



CLINICAL REPORT

Preparing for Pediatric Emergencies: Drugs to Consider

Guidance for the Clinician in Rendering
Pediatric Care

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ABSTRACT

This clinical report provides current recommendations regarding the selection and use of drugs in preparation for pediatric emergencies. It is not intended to be a comprehensive list of all medications that may be used in all emergencies. When possible, dosage recommendations are consistent with those used in current emergency references such as the *Advanced Pediatric Life Support* and *Pediatric Advanced Life Support* textbooks and the recently revised American Heart Association resuscitation guidelines.

INTRODUCTION

The purpose of this document is to assist health care professionals and facilities in their preparation for pediatric emergencies. This clinical report enables the practitioner to review current recommendations for the use of emergency medications in acutely ill children who require pharmacologic intervention. New agents and changing patterns of practice make it necessary to revise and update this clinical report.

This document is not intended to be an all-inclusive list of drugs used in pediatric emergencies, and it does not provide detailed drug information. Antimicrobial agents are not included in this document. Descriptions of medication indications and adverse effects are limited. Although not all-inclusive, the drug information listed in Table 1 should be helpful to practitioners and institutions when selecting which pharmacologic agents to have readily available for use in pediatric emergencies. The selection of which drugs to have available will depend on the setting; although emergency departments and hospitals will likely need the majority of the agents listed, a much more limited selection would likely be needed in a practitioner's office. This information should also be helpful for creating or editing preprinted drug-dosage charts. Table 2 contains a list of rescue, reversal, and antidote medications that may be useful in specific settings; it lists only the agents and indications and is not augmented with textual descriptions.

Dosages are generally given as milligrams per kilogram. The format for presented dosages is consistent with American Academy of Pediatrics recommendations for reducing medication errors.¹ For high-potency drugs such as prostaglandins, vasoactive amines, nitroprusside, and fentanyl, dosages are given as micrograms per kilograms. Historically, the weight-based "rule of 6" was recommended for preparation of vasoactive drip medications.² However, the Joint Commission and other organizations have recommended that standardized drip concentrations should replace rule-of-6 calculations to reduce the possibility of medication errors.³ The selection of drugs for use in pediatric emergencies is only one part in a large system or program that needs to be designed effectively to manage pediatric patients in an emergency situation. It is the creation, monitoring, and evaluation of these systems that will result in an improved outcome for pediatric patients.⁴

Rates and routes of administration are drug specific, and proper infusion systems should be used. Both adverse events and therapeutic effectiveness are dose and rate dependent, especially when highly potent vasoactive medications are administered. In general, most drugs should be administered over several minutes to avoid transient excessive blood concentrations. However, exceptions exist. One example is adenosine, for which rapid infusion is needed for efficacy. Another example of the importance of administration rate is phenytoin/fosphenytoin, for which slow infusion is necessary to minimize adverse events. Please refer to the text below. Unless otherwise indicated, the intravenous (IV) route is preferred. In an emergency, intraosseous (IO) administration is an acceptable alternative when IV access cannot be promptly obtained. Although certain drugs (lidocaine, epinephrine, atropine, naloxone [memory aid: LEAN]) can be administered endotracheally if no

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The guidance in this report does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

Key Words

pediatric emergency, drugs, resuscitation, emergency preparedness

Abbreviations

IV—intravenous
IO—intraosseous
ET—endotracheal
RSI—rapid-sequence intubation
VT—ventricular fibrillation
PE—phenytoin equivalent

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TABLE 1 Potentially Useful Drugs in Pediatric Emergencies

