Paediatric Crisis Management

1. Anaphylaxis
2. Massive transfusion protocol
3. ROTEM guidelines
4. Pulseless arrest
5. Pulseless arrest shockable rhythm
6. Tachycardia
7. Bradycardia
8. LA toxicity
9. Malignant Hyperthermia
10. Hyperkalemia
11. Blood transfusion reactions

Paediatric Anaphylaxis (0-12yrs) Initial Management

Cardiac arrest (Pulseless electrical activity PEA)		**Start CPR immediately** **10mcg/kg of IV adrenaline, repeat 1-4 min as needed** **20ml/kg crystalloid** **Advanced life support for non-shockable rhythms**
DR	**Danger & Diagnosis** **Response to Stimulus**	**Unresponsive hypotension or bronchospasm** **Remove triggers eg. latex, chlorhexidine, colloid** **Stop procedure. Use minimal volatile/ TIVA if GA**
S	**Call for help** **Organise team**	**Call for help, press OT code blue button if needed** **Assign team leader and scribe**
AB	**Secure airway** **100% Oxygen**	**Check capnography, no trace = wrong place** **Confirm FiO2 100%** **Intubate: early airway edema**
C	**Rapid fluid bolus** **Large volume resuscitation**	**If hypotensive, elevate legs** **Bolus 20ml/kg crystalloid, repeat as needed** **Large bore IV access, warm IV fluids**
D	**Adrenaline bolus kiv repeat** **Prepare adrenaline infusion**	**Initial IV adrenaline bolus (0.1mg adrenaline in 10ml NS = 10mcg/mL)** **Moderate 1 to 2 mcg/kg** **Life threatening 4 to 10 mcg/kg** **Peripheral IV adrenaline infusion: dilute 1.5mg adrenaline in 50mL N/S** *Concentration: 0.1mcg/kg/min = 0.2mL/kg/hr* **IM adrenaline 0.01mL/kg *if no IV access* (1:1000 = 1mg/mL)** **< 6years 0.15ml (150mcg)** **6-12 years 0.3mL (300mcg) every 5min, on lateral thigh** **>12 yr or adult 0.5mL**

Adapted from ANZAAG-ANZCA Perioperative Anaphylaxis Management Guidelines

Paediatric Anaphylaxis

Refractory Management

Triggers removed?

- Chlorhexidine, including impregnated CVCs
- Synthetic colloid
- Latex

Monitoring

- Consider arterial line
- Consider TTE/ TEE

Resistant Hypotension

- Additional IV fluid bolus 20-40mL/kg
- Continue adrenaline infusion
- Add 2nd vasopressor
- Consider CVC
- TTE / TEE

- Additional IV fluid bolus 20-40mL/kg
- **Noradrenaline infusion** 0.1 to 2 mcg/kg/min
  Peripheral dilution: 1.5mg noradrenaline in 50mL N/S
- **Vasopressin infusion** 0.02 to 0.06mcg/kg/hour
  CVL: 1unit/kg in 50mL, 2mL bolus then 1-3mL/hour
  Peripheral access max. concentration = 1unit/mL
- Glucagon 20-30mcg/kg IV to max 1mg, over 5min

Resistant Bronchospasm

- Consider
  - Esophageal intubation
  - Airway device/ Circuit malfunction
  - Tension pneumothorax
- Continue adrenaline infusion
- Add alternative bronchodilators

- **Salbutamol MDI** (100mcg/puff)
  ≤10kg 5 puffs; >10kg 10 puffs
- Consider Ipratropium bromide MDI (in MOT ADC)
  ≤10kg 2 puffs; >10kg 4 puffs
- **Magnesium sulphate 50%: 50mg/kg** dilute in 100ml NS over 20 min, max 2g per dose. (0.1mL/kg 50% solution = 1mg/kg)
- **Aminophylline 5mg/kg** in 50mL N/S over 20min (max 500mg), max peripheral concentration: 2.5mg/mL
- **Hydrocortisone 2-4mg/kg** (max 200mg)

