Anesthetic Considerations in Patients with Congenital Heart Disease undergoing Non-cardiac Surgery

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Outline

- Anesthetic considerations
- Type of CHD circulation
- Risk classification of CHD patients
  - Cyanotic heart disease
  - Infective endocarditis prophylaxis
  - Case examples

Anesthetic Considerations

1. Knowledge of underlying lesion and type of circulation: change in SVR/PVR? SpO2?

Underlying Lesions

- Obtain information about cardiac lesion, altered physiology, its implication under anesthesia

- Group of patients with CHD

  - Non-operated patients

  - Previous palliative surgery

  - Previous corrective surgery

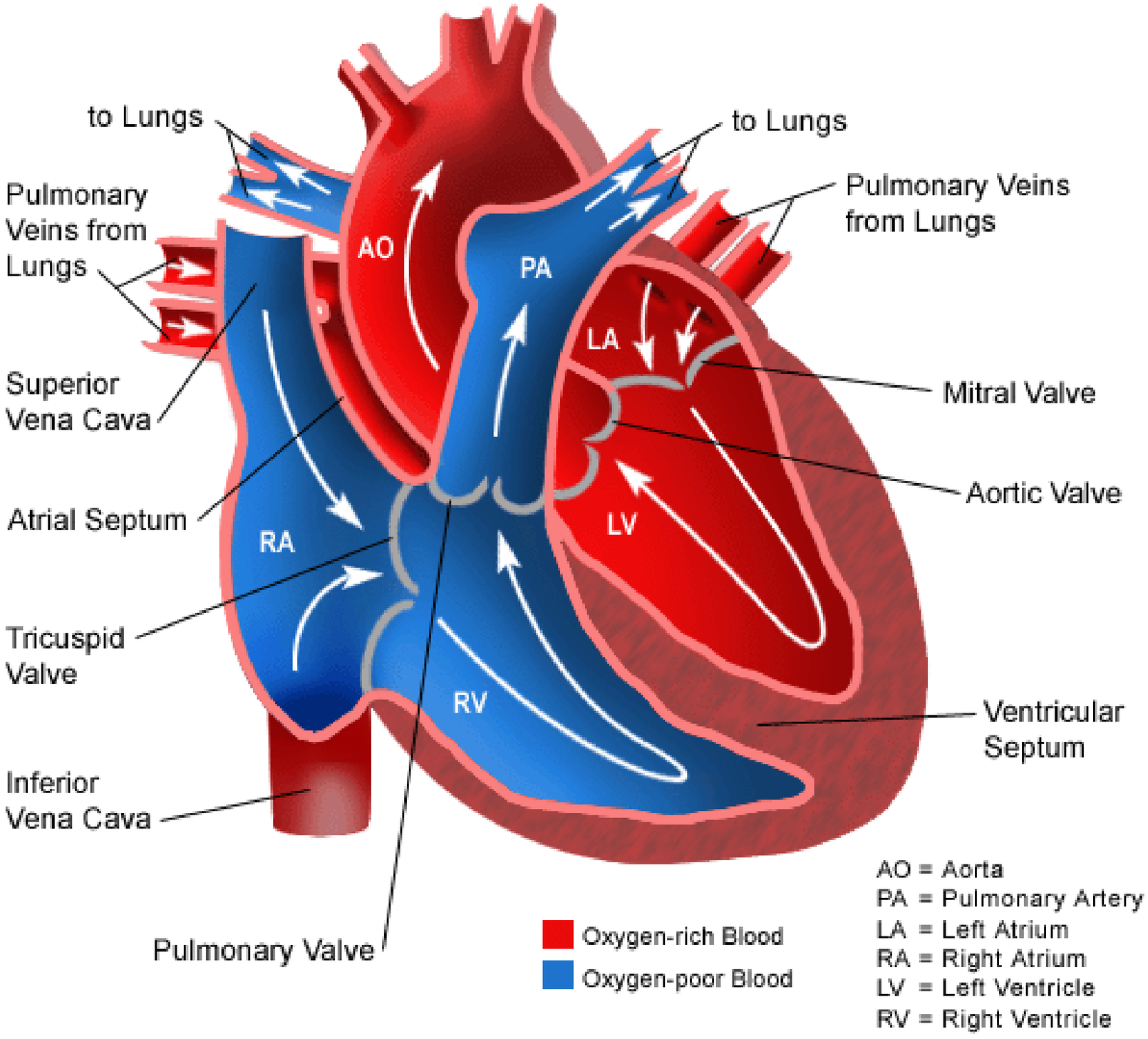
Types of Circulation

1. Normal circulation

2. Parallel or Balanced Circulation

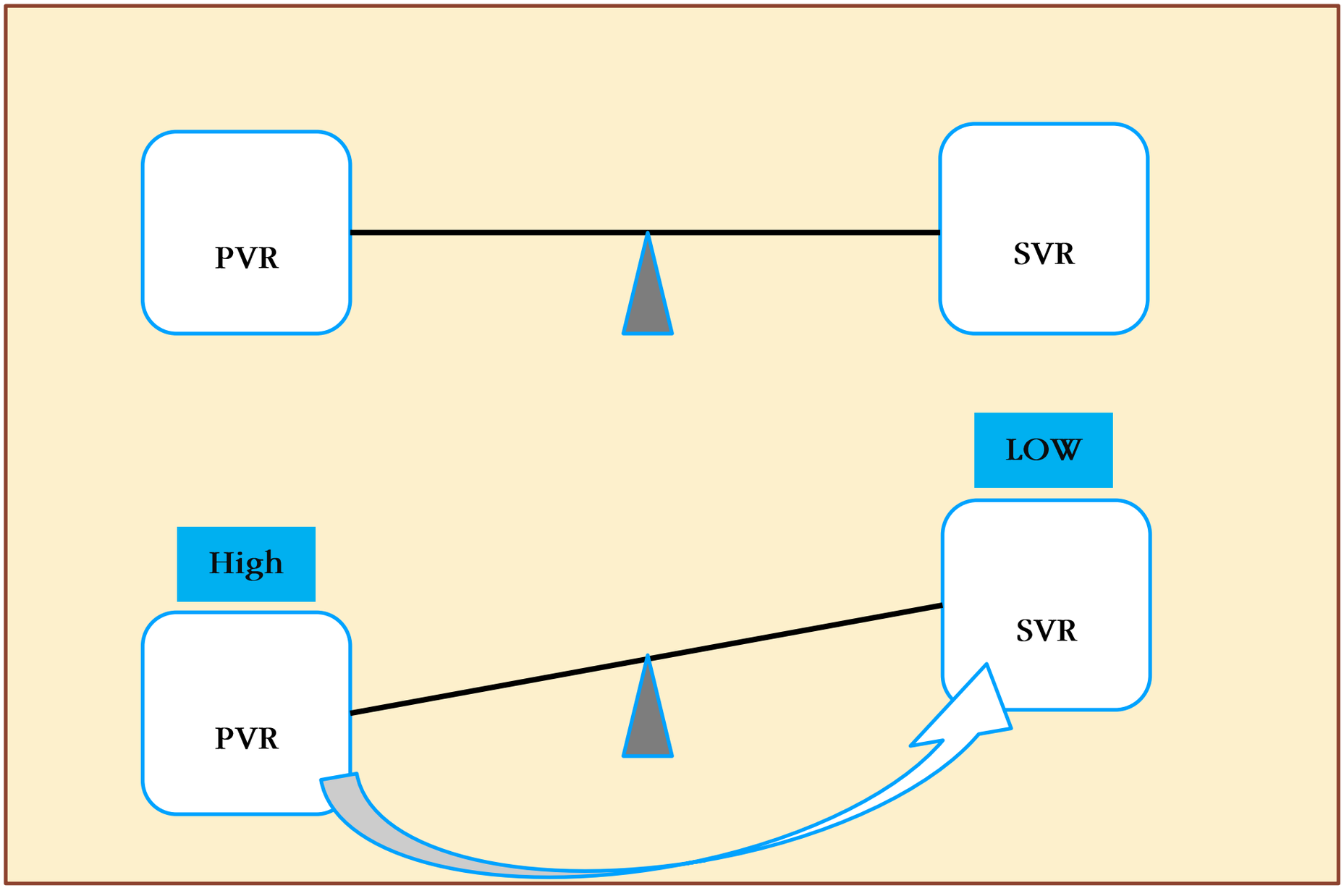
3. Single Ventricular Circulation

1. Normal or Series Circulation



2. Parallel or Balanced Circulation

Ex. Large ASD, VSD, truncus arteriosus.



