RECOVER Recommendations: Clinical Guidelines for Veterinary CPR
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Introduction: Since 1992, the International Liaison Committee on Resuscitation (ILCOR) has developed evidence-based guidelines for human cardiopulmonary resuscitation (CPR) based on extensive reviews of the literature. These guidelines are updated every 5 years, published in Circulation, and provide a foundation for training of healthcare professionals and laypersons. Fortunately, standardized evidence-based CPR guidelines for veterinary patients became available recently, when the first published veterinary-specific guidelines for CPR were published in the Journal of Veterinary Emergency and Critical Care.

Key Points:
- Early delivery of high quality chest compressions with minimal interruption is extremely important
- Chest compressions should be delivered in uninterrupted cycles of 2 minutes with most patients in lateral recumbency at a compression rate of 100-120/min, compression depth of 1/3 – 1/2 of the width of the chest, and allowing for full elastic recoil of the chest between compressions
- Early intubation and ventilation is highly valuable with a ventilation rate of 10 breaths/min, tidal volume of 10 mL/kg, and inspiratory time of 1 second delivered simultaneously with compressions
- Mouth-to-snout ventilation is an acceptable alternative if intubation supplies are not available and should be delivered in repeated rounds of 30 chest compressions followed by 2 rapid breaths in cycles of 2 minutes
- After each 2 minute cycle of basic life support (BLS), the compressor should be rotated to prevent fatigue, which could decrease the quality of chest compressions
- Algorithms related to CPR, emergency drugs and doses, and post-cardiac arrest care are available to guide rescuers during CPR
- Post-cardiac care is focused on respiratory optimization to maintain normoxemia and normocapnia, hemodynamic optimization to achieve normotension or mild hypertension, neuroprotective interventions based on the neurologic status of the patient, and intensive monitoring

Reassessment Campaign on Veterinary Resuscitation (RECOVER)
The primary goal of the RECOVER initiative was to develop consensus guidelines for CPR in dogs and cats, based on a systematic review of the literature focusing on studies that include veterinary species. An advisory committee, which was overseen by the RECOVER chairs with the assistance of administrative support, was composed of a liaison from ILCOR, JVECC, EVECCS, AVECCT, animal rescue, and private practice, as well as experts from ACVECC, ACVA, and industry. Representatives of ACVECC and VECCS leadership were also included.
Specific clinically relevant questions were posed and worksheets were designed for groups to collect evidence from the literature to answer the specific question(s). Worksheet domains included five topics: 1) Preparedness and prevention, 2) Basic life
support, 3) Advanced life support, 4) Monitoring, and 5) Post-cardiac arrest care. Once questions were composed, worksheet authors were solicited, and a literature search strategy was planned. Following completion of all worksheets, proposed guidelines and worksheets were posted to the internet (http://acvecc-recover.org/) and some of the proposed guidelines were also presented at the International Veterinary Emergency and Critical Care Society meeting in September 2011. After a 4-week period for review of the guidelines, feedback was collected and used to modify the guidelines. Ultimately, 101 clinical guidelines were published in June of 2012.

Because of the variability in the quality and evidence supporting each guideline, “Class” and “Level” descriptors were adapted from ILCOR and added. “Class” categorizes the risk-benefit ratio of the intervention described (Table 1) and “Level” categorizes the strength of the evidence available to support the recommendation (Table 2).

**Table 1:** Class descriptors for the clinical RECOVER guidelines

<table>
<thead>
<tr>
<th>Class</th>
<th>Risk:benefit ratio</th>
<th>Clinical recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Benefit &gt;&gt;&gt; Risk</td>
<td>Should be performed</td>
</tr>
<tr>
<td>IIa</td>
<td>Benefit &gt;&gt; Risk</td>
<td>Reasonable to perform</td>
</tr>
<tr>
<td>IIb</td>
<td>Benefit ≥ Risk</td>
<td>May be considered</td>
</tr>
<tr>
<td>III</td>
<td>Risk &gt; Benefit</td>
<td>Should not be performed</td>
</tr>
</tbody>
</table>