Adenosine	Diphenhydramine	Glucagon	Lorazepam	Phenytoin
Albuterol	Dobutamine	Glucose	Magnesium sulfate	Prednisone/Prednisolone
Alprostadil	Dopamine	Haloperidol	Mannitol	Procainamide
(see Prostaglandin E ₁)	Epinephrine	Hydrocortisone	Methylprednisolone	Propranolol
Amiodarone	Epinephrine, racemic	Insulin	Midazolam	Prostaglandin E ₁
Atropine	Etomidate	lpratropium	Milrinone	Rocuronium
Bicarbonate, sodium	Fentanyl	Kayexalate™ (see sodium polystyrene sulfonate)	Morphine	Sodium polystyrene sulfonate
Calcium chloride	Flumazenil		Nalmefene	
Charcoal, activated	Fosphenytoin		Naloxone	Succinylcholine
Dexamethasone	Furosemide	Ketamine	Nitroprusside	Thiopental
Diazepam		Levalbuterol (see albuterol)	Norepinephrine	Vecuronium
		Lidocaine	Phenobarbital	
Adenosine				
Indication	Supraventricular tachycardia			
Dosage	Initial dose: 0.1 mg/kg IV (maximum: 6 mg for first dose) as rapidly as possible, followed by immediate rapid flush of the IV catheter with 5–10 mL of normal saline. A 2-syringe technique is preferred; a larger flush of up to 20 mL may be helpful in older children. The most proximal IV site possible should be used. Adenosine may be given intraosseously if IV access has not been achieved.			
Subsequent doses	If no AV block occurs and there is no response within 30 s, give double the initial dose (0.2 mg/kg, up to 12 mg maximum for second/subsequent doses) followed by immediate rapid saline flush as described above.			
Note	Continuous electrocardiographic monitoring should be employed during use. A defibrillator must be immediately available.			
Warning	Contraindicated in patients who have had a heart transplant; contraindicated in second- and third-degree AV block or sick-sinus syndrome unless a pacemaker has been placed.			
Albuterol				
Indication	Asthma exacerbation, bronchospasm			
Dosage	Intermittent treatment with 0.5% nebulizer solution (5 mg/mL): minimum dose 2.5 mg (0.5 mL) every 20 min for 3 doses, then 0.15–0.30 mg/kg up to 10 mg every 1–4 h as needed. Dilute in a minimum of 2–3 mL of saline solution for adequate nebulization.			
	Continuous/prolonged nebulization: 0.5 mg/kg per h up to 10–15 mg/h diluted in a larger amount of saline by prolonged nebulization (total amount of fluid is determined by particular type of nebulizer delivery device, usually 25–30 mL for 1 h of nebulization).			
	Metered-dose inhaler: 4–8 puffs (90 µg per puff) every 15–20 min for 3 doses. Repeat every 1–4 h as needed. A spacer/holding chamber must be used when administering metered-dose inhaler treatments.			
	Administration can be repeated and dose can be adjusted until desired clinical effect unless patient develops symptomatic tachycardia.			
Notes	Oxygen is the preferred gas source for nebulization. Supplemental oxygen may be needed when compressed air–driven nebulizers are used or when the oxygen flow rate dictated by the nebulizer device is inadequate to maintain adequate oxygen saturation.			
	Levalbuterol may also be used; the dose is half of the (racemic) albuterol dose listed above.			
Alprostadil—see prostaglandin E ₁				
Amiodarone				
Indication	Pulseless ventricular fibrillation (VT)			
Dosage	IV/IO: 5 mg/kg rapid bolus (maximum: 300 mg); may be repeated up to a total daily dose of 15 mg/kg.			
Indication	VT/supraventricular tachycardia with a pulse.			
Dosage	IV/IO: 5 mg/kg (maximum: 300 mg) over 20–60 min. Adjust administration rate to urgency. May be followed by infusion of 5 µg/kg per min, increased to maximum of 10 µg/kg per min. Concentration of continuous infusion should not exceed 2 mg/mL and should be diluted with D5W.			
Note	Amiodarone is only appropriate in pulseless ventricular arrhythmias after defibrillation and epinephrine have been initiated. Because of its long half-life and potential drug interactions, cardiologist consultation is recommended when considering amiodarone treatment outside of the cardiac arrest setting.			
Warning	May cause hypotension, bradycardia, heart block, prolonged QT interval, and torsades de pointes VT. Should not be used in combination with procainamide or other drugs that cause QT prolongation without expert consultation. Contraindicated in severe sinus node dysfunction, marked sinus bradycardia, and second- and third-degree AV block.			
	Do not confuse name with amrinone; potential fatal complications if drugs or dosages are interchanged.			
Atropine				
Indication	Symptomatic vagally mediated bradycardia or AV block			
	Symptomatic bradycardia unresponsive to oxygenation, ventilation, and epinephrine			
Dosage	IV/IO: 0.02 mg/kg.			
	Minimum single dose: 0.1 mg.			
	Maximum single dose: 0.5 mg for a child, 1.0 mg for an adolescent.			
	May repeat dose every 5 min to maximum total dose of 1 mg for a child and 2 mg for an adolescent or adult.			
	IM: 0.02–0.04 mg/kg.			

TABLE 1 Continued

	ET: Neonates: 0.01–0.03 mg/kg. Children and adolescents: 0.03–0.06 mg/kg. Follow with or dilute in saline flush (1–5 mL) based on patient size.
Note	Oxygenation and ventilation are essential first maneuvers in the treatment of symptomatic bradycardia. Epinephrine is the drug of choice if oxygen and adequate ventilation are not effective in the treatment of hypoxia-induced bradycardia.
Indication	Anticholinesterase poisoning
Dosage	IV: for children, 0.05 mg/kg (up to initial adult dose: 2–5 mg). Repeat/adjust dose as needed for clinical effect. If response to initial dose is inadequate, may double the dose and repeat every 10–20 min as needed to dry pulmonary secretions and achieve anticholinergic effect (atropinization). Anticholinesterase or nerve gas poisonings may require large doses of atropine and the addition of pralidoxime.
Indication	Prevention of bradycardia associated with RSI
Dosage	IV/IO: 0.01–0.02 mg/kg (minimum dose: 0.1 mg; maximum dose: 1 mg) before administration of sedative/anesthetic and paralytic agents.
Warning	Atropine sulfate comes in different concentrations; calculate dosage accordingly.
Bicarbonate, sodium	
Indication	Metabolic acidosis Hyperkalemia Sodium channel blocker (eg, tricyclic antidepressant) overdose
Dosage	IV/IO: 1–2 mEq/kg given slowly; do not give by ET route.
Notes	Only the 0.5 mEq/mL concentration should be used for newborn infants; dilution of available stock solutions may be necessary. Do not mix sodium bicarbonate with vasoactive amines or calcium. Routine initial use of sodium bicarbonate to treat cardiac arrest is not recommended. However, sodium bicarbonate may be used in patients with documented metabolic acidosis after effective ventilation has been established (effective ventilation is needed to allow elimination of excess CO ₂ produced by bicarbonate). For sodium channel blocker overdose, titrate bicarbonate to maintain a serum pH of 7.45–7.55, followed by infusion of 150 mEq NaHCO ₃ /L solution to maintain alkalosis.
Calcium chloride	
Indications	Hypocalcemia Hyperkalemia Hypermagnesemia Calcium channel blocker toxicity
Dosage	IV/IO: 20 mg/kg (0.2 mL/kg for 10% CaCl ₂). Give by slow push for cardiac arrest; infuse over 30–60 min for other indications. Monitor heart rate; repeat dose as necessary for desired clinical effect.
Notes	Calcium chloride administration results in a more rapid increase in ionized calcium concentration than calcium gluconate and is preferred for the critically ill child. Calcium gluconate (dose: 60 mg/kg) may be substituted if calcium chloride is not available. Recommended for cardiac resuscitation only in cases of documented hyperkalemia, hypocalcemia, hypermagnesemia, or calcium channel blocker toxicity.
Warning	Stop injection if symptomatic bradycardia occurs. Administration through a central venous catheter is preferred; extravasation through a peripheral IV line may cause severe skin and soft tissue injury.
Charcoal, activated	
Indication	Acute ingestion of selected toxic substances
Dosage	1–2 g/kg PO or nasogastrically; adolescent/adult dose: 50–100 g.
Note	Consultation with poison center/clinical toxicologist is strongly encouraged before use (national Poison Control Center telephone number: 800-222-1222). Iron, lithium, alcohols, ethylene glycol, alkalis, fluoride, mineral acids, and potassium are not bound by activated charcoal.
Warnings	If airway protective reflexes are impaired, the risk of administering activated charcoal may outweigh the benefits. Commercially available preparations of activated charcoal often contain sorbitol as a cathartic. Fatal hypernatremic dehydration has been reported after repeated doses of charcoal with sorbitol. Non-sorbitol-containing products should be used for children <1 y old and if repeated doses of charcoal are necessary.
Dexamethasone	
Indication	Emergency treatment of elevated ICP caused by brain tumor
Dosage	IV/IO: 1–2 mg/kg.
Indication	Laryngotracheobronchitis (croup) Asthma exacerbation
Dosage	IV, IM, or PO: 0.6 mg/kg (maximum: 16 mg).
Note	Further dosing and route of administration determined by clinical course.
Diazepam	
Indication	Status epilepticus
Dosage	IV: 0.1–0.3 mg/kg every 5–10 min (maximum: 10 mg per dose). Administer over ~2 min to avoid pain at IV site. Rectal: 0.5 mg/kg up to 20 mg (this route may be useful when IV access is unavailable, but absorption may be erratic).
Note	IM route is not recommended because of tissue necrosis (other benzodiazepines, such as lorazepam and midazolam, may be given IM). Diazepam should be followed immediately by a long-acting anticonvulsant, such as phenytoin/fosphenytoin, because it is rapidly redistributed and seizures often recur within 15–20 min. Lorazepam may be preferred, because it has a prolonged duration of anticonvulsant activity.

