

- Ventricular shunts carry an inherent risk of blockage/disconnection, leading to a spectrum of presentations
- Presenting symptoms of a shunt malfunction can be subtle & require a high index of suspicion for hydrocephalus
- Not all shunt blockages are accompanied by an increase in ventricle size on CT brain
- When in doubt, always discuss with the tertiary paediatric neurosurgical team in CHI @ Temple Street
- A child with signs of impending herniation will likely require time-critical transfer by the referring team to CHI @ Temple Street

PICU should be contacted in conjunction with Neurosurgery if there are signs of critical hydrocephalus (see below) and/or airway/haemodynamic stabilisation is required for safe transfer to CHI

### VP Shunt Symptom Triage

#### Critical hydrocephalus

- **Cushing's Triad**
  - Bradycardia
  - Hypertension
  - Irregular resp rate/apnoea
- **Acute mental status change**
  - GCS  $\leq 8$
  - Extreme agitation
  - Unresponsive
- **Active seizure or posturing**
  - particularly if no history of epilepsy

#### High Risk for hydrocephalus

- Drowsiness / Altered mental status
- Headache
- Vomiting
- Symptoms similar to previous obstruction/infection
- Full/Bulging Fontanelle (if still open)
- Ataxia/new cranial nerve palsy

#### Signs of Potential Infection

- Meningismus
- Erythema and/or exudate at insertion site
- Swelling over reservoir site
- Fever  $>38^{\circ}\text{C}$  with last shunt revision  $\leq 3$  months ago
- Full / Bulging fontanelle (if open)

### Key Investigations

- Place on continuous **cardiorespiratory monitoring** including HR /RR /NIBP /O<sub>2</sub>sats
- **Shunt series** – Plain films: AP/Lateral skull & neck, AP Chest and Abdomen
- **CT Brain** – non contrast
- **Intravenous access** (ideally x2) – send FBC, CRP, Blood culture
- Careful examination of fontanelle, shunt surgical sites, erythema/tenderness along shunt tubing

### Management of suspected blocked VP Shunt

#### All Patients

- Nurse **head up** at  $30^{\circ}$  with head in midline (can be increased to  $45^{\circ}$  if herniation suspected/acute deterioration)
- **Nil by mouth**
- Commence IV maintenance fluid – typically 0.9% NS + 5% Dex (in  $<1\text{yr}$  or hypoglycaemic) / Hartmanns if  $>1\text{yr}$  + BGL normal
- **Analgesia** – Paracetamol/Ibuprofen +/- additional as required
- **Antiemetic** – Ondansetron – see overleaf for dosing (as per Clinibee)
- **Antimicrobials** – If shunt infection is suspected: Commence IV Vancomycin IV **AND** CefTAZidime (see overleaf/Clinibee)

#### Patients with signs of Critical Hydrocephalus

- **Anaesthesiology** consultation re urgent intubation and haemodynamic stabilisation
- **Secure airway** if GCS is falling, is  $\leq 8$  or there are other signs of impending herniation
- Follow **IPATS Severe TBI protocol** from this point forward, which will include:
  - Tight ETCO<sub>2</sub>, PaO<sub>2</sub>, Glucose, Temp & BP control
  - Potential use of **Inotropes** to improve cerebral perfusion pressure (**Noradrenaline** 1<sup>st</sup> line)
  - Potential use of **Osmotic agents** (Recommend **3% saline** 3-5ml/kg over 15min)



IPATS unlikely to retrieve this time-critical emergency unless patient is  $<60\text{min}$  away from CHI @ Temple Street

# Respiratory Support



Pre-Intubation  
Checklist



Intubation  
Equipment Sizing  
Guide



Invasive  
Ventilation  
setup <15Kg



Paediatric  
Ventilation Guide



P37 Activation  
Guide

CI

## Critical Infusions / Medications

CI

Doses for quick reference only – please prescribe using the CHI 'CLINIBEE' app or after direct consultation with accepting consultant

CHI Critical care infusion dosing and formulation guides available via QR codes. Please ensure correct guide is used