Consider differential diagnosis

Paediatric Anaphylaxis

Post Crisis Management

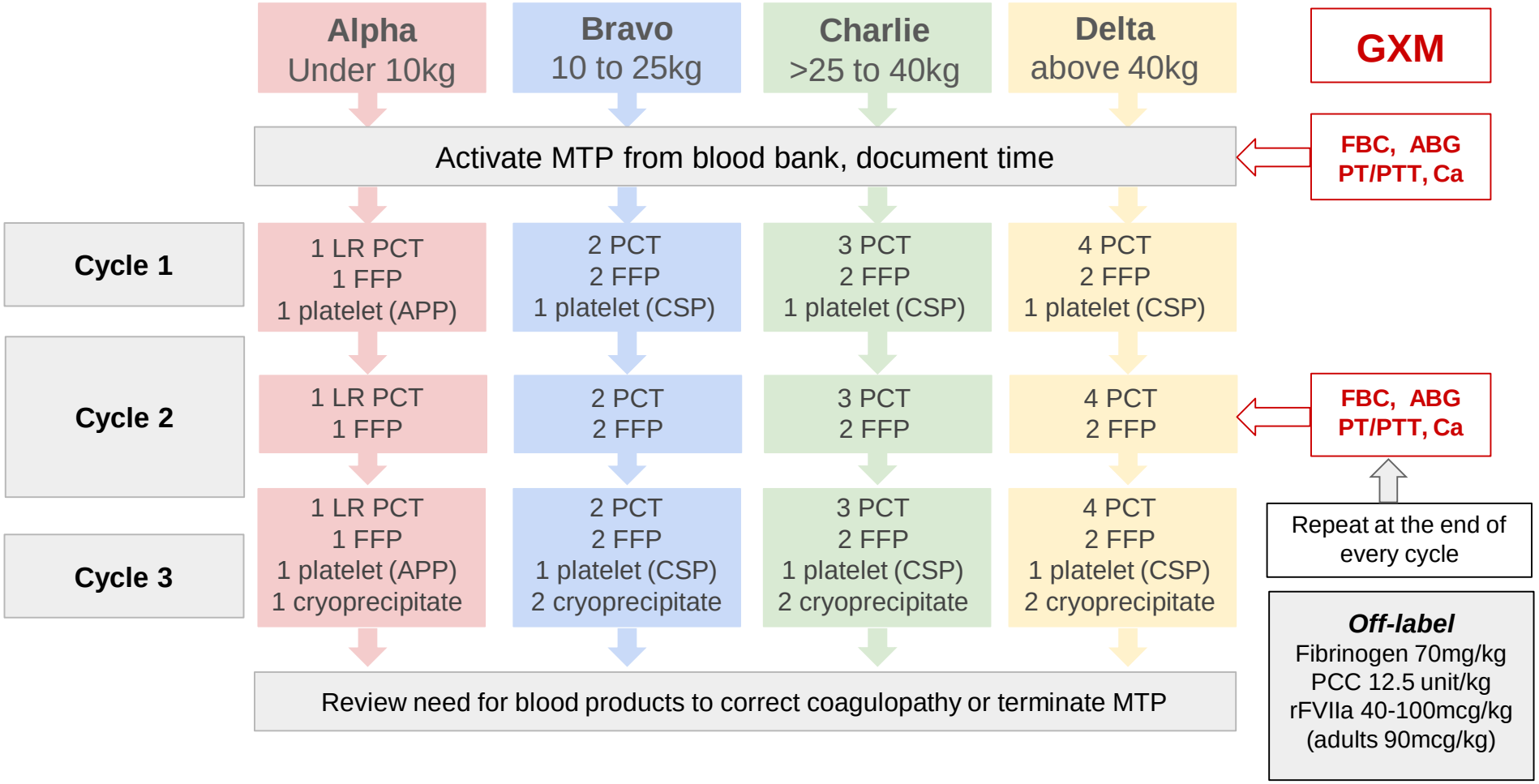
Once stabilised

Consider Steroids	**IV dexamethasone 0.1-0.4mg/kg** **IV hydrocortisone 2-4mg/kg**
Consider ORAL anti-histamines	IV anti-histamines *not recommended*

Consider: Proceed / cancel surgery
Postop HD or CICU monitoring

Investigations ***Tryptase, serum***	**Serum tryptase** (paediatric brown top tube, 1.5mL) 1st sample ASAP during the event 2nd sample 1-2h after onset of event 3rd sample 24h after onset **Other investigations as clinically indicated**
Referral to allergist	For investigation of anaphylaxis
Monitoring	Monitor closely for 6 hours, consider HD/ICU Anaphylaxis may persist >24h despite aggressive treatment

Paediatric Massive Transfusion Protocol



Paediatric Massive Transfusion Protocol

Indications for MTP
Child given > 40ml/kg fluid bolus or > 20ml/kg blood products
Due to hemorrhagic shock from uncontrolled bleeding

Associated severe head injury/ spinal cord injury

Keep normal cerebral perfusion pressure; CPP = MAP - ICP
Treat hypotension aggressively

Targets
Temp >35℃, treat hyperthermia aggressively
Platelets > 50k if no significant head injury
> 100k if significant head injury
Blood gases: pH >7.2
BE < -6
Ca >1.1mmol/L
Watch for hyperkalemia
PT/ APTT <1.5x normal, INR ≤ 1.5
Fibrinogen >1.0 g/dL
Lactate < 3 mmol/L

No severe head injury/ spinal cord injury

Haemostatic resuscitation with permissive tachycardia

Systolic BP goals

<1month old	60 mmHg
1month to 1yr	70 mmHg
1 to 10 yrs	70 + (age in yrs x 2)
>10 yrs old	90 mmHg

Paediatric ROTEM Transfusion Algorithm

Physiological targets: Temp>36℃ pH >7.2 iCa >1mmol/L Hb >7g/dL

STEP 1: HYPERFIBRINOLYSIS

1

FIBTEM CT > 300 sec
AND
EXTEM A5 ≤ 35 mm
→ TXA 15 mg /kg + 50 mg/Kg FIB CONC

OR

ML% ≥ 5%
→ TXA 15 mg/kg (max 1g)

