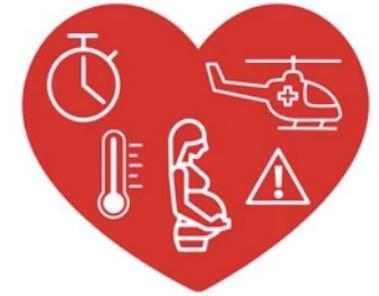


# Adult special circumstance in resuscitation

## 2025



## SPECIAL CIRCUMSTANCES

Guidelines 2025

### Adult special circumstances in resuscitation

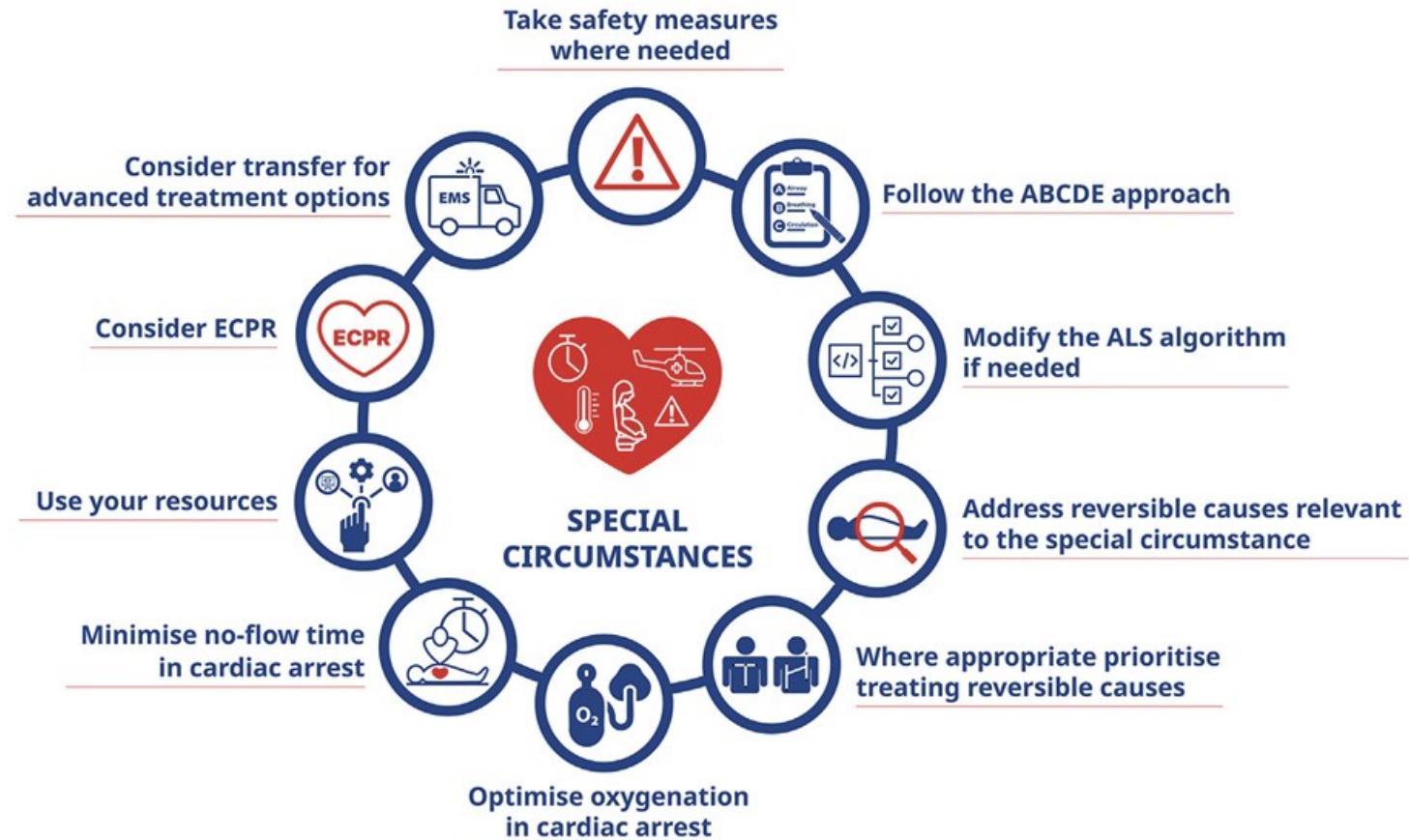
GUIDELINES  
2025  
EUROPEAN RESUSCITATION COUNCIL®

### Part 10: Adult and Pediatric Special Circumstances of Resuscitation: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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# SPECIAL CIRCUMSTANCES IN ADULT RESUSCITATION

## KEY MESSAGES



**Fig. 1 – Key messages of the ERC Guideline 2025 Special Circumstances in Resuscitation.**

## **TOP 10 TAKE-HOME MESSAGES FOR SPECIAL CIRCUMSTANCES OF RESUSCITATION**

1. Anaphylaxis: Isotonic intravenous (IV) fluids may be used for fluid resuscitation in cardiac arrest from anaphylaxis, whereas standard anaphylaxis dose of epinephrine administered via autoinjector or intramuscularly may not offer benefit. Glucagon may be reasonable to administer in cases refractory to standard treatment when  $\beta$ -blocker exposure is suspected. Extracorporeal membrane oxygenation (ECMO) is reasonable in refractory cases.
2. Cardiac interventional laboratory: Some adults in cardiac arrest in the cardiac interventional laboratory may require specialized interventions, including performing a corrective procedure to treat the etiology of the arrest, mechanical cardio-pulmonary resuscitation (CPR), extracorporeal life support (ECLS), or intracoronary epinephrine.
3. ECLS: While ECLS is not available in every setting, adults and children in cardiac arrest or a peri-arrest state with a potentially reversible etiology may be supported with ECLS devices, such as venoarterial ECMO (VA-ECMO), in disease processes such as anaphylaxis, asthma, cardiac surgery, cardiac interventional laboratory, hypothermia, and pulmonary embolism (PE) and in poisonings like  $\beta$ -blockers, calcium channel blockers (CCBs), cocaine, local anesthetics, sodium channel blockers, and sympathomimetics.

- 
- 4. High-consequence respiratory pathogen: Chest compressions, bag-mask ventilation, defibrillation, suctioning, and endotracheal intubation should be considered aerosol-generating procedures, which pose a risk of infection to resuscitation team members. However, a real-world study found that rates of severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) transmission to resuscitation team members using personal protective equipment (PPE) were low.
  - 5. Hyperkalemia: Clinical evidence supporting IV calcium or IV sodium bicarbonate administration is limited in humans and uncertain to improve survival or favorable neurological outcomes. The utility of other therapies intended to lower potassium concentrations in the setting of cardiac arrest is unclear when weighing their possible benefits against the risk of harm if well-established interventions, such as CPR, are interrupted.

6. Hyperthermia: Adults and children with life-threatening hyperthermia from environmental causes, cocaine poisoning, or sympathomimetic poisoning should be rapidly cooled, ideally at a rate of at least 0.15 °C/min (0.27 °F/min). This is best achieved with immersion in ice water.
7. Hypothermia: Adults and children with life-threatening environmental hypothermia may survive with good neurological outcomes even after prolonged cardiac arrest. Patients should be rewarmed concurrently with resuscitation efforts. ECLS can be used where available.
8. Left ventricular assist device (LVAD): The absence of a palpable pulse can make confirming cardiac arrest in adults and children with an LVAD difficult; thus perfusion is assessed using skin color, skin temperature, capillary refill, mean arterial pressure, and partial pressure of end-tidal carbon dioxide. Treatment includes prioritization of CPR while simultaneously assessing and attempting to restart LVAD function if a second rescuer is available.

9. Pregnancy: Management of cardiac arrest during pregnancy is a complex clinical scenario that requires resuscitation strategies that accommodate for the physiological changes of pregnancy. Resuscitation priorities include early airway management and left lateral uterine displacement.
10. Opioids: An opioid antagonist (eg, naloxone) should be given to people with respiratory arrest from suspected opioid overdose. Trained rescuers, lay rescuers, and members of the general public can all administer naloxone. During resuscitation of cardiac arrest due to presumed opioid overdose, an opioid antagonist may be reasonable to administer if high-quality CPR is not interrupted.

## Special Causes

- Anaphylaxis
- Hypokalemia
- Hyperkalemia
- Hyperthermia
- Hypothermia
- Coronary Thrombosis
- Toxin
- Trauma

## Special Setting

- Catheterization laboratory
- Drowning
- Cardiac arrest in the operating room (OR)
- Cardiac arrest in Sports
- Emergency medical services (EMS) and transportation
- Inflight cardiac arrest and microgravity resuscitation

## Special Population

- Asthma and chronic obstructive pulmonary disease
- Cardiac arrest in hemodialysis patients
- Resuscitation in obese patients
- Resuscitation in patients with pectus excavatum
- Cardiac arrest in pregnancy

# Anaphylaxis

	ERC guidelines 2021	ERC guidelines 2025
<b>Anaphylaxis</b>	<ul style="list-style-type: none"><li>There is no evidence that supports the routine use of either steroids or antihistamines</li></ul>	<ul style="list-style-type: none"><li>Antihistamine administration should not delay the administration of adrenaline.</li><li>The ERC recommends against the routine use of corticosteroids.</li></ul>



**Adrenaline IM : First Line**

# ANAPHYLAXIS

## Recommendations for Adults and Children in Cardiac Arrest From Anaphylaxis

COR	LOE	Recommendations
<b>2a</b>	<b>C-EO</b>	1. It is reasonable to fluid resuscitate adults and children in cardiac arrest from anaphylaxis with isotonic IV fluids.
<b>2a</b>	<b>C-EO</b>	2. It is reasonable to use extracorporeal CPR (ECPR) for adults and children in cardiac arrest from anaphylaxis refractory to pharmacological interventions.
<b>2b</b>	<b>C-EO</b>	3. It may be reasonable to administer glucagon to adults and children who are in cardiac arrest from anaphylaxis with suspected or confirmed concurrent $\beta$ -blocker use and who are refractory to standard ALS or PALS medications.
<b>2b</b>	<b>C-EO</b>	4. For adults and children in cardiac arrest from rocuronium-induced anaphylaxis, the effectiveness of sugammadex is uncertain.
<b>2b</b>	<b>C-EO</b>	5. For adults and children in cardiac arrest from anaphylaxis, the effectiveness of standard anaphylaxis intramuscular (IM) epinephrine dose is uncertain.

# Anaphylaxis

- Beta-Blockers: Glucagon
- Rocuronium? : Sugammadex
- IV Fluid : distributive shock- peripheral vasodilation with increased vascular permeability
- Supine position + raise leg
- Sitting position+ leg stretched if airway symptom without circulation problem
- Nb response adrenaline: Bradrelaline, Vasopressin
- Initial rhythm most PEA, Hypovolemia, Hypoxia
- Rapid IV of first generation H1 antihistamine: hypotension
- Steroid ?: Recent study

Pre-hospital Steroid: Second dose of adrenaline, ICU admission

**TABLE 14-4** Drug Treatment of Anaphylaxis and Allergic Reactions

Drug	Adult Dose	Pediatric Dose
<b>First-Line Therapy</b>		
Epinephrine	IM: 0.3–0.5 milligram (0.3–0.5 mL of 1:1000 dilution); or EpiPen® 0.3 milligram epinephrine (or equivalent preformulated product)  IV bolus: 100 micrograms over 5–10 min; mix 0.1 milligram (0.1 mL of 1:1000 dilution) in 10 mL NS and infuse over 5–10 min  IV infusion: start at 1 microgram/min; mix 1 milligram (1 mL of 1:1000 dilution) in 500 mL NS and infuse at 0.5 mL/min; titrate dose as needed	IM: 0.01 milligram/kg (0.01 mL/kg of 1:1000 dilution) or EpiPen Junior® 0.15 milligram of epinephrine (or equivalent preformulated product)  IV infusion: 0.1–0.3 microgram/kg per min; titrate dose as needed; maximum, 1.5 micrograms/kg per min
Oxygen	Titrate to $Sao_2 \geq 90\%$	Titrate to $Sao_2 \geq 90\%$
IV fluids: NS or LR	1–2 L bolus	10–20 mL/kg bolus
<b>Second-Line Therapy</b>		
<i>H<sub>1</sub> Blockers</i>		
Diphenhydramine	25–50 milligrams IV, IM, or PO every 6 h	1 milligram/kg IV, IM, or PO every 6 h
<i>H<sub>2</sub> Blockers</i>		
Ranitidine	50 milligrams IV over 5 min	0.5 milligram/kg IV over 5 min
Cimetidine	300 milligrams IV	4–8 milligrams/kg IV
<i>Corticosteroids</i>		
Hydrocortisone	250–500 milligrams IV	5–10 milligrams/kg IV (maximum, 500 milligrams)
Methylprednisolone	80–125 milligrams IV	1–2 milligrams/kg IV (maximum, 125 milligrams)
Prednisone	40–60 milligrams PO daily or 20–30 milligrams PO twice daily	1–2 milligrams/d PO divided twice a day or daily
	To be used after initial IV dose (for outpatients: 3–5 d; tapering not required)	To be used after initial IV dose (for outpatients: 3–5 d; tapering not required)
<b>Treatment of Bronchospasm, Add:</b>		
Albuterol (salbutamol)	Single treatment: 2.5–5.0 milligrams nebulized (0.5–1.0 mL of 0.5% solution)	Single treatment: 1.25–2.5 milligrams nebulized (0.25–0.5 mL of 0.5% solution)
	4–6 puffs from MDI with holding chamber	4–6 puffs from MDI with holding chamber
	Both repeated every 20 min as needed	Both repeated every 20 min as needed
	Continuous nebulization: 5–10 milligrams/h	Continuous nebulization: 3–5 milligrams/h
Ipratropium bromide	Single treatment: 250–500 micrograms nebulized	Single treatment: 125–250 micrograms nebulized
	4–6 puffs from MDI with holding chamber	4–6 puffs from MDI with holding chamber
	Both repeated every 20 min as needed	Both repeated every 20 min as needed
Magnesium sulfate	2 grams IV over 20 min	25–50 milligrams/kg IV over 20 min
<b>Treatment for Patients on β-Blockers with Refractory Hypotension, Add:</b>		
Glucagon	1 milligram IV every 5 min until hypotension resolves, followed by 5–15 micrograms/min infusion	50 micrograms/kg IV every 5 min

Abbreviations: H<sub>1</sub> = histamine-1; H<sub>2</sub> = histamine-2; LR = lactated Ringer's; MDI = metered-dose inhaler; NS = normal saline;  $Sao_2$  = arterial oxygen saturation.



Hydrocortisone  
Methylprednisolone  
Prednisolone

Confirm Diagnosis : Mast cell tryptase

{Three time sample}## Initial, 1-2 after onset, 24 hours(Baseline)

Rising 30 min after onset Peak 1-2 hrs Half life 2 hrs Back to normal 6-8 hrs

# Kounis Syndrome

- Acute coronary syndrome in the setting of allergic or anaphylactic reactions, usually secondary to allergic coronary vasospasm

## Types of Kounis Syndrome

Vasospastic allergic angina, allergic myocardial infarction and stent thrombosis with occluding thrombus infiltrated by eosinophils and/or mast cells constitute are the three reported variants of this syndrome.

