

JOINT TRAUMA SYSTEM K9 CLINICAL PRACTICE GUIDELINE



Cardiopulmonary Resuscitation (CPR) (K9 CPG: 05)

This CPG provides guidance on Basic and Advanced Life Support for military working dogs that have sustained cardiopulmonary arrest.

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TABLE OF CONTENTS

BACKGROUND	2
Indications for CPR	2
Causes of CPA and Goals for CPR	2
Diagnosis of Cardiopulmonary Arrest (CPA)	2
BASIC LIFE SUPPORT	4
Chest Compressions	4
Ventilation	4
ADVANCED LIFE SUPPORT	4
Initiate Monitoring	5
Capnometry	5
Electrocardiogram	5
Obtain Vascular Access	5
Administer Drug Reversals	5
Evaluate Electrocardiogram (ECG)	5
RESUSCITATIVE THORACOSTOMY & OPEN CHEST CPR	6
POST RESUSCITATION CARE	6
Post Arrest Monitoring	7
Respiratory Optimization	7
Hemodynamic Optimization	7
Neuroprotection	7
DISCONTINUATION OF CPR	8
PERFORMANCE IMPROVEMENT (PI) MONITORING	10
REFERENCES	10
APPENDIX A: CLASS VIII MEDICAL MATERIEL	12

SUMMARY OF CHANGES

1. Added causes of cardiopulmonary arrest (CPA), expected recovery outcomes for military working dogs (MWDs) with CPA, and diagnosis guidelines for CPA.
2. Updated cardiopulmonary resuscitation (CPR) cycle length and ventilation rate.
3. Expanded Advanced Life Support (ALS) monitoring guidelines.
4. Added ALS drug reversal doses.
5. Added medications which can supplement ALS for specific clinical indications.
6. Expanded defibrillation guidelines.
7. Amended guidelines for resuscitative thoracostomy and open-chest CPR.
8. Updated seizure control medications.
9. Updated medical management of cerebral edema.
10. Updated post-resuscitation monitoring parameters for blood pressure, end-tidal carbon dioxide (ETCO₂) and oxygen saturation (SpO₂).
11. Added medication doses for post-resuscitation hemodynamic optimization.
12. Added Class VIII Medical Materiel list.

BACKGROUND

INDICATIONS FOR CARDIOPULMONARY RESUSCITATION

Cardiopulmonary resuscitation (CPR) is indicated during cardiopulmonary arrest (CPA) when the tactical situation and available resources allow. CPR is the most appropriate therapeutic intervention for CPA, though other interventions and additional resources may be required for patient and personnel safety depending on the cause.

CAUSES OF CPA & GOALS FOR CPR

CPA is the abrupt cessation of spontaneous and effective ventilation and circulation. Causes of CPA include natural death as well as unexpected death due to illness, injury or iatrogenic factors.