TABLE 1 Continued

Warning	There is an increased incidence of apnea when diazepam is given rapidly IV or when it is used in combination with other sedative agents. Monitor oxygen saturation and respiratory effort. Be prepared to support ventilation. Flumazenil may be administered to reverse life-threatening respiratory depression caused by diazepam or other benzodiazepines; however, it also counteracts the anticonvulsant effects and may precipitate seizures.
Diphenhydramine	
Indications	Acute hypersensitivity reactions Dystonic reactions
Dosage	IV/IM: 1–2 mg/kg (maximum initial dosage: 50 mg).
Note	May cause sedation and respiratory suppression, especially if using other sedative agents. May cause hypotension. Rapid IV administration may precipitate seizures. All doses may cause paradoxical excitement or agitation.
Dobutamine	
Indication	Cardiogenic shock, congestive heart failure
Dosage	IV infusion: 2–20 μ g/kg per min, titrated to desired clinical effect.
Warning	May cause tachyarrhythmias/ectopic beats, hypotension, and hypertension. Extravascular administration can result in severe skin injury. Phentolamine (dose: 0.1–0.2 mg/kg up to 10 mg diluted in 10 mL of 0.9% sodium chloride) injected intradermally at extravasation site may be helpful for counteracting dermal vasoconstriction.
Dopamine	
Indication	Cardiogenic/distributive shock
Dosage	IV infusion: 2–20 μ g/kg per min, titrated to desired clinical effect.
Note	Effects are dose dependent; low-dose (1–5 μ g/kg per min) infusions usually stimulate dopaminergic and β -adrenergic receptors; α -adrenergic effects predominate at higher doses.
Warning	May cause arrhythmias and hypertension. Infusion rates of >20 μ g/kg per min may cause peripheral, renal, and splanchnic vasoconstriction and ischemia. Extravascular administration can result in severe skin injury. Phentolamine (dose: 0.1–0.2 mg/kg up to 10 mg diluted in 10 mL of 0.9% sodium chloride) injected intradermally at extravasation site may be helpful for counteracting dermal vasoconstriction.
Epinephrine	
Dosage/formulation	Epinephrine is available in 2 concentrations: 1:1000 (1 mg/mL) and 1:10 000 (0.1 mg/mL). Use caution to ensure selection of the appropriate concentration for the route of administration and patient age/condition. To convert mg/kg dosage to mL/kg: 0.01 mg/kg = 0.1 mL/kg of 1:10 000 solution and 0.1 mg/kg = 0.1 mL/kg of 1:1000 solution.
Indication	Cardiopulmonary resuscitation
Dosage	
IV/IO	Newborn infants: 0.01–0.03 mg/kg of 1:10 000 solution. Older infants/children: 0.01 mg/kg of 1:10 000 solution (maximum: 1 mg), repeated every 3–5 min.
ET	Newborn infants: 0.03–0.10 mg/kg of 1:10 000 solution. Older infants/children: 0.1 mg/kg of 1:1000 solution (maximum: 10 mg). Follow ET administration with saline flush or dilute in isotonic saline (1–5 mL) based on patient size.
Note	IV high-dose epinephrine (0.1 mg/kg) is no longer recommended for routine use in resuscitation. It may be considered in exceptional circumstances such as β -blocker poisoning.
Indication	Anaphylaxis
Dosage	IM/SC: 0.01 mg/kg of 1:1000 solution (maximum: 0.3–0.5 mg), repeated every 5–20 min. The IM route is preferred for anaphylaxis. Severe reactions (eg, latex allergy) may require IV epinephrine (see above); a continuous infusion of epinephrine may be necessary.
Indication	Continued shock after volume resuscitation
Dosage	IV infusion: 0.1–1.0 μ g/kg per min. Start at lowest dose and titrate to desired clinical effect. Doses as high as 5 μ g/kg per min are sometimes necessary.
Warning	IV infiltration can result in severe skin injury. Phentolamine (dose: 0.1–0.2 mg/kg up to 10 mg diluted in 10 mL of 0.9% sodium chloride) injected intradermally at extravasation site may be helpful for counteracting dermal vasoconstriction.
Indication	Severe asthma exacerbation
Dosage	SC: 0.01 mg/kg of 1:1000 solution (maximum: 0.3–0.5 mg); may repeat every 20 min up to 3 doses. Begin simultaneous treatment with inhaled β -agonist (albuterol) and corticosteroids.
Indication	Laryngotracheobronchitis (croup)
Dosage	0.5 mL/kg of 1:1000 solution (maximum: 5 mL = 5 mg) administered by nebulizer.
Epinephrine, racemic	
Indication	Laryngotracheobronchitis (croup) Acute airway edema
Dosage	2.25% inhalation solution: 0.05 mL/kg (maximum: 0.5 mL) in 2 mL of normal saline administered by nebulizer.
Note	Many institutions use a standard 0.5-mL dose of racemic epinephrine for all patients. If racemic epinephrine is not available, single-isomer L-epinephrine (1:1000) can be substituted in a dosage of 0.5 mL/kg up to 5 mL.
Etomidate	
Indication	Sedation for RSI
Dosage	IV/IO: 0.2–0.4 mg/kg (maximum: 20 mg).
Etomidate	
Indication	Sedation for RSI
Dosage	IV/IO: 0.2–0.4 mg/kg (maximum: 20 mg).

