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SPECIAL ARTICLE

2024 RECOVER Guidelines: Updated treatment recommendations for CPR in dogs and cats

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Abstract

Objective: After the 2012 Reassessment Campaign on Veterinary Resuscitation (RECOVER) CPR Guidelines, this is an update of evidence-based consensus guidelines for Basic Life Support (BLS), advanced life support (ALS), and periarrest monitoring.

Design: These RECOVER CPR Guidelines were generated using a modified version of the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system for evidence evaluation and translation of this evidence into clear and actionable clinical instructions. Prioritized clinical questions in the Population, Intervention, Comparator, and Outcome (PICO) format were used as the basis to conduct systematic literature searches by information specialists, to extract information from relevant publications, to assess this evidence for quality, and finally to translate the findings into treatment recommendations. These recommendations were reviewed by the RECOVER writing group and opened for comment by veterinary professionals for 4 weeks.

Abbreviations: ALS, advanced life support; BLS, basic life support; CPA, cardiopulmonary arrest; ETT, endotracheal tube; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; IO, intraosseous; IPPV, intermittent positive pressure ventilation; MON, Monitoring [domain]; PEA, pulseless electrical activity; PICO, Population, Intervention, Comparator, and Outcome; PVT, pulseless ventricular tachycardia; RECOVER, Reassessment Campaign on Veterinary Resuscitation; ROSC, return of spontaneous circulation; VF, ventricular fibrillation.

Jamie M. Burkitt-Creedon, Manuel Boller, and Daniel J. Fletcher contributed equally to this work.

Setting: Transdisciplinary, international collaboration in university, specialty, and emergency practice.

Results: A total of 40 worksheets were prepared to evaluate questions across the 3 domains of BLS, ALS and Monitoring, resulting in 90 individual treatment recommendations. High-dose epinephrine is no longer recommended, and atropine, if used, is only administered once. Bag–mask ventilation is prioritized over mouth-to-nose ventilation in nonintubated animals. In addition, an algorithm for initial assessment, an updated CPR algorithm, a rhythm diagnosis tool, and an updated drug dosing table are provided.

Conclusions: While the majority of the BLS and ALS recommendations remain unchanged, some noteworthy changes were made due to new evidence that emerged over the past 10 years. Indirectness of evidence remains the largest impediment to the certainty of guidelines formulation and underscores an urgent need for more studies in the target species of dogs and cats.

KEYWORDS

canine, cardiopulmonary resuscitation, clinical trials, consensus guidelines, critical care, evidence-based medicine, feline

1 | INTRODUCTION

CPR is the only practical method shown to achieve return of spontaneous circulation (ROSC) in the clinical veterinary setting for dogs and cats that experience cardiopulmonary arrest (CPA). For this reason, it is important that veterinary professionals know how to perform optimal CPR to extend high-quality life in patients with acute, reversible causes of CPA. Reports from single emergency or referral veterinary hospitals suggest that CPR survival in dogs and cats undergoing CPR is low and ranges from 5% to 7% in dogs and 1% to 19% in cats.[1–4] Evidence has shown that dogs and cats experiencing CPA in association with an acute, reversible cause such as anesthesia are significantly more likely to survive.[4–6] These studies underscore the need to improve CPR practices in the small animal veterinary community, especially where elective anesthetic procedures are commonly performed.

The first evidence-based consensus guidelines on veterinary CPR were developed by the Reassessment Campaign on Veterinary Resuscitation (RECOVER) initiative and were published in 2012 (2012 RECOVER CPR Guidelines).[7] Since that time, the procedures recommended in the 2012 RECOVER CPR Guidelines have become widely accepted as the international veterinary standard for CPR in dogs and cats. More than 80,000 individuals have completed online RECOVER CPR training[a] and over 11,000 of these have become RECOVER Certified BLS Rescuers and RECOVER Certified ALS Rescuers by completing in-person Rescuer Certification based on the 2012 Guidelines. One internet survey-based study in North America showed that CPR practices changed to conform to the 2012 RECOVER CPR Guidelines when compared to CPR practices prior to publication of these guidelines.[8] Analysis of the same survey data also revealed that veterinarians aware of the 2012 RECOVER CPR Guidelines were more likely to adhere to the evidence-based treatment recommendations contained therein than veterinarians who were unaware of the guidelines.[9] The impact of the guidelines on the critical outcomes of survival to hospital discharge and favorable neurologic outcome cannot be determined at this time due to a lack of relevant clinical data, though preliminary studies suggest a possible positive impact.[2,4] To our knowledge, no large scale, multicenter epidemiological investigations have been published describing critical CPR outcomes in dogs and cats.

Since the publication of the 2012 RECOVER CPR Guidelines, more human, canine, feline, and other studies have provided evidence to update and augment the 2012 RECOVER CPR Guidelines. Thus, the RECOVER Initiative sought to revise the RECOVER CPR Guidelines for dogs and cats through exhaustive evidence evaluation, analysis, and summary. The treatment recommendations contained within this document are the culmination of that effort for the Basic Life Support (BLS), Advanced Life Support (ALS), and Monitoring (MON) domains. Critical treatment recommendation updates appear in Box 1. Other important domains of veterinary CPR including Prevention and Preparedness and Post-cardiac Arrest Care are being updated in a rolling fashion and will be published in separate articles.

2 | METHODS

2.1 | Definitions

BLS is defined as the administration of external chest compressions and intermittent positive pressure ventilation (IPPV) with the intention to support the cardiorespiratory system in animals that are pulseless and apneic. BLS can be performed in a nonclinical setting by trained individuals.

BOX 1: Critical Reassessment Campaign on Veterinary Resuscitation (RECOVER) CPR Guideline updates for 2024

- Perform chest compressions in cats and small dogs using any of 3 techniques:
  - Circumferential
  - One-handed palm
  - One-handed thumb-to-fingers
- Perform chest compressions to 25% depth (rather than 33%–50%) when patient is in dorsal recumbency
- For nonintubated cats and dogs, deliver breaths with a tight-fitting face mask using supplemental O_2 if available
- For nonintubated cats and dogs, when no tight-fitting face mask is available:
  - When risk to rescuer is low, give mouth-to-nose breaths
  - When risk to rescuer is high or unknown, perform chest compression-only CPR
- Optimize circulatory support (chest compression technique, fluid therapy, vasoconstrictors) to achieve $ETCO_2$ ≥18 mm Hg
- High-dose epinephrine (0.1 mg/kg) is no longer recommended; when epinephrine is used, dose(s) of 0.01 mg/kg are recommended
- If atropine is used, administer once early in the CPR effort and do not repeat
- For patients with a shockable rhythm, if a shockable rhythm persists after the first defibrillation attempt, starting with shock #2:
  - Double the initial defibrillation energy dose and remain at this dose for all subsequent shocks
  - Consider standard-dose epinephrine or vasopressin to support vasomotor tone every other 2-minute cycle
  - Consider esmolol loading dose followed by CRI
  - Consider giving antiarrhythmics (amiodarone in cats, lidocaine in dogs).

ALS is defined as the use of monitoring tools such as electrocardiography and capnography to guide cardiovascular support measures, electrical defibrillation when indicated, acquisition of vascular access and the administration of drugs, and other adjunctive therapies. Unlike BLS, ALS can only be performed in a clinical setting due to the techniques and equipment used.

A *refractory shockable rhythm* is either ventricular fibrillation (VF) or pulseless ventricular tachycardia (PVT) that persists after the team has performed an electrical defibrillation, completed the next full 2-minute chest compression cycle, evaluated the ECG again, and confirmed that the animal remains pulseless with a shockable rhythm of either VF or PVT.

ROSC has been defined previously in dogs and cats as clinical signs of restored effective circulation for >30 seconds, such as a palpable pulse, systolic blood pressure measurement of >60 mm Hg on a direct arterial blood pressure waveform, or a marked increase in $ETCO_2$.[10] However, for the purpose of evidence evaluation and summary for creation of these guidelines, we accepted other investigators' definitions of ROSC, which may have differed from this definition and from each other.

2.2 | Evidence evaluation

Full explanation of the methods used to generate the guidelines is available in a companion paper.[11] What follows here is an overview. These RECOVER CPR Guidelines were generated using a modified version of the GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) system for guidelines generation in health care.[12]

The RECOVER Co-Chairs assigned content experts to serve as chairs for the 3 CPR topic domains of BLS, ALS, and MON. These Domain Chairs generated research questions in the Population, Intervention, Comparator, and Outcome (PICO) format including multiple relevant outcomes for each PICO question. PICO questions were rated as high priority, moderate priority, or lower priority. Because of the number of PICO questions generated in each domain and the number of volunteers available to review and summarize evidence and generate treatment recommendations, only high-priority PICO questions were evaluated. The BLS domain investigated 20 PICO questions, the ALS domain investigated 17, and the MON domain investigated 13.

Domain Chairs prioritized the outcomes for each PICO question by clinical importance so that treatment recommendations could be generated based on the evidence pertaining to the highest priority outcomes for which clinically relevant evidence was available. Outcomes used for most PICO questions included favorable neurologic outcome, survival to hospital discharge, ROSC, and surrogate markers of perfusion, in this order of priority. Additional or different outcomes were investigated for various PICO questions where Domain Chairs deemed this appropriate.

Specialist librarians (Information Specialists) worked with Domain Chairs to create search strings for entry into medical databases. Search strings were developed using an iterative process among Information Specialists and Domain Chairs to optimize the number and type of articles returned in the searches.[13] Once potentially relevant articles were identified, 2 Evidence Evaluators (specialist veterinarians, general veterinarians in emergency or specialty practice, or veterinary technician specialists in relevant fields such as emergency and critical care, anesthesia, and cardiology) reviewed abstracts independently to eliminate irrelevant material and leave only pertinent primary literature for review. Domain Chairs resolved any conflicts. Relevant publications were then reviewed for each PICO by the same Evidence Evaluators.