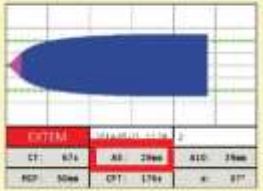
STEP 2: FIBRINOGEN

2

FIBTEM A5 ≤ 10 mm
→ FIB CONC 50 mg/kg
OR
CRYO 5 mL/kg

STEP 3: PLATELETS

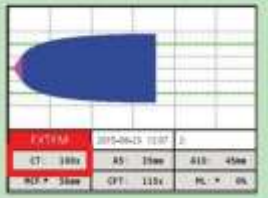
3



FIBTEM A5 > 10 mm
AND
EXTEM A5 ≤ 35 mm
→ PLATELETS 10–15 mL/kg

STEP 4: FACTORS

4



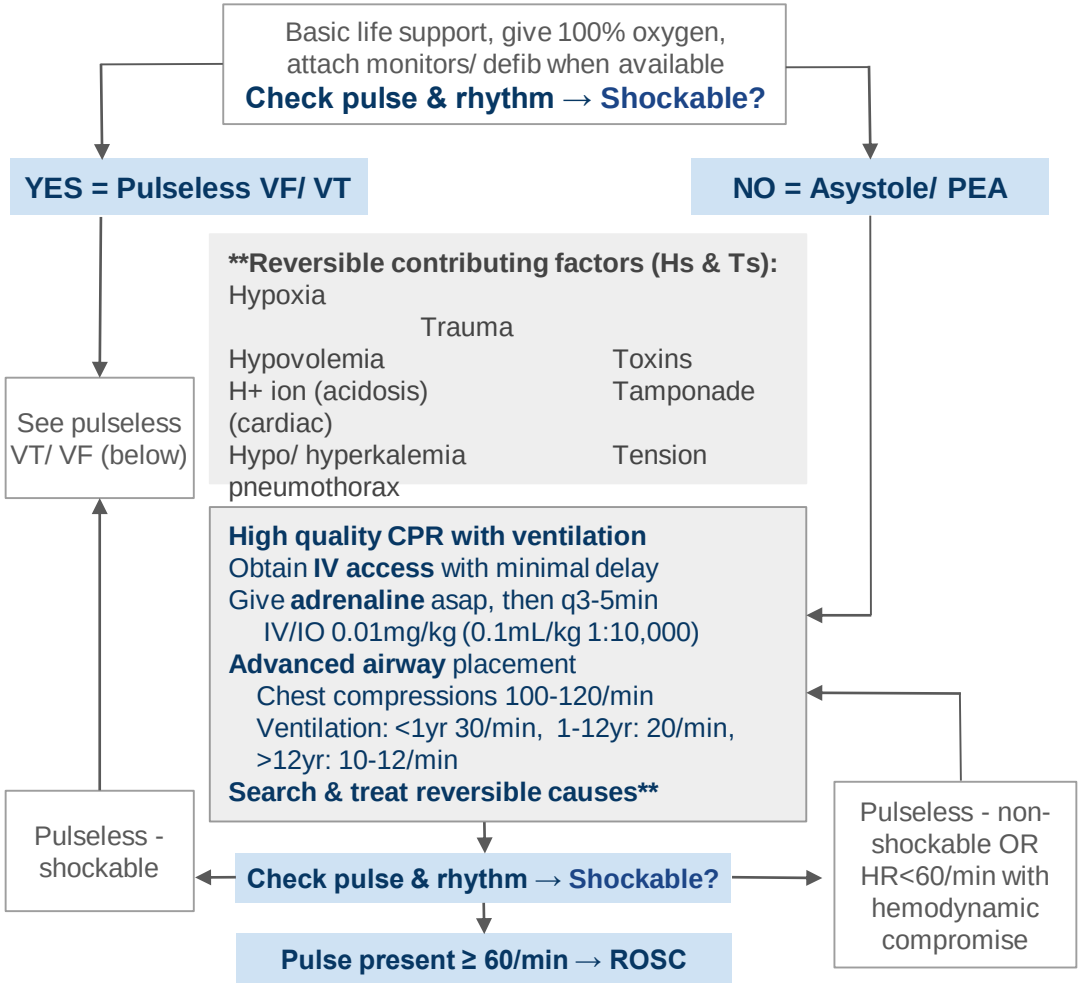
FIBTEM A5 > 10 mm
AND
EXTEM CT ≥ 90 s
→ FFP 15 mL/kg
OR
PCC 10 IU/Kg

George, S., Wake, E., Sweeny, A., Campbell, D.,Winearls, J. (2022)
Rotational thromboelastometry in children presenting to an Australian major trauma centre: A retrospective cohort study. Emergency Medicine Australasia, 34: 590-598

Suggested paediatric ROTEM reference ranges

	EXTEM					INTEM				
Age group	CT(s)	CFT (s)	⍺ (°)	MCF (mm)	LI 30 (%)	CT(s)	CFT (s)	⍺ (°)	MCF (mm)	ML (%)
Newborns (0-30 days)	35-70	40-150	52-82°	40-80	90-100	65-135	50-220	45-75°	40-70	0-15
Infants (1-12 months)	35-70	30-140	54-76°	45-82	95-100	60-130	45-200	48-78°	42-76	0-12
Children (1-12 yrs)	33-69	25-120	58-78°	50-84	95-100	55-120	40-180	50-80°	44-78	0-10
Adolescents (12-18 yrs)	33-69	20-110	60-74°	55-86	97-100	50-110	35-160	52-82°	46-80	0-10
Adults	38-79	34-159	63-83°	50-72	94-100	100-240	30-110	70-83°	50-72	0-8

Paediatric Pulseless arrest



For paediatric patients with pre-existing invasive BP monitoring, consider diastolic BP to guide resuscitative efforts.

Infants DBP > 25mmHg
1-12 years > 30mmHg
Above 12 years > 35mmHg

Post arrest care

A&B: Oxygenation and ventilation
O2: Avoid hypoxia/ hyperoxaemia, keep SpO2 94-98%
CO2: Target appropriate PaCO2, avoid hypocapnia

Circulation
Monitor BP, set hemodynamic goals after ROSC
IV fluids and/or inotropes to maintain SBP above 5th percentile

Disability Treat clinical seizures.