Type	Cardiac history	Pathological changes
I	Normal coronary arteries No risk factors for IHD	Coronary artery <b>vasospasm</b>
II	Inactive preexisting atheromatous disease	Plaque erosion or rupture causes vasospasm or <b>infarction</b>
III	Previous coronary artery stenting	<b>Stent thrombosis</b> secondary to platelet activation

**Kounis Syndrome variants:** Kounis describes three reported variants in his 2013 paper "Coronary Hypersensitivity Disorder" – vasospastic allergic angina (type I), allergic myocardial infarction (type II) and stent thrombosis (type III)

## Clinical significance

- Diagnosis and treatment requires attention to both cardiac and anaphylactic pathophysiology
- Morphine must be avoided in Kounis Syndrome as it may stimulate histamine release and exacerbate mast-cell induced vasospasm
- Some authors advocate that adrenaline should be used with caution as it may aggravate coronary ischaemia by worsening vasospasm
- ECG changes often resolve upon treatment and withdrawal of underlying allergic insult
- Patients who undergo angiography will have improvement of vasospastic changes with administration of intracoronary nitroglycerine

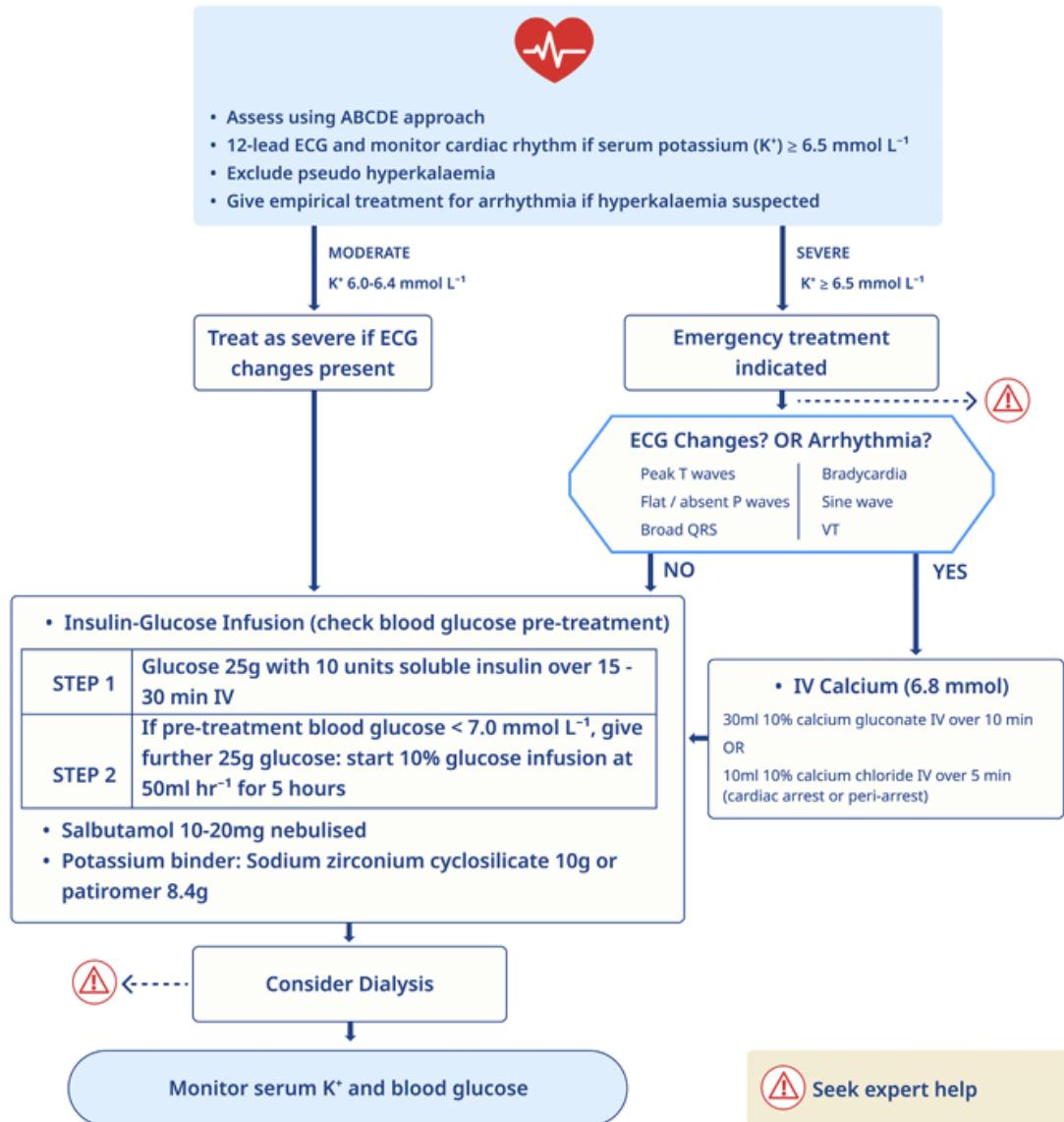
# Hyperkalemia-Hypokalemia

ERC guidelines 2021

ERC guidelines 2025

## Resuscitation in hyper/hypokalaemia and other electrolyte disorders

- Protect the heart: Give 10 ml calcium chloride 10 % IV by rapid bolus injection. Consider repeating dose if cardiac arrest is refractory or prolonged.
- No evidence for or against use of IV calcium in hyperkalaemia.
- ECG – record pre and post IV calcium.
- Recommendation against the routine use of sodium bicarbonate in the treatment of hyperkalaemia in non-cardiac arrest cases.
- Hyperkalaemia algorithm revised – emphasis on initiation of potassium-lowering treatments. Guidance in cardiac arrest added.



**Fig. 2 – Treatment algorithm of hyperkalaemia in adults.**

ABCDE – airway breathing circulation disability exposure, ECG – electrocardiography, IV – intravenous, VT – ventricular tachycardia, K – potassium.

### Indications for dialysis

Dialysis is the most definitive treatment for hyperkalaemia, and the main indications with hyperkalaemia are:

- Severe life-threatening hyperkalaemia with or without ECG changes or arrhythmia;
- Hyperkalaemia resistant to medical treatment;
- End-stage kidney disease;
- Oliguric acute kidney injury (urine output < 400 mL/day);
- Marked tissue breakdown (e.g. rhabdomyolysis).

Blood sugar 7 mmol/L = 126 mg%

## HYPERKALEMIA

Recommendations for Adults and Children in Cardiac Arrest From Suspected Hyperkalemia		
COR	LOE	Recommendations
<b>2b</b>	<b>C-LD</b>	1. The effectiveness of IV calcium administration for adults and children in cardiac arrest from suspected hyperkalemia is not well established.
<b>2b</b>	<b>C-EO</b>	2. The effectiveness of IV sodium bicarbonate administration for adults and children in cardiac arrest from suspected hyperkalemia is not well established.
<b>2b</b>	<b>C-EO</b>	3. The effectiveness of IV insulin and glucose for adults and children in cardiac arrest from suspected hyperkalemia is not well established.
<b>3: No Benefit</b>	<b>C-EO</b>	4. Inhaled $\beta_2$ -agonists for adults and children in cardiac arrest from suspected hyperkalemia is not recommended.

**TABLE 17-19** Emergency Therapy of Hyperkalemia

Therapy	Dose and Route	Onset of Action	Duration of Effect	Mechanism
Calcium chloride (10%)*	5–10 mL IV	1–3 min	30–50 min	Membrane stabilization
Calcium gluconate (10%)*	10–20 mL IV	1–3 min	30–50 min	Membrane stabilization
NaHCO <sub>3</sub> <sup>†</sup>	50–150 mEq IV if accompanying metabolic acidosis	5–10 min	1–2 h	Shifts [K <sup>+</sup> ] into cell
Albuterol (nebulized)	10–20 milligrams in 4 mL of normal saline, nebulized over 10 min	15–30 min	2–4 h	Upregulates cyclic adenosine monophosphate, shifts [K <sup>+</sup> ] into cell
Insulin <sup>‡</sup> and glucose <sup>§</sup>	5–10 units regular insulin IV Glucose 25 grams (50% solution) IV	30 min	4–6 h	Shifts [K <sup>+</sup> ] into cell
Furosemide	40–80 milligrams IV	Varies	Varies	Renal [K <sup>+</sup> ] excretion
Sodium polystyrene sulfonate	25–50 grams PO or PR	1–2 h	4–6 h	GI [K <sup>+</sup> ] excretion
Hemodialysis	—	Minutes	Varies	Removes [K <sup>+</sup> ]

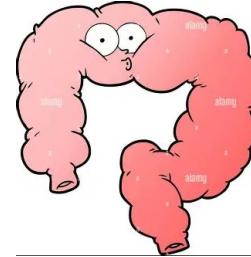
\*Calcium chloride has three times the elemental calcium when compared to calcium gluconate. 10% calcium chloride = 27.2 milligrams [Ca<sup>2+</sup>]/mL; 10% calcium gluconate = 9 milligrams [Ca<sup>2+</sup>]/mL. Due to its short duration, calcium administration (both chloride and gluconate) can be repeated up to four times per hour.

<sup>†</sup>May be institutional variations in treatment with sodium bicarbonate; refer to Batterink et al<sup>11</sup> and Rossignol et al<sup>12</sup> for full discussion.

<sup>‡</sup>Reduce dose of insulin in patients with renal failure.

<sup>§</sup>Glucose infusion should be administered after initial bolus to prevent hypoglycemia. Glucose should not be administered in hyperglycemic patients.

Salbutamol  
10-20 mg



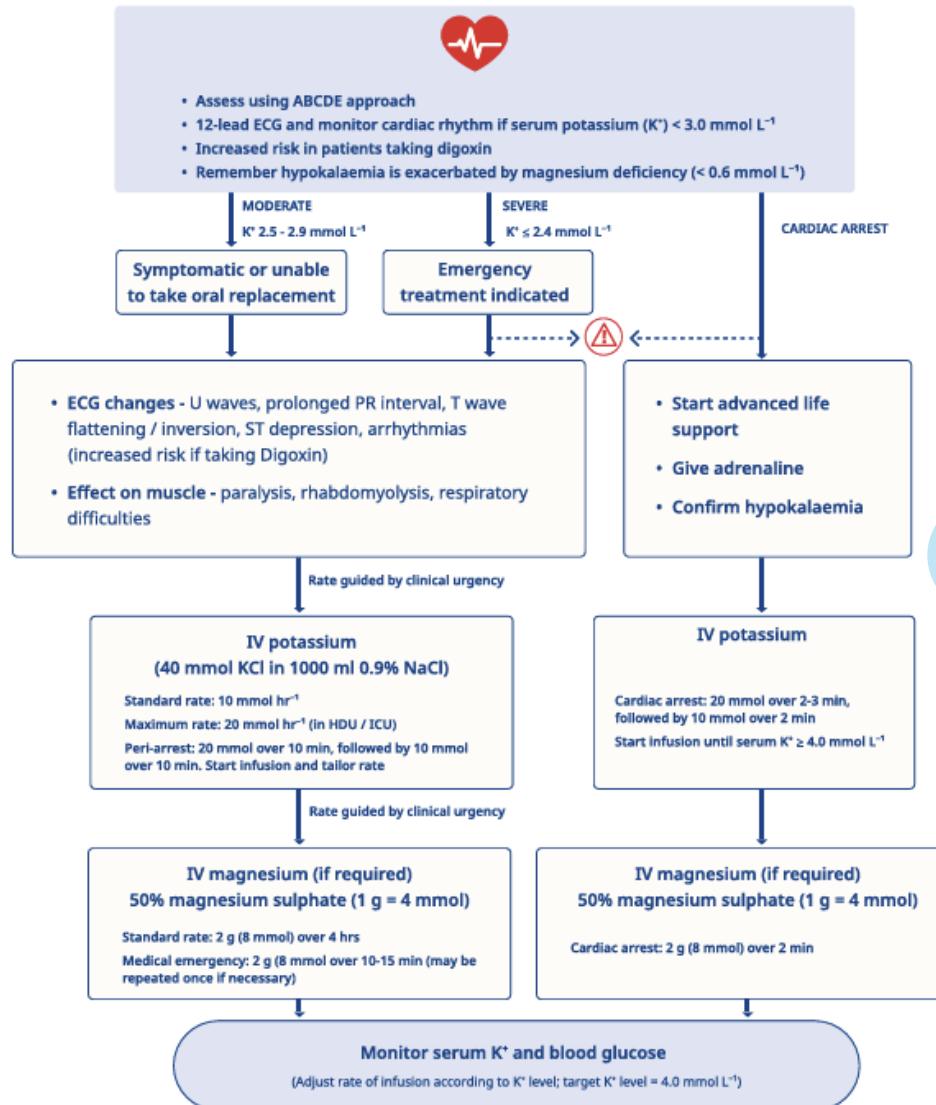
Potassium binders  
Sodium polystyrene sulfonate (SPS)  
Patiromer  
Sodium zirconium cyclosilicate (Lokelma)

Kalimate (calcium polystyrene sulfonate) GI-Bowel  
ischemia-Obstruction

**Table 3. Insulin-Glucose Dosing for Cardiac Arrest From Suspected Hyperkalemia**

Population	Glucose	Insulin	Administration notes
Adults			
Standard dose	D <sub>50</sub> W or glucose 50%: 50 g IV bolus	10 Units regular insulin	Administer insulin IV over 15–30 min
Children			
Standard dose	D <sub>10</sub> W or Glucose 10%: 5 mL/kg IV bolus	0.1 Units/kg regular insulin	Administer insulin IV over 15–30 minutes max 10 U for severe hyperkalemia

D<sub>50</sub>W indicates 50% dextrose in water; D<sub>10</sub>W, 10% dextrose in water; and IV, intravenous.



**K20 mmol over 2-3 min follow by 10 mmol over 2 min**



Seek expert help

## *Hypokalaemia*

- Treatment is guided by the severity of hypokalaemia and presence of symptoms and/or ECG abnormalities.
- Where appropriate replace potassium and correct magnesium deficit concurrently.
- Give IV 20 mmol potassium chloride over 2–3 min, followed by 10 mmol over 2 min in hypokalaemic cardiac arrest then monitor K<sup>+</sup> level and adjust infusion rate accordingly.

## HYPOKALEMIA < 2.5

- \* Check for any potential exacerbating factors
  - (e.g. digoxin toxicity, hypomagnesaemia)
- \* Monitor serum K+  
(adjust replacement as needed depending on level)
- \* Prevent recurrence (assess and remove cause)

*Causes.* The main causes of hypokalaemia include:

- gastrointestinal loss (e.g. diarrhoea);
- drugs (e.g. diuretics, laxatives, steroids);
- renal losses (e.g. renal tubular disorders, diabetes insipidus, dialysis);
- endocrine disorders (e.g. Cushing's syndrome, hyperaldosteronism);
- metabolic alkalosis;
- magnesium depletion;
- poor dietary intake.

