

CHAPTER 5

Cardiopulmonary Resuscitation (CPR)

Indications for CPR

HCPs should consider CPR of MWDs in cases of non-traumatic cardiopulmonary arrest (anesthesia-related, hypothermia, near drowning, electrocution). If the tactical situation and resources permit, HCPs may consider CPR in MWDs with CPA due to blast injury, blunt trauma, or penetrating trauma, although successful resuscitation in these cases is unlikely. Overall survival in dogs is approximately 5%.

Clinical Management Algorithm for CPR

In general, CPR is performed in much the same manner as for people.¹ Management guidelines for CPR in dogs are provided (See Figure 31 and [Table 10](#)).

Basic Life Support²⁻⁴

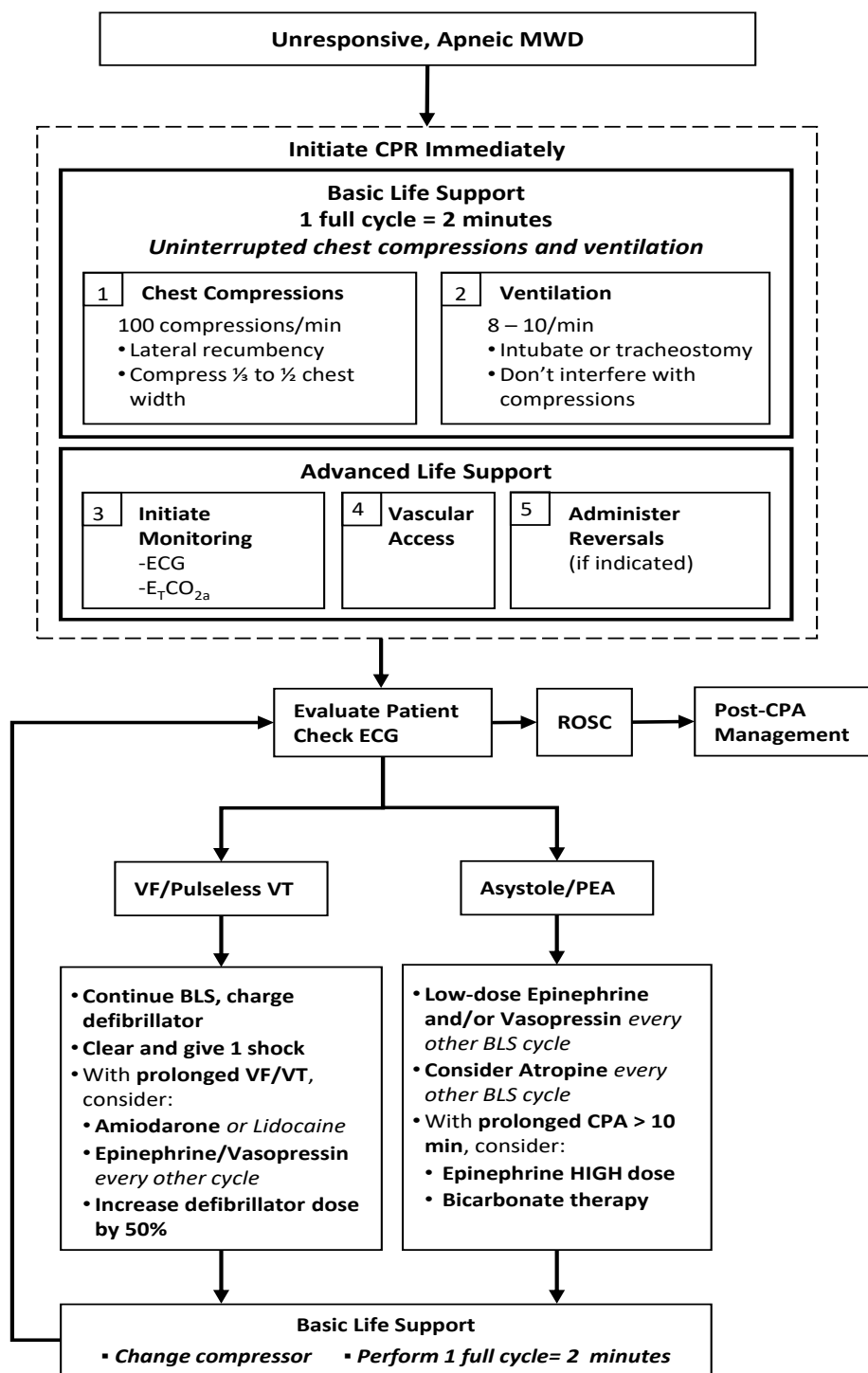
2-person, closed-chest CPR should be initiated as soon as CPA is declared.

