AUSTRALIAN RESUSCITATION COUNCIL

NEW ZEALAND Resuscitation Council
Whakahauora, Aotearoa

GUIDELINE 12.4

MEDICATIONS & FLUIDS IN PAEDIATRIC ADVANCED LIFE SUPPORT

All intravenous (IV) and intraosseous (IO) drugs should be flushed with small boluses of 0.9% sodium chloride or 5% glucose (for amiodarone). This ensures that the drugs enter the circulation and prevents precipitation or inactivation as occurs when sodium bicarbonate mixes with calcium, or when sodium bicarbonate mixes with adrenaline. Medications used in paediatric CPR are listed alphabetically. See guideline 12.5 for use in treatment of specific dysrhythmias.

ADRENALINE

Both *alpha* and *beta* effects of adrenaline are useful in management of cardiopulmonary resuscitation. *Alpha* vasoconstrictor effects diverts blood to the cerebral and coronary circulation and can facilitate defibrillation while *beta* effects are chronotropic and inotropic.

The optimal dose and frequency of administration of adrenaline in children are unknown. The initial and any subsequent dose by the intravenous or intraosseous route is 10mcg/kg, (10 micrograms/kg) with a maximum single dose of 1mg. [1] [Class A; Expert Consensus Opinion]. In special circumstances such as *beta*-blocker use or poisoning, larger doses may be used but are otherwise not recommended.

Higher and excessive doses of adrenaline may have significant complications of severe vasoconstriction, hypertension and tachydysrrhythmias. In the treatment of in-hospital paediatric arrest, administration of 100 mcg/kg after an initial 10 mcg/kg was associated with lower short-term survival than administration of first and subsequent doses of 10 mcg/kg [LOE II] [1].

The systemic absorption of adrenaline from endotracheal tube (ETT) administration is variable. Although unproven to be the optimal dose, 100mcg/kg is the accepted paediatric endotracheal ETT dose [1] [Class A; Expert Consensus Opinion].

Adrenaline is used to treat asystole, severe bradycardia, ventricular fibrillation and electromechanical dissociation. It should be given intravenously or intraosseously at intervals of every second cycle (Guideline 12.3) [Class A, Expert Consensus Opinion]. Instead of repeated bolus doses, a continuous infusion of approximately 0.1 – 0.2 mcg/kg/min or higher doses may be given – preferably into a large vein to avoid extravasation necrosis.

AMIODARONE

Amiodarone is an antiarrhythmic drug with complex pharmacokinetics and pharmacodynamics. It is effective for adult shock-resistant ventricular fibrillation and more efficacious than lignocaine and has been used to treat paediatric life-threatening ventricular arrhythmias [1] [LOE III-3]. The initial paediatric dose for shock-resistant ventricular fibrillation and pulseless ventricular tachycardia is a bolus of 5 mg/kg, which may be repeated. [Class A; Expert Consensus Opinion]. If amiodarone is not available, lignocaine may be used but no data exists on its effectiveness in paediatrics [1]. Acute adverse effects of amiodarone which may be related to the rapidity of infusion include hypotension, bradycardia and heart block, while long-term adverse effects include hypothyroidism and pulmonary toxicity.

In children, amiodarone can be used to successfully treat a wide range of other tachydysrhythmias, notably atrial tachycardias, (recurrent) supraventricular tachycardia, pulsatile ventricular tachycardia junctional ectopic tachycardia [Class A; LOE III-3] and wide QRS-complex tachycardia [Class A; Expert Consensus Opinion] (Refer Guideline 12.5).

ATROPINE

Parasympathetic cardiac blockade with atropine may be indicated if bradycardia is caused by vagal stimulation or cholinergic drug toxicity [1].

The IV or IO dose is 20mcg/kg [Class A; Expert Consensus Opinion] and the ETT dose 30 mcg/kg [1] [Class A; LOE II].

Bradycardia caused by hypoxaemia should be treated with ventilation and oxygen but if unresponsive, should be treated with adrenaline [1].

Severe bradycardia and or bradycardia with hypotension should be treated with adrenaline, not atropine.

CALCIUM

Calcium may be used as an inotropic or vasopressor but it has no place in the management of an arrhythmia unless it is caused by hyperkalaemia, hypocalcaemia, hypermagnesaemia or calcium channel blocker [1]. It should not be given routinely at cardiac arrest [Class A; Expert Consensus Opinion] and is associated with worse outcome [1].