TABLE 1 Continued

Notes	Will lower ICP and does not usually lower blood pressure. Desirable agent for patients with head injury, multisystem trauma, or hypotension. Rapid onset: duration ~ 10–15 min. This agent does not have analgesic properties. May cause brief myoclonic activity (hiccups, cough, twitching) and may exacerbate focal seizure disorders. Causes transient adrenal suppression that is not clinically significant.
Fentanyl	
Indications	Pain Adjunct to intubation
Dosage	IV: 1–2 $\mu\text{g}/\text{kg}$. Repeat dose as necessary to desired clinical effect.
Notes	Rapid administration of fentanyl has been associated with both glottic and chest wall rigidity, even with dosages as low as 1 $\mu\text{g}/\text{kg}$. Therefore, fentanyl should be titrated slowly over several minutes when used for treatment of pain. More rapid administration is allowable before intubation, particularly if a muscle relaxant is also being administered. Higher doses (1–5 $\mu\text{g}/\text{kg}$) are often recommended for intubation.
Warning	There is an increased incidence of apnea when combined with other sedative agents, particularly benzodiazepines. Be prepared to administer naloxone or nalmeferene and provide respiratory support. May cause chest wall and glottic rigidity, which may be reversed with naloxone/nalmeferene or a muscle relaxant. Be prepared for the loss of the desired clinical effect (analgesia) if a reversal agent is given.
Flumazenil	
Indications	Benzodiazepine overdose Required or desired reversal of therapeutic benzodiazepine effect
Dosage	IV: 0.01–0.02 mg/kg (maximum: 0.2 mg); repeat at 1-min intervals to a maximum cumulative dose of 0.05 mg/kg or 1 mg, whichever is lower. When IV access is unavailable, may be given IM.
Note	Most patients with oversedation attributable to benzodiazepines may be managed with supportive care alone. The duration of action of flumazenil is shorter than for most benzodiazepines; repeat dosage may be necessary. Patients should be observed continuously for at least 2 h after the last dose of flumazenil.
Warning	May precipitate acute withdrawal in benzodiazepine-dependent patients. Use with extreme caution in children with underlying seizure disorders who are being treated with benzodiazepines; flumazenil reverses the anticonvulsant effects and may precipitate seizures. Contraindicated in tricyclic antidepressant overdose; may induce seizures or arrhythmias.
Fosphenytoin	
Indication	Status epilepticus
Dosage	Given in phenytoin equivalents (PE). IV: 15–20 PE/kg, infused at a rate of 1–3 PE/kg per min (maximum rate: 150 PE per min). IM: 15–20 PE/kg.
Notes	When given IV, itching is common and controllable by reducing the flow rate. Lower risk of hypotension or cardiac effects than phenytoin.
Warning	Rate of infusion should not exceed 3 PE/kg per min. Monitor heart rate via ECG, and reduce the rate of infusion if heart rate decreases by 10 beats per min.
Furosemide	
Indications	Fluid overload Congestive heart failure/pulmonary edema
Dosage	IV/IM: 1–2 mg/kg (usual maximum dose: 20 mg for patients not chronically on loop diuretics).
Note	May cause significant hypokalemia.
Glucagon	
Indication	Hypoglycemia caused by insulin excess (as adjunct to glucose).
Dosage	IV/IM/SC: 0.03 mg/kg up to maximum of 1 mg; repeat every 15 min up to a total of 3 doses if needed for clinical effect.
Indication	β -adrenergic blocker or calcium channel blocker overdose.
Dosage	IV: 0.03–0.15 mg/kg, followed by an infusion of 0.07 mg/kg per h (maximum: 5 mg/h).
Adolescent dosage	5–10 mg over several min, followed by infusion of 1–5 mg/h. Reconstitute doses of >2 mg in sterile water rather than the diluent supplied by the manufacturer.
Note	May cause nausea/vomiting because of delayed gastric emptying.
Glucose	
Indications	Hypoglycemia Hyperkalemia
Initial Dose	
Children	IV/IO: 0.5–1.0 g/kg.
Neonates	IV: 200 mg/kg as D10W only.
Maintenance dose	Constant infusion of D10W-containing IV fluids with appropriate maintenance electrolytes at a rate of 100 mL/kg per 24 h (7 mg/kg per min). Older children may require a substantially lower dose. The rate should be titrated to achieve normoglycemia, because hyperglycemia has its own adverse central nervous system effects.
Notes	For D10W: 200 mg/kg = 2 mL/kg; 0.5–1.0 g/kg = 5–10 mL/kg. For D25W: 0.5–1.0 g/kg = 2–4 mL/kg. For D50W: 0.5–1.0 g/kg = 1–2 mL/kg. D50W is irritating to veins; dilution to 25% dextrose is desirable. Glucose, sodium, and potassium levels should be monitored carefully. Depending on etiology, hypoglycemia may recur.

