NONCARDIAC SURGERY IN CHILDREN WITH CONGENTIAL HEART DISEASE

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CHD : A BACKGROUND SUMMARY

CHD is the most common birth defect : around 1 in 125

Importantly, these childen live longer, survive despite life limiting disability and reach adulthood more than ever

Children with CHD are prone to all of the illnesses of childhood and may present to non specialist centres for a whole host of elective and non elective procedures

CHD is present as a spectrum : good evidence suggesting increased mortality regardless of defect, but consider a small, non reversing ASD vs the univentricular child…..

HOW TO STRATIFY?

Very difficult to apply a one size fits all model : too many variables

Most important factors are:

- **Physiological status of the child**
- **Complexity of stage of repair**
- **(Age of the child)**

HOW TO STRATIFY?

Not a simple process

Consider 3 main points

- Physiology
- Location
- Type of surgery

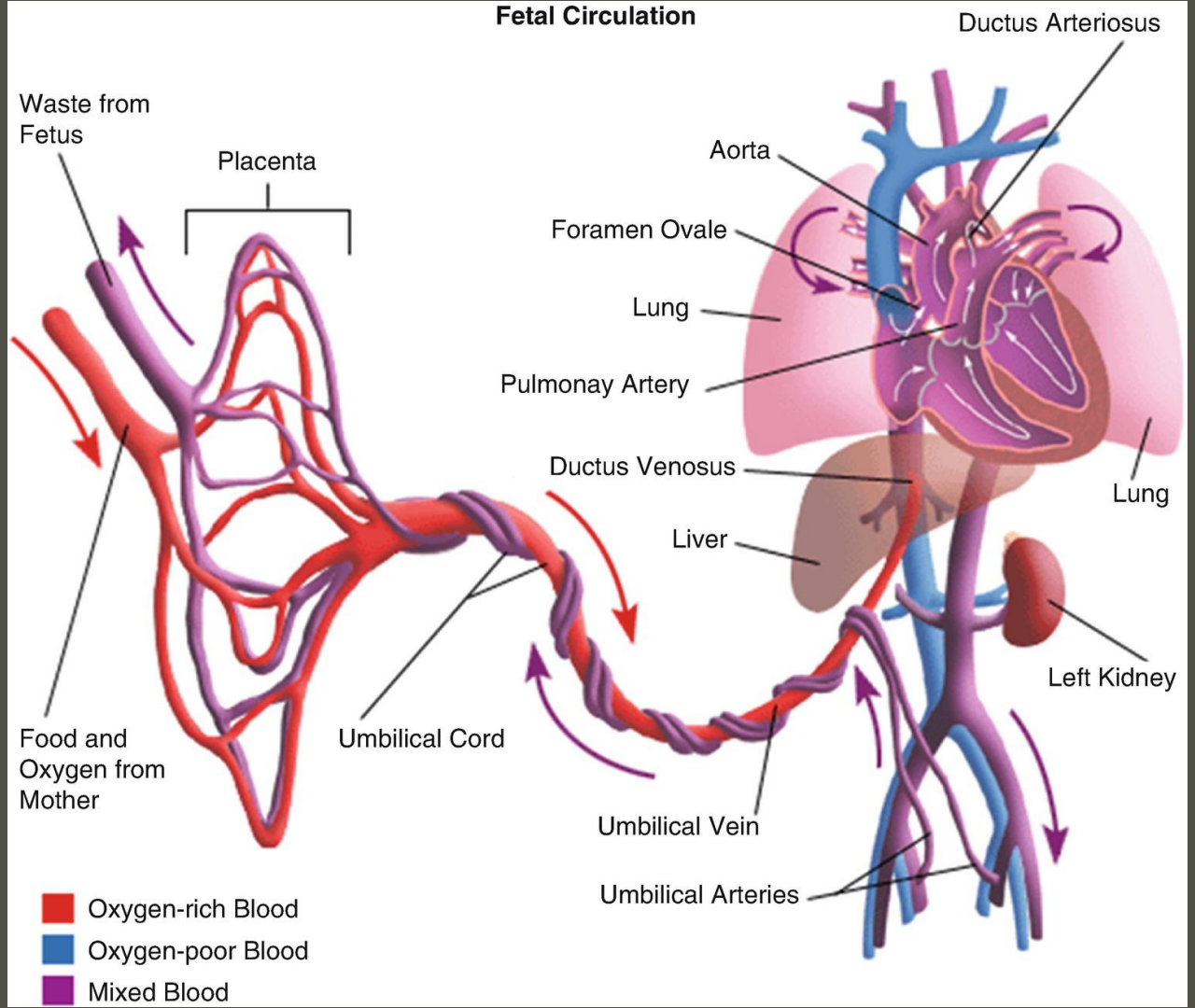
A combination of all of the above will determine the individual level of risk for the patient.