A purpose-developed, web-based evaluation system was used to guide Evidence Evaluators through a systematic review using a predetermined, standardized set of questions designed to identify key aspects of evidence quality (eg, risk of bias, consistency with population of interest, consistency of outcomes). This evaluation system used these data to generate Evidence Summary Tables for each outcome for every PICO question. Evidence Evaluators also wrote overview summaries of the evidence for their PICO question. Finally, the Domain Chairs generated Evidence Profile Worksheets consisting of a structured summary (introduction, consensus on science, treatment recommendations, justifications for the treatment recommendations, and knowledge gaps for future study) and additional notes made during evaluation of individual studies for each PICO question. These Evidence Profile Worksheets were reviewed and edited by the Co-Chairs. The Co-Chairs and each set of Domain Chairs met to reach consensus on these documents. The treatment recommendations and links to the Evidence Profile Worksheets were then posted at the RECOVER Initiative website[a] for a 4-week open comment period beginning in August 2023; Evidence Evaluators and listservs for relevant specialty and other professional organizations were notified directly of this comment period. Following this period, comments were considered by the Co-Chairs and Domain Chairs, and relevant treatment recommendations honed to create a finalized set of consensus guidelines for CPR in dogs and cats, which appear in this paper. The structured summary for each PICO question can be found in the respective domain manuscripts[14–16] and the additional study evaluation notes appear in the full Evidence Profile Worksheets.

In accordance with the GRADE system, each treatment recommendation is written either as a *recommendation* where the RECOVER group found stronger evidence (or perceived risk/benefit relationship, where evidence was poor or not available) or as a *suggestion* where the RECOVER group found weaker evidence (or perception of risk/benefit relationship, where evidence was not available), for or against the intervention.

3 | TREATMENT RECOMMENDATIONS FOR CPR IN DOGS AND CATS

Table 1 contains all new and updated RECOVER CPR Guidelines for the BLS, ALS, and MON domains as well as 6 recommendations from the 2012 RECOVER CPR Guidelines[7] that were not updated on the current iteration. The 2012 treatment recommendations are denoted with “2012” in the PICO column. The consensus on science, justification for the treatment recommendations, knowledge gaps for each PICO, and full references associated with these treatment recommendations are contained within the accompanying BLS, ALS, and MON domain papers.[14–16] Further information about clinical application of select recommendations appears in the sections that follow.

4 | BLS TECHNIQUES USED IN DOGS AND CATS

The purpose of BLS is to support the cardiorespiratory system by the administration of external chest compressions and IPPV. Unless a Do Not Resuscitate order is in place, BLS should be initiated in any dog or cat that is nonresponsive and apneic (MON-11). The methods used to perform BLS vary depending on patient characteristics, the equipment and supplies available, and the number of rescuers.

4.1 | Initiating single-rescuer BLS in any setting

When an unresponsive patient is encountered, the rescuer should call for help, stimulate the patient vigorously, and, in the absence of a response, determine whether the patient is breathing (Figure 1). If the patient is apneic and only 1 rescuer is available to initiate BLS, we recommend that the rescuer evaluate the patient’s airway and, if safe, attempt to clear any obvious airway obstruction before starting chest compressions (BLS-11). This patient assessment and airway evaluation should be as brief as reasonably possible, so that chest compressions are not delayed by more than 10–15 seconds. During single-rescuer BLS, we recommend a compression-to-ventilation (C:V) ratio of 30 compressions:2 breaths (30:2) (BLS-09). The rescuer delivers 30 chest compressions at the recommended rate, then, during a chest compression pause of no more than a few seconds, delivers 2 breaths, and immediately begins another round of 30 chest compressions. This cycle continues until additional rescuers arrive, ROSC occurs, or the resuscitation effort is terminated. Nonintubated dogs and cats should be ventilated using a tight-fitting facemask fitted with a manual resuscitator (BLS-10); oxygen can be supplemented if it is available. If no tight-fitting facemask is available, we recommend provision of rescue breaths by the mouth-to-nose technique unless there is risk to the rescuer (eg, zoonotic disease or narcotics overdose) (BLS-10). Rescue breaths should be delivered with the animal’s neck and head in alignment with the spine to avoid obstructing the airway. If the rescuer believes there is personal risk involved in providing mouth-to-nose rescue breaths, chest compression-only CPR should be performed (BLS-10).

4.2 | Initiating multi-rescuer BLS in the clinical setting

Most veterinary CPR events occur in the clinical setting, and many occur in settings with 2 or more veterinary professionals available, facilitating multi-rescuer CPR. When multiple rescuers are available to initiate BLS, 1 rescuer immediately begins chest compressions, while a second evaluates the patient’s airway (BLS-11). If an obvious upper airway obstruction is identified, it should be removed if it is safe and feasible to do so, or other methods should be employed to establish a patent airway (eg, tracheostomy). In either case, the patient should be endotracheally intubated as soon as possible (BLS-11). Endotracheal intubation should be confirmed by direct visualization of the endotracheal tube (ETT) passing through the arytenoid cartilages if possible; ALS methods to confirm endotracheal intubation are discussed below. The ETT should be secured in place, usually with a tie behind the ears; a tie over the dorsal surface of the muzzle also works in meso- or dolichocephalic dogs. After the ETT is secure, the cuff should be inflated to create an airtight seal for positive pressure ventilation. Multi-rescuer BLS should be performed in 2-minute cycles of chest compressions with simultaneous IPPV as described in detail below.

TABLE 1 Treatment recommendations for dogs and cats with cardiopulmonary arrest.

Treatment recommendation	Strength of recommendation	Quality of evidence	PICO
BLS			
Initiating CPR			
In apneic, unresponsive dogs and cats, we recommend that BLS be started without attempting to palpate femoral or apex pulses.	Strong	Very low	MON-11
For single-rescuer CPR in dogs and cats, prior to initiation of chest compressions, we recommend that an airway evaluation be performed during the initial patient assessment, (shake & shout) prior to initiation of chest compressions.	Strong	Expert opinion	BLS-11
For multi-rescuer CPR in dogs and cats, we recommend that chest compressions be initiated without delay to assess airway and gain airway access.	Strong	Very low	BLS-11
For multi-rescuer CPR in dogs and cats, we recommend that the airway be evaluated and the animal endotracheally intubated as soon as possible after initiation of chest compressions.	Strong	Expert opinion	BLS-11
Positioning and chest compression point			
We recommend performing chest compressions in lateral recumbency in non-wide-chested dogs.	Strong	Very low	BLS-04
We suggest lateral chest compressions focused over the widest part of the chest in wide-chested dogs until an endotracheal tube is in place and secured.	Weak	Expert opinion	BLS-05
In wide-chested dogs that are positionally stable in dorsal recumbency, we suggest moving the dog to dorsal recumbency during an inter-cycle pause and performing chest compressions over the sternum directly over the heart once an endotracheal tube is placed.	Weak	Expert opinion	BLS-05
We recommend performing chest compressions with hand placement over the heart in medium- to large-sized, keel-chested dogs.	Strong	Very low	BLS-03
We suggest performing chest compressions with hand placement over the widest part of the thorax in medium- to large-sized, round-chested dogs.	Weak	Very low	BLS-02
We recommend that chest compressions in cats and small dogs be performed using 1 of the following 3 methods, based on a combination of compressor preference and real-time markers of perfusion (eg, $ETCO_2$, direct blood pressure monitoring):			BLS-12
a) using a circumferential 2-thumb chest compression technique with the animal in lateral recumbency and both of the thumbs directly over the heart	Strong	Very low	
b) using a 1-handed technique with the dominant hand wrapped around the sternum at the level of the heart performing compressions between the flat portion of the fingers and the flat portion of the thumb	Strong	Expert opinion	
c) using a 1-handed technique with heel of the dominant hand compressing one-third to one-half of the chest width over the area of the heart with the animal in lateral recumbency while the nondominant hand supports the dorsal thorax.	Strong	Expert opinion	
Compression rate and technique			
We recommend using a chest compression rate of 100–120 compressions per minute during CPR in dogs and cats.	Strong	Very low	BLS-07
In dogs and cats that are positioned in lateral recumbency, we recommend providing chest compressions to a depth of one-third to one-half of the lateral diameter of the chest at the compression point.	Strong	Very low	BLS-18
In dogs and cats that are positioned in dorsal recumbency, we recommend providing chest compressions to a depth of one-quarter of the anterior–posterior diameter of the chest at the compression point.	Strong	Very low	BLS-18
We recommend allowing full chest wall recoil between chest compressions in dogs and cats undergoing CPR.	Strong	Moderate	BLS-01
We recommend targeting a duty cycle of 50:50 for compression:noncompression during CPR in dogs and cats.	Strong	Moderate	BLS-01
We recommend against the use of active compression–decompression CPR in dogs and cats.	Strong	Expert opinion	BLS-06

(Continues)

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TABLE 1 (Continued)