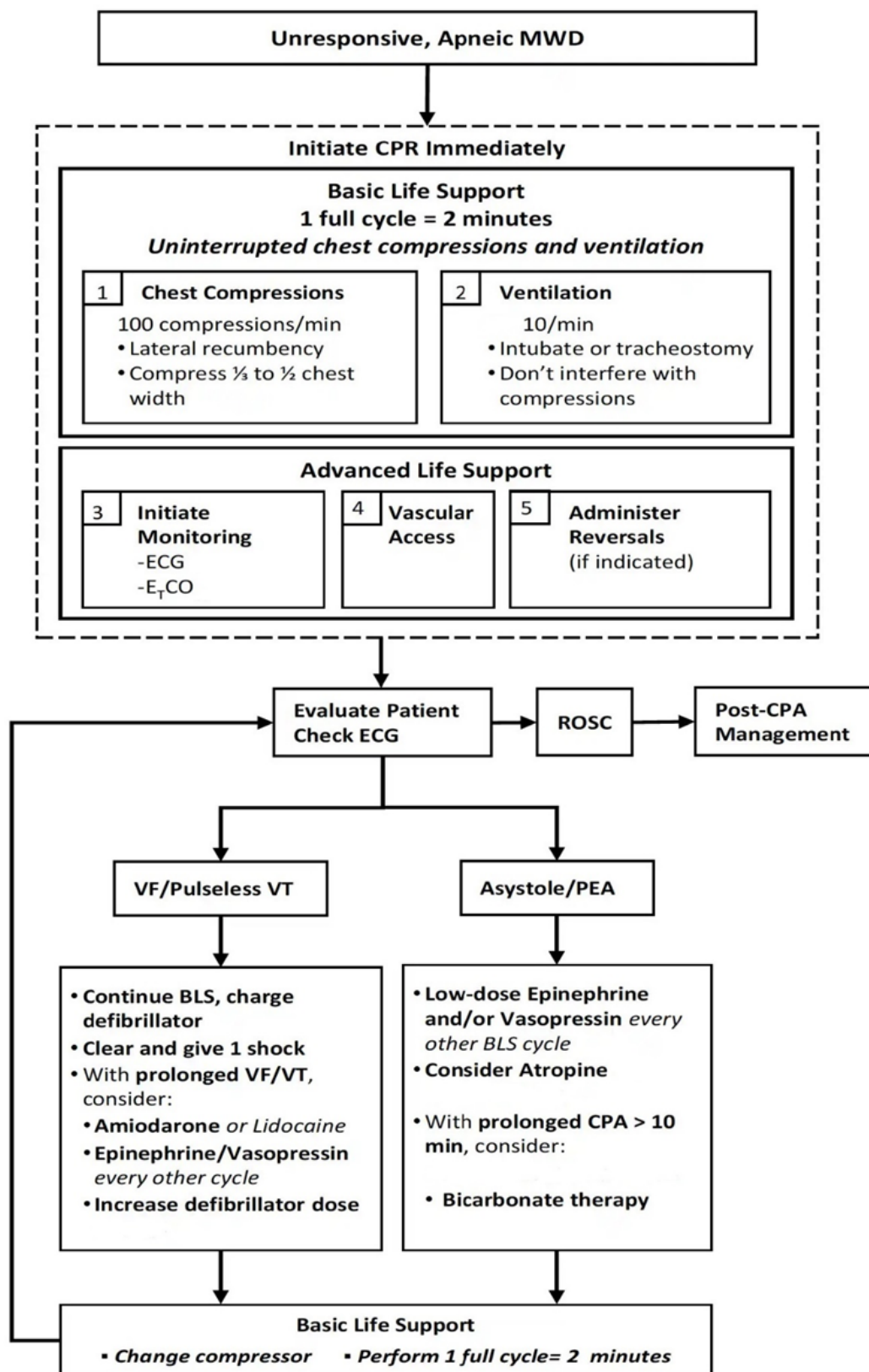
The goal of CPR is to preserve myocardial and cerebral perfusion while attempting to reestablish spontaneous circulation. CPR should follow a strict algorithm ([Figure 1](#)) to reduce variability and optimize successful outcomes.

Return to spontaneous circulation (ROSC) rates range from 35-58%.¹ Survival to hospital discharge ranges from 5-7% in dogs (all causes of CPA), but dogs with no underlying disease factors are more likely to survive.^{2,3}

DIAGNOSIS OF CPA

Declare CPA in any unresponsive and apneic MWD that is not under general anesthesia or deep sedation. Agonal breathing may ensue. Precordial and femoral pulses are absent.

During general anesthesia, when responsiveness cannot be assessed, use a non-perfusing (arrest) ECG rhythm to confirm diagnosis. Arrest rhythms include asystole, pulseless electrical activity (PEA), ventricular fibrillation, and pulseless ventricular tachycardia.