Effects of respiratory maneuvers on pulmonary and systemic vascular resistance

Treatment	PVR	SVR	Q_p/Q_s
Increase FiO_2	Decrease	Increase	Increase
Increase CO_2	Increase	Decrease	Decrease
Increase pH	Decrease	Increase	Increase
PEEP	Increase	No effect	Decrease

Abbreviations: FiO_2, fraction of inspired oxygen; PEEP, positive end-expiratory pressure; PVR, pulmonary vascular resistance; SVR, systemic vascular resistance.

Atrial Septal Defect

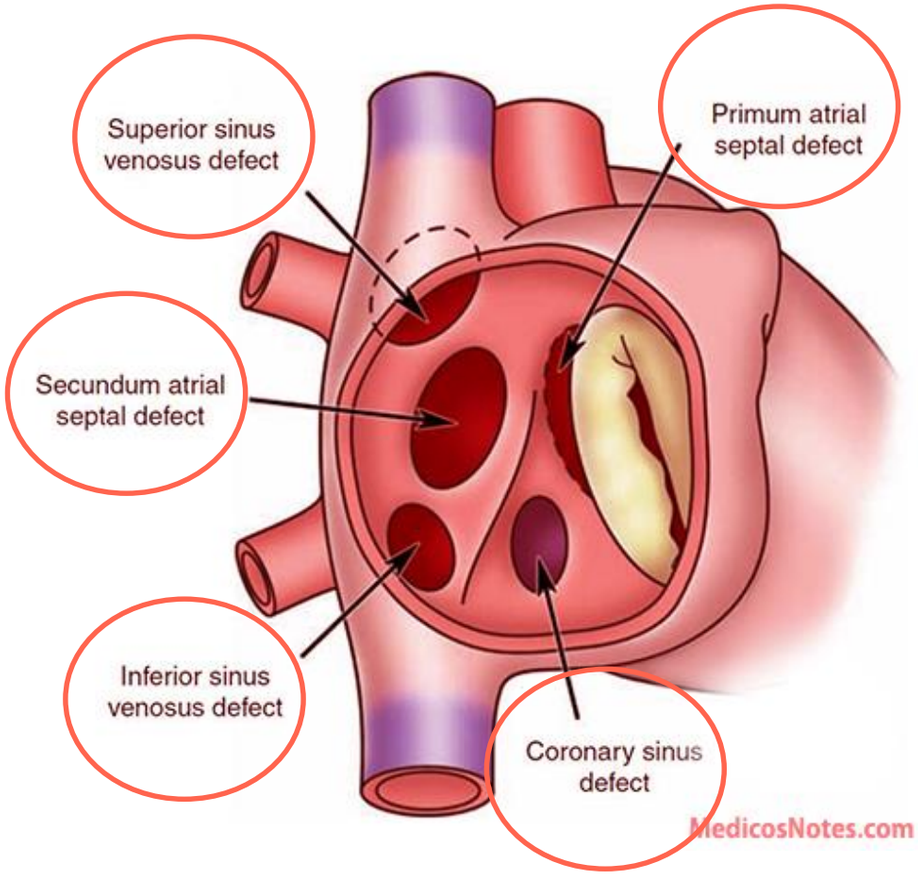
Types:

Ostium secundum 75%

Ostium primum 15%

Sinus venosus 10%

Coronary sinus rare



Atrial Septal Defect

Physiology: left to right shunt

Preop: rarely cause symptoms, CHF

Surgery: sutures, pericardial patch, cardiac catheterization

Postop: SA node injury and dysrhythmias (immediate postop), post pericardiotomy syndrome (first few days)

Ventricular Septal Defect

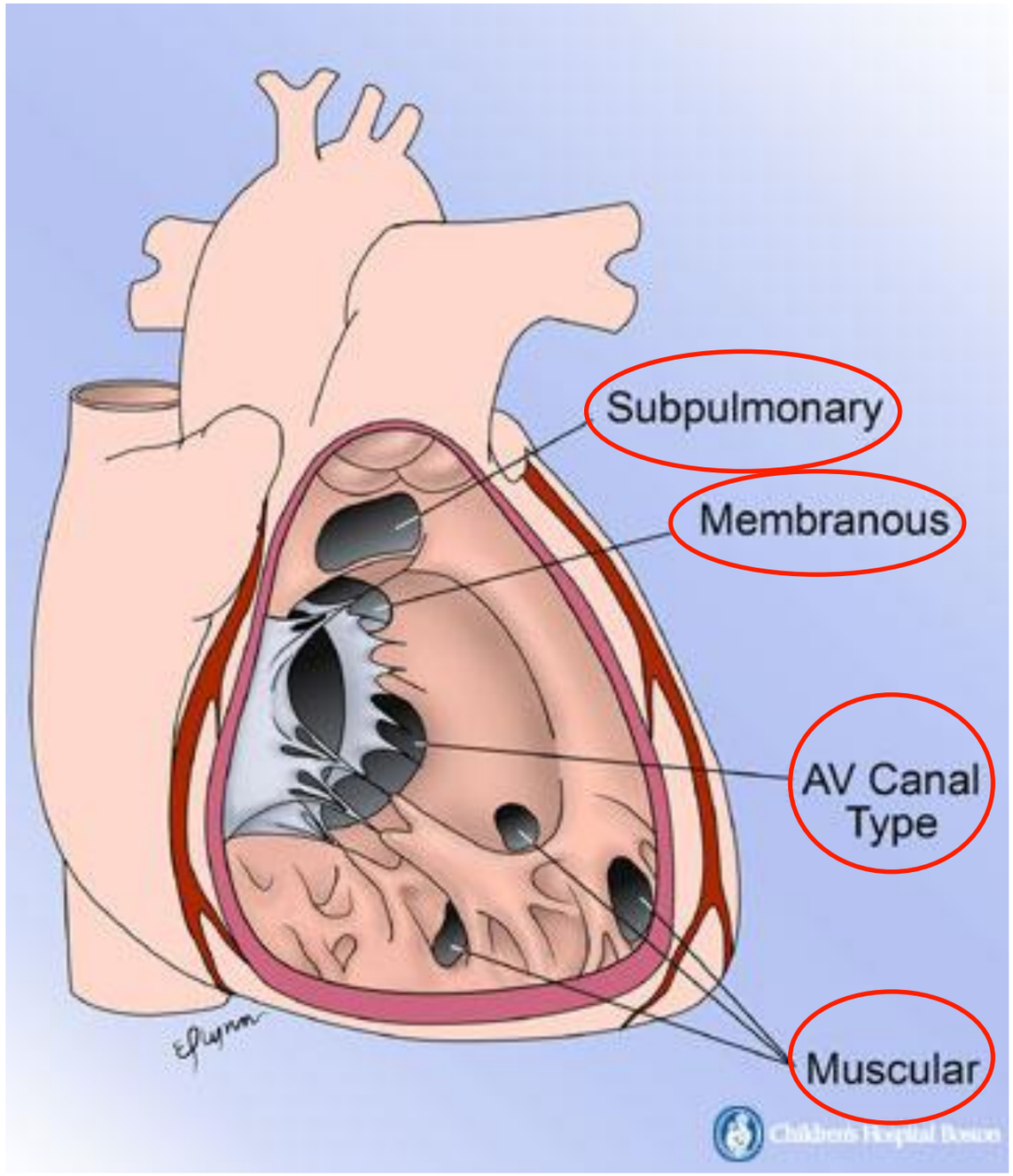
Types:

