# Paediatric Intensive Care Unit

## Post-operative management following insertion of Blalock-Taussig (BT) Shunt or Central Shunt

| | |
|---|---|
| Staff relevant to: | Medical and Nursing staff caring for children in the PICU |
| Approval date: | January 2024 |
| Version: | Vs.2 |
| Revision due: | January 2027 |
| Written by:<br>Updated by: | C Westrope<br>Modther Sayed (Vs 2) |
| Trust Ref: | C49/2020 |

| **Related Guidelines and Policies:** | |
|---|---|
| C149/2016 | Handover of Post-Operative Cardiac Patients to PICU UHL Childrens Intensive Care Guideline |
| C90/2016 | Feeding UHL Childrens Intensive Care Guideline |
| C91/2016 | Chylothorax Post Cardiac Surgery UHL Childrens Intensive Care Guideline |

## Contents

## *Scope*

To assist EMCHC nursing and medical and allied health professional staff in the routine care and management, and potential post-operative complications of a neonatal patient following the insertion of a BT Shunt or central shunt

*Background*

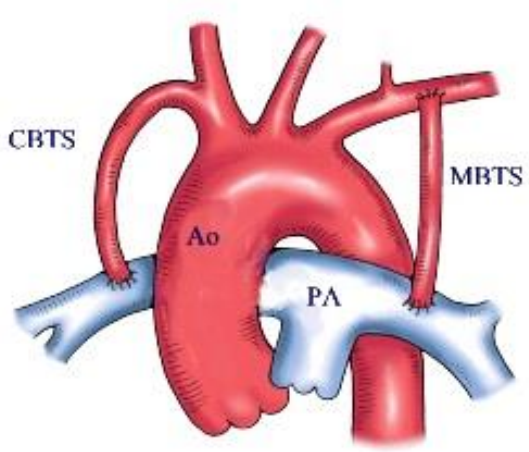
The BT shunt is usually inserted in patients with cyanotic congenital heart disease to optimise blood flow to the lungs. The annual number of BT shunts being performed has fallen over the last 20 years. This is largely due to advancing surgical technique. BT shunts were originally used predominately in the management of Tetralogy of Fallot (TOF), now most TOF go straight to a full repair. BTS however remains an option for infants; particularly those that are unstable at presentation or who have anatomical considerations that prevent early total correction [1-2].

Operative options:

- Classic Blalock- Taussig shunt (BT shunt): subclavian artery to right pulmonary artery rarely performed today.
- Modified BT shunt: usually 3.5 - 4mm synthetic tube from the systemic artery (typically right subclavian) to the pulmonary artery
- Central shunt: usually 3.5 - 4mm synthetic tube from the aorta to the pulmonary artery
- Can be performed through median sternotomy or lateral thoracotomy.

The classical BT shunt (CBTS) was first performed in the 1940s and is created by division of the subclavian artery (left or right) and anastomosis to the ipsilateral pulmonary artery (PA). The main advantage is that the shunt grows with the patient and the main disadvantage is loss of pulses in the ipsilateral upper limb and resulting decreased growth and strength. The classical BT shunt is seldom used these days.

The modified BT shunt (MBTS) is now performed and consists of a Gore-Tex (PTFE) graft (3.5- 5.0mm diameter) interposed between the innominate or subclavian artery and the ipsilateral pulmonary artery (PA). This can be performed on the left or right side, but is routinely on the right side. It is usually a non-bypass procedure and is performed through a lateral thoracotomy.




Postoperatively, pulmonary and systemic vessels are fed from the same common source. The balance of systemic and pulmonary flows (Qp:Qs) is of utmost importance, and is the

principal determinant of systemic oxygen saturation (SaO2). Ideally the post-op SaO2 is 75-80%, and this gives a Qp:Qs ratio range of 1:1-1.8
The immediate post-operative period is a time where the incidence of shunt failure is high. This can present acutely with precipitously dropping saturations and ETCO2. Acute shunt failure is usually secondary to the shunt clotting off or kinking. This is an emergency and the management is discussed below

*Routine post-operative management following BT Shunt insertion*

On admission to PICU, patient handover from theatre teams to PICU team should follow unit protocol (see EMCHC Cardiac Handover protocol Handover of Post-Operative Cardiac Patients to PICU UHL Childrens Intensive Care Guideline) Keep NIRS on.