Figure 1. CPR Algorithm for Military Working Dogs.⁴

BASIC LIFE SUPPORT

Immediately begin Basic Life Support (BLS) during CPA.

One cycle of BLS is 2 minutes of sustained compression and ventilation (simultaneously if two rescuers are present). If only one rescuer, a compression to ventilation ratio of 30:2 is recommended.

CHEST COMPRESSIONS

Body position: lateral recumbency on either side (Figure 1 above) with rescuer adjacent to the MWD's back.

Hand position: at the widest point of the chest (thoracic pump theory).

Only in very lean and narrow chested MWDs can the hands be positioned directly over the heart at the point of the flexed elbow on the body wall (cardiac pump theory).

Rate: 100 – 120 compressions per minute.

Depth: 1/3 to 1/2 the width of the chest. **ALWAYS** allow for complete elastic recoil of the chest wall.

Figure 2. MWD body position for CPR



VENTILATION

Mouth-to-snout resuscitation may be attempted if there is only a single rescuer (rate of 30 compressions to 2 breaths). In MWDs that may pose risk to the rescuer (e.g., potential zoonotic disease, illicit drug or HAZMAT exposure), perform chest compression-only CPR.

Intubate (with a cuffed endotracheal tube) as soon as possible after initiating chest compressions. DO NOT STOP chest compressions to achieve intubation (intubate in lateral recumbency). Inflate the cuff and secure the tube.

Perform a tracheostomy or cricothyrotomy (see [Emergency Airway Management K9 CPG](#)) if airway cannot be obtained (while continuing chest compressions).

Supply 100% oxygen during CPR when possible.

Rate: 10 breaths per minute. Each breath should be 1 second long, with full release after each breath.

Tidal volume: 10 mL/kg is recommended and can be achieved using a 1 second inspiratory time with a bag valve mask (BVM) / AMBU bag.

ADVANCED LIFE SUPPORT

Once BLS is underway, begin Advanced Life Support (ALS) if resources allow.

Most dogs will have PEA or asystole as the initial arrest rhythm. Administer ALS drug therapy if ECG capability is not available to dictate whether to use drugs or defibrillation.

Bradycardia due to a pronounced vagal response is common in dogs, and the immediate use of vagolytic therapy (atropine) may prevent impending CPA.^{5,6}

INITIATE MONITORING

Capnometry

End tidal CO₂ (ETCO₂) is important to monitor during CPR. It indicates efficacy of compressions (higher ETCO₂ values associated with increased perfusion, > 12 mmHg can indicate proper endotracheal tube placement, and 18 mmHg is the minimum end-target during CPR).⁷

An acute rise in ETCO₂ can signal ROSC. An ETCO₂ cutoff of 18 mmHg is optimal to predict future ROSC.⁸

Electrocardiogram

Evaluate after each 2-minute cycle of BLS to identify if ROSC has occurred.

Can identify if a shockable rhythm for defibrillation has developed or see if a non-shockable rhythm has developed to prevent unnecessary defibrillation.

OBTAIN VASCULAR ACCESS

Intravenous (IV) or intraosseous (IO) catheters may be used during CPR, but IV drug administration is preferred. (See [K9 Normal Clinical Parameters CPG](#) for venous access anatomy).

ADMINISTER DRUG REVERSALS

- Naloxone (for opioid reversal) – 0.01 – 0.04 mg/kg IV/IO, intramuscular (IM), subcutaneous (SC) or intranasal (IN).
 - Repeat every 1-2 minutes if required, to effect.
 - If IM, IN or SC, effects may be delayed up to 5 minutes.
- Flumazenil (for benzodiazepine reversal) – 0.01 – 0.02 mg/kg IV/IO, repeat every hour if needed.
- Atipamezole (for alpha-2 adrenoreceptor agonist reversal) – inject the same volume IV or IO as was used for dexmedetomidine or medetomidine.