TABLE 1 Continued

Haloperidol	
Indication	Psychosis with agitation
Dosage	IM/IV: 0.05–0.15 mg/kg; may repeat hourly as necessary. Maximum single dose: 5 mg.
Notes	Hypotension and dystonic reactions may occur. Repeated doses can prolong QT interval and precipitate torsades de pointes.
Hydrocortisone	
Indication	Adrenal insufficiency
Dosage	IV/IO: 2–3 mg/kg (maximum: 100 mg) over 3–5 min, followed by 1–5 mg/kg every 6 h for infants or 12.5 mg/m ² every 6 h for older children.
Note	Do not underdose. Strongly consider concomitant fluid bolus of 20 mL/kg of D5NS or D10NS during the first hour of treatment.
Insulin, regular	
Indication	DKA
Dosage	IV infusion: 0.05–0.10 unit/kg per h. Neonatal IV: 0.05 unit/kg per h. SC: 0.25–0.50 unit/kg per dose.
Note	IV bolus insulin is not generally recommended for children with DKA. Monitor blood glucose and potassium concentrations hourly or more closely as needed, with the goal of gradually reducing the blood glucose level by 50–100 mg/dL per h. Appropriate fluid and electrolyte therapy is also essential when treating DKA.
Indication	Hyperkalemia (although glucose alone is effective).
Dosage	IV: 0.1 unit/kg with 400 mg/kg glucose. Ratio is 1 unit of insulin for every 4 g of glucose.
Ipratropium	
Indication	Adjunct to β -agonists for status asthmaticus/bronchospasm
Preparation	Nebulized solution (0.25 mg/mL).
Dosage	Children < 12 y old: 0.25 mg nebulized every 20 min for up to 3 doses. Children \geq 12 y old: 0.5 mg nebulized every 20 min for up to 3 doses.
Notes	May be mixed with albuterol for nebulization. Should not be used as first-line therapy.
Kayexalate (Sanofi-Aventis, Bridgewater, NJ)—see sodium polystyrene sulfonate	
Ketamine	
Indications	Sedation/analgesia Adjunct to intubation Infundibular spasm (hypercyanotic spell with tetralogy of Fallot)
Dosage	IV: 1–2 mg/kg, titrate repeat doses to desired effect. IM: 4–5 mg/kg (onset of action within ~ 5 min); may repeat half the initial dose if patient is not fully dissociated.
Notes	Doses listed above are recommended to achieve dissociative sedation/anesthesia. Lower doses may be used to provide analgesia without full dissociation. Laryngospasm may occur, most often associated with rapid infusion or concomitant upper respiratory infection. It is usually reversible with oxygen administration, repositioning of the airway, and brief positive-pressure ventilation. Rarely, treatment with a muscle relaxant may be required.
Warning	Atropine or glycopyrrolate may be used to prevent increased salivation. Be prepared to provide respiratory support. Monitor oxygen saturation. Avoid use in patients with increased ICP or increased intraocular pressure.
Levalbuterol—see albuterol	
Lidocaine	
Indication	Ventricular arrhythmias, wide complex tachycardia
Dosage	IV/IO: 1 mg/kg (maximum: 100 mg), repeat every 5–10 min to desired effect or until maximum dose of 3 mg/kg is given. IV infusion: 20–50 μ g/kg per min. ET: 2–3 mg/kg, followed by or diluted in isotonic saline (1–5 mL) based on patient size.
Note	Recent data suggest that lidocaine is less effective than amiodarone but may be used if amiodarone is not available.
Warning	High concentrations may cause myocardial depression, hypotension, and seizures. Contraindicated in complete heart block and wide complex tachycardia attributable to accessory conduction pathways.
Indication	ICP protection before ET intubation or airway manipulation.
Dosage	1–2 mg/kg IV as a single dose 30 s to 5 min before airway instrumentation.
Note	Considered optional adjunct for RSI in patients with head injury/increased ICP. When a neuroprotective agent that reduces ICP (eg, etomidate, thiopental) is used, lidocaine is less likely to provide additional benefit.
Lorazepam	
Indication	Status epilepticus
Dosage	IV/IM: 0.05–0.10 mg/kg (maximum: 4 mg per dose). May repeat dose every 10–15 min if needed for continued seizures.
Warning	There is an increased incidence of apnea when combined with other sedative agents. Monitor oxygen saturation and be prepared to provide respiratory support. Flumazenil may be administered to reverse life-threatening respiratory depression caused by lorazepam; however, it will also counteract the anticonvulsant effects and may precipitate recurrence of seizures.

