The Collapsed Patient
Syncope and Look-a-Likes

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Personal Background
Totally Inappropriate Anatomy Sniffer

Security/Squirrel Alarm

Dead Bird Smell Collection Area

Coffee Table Clearing Mechanism

Unconditional Adoration Chamber

Face Moisturizer/Bottom Cleaner

Scratch-Activated Foot Wag Throttle

Low-Output Walk-Interuption Device (Male Variant)

Plastic Bag Fulfillment Line

Revised Canine Anatomy
Whatever you do in life, always give 100%.

Unless you're donating blood.

your e-cards
someecards.com
Objectives

- Review the pathophysiology of syncope and the look-a-likes
- Review the causes of syncope
- Review the look-a-likes and how to differentiate from syncope
- Patient evaluation and the associated risks
- Treatment
Background

• Collapse, syncope, fainting
  – Somewhat interchangeable
• Collapse + loss of consciousness (LOC)
  – Syncope
  – Transient LOC (TLOC)
• Collapse
  – Sudden loss of postural tone
  – +/- LOC
• TLOC
  – Global cerebral hypoperfusion
Background

• Challenging cases
  – Benign?
  – Near death experience?
  – Intermittent
  – Rare
  – Normal afterwards
• Importance
  – Seizure vs syncope?
Collapse with TLOC

Without cerebral hypoperfusion
- Seizure
- Metabolic
  - Addison’s
  - Hypoglycemia
  - Drugs
  - Anemia
  - Hypoxemia

With cerebral hypoperfusion
- Syncope
  - Cardiac
    - Arrhythmia
    - Structural heart disease
  - Reflex-mediated
    - Vasodepressor
    - Cardioinhibitory
    - Mixed
  - Orthostatic hypotension
    - Drugs
    - Hemorrhage
    - Volume redistribution

TLOC = Transient loss of consciousness
Syncope with Cerebral Hypoperfusion
Pathophysiology - Cardiac

• Transient loss of consciousness (TLOC)
  – Acute drop in systemic blood pressure
  – Altered cerebral blood flow

\[ \text{BP} = \text{CO} \times \text{SVR} \]
\[ \text{CO} = \text{HR} \times \text{SV} \]

- LV afterload
- Contractility
- Preload
- Afterload
- Arrhythmogenicity

- Altered cerebral blood flow

\[ \text{syncope} \]
Pathophysiology - Cardiac

Cardiac Syncope

Bradycardia

Tachycardia

Structural Heart Disease

SSS
High grade 2nd or 3rd deg AVB
Atrial standstill

VT
SVT
AT
AF
OAVRT

PS
AS
PH with PTE
HWD
Advanced AV valve disease
DCM
HOCM
Pathophysiology - Cardiac

- Cats
  - Syncopal like syndrome with high grade AVB
    - Facial and whisker twitches
    - Salivation
    - Urination/defecation
    - Disorientation
    - Collapse + TLOC
  - Results in prolonged cerebral hypoperfusion
    - Hypoxic convulsive syncope
Pathophysiology - Cardiac

- Structural heart disease
  - Can result in syncope
    - Exertion
    - CO cannot meet demands
  - SAS, AS, PS
  - Primary pulmonary hypertension
    - With massive PE
      - Obstructs blood flow
      - Reduced CO

- Alternatively
  - Primary pulmonary hypertension
    - Increased intraventricular systolic pressure
    - Rise in mechanoreceptor stretch
    - Results in reflex-mediated syncope
    - With chronicity
      - Remodeling and scarring
        » Result in severe outflow obstruction
        » Arrhythmia >> syncope
Pathophysiology - Reflex-mediated syncope

Reflex-mediated syncope

- Vasovagal neurocardiogenic
- Situational
- Carotid sinus hypersensitivity

Emotion
Stress
Fear
Pain
Not documented

- Intense activity
- Excitement
- Coughing
- Vomiting
- Urination/defecation

Baroreceptor
Cervical neoplasia

Not documented
Pathophysiology

Orthostatic syncope
(Postural hypotension)

Drug induced hypotension

Volume Depletion

- ACP, hydralazine, amlodipine
- nitrates, β blocker, diuretics

Dehydration
Hemorrhage
Blood volume redistribution
Patient evaluation
History and PE

• Careful history
  – What, when, how long, what else??
• PE
• Seizure vs syncope
  – Easier said than done
  – TLOC
  – Event includes
    • Disorientation – seizure??
    • Slower recovery to normal - seizure??
    • Hypersalivation - seizure??

• Event includes
  – Flaccid collapse, urination, defecation - Syncope?
  • Not always
    – Extensor rigidity associated with arrhythmia
Emergency

• Determine threat to life
  – Arrhythmia
  – Treat as needed
• Drug related
  – Treat as indicated
• Recognize lower risk cause and consider referral
  – Reflex mediated
  – Tussive syncope
• Repeat episode
  – Hospitalize
• Seizure?
  – Hospitalize
Emergency - Diagnostics

- Blood pressure
  - Hypotension
  - < 90 mmHg
    - Anesthesia induced
    - Cardiac failure
    - Drug induced
    - Hypovolemia
    - Shock
    - Neurogenic (noncardiogenic) pulmonary edema

- Hypertension
  - > 200 mmHg
    - Situational
    - Secondary
      - Kidney disease
      - Diabetes mellitus
      - HAC (dogs)
      - Hyperthyroidism (cats)
    - Pheochromocytoma, hyperaldosteronism
  - End organ injury
ECG

