

PAEDIATRIC CARDIAC ANAESTHESIA

Pre-operative visit

The aims of the pre-operative visit are to establish and optimize the child's clinical condition to facilitate the formulation and execution of an anaesthetic plan, and to establish rapport with the child and parents. Discussion with the parents should include the following: premedication if required, fasting, the induction process, invasive lines, the transfusion of blood/ blood products, inotropic support, analgesia/sedation, and the type of post-operative care (ICU in most instances). The insertion of trans-esophageal echocardiography (TEE) probe by the anesthetists in certain corrective surgeries (septal defect repairs, valvular surgery) and its associated risks should be conveyed and consent obtained.

Blood and blood products for cardiac surgery

1. Open heart surgery

3 units of PCT (packed cells), 2 units of FFP and 10mls/kg platelets to be grouped and matched for each patient regardless of weight. More blood products including cryoprecipitate may have to be matched and confirmed as required (eg in redo cardiac surgeries).

a. For children less than 15kg:

- 3 units of packed cells (to be stored in MOT blood fridge prior to induction); Fresh blood should be requested for neonates.
- 2 units of FFP; +/- Cryoprecipitate
- 20 mls/kg platelets should be confirmed and available in the KKH blood bank. This is sent for only when instructed by the anaesthetist.

b. For children more than 15 kg:

- 3 units of packed cells (to be in MOT blood fridge at prior to induction), 2 more units in KK blood bank
- 2 units of FFP; +/- Cryoprecipitate
- platelets 20 mls/kg (or 2 CSP for bigger children) to be confirmed and available in KKH blood bank. These are sent for only when confirmed by the anaesthetist.

2. Closed heart surgery

- 20 mls/kg of packed cells should be grouped and cross matched and available in KK MOT blood fridge
- 10 mls/kg of FFP should also be available for cyanotic patients in the KKH blood bank but this is sent for only when requested by the anaesthetist.

The blood and blood products are arranged by cardiac surgery resident. Cross check by anaesthesia resident at the time of anaesthesia premed is mandatory.

Preparation of the operating theatre

1. Check anaesthetic machine and other appropriate equipment
2. Drugs (print cardiac calculator; refer annex 1)
3. Thermoregulatory equipment
4. Fluids
5. Blood/ blood products
6. Defibrillator
7. Rotem
8. Monitoring equipment. These include:
9. Invasive Lines

DRUGS to prepare for patient for cardiac op include:

A. *Resuscitation:*

- atropine
- adrenaline 1: 10,000 (or 1:100,000 for neonates)
- calcium chloride 10%
- 8.4% NaHCO₃ (4.2% for neonates)
- phenylephrine

B. *Induction agents/ paralyzing agents*

C. *Sedation* (midazolam /dexmedetomidine infusion) and
Analgesia (morphine/ fentanyl infusion)

D. *Antibiotics:* cefazolin 50 mg/kg (repeat after 8 hours)

If patient is allergic to penicillin, please order IV Vancomycin

E. *Inotropes* (to confirm with anaesthesia consultant).

Commonly used inotropes include adrenaline, milrinone, dobutamine, dopamine)

F. *Vasodilators* (to confirm with anaesthesia consultant)

Commonly used vasodilators include sodium nitroprusside, GTN infusion, phentolamine

G. *Heparin* 300 IU/kg for open heart surgery

The ACT should be checked 3 minutes after injection of heparin and should be > 450 seconds before CPB is initiated. Check the dosage with anesthetist consultant for closed heart procedures like BT shunt or coarctation of aorta.

Other drugs that may be required include

- i) Tranexamic Acid:
- ii) Loading dose 25 mg/kg IV after induction in 1 hour followed by 2.5 mg/kg/hr. Continue the infusion for 4-6 hrs in ICU after shifting.
- iii) esmolol
- iv) amiodarone
- v) magnesium
- vi) methylprednisolone

MONITORING:

- i) Standard anaesthetic monitors including two SpO₂ probes
- ii) Temperature: nasal or esophageal, rectal
- iii) Invasive lines:
- iv) Urinary catheter
- v) NIRS
- vi) TEE probe

INVASIVE LINES:

- i) arterial line: site (consider the size of the patient, previous surgery, current surgery)
- ii) central venous line (CVL)
Possible sites (IJV/ femoral vein / direct atria).
Considerations include:
 - left IJV should be avoided in children with persistent left SVC
 - avoid IJV for infants with univentricular physiology
 - cava-pulmonary shunts: single lumen IJV CVL to monitor PA pressures after shunt and triple lumen femoral CVL
 - transthoracic lines may be placed to measure LA/ PA pressure post bypass
- iii) PA line (double switch operation)

Conduct of anaesthesia (print bypass checklist; see annex 2)

Either inhalation with sevoflurane or intravenous induction with ketamine, fentanyl, midazolam, thiopentone or propofol is used. The choice of induction is dependent on the functional status of child. At the very least, a pulse oximeter should be placed before induction. Other monitors should be placed as soon as the child tolerates it

For duct dependent lesions, avoid high FiO_2 and avoid hyperventilation. The child is then paralyzed, IPPV commenced, vascular access lines are placed and anaesthesia is maintained with a sevoflurane: air:oxygen mixture.