Perimembranous 80 %

Subpulmonary 5 – 7 %

Muscular 5 – 20%

AV canal 5 – 8 %



Ventricular Septal Defect

Physiology: left to right shunt

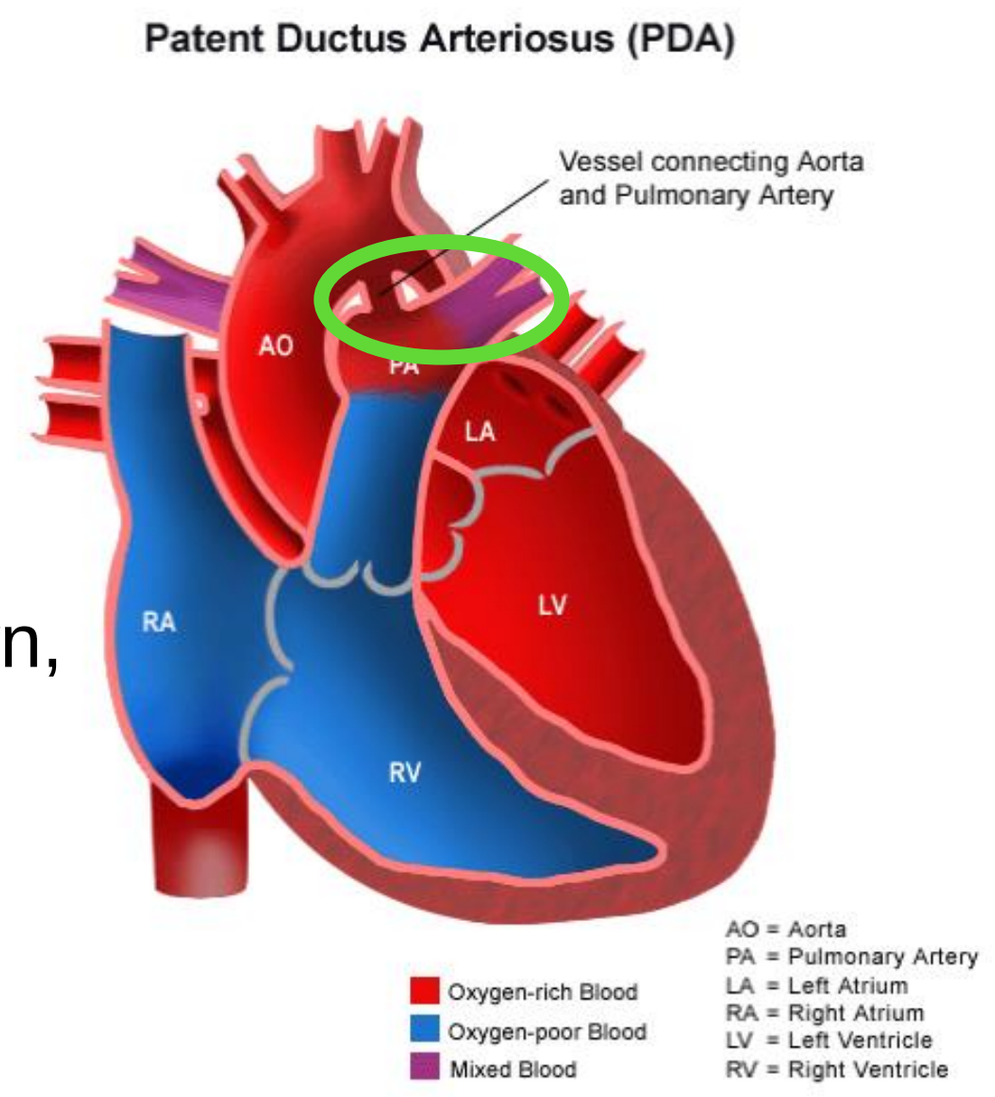
Preop: identify type and size of VSD.
The potential PHT needs to be followed closely to determine the timing of surgery