Environment: targeted temperature management
Monitor core temperature & treat fever.
Target normothermia (36 to 37℃)

Glucose control & electrolytes
Avoid hypoglycemia, keep blood glucose >3.5mmol/L
Maintain electrolytes within normal ranges

Pulseless arrest with shockable rhythm

Basic life support, give oxygen, attach monitors/ defib when available
Check rhythm → Shockable?

→ Not shockable = Asystole/ PEA → See asystole/ PEA algorithm

YES = Pulseless VF/ VT

1st shock
2-4 J/kg
Resume CPR

2nd shock
4 J/kg
Resume CPR

3rd shock
4 J/kg
Resume CPR

4th shock
4 J/kg
Resume CPR

5th shock
4 J/kg
Resume CPR

6th shock
4 J/kg
Resume CPR

Perform CPR 2min, check pulse & rhythm → Shockable?
Give adrenaline every other shock q3-5min.

CPR 2min then check pulse & rhythm → Shockable?

Minimise time between compressions & shock delivery

Monitor quality of CPR

Assess & manage for reversible causes
- Hs & Ts**

IV/ IO adrenaline 0.01mg/kg (max 1mg), q3-5min or every other shock

IV/ IO amiodarone 5mg/kg OR **IV/ IO lignocaine 1mg/kg** (max 100mg) initial bolus, then infusion 20-50mcg/kg/min

IV/ IO adrenaline 0.01mg/kg (max 1mg), q3-5min or every other shock

IV/ IO amiodarone 5mg/kg (max 3 doses) OR **IV/ IO lignocaine if not given earlier, 1mg/kg** (max 100mg) initial bolus, then infusion 20-50mcg/kg/min

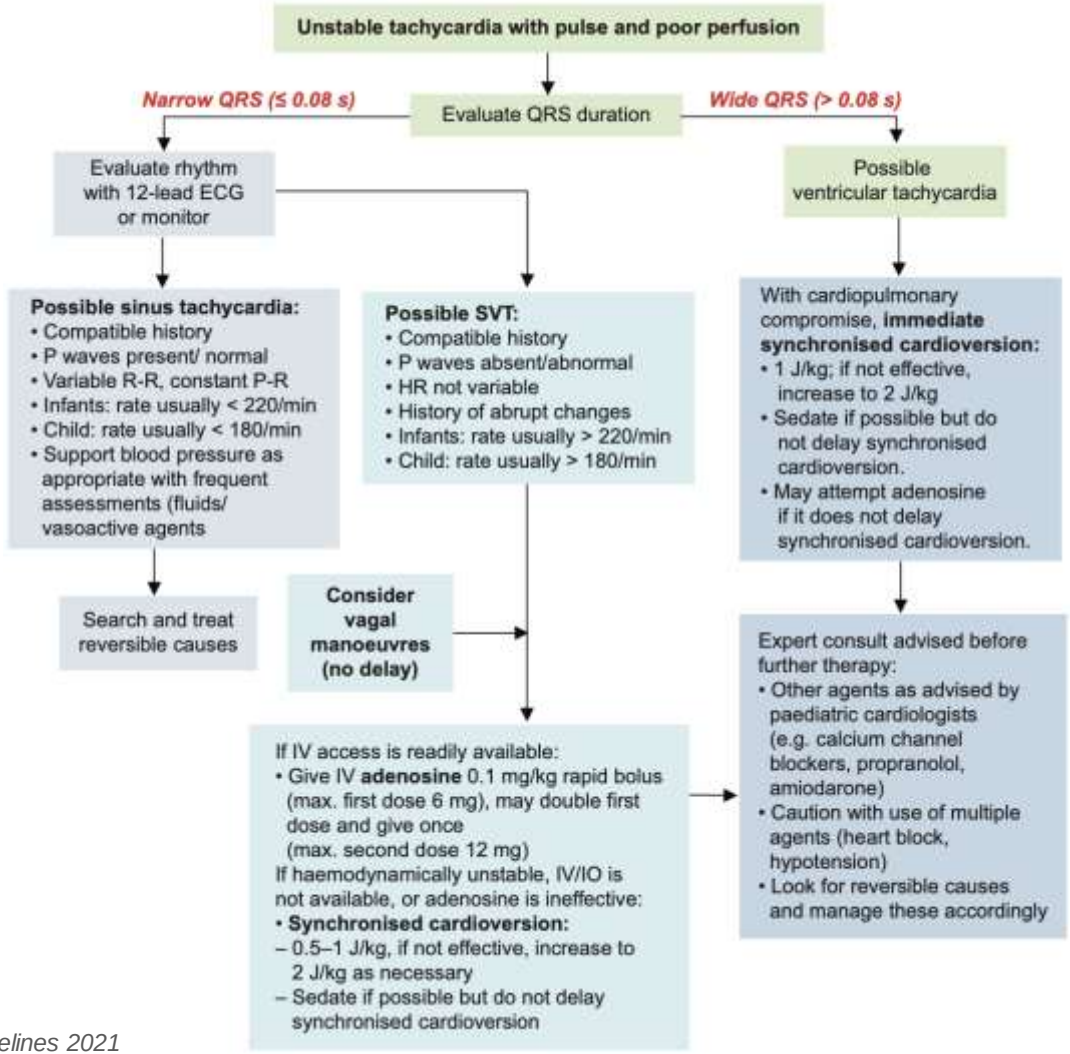
Consider other antiarrhythmics:
IV/ IO lignocaine 1mg/kg followed by **infusion 20-50mcg/kg/min** (May repeat bolus after 15min, if delay in starting infusion >15min)
IV/ IO amiodarone 5mg/kg, up to 3 times
IV/ IO magnesium sulphate 50mg/kg (max 2g) for torsades des pointes.
Consider increasing energy dose of shocks up to **max 10 J/kg** for refractory VF

