SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIO PULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME : CPB AND PERFUSION TECHNOLOGY

III YEAR

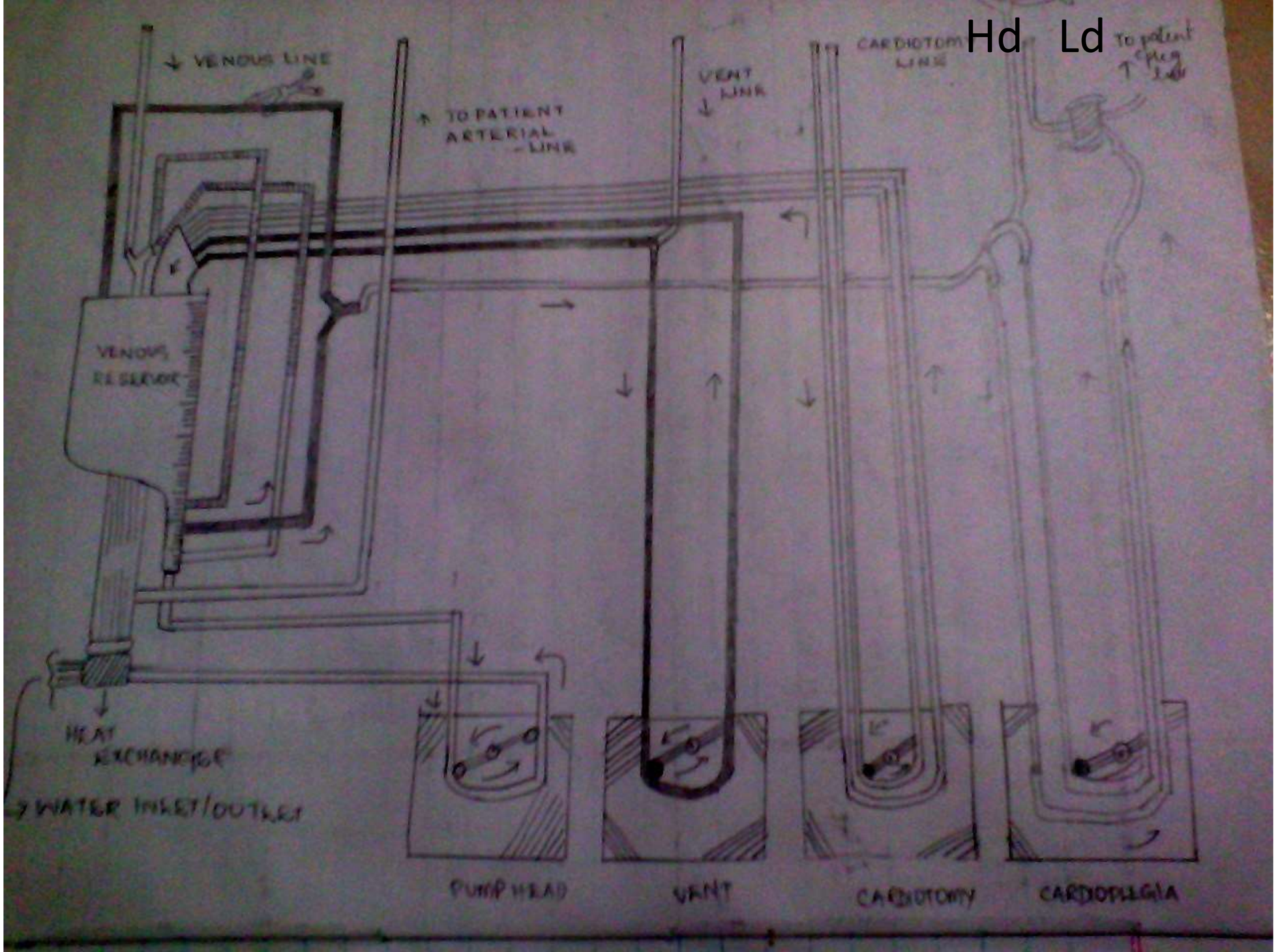
TOPIC : **INDUCED CARDIAC ARREST ND MYOCARDIAL PROTECTION**

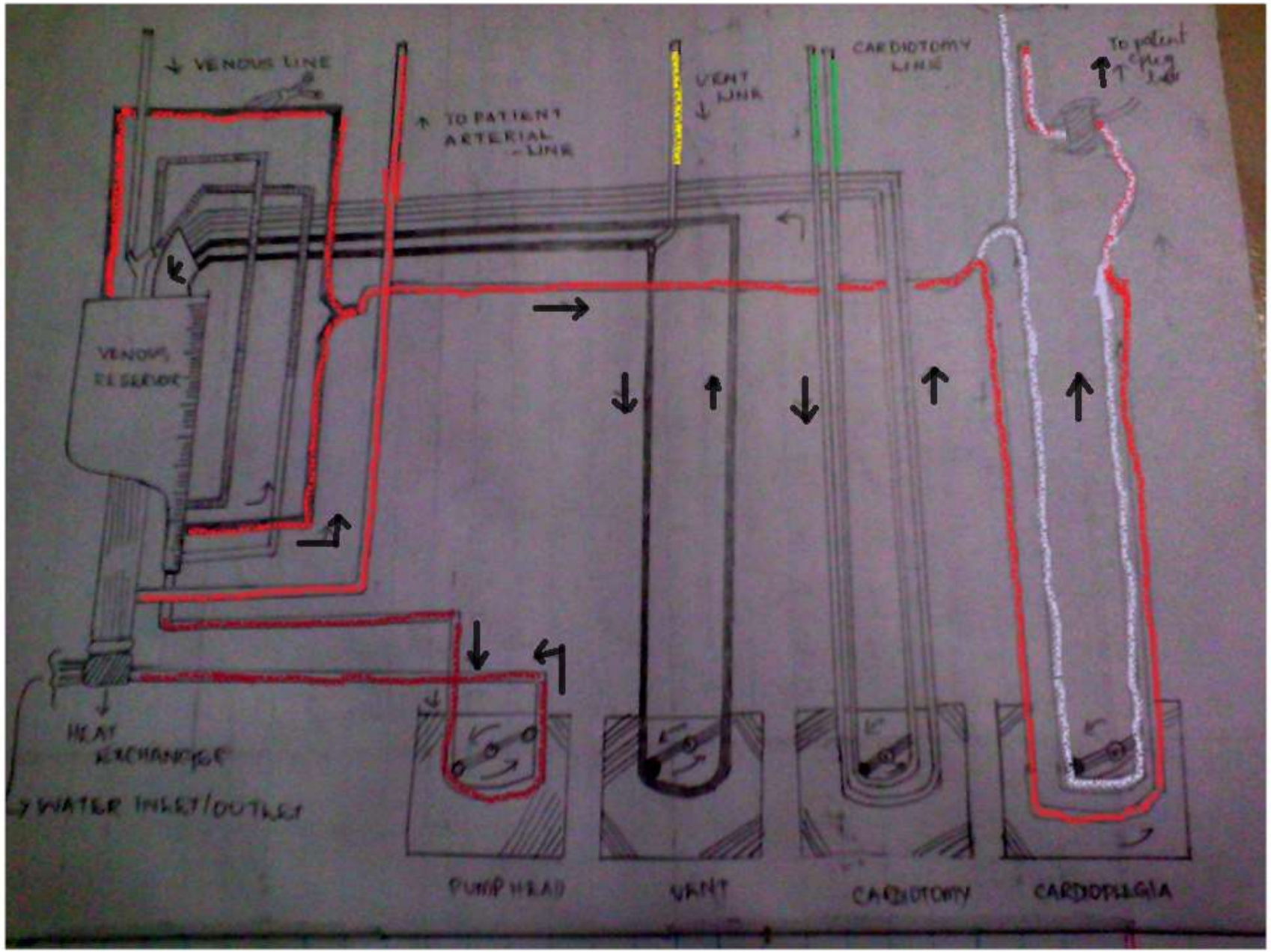

CSC 14

REMEMBER THOSE DAYS…. THE DAYS WEN

“Any surgeon who operates upon the heart, should lose the respect of his colleagues."

At the time that Billroth made that statement, cardiac surgery was indeed very hazardous because knowledge and techniques were not available to make it safe.


Hd Ld
VENOUS LINE
TO PATIENT ARTERIAL LINE
VENT LINE
CARDIOTOMY LINE
To patient
VENOUS RESERVOIR
HEAT EXCHANGER
WATER INLET/OUTLET
PUMP HEAD
VANT
CARDIOTOMY
CARDIOPLEGIA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GOALS OF MYOCARDIAL PROTECTION

- Protect against ischemic injury
- Provide a bloodless, motionless heart
- Allow effective post ischemic myocardial resuscitation
- Aids in membrane stabilization

- **The term myocardial protection encompasses more than just cardioplegia, and can be said to include things such as the perioperative management of patients with medical treatment (such as beta-blockers, etc.), or support devices (such as intra aortic balloon pumps), better anesthetic agents, and better hemodynamic management.**

HISTORY

- MELROSE -1955 -Elective cardiac arrest

- ALTERNATE ROUTES – cplegia administration and

- <u>Direct ostial cannulation</u> - ostial stenoses

- <u>Bretschneider</u> - cardioplegia based on intracellular electolyte
- Subendocardial necrosis - valve pt with nor.cor.

