arterial blood gases**
- *Acid base base balance**

Patient weight kg	Pump flow rate (ml/kg/min)
0-7	120-200
7-10	100-175
10-20	80-150
> 20	50-75



Determinants of optimum flow rate is based on systemic oxygenation & acid base balance. These data are less useful during deep hypothermia in which metabolism is severely reduced and cerebral autoregulation is lost

Anticoagulation :

- * Heparin : 300 – 400 u/kg
- * ACT >480 seconds
- * Plasma Heparin concentration

Hypothermia

Necessary to tolerate reduction
of flow rate on CPB

Protective effect of hypothermia :

- (1) ↓ metabolic rate & O₂ consumption lead to tolerance of low flow rate of CPB without affecting global oxygenation
- (2) Preserve high energy phosphate
- (3) ↓ calcium entry into cell & decrease cell membrane permeability

Classification Of Pediatric Perfusion According To Degree Of Hypothermia

Normothermic Perfusion

Older children
Simple cases
Need high flow rate and HCT

Moderate Hypothermic Perfusion

25-30c
Older children
Repair of VSD, F4, SAM
Low flow rate

Profound Hypothermic Perfusion

Neonate
Temp. below 18c
Complex surgery
Low flow rate

Circulatory Arrest

Neonate
Cannulae off field
Complex surgery (aortic arch)
Excellent surgical condition

Conduct Of CPB



Anticoagulation



Cannulation



Initiation Of CPB (Separation From Anaesthesia Machine)



Maintaining CPB (Period Of Surgical Repair)



Ending CPB (Weaning)



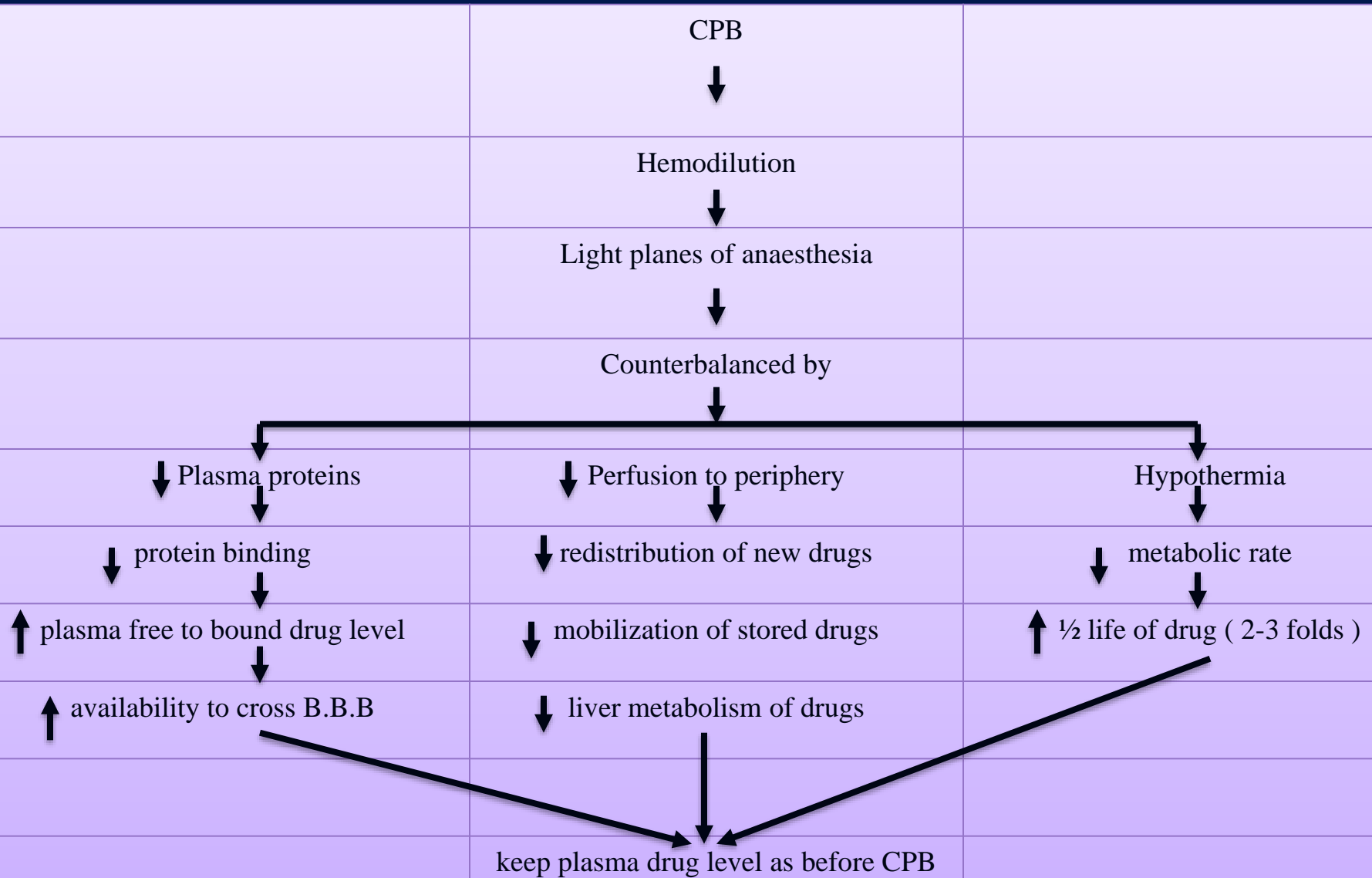
Reversal Of Anticoagulation & Removal Of Cannulae

