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Post-Cardiac Arrest Care

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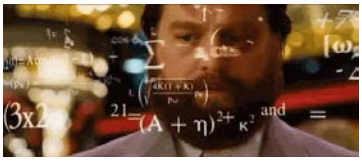
CARE Charlotte, Fall CE

November 2019

What Are You Thinking Doc?



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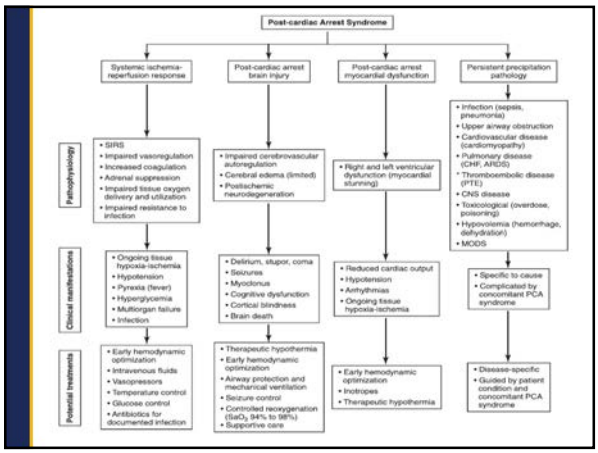

Post-Cardiac Arrest Syndrome (PCA)

- Combination of:
  - Multi-organ failure
  - Cardiogenic shock
  - Anoxic brain injury
  - Sequela of preexisting diseases
- Successful resuscitation to discharge requires multifaceted therapeutic interventions

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Introduction

- First goal is to get them back (ROSC; return of spontaneous circulation)
- Humans
  - 60-70% experiencing ROSC will not survive to discharge
- Veterinary Medicine
  - 2-10% will survive to discharge after ROSC
  - ROSC rates of 35-45%
- PCA (post cardiac arrest syndrome) is the suspected likely cause of the lack of survival
- RECOVER guidelines highlight PCA (Recover Part 6) and current literature review

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Post-Cardiac Arrest Syndrome (PCA)

- Two patterns of care during the PCA phase
- One aims at pathophysiologic processes that occur in the post-resuscitation phase
  - Ischemia and reperfusion (IR) injury
  - PCA brain injury
  - PCA myocardial dysfunction
  - Persistent precipitating pathologic conditions
- Second pattern responds to a shift in treatment prioritization as time after ROSC progresses

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Propagating Sustained ROSC

- Majority of dogs and cats die within the first few hours
  - Due to re-arrest
- Immediate goals after ROSC:
  - Sustain spontaneous circulation
  - Maintain perfusion of vital organs
  - All to prevent further injury and arrest
  - Think about the brain and the mycocardium
- Best to use all the monitors!
  - ETCO2, BP, HR/ECG, temp, SpO2
- Obtain new baseline data points
  - PCV, TS, BG, electrolytes, blood gas

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Propagating Sustained ROSC

- Utilize vasopressor support as needed
- Ventilatory assistance
  - Almost always necessary during the immediate ROSC phase
  - Either manual or mechanical
  - Target PaCO2 of 32 to 43 mm Hg in dogs and 26 to 36 mm Hg in cats.
- Sustained ROSC for 20 to 40 minutes?
  - Now direct attention towards prevention of further organ injury
  - Titrate supportive care to the needs of the patient

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Key Concepts of PCA

- Hemodynamic optimization → targeted fluid therapy for each patient
- Maintaining normoxemia → avoiding hyperoxemia or hypoxemia
- Maintaining mild hypothermia → avoid overheating
- Low-dose corticosteroids treatment → if persistent hypotension requiring vasopressors exists
- Hypertonic saline → for suspected cerebral edema
- Optimization of PCA care has the potential to save lives

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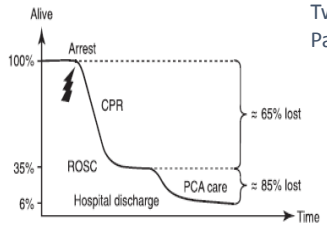
Epidemiology of Veterinary CPR

Two Phases of Patient Losses



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Hofmeister EH, Brainard BM, Egger CM et al; JAVMA 235(1):50-57, 2009.