The following are **general principles in hypokalemia correction:**

1. Use potassium chloride and avoid administering  $K^+$  in glucose solutions, to reduce insulin-induced  $K^+$  transfer into cells.
2. Potassium is irritating to the endothelium; adequate dilution is mandatory to prevent pain and phlebitis (maximum recommended  $[K^+]$  in 500 mL of a saline solution is 40 mEq, to be infused in 4 to 6 hours in a peripheral line). If a more aggressive correction is needed, an identical solution can be administered in a second peripheral line. Higher concentrations can be administered through a central line, but infusion rates should never exceed 20 mEq/h.
3. Reassessing serum  $[K^+]$  should be adjusted to infusion rate and coexisting factors (e.g., concomitant acid-base imbalance, volume depletion, cardiac arrhythmias).
4. ECG monitoring is recommended.
5. In most cases, hypokalemic patients are also hypomagnesemic. Thus, magnesium (20 to 60 mEq/24 h) may be added to the infusion both to optimize tubular reuptake of potassium and to contrast proarrhythmic effect of hypokalemia.<sup>1</sup>



**TABLE 17-14** Symptoms and Signs of Hypokalemia

Cardiovascular	Hypertension Orthostatic hypotension Potentiation of digitalis toxicity Dysrhythmias (usually tachyarrhythmias) T-wave flattening, QT prolongation, U waves, ST depression
Neuromuscular	Malaise, weakness, fatigue Hyporeflexia Cramps Paresthesias Paralysis Rhabdomyolysis
GI	Nausea, vomiting Abdominal distention Ileus
Renal	Increased ammonia production Urinary concentrating defects Metabolic alkalemia, paradoxical aciduria Nephrogenic diabetes insipidus
Endocrine	Glucose intolerance

**TABLE 17-15** Interpretation of Urinary Potassium

Spot Urinary Potassium	Possible Mechanism
$U_{K^+} < 10 \text{ mEq/L}$	Decreased $K^+$ intake, nonrenal losses GI losses Sweat losses Nasogastric suction ( $\downarrow U_{Cl^-}$ ) Transcellular shift Alkalosis ( $\downarrow U_{Cl^-}$ ) Hypomagnesemia ( $\uparrow U_{Mg^{2+}}$ ) Hypokalemic periodic paralysis Thyrotoxic hypokalemic periodic paralysis (calculate TTKG)
$U_{K^+} > 20 \text{ mEq/L}$	Renal losses If hypernatremia coexists consider: hyperaldosteronism (calculate TTKG) Massive GI losses (secondary to metabolic alkalosis)

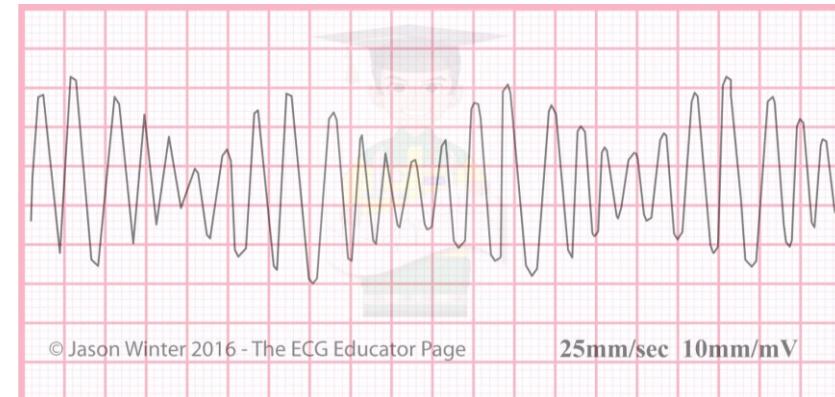
Abbreviations: TTKG = transtubular  $K^+$  gradient;  $U_{Cl^-}$  = urinary chloride;  $U_{K^+}$  = urinary potassium.



# POLYMORPHIC VENTRICULAR TACHYCARDIA

## Recommendations for Treatment of Adults With Polymorphic Ventricular Tachycardia

COR	LOE	Recommendations
1	B-NR	<ol style="list-style-type: none"><li>1. Immediate unsynchronized shock is recommended for adults with sustained polymorphic ventricular tachycardia.</li></ol>
2b	C-LD	<ol style="list-style-type: none"><li>2. Magnesium may be considered for treatment of adults with recurrences of polymorphic ventricular tachycardia associated with a long QT interval (torsades de pointes).</li></ol>
2b	C-LD	<ol style="list-style-type: none"><li>3. IV lidocaine, amiodarone, and measures to treat myocardial ischemia may be considered to treat recurrences of polymorphic VT in adults in the absence of a prolonged QT interval.</li></ol>
3: No Benefit	C-LD	<ol style="list-style-type: none"><li>4. Routine use of magnesium is not recommended for the treatment of polymorphic VT in adults with a normal QT interval.</li></ol>



Magnesium; Long QT interval

Amiodarone Indication	Amount and Route	Contraindications
VF or pulseless VT unresponsive to defibrillation	First dose: 300 mg IV/IO push Second dose: 150 mg IV/IO push	<ul style="list-style-type: none"><li>Rapid infusion may lead to hypotension.</li></ul>
SVT or unstable VT	150 mg IV/IO over 10 minutes	<ul style="list-style-type: none"><li>Cumulative dosing should not exceed 2.2 grams in 24 hours.</li></ul>
With ROSC following amiodarone use	Continuous IV infusion at 1 mg/min for 6 hours THEN Continuous IV infusion at 0.5 mg/min for 18 hours	<ul style="list-style-type: none"><li>Obtain cardiology consult before administering with other medications that may prolong the QT interval.</li></ul>

**Table 2 – Calcium and magnesium disorders with associated clinical presentation, ECG manifestations and recommended treatment.**

Disorder	Causes	Presentation	ECG	Treatment
<b>Hypercalcaemia</b> Calcium $> 2.6 \text{ mmol L}^{-1}$	Primary or tertiary hyperparathyroidism Malignancy Sarcoidosis Medications	Confusion Weakness Abdominal pain Hypotension Arrhythmias Cardiac arrest	Short QT interval Prolonged QRS interval Flat T waves AV block Cardiac arrest	Guided by underlying cause Fluid replacement IV Furosemide 1 mg kg $^{-1}$ IV Hydrocortisone 200–300 mg IV Pamidronate 30–90 mg IV
<b>Hypocalcaemia</b> Calcium $< 2.1 \text{ mmol L}^{-1}$	Chronic kidney disease Acute pancreatitis Calcium channel blocker overdose Toxic shock syndrome Rhabdomyolysis Tumour lysis syndrome Massive blood transfusion	Paraesthesia Tetany Seizures AV-block Cardiac arrest	Prolonged QT interval T wave inversion Heart block Cardiac arrest	Bolus: 10–20 mL 10 % Calcium gluconate over 5–10 min Infusion: 100 mL 10 % Calcium gluconate in 1000 mL 0.9 % Saline or 5 % Glucose at 50 mL h $^{-1}$ IV (monitor Ca $^{2+}$ level and adjust rate) 50 % Magnesium sulphate 4–8 mmol IV (if necessary)
<b>Hypermagnesaemia</b> Magnesium $> 1.1 \text{ mmol L}^{-1}$	Renal failure Iatrogenic	Confusion Flaccid paralysis Respiratory depression Hypotension AV-block Cardiac arrest	Prolonged PR and QT intervals T wave peaking AV block Cardiac arrest	Consider treatment when magnesium $> 1.75 \text{ mmol L}^{-1}$ : 10 % Calcium gluconate (10–30 mL) or 10 % Calcium chloride (5–10 mL) IV repeated if necessary Saline diuresis – 150 mL 0.9 % saline/ hr IV and Furosemide 1 mg/kg IV Haemodialysis – when renal function impaired or severe symptoms, but risk of causing hypocalcaemia. Ventilatory support if necessary
<b>Hypomagnesaemia</b> Magnesium $< 0.6 \text{ mmol L}^{-1}$	GI loss Polyuria Starvation Alcoholism Malabsorption	Tremor Ataxia Nystagmus Seizures Arrhythmias – torsade de pointes Cardiac arrest	Prolonged PR and QT intervals ST-segment depression T-wave inversion Flattened P waves Increased QRS duration Torsades de pointes	Severe or symptomatic: 50 % Magnesium sulphate 2 g (8 mmol) IV over 15 min Torsades de pointes: 50 % magnesium sulphate 2 g (8 mmol) IV over 1–2 min Seizures: 50 % magnesium sulphate 2 g (8 mmol) IV over 10 min



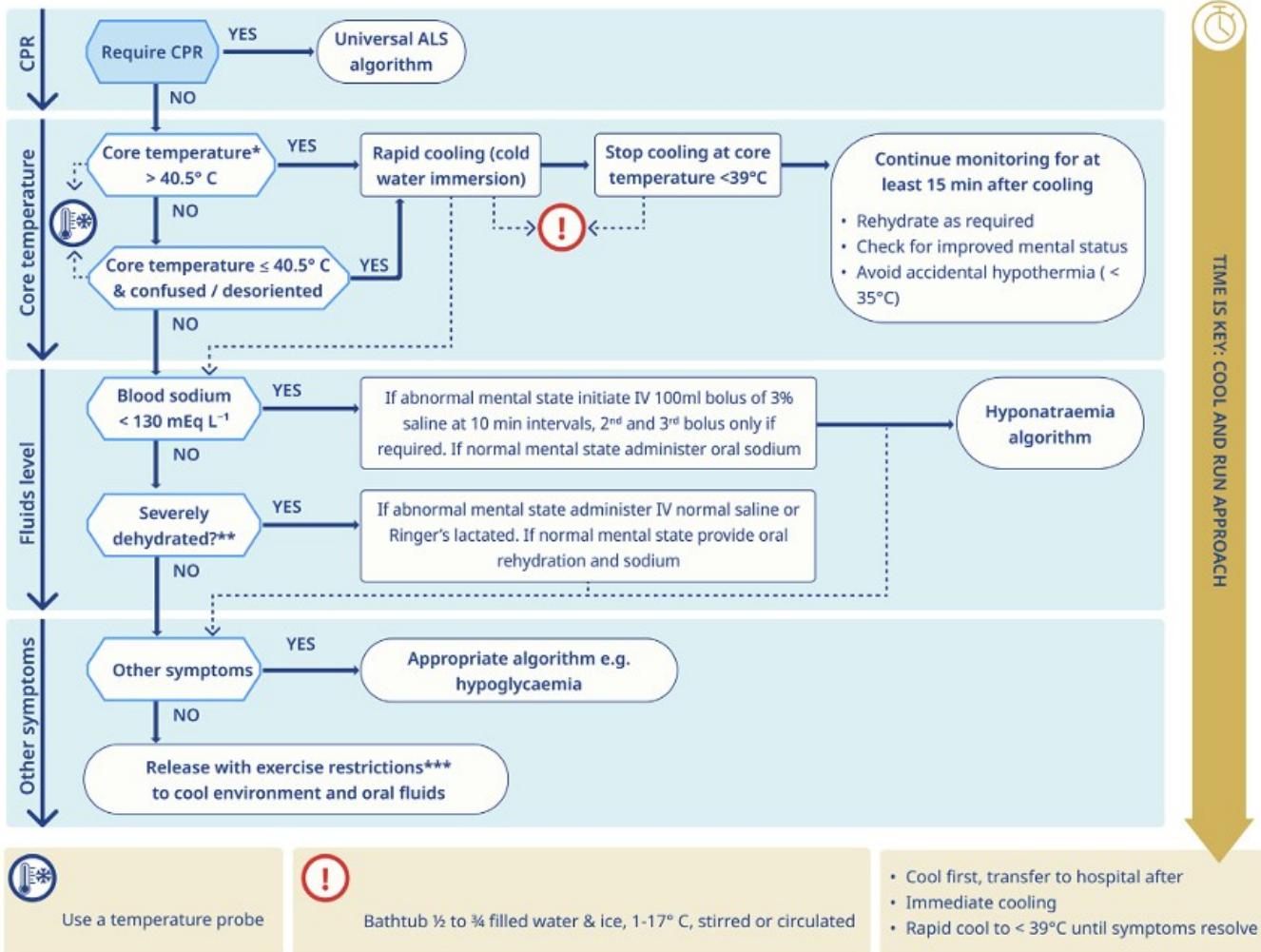
# Hyperthermia

## Summary of changes

	ERC guidelines 2021	ERC guidelines 2025
<b>Hyperthermia, malignant hyperthermia and toxin induced hyperthermia</b>		<ul style="list-style-type: none"><li>• Figure for treatment of malignant hyperthermia added.</li><li>• Section on toxin-induced hyperthermia with table added.</li></ul>
<b>Accidental hypothermia and avalanche rescue</b>	<ul style="list-style-type: none"><li>• Scoring systems established</li></ul>	<ul style="list-style-type: none"><li>• Revised Swiss Staging for hypothermia, when core temperature cannot be measured.</li><li>• Heart rate &lt; 45/min as new high-risk criterion for hypothermia-induced cardiac arrest.</li><li>• Criteria for qualification for extracorporeal life support do not apply for rewarming of arrested hypothermic patients, e.g. unwitnessed cardiac arrest, asystole as presenting arrhythmia.</li><li>• New avalanche rescue algorithm.</li><li>• BLS avalanche rescue algorithm for cases with insufficient personnel on site.</li></ul>



# Hyperthermia



*Malignant hyperthermia*



**QR code. 1 – Malignant hyperthermia algorithm.**

Treatment of malignant hyperthermia, modified from (Hopkins et al., 2021)<sup>91</sup> and (Kollman-Camaiora et al., 2017).<sup>109</sup>

- 
- Stop triggering agents immediately. This includes turning off and removing vaporiser and changing the ventilator circuit.
  - Give IV 2.5 mg/kg dantrolene as soon as possible.
  - Start active cooling.
  - Give 100 % oxygen and aim for normocapnia using hyperventilation.
  - Change the ventilator. If the ventilator cannot be changed, change charcoal filters

**Table 4 – Toxins inducing hyperthermia.**

Category	Substance	Mechanism	Symptoms	Diagnostic testing	Specific Management
<b>Antipsychotics</b> <sup>113–117</sup>	Risperidone, Aripiprazole, Haloperidol, Olanzapine, Quetiapine, Clozapine, Blonanserine	Dopamine antagonism/acute withdrawal of dopamine agonists → neuroleptic malignant syndrome (NMS)	Hyperthermia, muscle rigidity, tremor, autonomic dysfunction, altered mental status	Blood testing for antipsychotics	Benzodiazepines against agitation. Bromocriptine for hypodopaminergic state. Dantrolene as muscle relaxant
<b>Antidepressants</b> <sup>118–122</sup>	Lithium, MAOI, SSRI, SNRI, TCA	Serotonin syndrome	Hyperthermia, flushing, shivering, akathisia, agitation, mydriasis, autonomic dysfunction	Blood testing for antidepressants, serum lithium level	Benzodiazepines against agitation. Consider Chlorpromazine. Consider sodium bicarbonate for TCA
<b>Recreational/Party Drugs</b> <sup>123–137</sup>	MDMA (Ecstasy), LSD	Central catecholamine release and reuptake inhibition in the CNS, hypermetabolic condition with skeletal muscle stimulation, tachycardia and vasoconstriction	Hyperthermia, euphoria, hallucinations, agitation, shivering, mydriasis, nausea	Urine screening (MDMA, LSD)	Benzodiazepines for agitation. Dantrolene for hyperthermia. Consider carvedilol for MDMA
	Methamphetamine		Hyperthermia, hallucinations, tremor, agitation, mydriasis Autonomic dysfunction	Urine or blood screening for amphetamines	Ammonium chloride for excretion (urine acidifier). Activated charcoal to reduce absorption
	Cocaine	Nonselective dopamine, serotonin, noradrenaline reuptake inhibitor. CNS stimulation, sympathetic system activation. Direct sodium channel blockade. Coronary vasoconstriction	Hyperthermia, hallucinations, tremors, agitation, mydriasis, autonomic dysfunction, arrhythmias, chest pain	Urine and blood screening	Consider sodium bicarbonate for broad complex tachycardia or cardiac arrest, avoid β-blockers
<b>Anticholinergics</b> <sup>138–142</sup>	Atropine, scopolamine, plant alkaloids (belladonna, brugmansia, amanita)	Blockade of muscarinic receptors. Anticholinergic hyperthermic syndrome	Hyperthermia, tachycardia, sweating Inhibititon, dry skin & mucus membranes, flushing, mydriasis, altered mental status	Urine and serum screening	Benzodiazepines and central acting cholinesterase inhibitors against agitation. Activated charcoal within 1st hour (time window may be extended as anticholinergics reduce gastrointestinal motility)
<b>Sympathomimetics</b> <sup>143–145</sup>	Ephedrine, pseudoephedrine	Sympathetic system activation Increased metabolic rate and peripheral vasoconstriction	Hyperthermia, tachycardia, hypertension, arrhythmias, muscle twitching, nausea, mydriasis, urinary retention	Urine screening, serum toxicology testing for pseudoephedrine/ ephedrine	Benzodiazepines against agitation
<b>Salicylates</b> <sup>146,147</sup>	Aspirin, methyl salicylate	Uncoupling of oxidative phosphorylation leading to increased heat production.	Mild hyperthermia, nausea, tachypnea, confusion, tinnitus	Serum salicylate levels	Urine alkalinization with NaHCO <sub>3</sub> . Prevent hypoglycemia. Consider dialysis for drug excretion and cooling
<b>Miscellaneous</b> <sup>148,149</sup>	Dinitrophenol (DNP)	Uncoupling of oxidative phosphorylation leading to increased heat production	Hyperthermia, sweating, flushing, agitation, tachycardia & tachypnea, fatigue	Serum toxicology testing for DNP	Consider dantrolene

CNS denotes central nervous system, LSD denotes lysergic acid diethylamide, MAOI – Monoaminoxidase inhibitor, MDMA – 3,4-Methylenedioxymethamphetamine, SNRI – Serotonin and norepinephrine reuptake inhibitor, SSRI – Selective serotonin reuptake inhibitor, TCA – Tricyclic antidepressant.