EVALUTE ELECTROCARDIOGRAM (ECG)

Perform quickly, with no more than 10 seconds of interruption in chest compressions. Continue BLS and re-evaluate ECG after each 2-minute cycle.

Intervene according to rhythm with either ALS drugs (every other cycle) or defibrillation and repeat until ROSC is achieved or CPR efforts are halted.

- **ROSC** – do not resume compressions, enter post-resuscitation care.
- **Asystole or PEA** – administer vasopressor NOW and every 3 to 5 minutes (roughly every other cycle of CPR). If IV/IO access is not available, can give intratracheal at 5-10 times the dose, diluted with sterile saline and administered through a catheter longer than the endotracheal tube.
 - Vasopressor
 - Low dose epinephrine – 0.01 mg/kg IV or IO.
 - High dose epinephrine is not recommended.⁹
 - Vasopressin – 0.8 U/kg in place of epinephrine, but improved survival has not been noted.
 - Atropine – consider a single dose at 0.04 mg/kg IV, particularly if arrest was vagally-mediated.
 - Lidocaine – 2 mg/kg IV can be administered if refractory pulseless ventricular tachycardia or ventricular fibrillation is present after the initial shock has been unsuccessful. If lidocaine is unavailable, amiodarone can be administered (5 mg/kg IV).

- Apart from the medications listed above, no other routine medications are recommended during CPR.
 - Corticosteroids are not recommended.
 - Fluids are not recommended unless hypovolemia is causing the CPA.
 - Alkalinization therapy (sodium bicarbonate 1 mEq/kg IV) may be considered in prolonged CPA (> 10 – 15 minutes). This may cause increased ETCO₂ that is not related to ROSC.
 - Magnesium infusion can be considered for treatment of torsades de pointes ([Table 1](#)).
 - Amiodarone infusion can be considered in ventricular tachycardia (VT) or ventricular fibrillation (VF) that is refractory to defibrillation and is preferred over lidocaine for this indication ([Table 1](#)).
- **Ventricular fibrillation or pulseless ventricular tachycardia** – administer external defibrillation. Continue BLS while preparing for defibrillation. If CPA occurred > 4 minutes prior to rhythm diagnosis, finish the 2-minute cycle of BLS. If CPA occurred < 4 minutes, administer the shock as soon as the defibrillator is charged.
 - A biphasic defibrillator should be used to deliver shock at a dose of 2 J/kg (first attempt) and 4 J/kg (second and subsequent attempts).⁹
 - Avoid using alcohol during defibrillation to reduce risk of fire.
 - Place patient in dorsal recumbency with forelimbs secured overhead and out of contact.
 - Apply conductance paste or conductive electrode gel liberally to both paddles.
 - Place paddles on opposite sides of the thorax at costochondral junction and directly over the heart (4th – 6th rib space) and squeeze together to ensure firm pressure.
 - Charge paddles, then CLEAR all personnel; visually confirm no one is contacting the patient or the table, then discharge defibrillator.
 - Resume full 2-minute cycle of BLS before re-evaluating ECG.

RESUSCITATIVE THORACOSTOMY & OPEN CHEST CPR

Open chest CPR is NOT indicated in MWDs in an operational environment UNLESS CPA occurs during a thoracic or abdominal surgical procedure when the MWD is under general anesthesia. Cardiac massage can then be performed directly (if during a thoracic procedure) or through a trans-diaphragmatic approach (during an abdominal procedure).

This procedure should ONLY be attempted in these circumstances if the provider skill level and medical resources are sufficient. The MWD will require intensive critical care support post-operatively.

POST RESUSCITATION CARE

Post CPA care and monitoring is extremely important to increase chances of sustained ROSC and survival. Coordinate medical evacuation to a higher echelon of care.

Multiorgan failure, cardiogenic shock, anoxic brain injury and underlying causes of death may all contribute to subsequent arrest in the post-resuscitation period, typically within 24 hours.