**Table 2:** Level descriptors for the clinical RECOVER guidelines

<table>
<thead>
<tr>
<th>Level</th>
<th>Populations Studied</th>
<th>Criteria for Recommendation</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Multiple populations</td>
<td>Multiple high quality and/or high level of evidence studies</td>
</tr>
<tr>
<td>B</td>
<td>Limited populations</td>
<td>Few to no high quality and/or high level of evidence studies</td>
</tr>
<tr>
<td>C</td>
<td>Very limited populations</td>
<td>Consensus opinion, expert opinion, guideline based on physiologic/anatomic principles, standard of care</td>
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**RECOVER Recommendations**

**Preparedness and Prevention:** The location, storage, and content of resuscitation equipment should be standardized and regularly audited (I-A). Availability and clear visibility of cognitive aids such as checklists, algorithm charts, and dosing charts (separated into categories based on indication and provided in volume of drug administered according to body weight) in areas in which CPR might take place, such as procedure areas, anesthesia induction rooms, surgery suites, and intensive care units is recommended (I-B).

**CPR Training:** CPR training should include both didactic components targeted at cognitive performance and opportunities to practice hands-on skills with quality feedback (I-A). Refresher training at least every 6 months is recommended to reduce the risk of decay of skills (I-A). Structured assessment after CPR training is recommended (I-A) and structured debriefing after a real resuscitation effort or simulated CPR is also recommended to allow
participants to review and critique their performance and the performance of the team (I-A).

**Team Dynamics**: Veterinarians or technicians can be considered leaders of a CPR team (IIb-B), but specific leadership training is recommended for individuals who might need to lead a CPR attempt (I-A). Clear, directed orders given to one team member by another, after which the receiving team member repeats the order back to the requestor to verify the accuracy of the receiver's perception, are helpful.

**Basic Life Support (BLS)** includes the recognition of cardiopulmonary arrest (CPA), administration of chest compressions, airway management, and provision of ventilation. It must be provided immediately upon diagnosis or suspicion of CPA, specifically in patients that are apneic and unresponsive.

**Delay in starting CPR**: Aggressive administration of CPR in patients suspected of being in CPA is recommended, as the risk of injury due to CPR in patients not in CPA is low (I-B). No more than 5-10 seconds should be used to assess patients that are apneic and unresponsive, before starting CPR. The use of pulse palpation (III-B), Doppler (III-C), ECG (III-B), or end-tidal CO₂ (EtCO₂) (III-B) to support a diagnosis of CPA before initiating CPR in an apneic and unresponsive patient is not recommended.

**Chest compressions** should be initiated as soon as possible upon recognition of CPA and if multiple rescuers are present, airway and ventilation management should not delay commencement of chest compressions. Chest compressions should be done in either left or right lateral recumbency in both dogs and cats (I-B). In most large and giant breed dogs, chest compressions should be delivered with hands placed over the widest portion of the chest (IIa-C) in support of the “thoracic pump theory”. In keel- (narrow, deep) chested dogs (e.g., Greyhounds), chest compressions should be performed with the hands positioned directly over the heart (IIb-C) in support of the “cardiac pump theory”. In dogs with barrel-chested conformations (e.g., English bulldogs), sternal compressions in dorsal recumbency might be considered (IIb-C) in support of the “cardiac pump theory”. Circumferential or lateral compressions can be considered in cats and small dogs (IIb-C) in support of the “cardiac pump theory”. Compression rates of 100-120/min are recommended in dogs and cats (I-A) using deep chest compressions of 1/3 – 1/2 the width of the thorax in most patients (IIa-A) and allowing for full chest wall recoil between compressions (I-A).