In open heart surgery, cardiopulmonary bypass is used. This may be conducted under normothermic or hypothermic conditions. Under certain circumstances where reconstruction of the aortic arch or better surgical exposure of intracardiac defects is needed, total circulatory arrest (TCA) is employed. In this case, the patient is cooled to less than 20°C . Ice packs on the head and cooling of the operating theatre to 18°C are indicated.

When rewarming, think of the following:

- i) Use of vasodilators to aid in rewarming. This is more commonly practiced for deep hypothermia in < 25 degree Celsius. The drugs which can be used for this purpose include IV SNP and GTN infusion.
- ii) Turn on warming devices eg warming blanket, bair hugger. Remove ice pack from patient's head.
- iii) Start inotropic infusions when patient's temperature is at least 32 degree Celsius
- iv) Re-zero invasive lines
- v) Call for blood/ blood products

Before coming off bypass, check for the following:

- i) Temperature: core temperature should be at least 36.5°C
- ii) Stable cardiac rate and rhythm
- iii) Stable hemodynamics
- iv) Normal electrolytes (Ca⁺ / K⁺), base excess < -5mmol/L, gas exchange, Hb / Hct levels (check the last blood gas done on pump with perfusionist)
- v) Blood products in OT

Use of blood from CPB: The unused blood from bypass circuit maybe used for transfusion after it is hemoconcentrated by perfusionist. Ideally, this should be used if the bypass time is less than 3 hours and excessive use of suction had been avoided during CPB by the surgeons.

Re-sternotomy

Re-sternotomy may be required in certain instances. Potential problems include bleeding and arrhythmias.

Ensure:

- Arrange for 5 units of PCT, 2 units FFP, 2 CSP and cryoprecipitate available in KKH blood bank
- Bring 3 units of PCT to MOT blood fridge (check 1 unit of PCT before skin incision but do not warm – keep in blood box with cool packs. If it is not required after chest is opened, remember to put blood back in the MOT blood fridge)
- Defibrillation pads – apply to back, making sure no direct contact between each pad or with ECG pads. Remember to apply extra set of ECG pads for Defib machine. Check that the ECG waveform obtained on the Defib machine is good.
- Groin exposed and prepared for fem-femoral bypass

An *oscillating saw* is used for sternal opening (no need to let lungs down in this instance).

Transfer of patient to ICU

- Period when hemodynamic instability can occur
- Make sure that patient is stable before transfer
- Transfer one monitoring device at a time and make sure someone constantly looks at the numbers
- Make sure all lines are free and of sufficient length
- Ensure resuscitation drugs and fluid boluses are available at all times
- Make sure you are able to ventilate and oxygenate appropriately
- Transfer patient from table to bed when all the above fulfilled
- Ensure patient has adequate sedation and analgesia (midazolam/dexmedetomidine/morphine/fentanyl infusion)
- Call ICU to inform of patient's impending arrival
- The cardiothoracic registrar should accompany the child to ICU
- Hand over to ICU registrar /consultant concisely and precisely about perioperative events. The SBAR handover form has to be duly filled and signed by both PAN and ICU after handover

Chest left open

In certain instances e.g. when there is myocardial oedema, the chest may be left opened. Hemodynamic instability would result if attempts to close the chest were made at this point. The following should be ensured:

1. the handover to ICU staff must include the fact that the child's chest has been left opened.
2. when the chest wound has been covered, there must be obvious stickers to indicate that the chest has been left opened
3. the child must be kept sedated and paralyzed for the duration that the chest is left opened. This is usually achieved by making a **“3-in-1” cocktail**.

midazolam 3mg/kg, fentanyl 250mcg/kg, rocuronium 25mg/kg into a 50 ml syringe with NS.
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Running this cocktail at 1ml/hr would then give:

Midazolam	1 mcg/kg/min
Fentanyl	5 mcg/kg/hr
Rocuronium	0.5mg /kg/hr

4. antibiotics prophylaxis should be continued for the duration that the chest is left opened.

The chest is usually closed within 24-48 hours when the patient is hemodynamically stable and the oedema has settled. This is usually done in the ICU.

