ANESTHESIA FOR PATIENTS POST CHD REPAIR

ABDULLAH HALAWANI, MBBS, FRCPC.
Consultant CVT Anesthesiologist
Head, Section of Pediatric Anesthesia
KFSH & RC, Riyadh
Congenital Heart Disease (CHD) is one of the most common inborn defects, occurring in ~ 0.8% of newborn infants

- Relative frequency of common congenital heart defects:

  **Acyantoic lesions**
  Ventricular septal defect (VSD) 35%
  Atrial septal defect (ASD) 9%
  Patent ductus arteriosus (PDA) 8%
  Pulmonary stenosis 8%
  Coarctation of the aorta (CoA) 6%
  Aortic Stenosis 6%
  Atrioventricular septal defect (AVSD) 3%

  **Cyanotic lesions**
  Tetralogy of Fallot (TOF) 5%
  Transposition of the great arteries (TGA) 4%
• The major advances made over the last 30 years in congenital cardiac surgery have resulted in an increased number of children born with heart disease who enjoy long term survival - 85% of these babies are expected to reach adulthood.

• The anesthetists role is pivotal in the management of these cases, particularly during non cardiac surgery when their understanding of the pathophysiology should lead the decisions of the operative team.

• An increasing number of follow-up studies have led to an improved understanding of the hemodynamic and electrophysiologic sequelae following neonatal and infant surgery.
Objectives

- Caring for children with underlying cardiac disease presents a unique set of challenges.

- A thorough understanding of the pathophysiology of each cardiac lesion is essential in order to provide optimal perioperative care for pediatric cardiac patients.

- Within each category of lesions there exists a spectrum of severity and a variety of surgical treatments, resulting in varying pathophysiology even for children with the same anatomic diagnosis.
Issues related to all survivors of complex CHD surgery

- Endocarditis Prevention
- Rhythm Disturbances
- Sudden Death and Exercise Limitations
- School Performance and Academic Difficulties
- Insurance, Medication Burden, and family stress
- Communication with the Pediatrician and the Cardiac Team
- The Transition to Self-care and Adult Medicine
Endocarditis Prevention

- Infective Endocarditis is a serious and potentially life threatening complication in the patient with congenital or acquired heart disease

Cardiac conditions for which prophylaxis with procedures is reasonable

- Prosthetic cardiac valve or prosthetic material used for cardiac valve repair
- Previous infective endocarditis
- Congenital heart disease ONLY
  - Unrepaired cyanotic CHD, including palliative shunts and conduits
  - Completely repaired congenital heart defect with prosthetic material or device during the first 6 months after the procedure
  - Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or device (which inhibits endothelialisation)

Cardiac transplantation recipients who develop cardiac valvulopathy
Rhythm Disturbances

• Patients who undergo cardiac surgery risk the development of early and late postoperative arrhythmia & conduction abnormalities including
  - SVT, Atrial Flutter or Fibrillation
  - Ectopic Atrial Tachcardia
  - Sick Sinus Syndrome
  - Ventricular Tachycardia
  - A – V Block and sudden death
Rhythm Disturbances

These abnormalities may result from:

• Long-standing pressure overload and ventricular fibrosis
  - e.g TOF

• Volume overload
  - e.g L → R Shunt lesions
  - TOF after repair with free pulmonary regurgitation and volume overload
Rhythm Disturbances
Factors that influence the development of such events

- Hemodynamic changes resulting from/during the operative procedure:
  - Elevation of atrial pressure after FONTAN operation
  - Residual pulmonary insufficiency after TOF repair
  - Residual VSD, ASD
  - Ventricular Outflow Tract Obstruction
  - Presence or development of pulmonary vascular disease
  - Ventricular dysfunction
  - Scars due to ventriculotomies

- Factors affecting myocardial preservation:
  - Long-standing myocardial hypertrophy
  - Cardiopulmonary bypass time
  - Myocardial ischemia duration
  - Technique of cardioplegia
Sudden Death and Exercise Limitations

• These children have often been identified since birth and are usually excluded from competitive activity that is likely to put them at risk for sudden death.