- Cooley et al - stone heart condition”

- ASD patients-Enzyme evidence of MI

- INTRA OP Myocardial protection ADEQUATE???

“Reintroduction of cardioplegia”

PHYSIOLOGY

•Cardioplegic solution is the means by which the ischemic myocardium is protected from cell death.

•This is achieved by reducing myocardial metabolism through a reduction in cardiac work load.

•St. Thomas' Solution
•Bretschneider Solution
•University of Wisconsin Solution
•Custodiol HTK
•Celsior

There are many cardioplegic solutions of varying additives. The only vital additive in most solutions is potassium chloride in a 20-30 mmol/L concentration range. Other additives such as mannitol, sodium bicarbonate, procaine, are of secondary importance.

LOONEY TUNES, DONA
FLIN STONES,TOM N JERRY
,POPEYE,CHOTTA BEEM.
“CARTOON”

M PLEGIA,COLD
LEGIA,CRYSTALLOID,B
LOOD
PLEGIA,INTERMITTENT
AORTIC CROSS
CLAMPING,MINIPLEGIA
,DEL NIDO……
“MYOCARDIAL
PROTECTION”
EGIA

MYOCARDIAL PROTECTION -OPTIONS

- **No cardioplegia – Fibrillation**
  Cont.bloodflow
- **Cardioplegia**

- **Type (blood vs crystalloid, cont vs intermittent)**
- **Route (antegrade vs retrograde)**
- **Temperature (warm vs cold)**
- **Composition**

TYPES

•CRYSTALLOID

❖Does not contain hemoglobin

❖Delivers dissolved oxygen only

•Can be used only with myocardial hypothermia

•BLOOD(2:1, 4:1, 8:1, blood only)

1. oxygenated environment.
2. intermittent reoxy of the heart during arrest.
3. limit hemodilution when large vol of CP used.
4. excellent buffering capacity.
5. osmotic properties.
6. electrolyte composition and pH are physiologic.

7.endogenous antioxidants and free radical scavengers.