Post-Cardiac Arrest Syndrome (PCA)

- Conflicting views on:
  - IV fluids
  - Vasopressors
  - Hyperosmotic therapy (mannitol/hypertonic saline)
  - Steroids
  - Seizure prophylaxis
  - Thermoregulation
- Most recommendations modeled after human literature
- Not a lot of information for dogs/cats
- Next RECOVER initiative aims to correct that gap

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Ischemia and Reperfusion (IR)

- ROSC leads to a whole body global IR syndrome
- Shares characteristics with severe sepsis
  - Inflammation
  - Coagulation effects
  - Endothelial dysfunction
- Therapeutic considerations in human medicine involve
  - Early hemodynamic optimization
  - Glycemic control
  - Critical illness–related corticosteroid insufficiency (CIRCI) Titration is guided by monitoring
- Assessment and reassessment of defined treatment endpoints

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IR: Hemodynamic Optimization

- Its all about the monitoring!
- Also all about EGDT = early goal-directed therapy
  - EGDT, established by a Rivers et al study
  - Sets the stage for hemodynamic optimization in patients with sepsis and septic shock
- EGDT uses an algorithm
  - Single interventions are started or discontinued based on predefined physiologic endpoints
  - Emphasis on early resuscitation
- Human EGDT PCA Interventions:
  - Optimize tissue oxygen delivery
  - Decrease tissue oxygen demand

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IR: Hemodynamic Optimization

- Veterinary guidelines, published by the RECOVER initiative
- Resuscitation endpoints:
  - Central venous pressure (CVP; 0 mm Hg < CVP < 10 mmHg)
  - Mean arterial blood pressure (MAP 80 to 120 mm Hg)
  - Perfusion parameters
    - Central venous oxygen saturation [ScvO2] > 70 %
    - Lactate < 2.5 mmol/L
  - Monitoring for markers of vasodilation
    - Injected mucous membranes or shortened capillary refill time, pulse quality
  - Echocardiographic determination of left ventricular function
- Guides effective yet safe treatment with fluids, vasopressors, and inotropes
- Immense diversity of the PCA patient's response to injury and treatment
- "One-size-fits-all" therapeutic strategy is not appropriate

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IR: Hyperglycemia / Glycemic Control

- Hyperglycemia is common after cardiac arrest
- Associated with worse prognosis in humans
- Animal studies
  - Hyperglycemia worsens ischemic brain injury
- Insulin CRI and tight glycemic control
  - Controversial and difficult
- Goals: Avoid hypoglycemia, monitor BG and ensure decreasing on its own, +/- utilize insulin

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IR: Adrenal Dysfunction

- Steroids are key for the body's response to severe stress and are important for regulation of vascular tone and endothelial permeability
- Relative adrenal insufficiency appreciated in human medicine after ROSC.
- Low-dose steroid for septic shock remains controversial
- Evidence for use during PCA is lacking
- Due to risks, administration of corticosteroids during PCA is not recommended

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IR: Adrenal Dysfunction

- Patients with vasopressor-dependent shock
- With or without evidence for low serum cortisol
- May benefit from low dose hydrocortisone
- However, not a routine drug carried in most veterinary hospitals
  - Specialty centers included

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PCA Brain Injury

- In humans, cerebral dysfunction after cardiac arrest
  - Most common single cause of death
- PCA brain injury results from global cerebral IR
- Aspects of cerebral IR injury
  - Most of the injury is sustained during reperfusion and not during ischemia
  - Activation of proteases leading to neuronal death and production of reactive oxygen species (ROS)
  - Limiting cells protective and repair mechanisms
- Mild therapeutic hypothermia may help

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PCA Brain Injury

- Brain injury is sustained during reperfusion
  - Not during the extended duration of ischemia
- Optimize the reperfusion process → you can extend the tolerated duration of ischemia
- Glycolysis allows for some continued energy production
- Cerebral ATP stores are typically depleted quickly
  - 2 to 4 minutes

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PCA Brain Injury

- Controlled re-oxygenation is key
- Due to large amounts of ROS generated after CPR
- Reintroducing O2 conflicts with the toxic potential of O2
- Oxygen is a substrate for ROS
- GOALS:
  - Inspired oxygen concentration, should be titrated to normoxemia
  - PaO2 80 to 100 mm Hg
  - SpO2 94% to 98%
  - Avoiding both hypoxemia and hyperoxemia

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Mild Therapeutic Hypothermia (MTH)