Treatment recommendation	Strength of recommendation	Quality of evidence	PICO
Ventilation			
In nonintubated dogs and cats undergoing CPR or during single-rescuer CPR, we recommend provision of rescue breaths if feasible and safe during pauses in chest compressions.	Strong	Very low	BLS-10
In nonintubated dogs and cats undergoing CPR, we recommend the use of a tight-fitting facemask and a manual resuscitator to deliver rescue breaths.	Strong	Very low	BLS-10
In nonintubated dogs and cats undergoing CPR that pose minimal risk to the rescuer (eg, due to potential for zoonotic disease or narcotics exposure), when a tight-fitting facemask and manual resuscitator are not available, we recommend provision of rescue breaths via the mouth-to-nose (mouth-to-snout) technique.	Strong	Very low	BLS-10
In nonintubated dogs and cats that may pose risk to the rescuer (eg, due to potential for zoonotic disease or narcotics exposure), when a tight-fitting facemask and manual resuscitator are not available, we recommend chest compression-only CPR.	Strong	Expert opinion	BLS-10
We recommend a compression:ventilation ratio of 30 chest compressions:2 breaths (30:2) in nonintubated dogs and cats undergoing CPR.	Strong	Very low	BLS-09
In intubated dogs and cats undergoing CPR, we recommend a respiratory rate of 10 breaths per minute.	Strong	Very low	BLS-14
We recommend administering positive pressure ventilation at a tidal volume of 10 mL/kg and a 1-second inspiratory time during CPR in intubated dogs and cats.	Strong	Very low	BLS-13
We recommend that a peak inspiratory pressure be applied that creates visible but not excessive chest rise.	Strong	Expert opinion	BLS-19
During CPR in dogs and cats, the use of an FiO_2 of 1.0 (100% oxygen) is reasonable.	Benefit >> risk	Limited populations studied	2012 RECOVER CPR Guidelines
During CPR in dogs and cats, the use of an FiO_2 of 0.21 (21% oxygen—room air) may be considered.	Benefit ≥ risk	Limited populations studied	2012 RECOVER CPR Guidelines
In dogs and cats that experience CPA while undergoing mechanical ventilation, we suggest switching to manual ventilation.	Weak	Expert opinion	BLS-20
We recommend against the routine use of a peak inspiratory pressure that exceeds 40 cm H_2O.	Strong	Expert opinion	BLS-19
If delivering breaths by mechanical ventilator during CPR in dogs and cats, ventilator settings should be adjusted to assure breaths are delivered (eg, volume control mode; TV 10 mL/kg; RR 10/min; PEEP 0 cm H_2O; pressure limit 40 cm H_2O; and a trigger sensitivity least likely to detect a breath [eg, −10 cm H_2O]).	Strong	Very low	BLS-20
CPR cycles			
In intubated dogs and cats undergoing CPR, we recommend delivering CPR in 2-minute cycles of continuous high-quality chest compressions.	Strong	Expert opinion	BLS-08
We recommend the cycles of chest compressions delivered by an individual rescuer not extend beyond 2 minutes in intubated dogs and cats undergoing CPR.	Strong	Low	BLS-15
We recommend that if a rescuer perceives they are becoming fatigued, or if other rescuers perceive inadequate chest compression quality, it is reasonable to change compressors during a cycle while minimizing interruption in chest compressions (<1 s).	Strong	Expert opinion	BLS-15
We recommend minimizing pauses between compression cycles (<10 s) in dogs and cats during CPR.	Strong	Low	BLS-16
We suggest interrupting a 2-minute chest compression cycle only when ROSC is suspected based on a combination of (1) a sudden and persistent increase in $ETCO_2$ of great magnitude (eg, by ≥10 mm Hg to reach a value that is ≥35 mm Hg) and (2) evidence of an arterial pulse distinct from chest compressions.	Weak	Expert opinion	BLS-17
In the absence of capnography data, we recommend against interruption of a 2-minute chest compression cycle even if ROSC is suspected.	Strong	Expert opinion	BLS-17

(Continues)

TABLE 1 (Continued)

Treatment recommendation	Strength of recommendation	Quality of evidence	PICO
ALS			
Carbon dioxide measurement			
In dogs and cats undergoing CPR, detection of ETCO_2 using a waveform capnograph attached to the breathing circuit is adequate to confirm proper ETT placement if a waveform is present and CO_2 is consistently detected.	Strong	Very low	MON-01
In dogs and cats undergoing CPR with a CO_2 detection device in place, an ETCO_2 ≥12 mm Hg likely indicates proper ETT placement; if the ETCO_2 <12 mm Hg, we recommend the rescuer confirm tracheal intubation by other means.	Strong	Very low	MON-01
In intubated dogs and cats undergoing CPR that are instrumented with any CO_2 detection device, when ETCO_2 is 0 or very low (eg, <5 mm Hg) despite high-quality chest compressions, we recommend confirmation of tracheal intubation by other means (eg, direct visualization of the tube passing through the arytenoid cartilages, lung auscultation during the pause between chest compression cycles) and reintubation if indicated.	Strong	Very low	MON-01
We recommend continuous measurement of ETCO_2 to guide chest compression quality during CPR in dogs and cats.	Strong	Very low	MON-07
We recommend optimizing CPR to maximize ETCO_2 to no less than 18 mm Hg in dogs and cats undergoing CPR.	Strong	Very low	MON-10
Drug administration routes			
We recommend that CPR drugs be administered preferentially via an IV catheter rather than via an IO catheter.	Strong	Very low	ALS-14
If attempts at IV access are not successful within 2 minutes, we suggest that rescuers pursue IO catheter placement and to concurrently attempt to secure IV and IO access if adequate personnel are available.	Weak	Very low	ALS-14
In animals in which IV or IO access is not possible, the use of the intratracheal route for epinephrine, vasopressin, or atropine may be considered.	Benefit ≥ risk	Limited populations studied	2012-ALS09
If the intratracheal route is used for drug administration during CPR, drugs should be diluted with saline and administered via a catheter longer than the ETT.	Benefit >>> risk	Limited populations studied	2012-ALS09
Vasopressors			
We recommend the use of epinephrine for nonshockable rhythms during CPR in dogs and cats.	Strong	Low	ALS-06
We suggest administering epinephrine at a standard dosing interval of 3–5 minutes.	Weak	Very low	ALS-07
We recommend against the routine use of high-dose epinephrine during CPR in dogs and cats.	Strong	Low	ALS-08
We recommend against the use of epinephrine in shockable rhythms in dogs and cats before the first defibrillation attempt.	Strong	Very low	ALS-16
We suggest the use of vasopressin (0.8 U/kg, or epinephrine 0.01 mg/kg if vasopressin is not available) in shockable rhythms in dogs and cats in which the shockable rhythm persists beyond the first shock.	Weak	Expert opinion	ALS-16
Vagolytics (atropine)			
We suggest that atropine (0.04 mg/kg IV or IO) may be administered once during CPR for dogs and cats with nonshockable arrest rhythms.	Weak	Low	ALS-09
We recommend that if atropine is used, it is given as early as possible in the CPR effort.	Strong	Very low	ALS-09
We recommend against administering repeated doses of atropine during CPR for dogs and cats with nonshockable arrest rhythms.	Strong	Very low	ALS-09 ALS-19
Defibrillation			
We recommend using a biphasic defibrillator over a monophasic defibrillator in dogs and cats with shockable rhythms.	Strong	Very low	ALS-11
We recommend that for dogs and cats with shockable arrest rhythms, if an initial standard-dose (2 J/kg) electrical defibrillation is unsuccessful, the second and subsequent shocks be delivered at a dose of 2× the initial dose (4 J/kg).	Strong	Low	ALS-12

(Continues)

TABLE 1 (Continued)

Treatment recommendation	Strength of recommendation	Quality of evidence	PICO
Antiarrhythmics			
We suggest that intravenous lidocaine be administered to dogs (2 mg/kg) with refractory pulseless ventricular tachycardia or ventricular fibrillation after the initial shock has been unsuccessful.	Weak	Moderate	ALS-01
If lidocaine is unavailable, we suggest that amiodarone may be administered intravenously (5 mg/kg) during CPR for PVT or VF refractory to the first shock in dogs.	Weak	Very low	ALS-02
We recommend against the use of amiodarone formulations containing polysorbate-80 in dogs due to the adverse hemodynamic side effects of these formulations that have been documented.	Strong	Moderate	ALS-02
We suggest that amiodarone may be administered intravenously (5 mg/kg) during CPR for PVT or VF refractory to the first shock in cats.	Weak	Very low	ALS-02
We suggest that intravenous lidocaine not be administered in cats with refractory pulseless ventricular tachycardia or ventricular fibrillation after the initial shock has been unsuccessful.	Weak	Moderate	ALS-01
We suggest administering esmolol (0.5 mg/kg IV or IO over 3–5 min followed by a CRI at 50 µg/kg/min) in dogs and cats with shockable rhythms that do not convert after the first defibrillation.	Weak	Very low	ALS-03
Other medications and interventions			
In cats and dogs with CPA after recently administered opioid drugs, we recommend that once BLS and other high priority ALS interventions have been initiated, naloxone should be administered (0.04 mg/kg IV or IO).	Strong	Very low	ALS-13
In dogs and cats that have received reversible anesthetic/sedative medication, administering reversal agents during CPR may be considered.	Benefit ≥ Risk	Very limited populations studied	2012-ALS13
We recommend against the use of intravenous fluid boluses in euvolemic dogs and cats during CPR.	Strong	Very low	ALS-10
We recommend the use of intravenous fluid boluses in dogs (20 mL/kg isotonic crystalloid or equivalent) and cats (10–15 mL/kg isotonic crystalloid or equivalent) with known or suspected hypovolemia during CPR.	Strong	Expert opinion	ALS-10
In dogs and cats in CPA, we suggest monitoring of plasma ionized calcium during CPR.	Weak	Expert opinion	MON-09
In dogs and cats in CPA with documented hypocalcemia (ionized calcium <0.8 mmol/L), we suggest administration of 10% calcium gluconate (50 mg/kg IV or IO over 2–5 min) or 10% calcium chloride (15 mg/kg IV or IO over 2–5 min).	Weak	Expert opinion	MON-09
We recommend against the routine administration of calcium in dogs and cats in CPA regardless of the arrest rhythm.	Strong	Very low	ALS-15 MON-09
In patients in CPA, we recommend administration of a single dose of 10% calcium gluconate (50 mg/kg IV or IO over 2–5 min) or 10% calcium chloride (15 mg/kg IV or IO over 2–5 min) if hyperkalemia was known or suspected to have contributed to the arrest.	Strong	Very low	ALS-15
We suggest against the routine administration of glucocorticoids during CPR.	Weak	Very low	ALS-04
In dogs and cats with vasopressor-resistant hypotension at the time of CPA or with known or suspected hypoadrenocorticism, we suggest intravenous administration of glucocorticoids during CPR.	Weak	Expert opinion	ALS-04
We suggest measuring potassium concentrations in all dogs and cats during CPR.	Weak	Very low	MON-08
We recommend measuring potassium concentrations as early as possible in dogs and cats during CPR in which severe potassium abnormalities are suspected.	Strong	Expert opinion	MON-08
In dogs and cats in CPA with an arterial catheter in place, we recommend optimizing BLS and ALS interventions to maximize DBP to no less than 30 mm Hg.	Strong	Very low	MON-12
Alkalinization therapy after prolonged CPA of greater than 10–15 minutes with administration of 1 mEq/kg of sodium bicarbonate may be considered.	Benefit ≥ risk	Limited populations studied	2012-ALS16

(Continues)

TABLE 1 (Continued)