- **Circulation** – Immediately begin sustained, forceful chest compressions with the MWD in lateral recumbency (on either side) at a rate of 100 compressions per minute. Sustain compressions for at least 2-3 minutes per cycle. Hand placement can be directly over the heart (where the elbow crosses the chest above the sternum when the forearm is pulled caudally) or over the widest part of the chest (See Figure 32). Ensure adequate relief of downward pressure during the relaxation phase of the compressions. As for people, “PUSH HARD and PUSH FAST.”¹
- **Airway** – Establish an airway as rapidly as possible and as soon as possible after identifying a patient in CPA. However, start chest compressions first! Intubate the MWD if possible; if intubation is not possible, perform an emergent tracheostomy without delay (See [Chapter 2](#)).
- **Breathing** – Ventilate the patient at a rate of 8-10 breaths per minute. Avoid hyperventilation. Give oxygen if available; room air is ac-

Figure 31. Positioning for Canine CPR.



Figure 31. CPR Algorithm for Military Working Dogs.²



Clinical algorithm for canine cardiopulmonary resuscitation. Adapted from Cole SG, Otto CM, Hughes D. Cardiopulmonary-cerebral resuscitation in small animals—a clinical practice review, Part II. J Vet Emerg Crit Care 2003;13:1323. Used with permission

Advanced Life Support⁵

Initiate ALS as soon as feasible, with ECG monitoring to guide management. Figure 31² and Table 10 direct specific actions based on the arrest rhythm present. In contrast to people, the most common arrest rhythm in MWDs is pulseless electrical activity (PEA; 24%), followed by asystole (23%), and then ventricular fibrillation (VF; 20%). Sinus bradycardia commonly precedes arrest in many situations in dogs.^{2,5}

- 70% of MWDs that arrest will have PEA, asystole, or sinus bradycardia as the initial arrest rhythm.^{2,5} Epinephrine or vasopressin are best choices for these rhythms or for empiric use if ECG capability is not available. In the deployed setting, there is no role for transthoracic pacing in MWDs with PEA or asystole.
- Bradycardia due to a pronounced vagal response is very common in dogs, and use of atropine may prevent development of cardiopulmonary arrest.
- VF, while present initially in only 20% of MWDs with an arrest rhythm, often develops during resuscitation.² Perform external defibrillation if possible and as rapidly as possible if VF is noted; biphasic defibrillation is ideal.^{5,7} Apply paddles to either side of the chest with the MWD in dorsal recumbency (on its back), or place a flat paddle under the MWD lying in lateral recumbency and a standard paddle on the upper chest wall. Defibrillate up to 3 times at each energy level if prior attempts are not successful, but perform aggressive chest compressions for at least 2 minutes before attempting each defibrillation.
- IV access is critical. Place multiple IV or IO catheters or perform venous cut-down (See [Chapter 6, Figure 33](#)). Follow all drugs with a 10 mL saline push. Do not give large volumes of fluids to MWDs during CPR, unless severe hypovolemia is thought present. Give fluids initially to facilitate drug delivery only.

Tips for Successful CPR in MWDs^{2,3}

- Avoid interrupting chest compressions! The key to successful resuscitation is to SUSTAIN chest compressions aggressively for 2-3 minutes before stopping to check status.
- Most people apply too little force when performing chest compressions! Do not be concerned with breaking ribs or injuring the heart or chest with BLS. In contrast to CPR in people, the thorax of MWDs is more compliant and fractures are rare.
- Maintain a steady and continuous rate of chest compression and ventilation. Minimize the number of times you stop to check the patient. Most people stop too frequently, which makes BLS less successful.
- During CPR, consider sodium bicarbonate (1-2 mEq/kg IV, repeated every 10 minutes) if metabolic acidosis (pH <7.0) is present, or empirically if CPR is prolonged >10 minutes.
- During CPR, consider magnesium sulfate (30 mg/kg IV, once) in patients with refractory VT.