• Individual assessment of the child’s cardiopulmonary function during exercise combined with the routine testing cardiovascular evaluation is essential to tailor appropriate activity level recommendations for these children and adolescents.
Patients with CHD undergo either

**TOTAL CORRECTION**
- ASD
- VSD
- TOF
- TGA
- PDA
- Truncus Arteriosus
- Valvular Heart Disease

**PALLIATIVE PROCEDURE**
- Single Ventricle
  - HLHS
  - HRV
- Complex forms and combinations of CHD

Procedures include:
- Shunts
- Norwood procedure
- PA Banding
- Fontan procedure

Non operated patients. These include patients with benign lesions and the undiagnosed.
Systemic to Pulmonary Arterial Shunts
( To Increase PBF )

- Classic Blalock-Taussig
- Central
- Waterston
- Modified Blalock-Taussig
- Pott’s

This procedure diverts blood from an aortic branch to the pulmonary artery, allowing blood to flow to the lungs to receive oxygen.
Shunts

• The flow through a shunt (Diameter & ratio of the impedances between the upstream and the downstream cavities, SVR/PVR)

• R – L Shunts:
  Increasing the inspired oxygen concentration has minimal effect, whereas arterial vasoconstriction increases SpO2

• L – R Shunts:
  A modified Blalock-Taussig shunt (BT Shunt), is created to supplement insufficient pulmonary blood flow. Its dimension is fixed so its output is proportional to the systemic arterial pressure
  Low BP → Low PBF → Low SpO2

• Bidirectional: keep in mind the balance of PVR and SVR
Cavopulmonary Shunts
( To reduce ventricular work )
Pulmonary Artery Banding
( To Decrease PBF )
Pulmonary Hypertension

• common complication of unrestricted L-to-R shunt

• As long as the pulmonary arterial pressure is not fixed it will be increased by hypothermia, stress, pain, acidosis, hypercarbia, hypoxia and elevated intrathoracic pressure
Preoperative Evaluation

• Review underlying anatomy and physiology of cardiac lesion:
  a) Previous cardiac surgeries
  b) Evaluate existing residua or sequelae

• Assess other pre-existing diseases or congenital anomalies

• Review information from last cardiology examination:
  a) Recent cardiac cath., Echo., or MRI
  b) Functional status and reserve at time of last examination
  c) Presence of high risk factors:
    - CHF
    - Dysrhythmias
    - Pulmonary hypertension
    - Cyanosis

Preoperative Evaluation

• Review changes since last cardiology examinations:
  a) History and Physical examination
  b) Laboratory data
  c) Current medications
• Review proposed surgical procedure:
  a) Elective vs. Emergent
  b) Expected length and invasiveness
  c) Need for Endocarditis prophylaxis
• Discuss anesthetic plan and risks with parents
• Plan treatment of potential complications:
  a) Dysrhythmias
  b) Pulmonary hypertension
  c) Ventricular dysfunction
• Plan postoperative care:
  a) Monitoring
  b) Pain management
  c) Cardiology follow-up as needed
Preoperative Evaluation

• Upper and lower RTI can cause changes in airway reactivity and PVR which may be poorly tolerated in children with decreased pulmonary compliance or pulmonary hypertension.

• In particular, patients with bidirectional Glenn or Fontan physiology may be compromised by changes in PVR.
Physical Examination

• Vital signs: BP, HR, RR, Temp., Height, Weight, SpO2
• Airway Assessment
• Cardiorespiratory Function
  - Wheezing
  - Retraction
  - Increased work of breathing
  - Cardiac Murmur, Thrill
• Examination of extremities for:
  - Cyanosis
  - Edema
  - Adequacy of perfusion
  - Vascular access sites
Fasting Guidelines

• Although a 6-hour fast from solid food is still recommended, in recent years NPO guidelines have been modified to allow ingestion of clear liquids until 2 hours prior to surgery.

• Cyanotic and shunt-dependent patients would be adversely affected by prolonged periods of fasting and possible dehydration
  - Clear liquids
  - I.V Infusion
Premedication

- In the pediatric cardiac population, the primary goals of premedication are to achieve sedation and anxiolysis with minimal hemodynamic or respiratory effects.

