Cardiopulmonary Resuscitation: Approach and Impact of the Recover Guidelines

Edward Cooper, VMD, MS, DACVECC
Associate Professor – Clinical Emergency and Critical Care
The Ohio State University

Cardiopulmonary Arrest

“The abrupt and complete failure of the respiratory and circulatory system. Results in the cessation of blood flow, leading to tissue hypoxia and cell death.”

CPR Success in Small Animals

- Return of Spontaneous Circulation (ROSC)
  - Dogs: 28%
  - Cats: 42%

- Survival to discharge from the hospital
  - Dogs: 3-6%
  - Cats: 2.3 - 9.6%

- Animals that arrest under general anesthesia have the best chance at a positive outcome

CPR Success in Small Animals

- Low survival to discharge questions utility of CPR, esp for some patients
- Default directive is often to perform CPR until owner is contacted
- May perform unnecessary CPR
  - Associated with significant cost to owner
  - Associated with false hope/expectations
- Need to have an informed discussion and establish a code!
  - Especially if high risk of death or anesthesia
Predisposing Causes of CPA
- H's
  - Hypovolemia
  - Hypoxia
  - H+ (acidemia)
  - Hypercarbia
  - Hypo/hyperkalemia
  - Hypoglycemia
  - Hypothermia
- T's
  - Toxins/tablets
  - Trauma
  - Tampanode
  - Tension
  - Pneumothorax
  - Thrombosis
  - (pulmonary/cardiac)

Goal of CPR?
- Delivery of oxygen to the cells
- Maintain perfusion to the organs
- Brain
- Lungs
- Heart
- General circulation
- Reversing the cause of the CPA
- Waiting for...
- Return Of Spontaneous Circulation = ROSC

Emergency Preparedness
- Readily available, well stocked crash cart
  - Noted to be the cause in delay of CPR in 18% of cases
- Routine training of staff
  - Standard training focused on didactic and hands-on skills
  - Repeat every 6 months
- Delegation of team responsibilities
- Debriefing following arrest events

Recommended Crash Cart Items
Supplies:
- Endotracheal tubes (various sizes)
- Laryngoscope
- Manual resuscitator (Ambu) bag
- Electrocardiogram (ECG) monitor/defibrillator
- Capnograph
- Pressure bag for rapid fluid infusion
- Hypodermic needles (various sizes)
- Intravenous catheters
- Tape (½", 1", 2")
- Roll of gauze (2")
- Suture material
- Three-way stopcocks

Medications:
- Epinephrine
- Vasopressin
- Atropine
- Lidocaine
- Calcium gluconate
- 50% dextrose
- Isotonic crystalloids

Basic Life Support
- Recognition of CPA
- Administration of chest compressions
- Airway management
- Provision of ventilation

Recognition of CPA
- “Look, listen, and feel”?
  - Valuable time lost finding a pulse
  - Agonal breaths interpreted as “normal” breathing
- Just begin chest compressions in unresponsive, gasping patient
  - Risk of causing significant harm is low
Chest Compressions

- Compression Rate
  - 100-120 compression/minute
  - Sing in your head
    - "Stayin Alive"
    - "Another One Bites the Dust"

Chest Compression Quality

- Compression Depth
  - 1/3 – 1/2 width of the thorax
  - Target depth correlated with cardiac output and mean aortic pressures

- Compression:Relaxation time
  - Extremely important for cardiac filling
  - 1:1 to allow full chest wall elastic recoil
    - Lift the heel of the palm off the chest wall

- Rescuer hand position
  - Cardiac pump theory
    - Direct compression of the ventricles between the spine and sternum or rib cage
    - Hand placed over heart, cupped around thorax, or encircling the chest
    - Ideal method in:
      - Cats
      - Small dogs
      - Keel-chested dogs
      - Barrel-chested dogs

- Thoracic pump theory
  - Compression delivered over widest portion of chest
  - Alterations in intrathoracic pressure lead to forward flow
    - Ideal method in:
      - Medium – large breed dogs

- Under ideal conditions can only generate 25-30% of normal cardiac output
- Prevent rescuer fatigue
  - Stand above patient
  - Lock elbows
  - Bend at the waist
  - Use entire upper body, not just arms!