THE CIRCULATIONS

Normal or “Series” circulations

Parallel or “Balanced” circulation

Univentricular Circulations


Fetal Circulation
Ductus Arteriosus
Waste from Fetus
Placenta
Aorta
Foramen Ovale
Lung
Pulmonay Artery
Ductus Venosus
Lung
Liver
Left Kidney
Food and Oxygen from Mother
Umbilical Cord
Umbilical Vein
Umbilical Arteries
Oxygen-rich Blood
Oxygen-poor Blood
Mixed Blood

SERIES CIRCULATIONS ("NORMAL")

The normal state of things

- This is the goal of corrective surgery (usually)

A systemic and pulmonary circulation working in tandem, without mixing of oxygenated and deoxygenated blood

Large, uncorrected defects may behave as a parallel or balanced circulation dependent on PVR and SVR ratio (Eisenmengers phenomenon)

PARALLEL ("BALANCED") CIRCULATION

Communication of the pulmonary and systemic circulations

Examples:

any large uncorrected ASD/VSD

Hypoplastic Left heart Syndrome

BT shunt (staged repair)

The flow of blood is a balance of PVR / SVR : usually PVR is a function of SVR (as expected) but…..

PARALLEL ("BALANCED") CIRCULATION

Communication of the 2 circulations presents many issues for anaesthesia:

The knife edge of balance can be influenced by almost everything we do, e.g.:

- Excessive oxygen administration will cause pulmonary vasodilation : systemic perfusion reduces
- Large doses of myocardial/SVR depressant drugs (i.e. almost all induction agents) may cause flow reversal with excessive pulmonary bloodflow
- High PEEP ventilation can limit pulmonary bloodflow causing cyanosis and may precipitate a fluid overload state

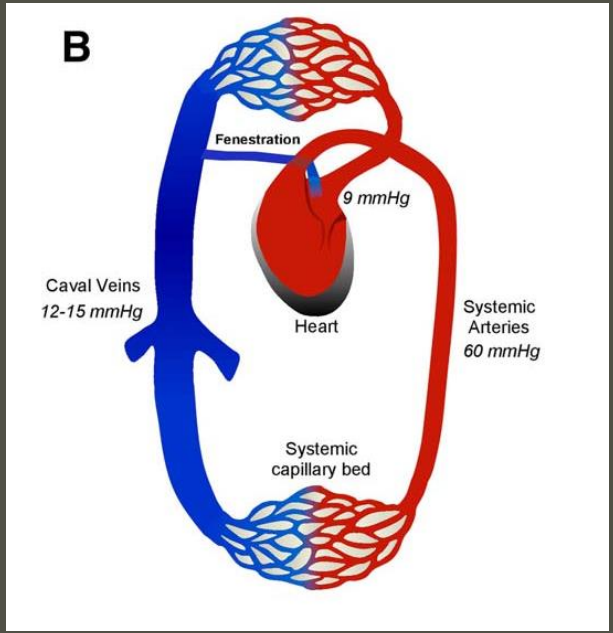
UNIVENTRICULAR CIRCULATIONS

Palliative management of non correctable CHD

Systemic flow is a function of myocardial work

Blood flows to the lungs passively

The end result is the **Fontan Circulation**



UNIVENTRICULAR CIRCULATIONS

Extremely challenging, regardless of stage of correction

Children should be transferred and managed in specialist centres

Whole host of anaesthetic issues with **no single strategy** fitting all situations:

Spontaneous breathing causes negative intrathoracic pressures and augments PBF

IPPV controls minute volume and oxygenation, but at the cost of pulmonary bloodflow

High risk	Intermediate risk	Low risk
Physiologically poorly compensated and/or presence of major complications (a) Cardiac failure (b) Pulmonary hypertension (c) Arrhythmias (d) Cyanosis	Physiologically normal or well compensated	Physiologically normal or well compensated
Complex lesions (single-ventricle or balanced circulation physiology, cardiomyopathy, aortic stenosis)	Simple lesions	Simple lesions
Major surgery (intraperitoneal, intrathoracic, anticipated major blood loss requiring transfusion)	Major surgery (intraperitoneal, intrathoracic, anticipated major blood loss requiring transfusion)	Minor (or body surface) surgery
Under 2 yr old	Under 2 yr old	Over 2 yr old
Emergency surgery	Emergency surgery	Elective surgery
Preoperative hospital stay more than 10 days	Preoperative hospital stay more than 10 days	Preoperative hospital stay less than 10 days
ASA physical status IV or V	ASA physical status IV or V	ASA physical status I–III

PHYSIOLOGICAL STATUS : WHAT IS OK?