****Search for & treat possible causes:**

Hypoxia	Trauma
Hypovolemia	Toxins
H+ ion (acidosis)	Tamponade (cardiac)
Hypo/ Hyperkalemia	Tension pneumothorax
Hypothermia	Thrombosis

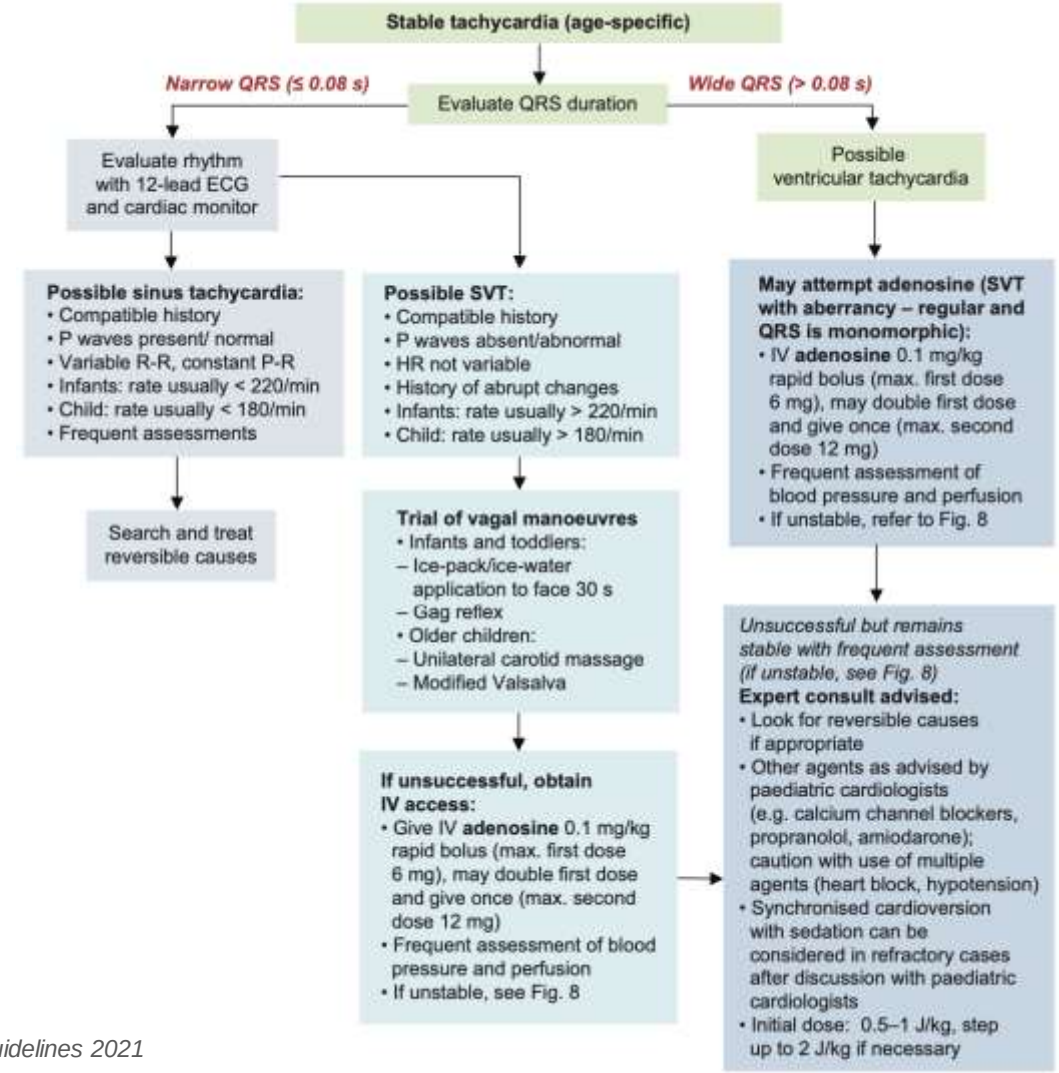
Singapore Paediatric Resuscitation Guidelines 2021