**Ventilation**: Rapid intubation of dogs and cats in CPA is recommended with the animal in lateral recumbency so that chest compressions can be continued during the procedure. Once the endotracheal tube (ETT) is in place, the cuff should be inflated so that ventilation and chest compressions can occur simultaneously (I-A). The ETT should be secured to the muzzle or mandible to prevent dislodgement. A ventilation rate of 10 breaths/min with a tidal volume of 10 mL/kg and a short inspiratory time of 1 second are recommended (I-A). In patients in which endotracheal intubation is not possible, mouth-to-snout ventilation can be accomplished by holding the patient’s mouth tightly closed, placing the rescuer’s mouth over the patient’s nares making a seal with the snout, and blowing into the nares. A
series of chest compressions at a rate of 100-120/min should be performed, followed by a brief interruption of chest compressions during which 2 breaths are delivered quickly, and the cycle is repeated (I-B).

**Cycles of CPR:** Chest compressions should be performed in 2-minute cycles without interruption in intubated patients when several rescuers are present (I-A). After each 2-minute cycle of compressions, the compressor should rotate to reduce lean due to fatigue, which reduces compression efficacy (I-B).

**Interposed abdominal compressions** in dogs and cats with CPA are reasonable when sufficient personnel trained in its use are available (IIa-B).

**Advanced Life Support (ALS)** encompasses the components of CPR performed after BLS has been initiated and until return of spontaneous circulation (ROSC) is achieved. It includes therapy with vasopressors, positive inotropes, and anti-cholinergics, as well as correction of electrolyte and acid-base disturbances and volume deficits, and prompt defibrillation.

**Vasopressor and Vagolytic Therapy:** The use of low-dose (0.01 mg/kg IV) epinephrine administered every 3-5 minutes early in CPR is recommended (I-B), but high-dose (0.1 mg/kg IV) epinephrine can be considered after prolonged (> 10 minutes) CPR (IIb-B). To minimize under- or over-dosing, this drug should be administered during *every other compressor cycle*. The use of vasopressin (0.8 U/kg IV) as a substitute or in combination with epinephrine every 3-5 minutes may be considered (IIb-B). Routine use of atropine (0.04 mg/kg IV) during CPR may be considered (IIb-C) and is most likely to be of benefit in dogs and cats with asystole or pulseless electric activity (PEA) associated with high vagal tone.

**Defibrillation** is the recommended primary treatment for ventricular fibrillation (VF) and pulseless ventricular tachycardia (PVT) (I-B). The use of a biphasic defibrillator is recommended over a monophasic defibrillator (I-A), at a dose of 4-6 J/kg with a monophasic defibrillator or 2-4 J/kg with a biphasic defibrillator (IIa-B). Defibrillation energy escalation (50% dose increase) is reasonable if the first counter-shock is unsuccessful (IIa-B). Immediate defibrillation is recommended in cases of CPA due to VF/PVT of duration of 4 minutes or less (I-B) or if VF is diagnosed during rhythm check between cycles of CPR (IIb-B). If the patient is known or suspected to have been in VF/PVT for > 4 minutes, the patient will most likely benefit from a 2-minute cycle of BLS before defibrillation (I-B). Administration of a single shock as opposed to 3 stacked shocks is recommended, with immediate resumption of CPR in the case of non-successful defibrillation (I-B). To maximize current through the ventricles, the paddles should be placed on opposite sides of the thorax approximately over the costochondral junction directly over the heart. A **precardial thump**, achieved by striking the patient with the heel of the hand directly of the heart, can be considered in patients with VF or PVT when defibrillation is not available, but is unlikely to be effective.
Other Drug Therapy: Amiodarone or lidocaine (if amiodarone is not available) may be considered in cases of VF/PVT resistant to electric defibrillation (IIb-B). Routine use of magnesium sulfate is not recommended for cardiac arrhythmias during CPR, although it can be considered for treatment of torsades de pointes (IIb-B). In cases of opioid toxicity, naloxone should be used (I-B) and might also be considered in case of recent opioid administration (IIb-B). Administering reversal agents during CPR might also be considered for patients that have received reversible anesthetic/sedative medication (IIb-C). IV calcium should not be used routinely during CPR (III-B), but can be considered in patients with documented moderate to severe hypocalcemia (IIb-C). Bicarbonate therapy (1 mEq/kg IV) may be considered after prolonged CPA (> 10-15 minutes) (IIb-B). The routine use of corticosteroids during CPR is not recommended (III-C).