Prophylactic anticonvulsant therapy may be considered in the post-arrest period but convincing evidence of benefit in human or veterinary medicine is lacking.

POST ARREST MONITORING

Following ROSC, ECG, blood pressure and pulse oximetry (SpO₂) monitoring should continue. ETCO₂ should be monitored until extubation.

Laboratory assessments, if available, should include acid-base, lactate, blood glucose and electrolyte monitoring every 4-6 hours, a complete blood count (CBC) and biochemistry panel every 12-24 hours, and baseline coagulation monitoring.

RESPIRATORY OPTIMIZATION

If not spontaneously breathing, continue positive pressure ventilation (with oxygen) until oxygenation (SpO₂) reaches 94 – 98% and ETCO₂ equals 32 – 43 mmHg.⁵ Avoid hyperoxemia or hypercapnia.

If spontaneously breathing, but normocapnia or normoxemia cannot be maintained, consider re-intubation and mechanical ventilation.

HEMODYNAMIC OPTIMIZATION

The following end points should be used as guidelines for post-arrest care:^{5,10}

- Systolic blood pressure: 100 – 200 mmHg
- Mean arterial pressure: 80 – 120 mmHg
- Central venous O₂ saturation ≥ 70%
- Lactate < 2.5 mmol/L
- Packed cell volume (PCV) > 25%

If goals are not achieved and the patient is hypovolemic, administer incremental isotonic fluid boluses (20 mL/kg isotonic crystalloid). Administer blood products if hemorrhage or pre-existing anemia contributed to CPA.

If goals are not achieved and hypovolemia is NOT present, vasodilation may be the cause and vasopressors may be required, which require critical care capability. Options include:

- Norepinephrine 0.05 – 2 mcg/kg/min IV
- Dopamine 2 – 10 mcg/kg/min IV
- Epinephrine 0.05 – 1 mcg/kg/min IV
- Routine use of corticosteroids is not recommended as part of post-arrest care.

If neither hypovolemia nor vasodilatory shock is likely, focused cardiac ultrasound should be used (if feasible or available) to determine if reduced systolic function is the cause of hemodynamic instability. If so, a positive inotrope should be administered.

- Dobutamine 5 – 20 mcg/kg min IV (start with low dose and titrate upward).

Control pathologic ventricular arrhythmias with lidocaine (2 mg/kg IV bolus to break or slow the rhythm, up to 8 mg/kg) followed by a constant rate infusion (50-75 mcg/kg/min).

NEUROPROTECTION

Control seizures that develop with diazepam (0.5 mg/kg, IV, IO or IN) or midazolam (0.3 mg/kg, IV, IO or IN), repeated every 15-30 minutes if necessary. If available, give levetiracetam 60 mg/kg IV and 20 mg/kg every 8 hours thereafter, or phenobarbital (4 mg/kg IV every 1-4 hours to load, up to 16 mg/kg) and 2.5 mg/kg IV every 12 hours thereafter.

If an MWD is showing signs of cerebral edema (abnormal mentation, cranial nerve deficits, or abnormal posture), administer mannitol (0.5 gram/kg, IV, over 15-20 minutes) or 7.5% hypertonic saline 2-4 mL/kg IV. Avoid hypoventilation, avoid jugular vein compression and maintain normoxemia and normotension.

Do not attempt tight control of blood glucose with insulin. Supplement IV fluids if hypoglycemia is present (2.5 - 5% dextrose CRI, with close monitoring to maintain glucose between 60 – 150 mg/dL) but avoid hyperglycemia.

While targeted temperature management, formerly known as therapeutic hypothermia, can improve neurologic outcomes and survival in dogs, this is not practical in the deployed setting due to the need for mechanical ventilation and advanced critical care. Tolerate mild hypothermia (> 92°F) if it develops and avoid rapid rewarming. Slow rewarming at a rate of < 1.8°F per hour is recommended.