No child is going to tell you how well they climb the stairs

We can look for **4 major risk factors for cardiac decompensation**

Cardiac failure

Pulmonary hypertension

Arrhythmias

Cyanosis

DETECTIVE WORK

History

Examination

Investigation

CYANOSIS AND ARRHYTHMIAS

Easy to detect and quantify : investigation based

All children with CHD should have a perioperative ECG

Common ECG findings: RBBB

Sinister ECG findings : Ventricular ectopics : **30% will die suddenly**

Cyanosis is a feature of uncorrected CHD. Typically represents a high risk group.

Tend to be significantly co-morbid

HEART FAILURE

Signs and symptoms differ with age. Universal features include:

Tachypnoea,

Tachycardia,

Sweating

Cool peripheries

In infants

Poor feeding,

Failure to gain weight,

Hepatomegaly

Children with cardiac failure undergoing non-cardiac surgery or investigations under general anaesthesia showed 10% suffered cardiac arrest and 96% required perioperative inotropic support

PULMONARY HYPERTENSION

PA pressure (PAP) >25 mm Hg at rest or 30 mm Hg during exercise

Typically screened for with TTE : challenging. Confirmed with cardiac catheterisation.

Risk of fatal pHTN crisis at diagnosis = 0.5%

Independent predictor of morbidity

Patients should be treated at specialist centre

CASE EXAMPLE : ELECTIVE TONSILLECTOMY AND SOME KIND OF HEART SURGERY….

2 year old male child

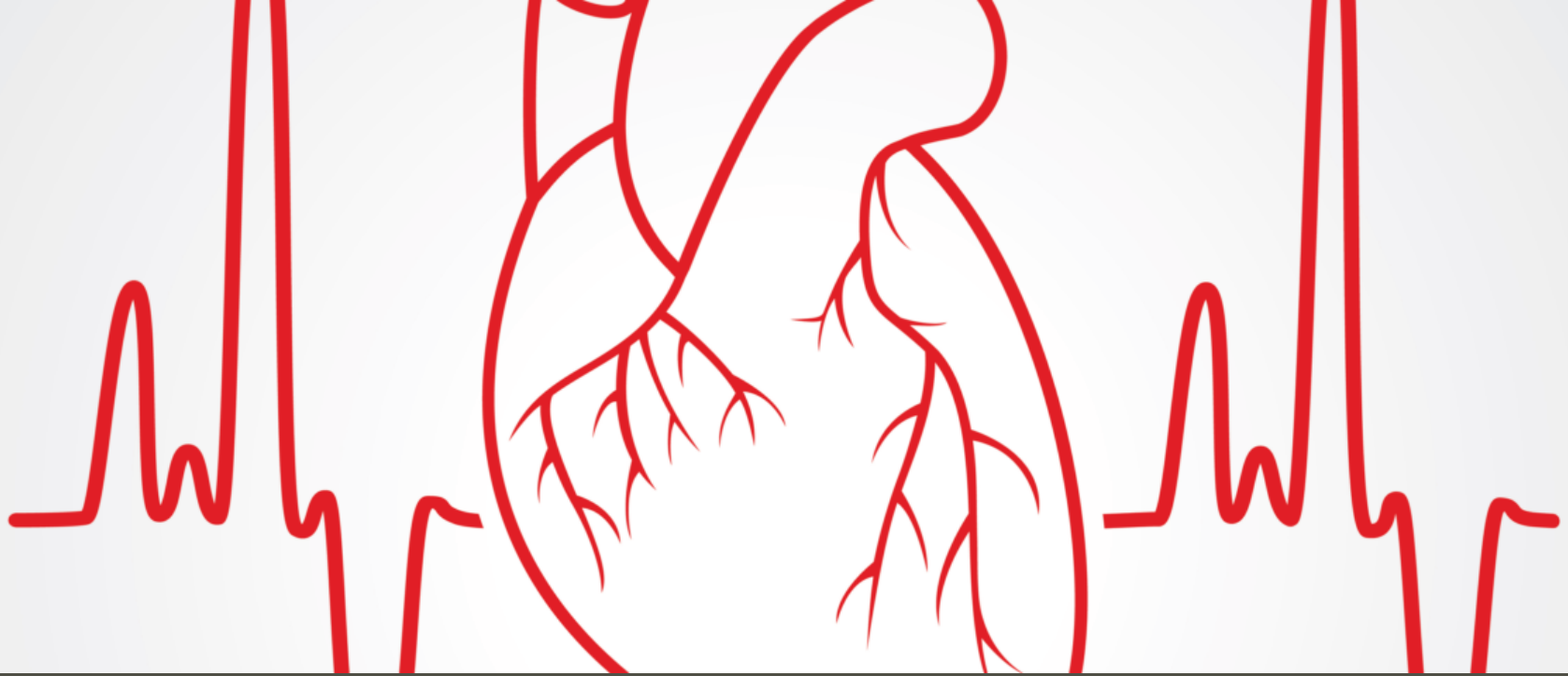
History of heart surgery at 6 months of age