- Midazolam 0.5 – 0.75 mg/kg PO
- Midazolam 0.05 – 0.2 mg/kg IV
- Ketamine 2 – 3 mg/kg IM
- Ketamine 0.2 mg/kg IV
Monitoring

- Standard monitors
- Additional pulse oximeter probe
- In patients with vasoconstriction (Hypothermia, poor peripheral perfusion) a pulse oximeter may be placed on the ear lobe, the tongue, or the buccal mucosa
- Direct observation of the patient:
  - Palpating arterial pulse
  - Checking capillary refill
  - Feeling an infant’s anterior fontanelle
- Presence of a classic or modified B – T Shunt, Coarctation of the aorta, or previous radial artery cut downs should be noted prior to placement of a radial arterial line
Monitoring considerations in cyanotic patients

- Studies of children with cyanotic CHD have demonstrated that pulse oximetry is less accurate below an SpO2 reading of 80 % and may overestimate the actual hemoglobin – oxygen saturation.

- Arterial desaturation due to intracardiac shunting is also associated with an increased arterial-to-end-tidal difference of PaCO2.
Considerations for patients with pacemakers and implanted cardiovertor – defibrillators

• It is important to monitor not only electrical but also mechanical evidence of cardiac function:
  - Manual palpation of the pulse
  - Auscultation of heart sounds
  - Pulse oximetry
  - Plethysmography
  - Arterial line

• ACC/AHA advocate preoperative and postoperative interrogation of pacemakers
Intraoperative Management

- The Goals are optimizing oxygen delivery and ventricular function

- Induction
  *Inhalational
  -The presence of right-to-left shunting can slow the inhalational induction.
  -Little effect on the speed of induction with left-to-right shunts
  *Intravenous (NO Air Bubbles)
  -Ketamine
  -Fentanyl + Midazolam
  -Propofol
  -Etomidate
Intraoperative Management

- Maintenance of anesthesia
  - Fentanyl has been the gold standard of narcotic anesthesia for pediatric cardiac patients
  - Remifentanil
    a) Pharmacokinetic studies of remifentanil in ASA 1 – 4 pediatric patients ranging age from 5 days to 17 years show a consistent half-life (3.4 – 5.7 min.)
    b) Non-specific esterase-based metabolism
    c) Not subject to the genetic variability and drug interactions seen with drugs that are dependent on plasma cholinesterase for clearance
Intraoperative Management

- Concomitant use of an inhaled agent, propofol infusion, or a benzodiazepines is important
- Muscle relaxants
  - For routine or RSI of anesthesia rocuronium 0.5 – 1.2 mg/kg may be used in place of succinylcholine
- Regional anesthesia is a useful adjunct to general anesthesia
  - Caudal block
  - Peripheral nerve blocks
Tetralogy of Fallot

• Anatomy
  - Overriding aortic root
  - RVOT Obstruction
  - VSD
  - RV Hypertrophy

• Variations/Associated lesions
  - Absent pulmonary valve variant usually includes aneurysmal dilatation of the PA’s with resultant airway compression and tracheo / bronchomalacia
  - CHARGE association, DiGeorge syndrome, Goldenhar’s syndrome
TOF

• Issues in unrepaired patients:
  - Dynamic RVOTO result in hyper cyanotic spells with right to left shunting of blood

• Issues in palliated patients:
  - Modified BT shunt

• Issues in repaired patients:
  - Residual RVOTO
  - Residual VSD
  - Pulmonary Insufficiency
  - Arrhythmias
  - Stenosis of RV-to-PA conduit
TOF

Unrepaired
- tet spells

Palliated
- BT Shunt
- BP Monitoring
- SBP, Volume

Repaired
- Residual RVOTO
- Residual VSD
- PI, RVH
- Arrhythmias
- Stenosis of RV-PA conduit
Atrial Septal Defect

• Anatomy/Pathophysiology
  - Left-to-right shunting results in atrial dilatation and RV volume overload

• Variations/Associated lesions:
  - Sinus venosus defects are frequently associated with APVR
  - Primum ASD are often associated with a cleft in the anterior MV leaflet (MR)
ASD

