ANIMAL MEDICAL CENTER of SEATTLE
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CPR – A brief review of closed-chest CPR

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The RECOVER initiative was developed in 2012 by a group of veterinary and human specialists to provide an evidence-based, consensus CPR guideline for small animals. A brief review of the most important components of the RECOVER initiative will be reviewed here. Please note that the RECOVER guidelines are free to download at the Journal of Veterinary Emergency and Critical Care website: https://veccs.org/recover-cpr/

The diagnosis of cardiopulmonary arrest (CPA) is based on the presence of lack of breathing, absence of a palpable pulse and unconsciousness. Assessment of a suspected CPA patient should be rapid (ideally no >10-15 seconds to complete) and followed by immediate intervention to restore airway, breathing and circulation. There is evidence that initiation of CPR immediately in a patient with CPA outweighs the risks of performing CPR on an unresponsive patient not in CPA, therefore there should be no delay if there is suspicion of CPA.

Basic life support (BLS) includes restoration of circulation (chest compressions) and ventilation (airway and breathing). The goals of chest compressions are to provide the following: pulmonary blood flow for O_2 uptake and CO_2 elimination and tissue perfusion for delivery of O_2 to the tissues. At best, chest compressions only provide 20-30% of the cardiac output; therefore technique is critical to providing enough cardiac output. Chest compressions are generally done with the patient in lateral recumbency with a compression depth of 1/3 – 1/2 the width of the chest at a rate of 100-120 compressions per minute. The use of a metronome or "Staying Alive" by the Bee Gees can help to ensure the correct compression rate. Interruptions should only occur when a new compressor is taking over due to compressor fatigue or when exchanging compressor after a 2 minute BLS cycle. This is because it can take approximately 60 seconds of continuous chest compressions before coronary perfusion pressure (CPP) reaches a maximum with the CPP being a critical determinant of myocardial perfusion pressure (MPP). Use of the cardiac pump mechanism (direct compression of the left and right ventricles to increase ventricular pressure and opening of the pulmonic/aortic valves to provide blood flow to the lungs and tissues) is recommended in small dogs and cats. Recoil of the thorax between compressions is of utmost importance in regards to creating negative intrathoracic pressure to improve ventricular filling. Use of the thoracic pump mechanism (external chest compressions raise intrathoracic pressure to force blood from intrathoracic vessels into systemic circulation with the heart acting as a passive conduit) is recommended in medium and large dogs. Barrel-chested dogs will benefit most from compressions over the sternum while in dorsal recumbency. Locked elbows during compressions and utilization of the core muscles (as opposed to biceps and triceps) will ensure adequate compression force and reduction of compressor fatigue.

Endotracheal tube intubation should and can be done simultaneously with cardiac compressions – with mouth to snout ventilation provided only in cases where endotracheal tube intubation is impossible. Ventilation is done at a rate of 10 breaths per minute with an inspiratory time of 1 second and a tidal volume of 10 mL/kg. Hyperventilation should be avoided as it can lower the arterial CO_2, which can lead to cerebral vasoconstriction, decreasing O_2 delivery to the brain and leading to cerebral ischemia.

Advanced Life Support (ALS) focuses on monitoring, drug therapy +/- electrical defibrillation. Intravenous (IV) or intraosseous (IO) routes of drug administration are preferred. Placement of an IV/IO catheter should not interfere with BLS. The most effective tools for monitoring return of spontaneous circulation (ROSC) is with the ECG and end tidal CO_2 monitor ($ETCO_2$). All other monitors (i.e. SpO_2 and indirect blood pressure monitoring) will not provide adequate information in regards to ROSC due to patient movement/artifact during CPR efforts as well as their dependence on

pulsatile flow. The most common arrest rhythms identified on an ECG include: asystole, pulseless electrical activity (PEA), ventricular fibrillation (VF) or pulseless ventricular tachycardia (pulseless VT). Only VF and pulseless VT are shockable arrest rhythms. The goal of electrical defibrillation is to terminate the ventricular myocardial cell activity to allow the pacemaker to "reset" and take over in order to provide more coordinated contractions. If duration of VF is not known or is ≤4 minutes, cardiac compressions are done until the defibrillator is charged with immediate defibrillation done after successful charge. If the VF duration is thought to be ≥4 minutes, one full cycle of CPR should be done before defibrillation to allow myocardial cells to generate enough energy substrate to restore a normal membrane potential.

ECG evaluation should be done at rotation of the 2-minute BLS cycles. Communication in regards to the arrest rhythm during this brief pause should be announced by the group leader. Should there be disagreement on the ECG rhythm, cardiac compressions should be re-instituted whilst discussion about the rhythm diagnosis is done without delay in BLS. $ETCO_2$ provides information in regards to ROSC as its value is proportional to pulmonary blood flow and can help to determine chest compression efficacy. A dramatic increase in $ETCO_2$ (usually >15 mmHg) has been suggested to indicate ROSC. A $ETCO_2$ <15 mmHg may suggest inadequate chest compressions or compressor fatigue suggesting that the compressor either needs to improve their compression rate or the compressor should be rotated.

Depending on the suspected cause of CPA, use of vasopressors, parasympatholytics, reversal agents or anti-arrhythmics may be used. Regardless of the cause of the CPA, vasopressors are used to increase peripheral vasoconstriction. Based on the RECOVER initiative, the use of low doses of epinephrine is recommended initially (0.01 mg/kg IV/IO every other 2-minute BLS cycle) with prolonged CPR (>10 minutes) being the only indication to use high-dose epinephrine (0.1 mg/kg IV/IO every other 2-minute BLS cycle). Interchangeable use of epinephrine with vasopressin can improve vasoconstrictive effects. Vasopressin may be useful in acidic environments where α1 receptors become unresponsive to epinephrine. Vasopressin acts on peripheral V1 receptors as opposed to β1 receptors, therefore does not cause an increase in myocardial oxygen consumption and worsening of myocardial ischemia that can be seen with epinephrine upon ROSC. Atropine is indicated in patients suspected to have arrested due to PEA associated with increased vagal tone or with asystole; unfortunately there are very few studies to show a beneficial effect in the use of atropine during CPR in both the veterinary and human literature. The drugs described above can be administered via ET tube, should IV/IO access not be possible. Reversal agents are used if indicated: Naloxone to reverse opioids, flumazenil to reverse benzodiazepines and atipamezole/yohimbine to reverse α2 agonists.

The use of IV fluid therapy is only indicated in a patient suspected to be hypovolemic. Use of IV fluids in euvolemic or hypervolemic patients should be avoided, as it leads to an increase in right atrial pressure, which results in a decrease in cerebral and myocardial perfusion. The routine use of corticosteroids is not recommended at this time due to the documented risks outweighing the benefits. Patients with prolonged CPA (>10-15 minutes) may benefit from $NaHCO_3$ therapy.

As a general rule, when CPR fails to lead to ROSC after 15-20 minutes, efforts are discontinued. If a patient has achieved ROSC, immediate consultation/referral to a specialty referral center with a critical care specialist is recommended due to the intricacies associated with post-ROSC care. Post-CPA complications include: hypotension/hypovolemia, arrhythmias, respiratory failure, and organ dysfunction. Unfortunately, the success rate in veterinary medicine for ROSC after CPA and CPR is low (13-15%) with a rate of hospital discharge from a successful CPR being <16%.

References available upon request

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