Internal Cardiac Compressions

- Indications
  - Large dogs (>30 kg)
  - Pleural space disease
  - Pericardial effusion
  - Major chest trauma
  - External chest compression unsuccessful
  - Reversible cause of cardiac arrest
- Improved cardiac output achieved
- Increased morbidity if ROSC attained
Interposed Chest & Abdominal Compressions
- With appropriate trained personnel can improve venous return and cardiac output
- Alternate chest and abdominal compressions
  - Important not to do at the same time!
- Experimental evidence suggests no significant intra-abdominal trauma from compressions
  - Avoid in animals with abdom trauma or hemoabdomen

CPR Cycles
- Uninterrupted chest compressions lasting 2 minutes result in better survival
  - Avoid temptation to stop for frequent checks of ROSC!!
- At the end of each cycle change person performing chest compressions
  - Compressor fatigue – 2 minutes is long!
  - Compression rate, depth and effectiveness deteriorate over time

Ventilation
- Non-invasive
  - Mouth-to-snout
  - Tight fitting mask
- Invasive
  - Endotracheal intubation
  - Preferred whenever possible
  - Intubation should occur simultaneously with the institution of chest compressions
  - Intubation efforts should not delay compressions!!!
  - May need suction if fluid accumulation

Ventilation
- Goals
  - Optimize oxygenation
  - Avoid hypo- or hypercapnia
  - Minimize impedance to blood flow
- Recommendations
  - 10 breaths/minute
  - 10 ml/kg tidal volume
  - 1 sec inspiratory time
  - Hyperventilation can be harmful!!!
  - If not intubated – 30 compressions, 2 breaths

Advanced Life Support
- Drugs
- Correction of acid-base and electrolyte derangements
- Resolution of volume deficits
- Electrical defibrillation
- Provision of oxygen
- Miscellaneous interventions

Drug Therapy
- Potential routes of Delivery
  - Intravenous – peripheral
    - Percutaneous vs cut-down
    - Confirm existing catheter works!
  - Intravenous – central
  - Intraosseous
  - Intratracheal
Intravenous Drug Delivery

- Peripheral
  - Follow with fluid bolus to get drug into central circulation
  - Challenging to place if no access available
  - May require cut down to obtain access
- Central
  - Preferred method because higher concentrations enter central circulation
  - Central line permits sampling for ScvO₂
  - Difficult/time consuming to place
  - May require cut down to obtain access

Intraosseous Drug Administration

- Catheter permits access to non-collapsible venous plexus
- Anything given IV can also go IO!
- Supplies
  - Hypodermic needles
  - Bone marrow needle
  - EZ-IO drill

Intratracheal Drug Delivery

- Most resuscitation drugs can be delivered this route
  - EXCEPTION: SODIUM BICARB
- Double – triple the IV dose
- Administer through a red rubber catheter
- Chase with small amount of 0.9% NaCl

Vasopressor Therapy

- Peripheral vasoconstriction “cores” blood flow to vital organs
- Epinephrine
  - Catecholamine
    - α₁ – vasoconstriction
    - β₁ – inotropy and chronotropy
    - Increases myocardial oxygen consumption, myocardial ischemia, and risk of arrhythmias
  - Dose (1:1000 or 1 mg/ml concentration)
    - Low – 0.01 mg/kg IV
    - Currently recommended in most arrest situations
    - Can be repeated every 2-4 minutes
    - High – 0.1 mg/kg IV
    - Increased ROSC?
    - May worsen neurologic outcome
    - Consider high dose in prolonged CPR
    - Epi administration associated with increased ROSC, but has not been shown to result in increased survival to discharge!

Vasopressor Therapy

- Vasopressin
  - Nonadrenergic vasopressor
    - V1 receptor on vascular smooth muscle
  - Theoretical benefits
    - Efficacy in the face of acidosis
    - No positive inotropic or chronotropic effects
  - Acceptable alternative to initial or second dose of epinephrine ("non-inferior")
    - Removed from current human guidelines
  - Dose: 0.8 U/kg for one time administration
Parasympatholytic Therapy
- Atropine
  - Not recommended for routine use in people
  - No vasoconstriction
  - Significant tachycardia, O2 demand in ROSC
  - Increased vagal tone is thought to contribute to CPA in small animal patients
  - No clear detriment discovered in literature review
  - Consider using if suspect vagal arrest, or with prolonged CPR
  - Dose: 0.04 mg/kg IV q 3-5 minutes

Arrest Rhythms
- Asystole
- Pulseless Electrical Activity
- Ventricular Fibrillation