8.Provides substrate

9.less complex than other solutions to prepare.

10.Various forms- warm, cold, hot shot

11.Better ATP replenish

12.Lower periop morbidity & mortality

ADDITIVES

KCl	Diastolic arrest
THAM/Histidine	Buffer
Mannitol	Osmolality/Free Radical Scavenger
Aspartate/Glutamate	Substrate
$MgCl_2$	Ca^{2+} antagonist
CPD	↓ free Ca^{2+} conc
Glucose	Substrate
Lignocaine, Procaine	Optimize myocardial metabolism+ prevent cell damage
Blood	O_2 carrying

CARDIOPLEGIC TEMPERATURE

- ***Cold (9 ^{0}C)***
- ***Tepid (29 ^{0}C)***
- ***Warm (37 ^{0}C)***

- Tepid CP- most effective in reducing anaerobic lactate acid release during the arrest period.

Cold Blood Cardioplegia

Advantages

- Lowers myocardial oxygen demands
- oxygenated environment.
- limit hemodilution when large volume of CP used.
- excellent buffering capacity.

Pitfalls

- Hypothermic inhibition of mitochondrial enzymes
- Shifts oxyhaemoglobin dissociation curve to left
- Activates platelets, leukocytes, complement
- Impaired membrane stabilization

WARM INDUCTION (RESUSCITATION OF THE HEART)

- severe left ventricular dysfunction
- cardiogenic shock
- 500ml –warm plegia-immediately after x clamp
- preischaemic depletion of energy stores

warm induction showed improved aerobic metabolism and LV function.

WARM REPERFUSION (HOT-SHOT)

- Terminal warm blood plegia just before x clamp removal.
  - Warm blood: 35-37 degree
- Low potassium
- Buffers
- Metabolic substrates

◉ early myocardial metabolic recovery while maintaining electro-mechanical arrest

◉ repletion of energy stores

CONTINUOUS WARM CARDIOPLEGIA

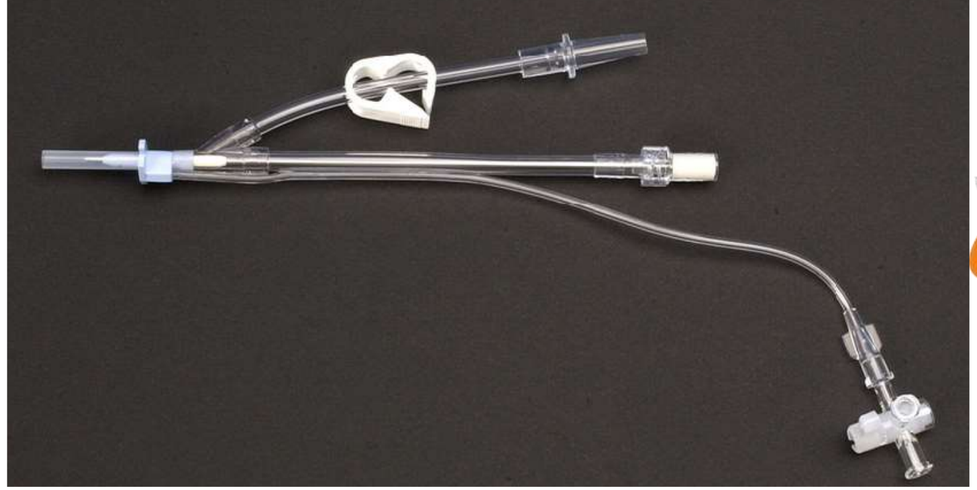
- avoidance of direct myocellular injury inflicted by any cold solution or environment
- increased rate of perioperative stroke and neurological events (randomised trial.)

- “The heart takes up oxygen over time rather than by dose, so that blood cardioplegic solutions must be delivered over a time interval, rather than by volume”

Buckberg GD

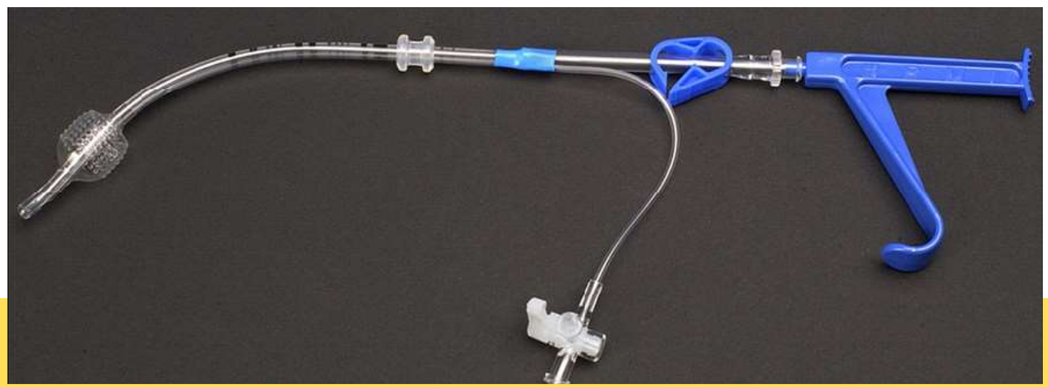
J Thorac Cardiovasc Surg 1991;102:895-903