Effects of CPB on anaesthetic agents

Pharmacokinetics of drugs change due to :

- Hemodilution
- ↓ perfusion to peripheral tissue
- Hypothermia

Pharmacokinetic changes during CPB



Effects Of CPB On Specific Anaesthetic Agents

Opioids :

- High dose opioids :
 - * Showed flat plasma drug level during CPB \rightleftharpoons opioid tissue level is constant at onset of bypass
 - * Need no opioid supplement during CPB
- Opioid infusion :
 - Drug level along course of CPB and during rewarming
- Fast track technique & warm CPB:
- Normothermia , high flow rate , low doses of opioids have dilutional effect on drug level
- Require opioid supplementation

Amensic Agents

- Rewarming period after hypothermia is time of recall
- Recall is uncommon at temperature below 30 c
- Supplement of benzodiazepines (midazolam) is required
- Dose of 0.1 – 0.15 mg/kg during rewarming

Neuromuscular Blocking Agents

- Drug level is affected by hemodilution at onset of CPB because of :
 - 1) Water soluble drugs
 - 2) Ionized
 - 3) Not bound to plasma proteins

- Require addition doses at onset of CPB

Inhalational agents

Lesser influence of CPB on uptake,
distribution & elimination

Check List For Initiation Of CPB

- 1) ACT adequately elevated
- 2) Observe face and neck for colour and venous engorgement
- 3) Ventilation continued till stable flow rate
- 4) Turn off ventilation vaporizers and I.V infusion when stable flow rate

Monitoring of CPB

Machine Performance

Pump Pressure
(Arterial Line Pressure)
Pump Flow Rate
Temperature

Adequate Perfusion

Arterial Pao₂ ,
Paco₂,PH

Venous Blood
Saturations

Biochemical Variables

K⁺
HCT

MONITORING OF PATIENT

- 1) Blood pressure
- 2) Urine output
- 3) ECG
- 4) BIS
- 5) Cerebral monitoring
- 6) Blood glucose level
- 7) Anticoagulation

Participation In Risk Management During CPB

- 1) Patient movement during CPB
- 2) Help in urgent scenario e.g pump circuit failure and o2 failure which requires immediate separation of CPB
- 3) Acute dissection of aorta from cannulation
- 4) Massive air embolism