Calcium (0.15 mmol/kg) is the antidote to hypotension caused by a calcium channel blocker. The intravenous or intraosseous dose is 0.2mL/kg of 10% calcium chloride or approximately 0.7mL/kg of 10% calcium gluconate (20 mg/kg). [Class A, Expert Consensus Opinion]

GLUCOSE

Hypoglycaemia may be present in paediatric critical illness [LOE IV], particularly in infants. Hyperglycaemia also occurs in paediatric critical illness and is associated with increased mortality [LOE IV] but it is not known if this is the cause. The normal level is 3-8 mmol/L.

The blood sugar level should be checked during CPR and after ROSC with the aim of ensuring normoglycaemia [3] [Class A; Expert Consensus Opinion]. Hypoglycaemia may be treated with 0.25g/kg glucose by IV or IO infusion with any hyperosmolar solution, for example, 0.5ml/kg of 50% (only via a central venous line) or 2.5ml/kg of 10%. Avoid extravasation, especially from peripheral veins, and avoid overdosage. The maintenance requirement to avoid hypoglycaemia in infancy is approximately 5-8 mg/kg/min.

LIGNOCAINE

Although lignocaine has a membrane stabilizing effect and a potential to aid defibrillation, it actually increases the defibrillation threshold. A benefit in the treatment of ventricular fibrillation has never been demonstrated. Indeed, it is associated with worse outcome compared with placebo when used as a prophylactic agent against dysrrhythmia after myocardial infraction [10-12.] [LOE I]**.** It is inferior to amiodarone for shock-resistant ventricular fibrillation [LOE II] and has little if any place in management of this dysrrhythmia [Class A; Expert Consensus Opinion]. It is inferior to amiodarone for the treatment of shock-resistant ventricular tachycardia [LOE II]. Lignocaine is not recommended in paediatric cardiac arrest unless amiodarone is not available (Class A, Expert Consensus Opinion) or when IV and IO access are impossible as lignocaine may be given via endotracheal tube. The dose of lignocaine is 1mg/kg IV or IO.

MAGNESIUM

Hypomagnesaemia may cause life-threatening ventricular tachyarrhythmia, particularly when associated with hypokalaemia. Magnesium is the preferred antidysrrythmic treatment for polymorphic ventricular tachycardia (*Torsade de pointes* – "Twisting of peaks") due to acquired or congenital prolonged QT interval syndromes [2] [Class A; LOE IV]. Neither increased ROSC nor survival in adults has been demonstrated in treatment of VF with magnesium [4] [LOE IV]. The intravenous or intraosseous bolus dose of magnesium sulphate is 0.1-0.2 mmol/kg followed by an infusion of 0.3mmol/kg over 4 hours.

POTASSIUM

Hypokalaemia may cause a life-threatening tachydysrhythmia. Emergency treatment is the intravenous or intraosseous administration of 0.03 - 0.07 mmol/kg by slow injection [Class A; Expert Consensus Opinion] over several minutes. If the situation is critical but not immediately life-threatening severe hypokalaemia may be treated with an infusion of 0.2 - 0.5mmol/kg/hour to a maximum of 1mmol/kg.

Extreme caution in the use of concentrated solutions of potassium is advised. Infusions should only be given by infusion pumps and frequent (half-hourly – hourly) serum monitoring with continuous ECG display is required, preferably in an intensive care unit setting. Mistakes in the calculation of potassium requirement and inadvertent administration of potassium cause avoidable deaths. (Note that a small bolus injection may cause a dangerous rise in serum potassium: a 1 mmol bolus of potassium in a 5 kg infant theoretically raises the serum level approximately 4 mmol/L). Therapies which rapidly decrease serum potassium level are intravenous glucose + insulin, inhaled or intravenous salbutamol + intravenous glucose or a combination of these agents (insulin + glucose + salbutamol) with or without sodium bicarbonate. Sodium bicarbonate alone is the least effective therapy [LOE III-1].

PROCAINAMIDE

Numerous observational studies and small case series [3] suggest that procainamide can be used to treat haemodynamically stable supraventricular tachycardia and ventricular tachycardia in children [Class B; LOE IV]. The intravenous dose is 10-15 mg/kg infused over 30-60 minutes.

SODIUM BICARBONATE

Sodium bicarbonate has a limited and unproven place in the management of cardiorespiratory arrest and routine administration is not recommended [1-3]. Administration of IV or IO sodium bicarbonate neutralizes hydrogen ions in the blood but in doing so produces carbon dioxide which may re-enter cells to exacerbate intracellular acidosis.

Other deleterious effects include hypernatraemia and hyperosmolality which may depress myocardial function. Nonetheless, administration of sodium bicarbonate may be useful in severe metabolic acidosis (pH < 7.1) or prolonged arrest. The IV or IO dose is 0.5-1 mmol/kg after adequate ventilation with oxygen and chest compression have been established [Class B; Expert Consensus Opinion].