SCI infusion  
table



NON-SCI  
infusion table

| CHI SCI Standard Concentrations PICU/Theatre: CONTINUOUS INFUSIONS AND LOADING DOSES (Version 4 Feb 2019) |          |             |              |                | Rate Calc (mL/hour)                    | Required Dose  | Default Rate (mL/hour) |
|---|----------|-------------|--------------|----------------|--|--|------------------------|
| Drug  | Category | Weight Band | SCI (Normal) | Diluent        | Usual Dose Range                       | Default Start Dose   |                        |
|   |          |             |              |                |  | Default Dose and Rate Calculator<br>All Weights in kg - rounding can occur |                        |
|   |          |             |              |                |  | Default Start  | Default Rate (mL/hr)   |
|   |          |             |              |                |  | 0.05microgram/kg/min   | 0.15 x Wt              |
| Adrenaline  | Cardio   | All ≤5kg    | 1mg/50mL     | Glucose 5%w/v  | 0 - 0.1 microgram/kg/min               | 0.05microgram/kg/min   | 0.05 x Wt              |
|   |          | >5 - ≤10kg  | 3mg/50mL     | NaCl 0.9%w/v   |  |  | 0.025 x Wt             |
| Noradrenaline   | Cardio   | All >10kg   | 6mg/50mL     | Glucose 10%w/v | 0 - 0.1 microgram/kg/min               | 0.05microgram/kg/min   | 0.15 x Wt              |
|   |          | All ≤5kg    | 1mg/50mL     | Glucose 5%w/v  |  |  | 0.05 x Wt              |
| Midazolam<br>(Large volume neat solution may be given using 250ml empty bag for patients > 20kg)          | CNS      | >5 - ≤10kg  | 3mg/50mL     | NaCl 0.9%w/v   | Sedation:<br>0-4microgram/kg/min       | 1microgram/kg/min  | 0.025 x Wt             |
|   |          | All >10kg   | 6mg/50mL     | Glucose 10%w/v |  |  | 0.3 x Wt               |
| Morphine  | CNS      | >2.5 - ≤5kg | 10mg/50mL    | NaCl 0.9%w/v   | Status Epilep:<br>0-24microgram/kg/min | 20microgram/kg/hr  | 0.12 x Wt              |
|   |          | >5 - ≤10kg  | 50mg/50mL    | Glucose 10%w/v |  |  | 0.06 x Wt              |
|   |          | >10 - ≤20kg | 50mg/50mL    |                | Neonate:<br>0-20microgram/kg/hr        |  | 0.06 x Wt              |
|   |          | >20kg       | 100mg/50mL   |                |  |  | 0.03 x Wt              |
|   |          | >5 - ≤10kg  | 10mg/50mL    | Glucose 5%w/v  | >1mth old:<br>0-40microgram/kg/hr      |  | 0.4 x Wt               |
|   |          | >10 - ≤20kg | 20mg/50mL    | NaCl 0.9%w/v   |  |  | 0.2 x Wt               |
|   |          | >20kg       | 50mg/50mL    | Glucose 10%w/v |  |  | 0.1 x Wt               |
|   |          |             |              |                |  |  | 0.05 x Wt              |
|   |          |             |              |                |  |  | 0.02 x Wt              |

| Drug        | Age                 | Frequently used bolus medications<br><u>An osmotic agent must be taken with patient for ambulance transfer</u>              |
|-------------|---------------------|---|
| 3% Saline   | All                 | 3-5ml/kg over 15 min. Can be repeated if required. Can be given via peripheral line or via IO if central access unavailable |
| Mannitol    | >1month<br>- <12yrs | 0.25 – 1.5g/kg, repeated if necessary 1-2 times after 4-8hrs  |
| Mannitol    | ≥12yrs              | 0.25 – 2g/kg, repeated if necessary 1-2 times after 4-8hrs  |
| Ondansetron | All ages            | 0.1mg/kg IV (max dose 4mg), repeated 8hrly as required. Ensure no evidence of prolonged QT before administration            |

**Note re concentration:**  
Mannitol 20% = 20g per 100ml  
Mannitol 10% = 10g per 100ml

CI

## As per Clinibee Antimicrobial Guidance for Ventriculitis with CNS shunt – July 2023

CI

| Neonates:   | CeftAZidime |
|---|-------------|
| Susceptible (S):  |             |
| < 7 days: 25mg/kg IV 24 hourly  |             |
| 7-21 days: 25mg/kg IV 12 hourly   |             |
| 21-28 days: 25mg/kg IV 8 hourly   |             |
| Increased Exposure (I) (e.g. severe infection, meningitis): 50mg/kg IV, frequency as above    |             |
| Over one month:   |             |
| Increased Exposure (I) (e.g. severe infection, meningitis): 50mg/kg IV 8 hourly. Max 9g / day |             |