**Table 3 – Treatment of hyperthermia.**

Degree of hyperthermia	Symptoms	Treatment
<b>Mild – Heat syncope</b>	Transient loss of consciousness and fast return to normal neurologic baseline.	Remove patient to a cool environment, passive cooling, resting and administration of oral isotonic or hypertonic fluids (the latter only if $\text{Na}^+ \leq 130 \text{ mmol L}^{-1}$ ).
<b>Moderate – Heat exhaustion</b>	Intense thirst, weakness, discomfort, anxiety, dizziness, syncope. Caused by mild to moderate hyperthermia ( $>40^\circ\text{C}$ ) due to exposure to high environmental heat or excessive exercise.	Additionally, lie patient flat and administer isotonic IV fluids. Simple external cooling measures are usually not required but may involve conductive (e.g. cold floor, ice sheets; commercial ice packs to hands, feet and cheeks), convective (cold water immersion, cold shower) and evaporative measures (spraying cold water, fanning bare skin).
<b>Severe – Heat stroke</b>	Triad of severe hyperthermia (core temperature $> 40^\circ\text{C}$ ), neurological symptoms and recent passive environmental exposure (classic or passive heat stroke) or excessive exercise (exertional heat stroke). Symptoms include central nervous system dysregulation (e.g. altered mental state, seizure, coma), tachycardia, tachypnoea and arterial hypotension. <sup>92</sup> Mortality is approximately 10 %, and when combined with hypotension approaches 33 %. <sup>98</sup> The outcome worsens if the core temperature is sustained at $> 40.5^\circ\text{C}$ .	Rapidly cool the patient to $< 39^\circ\text{C}$ , preferably $< 38.5\text{--}38.0^\circ\text{C}$ as quickly as possible. <sup>98</sup> Prioritise active cooling methods over passive cooling – a cooling rate $\geq 0.155^\circ\text{C min}^{-1}$ is recommended <sup>104</sup> . It is important to account for the time between symptom onset and the provision of care when selecting a cooling method, reaching the target temperature within 30 min of onset of heat stroke should be the goal <sup>104</sup> . For exertional heatstroke, a cooling rate faster than $0.10^\circ\text{C min}^{-1}$ is safe and desirable. Ice or cold-water immersion (from neck down) or full body conductive cooling should be used, cooling rates of $0.2\text{--}0.35^\circ\text{C min}^{-1}$ can be achieved. <sup>98,639</sup> Cold water immersion should be continued until the symptoms have resolved or for a reasonable amount of time, e.g. 15 min, because benefit outweighs risk (weak recommendation, very low certainty evidence). <sup>105</sup> If cold water immersion is not available, a combination of simple cooling techniques may be used, including conductive, convective and evaporative measures, although there are no comparative studies to guide the best option. <sup>105</sup> A systematic review concluded that water immersion ( $1\text{--}26^\circ\text{C}$ water) lowers body temperature faster and more effectively compared to passive cooling (low to very low certainty of evidence). Misting and fanning cooling techniques are marginally faster than passive cooling, and cold showers ( $20.8^\circ\text{C}$ ) cool faster than passive cooling. <sup>105</sup> IV isotonic or hypertonic fluids should be administered (if $\text{Na}^+ \leq 130 \text{ mmol L}^{-1}$ , for example up to $3 \times 100 \text{ mL } 3\% \text{ NaCl}$ at 10 min intervals). <sup>106</sup> Additional electrolyte replacement with isotonic fluids should be considered and substantial amounts of fluids may be required. Follow the ABCDE approach in any patient with deteriorating vital signs. Critically ill patients will require aggressive and extended treatment in an intensive care unit. <sup>92,107</sup> There may be a requirement for advanced cooling techniques including external or internal devices used for targeted temperature management. There are no specific medications lowering core temperature.

Treatment is progressive in accordance with the degree of hyperthermia.

# Hyperthermia

Recommendations for Adults With Life-Threatening Hyperthermia (Core Temperature >40 °C [104 °F])		
COR	LOE	Recommendations
1	C-EO	<ol style="list-style-type: none"><li>1. Active cooling is recommended to be initiated concurrently with standard resuscitation for adults with life-threatening hyperthermia.</li></ol>
2a	B-R	<ol style="list-style-type: none"><li>2. It is reasonable to choose immersion in ice water (1–5 °C [33.8–41 °F]) over other cooling methods in adults with life-threatening hyperthermia.</li></ol>
2a	B-R	<ol style="list-style-type: none"><li>3. If ice water immersion is not available, it is reasonable to choose immersion in tepid water (8–17 °C [46.4–62.6 °F]) or tarp-assisted ice water cooling over other cooling methods in adults with life-threatening hyperthermia.</li></ol>
2a	C-LD	<ol style="list-style-type: none"><li>4. It is reasonable to cool adults with life-threatening hyperthermia as rapidly as possible with a decrease of at least 0.15 °C/min (0.27 °F/min).</li></ol>
2a	C-LD	<ol style="list-style-type: none"><li>5. It is reasonable to stop active cooling for life-threatening hyperthermia when the core temperature of the adult patient reaches 38.6 °C (101.5 °F).</li></ol>
3: No Benefit	B-R	<ol style="list-style-type: none"><li>6. Dantrolene is not useful to treat adults with life-threatening hyperthermia from causes other than malignant hyperthermia.</li></ol>

# Hyperthermia

## Recommendations for Children With Life-Threatening Hyperthermia (core temperature, >40 °C [104 °F])

COR	LOE	Recommendations
1	C-EO	<ol style="list-style-type: none"><li>1. Active cooling is recommended to be initiated concurrently with standard resuscitation for children with life-threatening hyperthermia.</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>2. It is reasonable to choose immersion in ice water (1–5 °C; 33.8–41 °F) over other cooling methods in children with life-threatening hyperthermia.</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>3. If ice water immersion is not available, it is reasonable to choose immersion in tepid water (8–17 °C; 46.4–62.6 °F) or tarp-assisted ice water cooling over other cooling methods in children with life-threatening hyperthermia.</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>4. It is reasonable to cool children with life-threatening hyperthermia as rapidly as possible with a decrease of at least 0.15 °C/min (0.27 °F/min).</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>5. It is reasonable to stop active cooling for life-threatening hyperthermia when the core temperature of a child reaches 38.6 °C (101.5 °F).</li></ol>
3: No Benefit	C-EO	<ol style="list-style-type: none"><li>6. Dantrolene is not useful to treat children with life-threatening hyperthermia from causes other than malignant hyperthermia.</li></ol>

# Hypothermia

Summary of changes		
	ERC guidelines 2021	ERC guidelines 2025
<b>Accidental hypothermia and avalanche rescue</b>	<ul style="list-style-type: none"><li>• Scoring systems established</li></ul>	<ul style="list-style-type: none"><li>• Revised Swiss Staging for hypothermia, when core temperature cannot be measured.</li><li>• Heart rate &lt; 45/min as new high-risk criterion for hypothermia-induced cardiac arrest.</li><li>• Criteria for qualification for extracorporeal life support do not apply for rewarming of arrested hypothermic patients, e.g. unwitnessed cardiac arrest, asystole as presenting arrhythmia.</li><li>• New avalanche rescue algorithm.</li><li>• BLS avalanche rescue algorithm for cases with insufficient personnel on site.</li></ul>

# Hypothermia

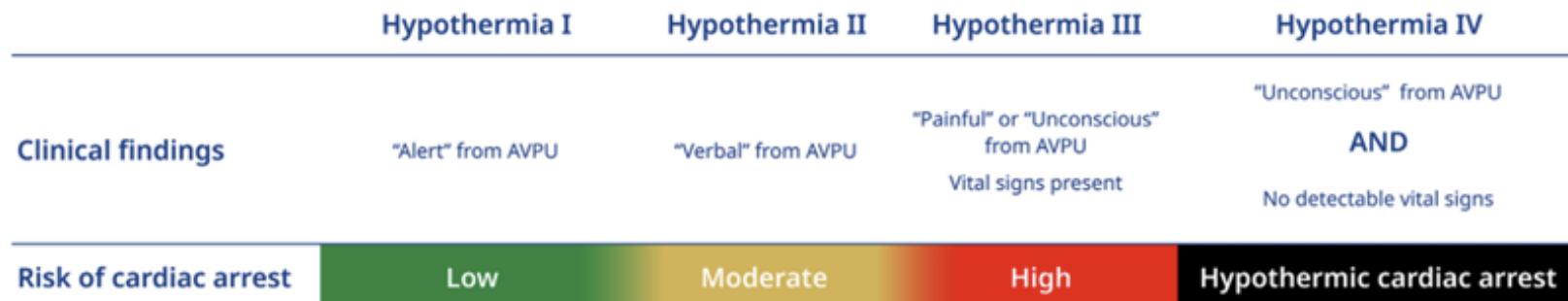
Check vital signs for up to **one minute** in an unconscious hypothermic patient  
Use the Swiss Staging System if core temperature cannot be measured.

**Table 5 – Swiss staging of accidental hypothermia.<sup>157</sup>**

Stage	Clinical Findings	Core temperature (°C) (if available)
Hypothermia I (mild)	Conscious*	35–32 °C
Hypothermia II (moderate)	Impaired consciousness*	<32–28 °C
Hypothermia III (severe)	Unconscious*; vital signs present	<28 °C
Hypothermia IV (severe)	Apparent death; Vital signs absent	Variable**

\* Consciousness may be impaired by comorbid illness (e.g. trauma, central nervous system pathology, toxic ingestion) or medications (e.g. sedatives, muscle relaxants, opioids) independent of core temperature.

\*\* The risk of cardiac arrest increases < 30 °C, older and sicker patients. Alternative causes should be considered. Some patients still have vital signs < 24 °C.



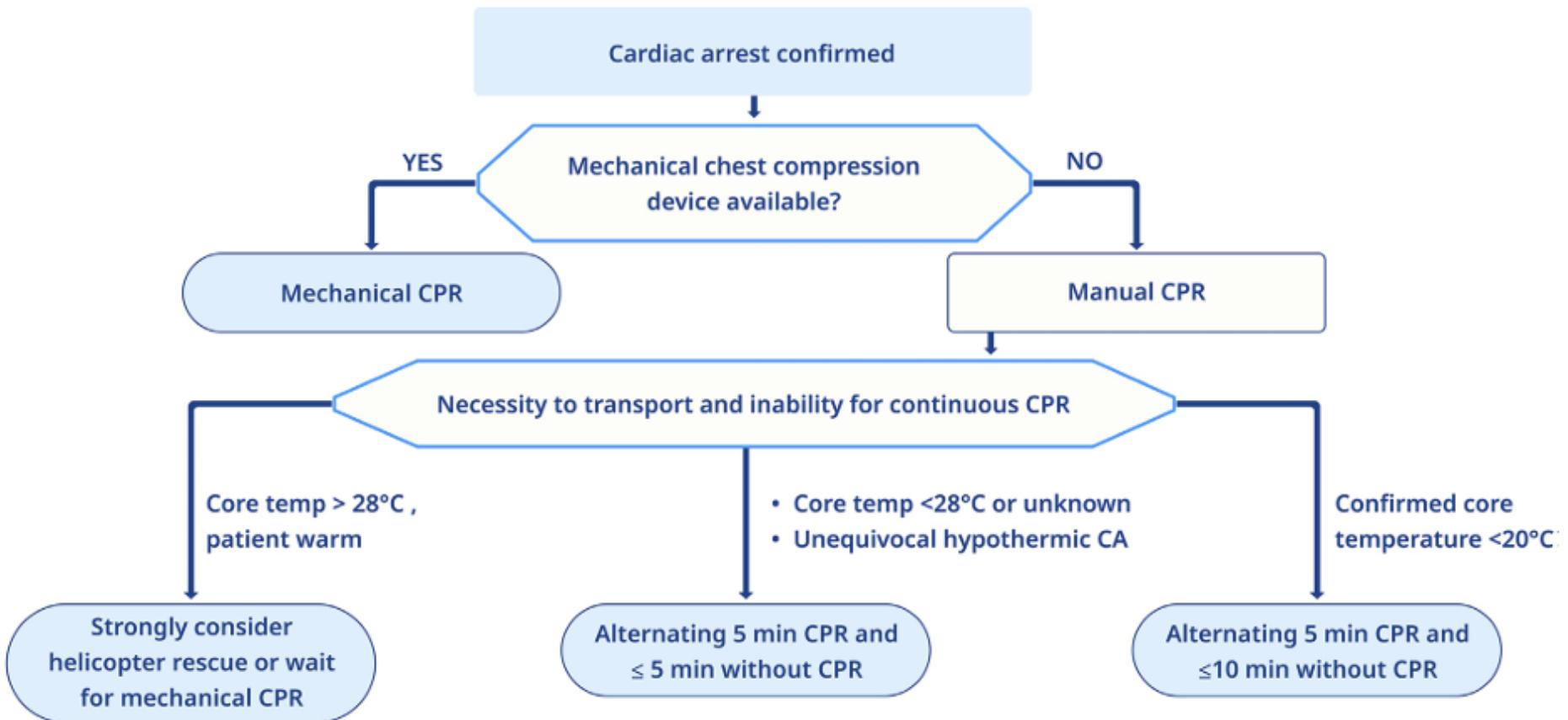
**Fig. 12 – Revised Swiss System for staging of accidental hypothermia.<sup>156</sup>**

AVPU – alert verbal pain unresponsive.

