Cardiac emergencies in the ER and ICU

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Introduction

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Conflict of Interest Disclosure

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Goals of this lecture

• How to differentiate cardiac from respiratory?
• Types of “cardiogenic shock”
• Congestive heart failure (CHF)
• Pericardial effusion
• FATE
• Arrhythmias
• Cardiototoxicants
How to differentiate respiratory vs. cardiac disease

- Presence of heart murmur (dog), gallop (cat)?
- Heart rate (dog)?
  - CHF → HR > 150-160
- Signalment
- proBNP
- Chest radiographs

CHF if the HR is < 150–160 bpm (canine)?

- Body’s goal: oxygen delivery
- Increase HR to increase cardiac output (CO)

Mistake: Assuming it is CHF if the HR is < 150–160 bpm (canine)

- With most heart failure, good contractility until failure
  - Exception: dilated cardiomyopathy (DCM)
- If HR < 160, likely not CHF!

Underutilizing your Patient’s Signalment to Guide Your Therapy

- Sex
- Age
- Weight
- Breed
- Presenting complaint

- 12-year-old miniature poodle, MC
- History:
  - DDX with heart murmur 3 years ago
  - No treatment
  - Chronic cough 2 years with excitement (“honking” cough)
- Current meds:
  - Enalapril X 3 years
  - Hydrocodone X 2 years as needed

- PC:
  - Progressive tachypnea X 3 days
  - Tachypnea and dyspnea
  - T 37.9°C (100.3°F)
  - HR: 170
  - RR panting
  - Fine crackles
- Diagnostics:
  - Furosemide 2-4 mg/kg IM or IV trial, q 15 minutes until RR improved!
  - Oxygen therapy
  - Echocardiography
Underutilizing your Patient’s Signalment to Guide Your Therapy

- **Sex:**
  - Male cats -> HCM (hypertrophic cardiomyopathy)
  - DCM (dilated cardiomyopathy) -> 73% male dogs
- **Age:**
  - 2 years old -> HCM
- **Weight:**
  - DCM -> > 15 kg
- **Breed:**
  - DCM -> Dobermans
  - HCM -> Maine coon
  - HCM -> Ragdolls (UK)

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Underutilizing Your Patient’s Signalment to Guide Your Therapy

- **2-year-old MC Maine Coon cat**
  - 1-day history of open-mouth breathing, 10-day history of ↑ RR/RE
  - **PC:**
    - Open-mouth breathing
    - Dull lung sounds
    - T 37.1°C (98.8°F)
    - HR 200
    - RR 100
    - Muffled heart sounds
    - No heart murmur

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Underutilizing Your Patient’s Signalment to Guide Your Therapy

- **9-year-old FS Westie**
  - **History:**
    - Chronic cough X 2 months
    - Exercise intolerance X 2 months
    - Heartworm (−)
  - **PC:**
    - Severe tachypnea
    - Cyanotic mm
    - Inspiratory crackles
    - T 38.8°C (101.8°F)
    - HR 120; I/VI murmur?
    - Pulse quality good
    - RR 100

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**WHAT THE HECK IS BNP?**

**BNP**

- B-type natriuretic peptide (BNP):
  - Causes vasodilation
  - Natriuresis (renal sodium and water loss)
  - Indirect measure of left atrial pressure
- Released with myocardial stretch
- Cleaved into NT-proBNP
- Not a standalone test
  - History
  - Signalment
  - CXR
  - Echo

**Canine proBNP**

- NTproBNP ≤ 900 pmol/L: NOT heart disease
  - Exception: Dobermans > 735 pmol/L -> occult DCM
- NTproBNP ≥ 900 pmol/L:
  - Dogs with heart murmur -> compatible with stretch of myocardium
  - “Clinically significant heart disease”

Canine NT-proBNP

- If VHS > 12 or NT-proBNP > 1500 pmol/L → ♦ risk of CHF in 3-6 months (Reynolds 2012)
- ♦ in BNP > 60% last visit associated with ♦ CHF in next 3-6 months
- In dogs with BNP:
  - < 900 pmol/L → more likely primary respiratory disease
  - >2,500 pmol/L → most likely CHF (Fox 2014)
- May not be accurate in Dobermans?

Canine NT-proBNP

- Falsely elevated with:
  - Renal disease
  - Pre-renal azotemia
  - Hyperthyroidism
  - Pericardial effusion
  - Severe arrhythmias
  - Pulmonary hypertension
  - Systemic hypertension

Feline proBNP

<table>
<thead>
<tr>
<th>SNAP Feline proBNP Result</th>
<th>Cardiopet proBNP Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>67</td>
</tr>
<tr>
<td>Abnormal</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 2: Results of the validation study. Data represents two independent lots of the SNAP Feline proBNP Test.