Paediatric Unstable Tachycardia



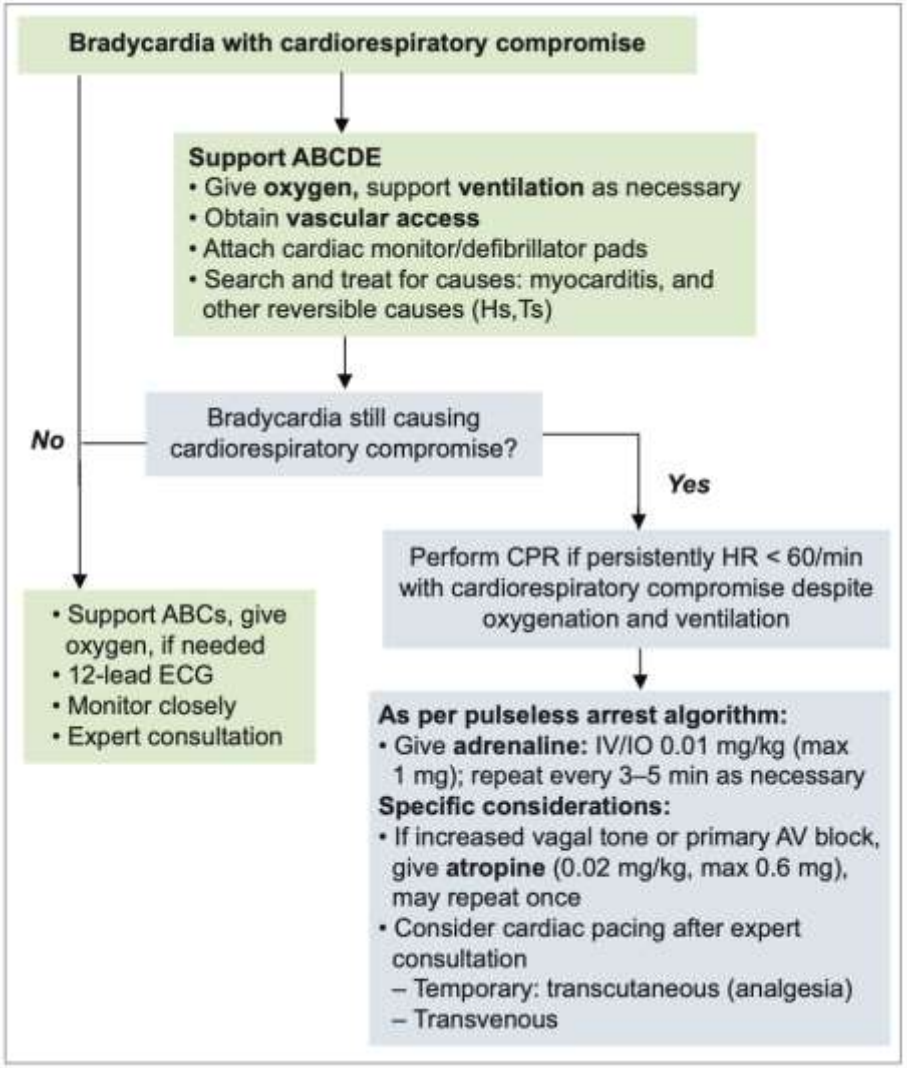
Singapore Paediatric Resuscitation Guidelines 2021

Paediatric Stable Tachycardia



Singapore Paediatric Resuscitation Guidelines 2021

Paediatric Bradycardia



Singapore Paediatric Resuscitation Guidelines 2021

Local Anaesthetic Toxicity

1 **STOP injecting the LA**, remember the infusion pumps.

2 **Call for help**, inform immediate clinical team of problem

3 Call for **cardiac arrest cart**, and **LA toxicity box**.

4 Give **100% oxygen**, ensure adequate lung ventilation:

Maintain the airway and intubate if necessary

Avoid hypercarbia - consider mild hyperventilation.

5 Confirm or establish **IV access**

6 **If circulatory arrest**:

- Start CPR using standard protocols but:
- Give **IV Lipid emulsion** (see Box A)

  Use **smaller adrenaline dose ≤1mcg/kg** instead of 1mg
- Avoid vasopressin
- Recovery may take >1 hour.
- Consider use of cardiopulmonary bypass if available

If no circulatory arrest:

- Conventional therapies to treat hypotension, brady & tachy-arrhythmias.
- Consider IV lipid emulsion (Box A)

7 **Control seizures**.

- Small incremental dose of IV midazolam 0.05-0.1mg/kg.
- Thiopentone or propofol can be used, beware negative inotropic effect
- Consider neuromuscular blockade if seizures uncontrolled

Box A: LIPID EMULSION Regime

Use 20% SMOFlipid® (propofol is not a suitable substitute)

Immediately:

- Give an initial IV bolus of lipid emulsion 1.5 mL/kg over 2-3 min (~100 ml for a 70 kg adult). See drug dosing guide.
- Start an IV infusion of lipid emulsion at 15 ml/kg/h (17.5 mL/min for a 70 kg adult)

At 5 and 10 minutes:

- Give a repeat bolus (same dose) if:
  - cardiovascular stability has not been restored or
  - an adequate circulation deteriorates

At any time after 5 minutes:

- Double the rate to 30 mL/kg/h if:
  - cardiovascular stability has not been restored or
  - an adequate circulation deteriorates

Do NOT exceed max cumulative dose 12 mL/kg (70 kg: 840 ml)

Box B: CRITICAL CHANGES

Cardiac arrest → check already done **1 to 5**, then → **6**

Box C: After the Event

Arrange safe transfer to appropriate clinical area
Exclude pancreatitis: regular review, daily amylase or lipase
Report as critical incident