Surgery: sutures, pericardial patch

Postop: heart block, junctional ectopic tachycardia (in infants), residual VSD

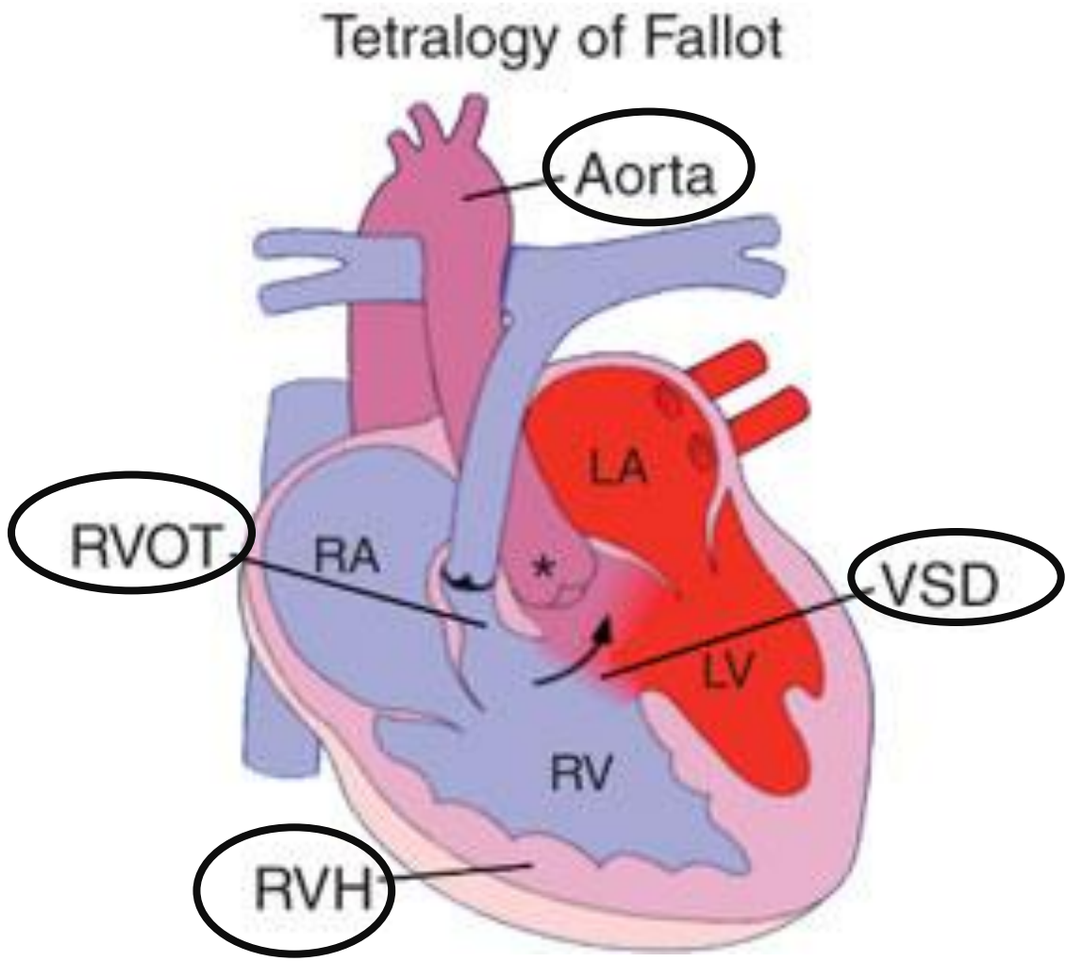
Patent Ductus Arteriosus

- **Physiology:** Left to right shunt.
- **Preop:** CHF (child>1 year old), pulmonary vascular disease
- **Surgery:** ligated or divided and sewn, or cardiac catheterization
- **Postop:** Complications are rare.



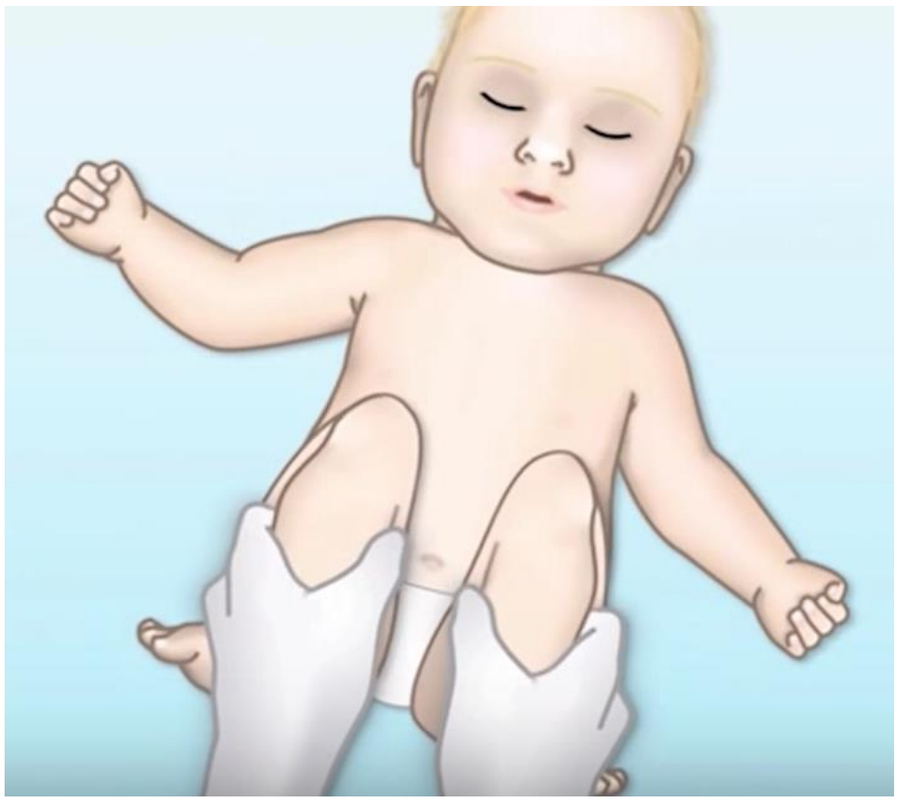
Tetralogy of Fallot

- Four cardiac abnormalities
  - VSD
  - Subpulmonic stenosis
  - Overiding of aorta
  - Right ventricular hypertrophy
- Degree of cyanosis
- ↓Pulmonary blood flow



Tet spell

- Profound hypoxemia
- ↑**O_2 demand:** crying, feeding, defecation
- Transient cerebral ischemia: paleness, unconsciousness
- Treatment:↑SVR, decreasing Rt to Lt shunt



TOF: Considerations

- Variable Rt to Lt shunt and pulmonary blood flow
- Associated conditions:

    Paradoxical embolus – avoid air bubbles in lines

    Polycythemia

    25% have another congenital abnormality

    Tracheoesophageal fistula & trisomy 21

- IE prophylaxis
- No air in IV line

TOF: Considerations

- Maintain intravascular volume and SVR.
- Avoid increases in PVR
- Ketamine is recommended for induction
- Right to left shunt tends to slow the rate inhalational agents
- Problems after surgery: residual RVOT obstruction, RV failure, heart block, residual VSD, late arrhythmia, sudden death

Hemodynamic Goals

TABLE 14.6 Cardiac grid for common congenital heart diseases (desired hemodynamic changes)

	Preload	PVR	SVR	HR	Contractility
ASD	↑	↑	↓	N	N
VSD (right-to-left)	N	↓	↑	N	N
VSD (left-to-right)	↑	↑	↓	N	N
PDA	↑	↑	↓	N	N
Infundibular pulmonary stenosis	↑	↓	N	↓	↓[a]

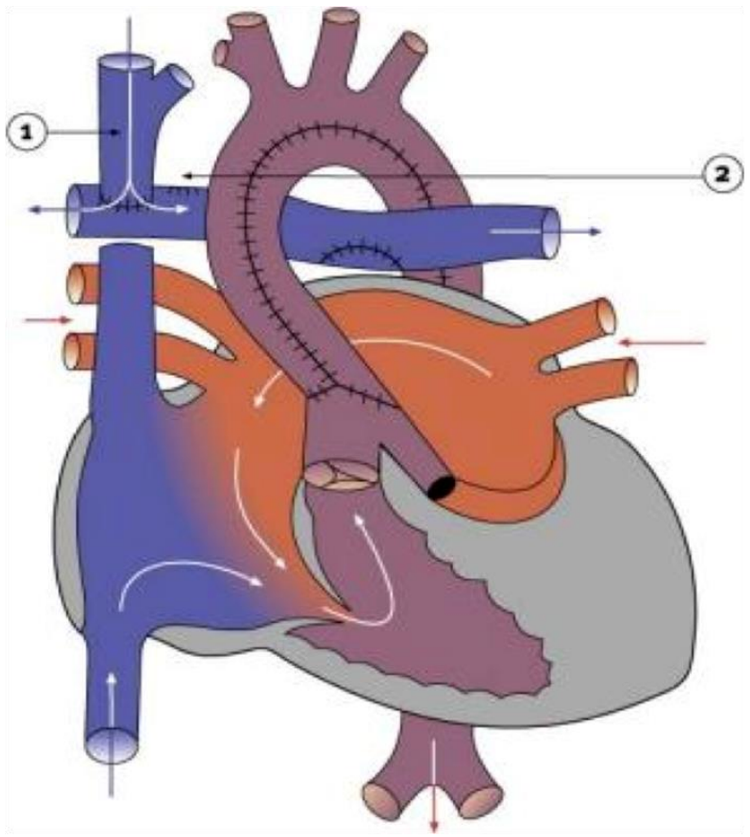
[a] = over –riding consideration ,N = normal or no change