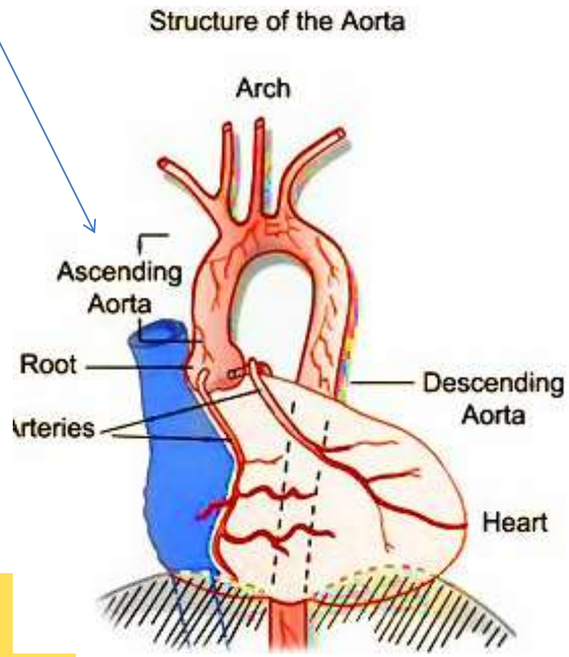
CARDIOPLEGIC ROUTE



Antegrade (aorta
- aortic root
- coronary ostium
- Coronary grafts)

- Retrograde (coronary sinus)
- Combined (ante/retro)





ANTEGRADE CARDIOPLEGIA

- Initial flow rate 150ml/min/m^2
- Initial dose- 15-20 ml/kg
- Perfusion pressure- 70-100mm Hg

Advantages

- Produces prompt arrest

Pitfalls

- poor distribution in *coronary patients*
- poor distribution in patients with *AR(when ostial cannulation is done)*
- risk of *ostial injury* from direct perfusion
- interruption of procedure during *mitral surgery/aortic surgery*

RETROGRADE CARDIOPLEGIA

- Correct catheter placement
- flow rate = 200mL/min
- perfusion pressure < 40 mmHg

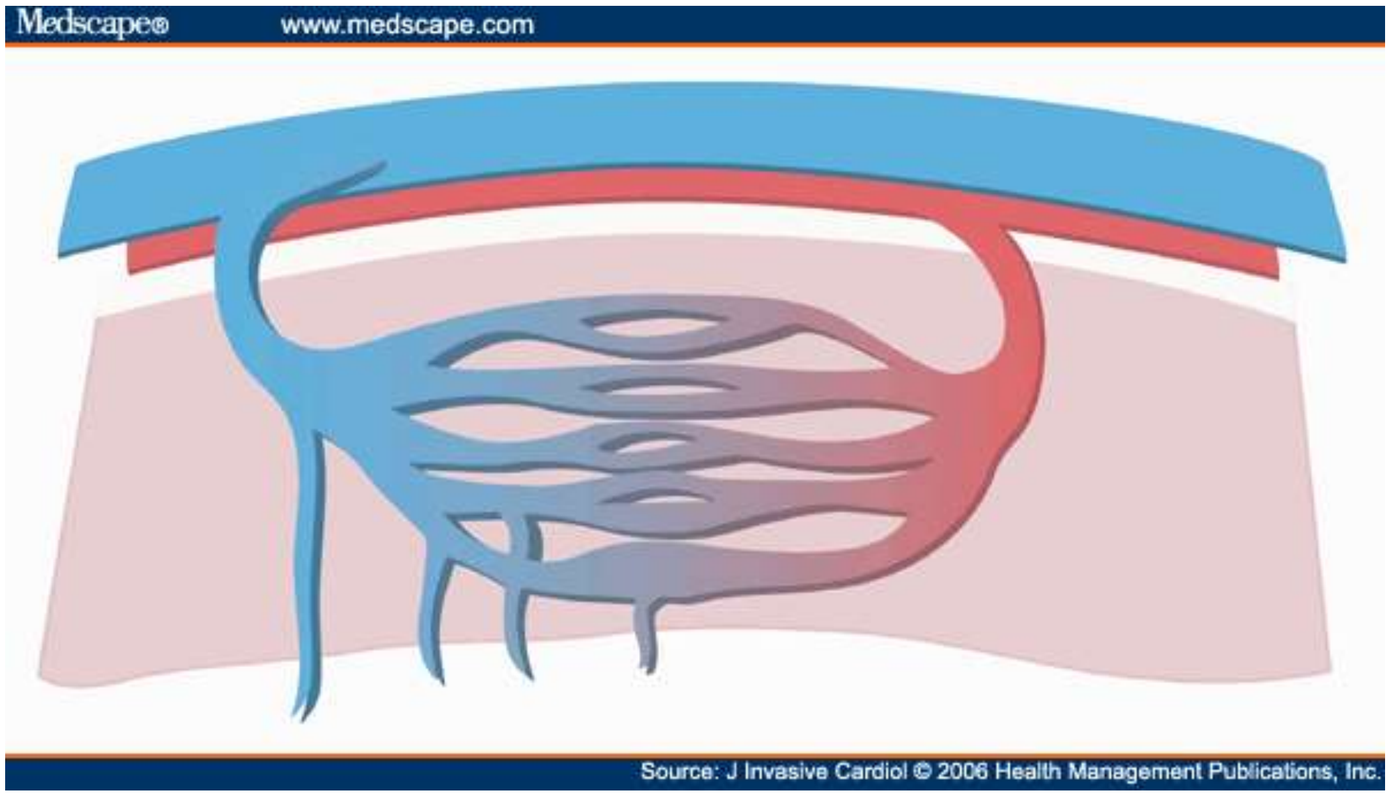
  prevent perivascular haemorrhage and oedema

Advantages

- Distribution of CP to regions supplied by occluded/stenosed vessels
- Improved subendocardial CP delivery
- Flushing of air and/or atheromatous debris

Pitfalls

- Shunting of CP into ventricular cavities via Thebesian channels
- Perfusion defects especially right ventricle and posterior septal regions
- Protection of the RV is suboptimal?



A schematic representation of the Thebesian venous system showing direct channels carrying venous drainage into the cardiac chambers.