**General principles**

Ensure that cardiac output is maximised to provide enough blood flow (adequate oxygen delivery) to both circulations.
The first steps are adequate preload and optimal contractility; further adjustments can be made by manipulation of systemic (Qs) and pulmonary blood flows (Qp). Use of afterload reduction can increase stroke volume and counteract pulmonary over circulation. Therapeutic strategies targeted at maximising pulmonary vascular resistance are of limited value in practice, because the largest component of the pulmonary resistance is provided by the shunt. Changes in pulmonary vascular and systemic vascular resistance may lead to changes in Qp/Qs as the shunt provides fixed resistance.
Titrate the O2 to achieve sats 75 – 85%. Changes in pH, ventilation pressure and haematocrit affect blood flow through lungs too.
Systemic vascular resistance is affected by pain, stress and exposure to cold too – minimise that. Continuous diastolic run off through shunt places coronary perfusion at risk – watch for low diastolic pressure or signs of ischaemia on ECG. Diastolic run off means an increased risk of necrotising enterocolitis

**Respiratory**

Will require ventilation at least overnight
Keep SaO2 70-85% (ideal 75-80%)
Gradually wean oxygen therapy down – titrate to achieve SaO2 75-80% (to avoid over-shunting).
2 hourly blood gases for 4 hours and then 4 hourly if stable.
Consider weaning ventilation on day 2 if everything has been stable (PICU Consultant decision)

Pre-requisites for extubation:

- Stable SaO2 75-80% in room air (or with minimal oxygen requirement) and requiring minimal ventilation
- Echo having shown adequately functioning shunt
- Otherwise haemodynamically stable
- Recent CXR showing clear lung fields and pleural spaces

**Cardiovascular system**

Check for shunt murmur when arrives back from theatre and again anytime when there are concerns over the patient, particularly if they have low SaO2.

Aim for BP in normal range unless otherwise ordered (see normograms for expected BP ranges in neonatal patient)

If inotropic support required:

1st line adrenaline to support cardiac performance
2nd line noradrenaline or vasopressin if low diastolic pressure/ over-shunting

An echocardiogram should be performed and documented in the notes by the cardiologist on PICU soon after theatre to assess shunt flow and cardiac function.

An ECG should be performed and compared to pre-op ECG to exclude ischaemic changes

Potential causes of hypotension/ low cardiac output:

Hypovolaemia/ bleeding
'Over-shunting' causing unbalanced circulation (particularly low diastolic pressure) (see below)
Over sedation
Tension pneumothorax
Shunt blockage (see below)
Septicaemia

**Fluids/ Nutrition**

Fluids should be restricted to 60ml/kg/day on day 1. Or 60-80 ml/kg/day if off bypass. Then can then be increased by 10- 20ml/kg/day depending upon the clinical status of the patient.
Beware of over-restriction causing intravascular depletion as this predisposes to shunt thrombosis and low cardiac output (as preload dependent circulation).
Feeds can be considered the day after surgery if everything has been stable.
If there are concerns of 'over-shunting' and a poor systemic output, feeds should be introduced as per high risk feeding protocol, or withheld if there is evidence/suspicion of NEC (see PICU Feeding guideline Feeding UHL Childrens Intensive Care Guideline)

**Antibiotics**

As per normal post-op protocol - follow perioperative antibiotic prophylaxis policy

**Analgesia/ Sedation**

The patient should be well sedated and provided with good analgesia on the first post-operative night as pain increases SVR. Use morphine as per Analgesia and Sedation protocol. Midazolam is usually not needed in neonates, but if it is used beware of cardio depressant and hypotensive effect. Can start to be weaned the following day depending upon the clinical status of the patient. Patients do not routinely need to be paralysed.

**Anticoagulation**

Introduction of anti-coagulant therapy with heparin should be instituted as soon as safely possible after theatre. Confirm with the consultant surgeon at handover that there are not

specific reasons to avoid the following standard approach. Patients are usually given heparin in theatre.

Prophylactic Heparin:

- Heparin 10 units/kg/h should be started 4 hours post cardiac surgery (if bleeding is not an issue – chest drains <3ml/kg/h).
- There is no loading dose given.
- There is no target APTT
- Once on feeding (ideally > 60ml/kg/d of enteral intake) commence Aspirin 5mg/kg OD enterally.
- Prophylactic heparin doesn't need to be stopped for sternal closure.

Therapeutic Heparin

- See Heparin protocol
- Review postop APTT
- For pacing wires removal : review APTTand Plt, consider stopping Heparin infusion 2 hours prior removal (if in doubt, review with a consultant)

Aspirin 5mg/kg once a day is commenced once on feeds.

**Haemoglobin**

Should be kept around 120 g/L. Avoid too high levels as this may predispose to shunt thrombosis. Avoid a low Hb as patients with cyanotic heart disease require slightly higher Hb levels than normal.