Mum says he's been ok since

Still being followed up at regional centre 2-3 times a year

Always getting colds and runny noses

Snores terribly at night



PROBLEMS?

TETRALOGY OF FALLOT

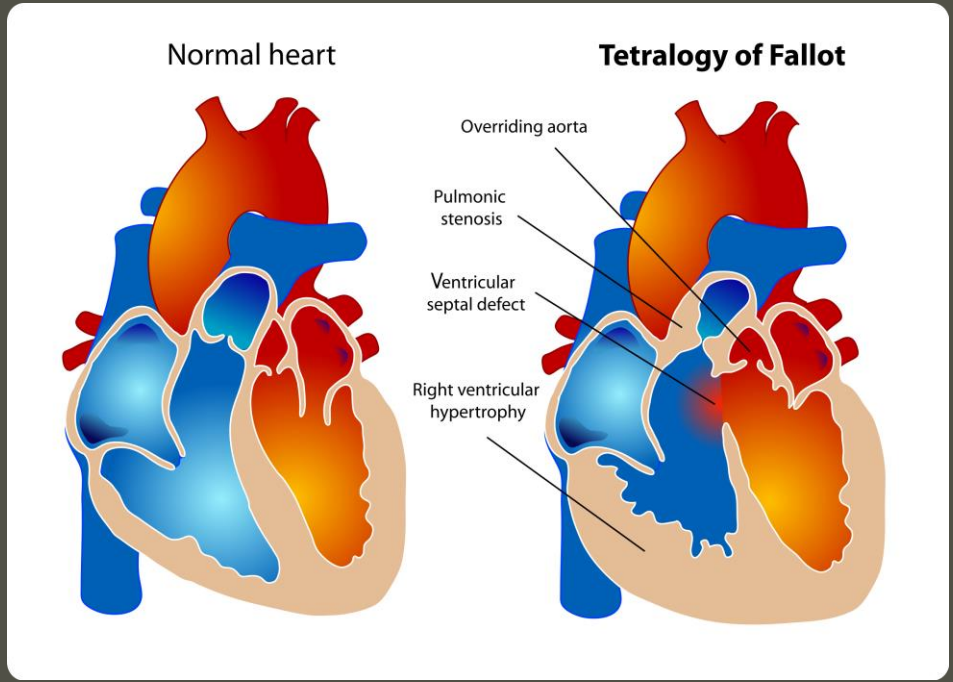
Most common form of CHD

Multiple associated conditions

Classical feature of cyanotic spells

Right ventricular obstruction with the VSD leads to a large right to left shunt

Surgical correction is indicated in the first year of life

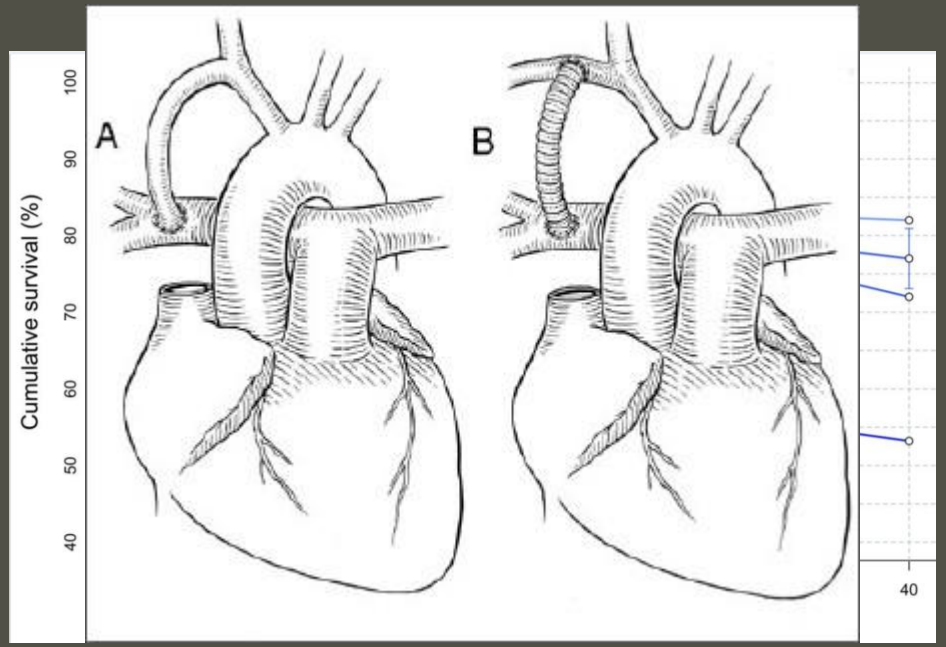


TETRALOGY OF FALLOT

Beware the palliatively corrected young child with a BTS

Surgical repair of TOF does NOT restore a “normal” heart:

- Residual VSD
- Degree of RVOTO
- Valvular incompetence
- Poorly compliant myocardium
- Arrythmia



RISK STRATIFYING

High risk	Intermediate risk	Low risk
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ANAESTHESIA FOR CORRECTED TOF

Review all available information

Risk stratify and discuss with regional centre

Preoperative

Intraoperative

Postoperative

Goals

Maintain SVR & PVR

Maintain sinus rhythm

Avoid exacerbating shunt fraction

PREOPERATIVE

Premedication : consider using to reduce anxiety

Can precipitate cyanotic spell with residual VSD/RVOTO

How to administer?

Traumatic vs Atraumatic methods

Minimise fasting +++

Orally

Midazolam : 0.25 -1 mg/kg

Ketamine: 2-4mg/kg

IV

Midazolam in small titated amounts, e.g. 0.05mg/kg

Ketamine 1-2mg/kg

Goals

Maintain SVR & PVR

Maintain sinus rhythm

Avoid exacerbating shunt fraction

INDUCTION

Many ways to do things

Inhalational induction

IV induction with ketamine : ideal induction agent

Opiod use recommended : cardiostability

Be patient