Electrical Defibrillation
- Most effective therapy for VF and pulseless VT
- Stop chaotic fibrillation waves and hope normal pacemaker activity resumes
- Not reanimating heart with electricity!!!
- Modern Defibrillators
  - Monophasic – unidirectional current flows from one electrode to the other
  - Biphasic – current initially flows in one direction then reverses and flows in the opposite direction

Biphasic now the standard of care in people
- Effectively terminate VF at lower doses
- Induces less myocardial injury
- Limited clinical reports of use in veterinary patients – now recommended by RECOVER
- Dose
  - Monophasic: 4-6 J/kg
  - Biphasic: 2-4 J/kg

Defibrillation Technique
- Apply conductive paste to paddles (no alcohol!!)
- Paddle placement - dorsal recumbency
  - Place on each side of thorax at costochondral junction
  - Press firmly against thorax
- Paddle placement - lateral recumbency
  - Posterior paddle placement under patient with other paddle positioned over top
- “Clear” CPR participants prior to discharge
- Quickly assess ECG for impact
- Resume compressions

Defibrillation Sequence
- Single defibrillation followed by 2 minutes high quality chest compressions
  - Myocardial perfusion increases chances of conversion with subsequent defibrillations
  - Epinephrine also increases success of defibrillation
- Reassess ECG after 2 minutes
  - 20% refibrillation rate at 6 seconds
  - 72% refibrillation rate at 60 seconds
Reversal Agents

- Naloxone
  - Opioid toxicity
    - Pure mu (morphine, hydromorphone, oxymorphone, methadone, and fentanyl)
    - Reversal of endogenous opioids?
- Flumazenil
  - Benzodiazepines (diazepam, midazolam, lorazepam)
- Yohimbine/Atipamezole
  - Alpha-2 Agonists (xyalzine, dexmedetomidine)

Miscellaneous Therapies

- NaHCO₃
  - Administered to correct acidosis in an effort to optimize catecholamine responsiveness
  - Not recommended for routine use in CPR
  - Consider after 15 minutes of CPA
  - Dose 1 mEq/kg
- Calcium gluconate
  - Only if documented ionized hypocalcemia or severe hyperkalemia associated with arrest
  - May improve cardiac and smooth muscle function

Monitoring Effectiveness of Compressions

- Capnography
  - Reflects peripheral perfusion and return of CO₂ to pulmonary circulation
  - The higher the ETCO₂, the better the circulation
  - ET CO₂ > 15-20 mmHg associated with increased likelihood of ROSC
  - Most useful monitoring tool during CPR
- Transcorneal Doppler
  - Evaluates carotid artery blood flow?
  - Not currently recommended
- Palpation of femoral pulses?
  - Venous vs arterial pulses?
  - Not currently recommended

Miscellaneous Therapies

- Corticosteroids
  - No demonstrated benefit of high-dose steroids during arrest or with ROSC
  - May cause greater harm
- Intravenous Fluids
  - Contraindicated in euvolemic or hypervolemic patients
  - Decrease coronary and cerebral perfusion pressures
  - Consider in patients with hypovolemia as underlying cause of arrest
  - “Shock doses” of crystalloid or colloid

CPR Emergency Drugs and Doses

Post-Arrest Care

- Most patients who survive CPA will not survive to be discharged from the hospital
- Post-arrest systemic inflammatory response
  - Cardiogenic shock
  - Anoxic brain injury
  - Multiple organ failure
  - Death
Post-Arrest Care

- Address underlying cause of arrest
- Optimize
  - Hemodynamic parameters
    - HR, BP, Hb, lactate,
  - Oxygenation/ventilation
    - PaO$_2$/SpO$_2$, PCO$_2$
  - Neurologic status
    - Mentation, seizure management

In Summary

- Be prepared!
- Reverse the reversible
  - Turn off gas!
  - Opioids – naxalone, Benzo – flumazenil, a2 - antecedan
- High quality chest compressions are key!
  - 100-120/min
  - 1/3 – 1/2 thoracic diameter compression depth
  - 1:1 compression:relaxation
- Ventilation
  - 10 breaths/min
  - 10 ml/kg tidal volume
  - 1 sec inspiratory time

In Summary

- Advanced life support
  - Vasopressors – low dose epi vs. vasopressin
  - Atropine o.k. if increased vagal tone
  - Biphasic defibrillation preferred for VF
- Monitoring
  - ECG
  - End-tidal CO$_2$
- Post-arrest period
  - Optimize hemodynamic status
  - Maintain normoxia and normocapnia
  - Neuroprotective strategies
    - Slow rewarming, hyperosmolar agents, barbiturates