Single Person CPR

Single-person CPR on dogs is extremely challenging, with very poor success rates, and should be initiated only if other personnel are immediately nearby and can be mobilized to assist in 1-2 minutes. If single-person CPR is performed, the responder should only perform chest compressions, as this optimizes circulation.

Post-Resuscitation Care⁶

Resuscitated MWDs will require intensive care to optimize long-term outcome. Many MWDs will arrest again, and most do so in the first 4 hours after resuscitation.^{2,3} Successful return of spontaneous circulation and resuscitation are unlikely if an MWD arrests again, and HCPs should balance resources against repeated attempts at resuscitation. Key management issues for MWDs in the post-resuscitation phase follow.

- Control seizures that develop with diazepam or midazolam (0.3 mg/kg; IV, IO, or intranasally), repeated every 15-30 minutes if necessary. If available, give phenobarbital (15 mg/kg IV or IO) loading dose, and 2.5 mg/kg IV every 12 hours thereafter if seizures persist or status epilepticus develops.
- Prevent and reduce cerebral edema. Use mannitol (1 gram/kg, IV, twice, 4-6 hrs apart), avoid hyperventilation, give a single dose of dexamethasone (0.5 mg/kg IV) or methylprednisolone sodium succinate (30 mg/kg, IV, once), avoid jugular vein compression, and maintain normoxemia and normotension.
- Maintain adequate ventilation, maintaining a patent airway and using manual IPPV at 8-10 breaths per minute, targeting an $E_T\text{CO}_2$ of 25-60 mmHg.
- Maintain adequate oxygenation, targeting a $\text{SpO}_2 > 95\%$ using supplemental oxygen for a minimum of 12 hours.
- Maintain normotension using IV fluids in bolus challenges, targeting a MAP > 65 mmHg or Sys > 90 mmHg. Isotonic crystalloids at 10-15 mL/kg over 15 minutes are usually effective.
- Use synthetic colloids if 2-3 bolus challenges do not achieve normotension. Give 2-3 bolus challenges of hydroxyethyl starch (HES) at 10 mL/kg over 15 minutes. Once normotension is achieved, give crystalloid IV fluids at 3-5 mL/kg/hour for maintenance. Given the dismal outcome in post-resuscitation MWDs that require vasopressor support, there is no role in the deployed setting for vasopressor therapy in MWDs in the post-resuscitation phase.
- Control pathologic ventricular arrhythmias with a lidocaine CRI (50-75 mcg/kg/min).
- Do not attempt tight control of blood glucose with insulin. Supplement IV fluids if hypoglycemia is present (5% dextrose), but avoid hyperglycemia.
- There is no role for therapeutic hypothermia in MWDs during the post-resuscitation period. Avoid hyperthermia; tolerate mild hypothermia ($>92^\circ\text{F}$) if it develops.

Discontinuation of CPR

CPR should be discontinued 1) if the animal is successfully resuscitated, 2) if the senior HCP directs that efforts cease, or 3) if effective CPR has been attempted for at least 20 minutes without success.

Resuscitative Thoracostomy and Open-Chest CPR

There is no role for open-chest CPR by HCPs in MWDs. Euthanasia is indicated for any MWD for which a resuscitative thoracostomy is deemed necessary to manage CPR (See [Chapter 21](#)).