Re-opening Chest in the ICU

This may be required for rapid access to heart when there is:

- Cardiac tamponade from bleeding
- Open resuscitation

2 possible scenarios:

- chest already wired and skin layers closed
- chest has been left “open”

In latter is more common and access to the heart is rapid as only the sutures stitching the clear PVC to skin needs to be taken out. Maintain “3-in-1” cocktail whilst ensuring the following:

- Adequate access for anaesthetist to ventilator, IV lines and head end of patient
- Adequate resuscitation drugs available
- Continue ongoing fluid / blood / blood product replacement
- Additional sedative / hypnotic / muscle relaxant bolus may be required

In cases where the sternotomy has to be re-opened, prepare as for chest opening in OT.

Ensure:

- Adequate access for anaesthetist to ventilator, IV lines and head end of patient
- Adequate resuscitation drugs available
- Continue ongoing fluid / blood / blood product replacement

Additional sedative /hypnotic /muscle relaxant bolus may be required.

Chest closure in ICU

In cases where the sternotomy has been left open due to hemodynamic instability, myocardial oedema or bleeding, chest closure may be carried out once patient is stable. This is usually within 24-48h post operatively.

Paediatric Intensivists often take over care of the patient during this time as part of continuing care. In the event that they are not able to, the anaesthetist may also look after the patient during the procedure.

Ensure:

- Adequate access for anaesthetist to ventilator, IV lines and head end of patient
- Resuscitation drugs available (but not opened / drawn up as patient should be stable)
- Fluid boluses /blood products available
- “3-in-1” cocktail / sedation, analgesia and muscle relaxant infusions are in progress
- Additional sedative /hypnotic /muscle relaxant bolus may be required
- Constant monitoring of cardiovascular status when sternotomy is closed – fluid bolus may be required, and ventilation parameters may need to be adjusted for change in filling pressure requirements and chest compliance respectively.

PDA Ligation in NICU OT

This elective operation is done in the NICU OT for premature ill babies. The baby is placed in the left thoracotomy position and operation is carried out in the open care Resuscitaire.

Ensure:

- The baby is reviewed preoperatively. Note the airway intervention and ventilation mode, location of invasive lines and peripheral IV cannula, medications, significant clinical findings and laboratory results.
- If the baby is not intubated or lined, arrange for NICU colleagues to intubate, set arterial line and insert peripheral IV cannula 2 hours prior to scheduled time for surgery.
- Have the NICU team shift the baby into NICU OT 30 minutes before operation (you may have to call NICU nurse in charge to confirm the exact time)
- Have one unit of PCT in KK MOT blood fridge
- Prepare the anesthetic and resuscitation drugs after discussing with the anesthesia consultant. Anesthetic tray prep may include: Ketamine, muscle relaxant, Fentanyl (ask from NICU), Cefazolin, 100cm extensions, anti-reflux valves
- Instruct AU nurse to bring: a bottle of 5% albumin, portable ETCO₂ monitor, fluid warmer, 3M plastic, gamgees /gauzes, micropore eye tapes, masking tape.

Complications of PDA Ligations

- Bleeding - usually minimal unless the duct tears in which case it can be catastrophic.
- Inadvertent ligation of the aorta or pulmonary artery. The correlating signs of duct occlusion are the disappearance of murmur and rise in blood pressure (mainly diastolic). On the other hand if the aorta is ligated the lower limb SpO₂ trace will disappear, right arm BP will be unrecordable. With PA occlusion the ETCO₂ will disappear.
- Thoracic duct and recurrent laryngeal nerve injury
- Pneumothorax - usually a chest tube will be placed postoperatively to drain residual air.

ROTEM

The Rotational Thromboelastometry provides global information on the dynamics of clot development, stabilization and dissolution that reflect in vivo hemostasis. Its use during cardiac surgery has been shown to significantly reduce the use of blood component therapy and overall blood loss.

The ROTEM test is performed during rewarming of the child. The graph generated by the machine indicates the requirement of various blood components that is required after heparin reversal with protamine after coming off bypass.

Depending on the bleeding status, a second ROTEM test can be done after transfusing the required blood products.

ECMO (Extracorporeal Membrane Oxygenation)

ECMO is a well-established therapy as a mode of cardiac and respiratory support in reversible cardiac and pulmonary failure in neonatal and paediatric patients.

ECMO is instituted in pediatric patients when conventional modes of cardiorespiratory supports have failed. Mechanically, blood is drained from the venous system, pumped through an artificial lung where oxygen is added and carbon dioxide removed and then, depending on the configuration of the circuit, returned to either the venous or arterial circulation.

The role of anesthetist during institution or separation of ECMO would be:

- a) To provide anaesthesia for the procedure.
- b) Hemodynamic and respiratory monitoring of the child during the procedure.
- c) Be ready for transfusion of blood products.
- d) To maintain anticoagulation with heparin during institution of ECMO.