DISCONTINUATION OF CPR

CPR should be discontinued if:

1. ROSC is achieved.
2. If the provider or team lead directs that efforts cease.
3. If effective CPR has been attempted for at least 20 minutes without success.

Table 1. MWD CPR Protocol

BASIC LIFE SUPPORT		
Focus	Actions	Comments
CIRCULATION	<u>IMMEDIATE</u> chest compressions: <ul style="list-style-type: none">- 100 per minute- Compress chest by 1/3 – 1/2	SUSTAIN for 2-minute cycles.
AIRWAY	Clear airway → intubate or perform tracheostomy/cricothyrotomy	Don't interfere with compressions!
BREATHING	Manually ventilate (100% oxygen) <ul style="list-style-type: none">- 10 breaths per minute	Don't over-ventilate.
ADVANCED LIFE SUPPORT		
<div>1. ECG interpretation is essential.</div> <div>2. Venous access is critical → place multiple peripheral lines and/or IO catheters.</div> <div>3. Follow all drugs with 10 mL saline flush.</div> <div>4. Do NOT give large volumes of fluids during CPR, unless the MWD is hypovolemic.</div>		
ASYSTOLE, PEA		
Drugs	Dose and Route	Comments
Epinephrine or Vasopressin	0.01 mg/kg – IV or IO 0.8 U/kg – IV or IO	Use drugs over defibrillation if ECG is not available, or if indicated by ECG (asystole, PEA).
Atropine (consider a single dose)	0.04 mg/kg – IV or IO	
VENTRICULAR FIBRILLATION or PULSELESS VENTRICULAR TACHYCARDIA		
Electrical Defibrillation	2-4 Joules/kg (biphasic)	If conversion to PEA or asystole occurs, switch to drug algorithm above (ASYSTOLE, PEA).
	Immediately start compressions for 1 cycle (2 minutes) following every defibrillation attempt.	
	For second and subsequent defibrillation attempts, dose should be 4 Joules/kg	

OPTIONS IF DEFIBRILLATION IS UNSUCCESSFUL:		
Amiodarone	2 – 5 mg/kg IV or IO	Nexterone® IV formulation is preferred to avoid type II hypersensitivity reactions. Avoid formulations containing polysorbate-80.
Lidocaine	2 mg/kg – IV or IO	
Magnesium sulfate (if patient has torsades de pointes)	0.3 mEq/kg, IV, once	
Epinephrine and/or Vasopressin	0.01 mg/kg – IV or IO 0.8 U/kg – IV or IO	Given every other 2-minute cycle.
POST-RESUSCITATION MANAGEMENT		
Respiratory Optimization: <ul style="list-style-type: none"> - Target ETCO₂ (or if extubated, central venous partial pressure of CO₂) of 32 – 43 mmHg. - Target normoxemia SpO₂ of 94-98% with supplemental oxygen, as needed. - Consider manual ventilation if goals not achieved. 		
Hemodynamic Optimization: <ul style="list-style-type: none"> - Target DBP ≥ 30 mmHg. - Intervene with vasopressors or inotropes if hypotensive. 		
CONTROL SEIZURES		
Midazolam or Diazepam	0.3 mg/kg – IV, IO or IN PRN 0.5 mg/kg – IV, IO or IN PRN	
Levetiracetam or Phenobarbital	60 mg/kg IV followed by 20 mg/kg every 8 hours 4 mg/kg every 1-4 hours (up to 16 mg/kg), then 2.5 mg/kg every 12 hours	
IF EVIDENCE OF CEREBRAL EDEMA		
Mannitol or Hypertonic Saline	0.5 – 1 gram/kg – IV over 30 minutes 30 mL/kg, IV, once	<ul style="list-style-type: none"> - Avoid hypoventilation - Avoid jugular venous compression - Avoid rapid rewarming - Tolerate mild hypothermia
CONTROL PATHOLOGIC VENTRICULAR ARRHYTHMIAS		
Lidocaine	Bolus 2 mg/kg IV (up to 4 times), then CRI at 50 – 75 mcg/kg/min	Look for underlying electrolyte imbalances.
CONTROL HYPOGLYCEMIA		
Supplement IV fluids with 2.5 - 5% dextrose. Monitor blood glucose every 4 to 6 hours. Avoid intensive glucose titration.		