Airway management

Discuss with surgeons re: LMA vs ETT

Avoid histamine releasing NMBs

Implication for reversal of BIQ class drugs : neostigmine/atropine use

MAINTENANCE

Volatile vs TIVA

Desflurane best avoided

Nitrous best avoided

Isoflurane / Sevoflurane most commonly used as maintenance

TIVA reserved for expert users

Propofol main issues:

1. Bolus dosing at induction/titration can produce profound changes in SVR → shunt dynamics
2. Theoretical risk of accumulation
3. No accounting for changes in onset speed due to shunt dynamics in pump

MAINTENANCE

Manage periods of sympathetic stimulation:

Robust analgesia intraop, e.g fentanyl/morphine

Deepening plane of anaesthesia

Maintain SVR, PVR and restore euvolaemia

Avoid and manage

Hypothermia

Acid/Base disturbance

Hypercarbia

Hyperoxia

All will alter SVR/PVR dynamics and relationships

EXTUBATION AND POST OP

Reversal of NMB must be complete

Technique depends on agent used

Consider LMA exchange

Deep extubation in experienced hands

Precautions re: soiled airway unchanged.

Post operatively

Risk stratified

Ideally increased period of close monitoring, e.g. PACU or paediatric HDU

Not suitable candidates (typically) for day case surgery

SUMMARY

Investigate, stratify and **discuss** CHD patients with their/our regional centre

Do not anaesthetise high risk patients in peripheral sites

Children with CHD have increased risk of perioperative morbidity and mortality.

Highest risk factors are complex disease, poorly compensated physiology, and the presence of long-term complications.

There are a variety of ways to anaesthetise these children. Be vigilant, patient and use a balanced technique