VASOPRESSIN

Vasopressin is an alternative vasopressor to adrenaline but a meta-analysis of trials comparing vasopressin with adrenaline shows that vasopressin offers no advantages in the treatment of adult ventricular fibrillation or tachycardia, pulseless electrical activity or asystole [LOE I] [1].

Although vasopressin has been used in a series of paediatric case reports it has not been investigated systematically in the paediatric age group and the optimal dose is unknown [1]. However, by extrapolation from adult experience a bolus dose would be approximately 0.5-0.8 U/kg IV or IO [Class B; Expert Consensus Opinion].

FLUID THERAPY

If hypovolaemia is suspected as the cause of cardiorespiratory arrest, intravenous or intraosseous crystalloid may be used initially for resuscitation [1] [Class A] as a bolus of 20mL/kg. Additional boluses or colloid solution should be titrated against the response.

REFERENCES

1. de Caen AR, Kleinman ME, Chameides L, Atkins DL, Berg RA, Berg MD, Bhanji F, Biarent D, Bingham R, Coovadia AH, Hazinski MF, Hickey RW, Nadkarni VM, Reis AG, Rodriguez-Nunez A, Tibballs J, Zaritsky AL, Zideman D, On behalf of the Paediatric Basic and Advanced Life Support Chapter Collaborators. Part 10: Paediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation 2010;81:e213–e259.
2. Consensus on Science and Treatment recommendations. Part 6: Paediatric basic and advanced life support. Resuscitation 2005; 67: 271-291.

3. American Heart Association in collaboration with International Liaison Committee on Resuscitation. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care: International Consensus on Science, Part 10: pediatric advanced life support. Resuscitation 2000; 46: 343-399.
4. Advanced life support (Adult): 2010 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation 2010; 122: S345-S421.

TABLE of DRUGS, FLUIDS, ENDOTRACHEAL TUBES and DIRECT CURRENT SHOCK FOR PAEDIATRIC RESUSCITATION

Age	0	2m	5m	1y	2y	3y	4y	5y	6y	7y	8y	9y	10y	11y	12y	13y	14y
Body weight kg *	3.5	5	7	10	12	14	16	18	20	22	25	28	32	36	40	46	50
Height cm *	50	58	65	75	85	94	102	109	115	121	127	132	138	144	151	157	162
Adrenaline 1in 1000: mL (10 mcg/kg)	0.035	0.05	0.07	0.10	0.12	0.14	0.16	0.18	0.2	0.22	0.25	0.28	0.32	0.36	0.4	0.46	0.5 mL
Adrenaline 1in 10,000: mL (10 mcg/kg)	0.35	0.5	0.7	1	1.2	1.4	1.6	1.8	2	2.2	2.5	2.8	3.2	3.6	4	4.6	5 mL
Amiodarone: mg (5 mg/kg)	17.5	25	35	50	60	70	80	90	100	110	125	140	160	180	200	230	250 mg
Lignocaine 1%: mL (1mg/kg)	0.3	0.5	0.7	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.6	5.0 mL
Sodium bicarbonate 8.4%: mL (1 mmol/kg)	3.5	5	7	10	12	14	16	18	20	22	25	28	32	36	40	46	50 mL
Fluid volume: mL (20 mL/kg)	70	100	140	200	240	280	320	360	400	440	500	560	640	720	800	920	1000 mL
Endotracheal tube																	
Uncuffed size: Age/4 + 4 mm (2 years and above)	3.5	3.5	3.5	4	4.5	4.5	5	5	5.5	5.5	6	6	6.5	6.5	7	7	7.5 mm
Cuffed size: Age/4 + 3 mm	3	3	3	3	3.5	3.5	4	4	4.5	4.5	5	5	5.5	5.5	6	6	6.5 mm
Oral length: Age/2 + 12 cm (2 years and above)	9.0	11	11.5	12	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19 cm
Nasal length: Age/2 + 14 cm (2 years and above)	11	12	13	14	15	16	17	18	19	19	20	20	21	21	22	22	23 cm
Direct Current shock (biphasic or monohasic)																	
VF, pulseless VT, First Shock (4J/kg) and all subsequent shocks, unsynchronized: Joules	10	20	30	50	50	50	70	70	70	100	100	100	150	150	150	200	200 J
Pulsatile VT, synchronized (approx 2J/kg): Joules	5	10	15	20	20	30	30	40	40	40	50	50	70	70	80	90	100 J
SVT, synchronized (approx 1J/kg): Joules	3	5	7	10	10	15	15	20	20	20	30	30	30	30	50	50	50 J

* 50th percentiles

REFERENCE: Oakley P, Phillips B, Molyneux E, Mackway-Jones K. Updated standard reference chart. BMJ 1993; 306: 1613.