PERFORMANCE IMPROVEMENT (PI) MONITORING

POPULATION OF INTEREST

All MWDs with documented CPA.

INTENT (EXPECTED OUTCOMES)

- Return of spontaneous circulation.
- No evidence of organ injury (sustained CNS abnormalities, kidney or other organ compromise).
- Proper documentation of CPR in MWD's medical record.

PERFORMANCE / ADHERENCE MEASURES

- Number and percentage of patients in the population of interest (deployed MWDs) that sustained CPA.
- Number and percentage of patients in the population of interest (deployed MWDs) that regained spontaneous circulation at least once during CPR.
- Number and percentage of MWDs that survived the CPA event.

DATA SOURCE

- Patient Record
- Department of Defense MWD Trauma Registry

SYSTEM REPORTING & FREQUENCY

The above constitutes the minimum criteria for PI monitoring of this K9 CPG. System reporting will be performed annually; additional PI monitoring and system reporting may be performed as needed.

The system review and data analysis will be performed by direction of the Committee on K9 Combat Casualty Care Chair.

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APPENDIX A: CLASS VIII MEDICAL MATERIEL

Here's a detailed list of medical equipment and supplies specifically required for cardiopulmonary resuscitation (CPR) based on the Joint Trauma System's K9 Tactical Combat Casualty Care (K9TCCC) guidelines:

1. Airway & Ventilation

- Muzzle – prevent biting during resuscitation
- Bag-Valve-Mask (BVM) –for positive-pressure ventilation
- Endotracheal tube (ETT) +/- laryngoscope – sizes tailored for canines
- +/- tracheostomy or cricothyrotomy kit (if airway cannot be obtained with ETT)

2. Circulation Support

- Intravenous (IV) or intraosseous (IO) catheter setup – including fluids
- IV fluids – crystalloids for volume resuscitation
- Whole blood - if hemorrhage contributed to CPA

3. Monitoring & Adjuncts

- Pulse oximeter (SpO₂)
- Capnography/ETCO₂ monitoring – ideally battery powered
- Electrocardiogram
- Sphygmomanometer or Doppler with appropriate cuff size for canines
- CBC and chemistry portable analyzers (e.g., i-STAT)

4. Drugs for Advanced Life Support

- Drug Reversals
 - Naloxone
 - Flumazenil
 - Atipamezole
- Epinephrine – for cardiac arrest scenarios
- Atropine – for bradyarrhythmias during CPR
- Lidocaine – refractory pulseless ventricular tachycardia or ventricular fibrillation
- Calcium – supplementation if blood products administered
- Other ACLS medications:
 - Magnesium sulfate
 - Amiodarone
- Other post-resuscitation care medications:
 - Vasopressors – norepinephrine, dopamine
 - Seizure control – diazepam or midazolam, levetiracetam or phenobarbital
 - Mannitol or hypertonic saline

5. Defibrillation

- Defibrillator pads/paddles – adult size
- Conductance paste or conductive electrode gel

6. Supportive & Miscellaneous Supplies

- Gloves
- Clippers and scrub (chlorhexidine or betadine) – for IV/IO procedures
- Syringes/flushes – for drug delivery and line flushing
- Tape and securement materials – for ETT, IV catheters

For additional information including National Stock Number (NSN), refer to [Logistics Plans & Readiness \(sharepoint-mil.us\)](https://sharepoint-mil.us/LogisticsPlans&Readiness).

DISCLAIMER: This is not an exhaustive list. These are items identified to be important for the care of combat casualties.