Treatment recommendation	Strength of recommendation	Quality of evidence	PICO
OCCPR			
We recommend OCCPR in dogs and cats with abdominal organs or substantial accumulations of fluid or gas in the pleural or pericardial spaces.	Strong	Expert opinion	ALS-05
We recommend direct cardiac massage in dogs and cats undergoing abdominal or thoracic surgery.	Strong	Low	ALS-05
We suggest OCCPR in dogs and cats with penetrating thoracic trauma or rib fractures at or near the chest compression point.	Weak	Very low	ALS-05
In medium- and large-breed round-chested and wide-chested dogs in which OCCPR is feasible and clients are amenable to the procedure, we recommend that CCCPR be started immediately and OCCPR be started as soon as possible.	Strong	Low	ALS-05
We suggest attempting OCCPR in cats and small dogs (<15 kg) only if they have pleural or pericardial disease, penetrating thoracic trauma, if they are undergoing abdominal or thoracic surgery, or when CCCPR appears to be inadequate.	Weak	Expert opinion	ALS-05
We recommend discussing the pros and cons of OCCPR in any dog at risk of CPA when obtaining a "CPR code" at the time of hospitalization if OCCPR is offered by the practice and is indicated.	Strong	Expert opinion	ALS-05
Preventing cardiopulmonary arrest and re-arrest			
We recommend the use of atropine (0.04 mg/kg IV or IO) in dogs and cats with bradycardia causing hemodynamic compromise to attempt to prevent progression to CPA.	Strong	Expert opinion	ALS-09
We recommend immediate administration of naloxone (0.04 mg/kg IV or IO) in dogs and cats not in CPA that are bradycardic and/or unresponsive after administration of an opioid.	Strong	Very low	ALS-13
We recommend serial measurement of plasma lactate concentration in the PCA period.	Strong	Very low	MON-02
We recommend that serial plasma lactate concentration measurements be used to guide and evaluate response to treatment in dogs and cats in the PCA period.	Strong	Expert opinion	MON-02
We recommend measuring blood glucose concentration after ROSC in dogs and cats in which hypoglycemia or hyperglycemia are known or suspected.	Strong	Expert opinion	MON-03A
We suggest measuring blood glucose concentration in all dogs and cats as early as possible after return of spontaneous circulation.	Weak	Very low	MON-03A
We recommend measuring serum creatinine concentration as an indicator of acute kidney injury as soon as feasible in the PCA period, and subsequently no less often than every 24 hours during hospitalization in dogs and cats that achieve ROSC.	Strong	Very low	MON-03B
We recommend frequent or continuous blood pressure monitoring in patients at risk of CPA, including patients under anesthesia, in shock, and in the PCA period.	Strong	Very low	MON-04
We suggest the use of continuous, direct arterial blood pressure monitoring if feasible in patients at risk of CPA.	Weak	Very low	MON-04
In dogs and cats at risk of CPA (eg, under anesthesia, in shock, in respiratory distress, post-ROSC), we recommend against monitoring only with a pulse oximeter.	Strong	Very low	MON-05
In dogs and cats at risk of CPA (eg, under anesthesia, in shock, in respiratory distress, post-ROSC), we suggest continuous pulse oximetry monitoring in conjunction with continuous or frequent monitoring of other vital parameters such as respiratory rate, heart rate and rhythm, and arterial blood pressure.	Weak	Very low	MON-05
In cats under general anesthesia, we recommend continuous monitoring of pulse oximetry or pulse quality.	Strong	Very low	MON-05
In dogs and cats in which a pulse oximetry reading cannot be obtained and patient movement and nonpatient factors are ruled out as the cause, we recommend assessment of perfusion status by other means (eg, pulse palpation, blood pressure measurement, ECG monitoring, apnea monitoring, plasma lactate concentration measurement, point-of-care cardiac ultrasound).	Strong	Expert opinion	MON-05

(Continues)

TABLE 1 (Continued)

Treatment recommendation	Strength of recommendation	Quality of evidence	PICO
We recommend continuous ECG monitoring in dogs and cats at risk of CPA (eg, under anesthesia, in shock, in respiratory distress, post-ROSC, aspiration risk).	Strong	Very low	MON-06

Note: This table contains all new and updated RECOVER CPR Guidelines for the BLS, ALS, and MON domains as well as 6 recommendations from the 2012 RECOVER CPR Guidelines[7] that were not updated in the current iteration. The 2012 treatment recommendations are denoted with "2012" in the PICO column.

Abbreviations: ALS, advanced life support; BLS, basic life support; CCCPR, closed-chest CPR; CPA, cardiopulmonary arrest; CRI, constant rate infusion; DBP, diastolic arterial blood pressure; ETT, endotracheal tube; IO, intraosseous; MON, monitoring (domain); OCCPR, open-chest CPR; PCA, post-cardiac arrest; PEEP, positive end-expiratory pressure; PVT, pulseless ventricular tachycardia; ROSC, return of spontaneous circulation; RR, respiratory rate; TV, tidal volume; VF, ventricular fibrillation.

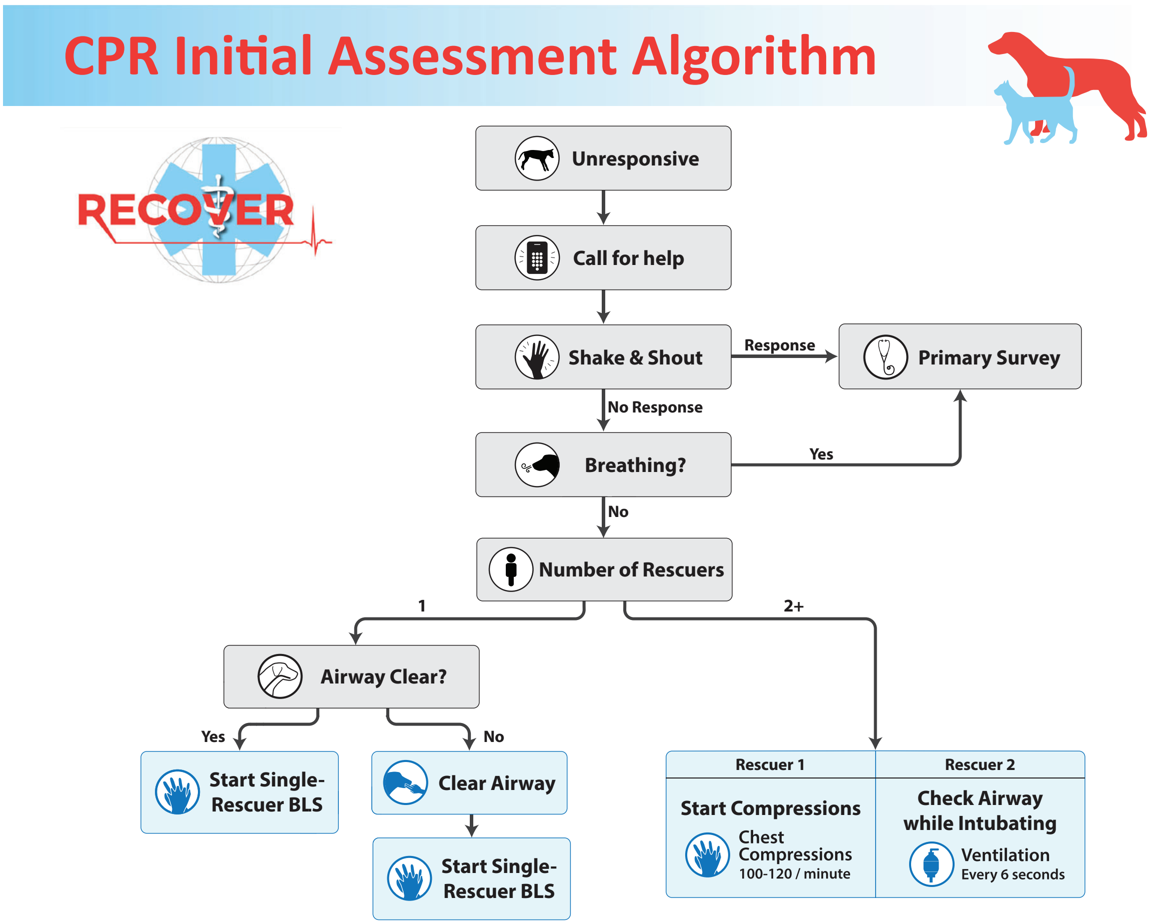

FIGURE 1 CPR initial assessment algorithm for dogs and cats. BLS, basic life support. Figure contributions by Allison Buck, MFA, CMI, Medical Illustrator, Educational Support Services, Cornell University College of Veterinary Medicine. Figure 1 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

4.3 | Performing chest compressions in dogs and cats

4.3.1 | Patient positioning

Chest compressions are performed with most dogs and cats lying in lateral recumbency (BLS-04, BLS-05, BLS-12). Wide-chested dogs such as English Bulldogs that naturally fall into dorsal recumbency can undergo chest compressions in that position (BLS-05; Figure 2).

4.3.2 | Compressor body position

To perform chest compressions in medium- to giant-breed dogs, regardless of patient body position, the compressor should lock their elbows in extension and wrists in flexion and position their shoulders directly over the wrists (Figure 3). In both the compression and decompression phases, the shoulders should remain vertically positioned over the wrists. With the animal on a standard table or gurney, this requires most rescuers to stand on a wide-based stool to achieve

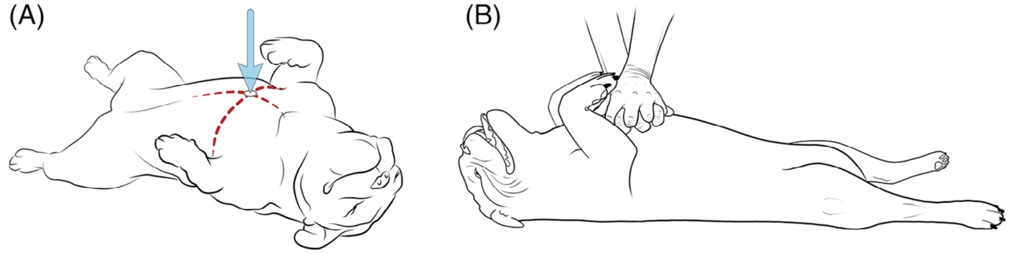

FIGURE 2 Wide-chested dogs. (A) Wide-chested dogs that fall naturally into dorsal recumbency may undergo chest compressions in dorsal recumbency. Illustration by Allison Buck, MFA, CMI, Medical Illustrator, Educational Support Services, Cornell University College of Veterinary Medicine. Copyright 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission. (B) With the dog positioned in dorsal recumbency, the compressor performs chest compressions with the heels of the hands stacked and placed on the mid-sternum. When compressions are performed over the sternum with the dog in dorsal recumbency, the thorax should be compressed approximately one-fourth of its depth during compression and allowed to recoil fully during decompression. Illustration by Chrisoula Toupadakis Skouritakis, PhD, MediaLab Services Director, Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California, Davis. Figure 2 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

proper body positioning. The compressor uses their core abdominal muscles to perform compressions while keeping the elbows locked, which increases chest compression force and reduces fatigue. The compressor may position themselves on their knees if the animal is lying on the floor, or on the treatment table if it is adequately sturdy and wide, as long as the shoulders are still directly above the wrists. Compressor body position is less vital than hand placement in cats and small dogs because increased chest compliance makes chest compressions easier.