Feline proBNP

![Figure 2](www.idexx.com)

What about cats?

What about cats?

![What about cats?](www.idexx.com)
TYPES OF SHOCK AND WHY YOU SHOULD RULE OUT CARDIOGENIC...

Types of shock
- Distributive shock → decreased intravascular blood volume
  - Hypovolemia
  - Hemorrhage
  - Increased vascular permeability
- Hypoxic shock → abnormal oxygen content or problems unloading oxygen to tissues/cells
  - Hypoxemia
  - Anemia
  - MetHb
  - COHb

• Metabolic shock
  - Normal perfusion and oxygenation, but cells can’t get adequate energy (cytopathic hypoxia)
  - Cyanide toxicosis
  - Hypoglycemia
  - Septic shock → inflammatory response (e.g., cytokines, proteases, etc.) → interfere with intracellular metabolism → decreased myocardial contractility/CO/D\textsubscript{O}_2

Cardiogenic shock
- Causes:
  - CVHD → backload regurgitation
  - DCM → poor contractility
  - PE → low preload
  - Toxins/drugs → myocardial damage or depression
  - HCM → poor preload
  - Arrhythmias → poor preload, inefficient contractility
  - Obstructive disease → stenosis

Cardiogenic shock
- NO FLUIDS for cardiogenic shock!
- Low-forward flow
- Poor cardiac output due to poor myocardial contractility or low preload

Radiographs
- No animal dies in radiology!
- Should we do CXR in dyspneic patients?
Doing too many chest x-rays (CATS!)

CONGESTIVE HEART FAILURE

Mitral Valve Endocardiosis

- Most common cause of congestive heart failure in small and medium-sized breeds of dogs
- Chronic degenerative disease
- Progressive valvular incompetence
- Regurgitation of blood
- Pump failure due to decreased forward flow
- Ultimately \( \rightarrow \) volume overload

CHF Diagnosis: Chest rads

- Radiographic signs of CHF associated with mitral insufficiency include:
  - Tracheal elevation
  - Left atrial enlargement
  - Pulmonary venous distension
  - Left ventricular enlargement
  - Pulmonary edema (perihilar and caudal lobes)

CHF: Initial Treatment

- Oxygen
- Cage rest
- Furosemide (1-4mg/kg – chart coming up)
- Sodium nitroprusside
  - Balanced vasodilator
  - Very effective - increasing venous capacitance and reducing ventricular afterload.
  - Dose is 0.5-3\( \mu \)g/kg/min IV

Emergency lasix dose range for cats and dogs

- Dogs
  - 2-4 mg/kg q 1-2 hours IV or IM
  - Alter with RR/RE improvement
  - Then q 6-12h
  - If no change after 8 mg/kg, reconsider diagnosis of CHF or start nitroprusside
- Standard maintenance: 1-2 mg/kg BID to TID PO

- Cats
  - 1-2 mg/kg IV or IM q 1-2 hours until stable
  - Then decrease dose to q 8-12hr
  - More sensitive to furosemide than dogs
- Standard maintenance: 1-2 mg/kg SID to BID PO

Monitor hydration and electrolytes
Nitrates: More info

• Begin at 1µg/kg/min
• Increase by 1µg/kg every 20-30 minutes until improvement in respiratory effort and thoracic auscultation.
• Maintained on the effective dose for up to 48 hours.
• Cyanide poisoning can result if nitroprusside is infused for more than 3 days.
• Blood pressure must be monitored

Nitrates: More info

• Alternative choice is 2% nitroglycerine ointment
• Venodilator - reduces pre-load
• The paste is applied cutaneously to a hairless area in the axilla or groin
• Dose of 0.25-1.0 inch q 6-12 h.

Ancillary therapy

• Occasionally dogs with severe CHF will exhibit anxiety and hyperexcitability
• Detrimental to their fragile status
• Mild sedation can be achieved:
  – Morphine sulfate 0.2-0.5mg/kg IV, IM or SQ
  – Butorphanol 0.1-0.4mg/kg IV, IM or SQ

Feline Cardiomyopathy

• Suspected in cats with dyspnea, heart murmurs, hypothermia, gallop rhythm or other arrhythmias.
• Easily stressed and fragile
• Placed in an oxygen-rich environment
• Pleural effusion (rapid, shallow, dull)

CHF Radiographs: CATS

HCM – V/D

• HCM vs. other
• Valentine-shaped heart
• DCM is not as common
  – Commercial food
CHF: Therapy

- Drugs ***
- Thoracocentesis (cat >>> dog)
- Oxygen
- Minimal patient handling (NO STRESS!)