COMBINED (ANTE/RETRO)

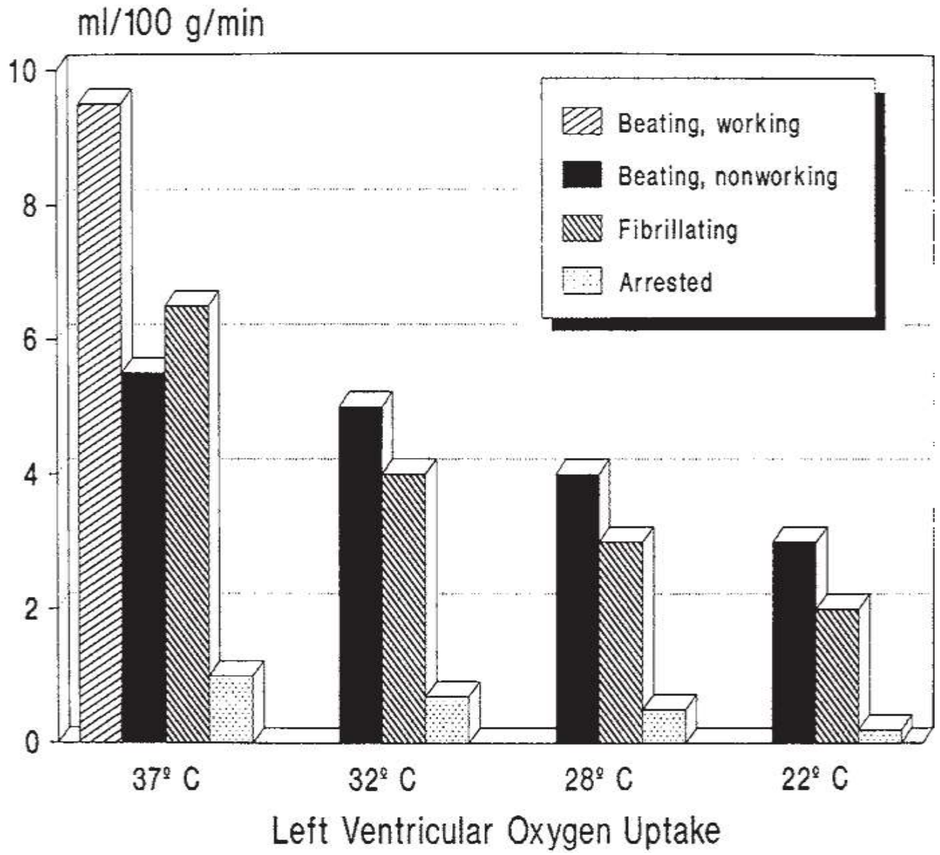
Various techniques

- Arrest with antegrade, additional doses given retrogradely with venting of aortic root
- Alternating technique-retrograde cardioplegia administered frequently+ interrupted antegrade cardioplegia down each completed graft
- Simultaneous method- retrograde continued while antegrade is given down each graft.

HYPOTHERMIA

- **Basal metabolism in the absence of myocardial contraction,the myocyte still requires oxygen for basic “house keeping” functions**

- **This basal metabolic need can be further reduced with hypothermia**



Myocardial oxygen demand (mvO2).
Notice that the most significant decrease in mvO2 occurs with the induction of the arrested state and secondarily by the production
of hypothermia.

•The oxygen consumption in the working ventricle is -- 8mL of O2/100g of myocardium/min

•The oxygen consumption in the empty beating heart is -- 5.6mL of O2/100g of myocardium/min

•The oxygen consumption in the potassium arrested heart is -- 1.1mL of O2 /100g of

	Oxygen Demand	Reduction
◉ Normothermic Arrest (37°C)	1mL/100g/min	90%
◉ Hypothermic Arrest (22°C)	0.30 mL/100g/min	97%
◉ Hypothermic Arrest (10°C)	0.14 mL/100g/min	~ 97%

NON CARDIOPLEGIC TECHNIQUES

INTERMITTENT AOXCL + VF + MODERATE HYPOTHERMIC PERFUSION (30°C TO 32°C)

- Quiet field (during ventricular fibrillation)
- Avoids the profound metabolic changes that occur with more prolonged periods of ischemia.
- Duration of fibrillation till completion of distals
- Heart defib, proximals using an aortic partial clamp

SYSTEMIC HYPOTHERMIA AND ELECTIVE FIBRILLATORY ARREST

- Systemic hypothermia (25-28°C)
- Elective fibrillatory arrest
- Maintenance of perfusion pressure between 80-100 mmHg
- Surgical field may be obscured by blood during revascularization

CONTINOUS CORONARY PERFUSION

- Continous blood perfusion of beating heart
- Attempt to mimic physiologic state
- Aortic root/ ostial infusion
- Used in OPCAB
- Unsafe for open heart
- Continous retro + Ao XCl- open heart