4.3.3 | Compressor hand placement

To perform chest compressions on medium- to giant-sized dogs, the heels of the compressor's hands should overlap, with the heel of the hand in contact with the chest positioned at the compression point described below; fingers may be interlaced or held together overlapping but should not fan out across the thorax. Figure 4 demonstrates 1 example of an appropriate hand position, with the heels of the hands overlapping and the fingers interlaced (Figure 4). In medium- to giant-sized, keel-chested dogs such as Sighthounds, we recommend the compressor's overlapping hands be placed with the heels directly over the dog's heart (BLS-03) (Figure 5). To locate the heart with the dog in lateral recumbency, the humerus should be rotated caudally so that caudal point of the elbow lies approximately one-third of the distance between the sternum and the spine; the heart lies under the point of the elbow in this position. Hand placement over the heart applies pressure to the ventricles (a "cardiac pump") to help force blood into the pulmonary artery and aorta during compression. In medium- to giant-sized, round-chested dogs such as Retrievers and Pitbull-type dogs, we recommend the compressor's overlapping hands be placed with the heels over the widest portion of the thorax (BLS-02) (Figure 6). The intrathoracic pressure changes generated by chest compression over the widest part of the thorax (a "thoracic pump") force blood through the aorta and large pulmonary veins during compression and allow the heart, intrathoracic vessels, and pulmonary circulation to refill with blood during decompression.[17–19] For dogs undergoing chest compressions in dorsal recumbency, the compressor's overlapping hands are placed with the heels over the mid-sternum.

In cats and small dogs, overlapping, 2-handed chest compressions could overcompress the heart. Thus, in these animals, we recommend that chest compressions be performed using 1 of 3 methods, based on a combination of compressor preference and real-time markers of perfusion when available (see Section 7.3) (BLS-12). The circumferential, 2-thumb technique compresses the heart between the thumbs and the opposing flat fingers of the ipsilateral hands (Figure 7A). The 1-handed technique compresses the heart between the thumb and the flat fingers of the dominant hand wrapped around the sternal portion of the thorax, while the nondominant hand braces the dorsal thorax (Figure 7B). The 1-handed heel technique compresses the heart under the heel of the dominant hand, while the nondominant hand braces the dorsal thorax (Figure 7C). While all images in Figure 7 demonstrate these chest compression techniques in lateral recumbency, the 2-thumb technique could also be performed with the thumbs over the sternum and the flat fingers compressing from the dorsum in a wide-chested puppy, for example.

4.3.4 | Chest compression rate and depth

Chest compressions are performed at 100–120/min in dogs and cats (BLS-07). In dogs and cats in lateral recumbency, we recommend providing chest compressions to a depth of one-third to one-half of the width of the thorax at the compression point (BLS-18). In dogs and cats positioned in dorsal recumbency, we recommend providing chest compressions to a depth of one-fourth of the thoracic depth at the compression point (BLS-18). The compressor must allow full recoil of the thorax between compressions to allow the heart to refill with blood (BLS-01).

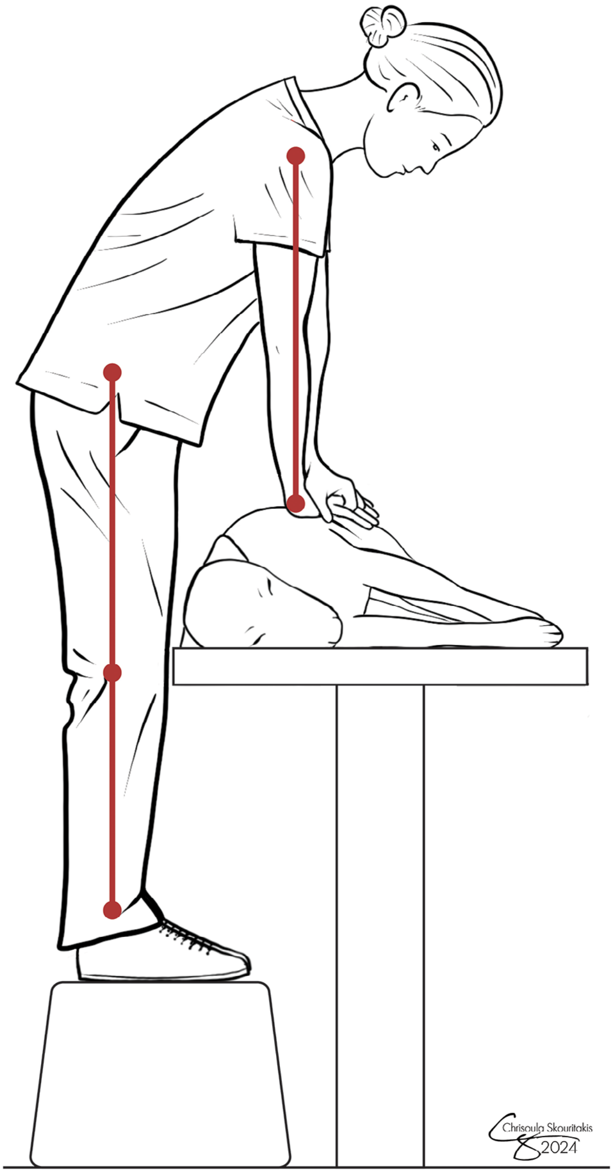

FIGURE 3 Appropriate rescuer posture for performing chest compressions in medium- to giant-breed dogs in any recumbency. Note that the rescuer's shoulders, elbows, and wrists are in alignment with the shoulders vertically positioned over the compression point. The compressor uses their core abdominal muscles to perform compressions while keeping the arms in rigid extension (ie, locked), which helps increase and sustain compression force. Illustration by Chrisoula Toupadakis Skouritakis, PhD, MediaLab Services Director, Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California, Davis. Figure 3 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

FIGURE 4 Example of an appropriate hand position for providing chest compressions in medium- to giant-breed dogs in any recumbency. Note the heels of the hands are overlapping or stacked and the fingers interlaced, which allows the compressor to apply more force to the patient's thorax with each compression. In this example, the hands are placed on the widest part of the thorax as would be done for a round-chested dog lying in lateral recumbency. Illustration by Chrisoula Toupadakis Skouritakis, PhD, MediaLab Services Director, Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California, Davis. Figure 4 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

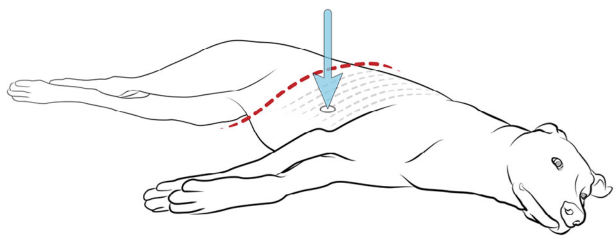

FIGURE 5 Keel-chested dogs. Note the "ski slope" shape of the thorax when the dog lies in lateral recumbency (red dashed line). The arrow indicates the recommended compression point over the heart (cardiac pump). Illustration by Allison Buck, MFA, CMI, Medical Illustrator, Educational Support Services, Cornell University College of Veterinary Medicine. Figure 5 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

4.4 | The 2-minute chest compression cycle

In intubated dogs and cats, CPR is performed using uninterrupted, 2-minute cycles of chest compressions (BLS-08). We recommend that cycles of chest compressions not extend longer than 2 consecutive minutes for an individual rescuer (BLS-15) and that if the compressor or other team member perceives that the compressor is becoming fatigued, it is reasonable to switch compressors mid-cycle while minimizing interruption to chest compressions (<1 s) (BLS-15). Pauses between 2-minute chest compression cycles to switch compressors should be as short as possible in order to minimize hands-off time, targeting less than 10 seconds (BLS-16).

5 | ADVANCED LIFE SUPPORT

ALS treatment recommendations are detailed in Table 1 and are described below in the explanation of the CPR algorithm. Doses for

TABLE 2 CPR dosage chart for dogs and cats.

Use	Intervention	Dose
Vasoconstriction	Epinephrine	0.01 mg/kg
	Vasopressin	0.8 U/kg
Vagolytic	Atropine	0.04–0.054 mg/kg
Antiarrhythmic	Lidocaine	2 mg/kg over 2–4 minutes
	Amiodarone	5 mg/kg over 2–4 minutes
	Esmolol	0.5 mg/kg over 3–5 minutes followed by CRI at 50 μg/kg/minute
Reversal	Naloxone	0.04 mg/kg
	Atipamezole	100 μg/kg
	Flumazenil	0.01 mg/kg
Buffer therapy	Sodium bicarbonate	1 mEq/kg
Electrical defibrillation	Biphasic defibrillator	External: 2–4 J/kg Internal: 0.2–0.4 J/kg
	Monophasic defibrillator	External: 4–6 J/kg Internal: 0.5–1 J/kg

Note: This table contains interventions at doses currently recommended for use in CPR in dogs and cats. Drugs should be administered IV or IO.
Abbreviations: CRI, constant rate infusion; IO, intraosseous.

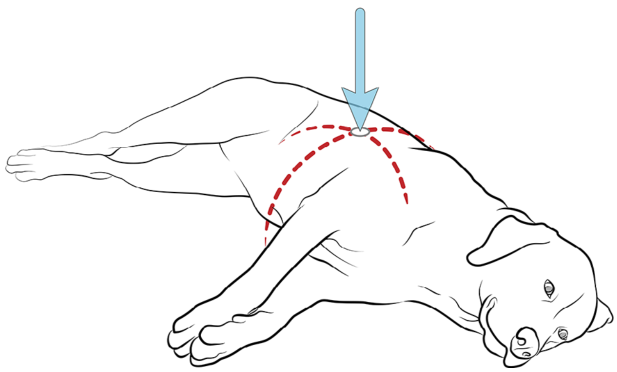

FIGURE 6 Round-chested dogs. Note the spherical shape of the thorax when the dog lies in lateral recumbency (red dashed lines). The arrow indicates the recommended compression point at the widest part of the thorax (thoracic pump). Illustration by Allison Buck, MFA, CMI, Medical Illustrator, Educational Support Services, Cornell University College of Veterinary Medicine). Figure 6 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

defibrillation and for drugs commonly used during CPR appear in Table 2.