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Monitor hydration and electrolytes

HCM Echocardiography

Dilated Cardiomyopathy

- Doberman, 8-year-old MC
- 3-week history of exercise intolerance
- PC:
  - Cyanotic
  - Coughing
  - Crackles all fields
  - 1/6 heart murmur
  - HR 180
  - T: 36.8ºC (98.2ºF)
  - RR: 100

DCM Echocardiography
Canine Dilated Cardiomyopathy

- Primary myocardial disease
  - Reduced contractility
  - Generalized cardiomegaly
  - Arrhythmias
  - Congestive heart failure

- Most commonly seen in middle-aged large breed male dogs
  - Doberman Pinschers
  - Great Danes
  - Irish Wolfhounds
  - St. Bernards
  - Bull Mastiffs.

Hx: 1-2 week history of exercise intolerance, weight loss, and anorexia.

PE:
- Signs of right-sided heart failure
  - Ascites
  - Hepatosplenomegaly
  - Jugular pulses

Left-sided heart failure
- Pale mucus membranes
- Slow capillary refill time
- Pulmonary crackles / Tachypnea
- Tachycardia
- Murmur
- Pulse deficits
- A-Fib!

Canine DCM - Radiographic findings

- Generalized cardiomegaly
- Pulmonary venous congestion
- Perihilar dorsal caudal pulmonary edema
- Pleural effusion

DCM - Treatment

- Cage rest
- Nasal oxygen (50-100 ml/kg/hr)
- Furosemide (2-4 mg/kg IV q 4-6 h initially)
- Positive inotropic support is usually indicated.
- Dobutamine (5-20 µg/kg/min)
  - Drug of choice unless rapid atrial fibrillation or tachycardia is present.
- For severe pulmonary edema
  - Sodium nitroprusside

Pericardial Effusion (PE) - Exam

- Tachycardic
- Muffled heart sounds
- Tachypneic
- Weak / collapse
- Pale MM
- Absent femoral pulses
- Electrical Alternans
- Ascites (chronic?)
Pericardial Effusion/Tamponade

- Echocardiography
  - Definitive diagnostic - mass?
  - Not required in the emergency setting

Pericardial Effusion

- Radiography
  - Cardiomegaly (mild to severe), +/- “Globoid”, enlarged vena cava, hepatomegaly, ascites

Cardiac Tamponade

Cardiac Tamponade / Ascites

Pericardial Effusion/Tamponade

- Causes
  - Dogs
    - Idiopathic and Neoplasia (90% of cases)
    - Other (coagulopathy, infectious, uremia, dialysis, left atrial tear, CHF, cyst, foreign body)
  - Cats
    - CHF, FIP, LSA, (other infectious, uremia, LA tear, idiopathic, other neoplasia)

Pericardial Effusion – Jugular Pulses
Pericardiocentesis

• Indications:
  – Pericardial effusion

• Aseptic preparation/technique

• 16 ga., multi-fenestrated catheter

• 3-way stopcock setup

How to perform a pericardiocentesis via TFAST ultrasound

Following pericardiocentesis...

• Cardiology consultation?

• Hospitalize vs. TGH?

• Yunnan Baiyao?

• Clinical experience
  – Filling up rapidly?
  – Other?

FELINE ARTERIOTHROMBOEMBOLISM (FATE)

Feline arteriothromboembolism (FATE)

• Acute presentation of thromboembolic event
  – Most commonly at aortic trifurcation - “saddle thrombus”
  – Can affect front legs, brain, GIT, kidneys as well
  – First indication of cardiac disease?

Presentation

• Acute onset of crying, dragging legs, +/- loss of bowel/urinary control, +/- dyspnea

• PE findings
  – Affected limbs cold, painful, absent pulses
  – Often a murmur or gallop on auscultation
  – +/- signs of congestive heart failure
**ER Diagnostics?**
- Doppler?
- Blood glucose comparison legs?
- Lactate comparison legs?

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**Therapy: Acute**
- Pain control: Opioids are analgesics of choice
  - Buprenorphine: 0.005-0.015 mg/kg IV q6-8hrs
  - Butorphanol (0.1-0.2 mg/kg IV q4-6hr)
- If dyspneic, furosemide (1mg/kg IM-or IV) and oxygen
- Aspirin: ¼ of an 81mg aspirin q 3 days
- Clopidogrel (Plavix): ¼ of a 75 mg tab PO SID
- Dalteparin (Fragmin): 100 mcg/kg SQ q8hr

Treat underlying cardiomyopathy

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**Long term prognosis/management**
- If due to underlying cardiac disease, long term prognosis generally poor (3-6 months)
- Sequela include:
  - Permanent deficits in affected limbs
  - Recurrence of thromboemboli
  - Progression of underlying cardiac disease (i.e. CHF, arrhythmias, sudden death)

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**CARDIAC ARRHYTHMIAS**

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**Approach to arrhythmia diagnosis**
- Physical exam
  - Tachycardia – too fast?
  - Bradycardia – too slow?
  - Irregular vs. regular
  - Pulse deficits
- Suspection of arrhythmia based on PE
- Confirm with an ECG

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**Continuous ECG Monitoring**
- Heart rate
  - Dogs: < 60 > 160
  - Cats: < 140 > 220
- Causes
  - Heart disease
  - Electrolyte imbalance
  - Myocardial hypoxia
  - Pain/stress
  - Splenic disease
  - Underlying disease
Use anti-arrhythmics if signs of poor perfusion!

