

- 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 ≤ 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 ≤ 3 months ago
- Full / Bulging fontanelle (if open)

Key Investigations

- Place on continuous **cardiorespiratory monitoring** including HR /RR /NIBP /O₂sats
- **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° with head in midline (can be increased to 45° 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 ≤ 8 or there are other signs of impending herniation
- Follow **IPATS Severe TBI protocol** from this point forward, which will include:
 - Tight ETCO₂, PaO₂, Glucose, Temp & BP control
 - Potential use of **Inotropes** to improve cerebral perfusion pressure (**Noradrenaline** 1st 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

Critical Infusions / Medications

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)
					Default Start Dose		
Drug	Category	Weight Band	SCI (Normal)	Diluent	Usual Dose Range	Default Dose and Rate Calculator All Weights in kg - rounding can occur	
						Default Start	Default Rate (mL/hr)
Adrenaline	Cardio	All ≤5kg	1mg/50mL	Glucose 5%w/v	0 -0.1microgram/kg/min	0.05microgram/kg/ min	0.15 x Wt
		>5 - ≤10kg	3mg/50mL	NaCl 0.9%w/v			0.05 x Wt
		All >10kg	6mg/50mL	Glucose 10%w/v			0.025 x Wt
Noradrenaline	Cardio	All ≤5kg	1mg/50mL	Glucose 5%w/v	0 -0.1microgram/kg/min	0.05microgram/kg/ min	0.15 x Wt
		>5 - ≤10kg	3mg/50mL	NaCl 0.9%w/v			0.05 x Wt
		All >10kg	6mg/50mL				0.025 x Wt
Midazolam <i>(Large volume neat solution may be given using 250ml empty bag for patients > 20kg)</i>	CNS	≤2.5kg	10mg/50mL	Glucose 5%w/v	Sedation: 0-4microgram/kg/min	1microgram/kg/min	0.3 x Wt
		>2.5 - ≤5kg	25mg/50mL	NaCl 0.9%w/v			0.12 x Wt
		>5 - ≤10kg	50mg/50mL	Glucose 10%w/v	Status Epilep: 0-24microgram/kg/min		0.06 x Wt
		>10 - ≤20kg	50mg/50mL				0.06 x Wt
		>20kg	100mg/50mL				0.03 x Wt
Morphine	CNS	≤2.5kg	2.5mg/50mL	Glucose 5%w/v	Neonate: 0-20microgram/kg/hr	20microgram/kg/hr	0.4 x Wt
		>2.5 - ≤5kg	5mg/50mL	NaCl 0.9%w/v			0.2 x Wt
		>5 - ≤10kg	10mg/50mL	Glucose 10%w/v	>1mth old: 0-40microgram/kg/hr		0.1 x Wt
		>10 - ≤20kg	20mg/50mL		0.05 x Wt		
		>20kg	50mg/50mL		0.02 x Wt		

Drug

Age

Frequently used bolus medications

An osmotic agent must be taken with patient for ambulance transfer

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	Note re concentration: Mannitol 20% = 20g per 100ml Mannitol 10% = 10g per 100ml
Mannitol	>1month - <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	

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

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

Vancomycin

Neonate:

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/Blocked VP shunt

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 ₂ 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 ₂ 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 ₂ in target. PEEP typically set to 5cmH ₂ 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"/>	Push dose pressors: (to correct hypotension) 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 1:100,000 Add 1ml Adrenaline 1:1000 to 100ml NS = 10mcg/ml solution (<u>label clearly</u>) Dose - 0.1ml/kg = 1microgram/kg per dose	
Maintain minimum systolic BP 0-10yr = [70mmHg + (age in years x2)] >10yr old = ≥90mmHg	<input type="checkbox"/>	2. Ephedrine diluted to conc. of 3mg/ml –as per Clinibee: Dose - 1-12yr = 500micrograms/kg Dose - >12yr = 3-7.5miligrams IPATS Suggestion: Doses 100-200mcg/kg 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: Dose - >1mo - 12yrs = 5-20micrograms/kg (max 500mcg) Dose - >12yrs = 100-500micrograms IPATS Suggestion: Doses 1-2mcg/kg up to 50-100mcg	
Noradrenaline infusion 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

Deep sedation required:	<input type="checkbox"/>	Suggested bolus CNS medications for transfer
• <2yr or haemodynamically unstable Morphine 20-40mcg/kg/hr AND Midazolam 3-5mcg/kg/min		Osmotic agents: 3% Saline (3-5ml/kg per dose) OR Mannitol 0.25-1.5gm/kg per dose. Suggest bringing minimum of 2 doses of either medication per patient.
• >2yr and haemodynamically stable Propofol 3-5mg/kg/hr +/- Remifentanyl 0.1 – 0.2mcg/kg/min	<input type="checkbox"/>	Anaesthetic agents: Use & dose at discretion of medically responsible consultant.
• Intermittent/continuous NMB blockade	<input type="checkbox"/>	1. Ketamine 0.5-2 mg/kg / Fentanyl 1-2mcg/kg 2. Rocuronium - 0.6-1.2 mg/kg 3. Propofol 1-2 mg/kg 4. Lorazepam Dose 0.1mg/kg max 4mg for seizures

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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<p>The Irish Paediatric Acute Transport Service (IPATS) has produced this clinical tool with the PICU & 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>	