Weaning From CPB

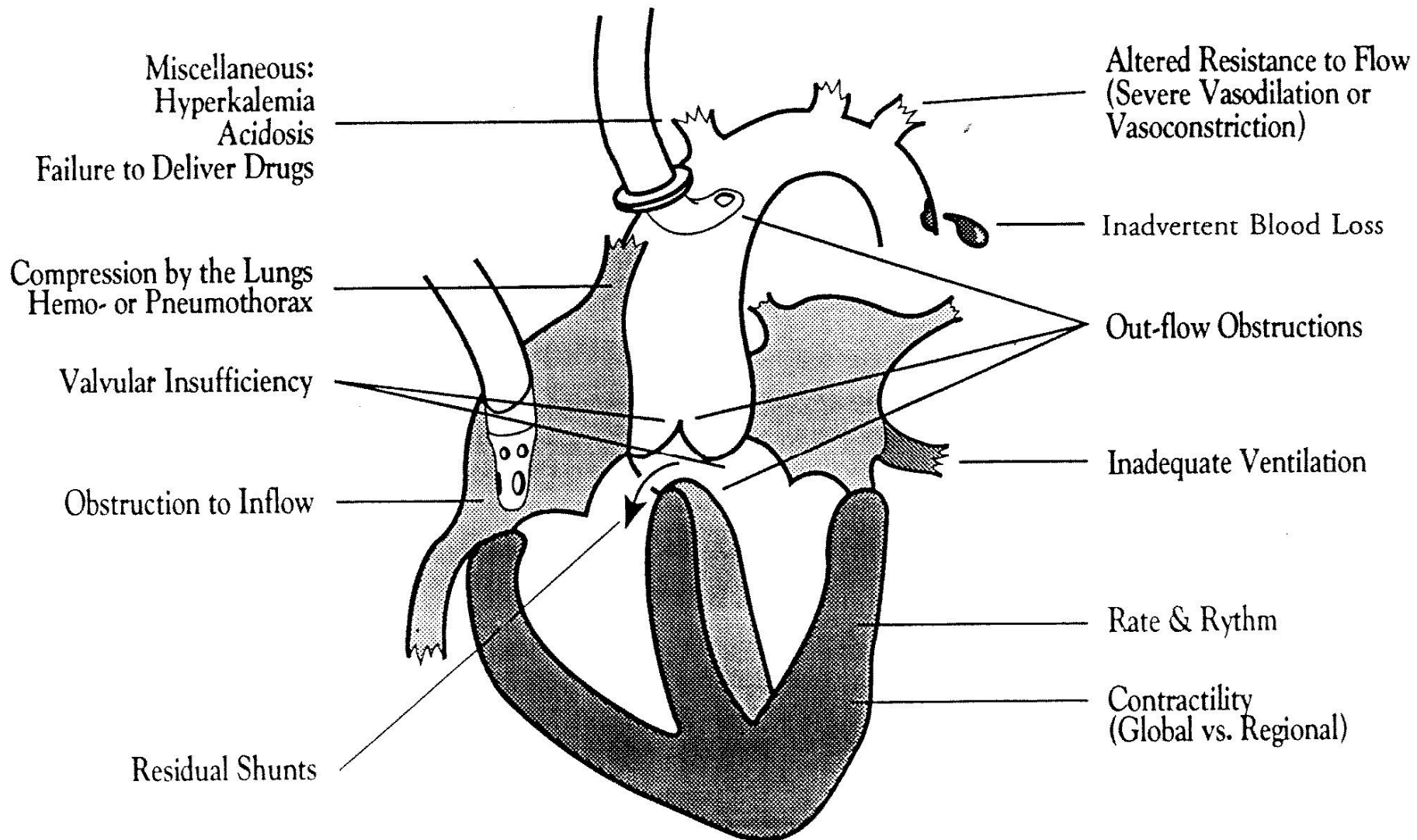
When to wean ??

- Surgical repair is complete
- Patient temperature is 37c
- Balance of physiologic parameters
 - ** Correct acidosis
 - ** K^+
 - ** Correct Ca^{++}
 - ** HCT 25-30 % OR preop. Level