*Adapted from **Association of Anaesthetists 2023.** www.anaesthetists.org/grh*

20% IntraLipid dosing guide

Weight (kg)	Initial bolus 1.5ml/kg over 2-3min	Infusion 15ml/kg/hour		Double infusion 30ml/kg/hour	Do NOT exceed max cumulative dose 12ml/kg
3	4.5 ml	45 ml/h	At 5 & 10min, give a repeat bolus if: Cardiovascular stability has not been restored OR an adequate circulation deteriorates	90 ml/h	36 ml
5	7.5 ml	75 ml/h		150 ml/h	60 ml
8	12 ml	120 ml/h		240 ml/h	96 ml
10	15 ml	150 ml/h		300 ml/h	120 ml
15	22.5 ml	225 ml/h		450 ml/h	180 ml
20	30 ml	300 ml/h		600 ml/h	240 ml
25	37.5 ml	375 ml/h		750 ml/h	300 ml
30	45 ml	450 ml/h		900 ml/h	360 ml
40	60 ml	600 ml/h		1200 ml/h *(max rate of BBraun infusion pump)*	480 ml
50	75 ml	750 ml/h			600 ml
60	90 ml	900 ml/h			720 ml
70	105 ml	1050 ml/h			840 ml

Malignant Hyperthermia

1 Declare Code Blue and MH Crisis, note the time.

2 Aim to abandon or finish surgery as soon as possible.

3 Call for MH box/dantrolene and cardiac arrest trolley.

4 Maintain anaesthesia with TIVA..

5 *Allocate enough staff to perform **6** , **7** and **8** simultaneously:*

6 Eliminate trigger drug (Box A)**. Hyperventilate 15L/min 100% O2. Insert activated charcoal filters** on inspiratory & expiratory limbs of breathing circuit.

7 Give Dantrolene (Box B).

8 Begin active body cooling (Box C)

9 Additional monitors: invasive BP, CVP, core & peripheral temp, urine output

10 Send urgent labs: ABG, U&E, glucose, FBC, PT/PTT, urinary pH, creatine kinase (peak 12-24h). Repeat as indicated.

11 Seek and treat complications (Box D).

12 Continue ventilation and plan ICU admission. Further dantrolene may be needed. (Ensure plan exists to counsel patient and family)

DANTROLENE STOCK

Located at:

*Adapted from **Association of Anaesthetists 2023.** www.anaesthetists.org/grh*

Box A: ELIMINATE TRIGGER DRUG

Turn off vaporisers & remove from anaesthesia workstation
Set fresh gas flow to 100% oxygen, 15L/min
Hyperventilate 2-3x normal minute ventilation
Place **activated charcoal filters** on both limbs of breathing circuit
Change soda lime & breathing circuit if feasible (not a priority)

Box B: DANTROLENE - delegate mixing

- **2-3mg/kg immediate IV bolus (adult approx 200mg)**
- **Repeat 1mg/kg every 5min, until EtCO2 < 50mmHg & temp <38.5**
- **Pause & observe**
- **Repeat 1mg/kg to maintain EtCO2 < 50mmHg & temp <38.5, even if 'exceeds' maximum dose 10mg/kg**

Box C: ACTIVE COOLING

Turn OFF active warming
Apply ICE to axillae & groins
Use cold IV fluids, consider cold peritoneal lavage
Consider surface cooling devices, intravascular devices, extracorporeal heat exchange

Box D: COMPLICATIONS & TREATMENTS

Metabolic acidosis: 0.5-1mL/kg sodium bicarbonate 8.4% if pH < 7.2
Hyperkalemia: 0.5-1mL/kg sodium bicarbonate 8.4%, 10% Dextrose 5mL/kg with 0.1unit/kg insulin (actrapid), IV calcium gluconate 0.3mL/kg
Myoglobinuria: Forced alkaline diuresis, aim UOP > 2mL/kg, urine pH >7.
DIC: FFP, cryoprecipitate, platelets
Tachyarrhythmias: amiodarone, beta blockers. AVOID Ca-channel blockers.

Dantrolene dosing guide

(Dilute 20mg dantrolene in 60ml sterile water)

Wt (kg)	Initial bolus 3mg/kg	Repeat 1mg/kg q5min	Max dose 10mg/kg
3	9 mg (27mL)	3 mg (9 mL)	30 mg (90 mL)
5	15 mg (45 mL)	5 mg (15 mL)	50 mg (150 mL)
8	24 mg (72 mL)	8 mg (24 mL)	80 mg (240 mL)
10	30 mg (90 mL)	10 mg (30 mL)	100 mg (300 mL)
15	45 mg (135 mL)	15 mg (45 mL)	150 mg (450 mL)
20	60 mg (180 mL)	20 mg (60 mL)	200 mg (600 mL)
25	75 mg (225 mL)	25 mg (75 mL)	250 mg (750 mL)
30	90 mg (270 mL)	30 mg (90 mL)	300 mg (900 mL)
40	120 mg (360 mL)	40 mg (120 mL)	400 mg (1200 mL)
50	150 mg (450 mL)	50 mg (150 mL)	500 mg (1500 mL)
60	180 mg (540 mL)	60 mg (180 mL)	600 mg (1800 mL)
70	210 mg (630 mL)	70 mg (210 mL)	700 mg (2100 mL)
80	240 mg (720 mL)	80 mg (240 mL)	800 mg (2400 mL)

Emergency treatment of Hyperkalemia (term infants & children)

Age> 1mo & K ≥5.5
Age ≤ 1mo & K ≥ 6

Initial treatment

Do ECG
Stop K+ containing fluids

Further treatment

Hyperkalemia kit

K+ 5.5 to 6 mmol/L

1. **Salbutamol** via MDI
2. If pH<7.25, consider **IV sodium bicarbonate** 1mL/kg/dose over 10-15min, diluted to 4.2% solution
3. PR/ oral resonium 1g/kg/dose