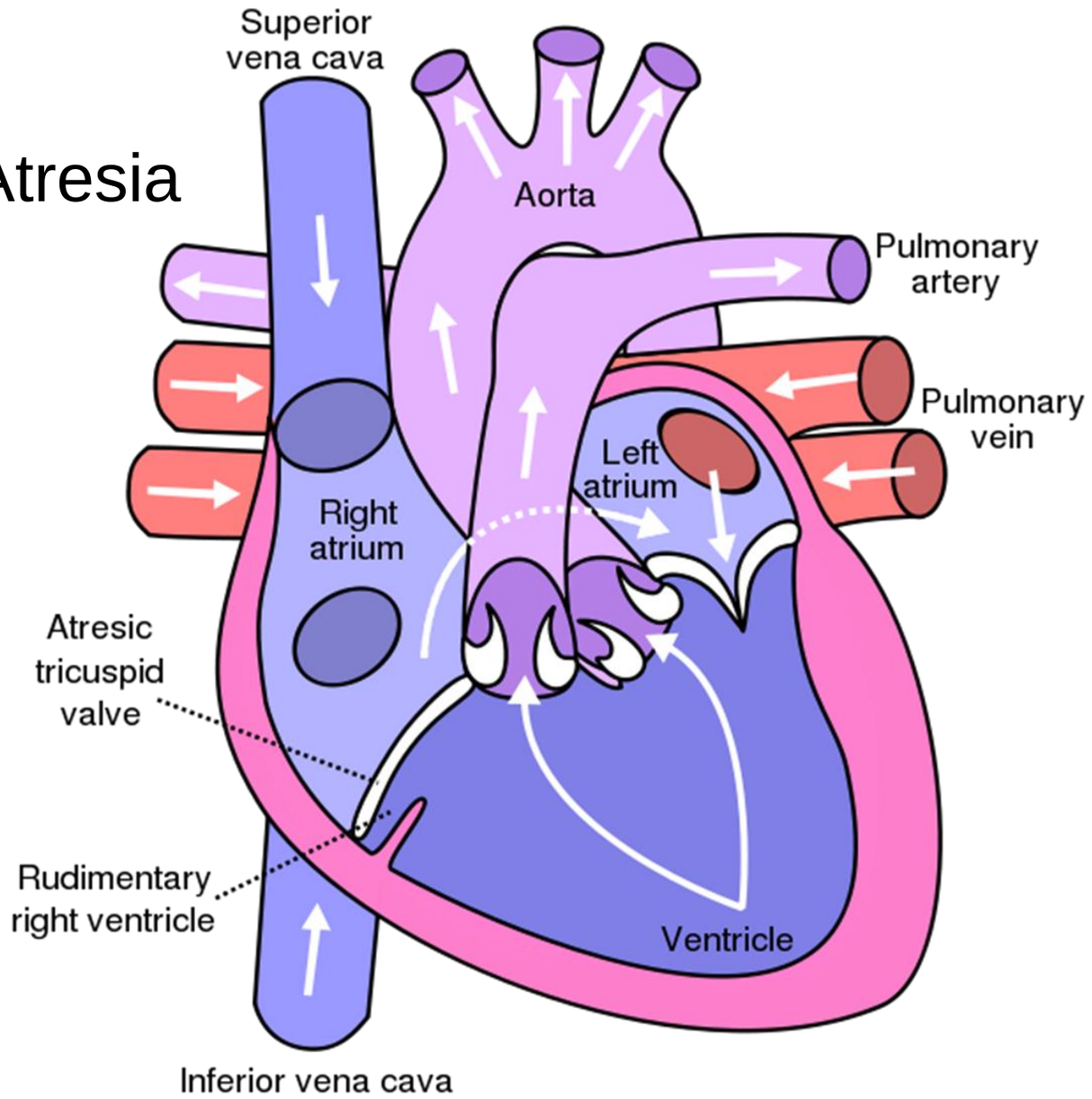
Frederick A. Hensley,Glenn P. Gravlee,Donald E. Martin,2012A Practical Approach to Cardiac Anesthesia

3. Single Ventricular Circulation

Ex. Blalock–Taussig, (BT)

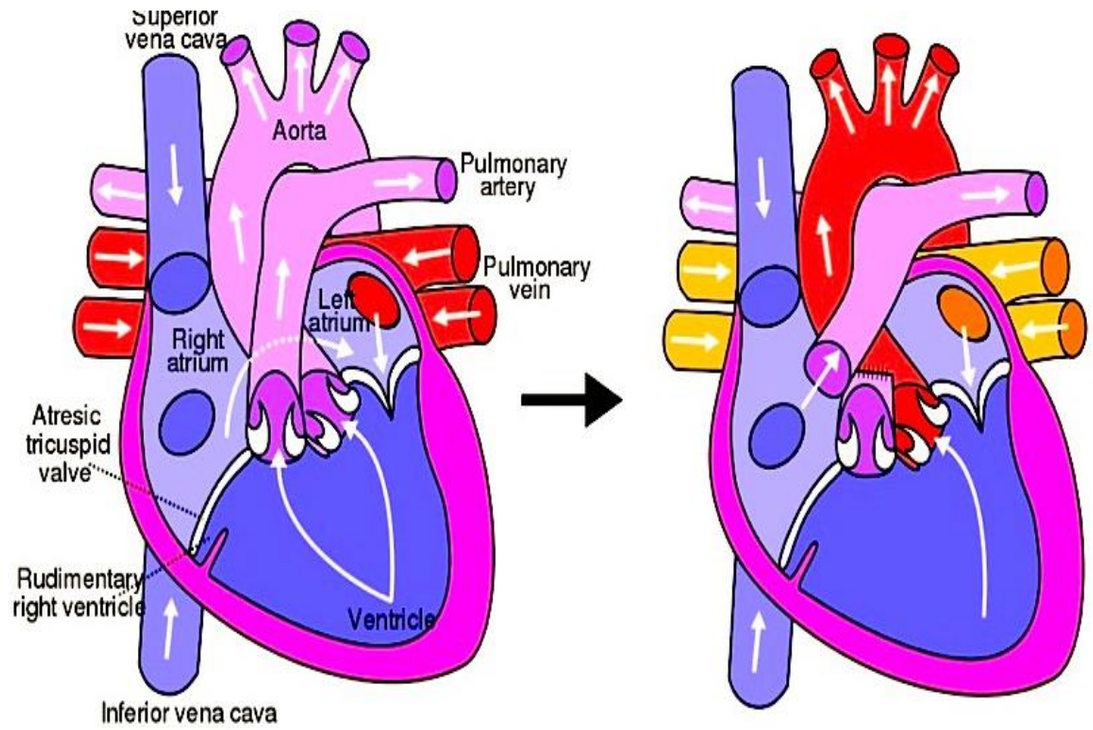
Glenn shunt, HLHS, Tricuspid Atresia





Fontan Circulation

- Divert blood from IVC to PA
- Passive pulmonary blood flow
- Single ventricle to pump blood to the whole body



- Complications: atrial thrombus, atrial arrhythmia, ventricular dysfunction, chylothorax, protein-losing enteropathy

Anesthetic Considerations

1. Knowledge of underlying lesion and type of circulation: change in SVR/PVR? SpO_2?

2. Evidence of long-term complications or high-risk category

Risk Classification of Children with Heart Disease undergoing Non-Cardiac Surgery

Table I Risk classification of children with heart disease undergoing non-cardiac surgery

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

Anaesthesia, Critical Care & Pain | Volume 12 Number 1 2012, Anaesthetic management of children with congenital heart disease for non-cardiac surgery