• Issues in Unrepaired patients:
  - RV volume overload
  - PA hypertension is rare
  - Atrial Tachyarrhythmias

• Issues in Repaired patients:
  - Residual defects
  - Atrial Dysrhythmias
  - Sinus node dysfunction is more likely after sinus venosus repair
  - Residual MR after primum defect repair

• Transcatheter device closure
Ventricular Septal Defect

- **Anatomy/Pathophysiology**
  - Left-to-right shunting of blood
  - Ventricular volume overload
  - Increased PBF
  - CHF
VSD

• Issues in Unrepaired patients:
  - Increased PBF
  - PA Hypertension
  - Eisenmenger’s syndrome
  - Recurrent respiratory infections
  - CHF

• Issues in palliated patients:
  - Patients with multiple VSD’s and severe CHF may have a PA band placed to limit PBF prior to definitive repair

• Issues in repaired patients:
  - Residual defect
  - RBBB, CHB, Ventricular arrhythmias
Atrioventricular Canal Defect

- **Anatomy/pathophysiology**
  - Failure of fusion of endocardial cushions
  - Ostium primum defect
  - Common AV valve
  - Interventricular communication

- **Variations/Associated lesions**
  - Trisomy 21 (down’s) syndrom
A – V Canal

• Issues in Unprepaired patients:
  - Increased PBF
  - Frequent Respiratory Infections
  - CHF

• Issues in Palliated patients:
  - PA banding

• Issues in Repaired patients:
  - Residual ASD/VSD
  - TV/MV Insufficiency
  - PA Hypertension
  - CHB
Truncus Arteriosus

• Anatomy/Pathophysiology
  - A single arterial trunk arises from both ventricles and supplies the coronary, pulmonary, and systemic circulations
  - VSD is present
  - The truncal valve may have a varying number of leaflets and may exhibit both stenosis and regurgitation

• Variations/Associated anomalies
  - DiGeorge syndrome
  - Hypocalcemia, T-Cell Deficiency
Truncus Arteriosus

- **Issues in Unrepaired patients:**
  - Pulmonary overcirculation
  - CHF
  - Pulmonary vaso-occlusive disease
  - Coronary ischemia

- **Issues in Repaired patients:**
  - Residual ventricular dysfunction
  - Residual VSD
  - Pulmonary Hypertension
  - Dysrhythmias
  - CHB, RBBB
  - RV – PA conduit stenosis
Single Ventricle Lesions and Physiology

• Hypoplastic Left Heart Syndrome (HLHS)
  - one of the most complex cardiac defects seen in the newborn and remains probably the most challenging to manage of all congenital heart defects.
  - Hypoplastic LV and ascending aorta
  - Aortic atresia / stenosis
  - Mitral atresia / stenosis
  - Restrictive inter-atrial communication
  - Coarctation of the aorta 80%
HLHS

- The First stage in palliation involves establishing unobstructed blood flow from the systemic ventricle to both systemic and pulmonary circuits with creation of a controlled source of PBF.
- Patients are frequently dependent on a modified BT shunt for PBF.
- SpO2 > 85% indicate pulmonary overcirculation, CHF.
- Adjust FiO2 and Pco2 to maintain saturation 70 – 80%.
• The second stage in palliation is a Bidirectional Glenn Shunt and take down of the B – T Shunt
• Ventricular function is generally improved as the volume load has been removed from the heart
• Adequate preload is very important in the anesthetic management of these patients
HLHS

- The final stage in palliation is Total Cavopulmonary Connection (Fontan)
- Avoid hypovolemia as PBF is dependent on preload
- Maintain sinus rhythm
- Avoid excessive airway pressure
- Usually arterial oxygen saturation is maintained between 80 – 90%
Conclusion

• The surgical success of recent decades have resulted in an increasingly complex group of patients with repaired CHD.

• Maintaining preload, judiciously using inotropes to support ventricular function, and promptly treating acidosis are the key factors in managing the patients.

• Expert opinion in the field should be sought when the lesion is complex and/or uncommon.
THANK YOU