6 | CPR ALGORITHM CONCEPT AND DEVELOPMENT

The main CPR algorithm for dogs and cats was updated along with the treatment recommendations (Figure 8). The algorithm was changed not only in substance but in design and purpose. The 2012 CPR algorithm contained diagrams and prose to teach CPR techniques to rescuers.[7] The revised version is designed as a cognitive aid to be referenced during CPR efforts in a clinical setting. A cognitive aid provides real-time guidance on performing a task or series of tasks,[20] and thus a streamlined appearance may be easier to reference quickly.

A draft algorithm was posted at recoverinitiative.org for a 4-week comment period during the summer of 2023 along with the treatment recommendations. Following this period, the Co-Chairs considered the comments and attempted to clarify the aid through reorganization of some elements. The finalized versions appear in these guidelines. Additionally, drugs and drug doses recommended during CPR in dogs and cats were updated (Table 2). We recommend that the algorithm and a drug dosing chart be posted or otherwise easily accessible in small animal clinical settings where CPR is likely to be performed such as the triage area, emergency room, ICU, anesthesia induction and recovery areas, surgical suite, cardiology procedure rooms, and other similar spaces.

7 | ALGORITHM TO IDENTIFY CARDIOPULMONARY ARREST AND START BLS

In response to public comments on the draft algorithm, the Co-Chairs created a separate algorithm to assist the veterinary professional in recognizing CPA (Figure 1). At the top of the flowchart, the rescuer finds a collapsed patient and is reminded to call out for team support ("Call for Help!"). The rescuer is then reminded to "Shake & Shout" to try to rouse the animal. If the animal responds, the patient has not experienced CPA and the rescuer should continue to the primary survey. If the animal is nonresponsive to stimulus, the rescuer is reminded to assess for regular breathing. If the animal is breathing regularly, it has not experienced CPA and the rescuer should continue

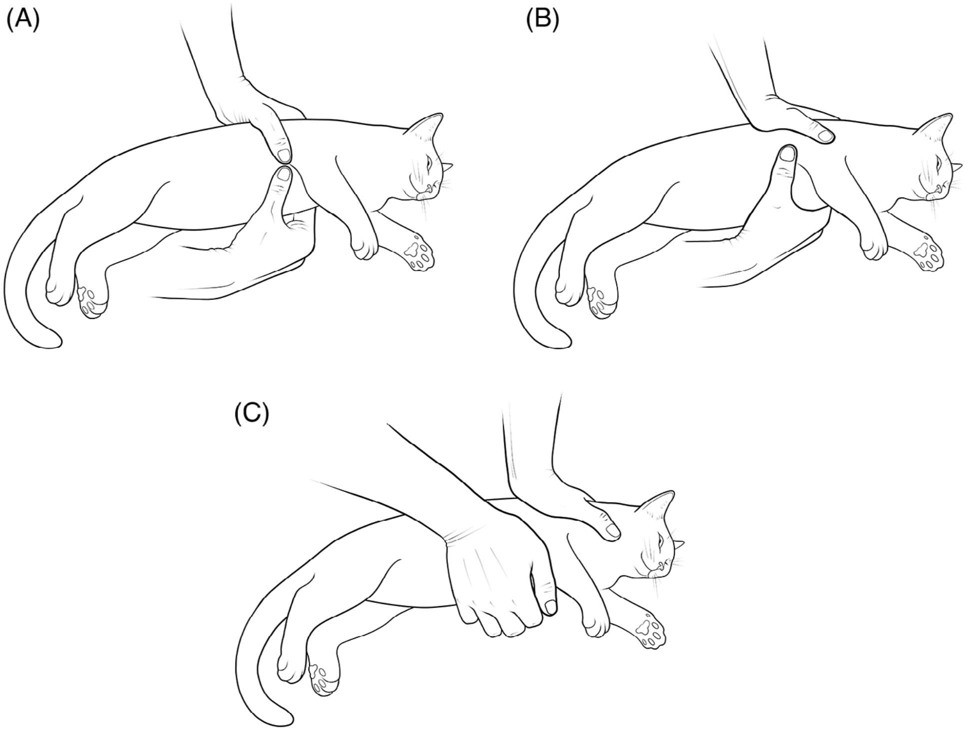

FIGURE 7 Different methods to deliver chest compressions in cats and small dogs. (A) The circumferential, 2-thumb technique compresses the heart between the thumbs and the opposing flat fingers of the ipsilateral hands. (B) The 1-handed technique compresses the heart between the thumb and the flat fingers of the dominant hand wrapped around the sternal portion of the thorax, while the nondominant hand braces the dorsal thorax. (C) The 1-handed heel technique compresses the heart under the heel of the dominant hand, while the nondominant hand braces the dorsal thorax. Illustrations by Chrisoula Toupadakis Skouritakis, PhD, MediaLab Services Director, Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California, Davis. Figure 7 © 2024 American College of Veterinary Emergency & Critical Care and Veterinary Emergency & Critical Care Society. All rights reserved. Reproduced with permission.

to the primary survey. Irregular breathing or agonal "gasps" should be classified as "No" for breathing.

When the rescuer deems an animal nonresponsive with no regular breathing effort, they immediately begin CPR (MON-11). A single rescuer proceeds down the left side of the chart to assess the animal's airway; if the airway is clear, the rescuer begins single-rescuer BLS immediately (BLS-11). If an upper airway obstruction is found, the rescuer should first clear the airway if deemed safe and begin single-rescuer BLS. If 2 or more rescuers are available when CPA is diagnosed, they proceed down the right side of the algorithm: Rescuer 1 begins chest compressions, while Rescuer 2 assesses the airway, clears it if necessary, and initiates ventilatory support (BLS-11). Single- and multi-rescuer BLS techniques are described in detail in Section 4.

8 | CPR ALGORITHM FOR DOGS AND CATS

This algorithm is for clinical settings in which endotracheal intubation is feasible and in which 3 or more rescuers are available (Figure 8). The explanation that follows is intended to lead the reader through the algorithm; the complete set of treatment recommendations appears in Table 1.

8.1 | Initiating BLS

Flow around the algorithm begins at the top at the blue box labeled "Start BLS." The rescuer starts a full 2-minute cycle of BLS, starting (1) chest compressions at 100–120/min (BLS-07). High-quality chest compressions should be administered in uninterrupted 2-minute cycles (BLS-08), while additional rescuers perform other interventions. Thus, while the first rescuer delivers chest compressions, another team member works to (2) intubate the animal in its current recumbency, tie in the ETT, and inflate the cuff; proper ETT placement can be confirmed with capnography (see Section 8.3 for details). Ventilation should begin at a rate of 10 bpm, or 1 breath delivered every 6 seconds (BLS-14). Each inspiration should last ~1 second, leaving 5 seconds for the expiratory phase (BLS-13). Ventilation may be done using a manual resuscitation bag or breathing circuit, such as from an anesthesia machine. Ventilating with 100% oxygen is reasonable, though ventilating using room air can be considered if a supplemental oxygen supply is not readily available; evidence regarding oxygen supplementation was not evaluated for this iteration of the RECOVER CPR Guidelines and therefore this information is based on a recommendation in people.[21] If using a manual resuscitation bag, it is imperative to select an appropriate size for the patient and ensure that the popoff valve is functional