# Hypothermia

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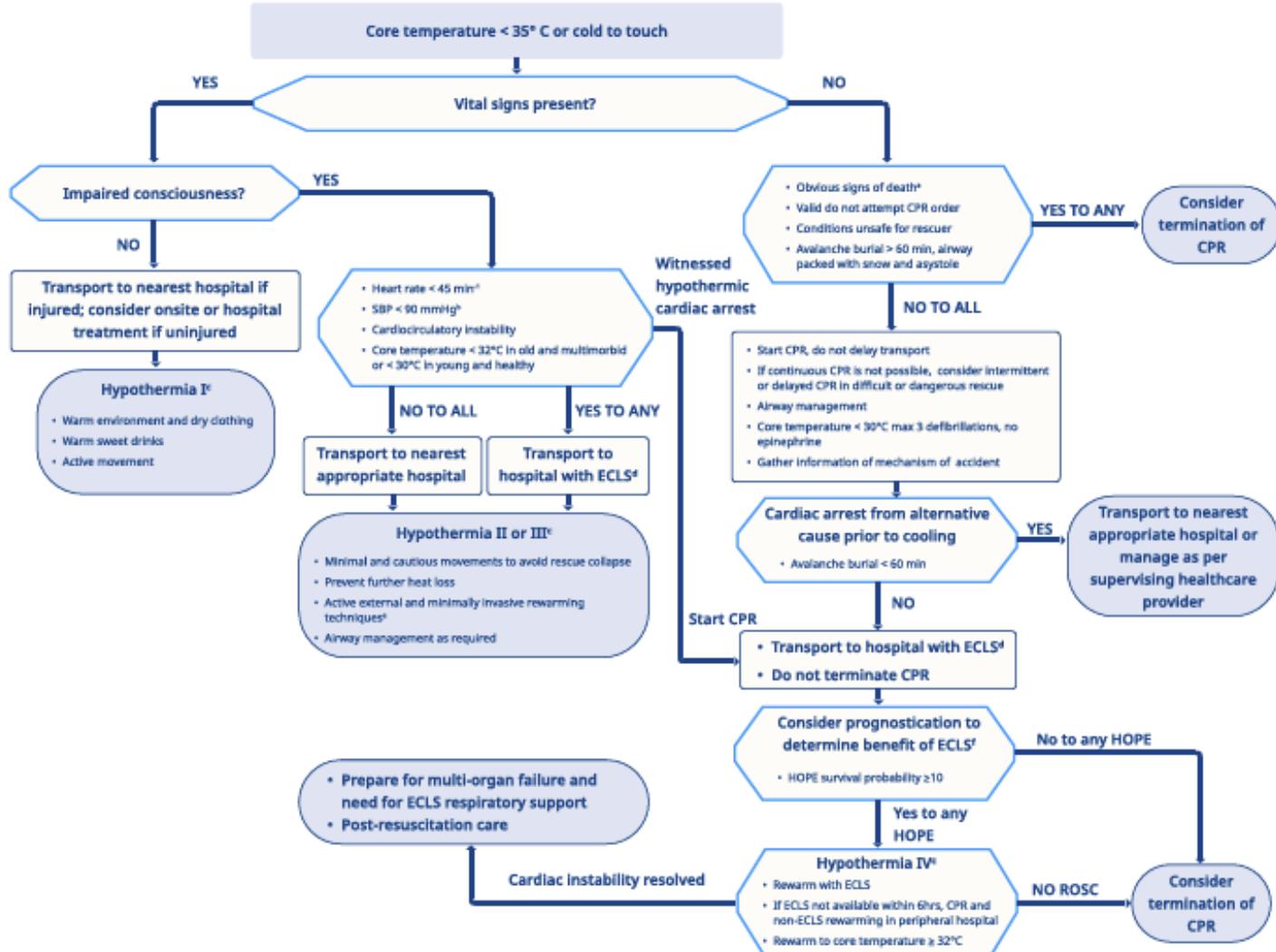
- Transfer hypothermic patients with risk factors for imminent cardiac arrest and those in cardiac arrest directly to an extracorporeal life support (ECPR) centre for rewarming.
  - Delay CPR or use intermittent CPR in hypothermic cardiac arrest patients with a core temperature below 28 °C when immediate or continuous CPR is not feasible.
  - Delay further defibrillation attempts if ventricular fibrillation (VF) persists after three shocks until core temperature is > 30 °C.
  - Below 30 °C adrenaline will accumulate and may have more detrimental than beneficial effects. Give IV 1 mg adrenaline once to facilitate ROSC unless planning imminent initiation of ECPR. Increase administration intervals for adrenaline to 6–10 min if the core temperature is 30–35 °C.
  - Consider use of a mechanical CPR device if transport is prolonged, or when there are difficulties with the terrain.
  - Base in-hospital prognostication of successful rewarming on the Hypothermia Outcome Prediction after Extracorporeal Life Support (HOPE) score.
  - Rewarm hypothermic arrested patients with veno-arterial extracorporeal membrane oxygenation (VA-ECMO).
- 
- Initiate non-extracorporeal life support rewarming if an ECPR centre cannot be reached within a reasonable time (e.g. 6 h).

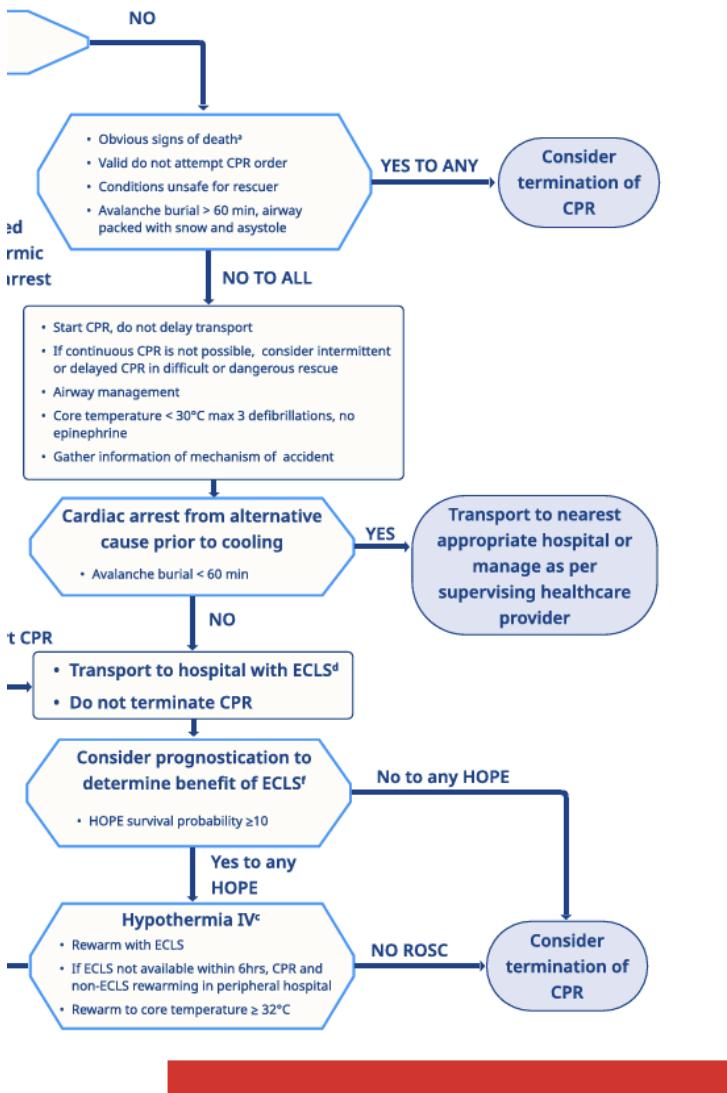


**Fig. 13 – Decision making in hypothermic cardiac arrest.**

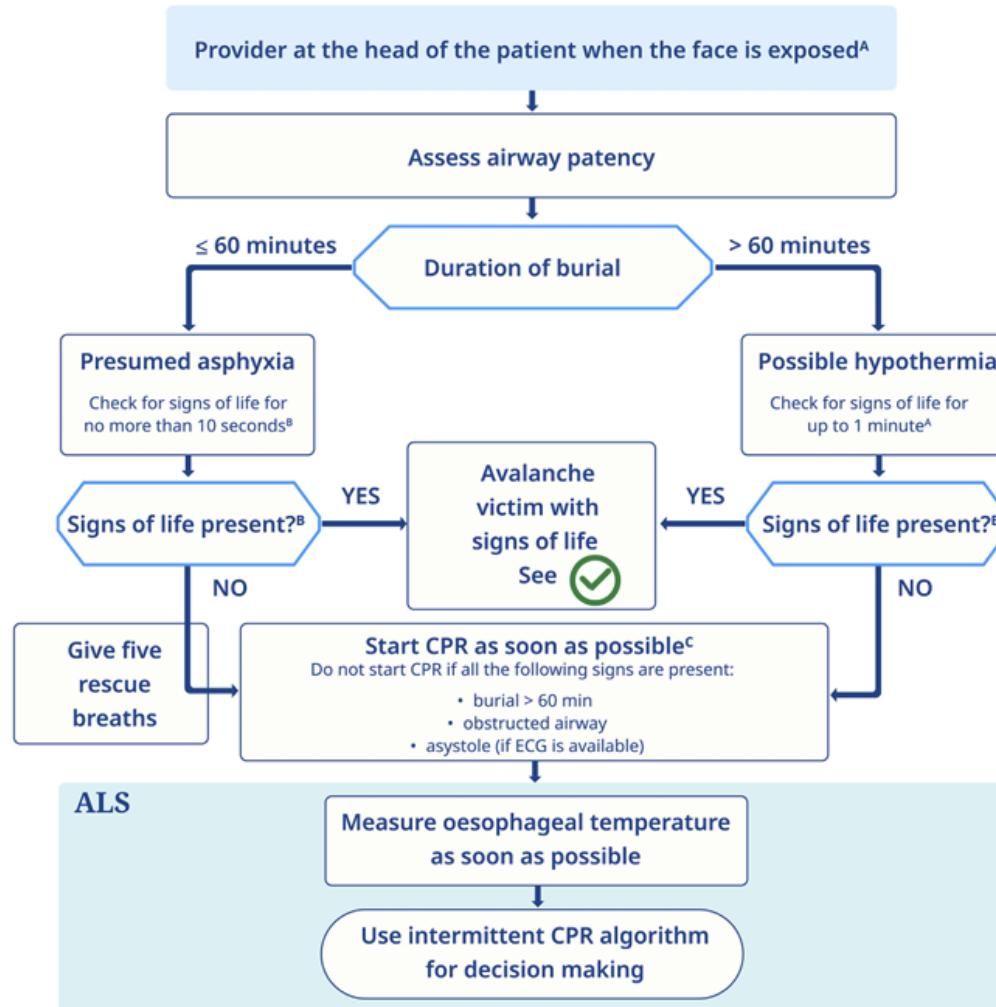
CPR – cardiopulmonary resuscitation. Delayed and intermittent CPR in hypothermic patients when continuous CPR is not possible during dangerous or difficult rescue.<sup>170</sup>

# Hypothermia





**Obvious sign of death**  
**Decapitation; truncal transection;**  
**whole body decomposed or whole body frozen solid**  
**(chest wall not compressible).**



#### Critically buried avalanche victim with signs of life

- ECG monitoring as soon as possible (ideally before handling or moving the patient)
- Gentle handling and consider potential trauma
- Transfer to the most appropriate hospital
- Consider transfer to an ECLS hospital for hypothermic patients with core temperature < 30°C or ventricular arrhythmia or systolic blood pressure < 90 mmHg
- The management of medical conditions which are not specific to avalanche victims (e.g. hypothermia, trauma) should follow the most recent recommendations

Recommendations for Adults With Life-Threatening Environmental Hypothermia (Core Temperature <30 °C [86 °F])		
COR	LOE	Recommendations
1	C-LD	<p>1. For adults with life-threatening environmental hypothermia with no obvious lethal injury, full resuscitative measures should be performed immediately and continued concurrently with rewarming.</p>
2a	B-NR	<p>2. It is reasonable to rewarm adults in hypothermic cardiac arrest using ECLS.</p>
2a	B-NR	<p>3. It is reasonable to use prognostication scores to guide the decision for initiating ECLS rewarming for adults in hypothermic cardiac arrest.</p>
2b	C-LD	<p>4. It may be reasonable to rewarm adults with environmental hypothermia (core temperature &lt;28 °C [82.4 °F]) and not in cardiac arrest using ECLS.</p>
2b	C-LD	<p>5. For adults in hypothermic cardiac arrest, it may be reasonable to defibrillate once and if unsuccessful, defer further defibrillation until the core temperature is ≥30 °C (86 °F).</p>
2b	C-LD	<p>6. It may be reasonable to rewarm adults with life-threatening environmental hypothermia with ECLS at a rate of 1.5–5 °C/hour (2.7–9 °F/hour).</p>
2b	C-EO	<p>7. It may be reasonable to defer administration of epinephrine until the core temperature is ≥30 °C (86 °F) for adults in hypothermic cardiac arrest.</p>
2b	C-EO	<p>8. If standard CPR is not possible due to environmental conditions, it may be reasonable to perform delayed or intermittent CPR during the resuscitation of adults in hypothermic cardiac arrest to facilitate rapid extraction.</p>
2b	C-EO	<p>9. It may be reasonable to transport adults in hypothermic cardiac arrest to a center with ECLS capability if it can be reached within 6 hours.</p>
3: No Benefit	B-NR	<p>10. It is not recommended to use end-tidal carbon dioxide (ETCO<sub>2</sub>) to predict outcomes for adults in hypothermic cardiac arrest.</p>

**Recommendations for Children With Life-Threatening Environmental Hypothermia (Core Temperature <30 °C [86 °F])**

COR	LOE	Recommendations
1	C-EO	<ol style="list-style-type: none"><li>1. For children with life-threatening environmental hypothermia with no obvious lethal injury, full resuscitative measures should be performed immediately and continued concurrently with rewarming.</li></ol>
2a	C-LD	<ol style="list-style-type: none"><li>2. It is reasonable to rewarm children in hypothermic cardiac arrest using ECLS.</li></ol>
2a	C-LD	<ol style="list-style-type: none"><li>3. It is reasonable to use prognostication scores to guide the decision for initiating ECLS rewarming for children in hypothermic cardiac arrest.</li></ol>
2b	C-LD	<ol style="list-style-type: none"><li>4. It may be reasonable to rewarm children with life-threatening environmental hypothermia with ECLS at a rate &lt;5 °C/hour (9 °F/hour).</li></ol>

Recommendations for Children With Life-Threatening Environmental Hypothermia (Core Temperature <30 °C [86 °F]) (Continued)		
COR	LOE	Recommendations
2b	C-EO	5. It may be reasonable to rewarm children with environmental hypothermia (core temperature <28 °C [82.4 °F]) and not in cardiac arrest using ECLS.
2b	C-EO	6. For children with hypothermic cardiac arrest, it may be reasonable to defibrillate once and if unsuccessful, defer further defibrillation until the core temperature is ≥30 °C (86 °F).
2b	C-EO	7. It may be reasonable to defer administration of epinephrine until core temperature is ≥30 °C (86 °F) for children in hypothermic cardiac arrest.
2b	C-EO	8. If standard CPR is not possible due to environmental conditions, it may be reasonable to perform delayed or intermittent CPR during the resuscitation of children in hypothermic cardiac arrest to facilitate rapid extraction.
2b	C-EO	9. It may be reasonable to transport children in hypothermic cardiac arrest to a center with ECLS capability if it can be reached within 6 hours.
3: No Benefit	B-NR	10. It is not recommended to use ETCO <sub>2</sub> to predict outcomes for children in hypothermic cardiac arrest.