- Only treatment proven in trials to be effective in increasing neurologically intact survival
- Protective effects via
  - Reduction of mitochondrial injury and dysfunction
  - Decrease in cerebral metabolism
  - Reduction of calcium inflow into cells and neuronal excitotoxicity
  - Reduced production of ROS
  - Reduced apoptosis
  - Suppression of seizure activity

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Mild Therapeutic Hypothermia (MTH)

- Optimal duration of MTH is unknown
- Many small animals are spontaneously hypothermic after CPA
- GOALS:
  - Allowing the patient to slowly rewarm to normal core temperature over time
  - Permissive hypothermia offers an alternative
  - Prevent hyperthermia

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PCA Seizure Control

- Seizures during the first 3 days after CPA
  - Humans
  - Associated with worse outcome
- Leads to a increase in cerebral metabolism and oxygen demand
- GOALS: Monitor for seizures and treated accordingly
- Use of mannitol or hypertonic saline
  - Go ahead and use if cerebral edema is suspected
  - Ex: coma, stupor, decerebrate posture

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Ventilation & Neuroprotection

- CO_2 responsiveness of cerebral arteries
  - May be disturbed after prolonged ischemia
  - Therefore, arterial vasodilation in response to increasing $PaCO_2$ is absent
- GOALS:
  - Avoid both hypoventilation and hyperventilation after ROSC
  - Control ventilation
    - Dog: $PaCO_2$ 32 to 42 mm Hg
    - Cat: $PaCO_2$ 26 to 36 mm Hg

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PCA Brain Injury: Prognosis

- Assessing PCA neurologic status → relevant for treatment decisions and prognosis
- Examination timing
  - Immediately after ROSC
  - Every 2 to 4 hours, at minimum
- Keep confounding factors in mind
  - Sedation
  - Neuromuscular blockade
  - Seizures
  - Postictal status
  - Pupil dilation from atropine use
- Neurologic deficit scoring systems / Modified Glasgow Coma Scale (MGCS)
- Any retention of normal neurologic function after ROSC supports favorable prognosis

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PCA Brain Injury: Prognosis

- Difficult to predict prognosis during the first 24 to 72 hours
- Clinical implication
  - It will be a costly endeavor for a patient whom remains alive, but comatose post ROSC
  - Time will determine if they will recover
- Waldrop et al
  - There is significant potential for neurologic recovery, provided adequate supportive care is possible
  - Dullness, ataxia, circling, seizures, and blindness, resolved in 90% of CPA survivors before hospital discharge

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PCA: Myocardial Dysfunction

- Characterized by:
  - Increased central venous and pulmonary capillary wedge pressure
  - Reduced systolic and diastolic ventricular function
  - Reduced cardiac output
- Complicated by ventricular tachyarrhythmias
- Reversible and can resolve within 48 hours
- Mechanism not fully understood
- Factors that worsen MD:
  - Intra-arrest administration of epinephrine
  - High energy and monophasic waveform defibrillation

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PCA: Myocardial Dysfunction

- Serial echocardiography
  - Best for diagnosis and monitoring
- Monitoring of right-sided filling pressures
  - Limits the risk for pulmonary edema
- Monitor perfusion parameters
- Dobutamine administration
  - Improve left ventricular function and cardiac output
- Cardiac arrhythmias should be addressed
- MTH may help

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Persistent Precipitating Pathology

- Causes of CPA in dogs and cats:
  - Hypoxemia (36%)
  - Shock (18%)
  - Anemia (13%)
  - Arhythmias (8%)
  - MODS (6%)
  - Traumatic brain injury (5%)
  - Anaphylaxis (1%)
  - Other causes (21%).
- Another study suggests that trauma is a more common

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Persistent Precipitating Pathology

- Variety of preexisting conditions exist
- Therefore, an individualized patient approach is vital
- Need critical care principles to support the patient:
  - Monitoring endpoints
  - Oxygenation
  - Ventilation
  - Circulation
  - Metabolism

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Persistent Precipitating Pathology

- Comorbidities influence the outcome from cardiac arrest
- Cardiac arrest may be an expected progression of the patient's disease
  - …but guidelines about limiting resuscitation were not set out
  - Ex: the end stage carcinomatosis patient that arrests
- Always appropriate to set limits on resuscitation efforts
- Discussion about CPR expectations should be held, prior to arrest.

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FURTHER READING:

- **JVECC RECOVER guidelines**

- **References: Available upon request**

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