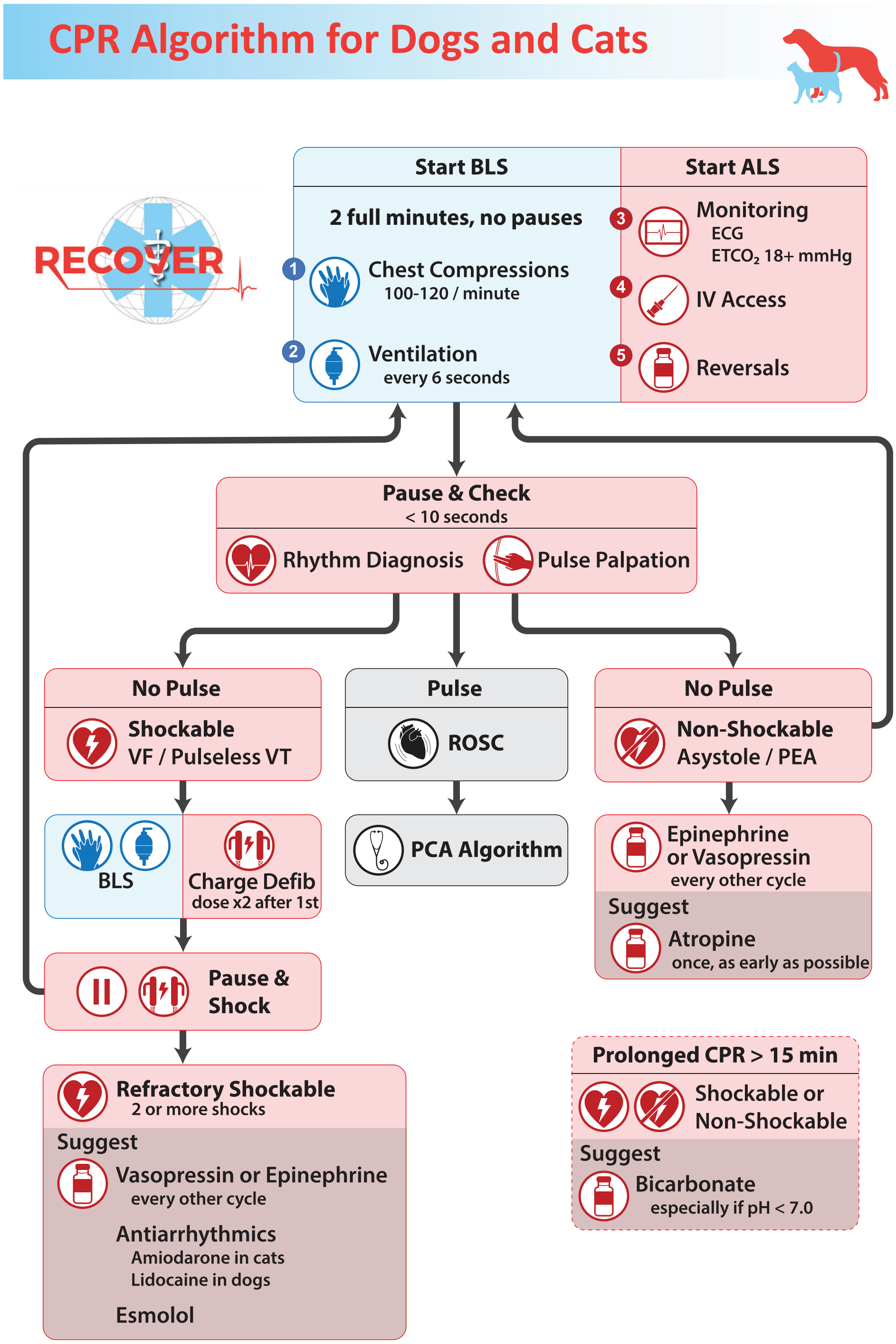

FIGURE 8 CPR Algorithm for Dogs and Cats. ALS, advanced life support; BLS, basic life support; Defib, electrical defibrillator; PCA, post-cardiac arrest; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia. Figure contributions by Allison Buck, MFA, CMI, Medical Illustrator, Educational Support Services, Cornell University College of Veterinary Medicine. Figure 8

to prevent overinflation of the lung. If using an anesthesia circuit, the popoff valve should be closed during the breath and the circuit pressure gauge should be used to deliver a peak airway pressure of 30–40 cm H_2O during chest compressions (BLS-19); this ensures adequate airway pressure to overcome chest compression pressure while minimizing the risk of barotrauma. Once the breath is delivered, the popoff valve should be opened until the next breath. During the brief pauses between chest compression cycles, the peak airway pressure should be kept to less than 20 cm H_2O on the pressure gauge when using an anesthesia circuit. Each breath should result in a visible but not excessive chest rise when evaluated during the “Pause & Check” (see below) (BLS-19). Once BLS is underway, rescuers beyond the first 2 should initiate ALS as soon as possible. With large enough teams, ALS can begin simultaneously with initiation of BLS.

8.2 | Initiating ALS

The first step of ALS is to begin (3) monitoring using an ECG and a waveform capnograph. Any ECG lead will suffice, and either sidestream or mainstream capnography is appropriate. Details about capnography appear in the following section. Vascular access (4) should be obtained. Direct intravenous access is preferable to intraosseous (IO) access if IV access is possible (ALS-14). If IV access cannot be obtained within 2 minutes, we suggest rescuers pursue IO catheterization while simultaneously continuing to attempt IV access if staffing allows (ALS-14). Intratracheal drug administration can be pursued if vascular access is not possible (2012-ALS09), though the IV or IO route is preferred to tracheal administration (see the 2012 RECOVER CPR Guidelines for details[7]). Any applicable reversal agents (5) should be administered as a final step of initiating ALS (ALS-13; 2012-ALS13); doses are listed in Table 2. These 5 steps to initiate CPR should be performed in the order indicated regardless of the cause of arrest; even if the CPA is associated with a reversible drug, simply reversing the drug will not result in ROSC. Spontaneous circulation can only be regained with adequate oxygen delivery to the heart. Thus, high-quality BLS in combination with appropriate rhythm diagnosis and ALS therapies such as defibrillation and vasopressor administration is always highest priority in animals with CPA regardless of cause. We recommend against the use of epinephrine in animals with shockable rhythms before the first defibrillation attempt (ALS-16); thus, epinephrine should only be considered during the first chest compression cycle in dogs and cats known to have a nonshockable rhythm at the time of arrest.

8.3 | Using capnographic information ($ETCO_2$)

As long as IPPV is maintained at a rate of 10/min with consistent tidal volumes, the measured $ETCO_2$ reflects the delivery of fresh aliquots of peripheral venous blood, relatively high in CO_2, into the pulmonary circulation. In other words, $ETCO_2$ becomes a measure of circulation rather than ventilation as long as IPPV technique remains consistent during CPR. We recommend continuous measurement of $ETCO_2$ to guide chest compression quality during CPR in dogs and cats (MON-07). We recommend optimizing chest compression quality and ALS interventions to achieve $ETCO_2$ no lower than 18 mm Hg during CPR in dogs and cats (MON-10).

Additionally, waveform capnography can be used to confirm ETT placement at the beginning of the CPR effort; consistent detection of CO_2 with the presence of a CO_2 waveform confirms placement in the airway (MON-01). Also, in dogs and cats with any CO_2 detection device in place (such as a capnometer without waveform), $ETCO_2 \geq 12$ mm Hg likely indicates proper ETT placement, while $ETCO_2 < 12$ mm Hg should lead the rescuer to confirm ETT placement by other means (eg, direct visualization, cervical palpation, cervical ultrasound) (MON-01). In intubated dogs and cats already undergoing CPR, when $ETCO_2$ is very low (eg, <5 mm Hg) despite high-quality chest compressions, we recommend confirmation of tracheal intubation by other means, such as direct visualization or chest auscultation during the pause between chest compression cycles (MON-01).

8.4 | Pause and check

Once the first full 2-minute chest compression cycle is complete, the team pauses for no longer than 10 seconds to evaluate the ECG as a group, while 1 team member palpates for a femoral pulse (BLS-16). Pulse check during the 10-second pause is required, as pulselessness should lead the team to continue CPR regardless of the ECG rhythm. Therefore, if enough personnel are available, 1 team member should begin palpating the pulse shortly before the Pause & Check and continue to palpate the pulse during the pause to minimize delays in restarting chest compressions. Chest compressions may generate palpable pulses, so pulselessness can only be definitively diagnosed after chest compressions have stopped. While presence or absence of a pulse determines whether or not to continue CPR, the ECG rhythm identified during pulselessness determines whether CPR efforts continue down the right or left pathway on the CPR Algorithm for Dogs and Cats (Figure 8). An algorithm for differentiating shockable and nonshockable ECG rhythms in pulseless animals is available as Figure 9.

8.5 | Patients with shockable rhythms follow the left path

For pulseless patients with VF (disorganized cardiac electrical activity) or PVT (regular ECG complexes at a rate >200/minute), the treatment is electrical defibrillation. Rescuers follow the left side of the chart by resuming chest compressions while the team readies the electrical defibrillator. We recommend using a biphasic defibrillator for electrical defibrillation (ALS-11). Initial external defibrillation dose with a biphasic defibrillator is ~2 J/kg (with a monophasic defibrillator, ~4 J/kg). Weight-based doses for defibrillation can be found in Table 2. Once the defibrillator is charged, the pads are covered with conductive electrode gel and applied to either side of the thorax over the area of the heart. All team members step away from the table and all associated equipment. The operator of the electrical defibrillator then calls “Clear!” and confirms that no team members are in contact with the patient, the table, or any associated equipment. Only then does the operator discharge the paddles. Immediately after electrical defibrillation, chest compressions are re-started for a full 2-minute cycle without evaluating the ECG rhythm, as directed by the far-left arrow directing the rescuers back to the top of the chart to the blue BLS “2 full minutes, no pauses” box. Although evidence of efficacy is minimal, if an electrical

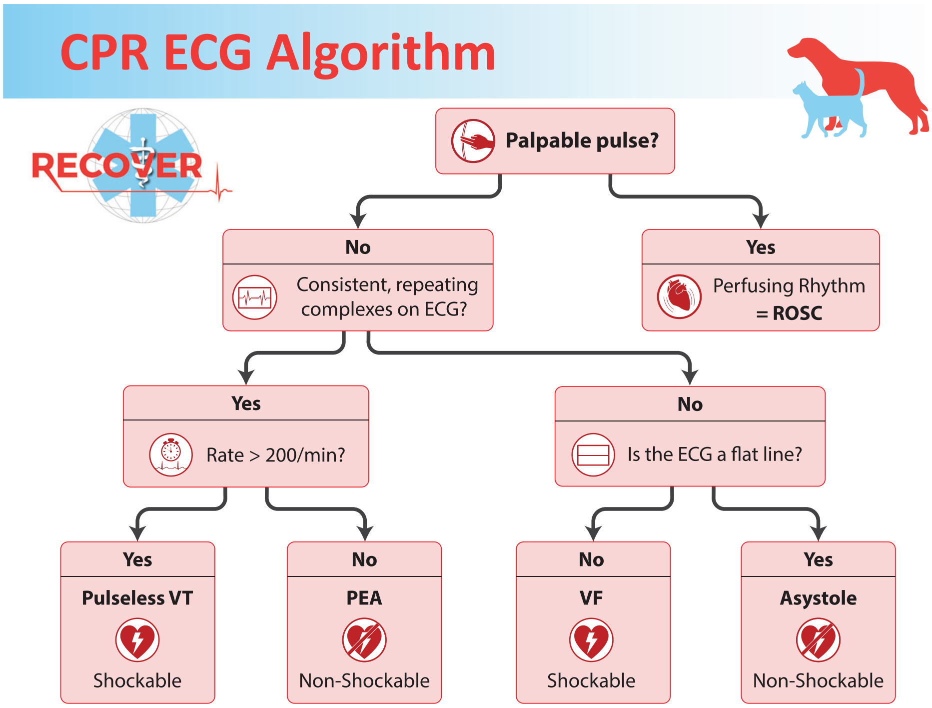

FIGURE 9 CPR ECG Algorithm. An algorithm for differentiating shockable and non-shockable ECG rhythms in pulseless animals. min, minute; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia. Figure contributions by Allison Buck, MFA, CMI, Medical Illustrator, Educational Support Services, Cornell University College of Veterinary Medicine. Figure 9

defibrillator is unavailable, a precordial thump may be attempted (see the 2012 RECOVER CPR Guidelines for details[7]).