TABLE 10. MWD CPR PROTOCOL.²⁻⁷

BASIC LIFE SUPPORT		
Focus	Actions	Comments
CIRCULATION	IMMEDIATE chest compressions FAST and HARD -- 100/min	SUSTAIN for 2 minute cycles!
AIRWAY	Clear airway > Intubate or Tracheostomy	Don't interfere with compressions!
BREATHING	Manually ventilate (100% oxygen) 8-10 breaths/min	Don't hyperventilate!
ADVANCED LIFE SUPPORT		
<ul style="list-style-type: none">■ ECG interpretation is essential■ Venous access is critical -- Place multiple peripheral lines and/or IO catheters -- Consider central line when able■ Follow all drugs with 10 mL saline push■ Do NOT give large volumes of fluids during CPR, unless the MWD is hypovolemic		
ASYSTOLE, PEA, SINUS BRADYCARDIA		
Drugs	Dose and Route	Comments
VASOPRESSIN <i>and</i> EPINEPHRINE	0.8 U/kg -- IV or IO — ONCE! 0.01 mg/kg -- IV or IO	70% of arrests have these initial arrhythmias. These drugs are best for empiric use if ECG is not available, or if indicated by ECG.
...and...		
ATROPINE	0.04 mg/kg -- IV or IO <i>only if bradycardia preceded arrest</i>	
VENTRICULAR FIBRILLATION or PULSELESS VENTRICULAR TACHYCARDIA		
ELECTRICAL DEFIBRILLATION	2 - 5 Joules/kg (biphasic) 4 – 6 J/kg (monophasic)	Only 20% of patients present initially with these arrhythmias. However, V Fib and pulseless V tach often develop during CPR.
	Immediately start compressions for 1 cycle after every defib attempt	
	Defibrillate TWICE more if needed at same energy level, BUT resume chest compressions for 1 cycle after each defib	
...DRUG THERAPY if DEFIBRILLATION UNSUCCESSFUL...		
EPINEPHRINE	0.01 mg/kg -- IV or IO	Give SODIUM BICARBONATE every 10 minutes during CPR if pH is <7.0 or CPR is prolonged more than 10 minutes. 1-2 mEq/L, IV
...or...		
VASOPRESSIN <i>and</i> LIDOCAINE	0.8 U/kg -- IV or IO -- ONCE! 2 mg/kg -- IV or IO	
...or...		Give MAGNESIUM SULFATE if patient has refractory VENTRICULAR TACHYCARDIA. 30 mg/kg, IV, once
AMIODARONE	5 - 10 mg/kg -- IV or IO	
DEFIBRILLATE at 50% INCREASED energy if REFRACTORY		

TABLE 10. MWD CPR PROTOCOL.²⁻⁷ (Continued)

POST RESUSCITATION MANAGEMENT		
<ul style="list-style-type: none"> ■ Maintain NORMOTENSION -- Target MAP of >65 mmHg or Systolic BP >90 mmHg ■ Maintain VENTILATION -- Target RR of 8 - 10 bpm -- Target E_TCO₂ of 25 - 60 mmHg; consider IPPV/MV if needed ■ Maintain OXYGENATION -- Target SpO₂ >95% with supplemental oxygen as needed 		
CONTROL SEIZURES		
MIDAZOLAM or DIAZEPAM		0.3 mg/kg -- IV, IO, or INTRANASAL <i>prn</i>
MANAGE CEREBRAL EDEMA		
MANNITOL	1 - 2 grams/kg -- IV over 30 min	<ul style="list-style-type: none"> ■ Avoid HYPERVENTILATION ■ Avoid JUGULAR VENOUS COMPRESSION ■ Avoid HYPERTHERMIA ■ Tolerate MILD HYPOTHERMIA
and		
DEXAMETHASONE	0.5 mg/kg -- IV -- ONCE	
...or...		
METHYLPREDNISOLONE	30 mg/kg -- IV -- ONCE	
CONTROL PATHOLOGIC VENTRICULAR ARRHYTHMIAS		
LIDOCAINE	CRI @ 50 - 75 mcg/kg/min	CORRECT H's and T's FIRST
CONTROL HYPOGLYCEMIA		
SUPPLEMENT IV fluids with 5% dextrose -- MONITOR blood glucose q4-6 -- AVOID intensive glucose titration		

CPR References

1. Neumar RW, Shuster M, Callaway CW, et al. 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Part 1: Executive summary. *Circulation* 2015;132:S315-367.
2. Fletcher DJ, Boller M, Brainard BM, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 7: Clinical guidelines. *J Vet Emerg Crit Care* 2012;22(S1):102-131.
3. Cole SG, Otto CM, Hughes D. Cardiopulmonary-cerebral resuscitation in small animals—a clinical practice review, Part II. *J Vet Emerg Crit Care* 2003;13:1323.
4. Hopper K, Epstein SE, Fletcher DJ, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 3: Basic life support. *J Vet Emerg Crit Care* 2012;22(S1):26-43.
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6. Smarick SD, Haskins SC, Boller M, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 6: Post-cardiac arrest care. *J Vet Emerg Crit Care* 2012;22(S1):85-101.
7. Lee SG, Moon HS, Hyun C. The efficacy and safety of external biphasic defibrillation in toy breed dogs. *J Vet Emerg Crit Care* 2008;18:362-369.