*Management of a Suspected Blocked BT Shunt*

## This is an emergency

**Risks/reasons;**
Kink / thrombosis – high risk in dehydration or high haematocrit
Competing shunt flow – PDA, collateral - MAPCA

Consider blocked shunt in any patient who has a **significant sustained desaturation (obstruction can be partial or complete)** or whose saturations and ETCO2 drop and a shunt murmur is weak or no longer audible.
BP will initially be preserved, but hypotension develops later, as myocardial oxygen delivery drops.

Arterial Blood paO2 reflects pulmonary blood flow (pulse oximetry is not as accurate at low O2 tension) PaO2 <3.7-4kPa is the critically low level at which CO2 clearance is also affected, leading to respiratory acidosis and metabolic acidosis from hypoxemia. This situation is unsustainable.

Most likely to occur in a new shunt or in a dehydrated patient known to have a shunt. It is also more likely if flow is competing with an open duct (PDA) or collateral (MAPCA)

**Management**
1) review most recent APTT, if below target range increased risk of blocked shunt.
2) check arterial blood gas, if low Pao2, rising lactate, fall NIRS from baseline.
3) Hand ventilate and increase FiO2, watch ETCO2 trace
    a. FiO2 as necessary to achieve the targeted oxygen saturations

b. Auscultate – is shunt murmur present?
c. Rule out respiratory reasons of desaturation
    i. **DOPE** (**D**isplaced ET position, **O**bstructed ET, **P**neumothorax, **E**quipment failure)
d. Call for urgent Echo, perform arterial gas, ask for chest X-ray
e. Call surgeon and cardiologist immediately

4) Heparin bolus 50 - 100 units/kg IV and continue Heparin infusion or increase already running
5) Bolus of sedation +/- paralysis (to facilitate ventilation and resuscitation)
6) Increase cardiac output: Bolus of fluid 5ml/kg aliquots +/- consider supporting contractility with Adrenaline
7) Increase SVR (Noradrenaline or vasopressin or phenylephrine infusion to increase flow through the shunt
8) Decrease PVR – hyperventilate, increase FiO2 (& consider iNO as a rescue), consider magnesium sulphate bolus but keep in mind blood pressure and hypotension.
9) Decide for catheter or surgical intervention or ECMO support – This decision shouldn't be delayed if there is any concern regarding surgical repair or a child is deteriorating despite medical interventions. Bring chest re-opening trolley, suction and diathermy units to bedside.
10) alternatively, if there is a chance for PDA re-opening consider prostin infusion
11) If thrombosis is suspected, consider Tissue Plasminogen Activator (Alteplase) * Decision by Intensivist, Cardiologist and Consultant surgeon. (see EMCHC TPA guidelines)
12) Restart prostin in neonates if duct has not been surgically ligated.

*Management of Pulmonary Over-circulation*

The management of pulmonary over-circulation can be complex and is dependent on the anatomy and physiology of the underlying lesion. The following is only a beginner's guide to recognising and managing this difficult problem. Consultant input is essential.

If the BT shunt is too big this may lead to relatively excessive pulmonary blood flow and high saturations described as pulmonary over-circulation. Excessive pulmonary blood flow typically presents with relatively high saturations, persistent tachycardia, congested lungs and failure to wean from ventilation.
This is more common if the ductus arteriosus is still open and may resolve as the duct closes.
Pulmonary over-circulation may reveal itself in the early post-operative period or become more problematic when ventilation is weaned.

**Diagnostic clues**
Relatively high saturations CXR- oedematous lungs
Low mixed venous saturations
Rising lactate
Increase in base deficit
Tachycardia
Relatively low mean blood pressure
Widening toe core temperature gap
Decreased splanchnic or cerebral NIRS
Signs of right heart failure e.g. large liver, ascites (late sign)
Low diastolic pressure – if low this may compromise coronary artery blood flow "coronary steal" (beware any diastolic blood pressure below 30)
Look for signs of ischaemia  on ECG trace

## Management

If ECG changes are present this is an **emergency**. Inform intensive care consultant, cardiologists and surgeons Repeat Echo and 12-lead ECG.

Mild form may be treated simply with fluid restriction and diuretics.

As this becomes more problematic, manipulation of pulmonary and systemic vascular resistance (PVR and SVR) is required.

**Manoeuvres to increase PVR (to reduce Qp)**
Reduce oxygen
Increase PEEP
Allow pCO2 to rise gently (aim arterial PaCO2 ~8Kpa)

**Manoeuvres to reduce SVR (to increase Qs)**

Consider reducing vasopressor therapy slowly
Consider vasodilation – e.g. Milrinone or SNP. This may potentially worsen coronary steal by lowering diastolic BP further (discuss with intensive care consultant)

**Other manoeuvres**

Over-circulation may also be present in conjunction with a low cardiac output state therefore inotropes may also be required

Paralysis may be helpful in this setting, facilitating control of PVR by mechanical ventilation (especially in babies breathing above ventilator rate). In addition may cause reduction in SVR

Blood transfusion to keep Hb 12-14 g/dl (this makes the blood more viscous and less likely to pass through the shunt) Beware though as transfusion can increase risk shunt thrombosis.