Review **K+** in 1 hour

K+ improving → monitor until normalised
K+ 5.5-6 → repeat salbutamol MDI
<u>K+ NOT improving</u>
Re-evaluate cause
K+ > 6 mmol/L → escalate to next level of treatment

K+ 6.1 to 6.9 mmol/L

Cardiac monitoring
Inform senior anaesthetist
1. **Salbutamol** via MDI
2. **IV dextrose/Soluble insulin (actrapid)****
3. Consider **IV calcium gluconate** 0.5-1mL/kg
4. If pH<7.25, **IV sodium bicarbonate** 1mL/kg over 10 to 15min, diluted to 4.2% solution
5. ± **IV frusemide** 1-2mg/kg

Review **K+** & glucose in 1 hour

K+ improving → monitor until normalised
K+ 5.5 to 6.9 → repeat MDI Salbutamol ± dextrose/ insulin (actrapid)** until normal
<u>K+ NOT improving</u>
Re-evaluate cause
K+ > 6.9 → escalate to next level of treatment

K+ 7mmol/L or ECG abnormal

Cardiac monitoring
Inform senior anaesthetist kiv CICU
1. **IV Calcium gluconate** 0.5-1ml/kg **or calcium chloride** 0.2mL/kg over 10min (if central access)
2. **Salbutamol** via MDI
3. **IV dextrose/ insulin (actrapid)****
4. **IV sodium bicarbonate** if pH <7.25, 1mL/kg over 10-15min, diluted to 4.2% solution +/- hyperventilation
5. Consider **IV frusemide** 1-2mg/kg

Review **K+,** glucose & ECG in 30min

K+ improving → monitor till normal
K+ 5.5 to 6 → can repeat Salbutamol MDI ± dextrose/insulin (actrapid)** until normal.
<u>K+ NOT improving</u>
Re-evaluate for cause
ECG changes persist → can repeat calcium
Consider **CRRT**

**** IV Dextrose 10% 5mL/kg per dose**
**** IV Soluble Insulin 0.1unit/kg per dose** (max 10units/dose) *Take 50units in insulin syringe, dilute to 50ml, to final concentration of 1unit per mL. Administer appropriate dose using diluted solution.*

Hyperkalemia Dosage Guidelines

Insulin and dextrose dosage guidelines for management of hyperkalemia in PRE-TERM neonate

DRUG	ROUTE	DOSE	SPECIAL INSTRUCTIONS
ACTRAPID (Soluble Insulin)	IV INFUSION	0.2 UNITS/KG/ HR	**SOLUTION A** Take **25 units of Actrapid** using INSULIN SYRINGE and reconstitute to **25 ml with Dextrose 5%** in the 20 ml syringe. **SOLUTION B** Draw **5 X BWT (kg) in mls** of **Solution A** and reconstitute to **50 ml with Dextrose 5%** in the 50ml syringe. Run **Solution B** at **2 ml/hr** with **Dextrose 10%** infusion. *Discard **Solution A***
Dextrose 10%	IV INFUSION	5 ML/KG/HR	Run with **Solution B** simultaneously.

Review serum K+, hypocount and ECG in 30 minutes.

Insulin and Dextrose Dosage Guidelines for Management of Hyperkalemia in TERM NEONATES, INFANTS & CHILDREN

DRUG	ROUTE	DOSE	SPECIAL INSTRUCTIONS
ACTRAPID (Soluble Insulin)	**IV BOLUS**	**0.1 UNIT/KG**	Take **50 units of Actrapid** using INSULIN SYRINGE and reconstitute to **50 ml with NaCL 0.9%** in the 50ml syringe. Final concentration is **1 unit/ml.** Draw **0.1 X BWT (kg) in mls** from the diluted solution (max 10 units). BWT ≤ 30 kg draw into 3ml syringe. BWT > 30 kg draw into 10ml syringe. Give as a bolus after starting the **Dextrose 10%.**
Dextrose 10%	**IV INFUSION**	**5 ML/KG**	Run **Dextrose 10%** over 20 minutes.

Review serum K+, hypocount and/or ECG in 30 minutes.

Suspected adverse blood transfusion reaction

Fever/ Chills	• Acute Hemolytic Reaction • Bacterial contamination • Febrile Non-hemolytic transfusion reaction
Hives/ Urticaria	• Mild allergic reaction • Anaphylaxis/anaphylactoid (with respiratory symptoms and/or hypotension
Dyspnea	• TRALI • Anaphylactoid/ anaphylactic • Transfusion related circulatory overload
Hypotension	• Acute hemolytic reaction • TRALI • Anaphylactoid/ anaphylaxis • Bacterial contamination

- All suspected transfusion reactions must be reported to the Blood bank.
- Stop blood transfusion temporarily, flush IV line with 0.9% saline.
- Monitor patient's vital signs.
- Repeat check the blood unit, patient's details (e.g. name and date of birth) on patient's wristband & transfusion slip to confirm details are correct. Review expiry date on blood unit.
- Coordinate with Blood bank regarding: 1) samples to be collected for investigation of suspected transfusion reaction and 2) further transfusion.

Specimens for Transfusion reaction workup

- Return the blood product pack + infusion to the blood bank and report the reaction to the blood bank
- Draw blood for transfusion investigations. Send 1st specimen immediately after and the 2nd specimen 24 hours later
- Use tube sizes appropriate to patient's age