# Pulmonary Embolism

Sudden onset of progressive dyspnea and absence of known heart or pulmonary disease

- Low ET<sub>O2</sub> values (<1.7 kPa/13 mmHg) while performing high quality CPR
- Use fibrinolytic drugs or surgical embolectomy or percutaneous mechanical thrombectomy for cardiac arrest when PE is the known cause of cardiac arrest
- Consider ECPR
- Set-up a multidisciplinary team

# Pulmonary Embolism

## *Modifications to ALS*

*Fibrinolysis.* If pulmonary embolism is the suspected cause of cardiac arrest, fibrinolytic drugs should be administered, based on evidence from an ILCOR CoSTR.<sup>201</sup> There is insufficient evidence

to recommend optimal drug and dosing strategy for fibrinolysis during CPR. ROSC and survival were observed after recombinant tissue type plasminogen activator (alteplase, bolus 50 mg IV with or without additional 50 mg after 30 min, or 0.6–1.0 mg/kg IV – max. 100 mg).<sup>197,207,208</sup> When thrombolytic drugs have been administered, continue CPR for at least 60–90 min.<sup>195,209,210</sup> Based on expert opinion, thrombolysis or surgical embolectomy should be considered for pregnant women with high-risk pulmonary embolism and PE causing cardiac arrest.<sup>193</sup>

# Pulmonary Embolism

**Table 6 – Non-specific patient characteristics observed with higher incidence in OHCA caused by pulmonary embolism compared with other causes<sup>193,198,205</sup>.**

## Symptoms preceding cardiac arrest

Sudden onset of dyspnoea

Pleuritic or substernal chest pain

Cough

Haemoptysis

Syncope (otherwise unexplained and/or repeated collapses)

Signs of DVT (unilateral low extremity swelling)

Signs of right ventricular strain on 12-lead ECG (if obtained before cardiac arrest)

- Inversion of T waves in leads V1–V4
- QR pattern in V1
- S1 Q3 T3 pattern (i.e. a prominent S wave in lead I, a Q wave and inverted T wave in lead III)
- Incomplete or complete right bundle-branch block

## Assessment during resuscitation

Female biological sex

Lower age

EMS witnessed cardiac arrest

PEA as first observed rhythm

Low ETCO<sub>2</sub> readings during high quality CPR (<1.7 kPa/13 mmHg)

Presence of right heart dilation with poor filling of the left heart, D sign (straightening of interventricular septum) and/or intracardiac thrombi (intra-arrest POCUS)

# Pulmonary Embolism

## Recommendations for Adults in Cardiac Arrest From PE

COR	LOE	Recommendations
<b>2a</b>	<b>B-NR</b>	1. For adults with confirmed PE as the precipitant of cardiac arrest, systemic fibrinolysis, surgical embolectomy, and percutaneous mechanical embolectomy are reasonable treatment options.
<b>2a</b>	<b>B-NR</b>	2. It is reasonable to use ECLS in adults with cardiac arrest from confirmed or suspected PE.
<b>2b</b>	<b>B-NR</b>	3. For adults in cardiac arrest from suspected PE, systemic fibrinolysis may be considered.
<b>2b</b>	<b>C-EO</b>	4. The optimal duration of CPR after administration of systemic fibrinolytic to adults in cardiac arrest from confirmed or suspected PE is unclear.

4. There are no trials comparing different durations of continued resuscitation following systemic fibrinolysis administration to adults in cardiac arrest from any cause, including confirmed or suspected PE. The 2019 European Society of Cardiology guidelines for the diagnosis and management of acute PE recommend continuing CPR for at least 60 to 90 minutes after administration of a systemic fibrinolytic based upon case reports and case series of adults who survived after 90 to 100 minutes of CPR.<sup>2,19,20</sup> There is significant variation in the duration of CPR after fibrinolysis between studies. One randomized trial investigating the use of systemic

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fibrinolysis to treat adults in PEA arrest continued CPR for at least 15 minutes after systemic fibrinolytic administration.<sup>16</sup> A second randomized trial continued CPR for at least 30 minutes after systemic fibrinolytic administration to adults in cardiac arrest.<sup>17</sup>

# Pulmonary Embolism

Recommendations for Children in Cardiac Arrest From PE		
COR	LOE	Recommendations
2a	C-LD	1. For children with confirmed PE as the precipitant of cardiac arrest, systemic fibrinolysis, surgical embolectomy, and percutaneous mechanical embolectomy are reasonable treatment options.
2a	C-LD	2. It is reasonable to use ECLS in children with cardiac arrest from confirmed or suspected PE.
2b	C-EO	3. For children in cardiac arrest from suspected PE, systemic fibrinolysis may be considered.
2b	C-EO	4. The optimal duration of CPR after administration of systemic fibrinolytic to children in cardiac arrest from confirmed or suspected PE is unclear.

# Coronary thrombosis

## 1. Prevent & be prepared



Promote cardiovascular health to reduce the risk of acute coronary events



Enhance health education to recognise symptoms & BLS training for likely rescuers



Strengthen regional STEMI networks to ensure timely PCI

## 2. Suspect & react



Evaluate 12-lead ECG after ROSC; repeat if inconclusive

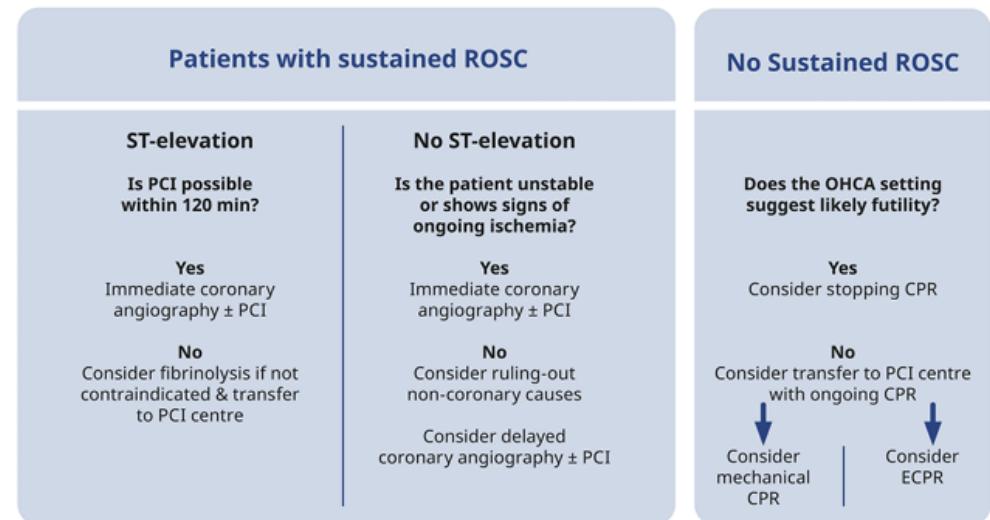


Assess clinical data suggesting acute coronary syndrome



Activate the STEMI network & transfer the patient to PCI centre if ST-elevation or ongoing ischemia

## 3. Resuscitate & establish reperfusion strategy

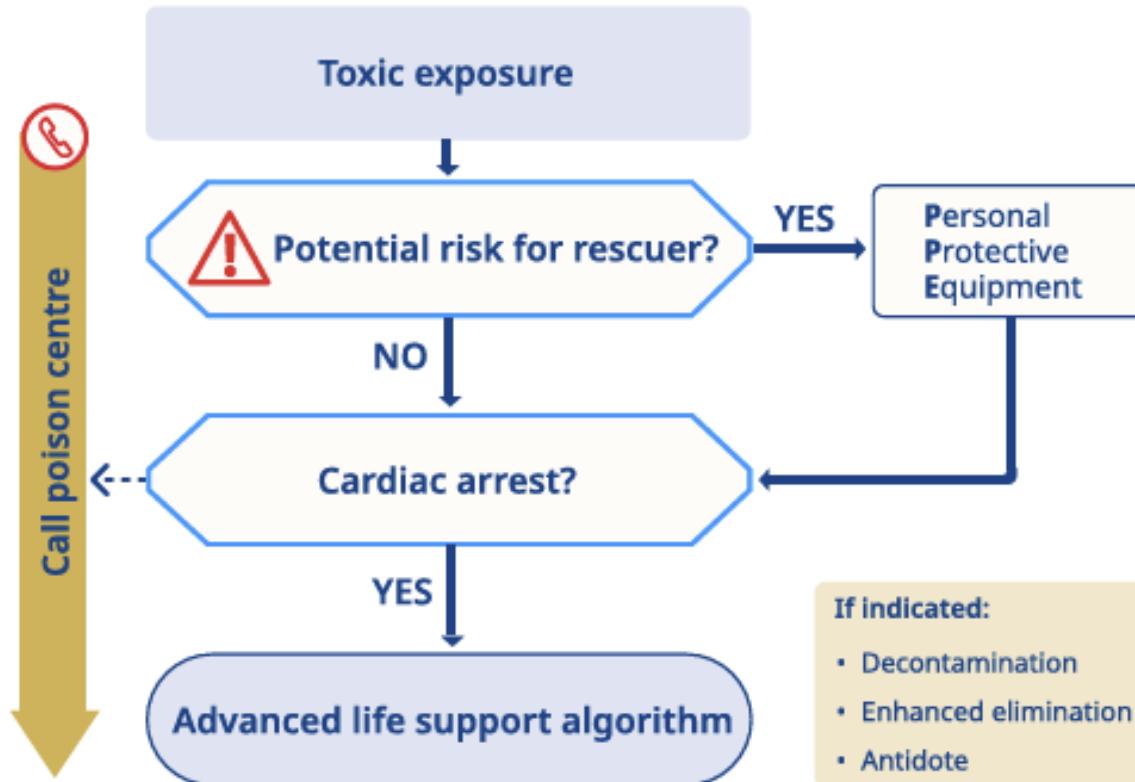


**Fig. 15 – Coronary thrombosis algorithm.**

BLS – basic life support, STEMI – ST elevation myocardial infarct, PCI – percutaneous coronary intervention, ECG – electrocardiography, OHCA – out-of-hospital cardiac arrest, ROSC – return of spontaneous circulation.

# Toxic agent

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**Fig. 7 – Management of toxic exposure.**

**Table. Common Toxidromes\***

Cardiac Signs			CNS/Metabolic Signs		
Tachycardia and/or Hypertension	Bradycardia and/or Hypotension	Cardiac Conduction Delays (Wide QRS)	Seizures	CNS and/or Respiratory Depression	Metabolic Acidosis
Amphetamines	Beta blockers	Cocaine	Cyclic antidepressants	Antidepressants (several classes)	Cyanide
Anticholinergic drugs	Calcium channel blockers	Cyclic antidepressants	Isoniazid	Benzodiazepines	Ethylene glycol
Antihistamines	Clonidine	Local anesthetics	Selective and non-selective norepinephrine reuptake inhibitors (eg, bupropion)	Carbon monoxide	Metformin
Cocaine	Digoxin and related glycosides	Propoxyphene	Withdrawal states	Ethanol	Methanol
Theophylline/caffeine	Organophosphates and carbamates	Antiarrhythmics (e.g., quinidine, flecainide)		Methanol	Salicylates
Withdrawal states				Opioids	
				Oral hypoglycemics	

\*Differential diagnosis lists are partial.

**Table 4. Commonly Used Doses of Antidotes for Resuscitation in Critical Poisoning**

Antidote	Indication	Initial dose (adult)*	Initial dose (pediatric)*	Maintenance infusion	Notes
Atropine	Organophosphates Carbamates	1–2 mg, doubled every 5 min	0.02 mg/kg, doubled every 5 min	10%–20% of the total loading dose per hour up to $2 \text{ mg} \cdot \text{h}^{-1}$ (adults)	Titrate to reversal of bronchorrhea, bronchospasm, and bradycardia.
Calcium chloride	$\beta$ -blockers CCBs	2000 mg  28 mEq $\text{Ca}^{2+}$  20 mL 100 mg/mL solution	20 mg/kg  0.28 mEq $\text{Ca}^{2+}/\text{kg}$  0.2 mL/kg 100 mg/mL solution	$20\text{--}40 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$  0.28–0.56 mEq $\text{Ca}^{2+} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$  0.2–0.4 mL $\text{kg}^{-1} \cdot \text{h}^{-1}$ 100 mg/mL solution	Titrate to blood pressure.  Do not exceed serum ionized calcium concentration 1.5–2 times the upper limits of normal.  Administer through central line, especially in children.
Calcium gluconate	$\beta$ -blockers CCBs	6000 mg  28 mEq $\text{Ca}^{2+}$  60 mL 100 mg/mL solution	60 mg/kg  0.28 mEq/kg $\text{Ca}^{2+}$  0.6 mL/kg 100 mg/mL solution	$60\text{--}120 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$  0.28–0.56 mEq $\text{Ca}^{2+} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$  0.6–1.2 mL $\text{kg}^{-1} \cdot \text{h}^{-1}$ 100 mg/mL solution	Titrate to blood pressure.  Do not exceed serum ionized calcium concentration 1.5–2 times the upper limits of normal.
Digoxin immune Fab	Digoxin	Acute overdose: 1 vial for every 0.5 mg digoxin ingested  Chronic poisoning: Use formula: dose in vials=serum digoxin concentration (ng/ mL) $\times$ weight (kg)/100  Acute overdose, critically ill, ingested dose unknown: 10–20 vials	Same as adult	None	1 vial contains 40 mg Fab. Lower doses may be equally effective. <sup>4</sup>

Glucagon	$\beta$ -blockers CCBs	2–10 mg	0.05–0.15 mg/kg	$1\text{--}15 \text{ mg}\cdot\text{h}^{-1}$ (adult)	Anticipate vomiting.
Flumazenil	Benzodiazepines	0.2 mg, titrated up to 1 mg	0.01 mg/kg	None	Many contraindications
Hydroxocobalamin	Cyanide	5 g	70 mg/kg	Repeat doses may be necessary.	Transient hypertension
Insulin	$\beta$ -blockers CCBs	1 U/kg	Same as adult	$1\text{--}10 \text{ U}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$	Regular human insulin. Monitor for hypoglycemia, hypokalemia, volume overload.
Intravenous lipid emulsion	Local anesthetics	<70 kg: 1.5 mL/kg  >70 kg: bolus 100 mL over 2–3 min	Same as adult	<70 kg: $0.25 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for up to 30 min  >70 kg: 200–250 mL over 15–20 min	All studies use 20% lipid emulsion.
Methylene blue	CCBs Methemoglobinemia	1–2 mg/kg, repeated every hour if needed	Same as adult	$1 \text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$ (for vasodilatory shock)	Maximum 7 mg/kg
Naloxone	Opioids	0.2–2 mg IV/IO/IM  2–4 mg intranasal  Repeat every 2–3 min as needed	0.1 mg/kg	Two thirds of the waking dose per hour	Titrate to reversal of respiratory depression and restoration of protective airway reflexes.
Pralidoxime	Organophosphates	2 g IV infusion over 15–30 min (do not bolus) or 0.6 g IM up to 3 doses	20–50 mg/kg	$1 \text{ g}\cdot\text{h}^{-1}$ (adult)  $10\text{--}20 \text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$ (pediatric)	
Sodium bicarbonate†	Sodium channel blockers Cocaine Local anesthetics	50–150 mEq	1–3 mEq/kg	Prepare 150 mEq/L solution, infuse at 1–3 $\text{mL}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$	Watch for hypernatremia, alkalemia, hypokalemia, hypochloremia.