Intratracheal administration of epinephrine, vasopressin, or atropine can be considered for patients in which IV or IO access is not possible (IIb-B). Unfortunately, the optimal delivery method and dose is not fully understood. A long catheter (e.g., urinary, red rubber) advanced to or beyond the level of the carina results in more effective drug administration compared to direct instillation into the ETT. If the intratracheal route is used, drugs should be diluted with saline or sterile water and administered via a catheter longer than the ETT (I-B) and doses 2-10X the standard IV dose considered.

Supplemental Oxygen Administration: The use of room air can be considered during CPR (IIb-B), but the use of 100% oxygen is also reasonable (IIa-B).

IV Fluid Administration: During CPR in euvoletic (e.g., healthy spay/neuter) or hypervolemic (e.g., congestive heart failure) dogs and cats, routine administration of IV fluids is not recommended (III-B). Patients with preexisting hypovolemia (e.g., trauma, GDV) are likely to benefit from increased circulating volume during CPR; therefore, administration of IV fluids in these patients is reasonable (IIa-C).

Open-chest CPR is more effective than closed-chest CPR in restoring ROSC and promoting good outcome in canine models of VF. However, studies investigating the utility of open-chest CPR in veterinary medicine are lacking and the resources and skills involved with open-chest CPR require careful consideration of its use. In patients with significant intrathoracic disease (e.g., tension pneumothorax, pericardial effusion), performing prompt open-chest CPR might be considered (IIb-C).

Monitoring Patients During CPA: EtCO₂ monitoring is likely a valuable adjunct for verification of correct ETT placement in conjunction with direct visualization, auscultation, or observation of chest excursions in dogs and cats with CPA (IIa-B), but should not be used as the sole measurement of correct ETT placement (III-B). EtCO₂ is an early indicator of ROSC (I-A) and measure of efficacy of CPR (IIa-B), allowing rescuers to use EtCO₂ to adjust their treatment to maximize perfusion during CPR. Limited data suggests that higher EtCO₂ values (> 15 mmHg in dogs, > 20 mmHg in cats) are associated with increased rate of ROSC. ECG is a valuable monitoring tool during CPR; evaluation of the ECG during inter-cycle pauses is recommended to obtain an accurate rhythm diagnosis and to guide ALS therapy (I-C). However, chest compressions should not be stopped during a complete 2-minute
cycle of CPR to allow ECG interpretation (III-B). For patients in VF, rapid assessment of the ECG to determine if VF has resolved immediately after defibrillation is reasonable, but should minimally delay resumption of chest compressions for another cycle (IIa-B). Similarly, palpation of the pulse to identify ROSC during inter-cycle pauses in CPR is reasonable as long as it does not delay resumption of chest compressions (IIb-C). Routine monitoring of electrolytes, especially during prolonged CPR, may be considered in all patients (IIb-B) and is recommended in patients with CPA that are known or suspected to have electrolyte derangements (I-C). Central or mixed venous blood gas analysis to evaluate effectiveness of CPR can be considered (IIb-B), but arterial blood gas analysis during CPR is not recommended (III-A).

Monitoring Patients at Risk of CPA: It is reasonable to use continuous ECG monitoring (IIa-C) and continuous Doppler monitoring or direct arterial pressure monitoring (IIa-C) in patients at risk of CPA. Continuous EtCO\textsubscript{2} monitoring is recommended in intubated and ventilation patients at risk of CPA (I-A).

Monitoring Patients after ROSC: Post-resuscitation monitoring should be sufficient to detect impending reoccurrence of CPA (I-C) and should be sufficient to guide therapy appropriate for the patient’s condition (I-C). Minimum post-resuscitation monitoring should include continuous ECG, intermittent arterial blood pressure monitoring, and assessment of oxygenation and ventilation (I-B). Other parameters that might be measured include blood glucose, lactate concentration, and body temperature (IIb-B).