TABLE 1 Continued

Magnesium sulfate	
Indications	Hypomagnesemia Torsades de pointes VT Refractory status asthmaticus
Dosage	IV/IO: 25–50 mg/kg (maximum: 2 g). Given by bolus for pulseless torsades, over 10–20 min for hypomagnesemia/torsades with pulses, and over 15–30 min for status asthmaticus.
Warning	Rapid infusion may cause hypotension and bradycardia. Have calcium chloride available if needed to reverse magnesium toxicity.
Mannitol	
Indication	Increased ICP
Dosage	IV: .25–1 g/kg given over 20–30 min.
Note	Larger doses (≥ 0.5 g/kg given over 15 min) may be appropriate in an acute intracranial hypertensive crisis. In conjunction with mannitol, other measures to control ICP such as hyperventilation, sedation/analgesia, head-of-bed elevation, cerebrospinal fluid drainage, barbiturates, and muscle relaxation (using a neuromuscular blocking agent) should be considered. A urine-collecting catheter should be placed when using mannitol. Monitor for hyperosmolality.
Note	Administer through a filter; do not use solutions that contain crystals.
Methylprednisolone	
Indications	Asthma/allergic reaction Laryngotracheobronchitis (croup)
Dosage	IV/IM: 1–2 mg/kg initial dose (must use acetate salt for IM route).
Indication	Spinal cord injury
Dosage	IV: 30 mg/kg over 15 min, followed in 45 min by a continuous infusion of 5.4 mg/kg per h for 23 h.
Note	Administration within 8 h of injury is optimal.
Midazolam	
Indication	Sedation/anxiolysis
Dosage	IV: 0.05–0.10 mg/kg given over 2–3 min (maximum single dose: 5 mg).
Note	Peak effect occurs at 3–5 min. Dose/observe and redose/observe every 3–5 min to avoid oversedation. Paradoxical agitation may occur, especially in younger children.
Dosage	PO: 0.25–0.50 mg/kg (maximum: 20 mg). Children <6 y old may require up to 1 mg/kg.
Indication	Adjunct for ET intubation
Dosage	IV: 0.2 mg/kg.
Note	Lower doses of midazolam are ineffective for RSI. After preoxygenation, allow sufficient time (2–3 min) for midazolam to take effect before administration of muscle relaxant.
Indication	Seizures
Dosage	IM: 0.2 mg/kg (maximum: 6 mg per dose); may repeat every 10–15 min.
Note	Other benzodiazepines (eg, lorazepam) are typically used for initial IV treatment of status epilepticus.
Indication	Refractory status epilepticus, not controlled by standard therapies.
Dosage	IV: Loading dose 0.15–0.20 mg/kg, followed by continuous infusion of 1 μ g/kg per min, increasing by increments of 1 μ g/kg per min (maximum: 5 μ g/kg per min) every 15 min until seizures stop.
Warning	There is an increased incidence of apnea when combined with other sedative agents. Be prepared to provide respiratory support regardless of route of administration. Monitor oxygen saturation. Flumazenil may be administered to reverse life-threatening respiratory depression caused by benzodiazepines such as midazolam; however, it will also reverse the anticonvulsant effects and may precipitate seizures.
Milrinone	
Indication	Myocardial dysfunction and increased SVR/PVR (eg, after cardiac surgery, normotensive septic shock).
Dosage	IV/IO: loading dose of 50–75 μ g/kg over 10–60 min. Infusion: 0.50–0.75 μ g/kg per min.
Warning	May cause hypotension, ventricular arrhythmias, and angina. Monitor blood pressure and ECG continuously. Intravascular volume must be maintained. Longer infusion times reduce the risk of hypotension.
Morphine	
Indications	Pain Infundibular spasm (hypercyanotic spell with tetralogy of Fallot)
Dosage	IV (slowly)/IM: 0.1 mg/kg.
Notes	Repeat dose as necessary for clinical effect. Burn pain often requires larger or more frequent doses. Higher doses may be necessary if patient is tolerant. Histamine release with flushing, itching, and hives is common. Histamine release may also cause hypotension, particularly in unstable cardiac/trauma patients; fentanyl may be preferred in these situations.
Warning	There is an increased incidence of apnea when combined with other sedative agents, particularly benzodiazepines. Be prepared to administer naloxone/nalmefene. Monitor the patient's vital signs and oxygen saturation. Be prepared to provide respiratory support.
Nalmefene	
Indication	Apnea/respiratory depression caused by opioid overdose
Dosage	IV/IM: 0.25–0.50 μ g/kg every 2 min.