(Continued)

**Table 4. Continued**

Antidote	Indication	Initial dose (adult)*	Initial dose (pediatric)*	Maintenance infusion	Notes
Sodium nitrite	Cyanide	300 mg	6 mg/kg	None	Watch for hypotension.
Sodium thiosulfate	Cyanide	12.5 g	250 mg/kg	None	

$\beta$ -blockers indicates  $\beta$ -adrenergic receptor antagonists; CCBs, calcium channel blockers; Fab, fragment antigen binding; IM, intramuscular; IO, intraosseous; IV, intravenous; and U, units.

\*Unless otherwise stated, the route of administration should be intravenous or intraosseous. Maximum pediatric dose should not exceed adult dose. Most antidotes should be repeated frequently and titrated to achieve control of critical signs and symptoms. The ideal dose of most antidotes is not known and is often controversial. Large doses are sometimes required to overcome competitive inhibition of molecular targets such as adrenergic receptors and ion channels. Consult a medical or clinical toxicologist, regional poison center, or topic-specific reference for detailed dosing and administration instructions.

†Different sodium bicarbonate solutions are typically used for adults (1 mEq/mL) and children (0.5 mEq/mL). Both formulations are hypertonic.

**Recommendations for Adults With Life-Threatening Benzodiazepine Poisoning (Continued)**

COR	LOE	Recommendations
<b>3: No Benefit</b>	<b>C-EO</b>	3. Flumazenil has no role in cardiac arrest related to benzodiazepine poisoning in adults.
<b>3: Harm</b>	<b>B-R</b>	4. Flumazenil administration is associated with harm in adults who are at increased risk for seizures or arrhythmias.

**Recommendations for Adults With Life-Threatening Benzodiazepine Poisoning**

COR	LOE	Recommendations
<b>2a</b>	<b>B-NR</b>	1. If combined opioid and benzodiazepine poisoning is suspected, it is reasonable to administer naloxone first (before other antidotes) in adults with respiratory depression or respiratory arrest.
<b>2a</b>	<b>C-LD</b>	2. Flumazenil can be effective in select adults with respiratory depression or respiratory arrest caused by pure benzodiazepine poisoning who do not have contraindications to flumazenil.

## Recommendations for Children With Life-Threatening Benzodiazepine Poisoning

COR	LOE	Recommendations
<b>2a</b>	<b>B-R</b>	1. Administration of flumazenil can be effective in select children with respiratory depression or respiratory arrest caused by pure benzodiazepine poisoning who do not have contraindications to flumazenil.
<b>2a</b>	<b>C-EO</b>	2. If combined opioid and benzodiazepine poisoning is suspected, it is reasonable to administer naloxone first (before other antidotes) in children with respiratory depression or respiratory arrest.
<b>3: No Benefit</b>	<b>C-EO</b>	3. Flumazenil has no role in cardiac arrest related to benzodiazepine poisoning in children.
<b>3: Harm</b>	<b>C-LD</b>	4. Flumazenil administration is associated with harm in children who are at increased risk for seizures or arrhythmias.

## TOXICOLOGY: $\beta$ -BLOCKERS

Recommendations for Adults and Children With Life-Threatening $\beta$ -Blocker Poisoning		
COR	LOE	Recommendations
1	C-LD	1. High-dose insulin or euglycemia therapy should be administered for hypotension refractory to vasopressor therapy in adults and children with life-threatening $\beta$ -blocker poisoning.
1	C-EO	2. Vasopressors should be administered for the treatment of hypotension in adults and children with life-threatening $\beta$ -blocker poisoning.
2a	C-LD	3. It is reasonable to administer a bolus of glucagon followed by continuous infusion for treatment of symptomatic bradycardia or hypotension in adults and children with life-threatening $\beta$ -blocker poisoning.
2a	C-LD	4. It is reasonable to use ECLS in adults with $\beta$ -blocker poisoning in cardiogenic shock refractory to pharmacological interventions.
2a	C-EO	5. It is reasonable to use ECLS in children with $\beta$ -blocker poisoning in cardiogenic shock refractory to pharmacological interventions.
2b	C-LD	6. It may be reasonable to use hemodialysis for life-threatening poisoning from atenolol, nadolol, or sotalol in adults with life-threatening $\beta$ -blocker poisoning.
2b	C-EO	7. It may be reasonable to use hemodialysis for life-threatening poisoning from atenolol, nadolol, or sotalol in children with life-threatening $\beta$ -blocker poisoning.
2b	C-EO	8. The usefulness of IV lipid emulsion (ILE) for adults and children with refractory shock due to $\beta$ -blocker poisoning is uncertain.
2b	C-EO	9. It may be reasonable to administer calcium in adults and children with life-threatening $\beta$ -blocker poisoning.

# TOXICOLOGY: CALCIUM CHANNEL BLOCKERS

Recommendations for Adults and Children With Life-Threatening CCB Poisoning		
COR	LOE	Recommendations
1	B-NR	1. High-dose insulin should be administered for hypotension in adults and children with life-threatening CCB poisoning.
1	C-LD	2. Vasopressors should be administered for hypotension in adults and children with life-threatening CCB poisoning.
2a	B-NR	3. It is reasonable to use ECLS in adults with CCB poisoning that is refractory to pharmacological interventions.
2a	C-LD	4. It is reasonable to use ECLS in children with CCB poisoning that is refractory to pharmacological interventions.
2a	C-EO	5. It is reasonable to administer calcium in adults and children with life-threatening CCB poisoning.
2b	C-EO	6. The usefulness of a glucagon bolus followed by continuous infusion for adults and children with life-threatening CCB poisoning is uncertain.
2b	C-EO	7. The usefulness of methylene blue for adults and children with refractory vasodilatory shock due to CCB poisoning is uncertain.
2b	C-EO	8. The usefulness of ILE for adults and children with refractory shock due to CCB poisoning is uncertain.

## Recommendations for Adults With Life-Threatening Cocaine Poisoning

COR	LOE	Recommendations
1	B-R	<ol style="list-style-type: none"><li>1. Sedation is recommended for adults with severe agitation from cocaine poisoning.</li></ol>
1	C-LD	<ol style="list-style-type: none"><li>2. Rapid external cooling with ice water immersion is recommended for adults with life-threatening hyperthermia (Core Temperature <math>&gt;40^{\circ}\text{C}</math> [<math>104^{\circ}\text{F}</math>]) from cocaine poisoning.</li></ol>

**Recommendations for Adults With Life-Threatening Cocaine Poisoning  
(Continued)**

COR	LOE	Recommendations
<b>2a</b>	<b>C-LD</b>	3. In adults with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer sodium bicarbonate.
<b>2a</b>	<b>C-LD</b>	4. In adults with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer lidocaine.
<b>2a</b>	<b>C-LD</b>	5. In adults with cocaine-induced coronary vasospasm or hypertensive emergencies, it is reasonable to administer vasodilators (eg, nitrates, phentolamine, CCBs).
<b>2a</b>	<b>C-EO</b>	6. It is reasonable to use ECLS in adults with cardiogenic shock from cocaine poisoning refractory to other treatment measures.
<b>3: No Benefit</b>	<b>C-LD</b>	7. In adults with cocaine-induced coronary vasospasm or hypertensive emergencies, administration of $\beta$ -adrenergic antagonists is not recommended.
<b>3: Harm</b>	<b>C-LD</b>	8. Prolonged use of physical restraint in adults with life-threatening cocaine poisoning without sedation is potentially harmful.

Recommendations for Children With Life-Threatening Cocaine Poisoning		
COR	LOE	Recommendations
1	C-EO	1. Sedation is recommended for children with severe agitation from cocaine poisoning.
1	C-EO	2. Rapid external cooling with ice water immersion is recommended for children with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from cocaine poisoning.
2a	C-EO	3. In children with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer sodium bicarbonate.
2a	C-EO	4. In children with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer lidocaine.
2a	C-EO	5. In children with cocaine-induced coronary vasospasm or hypertensive emergencies, it is reasonable to administer vasodilators (eg, nitrates, phentolamine, CCBs).
2a	C-EO	6. It is reasonable to use ECLS in children with cardiogenic shock from cocaine poisoning refractory to other treatment measures.
3: No Benefit	C-EO	7. In children with cocaine-induced coronary vasospasm or hypertensive emergencies, administration of β-adrenergic antagonists should not be performed.
3: Harm	C-EO	8. Prolonged use of physical restraint in children with life-threatening cocaine poisoning without sedation is potentially harmful.

## Recommendations for Adults With Life-Threatening Cyanide Poisoning

COR	LOE	Recommendations
1	<b>C-LD</b>	<ol style="list-style-type: none"><li>1. Hydroxocobalamin should be administered to adults with life-threatening cyanide poisoning.</li></ol>
1	<b>C-LD</b>	<ol style="list-style-type: none"><li>2. The combination of sodium nitrite and sodium thiosulfate should be administered to adults with life-threatening cyanide poisoning when hydroxocobalamin is unavailable.</li></ol>
2a	<b>C-EO</b>	<ol style="list-style-type: none"><li>3. In adults with concurrent carbon monoxide and cyanide poisoning (eg, from a house fire), administration of sodium thiosulfate alone is reasonable when hydroxocobalamin is unavailable.</li></ol>
2b	<b>C-EO</b>	<ol style="list-style-type: none"><li>4. In addition to administering hydroxocobalamin, it may be reasonable to administer sodium thiosulfate to adults with cyanide poisoning.</li></ol>

## Recommendations for Children With Life-Threatening Cyanide Poisoning

COR	LOE	Recommendations
1	C-EO	<ol style="list-style-type: none"><li>1. Hydroxocobalamin should be administered to children with life-threatening cyanide poisoning.</li></ol>
1	C-EO	<ol style="list-style-type: none"><li>2. The combination of sodium nitrite and sodium thiosulfate should be administered to children with life-threatening cyanide poisoning when hydroxocobalamin is unavailable.</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>3. In children with concurrent carbon monoxide and cyanide toxicity (eg, from a house fire), administration of sodium thiosulfate alone is reasonable when hydroxocobalamin is unavailable.</li></ol>
2b	C-EO	<ol style="list-style-type: none"><li>4. In addition to administering hydroxocobalamin, it may be reasonable to administer sodium thiosulfate to children with cyanide poisoning.</li></ol>

# TOXICOLOGY: DIGOXIN AND RELATED CARDIAC GLYCOSIDES

Recommendations for Adults and Children With Life-Threatening Poisoning From Digoxin and Related Cardiac Glycosides		
COR	LOE	Recommendations
1	B-NR	<ol style="list-style-type: none"><li>1. Digoxin-specific antibody fragments (digoxin-Fab) should be administered for adults and children with life-threatening digoxin or digitoxin poisoning.</li></ol>
2a	C-LD	<ol style="list-style-type: none"><li>2. It is reasonable to administer digoxin-Fab for adults and children with life-threatening poisoning due to Bufo toad and yellow oleander toxins.</li></ol>
2b	C-EO	<ol style="list-style-type: none"><li>3. It may be reasonable to administer digoxin-Fab to treat adults and children with life-threatening poisoning from cardiac glycosides other than digoxin, digitoxin, Bufo toad toxins, and yellow oleander toxins.</li></ol>
2b	C-EO	<ol style="list-style-type: none"><li>4. It may be reasonable to administer lidocaine or phenytoin to treat adults and children with ventricular arrhythmias caused by digoxin and related cardiac glycoside poisoning until digoxin-Fab can be administered.</li></ol>
3: No Benefit	B-NR	<ol style="list-style-type: none"><li>5. The use of hemodialysis, hemofiltration, hemoperfusion, or plasmapheresis to treat adults and children with life-threatening poisoning from digoxin and related cardiac glycosides is not recommended.</li></ol>

# TOXICOLOGY: LOCAL ANESTHETICS

## Recommendations for Adults and Children With Life-Threatening Local Anesthetic Poisoning

COR	LOE	Recommendations
1	C-LD	<ol style="list-style-type: none"><li>1. For adults and children with life-threatening local anesthetic poisoning, ILE should be administered.</li></ol>
1	C-LD	<ol style="list-style-type: none"><li>2. Benzodiazepines should be used to treat adults and children with seizures associated with local anesthetic systemic toxicity (LAST).</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>3. It is reasonable to administer sodium bicarbonate to adults and children for life-threatening wide complex tachycardia associated with local anesthetic toxicity.</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>4. It is reasonable to use ECLS in adults and children with local anesthetic toxicity with refractory cardiogenic shock.</li></ol>

# TOXICOLOGY: METHEMOGLOBINEMIA

## Recommendations for Adults and Children With Life-Threatening Methemoglobinemia

COR	LOE	Recommendations
1	B-NR	<ol style="list-style-type: none"><li>1. For adults and children with life-threatening methemoglobinemia, methylene blue should be administered.</li></ol>
2b	C-EO	<ol style="list-style-type: none"><li>2. Exchange transfusion may be reasonable as a treatment for adults and children with life-threatening methemoglobinemia that is not responsive to methylene blue.</li></ol>
2b	C-EO	<ol style="list-style-type: none"><li>3. Hyperbaric oxygen therapy may be reasonable as a treatment for adults and children with life-threatening methemoglobinemia that is not responsive to methylene blue.</li></ol>
2b	C-EO	<ol style="list-style-type: none"><li>4. For adults and children with life-threatening methemoglobinemia, it may be reasonable to administer ascorbic acid only when methylene blue is contraindicated or not available.</li></ol>
3: No Benefit	B-R	<ol style="list-style-type: none"><li>5. N-acetylcysteine is not recommended as a treatment for adults with life-threatening methemoglobinemia.</li></ol>

## Act Now. Save a Life.

Follow these steps to take action.

Unresponsive  
No breathing, abnormal breathing (eg, gasping)

Activate emergency response.



Get AED.



Start CPR.



Press hard. Press fast  
in the center of the chest.

Apply AED pads. Follow AED prompts.  
Resume CPR for 2 minutes.



If suspected opioid overdose, give a dose of naloxone (if available).  
Resume CPR.