- Cold peripheral limbs
- A prolonged CRT > 2.5 sec
- Tachycardiac
  - > 170 bpm (dogs)
  - > 240 bpm (cats)
- Poor pulse quality
- Hypotensive

**Anti-arrhythmics**

**PROS**
- Slow HR to allow ventricular filling
- Anti-inflammatory
- Free radical scavenger
- Analgesia

**CONS**
- Vomiting
- Diarrhea
- Seizures
- Negative inotrope
- Decrease myocardial function
- Increase fibrillation threshold
- Increase oxygen demand
- Arrhythmogenic

**Clinical application**

- Treat the underlying disease
- Assess the patient
  - Still hypotensive?
  - Painful?
  - Hypoxic?
  - Electrolytes?
  - Anemia?
- Perfusion?

**Clinical application**

- Perfusion?
- If treated underlying problems & hypoperfused:
  - Lidocaine
    - 1-4 mg/kg IV slow ➔ CRI 25-50 mcg/kg/min
    - Only ventricular arrhythmias
  - Procainamide
    - 6-8 mg/kg IV slow ➔ CRI 25-40 mcg/kg/min

Why we don’t tolerate a low heart rate either!

- We don’t tolerate HR < 40-50 bpm (dogs) or < 120 bpm (cats)
- Why?
  - No cardiac output
  - No forward blood flow
  - No perfusion
  - Causes cell death
  - Multiorgan dysfunction syndrome (MODS) ➔
    - Hypotension
    - Shock gut (dog)
    - AKI

Use anti-arrhythmics if signs of poor perfusion!

- Cold peripheral limbs
- A prolonged CRT > 2.5 sec
- Tachycardiac
  - > 170 bpm (dogs)
  - > 240 bpm (cats)
- Poor pulse quality
- Hypotensive
Treatment - Lidocaine

- Lidocaine is the drug of choice for ventricular arrhythmias
- Initial bolus of 2-8 mg/kg IV slowly - given to effect
- Followed by a constant rate infusion (30-80 μg/kg/min)

Treatment - Procainamide

- If fails to respond to lidocaine → consider
- For ventricular arrhythmias
- Procainamide
  - 2-6-8 mg/kg IV slow → CRI 25-100 mcg/kg/min

Beware the bradycardiac cat...

- Cold
- Flat
- Bradycardiac
- Poor pulses
- Pallor?

Toxins that result in cardiotoxicity

- Anything that causes tachycardiac:
  - SSRIs
  - Amphetamines/methylphenidate
  - Methylxanthines
  - Pimobendan
- Anything that causes hypotension:
  - Calcium channel blockers (CCB)
  - Beta blockers (BB)
  - ACE-inhibitors

Toxins that result in cardiotoxicity

- Anything that causes weird arrhythmias
  - Lamictal
  - Antiarrhythmics
- Any plant that has ‘dig’ or ‘glycoside’ in it!
  - Cardiac glycosides

Atkinson, KJ et al. Suspected lily-of-the-valley (Convallaria majalis) toxicosis in a dog. JVECC 2008; 18(4)
Why do we don’t tolerate a fast heart rate in poisoned patients:

• We don’t tolerate HR > 180 bpm in dogs; 240 bpm in cats

• Why?
  – No time to fill ventricle
  – Utilizes lots of myocardial injury
  – Results in myocardial injury (DCM)?
  – Higher risk of acute death (R on T and acute death)

Why do we don’t tolerate a fast heart rate in poisoned patients:

• Treatment:

  1) Always check the BP first!

  2) Sedation (acepromazine IF ↑ HR, BP, agitation)
     • More ace! More ace (and maybe some torb?)

  3) Beta-blockers (if ↑ HR, BP)
     • Do NOT use with bradycardia as it will slow HR too much!
     • Do NOT use with hypotension as the heart can’t compensate and ↑ HR!

Conclusion

• Be able to recognize the cardiac patient immediately

• Utilize signalment and PE findings to assist you

• Furosemide + oxygen therapy + low stress

• Feel comfortable with your ultrasound!

• Chest rads last!

Questions?

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