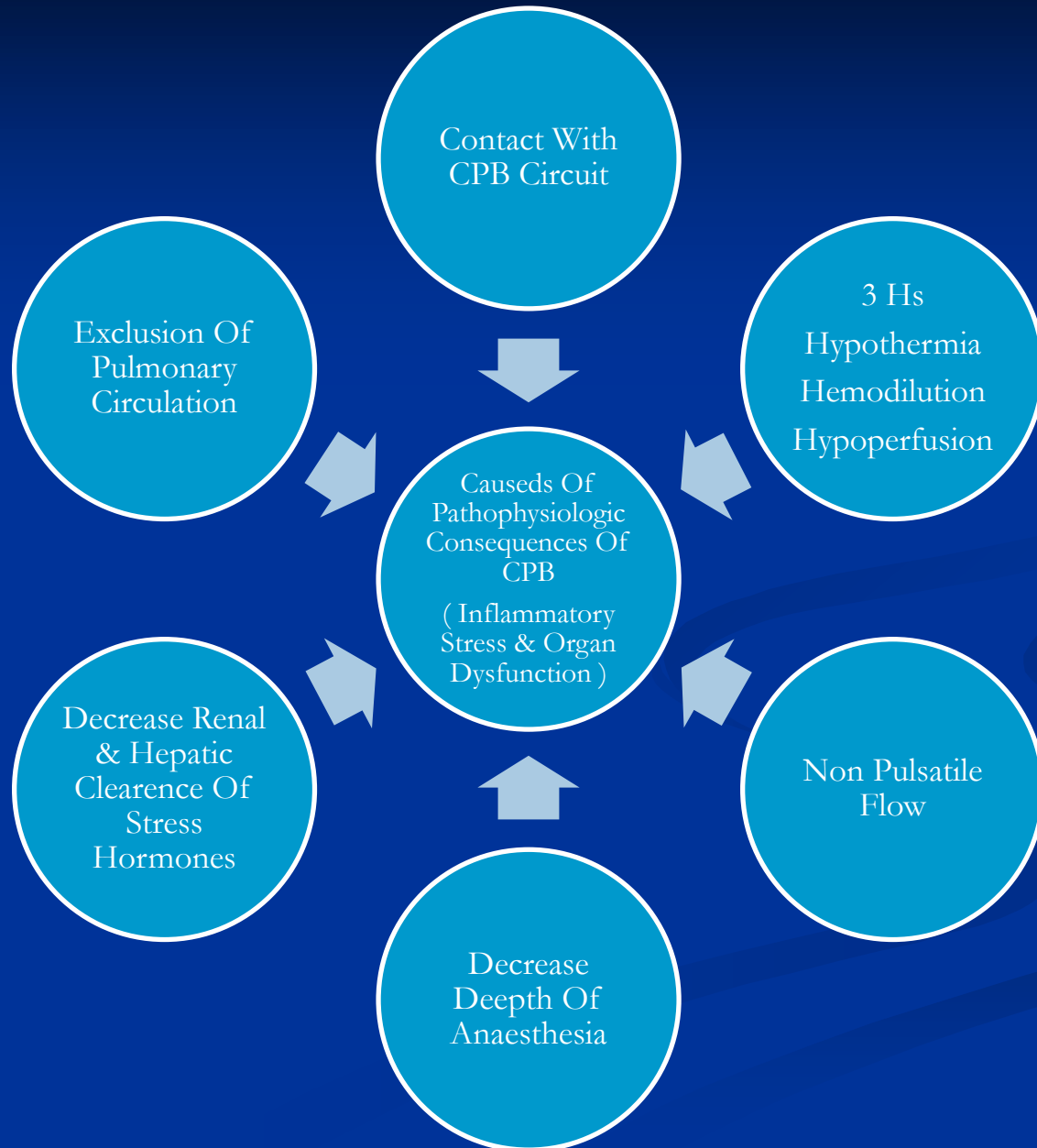
How To Wean From CPB

- 1) Ask perfusionist about fluid balance i.e how much blood is left in CPB
- 2) Ask perfusionist about venous oxygen saturation
- 3) Start lung ventilation
- 4) Reduce flow rate of CPB gradually
- 5) Fill the heart
- 6) Off bypass
- 7) Observe and optimize hemodynamics
- 8) Reverse Heparin & remove the cannulae
- 9) Start the hemostasis

Factors That May Result In Failure To Wean From CPB



PATHOPHYSIOLOGIC EFFECT OF CPB ON BODY ORGANS



Pathophysiologic Consequences Of CPB

Myocardial effect

Systemic & pul. Hypertension

Postop. Bleeding

Pul. Vascular reactivity

Increase catecholamine release

Complement activation

Cytokine release

Prostaglandin

Thromboxane

Renal Dysfunction

Pulmonary endothelial damage (Pul. Dysfunction)

Strategies For Optimizing The Use Of CPB In Neonates , Infants & Pediatrics

(1) Identification of patients at risk of mortality from bypass

- Patients requiring surgery in the 1st. Month are at risk
- Small size infant (1800 grams)
- Infants with reduced LV function
- Multiple congenital anomalies with CHD

- (2) Use of methyl prednisolone
- (3) Leukocyte depleted blood in the circuit and leukocytic blood filter
- (4) Minimize CPB circuit : low volume oxygenator, short tubes , and small diameter tubes.
- (5) Vacuum assisted venous drainage
- (6) Bicompatible coated circuit (Heparin coated circuit)

ULTRAFILTRATION

It is a hemofiltration technique that passes blood through a semipermeable membrane filter and using a transmembrane pressure gradient , remove water , electrolytes and other substances of small molecular size .

Types Of Ultrafiltration

❑ Conventional ultrafiltration

Removal of fluids during bypass

Difficult in neonates because of small circuit

❑ Modified ultrafiltration (MUF)

Effective method in neonates and sick infants

Performed after CPB completion

Remove fluid rich in inflammatory mediators.

Thank you for your attention!