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### Recommendations for Adults and Children With Opioid Overdose Following Successful Response to Opioid Antagonists

COR	LOE	Recommendations
1	C-LD	<ol style="list-style-type: none"><li>Adults with opioid overdose who respond to opioid antagonists (eg, naloxone) should be observed in a health care setting until a low risk of recurrent respiratory depression, normal level of consciousness, and normal vital signs are achieved.</li></ol>
1	C-EO	<ol style="list-style-type: none"><li>Children with opioid overdose who respond to opioid antagonists (eg, naloxone) should be observed in a health care setting until a low risk of recurrent respiratory depression, normal level of consciousness, and normal vital signs are achieved.</li></ol>
2a	C-LD	<ol style="list-style-type: none"><li>Repeated doses of opioid antagonists (eg, naloxone) can be beneficial in adults with opioid overdose who respond to opioid antagonists and develop recurrent respiratory depression.</li></ol>
2a	C-EO	<ol style="list-style-type: none"><li>Repeated doses of opioid antagonists (eg, naloxone) can be beneficial in children with opioid overdose who respond to opioid antagonists and develop recurrent respiratory depression.</li></ol>

**Recommendations for Adults and Children With Life-Threatening Opioid Overdose**

COR	LOE	Recommendations
1	B-NR	1. For trained rescuers assisting an adult or child with suspected opioid overdose who has respiratory depression or respiratory arrest and has a definite pulse, breaths or bag-mask ventilation should be provided.
1	B-NR	2. For lay rescuers assisting an adult or child with suspected opioid overdose who is unresponsive and not breathing normally, CPR with breaths should be provided.
1	B-NR	3. For trained rescuers assisting an adult or child with suspected opioid overdose in respiratory arrest with a definite pulse, an opioid antagonist (eg, naloxone) should be administered.
1	C-EO	4. Lay and trained rescuers should not delay performing standard resuscitation or activating the emergency response system while administering an opioid antagonist (eg, naloxone) or awaiting the person's response to an opioid antagonist.
2b	B-NR	5. For lay and trained rescuers, opioid antagonist administration may be reasonable for adults in cardiac arrest with suspected opioid overdose, provided that opioid antagonist (eg, naloxone) administration does not interfere with the delivery of standard resuscitation including high-quality compression-ventilation CPR.
2b	C-EO	6. For lay and trained rescuers, opioid antagonist administration may be reasonable for children in cardiac arrest with suspected opioid overdose, provided that opioid antagonist (eg, naloxone) administration does not interfere with the delivery of standard resuscitation including high-quality compression-ventilation CPR.

**Recommendations for Opioid Antagonist Education and Distribution Following Treatment for Opioid Overdose**

COR	LOE	Recommendation
1	C-LD	1. Adults who are treated for opioid overdose should receive an opioid antagonist (eg, naloxone) and teaching at the time of discharge from a health care setting.
1	C-EO	2. Children who are treated for opioid overdose, or their caregivers as appropriate, should receive an opioid antagonist (eg, naloxone) and teaching at the time of discharge from a health care setting.

## TOXICOLOGY: ORGANOPHOSPHATES AND CARBAMATES

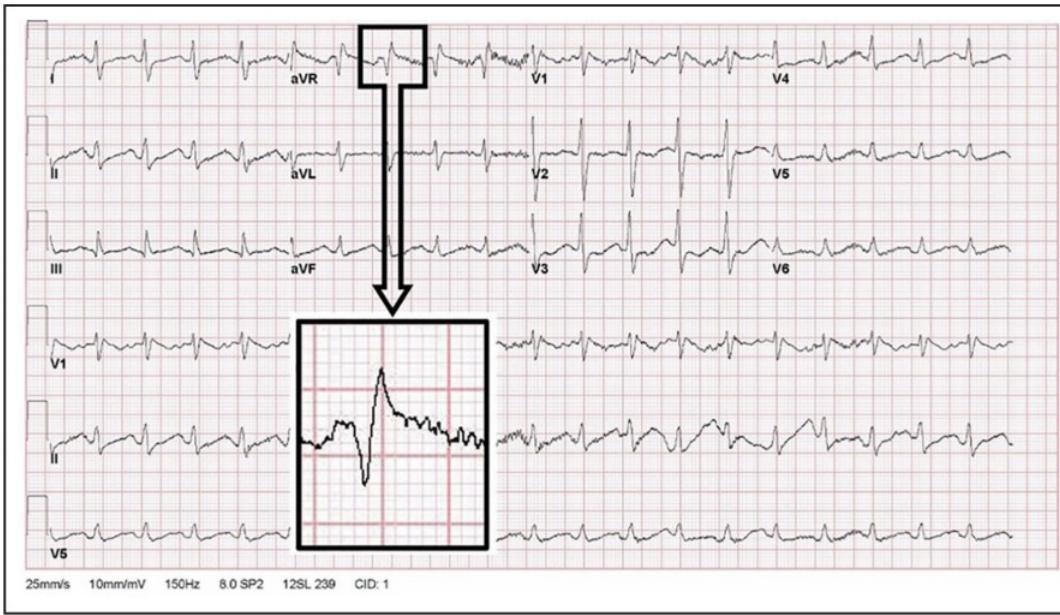
### Recommendations for Adults and Children With Life-Threatening Organophosphate or Carbamate Poisoning

COR	LOE	Recommendations
1	A	1. Atropine should be administered immediately for adults and children with life-threatening organophosphate or carbamate poisoning.
1	C-LD	2. Early endotracheal intubation is recommended for adults with life-threatening organophosphate or carbamate poisoning.
1	C-EO	3. Early endotracheal intubation is recommended for children with life-threatening organophosphate or carbamate poisoning.
1	C-EO	4. Benzodiazepines should be administered to treat seizures and agitation for adults and children with life-threatening organophosphate or carbamate poisoning.
1	C-EO	5. Use of appropriate PPE is recommended when caring for adults and children with life-threatening organophosphate or carbamate exposure.
1	C-EO	6. Dermal decontamination for external organophosphate or carbamate exposure is recommended for adults and children with life-threatening organophosphate or carbamate exposure.
2a	A	7. For adults with life-threatening organophosphate poisoning, the use of pralidoxime is reasonable.
2a	B-R	8. For children with life-threatening organophosphate poisoning, the use of pralidoxime is reasonable.
3: No Benefit	C-EO	9. Use of neuromuscular blockers metabolized by cholinesterase (eg, succinylcholine and mivacurium) is not recommended for adults and children with life-threatening organophosphate or carbamate poisoning.

# TOXICOLOGY: SODIUM CHANNEL BLOCKERS

## Recommendations for Adults and Children With Life-Threatening Sodium Channel Blocker Poisoning

COR	LOE	Recommendations
1	B-NR	1. Sodium bicarbonate should be used to treat adults with life-threatening cardiotoxicity from tricyclic and tetracyclic antidepressant poisoning.
2a	C-LD	2. It is reasonable to use sodium bicarbonate to treat children with life-threatening cardiotoxicity from tricyclic and tetracyclic antidepressant poisoning.
2a	C-LD	3. It is reasonable to use hyperventilation in combination with sodium bicarbonate for mechanically ventilated adults and children with life-threatening sodium channel blocker poisoning.
2a	C-EO	4. It is reasonable to use ECLS in adults and children with refractory cardiogenic shock from life-threatening sodium channel blocker poisoning.
2a	C-EO	5. It is reasonable to use sodium bicarbonate to treat adults and children with life-threatening cardiotoxicity caused by poisoning from sodium channel blockers other than tricyclic and tetracyclic antidepressants.
2b	C-EO	6. It may be reasonable to use Vaughan-Williams class Ib antiarrhythmics (eg, lidocaine) to treat adults and children with life-threatening cardiotoxicity from class Ia or Ic sodium channel blockers.
2b	C-EO	7. It may be reasonable to use ILE to treat adults and children with life-threatening sodium channel blocker poisoning refractory to other treatment modalities.



**Figure 9. Sodium channel blocker electrocardiogram.**

Reproduced with permission from Robert Hoffman, MD.

Recommendations for Adults With Life-Threatening Sympathomimetic Poisoning		
COR	LOE	Recommendations
1	B-NR	1. Sedation is recommended for adults with severe agitation from sympathomimetic poisoning.
1	C-LD	2. Rapid external cooling with ice water immersion is recommended for adults with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from sympathomimetic poisoning.
2a	C-EO	3. Vasodilators (eg, nitrates, phentolamine, CCBs) are reasonable for adults with coronary vasospasm from sympathomimetic poisoning.
2a	C-EO	4. It is reasonable to use ECLS in adults with cardiogenic shock from sympathomimetic poisoning refractory to other treatment measures.
2b	C-LD	5. The usefulness of dantrolene is uncertain for adults with life-threatening hyperthermia from MDMA toxicity.
3: Harm	C-LD	6. Prolonged use of physical restraint without sedation for adults is potentially harmful.

Recommendations for Children With Life-Threatening Sympathomimetic Poisoning		
COR	LOE	Recommendations
1	C-EO	1. Sedation is recommended for children with severe agitation from sympathomimetic poisoning.
1	C-EO	2. Rapid external cooling with ice water immersion is recommended for children with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from sympathomimetic poisoning.
2a	C-EO	3. Vasodilators (eg, nitrates, phentolamine, CCBs) are reasonable for children with coronary vasospasm from sympathomimetic poisoning.
2a	C-EO	4. It is reasonable to use ECLS in children with cardiogenic shock from sympathomimetic poisoning refractory to other treatment measures.
2b	C-EO	5. The usefulness of dantrolene is uncertain for children with life-threatening hyperthermia from MDMA toxicity.
3: Harm	C-EO	6. Prolonged use of physical restraint without sedation for children is potentially harmful.

## TOXICOLOGY: VOLATILES

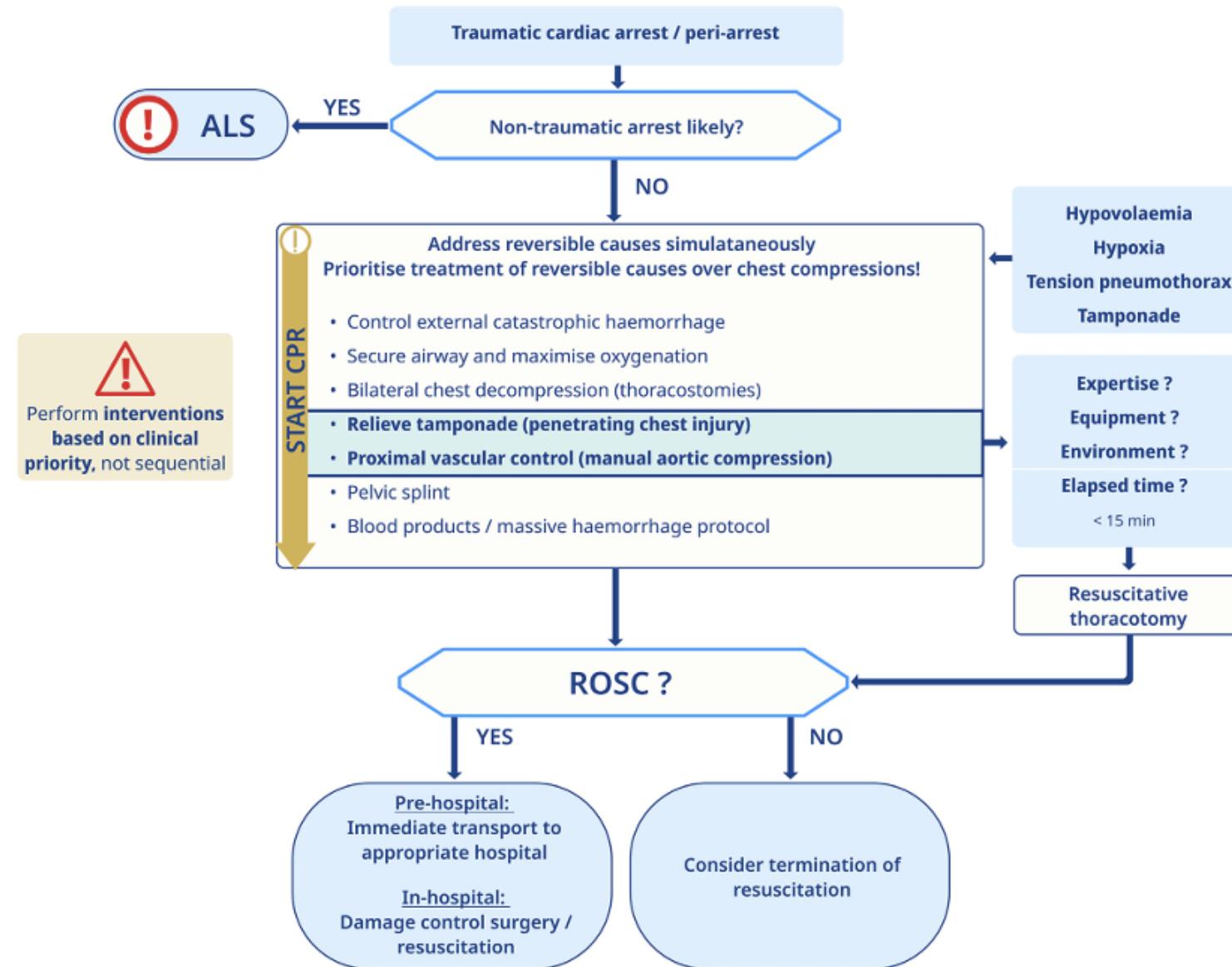
### Recommendation for Adults and Children With Life-Threatening Poisoning Following Volatile Hydrocarbon Exposure

COR	LOE	Recommendation
2b	C-EO	<ol style="list-style-type: none"><li>1. It may be reasonable to use <math>\beta</math>-adrenergic antagonists for adults and children with ventricular arrhythmias refractory to standard therapy.</li></ol>

## TOXICOLOGY: ECMO

Recommendations for the Use of VA-ECMO in Adults and Children With Life-Threatening Poisoning		
COR	LOE	Recommendations
<b>2a</b>	<b>B-NR</b>	1. It is reasonable to use VA-ECMO in adults and children with persistent cardiogenic shock or cardiac arrest due to poisoning that is refractory to pharmacological interventions.
<b>2a</b>	<b>C-EO</b>	2. It is reasonable to use VA-ECMO in adults and children with persistent arrhythmias due to poisoning when other treatments fail.
<b>2b</b>	<b>C-LD</b>	3. For adults and children with life-threatening poisoning, the effectiveness of VA-ECMO for poisoned patients with cardiovascular collapse from causes other than cardiogenic shock or arrhythmia has not been established.

# Trauma



**Table 8 – Major causes of traumatic cardiac arrest and their pathophysiology.**

Cause	Mechanism	Impact on Circulation
Hypovolaemic shock	Severe blood loss → inadequate preload & cardiac output	Decrease in right ventricular filling → hypotension, decrease in cardiac output → tissue hypoperfusion including coronary perfusion, → tissue hypoxia → metabolic acidosis, shock, ECG typically PEA, followed by asystole
Tension pneumothorax	Increased intrathoracic pressure → impaired venous return	
Cardiac tamponade	Pericardial blood accumulation → restricted ventricular filling	
Hypoxia/asphyxia	Airway compromise, lung injury, or Brain Impact Apnoea	Progressive hypoxaemia → bradycardia → PEA → asystole
Metabolic acidosis (contributing factor)	Ischaemia from prolonged hypoxia & hypoperfusion	Cardiac dysfunction, reduced contractility
Neurogenic shock (contributing factor)	Loss of sympathetic tone	Aggravates other shock states, worsening hypotension

## Special Causes

- Anaphylaxis
- Hypokalemia
- Hyperkalemia
- Hyperthermia
- Hypothermia
- Coronary Thrombosis
- Toxin
- Trauma

## Special Setting

- Catheterization laboratory
- Drowning
- Cardiac arrest in the operating room (OR)
- Cardiac arrest in Sports
- Emergency medical services (EMS) and transportation
- Inflight cardiac arrest and microgravity resuscitation

## Special Population

- Asthma and chronic obstructive pulmonary disease
- Cardiac arrest in hemodialysis patients
- Resuscitation in obese patients
- Resuscitation in patients with pectus excavatum
- Cardiac arrest in pregnancy