Post-cardiac Arrest (PCA) Care: The routine use of large volumes of IV fluids post-arrest is not recommended except in the case of strongly suspected or confirmed hypovolemia. Fluid therapy should instead be adjusted according to veterinary small animal emergency and critical care recommendations and should be avoided in patients with congestive heart failure (III-C). The use of vasopressor and/or positive inotropic support to reach hemodynamic goals is reasonable in dogs or cats with persistent hypotension and/or cardiovascular instability (IIa-B). It is also reasonable to assume that hypertension in the immediate post-cardiac arrest (PCA) period in dogs and cats is beneficial (IIa-B). It is reasonable to target normocapnia (\(\text{PaCO}_2 = 32-43 \text{ mmHg in dogs and 26-36 mmHg in cats}\)) in the PCA period (IIa-B); serial monitoring of EtCO\textsubscript{2} or arterial blood gases is necessary to assure adequacy of ventilation. It is reasonable to employ manual or mechanical ventilation in patients that are hypoventilating in the PCA period, are hypoxemic, or require high oxygen concentrations (\(\text{FIO}_2 \geq 60\%\)) to maintain normoxemia, or are at risk of respiratory arrest (IIa-C), but routine mechanical ventilation in all PCA patients is not recommended (III-B). Oxygen supplementation should be titrated to maintain normoxemia (\(\text{PaO}_2 = 80-100 \text{ mmHg, SpO}_2 = 94-98\%\)), especially early after resuscitation, but both hypoxemia and hyperoxemia should be avoided (I-A).

Hypothermia and Rewarming: Mild therapeutic hypothermia (MTH) (i.e., core body temperature of 32-34\(^\circ\)C) should be initiated in dogs and cats that remain comatose as soon as possible after ROSC and maintained for 24-48 hours if mechanical ventilation and advanced critical care capabilities are available (I-A). However, if advanced critical care capabilities including mechanical ventilation are not available, MTH should not be initiated
If mild incidental hypothermia is present in patients after ROSC, it is reasonable not to rapidly rewarl these patients. A slow rewarling rate of 0.25-0.5°C/hour is reasonable (IIa-A) and rewarling rates of > 1°C/hour should be avoided (III-A).

**Corticosteroid** administration routinely during PCA care is not recommended (III-C); however, administration of hydrocortisone (1 mg/kg IV q 6 h) to cats or dogs that remain hemodynamically unstable despite administration of fluids and inotropes/vasopressors during PCA care may be considered (IIb-C).

**Hyperosmotic Therapy:** Hypertonic saline and mannitol may be considered for dogs and cats with neurologic signs consistent with cerebral edema (e.g., coma, cranial nerve deficits, decerebrate postures, abnormal mentation), but the diuretic effects of mannitol should be recognized and fluid therapy titrated to prevent development of hypovolemia (IIb-C).

**Seizure prophylaxis** with barbiturates (e.g., phenobarbital) may be considered in dogs and cats during the PCA period (IIb-B).

**Referral Center Care:** Given the higher likelihood of availability of 24-hour care, intensive monitoring, and advanced therapeutics, referral of critically ill dogs and cats for PCA care to specialty facilities is reasonable (IIa-B).

**Small Animal Veterinary CPR Algorithms and Charts:** The main components of CPR and the chronological sequence are summarized in a “CPR Algorithm” chart. This algorithm gives step-by-step instructions for rescuers participating in CPR including recognizing a cardiopulmonary arrest, initiation of BLS and monitoring, establishment of vascular access, administration of reversal agents, vasopressors, and vagolytic therapy, and defibrillation, as well as indications for common CPR-related drugs. A “Post-Cardiac Arrest Algorithm” chart summarizes the major interventions recommended in the guidelines for patients that achieve ROSC. The “CPR Algorithm”, “CPR Emergency Drugs and Doses”, and “Post-Cardiac Arrest Algorithm” charts are available in Part 7: Clinical guidelines or for purchase online (www.veccs.org).

**Online Resources:**

Free online access to the RECOVER guidelines (published in the June 2012 issue of the *Journal of Veterinary Emergency and Critical Care*):

Free online access to the human CPR guidelines (published in 2010 in *Circulation*):
www.circulationaha.org