Risk Classification

High risk: Long term complications of CHD

- Cardiac failure
- Pulmonary hypertension
- Arrythmias
- Cyanosis

High Risk: Cardiac failure

- Volume overload: shunt, incompetent valve
- Pressure overload: outflow tract obstruction (AS, PS)
- S/S: tachypnea, tachycardia, sweating, cool peripheries feeding difficulties, failure to thrive

- Prolong IV induction time
- Avoid prolonged use of 8%sevoflurane, propofol
- Ketamine = agent of choice, (but controversial in PHT)

High Risk: Pulmonary Hypertension

- PAP ≥ 25 mmHg at rest or ≥30 mmHg during exercise
- PHT: ↓pulmonary compliance, ↑increased airway resistance
- Respiratory tract infections: poorly tolerated and have a greater impact on PVR
- 8 times major complications
- Treatment: 100% O_2, inhaled nitric oxide, i.v. prostacyclin, inotropic support of RV

High Risk: Arrhythmias

- **RBBB** is common but <u>unlikely</u> to generate heart block

- **Ventricular ectopics (VEs)** = ominous sign (30%die suddenly)
  Increased risk of VEs in patient who have undergone ventriculotomy or RV-PA conduit

- Mortality rate: 30% in single-ventricle circulation
  ∴refer the children to the specialized centre