| Neonate:  | Vancomycin |
|---|------------|
| Preterm (< 37 weeks gestation):   |            |
| See Clinibee for preterm dosing   |            |
| Term (≥37 weeks gestation):   |            |
| ≤7 days of life: 15mg/kg IV 12 hourly   |            |
| >7 days of life: 15mg/kg IV 8 hourly  |            |
| Over one month:   |            |
| 15mg/kg IV 6 hourly (maximum single dose 750mg). Standard maximum daily dose 3g.  |            |
| Note: On advice of ID/Microbiology, subsequent doses may need to be adjusted based on plasma trough monitoring to reflect the type and severity of infection and the clinical response. |            |
| Loading dose: Under ID/Micro for severe infections (e.g. bacteraemia, endocarditis, meningitis) consider a loading dose   |            |
| ≥ 12 years: 25mg/kg (max. 2g), followed 6 hours later by 15mg/kg (max single dose 750mg) 6 hourly to achieve faster therapeutic levels.   |            |

## In case of Cardiac Arrest

Doses for quick reference only – please follow appropriate APLS algorithm and contact neurosurgery  
Please contact consultant neurosurgeon re potential for emergent shunt tap

Adrenaline IV/IO/IM 10mcg/kg (0.1ml/kg 1:10,000)  
Amiodarone – (VT/VF after shock 3&5) - 5mg/kg  
Atropine – 20mcg/kg (min dose 100mcg, max 600mcg)

D/C shock – VT/VF 4J/kg  
AED – Paediatric attenuated if 1-8yrs / Adult >8yr

# Time Critical Pre-Departure Checklist

## Child with Elevated ICP

To be completed by referring team prior to departure  
Contact with the accepting PICU intensivist via 1800 222 378  
For advice during transfer

### Airway / Ventilation Considerations

|   |                          |  |                          |
|---|--------------------------|--|--------------------------|
| Appropriate Sized ETT well secured with spare intubation set available  | <input type="checkbox"/> | Blood gas (cap/ven/art) checked once on transport ventilator. Blood glucose reviewed.  | <input type="checkbox"/> |
| NGT inserted and attached to bile bag for drainage  | <input type="checkbox"/> | ETCO <sub>2</sub> in ventilation circuit and visible on transport monitor – targeting 4.5-5Kpa   | <input type="checkbox"/> |
| CXR performed and ETT & NGT position modified if required   | <input type="checkbox"/> | Oxygen titrated to achieve O <sub>2</sub> sats between 94-98% - <u>avoid hypoxia AND hyperoxia</u>   | <input type="checkbox"/> |
| Vent set to achieve 6-8ml/kg/min Tv + RR to keep ETCO <sub>2</sub> in target. PEEP typically set to 5cmH <sub>2</sub> O | <input type="checkbox"/> | Appropriately sized ETT suction catheters available (uncuffed ETT size x2 = Catheter French) i.e. 3.5 cuffed ETT has same internal diameter as a 4.0 uncuffed ETT ∴ (4 x 2) = 8 F suction catheter | <input type="checkbox"/> |
| Patient head in midline and elevated to 30° – 45° for transfer  | <input type="checkbox"/> | Maintain normothermia – monitor core body temp   | <input type="checkbox"/> |

### Circulation Considerations

It is always recommended that cardiac arrest medications are brought in addition to, and kept separate from, those suggested below