TABLE 1 Continued

Notes	Duration of action is 4–8 h (vs <1 h for naloxone). For reversal of respiratory depression in sedation/analgesia or patients with pain, lower doses are indicated to avoid complete reversal of analgesia. Do not administer nalmeferne to a newborn infant whose mother is suspected of long-term opioid use because of the risk of acute withdrawal.
Warning	May induce acute withdrawal in opioid-dependent patients. Patients should be observed continuously for recurrence of respiratory depression and other narcotic effects for at least 4 h after the last dose of nalmeferne. Not recommended for empiric use in coma of unknown etiology.
Naloxone	
Indication	Apnea/respiratory depression caused by opioid overdose
Dosage	
Newborn infants	IV/IM: 0.1 mg/kg (ET route not recommended for newborn infants).
Older infants/children	IV/IO/IM/SC: <5 y old or <20 kg: 0.1 mg/kg; ≥5 y old or ≥20 kg: 2 mg.
Notes	Use lower doses (1–15 μg/kg) to reverse respiratory depression associated with therapeutic opioid use. Doses may be repeated as needed to maintain opiate reversal. Do not administer naloxone to a newborn infant whose mother is suspected of long-term opioid use because of the risk of seizures/acute withdrawal.
Warning	May induce acute withdrawal in opioid-dependent patients. Patients should be observed continuously for recurrence of respiratory depression and other narcotic effects for at least 2 h after the last dose of naloxone.
Nitroprusside	
Indications	Hypertensive crisis Cardiogenic shock (associated with high SVR)
Dosage	IV: starting dose 0.3–0.5 μg/kg per min (maximum dose: 10 μg/kg per min). Start at the lowest dosage and titrate for the desired clinical effect.
Note	Bottle, burette, or syringe pump should be covered with protective foil to avoid breakdown by light. IV tubing does not need protective foil.
Warning	Administration may result in profound hypotension. Blood pressure should be monitored continuously with an arterial line. Extreme caution should be used to avoid accidental flushing/bolus injection of the IV line. May cause cyanide/thiocyanate toxicity and metabolic acidosis, especially in patients with hepatic or renal insufficiency.
Norepinephrine	
Indication	Hypotensive (usually distributive) shock, with low SVR and unresponsive to fluid resuscitation (eg, hypotensive septic shock, neurogenic shock).
Dosage	IV/IO: 0.1–2.0 μg/kg per min, titrated to desired effect.
Warning	May cause tachycardia, bradycardia, arrhythmias, and hypertension. Extravascular administration can result in severe skin injury. Phentolamine (dose: 0.1–0.2 mg/kg up to 10 mg diluted in 10 mL of 0.9% sodium chloride) injected intradermally at extravasation site may be helpful for counteracting dermal vasoconstriction.
Phenobarbital	
Indication	Status epilepticus
Dosage	IV: 20 mg/kg (maximum dose: 1000 mg), infused over 10 min. Repeat dose once if necessary after 15 min (maximum total dose: 40 mg/kg).
Warning	There is an increased incidence of apnea when combined with other sedative agents. Be prepared to provide respiratory support. Monitor oxygen saturation.
Phenytoin	
Indication	Status epilepticus
Dosage	Neonates IV: 10 mg/kg. Children IV: 20 mg/kg.
Notes	Maximum initial dose: 1000 mg. Recommended infusion time is 10–20 min; drug-delivery rate not to exceed 1 mg/kg per min. Neonates have an increased risk of toxicity because of decreased protein binding; phenobarbital is preferred. Phenytoin should be diluted in normal saline to avoid precipitation. Incompatible with glucose-containing solutions.
Warning	May cause hypotension and arrhythmias, especially with rapid infusion. Heart rate should be monitored, and the rate of infusion should be reduced if the heart rate decreases by 10 beats per min. If available, fosphenytoin is preferred, because it has a lower risk of adverse cardiac effects.
Prednisone/prednisolone	
Indication	Asthma, acute exacerbation
Dosage	Initial dose: 1–2 mg/kg PO (maximum: 60 mg); subsequent dose: 1–2 mg/kg per d divided in 1–2 doses per d for 3–10 d (maximum: 60 mg per d).
Notes	No advantage of IV or IM preparations over the PO route if gastrointestinal absorption is not impaired. No need to taper steroid dose if used for <10 d.
Procainamide	
Indications	Wide complex tachycardia with a pulse, atrial flutter/fibrillation, supraventricular tachycardia resistant to other drugs
Dosage	IV/IO loading dose: 15 mg/kg over 30–60 min. Adult dose: 20 mg/min IV infusion up to total maximum dose of 17 mg/kg (maximum loading dose: 1.0–1.5 g).
Warning	May cause hypotension, negative inotropic effect, prolonged QT interval, torsades de pointes, heart block, and cardiac arrest. If ≥50% QRS widening or hypotension occurs during administration of the drug, the remainder of the dose should be held. Cardiologist consultation is strongly recommended when considering the use of this medication. Should not be used with amiodarone or other drugs that prolong QT interval without expert consultation.

TABLE 1 Continued

Propranolol	
Indication	Infundibular spasm (hypercyanotic spell with tetralogy of Fallot)
Dosage	IV: 0.15–0.25 mg/kg per dose infused over 10 min in D5W. Maximum initial dose: 1 mg. May repeat dose once.
Note	Oxygen should be administered first. Morphine is considered the first-line drug for the treatment of infundibular spasm. Use with caution in congestive heart failure.
Prostaglandin E ₁ (alprostadil)	
Indication	Suspected or proven ductal-dependent cardiac malformation in the neonatal period
Dosage	IV/IO: 0.05–0.10 μ g/kg per min infusion in D5W (maximum dose: 0.2 μ g/kg per min).
Warning	Apnea, hyperthermia, and seizures may occur; however, none are reasons to stop infusion. Be prepared to provide respiratory support.
Rocuronium	
Indications	Paralysis to facilitate mechanical ventilation Emergency intubation
Dosage	IV: 1 mg/kg.
Notes	This drug does not provide sedation, analgesia, or amnesia. Satisfactory conditions for ET intubation (adequate relaxation) will generally occur in 60–90 s. Duration of action is ~30–45 min and is dose dependent.
Warning	Ventilatory support is necessary. Personnel with skills in airway management must be present and prepared to respond when this agent is administered. Age-appropriate equipment for suctioning, oxygenation, intubation, and ventilation should be immediately available.
Sodium polystyrene sulfonate (Kayexalate)	
Indication	Hyperkalemia
Dosage	PO: 1 g/kg up to 15 g (60 mL) every 6 h as needed. Rectal: 1 g/kg up to 50 g every 6 h as needed.
Warning	Avoid using the commercially available liquid preparation in neonates because of the hyperosmolar preservative (sorbitol) content. Hospital pharmacies can prepare sorbitol-free preparations. Extremely preterm neonates may develop intestinal hemorrhage (hematochezia) from rectal Kayexalate.
Succinylcholine	
Indications	Emergency intubation Laryngospasm
Dosage	IV: 1–2 mg/kg (2 mg/kg for infants <6 mo of age). IM: 4 mg/kg IM (5 mg/kg for infants <6 mo of age).
Notes	This drug does not provide sedation, analgesia, or amnesia. Atropine 0.02 mg/kg (minimum dose: 0.1 mg; maximum dose: 1 mg) is typically administered before succinylcholine to prevent bradycardia or asystole. If being used for patients with increased ICP, a defasciculation dose of a nondepolarizing agent (eg, 0.01 mg/kg of vecuronium) may be considered. Satisfactory conditions (adequate relaxation) for ET intubation generally occur 30–45 s after IV administration and 3–5 min after IM administration. Duration of action is ~5–10 min.
Warning	Causes increased serum potassium levels, which may be life-threatening in patients with a previous history of malignant hyperthermia, severe burns/crush injury, spinal cord injury, neuromuscular disease, or myopathy. When these contraindications exist, use a nondepolarizing muscle relaxant such as rocuronium. If cardiac arrest occurs immediately after administration of succinylcholine, suspect hyperkalemia (particularly in boys <9 y old).
Warning	Ventilatory support is necessary. Personnel with skills in airway management must be present and prepared to respond when this agent is administered. Age-appropriate equipment for suctioning, oxygenation, intubation, and ventilation should be immediately available.
Thiopental	
Indication	Sedation/anesthesia for RSI
Dosage	IV: 2–6 mg/kg.
Note	May need to use lower dose if other sedatives/narcotics have been administered. Flush with saline before administration of rocuronium or vecuronium to avoid precipitation and obstruction of IV tubing.
Warnings	IM administration leads to tissue necrosis. Be prepared to provide respiratory support. Monitor oxygen saturation. Causes vasodilation and decreased cardiac output; higher doses are associated with hypotension and apnea. If patient has cardiovascular dysfunction or volume depletion, consider etomidate as alternative.
Vecuronium	
Indications	Paralysis to facilitate mechanical ventilation Emergency intubation
Dosage	IV: 0.1 mg/kg for routine paralysis; 0.2 mg/kg for intubation.
Notes	This drug does not provide sedation, analgesia, or amnesia. Satisfactory conditions (adequate relaxation) for ET intubation generally do not occur until 2 min after administration. Duration of action is ~45–90 min (dose dependent). Rocuronium or succinylcholine is preferred for facilitating rapid intubation in emergency situations.
Warning	Ventilatory support is necessary. Personnel with skills in airway management must be present and prepared to respond when this agent is administered. Age-appropriate equipment for suctioning, oxygenation, intubation, and ventilation should be immediately available.