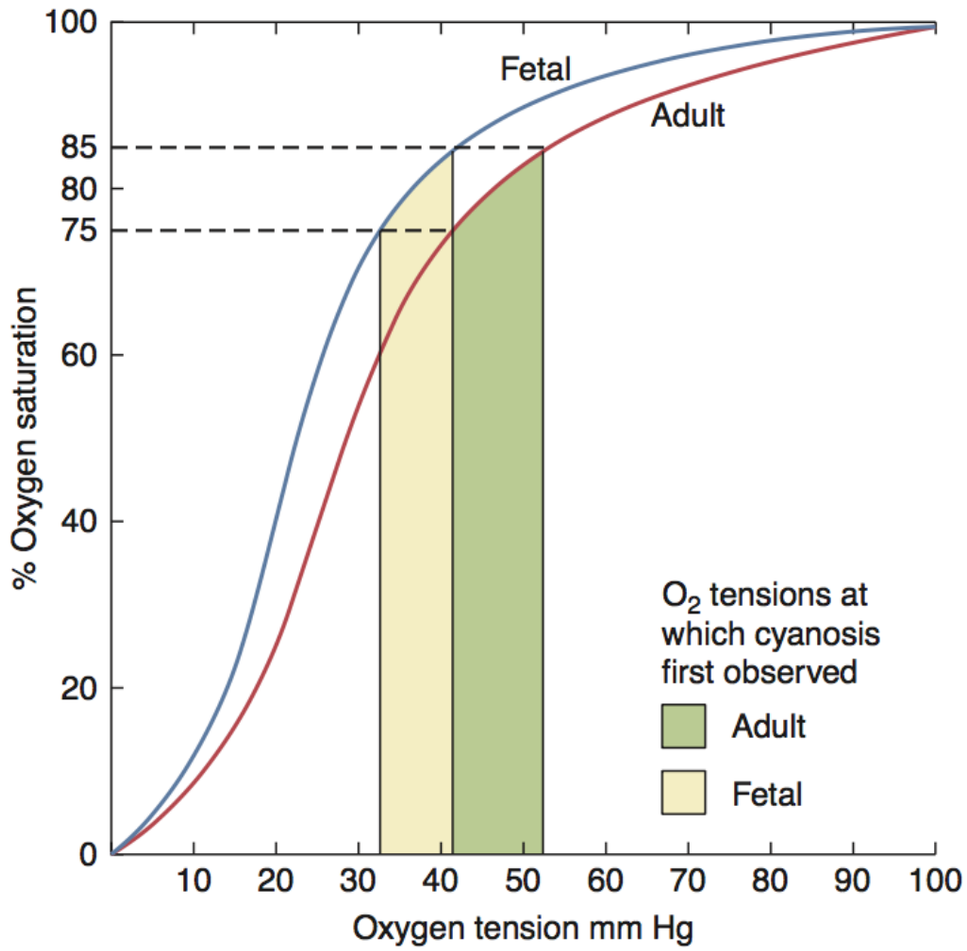
High Risk: Cyanosis

- Recognized when

  deoxyhemoglobin > 2.38 g/dL

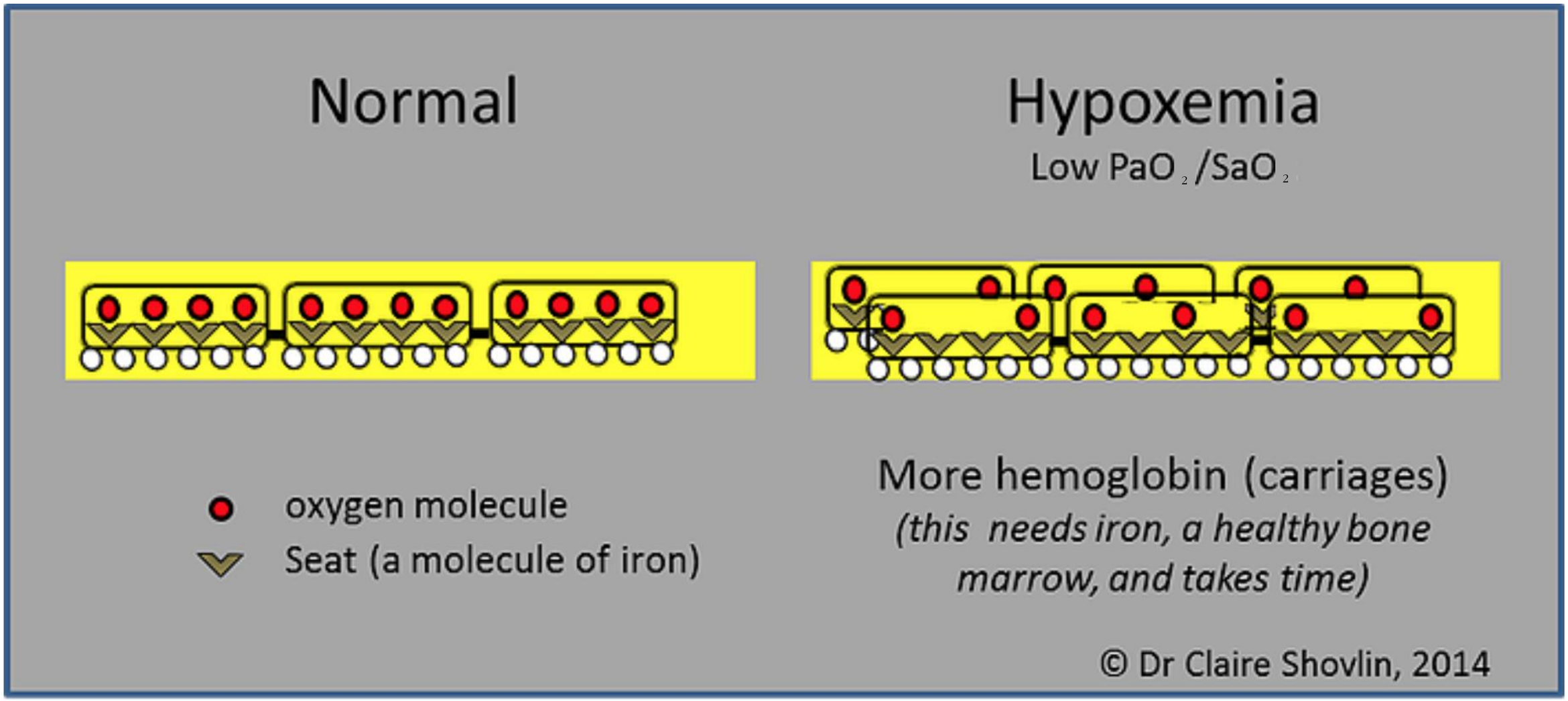
- Worse: agitation, crying, exercise

- Blunted ventilatory response to hypoxia



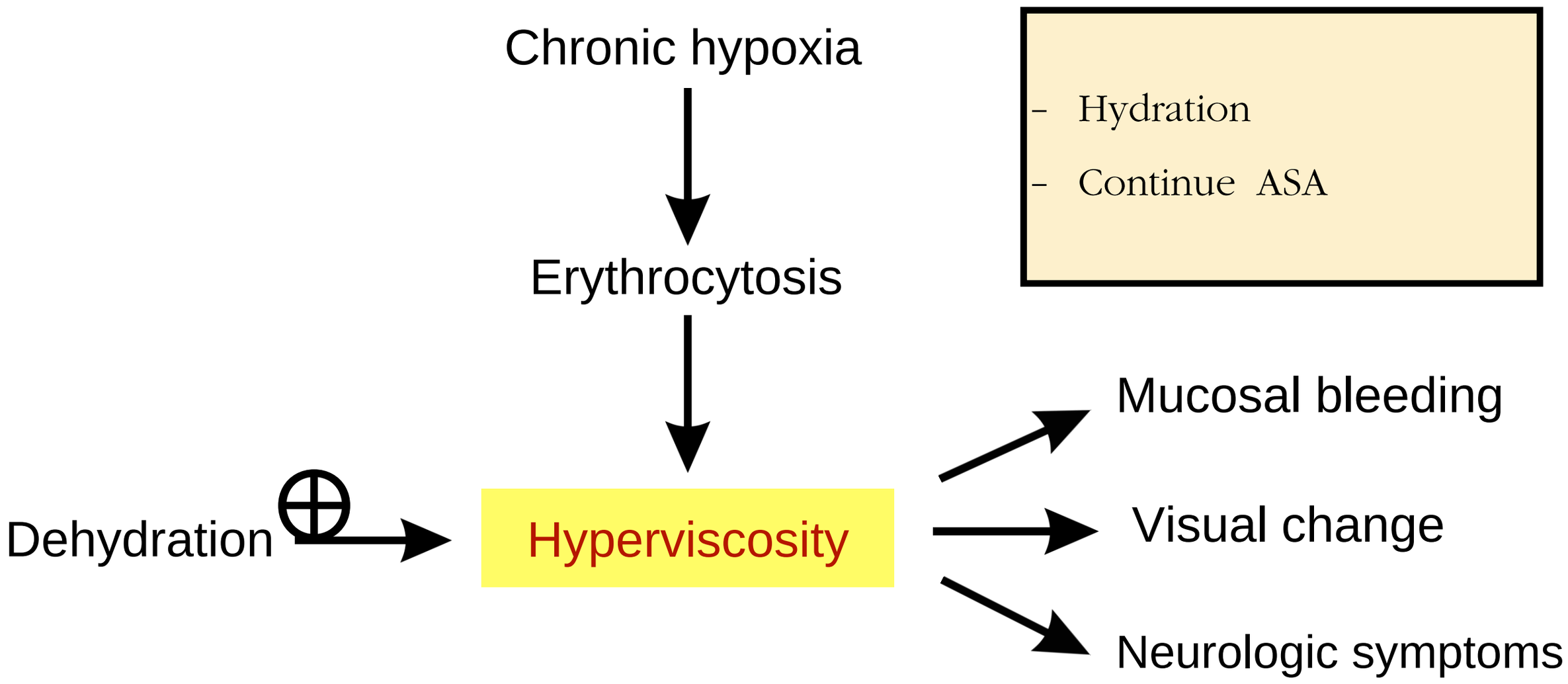
Evidence-Based Physical Diagnosis (Fourth Edition), 2018, Pages 69–72.e1

Cyanotic Heart



by Dr Claire Shovlin http://www1.imperial.ac.uk/medicine/people/c.shovlin

Cyanotic Heart



J Gen Intern Med. 2007 Dec;22(12):1775-7. Epub 2007 Oct 5.

Cyanotic Heart

Bleeding caution

↑Platelet microparticle
↓ Platelet aggregation

Impaired liver function
VitK deficiency

Platelet dysfunction

↓Coagulation factors

Local microcirculation sluggish

Coagulopathy

Hyperviscosity

J Gen Intern Med. 2007 Dec;22(12):1775-7. Epub 2007 Oct 5.
Journal of the American College of Cardiology. Volume 39, Issue 6, 20 March 2002, Pages 1072-1077

Cyanotic Heart

↓Hepatic perfusion

↓Glucose production

1969 Aug;40(2):209-16, Simultaneous Hypoglycemia and Acute Congestive Heart Failure

Hypoglycemia

Produce more insulin

University of Copenhagen 2013

May aggravate myocardial failure

Practical Approach to Cardiac Anesthesia 5 ed 2013

Dextrose containing solution

Congenital Heart Disease & Hypoglycemia

- Prevalence of low FPG (≤80 mg/dl) was higher in the unrepaired (58%), Fontan (47%), and biventricular group (33%) than in the healthy control (11%)

- Lower FPG independently predicted the hospitalization (FPG ≤ 84 mg/dl) and mortality (FPG ≤ 80 mg/dl)

International Journal of Cardiology 174 (2014) 306–312

Risk Classification

High risk: Complex lesions

- Single ventricle
- Balanced circulation physiology
- Cardiomyopathy
- Aortic stenosis

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Risk Classification

Intermediate risk: Type of Surgery

- Intraperitoneal surgery
- Intrathoracic surgery
- Vascular reconstructive surgery
- Hypovolemia with massive blood transfusion

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Risk Classification

Intermediate risk:

- Lesion: simple
- Age: under 2 years old
- Type of Surgery: Emergency
- Preoperative hospital stay: >10 days
- ASA physical status: IV or V

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Risk Classification

Low risk:

- Lesion: physiologically normal or well-compensated
- Age: more than 2 years old
- Type of Surgery: Elective, Minor or body surface area
- Preoperative hospital stay < 10 days
- ASA physical status I-III

Anaesthesia, Critical Care & Pain | Volume 12 Number 1 2012, Anaesthetic management of children with congenital heart disease for non-cardiac surgery

Anesthetic Considerations

1. Knowledge of underlying lesion and type of circulation: change in SVR/PVR? SpO_2?

2. Evidence of long-term complications or high-risk category

3. Venous access & IV hydration

Infective Endocarditis Prophylaxis

- Procedures on infected skin or musculoskeletal tissues

- Urinary tract procedural manipulation (e.g., cystoscopy) in the presence of enterococcal urinary infection or colonization

BOX 38-7 ***Cardiac Conditions Associated With the Highest Risk of Adverse Outcome From Endocarditis, for Which Prophylaxis Is Recommended***

Previous infective endocarditis
Congenital heart disease*
- Unrepaired cyanotic congenital heart disease, including palliative shunts and conduits
- Completely repaired congenital heart defects with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first 6 months after the procedure†
- Repaired congenital heart disease with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibited endothelialization)

Cardiac valvulopathy that develops in cardiac transplantation recipients

Infective Endocarditis Prophylaxis

TABLE 94-12 INFECTIVE ENDOCARDITIS PROPHYLAXIS

		Single Dose 30-60 min Before Dental Procedure	
Situation	**Drug**	**Adults**	**Children**
Oral	Amoxicillin	2 g	50 mg/kg
Unable to take oral medication	Ampicillin or	2 g IM/IV	50 mg/kg IM/IV
	Cefazolin/ceftriaxone	1 g IM/IV	50 mg/kg IM/IV
Allergic to penicillins/oral	Cephalexin or	2 g	50 mg/kg IM/IV
	Clindamycin or	600 mg	20 mg/kg IM/IV
	Azithromycin/clarithromycin	500 mg	15 mg/kg
Allergic to penicillins/unable to take oral medication	Cefazolin/ceftriaxone or	1 g IM/IV	50 mg/kg IM/IV
	Clindamycin	600 mg	20 mg/kg

Vancomycin is an alternative for patients who are unable to tolerate a β-lactam or when the infective agent is considered to be methicillin-resistant *Staphylococcus aureus*.