|   |                          |  |                          |
|---|--------------------------|--|--------------------------|
| Working Vascular Access x2 (IV/IO)  | <input type="checkbox"/> | If patient is already on an inotrope – discuss with PICU re additional inotrope to bring on transfer   | <input type="checkbox"/> |
| Continuous ECG monitoring on transport monitor  | <input type="checkbox"/> | <b>Push dose pressors:</b> (to correct hypotension)<br>Choice & dose at discretion of medically responsible consultant.  | <input type="checkbox"/> |
| NIBP set to auto q3-5min if art line unavailable  | <input type="checkbox"/> | 1. Adrenaline <b>1:100,000</b><br>Add 1ml Adrenaline 1:1000 to 100ml NS = 10mcg/ml solution ( <u>label clearly</u> )<br>Dose - 0.1ml/kg = 1microgram/kg per dose   |                          |
| Maintain <b>minimum systolic BP</b><br>0-10yr = [70mmHg + (age in years x2)]<br>>10yr old = ≥90mmHg                       | <input type="checkbox"/> | 2. Ephedrine diluted to conc. of 3mg/ml –as per Clinibee:<br>Dose – 1-12yr = 500micrograms/kg<br>Dose - >12yr = 3-7.5miligrams<br><b>IPATS Suggestion: Doses 100-200mcg/kg</b> up to 3-6mg typically sufficient – <u>Titrate with great care</u>             |                          |
| Rescue fluid available – 0.9% Saline  | <input type="checkbox"/> | 3. Phenylephrine 100mcg/ml - as per Clinibee:<br>Dose - >1mo - 12yrs = 5-20micrograms/kg (max 500mcg)<br>Dose - >12yrs = 100-500micrograms<br><b>IPATS Suggestion: Doses 1-2mcg/kg</b> up to 50-100mcg typically sufficient – <u>Titrate with great care</u> |                          |
| <b>Noradrenaline infusion</b> prepared and connected to patient (if in use dose range is 0.02mcg/kg/min to 0.2mcg/kg/min) | <input type="checkbox"/> |  |                          |

### Sedation / Neurosurgical Considerations

|   |                          |   |  |
|---|--------------------------|---|--|
| <b>Deep sedation required:</b>  |                          | <b>Suggested bolus CNS medications for transfer</b><br>Use & dose at discretion of medically responsible consultant.<br>Dose titration recommended if haemodynamically unstable |  |
| • <2yr <b>or</b> haemodynamically unstable<br>Morphine 20-40mcg/kg/hr AND<br>Midazolam 3-5mcg/kg/min      | <input type="checkbox"/> | 1. Ketamine 0.5-2 mg/kg   |  |
| • >2yr <b>and</b> haemodynamically stable<br>Propofol 3-5mg/kg/hr +/-<br>Remifentanyl 0.1 – 0.2mcg/kg/min | <input type="checkbox"/> | 2. Rocuronium - 0.6-1.2 mg/kg   |  |
| • Intermittent/continuous NMB blockade  | <input type="checkbox"/> | 3. Propofol 1-2 mg/kg   |  |
|   |                          | 4. Lorazepam Dose 0.1mg/kg max 4mg for seizures   |  |
|   |                          | 5. Fentanyl 1-2mcg/kg   |  |

## Further Reading / Resources

1. Children's Hospital of Philadelphia clinical pathway for evaluation/treatment of suspected VPS obstruction/infection. <https://www.chop.edu/clinical-pathway/ventricular-shunt-obstruction-infection-clinical-pathway>
2. Perth Children's Hospital – VPS troubleshooting guideline. <https://pch.health.wa.gov.au/For-health-professionals/Emergency-Department-Guidelines/Ventriculoperitoneal-shunt-problems>
3. Connecticut Children's medical centre suspected neurosurgical shunt malfunction guideline. <https://www.connecticutchildrens.org/wp-content/uploads/2021/02/Suspected-Shunt-Malfunction-02.01.21.pdf>
4. Ventriculoperitoneal shunt block: What are the best predictive clinical indicators? [Barnes et al. Archives of disease in childhood 2002;87:198-201](#)
5. Risk factors for Paediatric Ventriculoperitoneal shunt infection and predictors of infectious pathogens. McGirt et al. Clin Infect Dis. 2003 Apr 1;36(7):858-62. doi: 10.1086/368191. Epub 2003 Mar18. <https://pubmed.ncbi.nlm.nih.gov/12652386/>
6. NIH – Stat pearls CME - Ventriculoperitoneal shunt. Fowler et al. Stat pearls April 2023 <https://www.ncbi.nlm.nih.gov/books/NBK459351/>
7. Ventriculoperitoneal shunts in the Emergency Department: A Review. Ferras et al. Cureus 2020 Feb <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7053664/>

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| <b>Related Documents:</b>  |   |
| <p>The Irish Paediatric Acute Transport Service (IPATS) has produced this clinical tool with the PICU &amp; Neurosurgery departments in CHI. It has been designed for nurses, doctors and ambulance staff to refer to in the emergency care of critically ill children.</p> <p>This document and guidance represents the views of IPATS and was produced after careful consideration of available evidence in conjunction with clinical expertise and experience. It reflects the pragmatic care required in a time critical situation and does not override the individual responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient.</p> |   |