Dose / Volume

- Adult: 1200ml initial + 300 ml subsequently

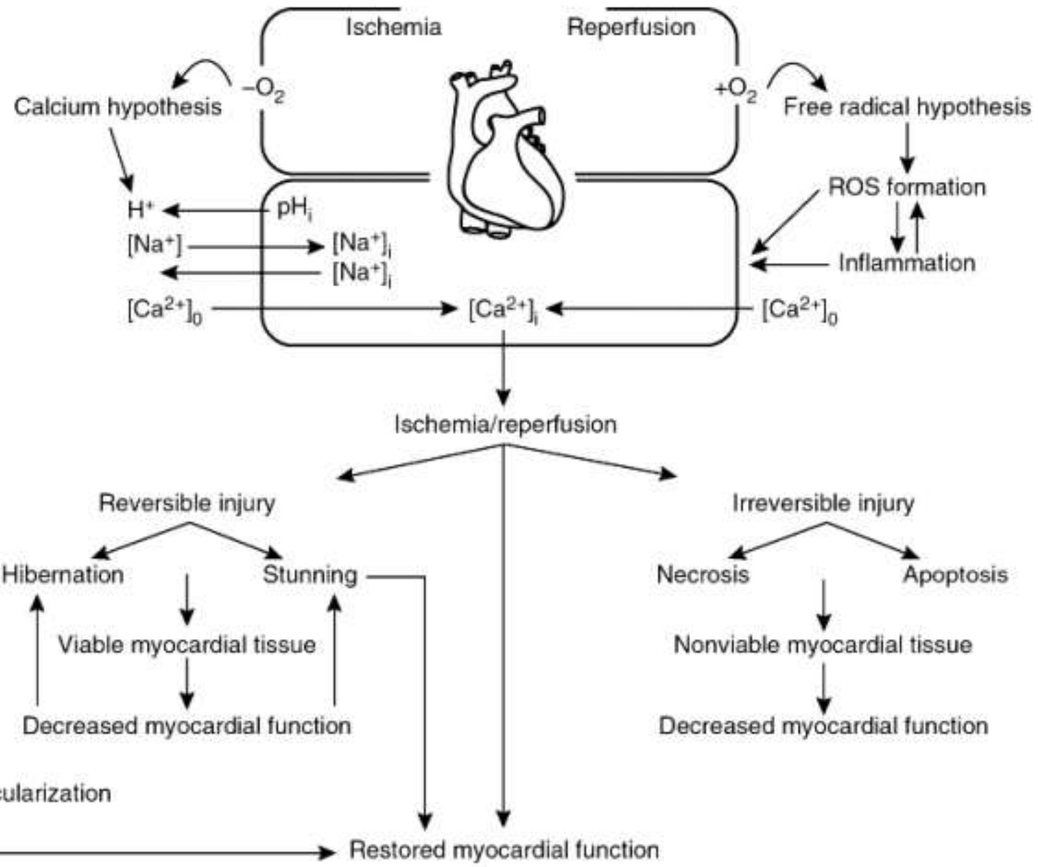
- or <u>15-20 ml/kg</u>

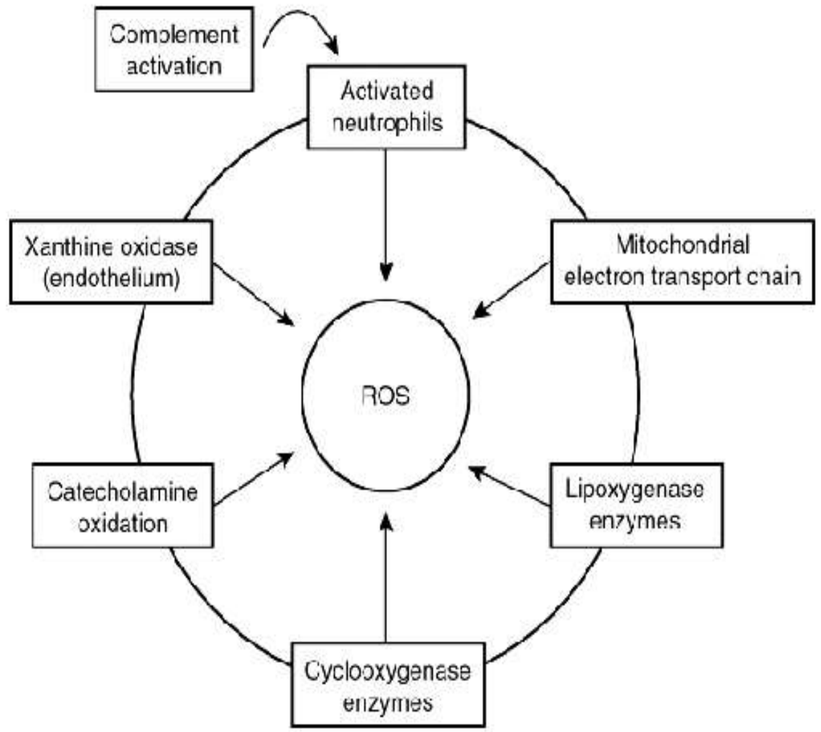
- **Pediatrics:** **BW < 15kg: 30ml/kg.**

BW: 15-25kg: 25ml/kg.

BW >25kg: 20 ml/kg

ISCHEMIC / REPERFUSION INJURY





Sources of Reactive oxygen species generation.

INNOVATIONS

	DEL NIDO	IN CMC VELLORE
B:C RATION		
>BLOOD : CLEAR	4:1	4:1
>KCL	2 Meq/ml (13 ml)	16 mmol/20ml
>NaHCO3(8.4%)	13ml	30ml(7.4%)
>Mannitol(20%)	16.3 ml	-------
>Magnesium(50%)	4 ml(MgSo4)	16 mmol/20ml(Mgcl2)
>lidocaine(1%)	13ml	1.0mmol/20ml(Procaine)
>Dose	20ml/kg	30ml/kg
>Temperature	8-12 degree c	8-12 degree c
> BASE	blood and Iveolyte -p from the circuit @ 4:1 ratio.	blood and Lactated ringer solution @ ratio 4:1