AV indicates atrioventricular; VT, ventricular tachycardia; D₅W, n% dextrose in water; IM, intramuscular; PO, per os (oral); DKA, diabetic ketoacidosis; ICP, intracranial pressure; SC, subcutaneous; PE, phenytoin equivalents; ECG, electrocardiogram; D₅NS, n% dextrose in normal saline; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance.

TABLE 2 Potentially Useful Rescue, Reversal, and/or Antidotal Agents

Agent/Condition	Rescue, Reversal, and/or Antidote
Chemical intoxications	
Alcohol, toxic (eg, methanol)	Ethanol, thiamine, fomepizole (4 methyl-1H-pyrazole)
Iron	Deferoxamine
Carbon monoxide	Oxygen
Cyanide	Hydroxocobalamin (Cyanokit; Dey, LP, Napa, CA) is preferred antidote; cyanide kit (amyl nitrate, sodium nitrate, sodium thiosulfate) may be used if hydroxocobalamin unavailable
Lead	Dimercaprol (British anti-Lewisite [BAL]); edetate calcium disodium (Ca- EDTA); DMSA (succimer [Chemet])
Drug intoxications	
Acetaminophen	<i>N</i> -acetylcysteine
Benzodiazepines	Flumazenil
β -adrenergic blockers	Glucagon
Digoxin	Digoxin immune Fab (Digibind; GlaxoSmithKline, Research Triangle Park, NC)
Heparin	Protamine sulfate
Isoniazid	Pyridoxine
Opiates	Naloxone, nalmefene
Envenomations	
Snake bites	Snake-specific antivenoms (eg, CroFab [Protherics, Yorkshire, United Kingdom] for Crotalidae [rattlesnakes]; coral snake antivenom, etc)
Black widow spider bites	<i>Latrodectus</i> antivenom
Metabolic crises	
Methemoglobinemia	Methylene blue
Hyperkalemia	Bicarbonate, glucose and insulin, calcium, sodium polystyrene resin (Kayexalate)
Miscellaneous	
Nondepolarizing muscle relaxants	Neostigmine, pyridostigmine, edrophonium
Cholinergics (organophosphates, carbamates)	Atropine, pralidoxime
Radionuclides	
Iodine	Potassium iodide
Plutonium	Pentetate calcium disodium (Ca-DTPA) within 24 h followed by pentetate zinc trisodium (Zn-DTPA)
Americium	Zn-DTPA or Ca-DTPA
Uranium	Sodium bicarbonate and tubular diuretics
Cesium	Prussian blue
Tritium	Water
Phosphorus	Individualize treatment; consult Poison Control Center

Consultation with a toxicologist or the Poison Control Center (national telephone number: 800-222-1222) strongly advised if considering antidote administration.

vascular access has been obtained, any vascular access (IV or IO) is preferred, because tracheal drug administration results in lower, less predictable drug concentrations than intravascular administration.⁵ If the endotracheal (ET) route is used, administer the drug with or diluted in 1 to 5 mL of isotonic saline solution followed by manual ventilations. ET administration of naloxone is no longer recommended for neonates.⁶

Most of the medications listed in this clinical report are used for airway management, resuscitation, sedation, analgesia, status epilepticus, or asthma. The Committee on Drugs recognizes that gaps exist in pediatric labeling and dosage information for many of these drugs. Despite these gaps, the package inserts, labels, and available medical literature should be consulted for additional information. The continued lack of clinical testing in pediatric populations before Food and Drug Administration approval of therapeutic agents makes it impossible to have the clinical data to support all pediatric dosing recommendations. Although local practice patterns and

individual preferences exist for the use and dosage of many of these medications, the information provided in this document includes recommendations that are based on consensus opinion and literature review. References for individual drug indications and dosing are not provided in this report. Dosages should be individualized, taking into account the patient's age, weight, underlying illness, concurrently administered drugs, and known hypersensitivity. This committee recommends use of the current *Advanced Pediatric Life Support*⁷ and *Pediatric Advanced Life Support*⁸ textbooks, updated American Heart Association guidelines,⁵ and additional references for more detailed information on pediatric resuscitation algorithms, rapid-sequence intubation (RSI), procedural sedation, and treatment of asthma.^{9,10} For newborn infants, practitioners can consult the *Textbook of Neonatal Resuscitation*¹¹ and updated American Heart Association guidelines⁶ for detailed information concerning management of neonatal emergencies and appropriate drugs, dosages, and routes of administration. In addition, pre-

printed medication cards and/or length-based resuscitation tapes (eg, Broselow tape) should be readily available at all sites that provide medical care for children.

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