Avoid inadvertent cooling as this will increase the SVR aim to keep patient warm.

**Surgical intervention**

The shunt may occasionally need to be clipped or taken-down. This may need to be done quickly if low diastolic pressure is compromising the coronary circulation. Some surgeons may leave the chest open the first post op night to facilitate urgent adjustment of the shunt if required

*Other known complications of BT shunt*

Haemorrhage from anastomosis may lead to haemothorax.

Poor shunt flow/ blockage with thrombus or shunt too small (unusual).

Shunt infection (rare) results in features of sepsis with elevated CRP and wcc (Discuss with cardiac surgeon before commencing antibiotics if this is felt to be a possibility.

Over shunting, additional blood supply from PDA (which is yet to close) or MAPCAs, or shunt too large.

Seroma – Gore-Tex can ‘sweat’. Seen on CXR or echo.

Chylothorax due to thoracic duct damage. (see Chylothorax Post Cardiac Surgery UHL Childrens Intensive Care Guideline)

Vocal cord palsy due to recurrent laryngeal nerve.

Diaphragmatic palsy due to phrenic nerve damage.

Shunt narrowing may occur at the site of anastomosis and may sometimes need to be treated with balloon angioplasty.

## 3. Education and Training

Training and raising awareness are on-going processes. On-going awareness is promoted through the induction and continuous bedside teaching. Training is provided for medical staff during lunchtime teaching (Wednesdays) and other sessions, and at junior doctors’ induction training. Nursing education is supported by the Practice Development teams, and nursing educators.

## 4. Monitoring Compliance

| What will be measured to monitor compliance | How will compliance be monitored | Monitoring Lead | Frequency | Reporting arrangements |
|---|---|---|---|---|
| Mortality post BT shunt operation | CCAD data audit | EMCHC M&M meeting | Ongoing | |
| BT shunt re-operation within 48hrs | CCAD data audit | EMCHC M&M meeting | Ongoing | |
| Anticoagulation started and documented as per protocol | Notes audit | Audit lead/CPM | 2 yearly | |

## 5. Supporting References

1. Post-operative management following insertion of a BT Shunt
Neonatology Clinical Guidelines King Edward Memorial/Princess Margaret Hospitals Perth Western Australia

2. Immediate Post-operative Management of Blalock- Taussig Shunt (BTS)
PICU Guidelines Royal Hospital for Sick Children, Glasgow, Scotland

Wolfe G K, Arnold J H. High frequency oscillation in paediatric respiratory failure. Paediatric and child health 2007; 17(3) 77-80

CareFusion Training Day - manufacturer product information

3. Cardiac: Blalock-Taussig Shunt (BT Shunt) Management Following Insertion
Neonatology Clinical Guidelines King Edward Memorial / NICU PCH / NETS

Western Australia

4. Immediate Post-operative Management of Blalock- Taussig Shunt (BTS) and central shunts
PICU guidelines NHSGGC, Glasgow, Scotland

## 6. Key Words

High frequency oscilation ventilation, Sensormedics

---

**The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.**
**As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.**

| CONTACT AND REVIEW DETAILS | |
|---|---|
| **Guideline Lead (Name and Title)**<br>Claire Westrope – Consultant PICU/ECMO | **Executive Lead**<br>**Chief medical officer** |
| **Details of Changes made during review:**<br>**January 2024**<br>Fluids should be restricted to 60ml/kg/day on day 1. Or 60-80 ml/kg/day if off bypass.<br>Management amendments -<br>7) Increase SVR (Noradrenaline or vasopressin or phenylephrine infusion to increase flow through the shunt<br>8) Decrease PVR – hyperventilate, increase FiO2 (& consider iNO as a rescue), consider magnesium sulphate bolus but keep in mind blood pressure and hypotension.<br>9) Decide for catheter or surgical intervention or ECMO support – This decision shouldn't be delayed if there is any concern regarding surgical repair or a child is deteriorating despite medical interventions. Bring chest re-opening trolley, suction and diathermy units to bedside.<br>12) Restart prostin in neonates if duct has not been surgically ligated.<br>Avoid inadvertent cooling as this will increase the SVR aim to keep patient warm.<br>Over shunting, additional blood supply from PDA (which is yet to close) or MAPCAs, or shunt too large | |