Miniplegia

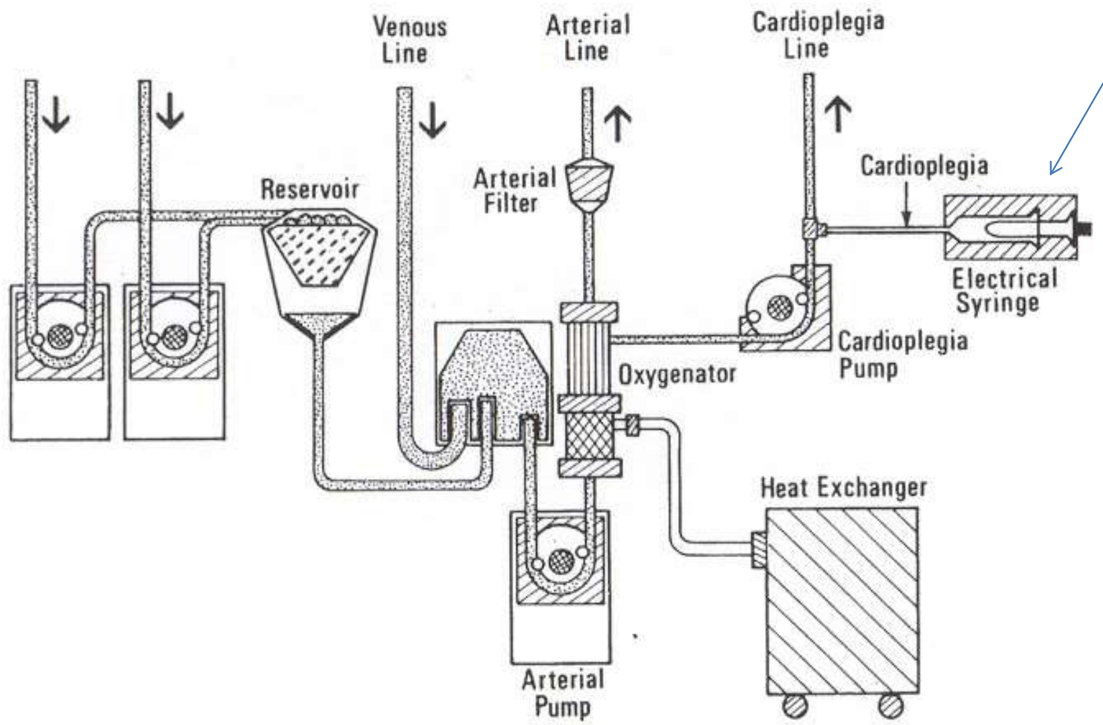


Fig 1. Cardioplegia set-up.

Miniplegia?

Pros

- Simple
- Cheap
- Less fluid
- Possible to do continuous

Cons

- Less precise
- No safety feedback
- Manually adjusted
- Higher risk of error

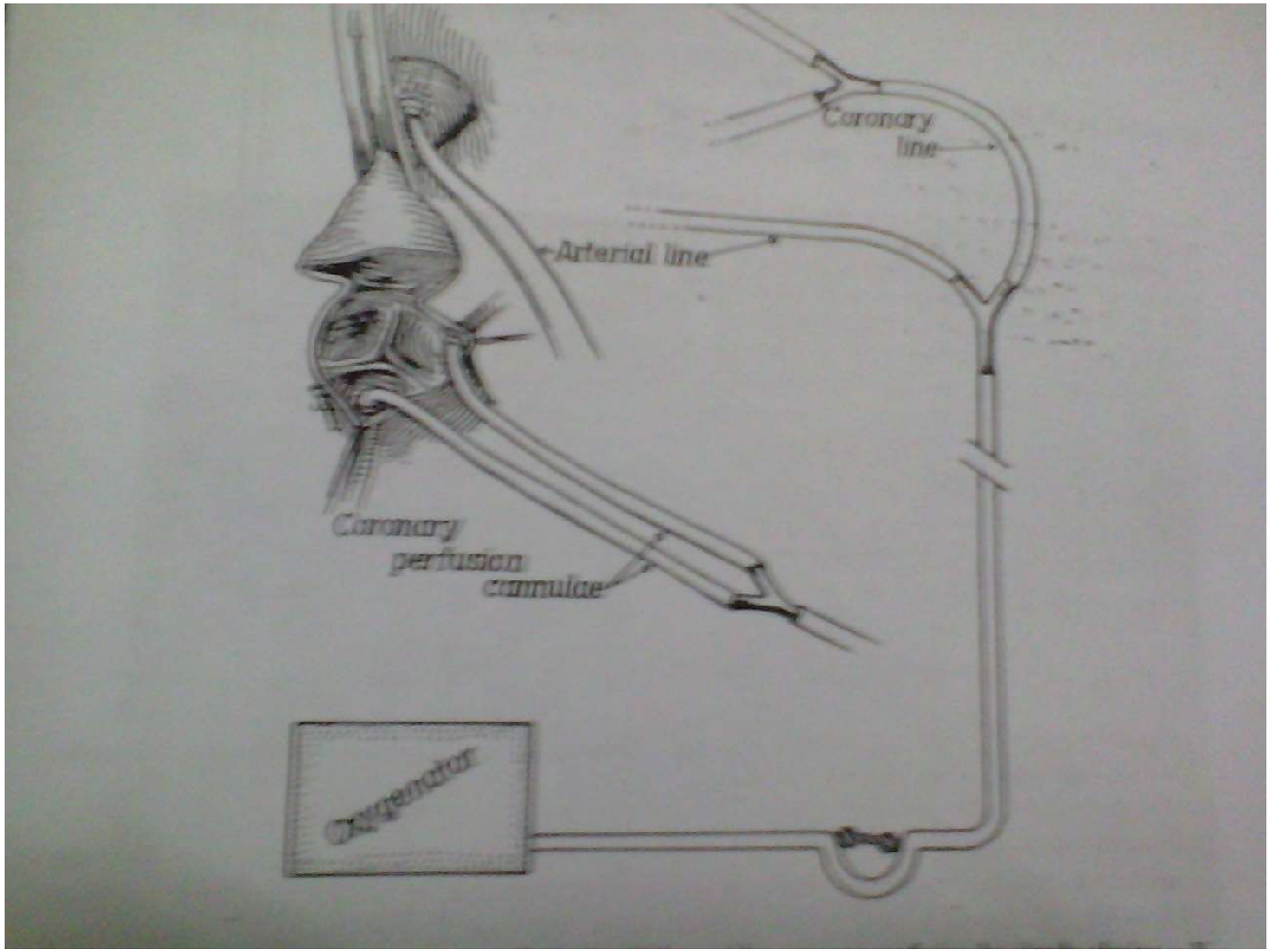
WHAT DO WE USE???