Example1: A 6-month-old boy with an unrepaired VSD presenting for emergency surgery for a scrotal swelling

Physiology: compensated

Lesion: simple

Risk category: intermediate (age<2 yr old, emergency surgery)

Management: depends on resource

Anaesthesia considerations:

- Possibility of poor cardiac reserve, avoid excessive anesthetic agents

- Avoid high FiO_2 (to minimize left-to-right shunt)

- Avoid air bubbles in venous lines (risk of paradoxical embolus)

Endocarditis prophylaxis: unnecessary

Example2: A 6-yr-old boy with a repaired tetralogy of Fallot 8 months ago with no residual defect, presenting for dental extractions due to dental caries

Physiology: compensated

Lesion: simple

Risk category: low (elective, minor surgery, well-compensate simple lesion, age >2 yr old)

Management: perform procedure in local hospital.

If VEs present on ECG—consider to be high risk

Anaesthesia considerations:

- Gas or i.v. induction

Endocarditis prophylaxis: unnecessary

Example3: An 8-yr-old boy with Fontan circulation presenting for emergency surgery for reduction and fixation of a supracondylar fracture with neurovascular compromise

Physiology: may be well-compensated

Lesion: complex single ventricle

Risk category: high (complex lesion, emergency)

Management: discuss with specialist.

- Transfer = risks limb loss from neuromuscular compromise

- Not transfer = risk life if local hospital anesthetist does not understand complex single-ventricle physiology

Example3: An 8-yr-old boy with Fontan circulation presenting for emergency surgery for reduction and fixation of a supracondylar fracture with neurovascular compromise

Anaesthesia considerations:

- Full stomach may require rapid sequence intubation.
- Optimize pulmonary blood flow
  - Spontaneous ventilation
  - Avoid hypoxia, hypercarbia and atelectasis
  - Avoid high pressures, high PEEP, and long inspiratory times
  - Slight head-up position & raising legs

Endocarditis prophylaxis: unnecessary

Anesthetic Considerations

1. Knowledge of underlying lesion and type of circulation: change in SVR/PVR? SpO_2?

2. Evidence of long-term complications or high-risk category

3. Venous access & IV hydration

4. Recent URI/LRI: may cause changes in airway reactivity and PVR

5. Routine drug therapy: ACE-I, ASA, warfarin

6. Cautious sedative premedication: avoid distress, minimize oxygen consumption, not oversedation

7. Endocarditis prophylaxis

Intraoperative Considerations

1. Invasive monitorings: depend on the type of surgery & cardiac lesion

Indian J Anaesth. 2012 Sep-Oct; 56(5): 491–495. Anaesthetic considerations in children with congenital heart disease undergoing non-cardiac surgery

RA (Neuraxial block)

- Reduce stress response from pain better than opioids, benefit in thoracolumbar and lower extremities surgery

- Optimize volume status and coagulation status

- Slowly titrated epidural is preferable to rapid spinal block

- RA or RA combined with GA has been used successfully in patients with single ventricles, shunt physiology, left-sided obstructive lesions, and pulmonary hypertension

J Obstet Anesth. 2016 Dec;28:83-91. doi: 10.1016/j.ijoa.2016.08.004. Epub 2016 Sep 7.
Anaesthetic management of parturients with univentricular congenital heart disease and the Fontan operation.
Smith's Anesthesia for Infants and Children.Clinical management of specialized surgical problems

Intraoperative Considerations

1. Invasive monitorings: depend on the type of surgery & cardiac lesion

2. Choice of anesthesia: GA vs RA

3. Induction agent: inhalation vs intravenous

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Induction of Anesthesia

Inhalation

- Rt.-to-Lt. shunt prolong inhalation induction
- Avoid in patient with poor cardiac function (myocardial depression)
- High cardiac output promotes clearance of anesthetics from lungs (greater effect in soluble agent)

Intravenous

- Prolong inductive time in low cardiac output state ∴slow titration & reduced dose

Intraoperative Considerations

1. Invasive monitorings: depend on the type of surgery & cardiac lesion

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3. Induction agent: inhalation vs intravenous

4. Maintain hemodynamic goals: preload, PVR, SVR, HR, contractility

5. Hypercyanotic spell during anesthesia

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Ventilation & Oxygenation

- Balance PVR & SVR, avoid PHT
- Avoid excessive PBF in Lt.-to-Rt. shunt lesions (pulmonary congestion)
- Pulmonary edema: require higher ventilator pressures
- In Rt.-to-Lt. shunt: pulse oximetry overestimate arterial oxygen saturation as saturation decreases; $EtCO_2$ underestimate $PaCO_2$, and discrepancy worsens with hypoxemia

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Intraoperative Tet Spell

- May be unable to do “squat position”

Treatment

- Volume expansion
- Alpha agonists: phenylephrine, levophed (↑SVR)
- Beta blocker: cease infundibular spasm

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7. Fluid management

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Fluid Management

- “**Goal-directed fluid therapy**” is recommended for major procedures with substantial blood loss or fluid shifts

- Avoid fluid & salt overload while avoid hypovolemia

- Based on parameters beyond HR and BP:

stroke volume variation (SVV), pulse pressure variation (PPV), doppler corrected flow time (FTc), central venous oxygen saturation

#Kaplan's Cardiac Anesthesia 7e 2017. Chapter47

Intraoperative Considerations

1. Invasive monitorings: depend on the type of surgery & cardiac lesion
2. Choice of anesthesia: GA vs RA
3. Induction agent: inhalation vs intravenous
4. Maintain hemodynamic goals: preload, PVR, SVR, HR, contractility
5. Ventilation & Oxygenation
6. Hypercyanotic spell during anesthesia
7. Fluid management
8. Plan for extubation

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Extubation

- “Fast-tract extubation" to avoid respiratory complications
- Risk factors for reintubation in PACU

Patient factors: age <1 yr, chronic pulmonary disease, preoperative hypoalbuminaemia, and renal insufficiency

Surgical factors: emergency case, head&neck, CVT and airway surgery, and operative time >3 hr

Anesthetic factors: NMBA, ASA physical status III

British Journal of Anaesthesia, Volume 109, Issue 4, 1 October 2012, Pages 636–642
Risk factors for reintubation in the post-anaesthetic care unit: a case–control study

Intraoperative Considerations

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Indian J Anaesth. 2012 Sep-Oct; 56(5): 491–495. Anaesthetic considerations in children with congenital heart disease undergoing non-cardiac surgery

THANK YOU