8.6 | Patients with nonshockable rhythms follow the right path

After the initial 10-second pause, for pulseless patients with a nonshockable rhythm such as asystole (no cardiac electrical activity) or pulseless electrical activity (organized electrical complexes at a rate <200/min), CPR efforts proceed down the right side of the algorithm by resuming chest compressions immediately for a full, uninterrupted 2-minute cycle and administering vasopressors to achieve peripheral vasoconstriction and redirect blood flow from the periphery to the core organs. The recommended vasopressor is either 1 standard dose of epinephrine (0.01 mg/kg; ALS-06) or 1 dose of vasopressin (0.8 U/kg) IV or IO, given every 3–5 minutes, while a nonshockable rhythm persists in the pulseless animal (ALS-07). If the team believes that high vagal tone may be contributing to the CPA event in an animal with a nonshockable rhythm, it is appropriate to administer a single dose of atropine (0.04–0.054 mg/kg) IV or IO once during the CPR event, as early as possible (ALS-09). In the US veterinary market, atropine is commonly available in 0.4–0.54 mg/mL concentrations; because the dosing range of atropine has some variability, it is acceptable to use 0.1 mL/kg body weight within this common concentration range. Atropine should not be repeated (ALS-09, ALS-19).

8.7 | Circling back to pause and checks

After each full 2-minute chest compression cycle, the algorithm reaches the "Pause & Check" box; the team views the ECG as a group, while 1 team member palpates for a femoral pulse. Each team member states aloud their interpretation of the ECG rhythm and chest compressions commence within 10 seconds (BLS-16), while the team decides as a group whether to follow the left "shockable" pathway or the right "nonshockable" pathway.

If the team has followed the left pathway because the pulseless animal has a shockable rhythm, performed an electrical defibrillation, completed a full 2-minute chest compression cycle, reached the red "Pause & Check" box again, and determined that the animal remains pulseless with a shockable rhythm of either VF or PVT, the shockable rhythm is deemed to be refractory. Chest compressions resume within 10 seconds, while the electrical defibrillator is again prepared, doubling the initial dose administered for external defibrillation (ALS-12). After defibrillation, chest compressions resume immediately for a full, uninterrupted 2-minute cycle without evaluating the ECG. The team may consider additional treatments for refractory shockable rhythms; these treatments can include vasopressin 0.8 U/kg (or epinephrine 0.01 mg/kg if vasopressin is not available) IV or IO every 3–5 minutes (ALS-16; ALS-07). Co-administration of esmolol (0.5 mg/kg IV or IO over 3–5 min followed by a CRI at 50 µg/kg/min) is suggested (ALS-03) to mitigate the pro-arrhythmogenic beta effects of endogenous and exogenous catecholamines. Additionally, lidocaine is suggested for

BOX 2: High-priority knowledge gaps in canine and feline CPR in the areas of BLS, ALS, and Monitoring

BLS

- It is unknown whether airway assessment and initiation of ventilation should be prioritized over chest compressions in dogs and cats with suspicion for a respiratory cause of CPA. Studies in dogs and cats comparing these 2 approaches ("Circulation-Airway-Breathing" vs "Airway-Breathing-Circulation") are needed.
- There is no clinical evidence to support a specific chest compression rate in dogs or cats.
- The ideal duration of manual, continuous chest compressions before switching rescuers in dogs and cats undergoing CPR is uncertain, particularly considering the wide variety in patient size and chest conformation in these species. The ideal length of a chest compression cycle may vary depending on patient size and shape.
- It is unclear whether healthcare providers are able to assess themselves and others for leaning during the recoil phase of CPR in dogs and cats.
- There is no evidence regarding the interruption of 2-minute chest compression cycles in dogs and cats when ROSC is suspected.
  - Complication type and frequency when chest compressions are administered to animals not in CPA are uncertain.
- It is unknown whether performing chest compressions with the hands flat versus interlaced fingers, or the dominant versus nondominant hand in contact with the patient, affects critical outcomes in dogs and cats.
- There is very little evidence regarding optimal ventilation rate during CPR in any species.

ALS

- The appropriate dosing interval of epinephrine in dogs and cats with nonshockable CPA rhythms is unknown.
- It is unknown whether use of vasopressin (or other vasoconstrictor) improves critical outcomes in dogs and cats in CPA with a shockable rhythm at any stage (early or late).
- It is unknown whether the combination of esmolol and epinephrine may be superior in dogs and cats than epinephrine alone.
- There are no studies evaluating the utility of atropine in dogs and cats with high vagal tone and/or bradycardia at the time of the arrest.
- The optimal timing for initiation of open-chest CPR - for dogs and cats with CPA is unknown.

MON

- It is unknown whether use of colorimetric CO_2 detection devices in dogs and cats would allow faster or more accurate confirmation of ETT placement within the trachea.
- It is unknown whether esophageal detection devices may help determine correct ETT placement, which is of particular interest in brachycephalic dogs and other animals in which direct visualization of the glottis is impossible.
- The design of the currently available pulse oximeter probes does not make them amenable to continuous monitoring of awake veterinary patients; development of probes that can be used in a continuous manner in veterinary species is encouraged.
- There are very limited experimental and no clinical data regarding the utility of direct blood pressure monitoring (for any target measure including DBP) in dogs or cats.
- Retrospective reports of clinical data regarding the usefulness of direct arterial blood pressure monitoring in dogs and cats undergoing CPR would be helpful to determine whether experimental studies in asphyxial models in dogs and cats could be justified.

dogs (2 mg/kg IV or IO; ALS-01) and amiodarone is suggested for cats (5 mg/kg IV or IO; ALS-02) for refractory shockable rhythms. Antiarrhythmics should be administered over 2–4 minutes. The CPR Algorithm for Dogs and Cats (Figure 8) lists these medications in a box titled "Refractory Shockable." It should be noted that the algorithm is a cognitive aid designed to help the rescuer remember to consider these medications after they have delivered at least 2 shocks for refractory shockable arrest rhythms and is not intended as a definition. Shockable arrest rhythms are considered refractory when they remain shockable after delivery of a single shock followed by a full 2-minute cycle of chest compressions.

For dogs and cats undergoing prolonged CPR in excess of 15 minutes, IV or IO sodium bicarbonate therapy can be considered, particularly if a measured blood pH is <7.0 (2012-ALS16) (see the 2012 RECOVER CPR Guidelines for details[7]).

8.8 | Discontinuing CPR for ROSC

If the team reaches the "Pause & Check" box and a femoral pulse is palpable during the 10-second pause, ROSC has been achieved and the team follows down the center gray PCA Algorithm pathway.[7] If ROSC is suspected during a chest compression cycle, we suggest interrupting the 2-minute cycle *only* when there is both (1) a sudden and persistent increase in $ETCO_2$ (eg, by $\geq$10 mm Hg to reach a value that is $\geq$35 mm Hg) and (2) evidence of an arterial pulse palpated distinct from chest compressions (BLS-17). In the absence of capnography data, we recommend against interruption of a 2-minute chest compression cycle even if ROSC is suspected (BLS-17).

Additional treatment recommendations for MON and ALS, including for open-chest CPR, are found in Table 1 and in the respective domain papers.[14,16] Table 1 contains all treatment recommendations, including those that do not appear in the CPR Algorithm for Dogs and Cats.

9 | DISCUSSION

The treatment recommendations contained herein resulted from exhaustive evaluation, analysis, and summary of evidence relating to BLS, ALS, and CPR-pertinent monitoring in many species. Veterinary experts worked together to tailor these recommendations to dogs and cats based on a combination of this evidence evaluation, analysis, and summary as well as expert opinion where inadequate evidence was available. Treatment recommendations were posted for feedback from the veterinary community, and feedback was used to create these final recommendations. For the first time in veterinary medicine, we used the GRADE approach to evidence evaluation, extended to include experimental animal studies since many of these studies were performed in our species of interest.[11]

The extensive literature search and evidence evaluation processes revealed numerous important knowledge gaps in most areas of canine and feline CPR. Moving forward, we intend to update individual CPR treatment recommendations on a continual basis in smaller sections as new questions and evidence arise. Box 2 contains a list of the RECOVER Initiative's highest priority knowledge gaps as of this writing for the domains of BLS, ALS, and MON.

The vast majority of the evidence used to create treatment recommendations was indirect in population; in other words, very few studies were conducted in dogs or cats, and nearly all nonhuman studies were experimental. Many studies were also indirect in intervention and comparator as well, and many studied different outcomes than our PICO questions specified. This indirectness reduced the level of evidence available to support most treatment recommendations in these guidelines.

We believe that veterinary teams can use the treatment recommendations contained in these guidelines to deliver high-quality CPR in dogs and cats that experience CPA. However, the principles and practices recommended herein are more likely to lead to positive patient outcomes when paired with interactive training and hands-on practice.[22] Therefore, we strongly recommend that veterinary professionals engage in simulator-based training sessions to improve their motor skills and to make routine the application of these principles during CPR.

A CPR registry has been developed to provide important clinical data on CPR practices and outcomes across many veterinary environments in the future.[23]

AUTHOR CONTRIBUTIONS

Jamie M. Burkitt-Creedon: Conceptualization; Formal analysis; Investigation; Methodology; Project administration; Supervision; Writing—original draft; Writing—review & editing. **Manuel Boller**: Conceptualization; formal analysis; funding acquisition; investigation; methodology; writing—original draft; writing—review and editing. **Daniel J. Fletcher**: Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Supervision; Writing—original draft; Writing—review & editing. **Benjamin M. Brainard**: Formal analysis; Investigation; Supervision; Writing—review & editing. **Gareth J. Buckley**: Formal analysis; Supervision; Writing—review & editing. **Steven E. Epstein**: Formal analysis; Investigation; Supervision; Writing—review & editing. **Erik D. Fausak**: Data curation; Investigation; Methodology; Writing—review & editing. **Kate Hopper**: Formal analysis; investigation; supervision; writing—review and editing. **Selena L. Lane**: Formal analysis; Investigation; Supervision; Writing—review & editing. **Elizabeth A. Rozanski**: Formal analysis; Investigation; Supervision; Writing—review & editing. **Jacob Michael Wolf**: Formal analysis; methodology; supervision; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

Drs. Burkitt-Creedon, Brainard, and Epstein are editors of the Journal but only participated in the review process as authors. The authors declare no other conflicts of interest.

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ENDNOTE

[a] www.RECOVERinitiative.org (Accessed on March 19, 2024).

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