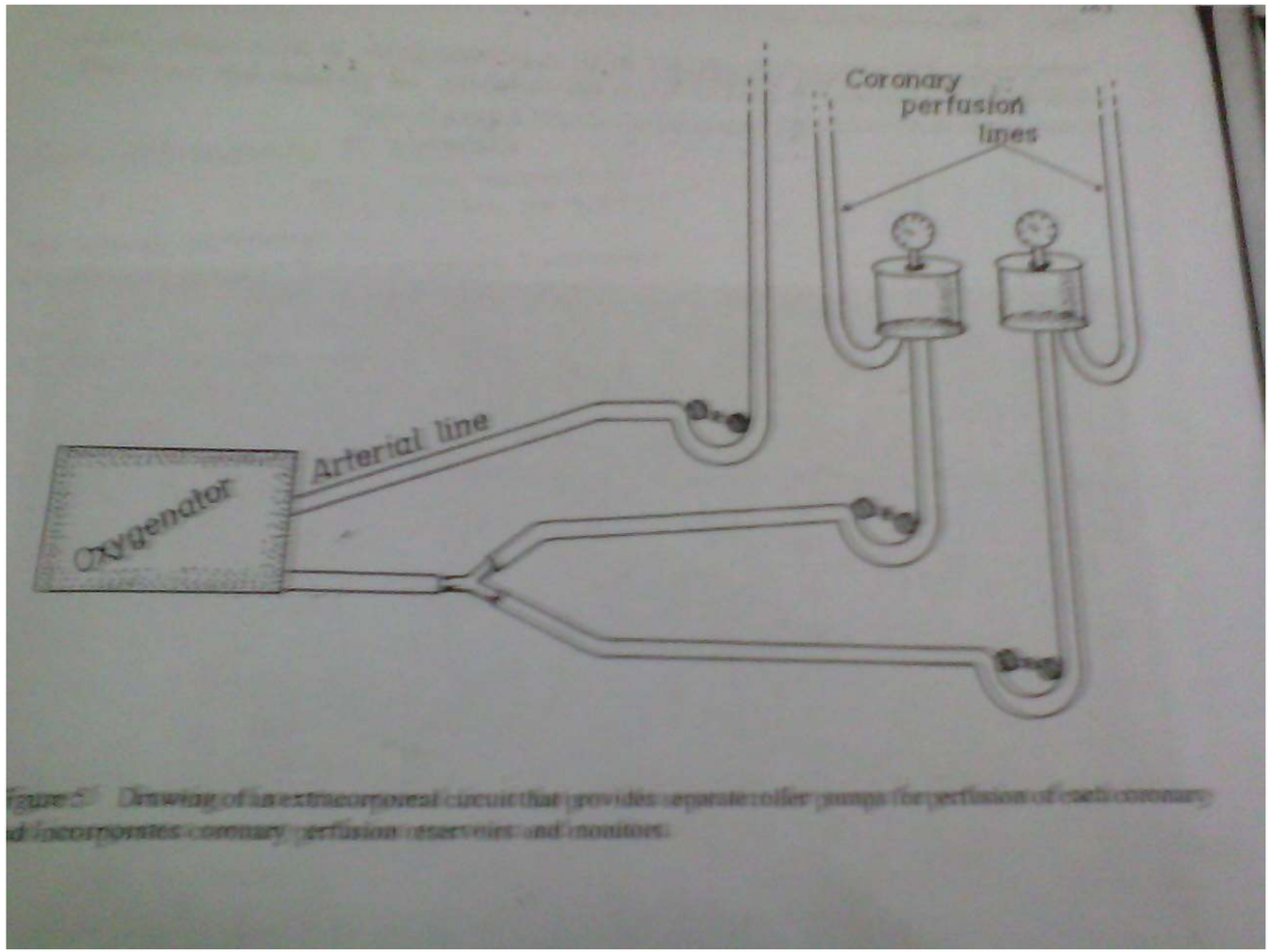
HIGH DOSE : IN 430 ML RINGER LACTATE BAG(2.5 MMOL K+)
40 ML CARDIOLPEGIA(32 MMOL K+)
30 ML BICARB
5 ML KCL(8 MMOL K+)
TOTALLY HIG DOSE CONTAINS 42.5 MMOL K+
AFTER DILUTION 22MMOL REACHES THE PATIENT

LOW DOSE : IN 460 ML RINGER LACTATE
20 ML CARDIOPLEGIA(16MMOL K+)
15 ML BICARB
TOTALLY LOW DOSE CONTAINS 18.5 MMOL K+
AFTER DILUTION 11MMOL K+ REACHES THE PATIENT

Therefore, institutional and the individual surgeon's experience remain the most important determinants of myocardial protection strategy at this moment.

Warm induction device


Coronary line
Arterial line
Coronary perfusion cannulae
Oxygenator


Coronary
perfusion
lines
Arterial line
Oxygenator

AFTER ALL THIS , I HOPE YOU DON’T NEED THIS TO WAKE YOU UP!


Thank
you!