• Bradycardia

Mobitz Type I – prolonged PR then drop

Mobitz II – PR interval maintained then drop

High grade AVB
• No 2 P's conducted
• Ex. 4:1

3rd degree (complete AVB)
ECG - Bradycardia

- Atrial standstill
- No identifiable P waves with normal QRS complexes consistent with atrial standstill and a junctional escape rhythm
- HR 73
ECG - Bradycardia

- Sinus arrest
- Sudden absence of impulse from SA
- No impulse → no depolarization → no contraction → drop in BP
- Longer the pause, worsening hypotension
- > 6 sec pause → medical emergency
ECG - Bradycardia

Pacemaker malfunction
ECG - Tachycardia

Monomorphic ventricular tachycardia

ARVC in Boxer
ECG - Tachycardia

Narrow complex tachycardia with suspected re-entrant

Pause with conversion to NSR
ECG – Tachycardia

- Atrial fibrillation
  - Multiple re-entrant circuits
  - AV acts as a gate keeper
  - Lone AF vs dogs with structural heart disease
    - Giant breeds = lone AF
  - Structural heart disease more common
    - Cats and dogs

https://www.cliniciansbrief.com/article/top-5-arrhythmias-dogs-cats
Pulmonary Hypertension

- ECG – nonspecific
- Thoracic radiography - nonspecific
- Echo – Gold standard, noninvasive
  - Subjective
    - RV changes associated with increased RV afterload
    - RVH
    - Septal wall flattening
    - Paradoxical septal wall motion
    - PA dilation
  - Objective
    - PA velocity profiles
    - Systolic PA pressure assessment
    - Doppler diastolic PA pressure assessment
Pericardial effusion – Syncope look alike

- Neoplasia
- Inflammatory/infectious
- Trauma
- Idiopathic
- Hypooncotic state → low albumin; uncommon
- PPDH

- Treatment → Pericardiocentesis
Diagnostics – Bloodwork

- Serum chemistry
  - Electrolytes
    - Hyperkalemia
  - Hypoglycemia
- T4/fT4
  - Hyperthyroidism
- Cardiac biomarkers
  - NTproBNP
- CBC
  - Anemia
  - Thrombocytopenia
- Neuro exam

Positive NTproBNP → likely cardiac related. Needs ECG and echocardiogram

Negative NTproBNP + no auscultable arrhythmia → likely not cardiac related BUT may have intermittent arrhythmia; consider Holter or implantable monitor (cardio consult)
Treatment

• Treat the underlying disease
  – Arrhythmia → antiarrhythmics or pacemaker
  – Reflex-mediated without structural heart disease
    • Difficult to manage
    • Possible pacemaker if bradycardia during event
      – If hypotensive + bradycardia – pacing may not help
  – Avoid pre-treatment with β-blocker to treat the tachycardia trigger
    • Can exacerbate the bradycardia related syncope

• Reflex-mediated syncope with high preload
  – Impending failure
  – ‘Cardiac unloading’
    • Diuretic, pimobenden, ACEi
Long Term Monitoring

Implantable loop recorders (ILR)

Holter monitor

AliveCor

In House telemetry
• Differentiating syncope vs seizure vs neuromuscular collapse

<table>
<thead>
<tr>
<th>Clinical features</th>
<th>Syncope</th>
<th>Seizure</th>
<th>Neuromuscular collapse*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentation</td>
<td>Normal</td>
<td>May be abnormal</td>
<td>Normal</td>
</tr>
<tr>
<td>Gait</td>
<td>Normal</td>
<td>Normal</td>
<td>Often abnormal</td>
</tr>
<tr>
<td>Alteration of consciousness</td>
<td>Yes</td>
<td>Frequent¹</td>
<td>No</td>
</tr>
<tr>
<td>Tonic-clonic muscle activity</td>
<td>Rare</td>
<td>Usually</td>
<td>Variable depending on specific disease</td>
</tr>
<tr>
<td>Trigger events (excitement, activity, cough, gag, etc.)</td>
<td>Possible</td>
<td>Usually none</td>
<td>Variable depending on specific disease</td>
</tr>
<tr>
<td>Duration of episode</td>
<td>Seconds to few minutes</td>
<td>Minutes to hours</td>
<td>Varies</td>
</tr>
<tr>
<td>Prodromal phase</td>
<td>Very rare</td>
<td>Rare to common</td>
<td>Rare</td>
</tr>
<tr>
<td>Abnormal mentation after the event</td>
<td>Uncommon</td>
<td>Frequent</td>
<td>No</td>
</tr>
<tr>
<td>Urination/defecation during the event</td>
<td>Uncommon</td>
<td>Frequent</td>
<td>No</td>
</tr>
<tr>
<td>Response to antiseizure medication</td>
<td>No</td>
<td>Usually</td>
<td>No</td>
</tr>
</tbody>
</table>

¹ Neuromuscular causes include polymyositis, polyneuropathy, myasthenia gravis, narcolepsy, botulism, tick paralysis, hepatic encephalopathy, paraneoplastic syndromes, and central nervous system lesions

² Some seizures (e.g. simple focal/partial seizures) are not associated with alteration of consciousness.
Classification of syncope

<table>
<thead>
<tr>
<th>Category of syncope</th>
<th>Cause of syncope</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac syncope</td>
<td>Bradyarrhythmia</td>
<td>Sick sinus syndrome, AVB: high grade 2nd or 3rd degree, atrial standstill</td>
</tr>
<tr>
<td></td>
<td>Tachyarrhythmia</td>
<td>Ventricular tachycardia, atrial tachycardia, atrial fibrillation, OAVRT</td>
</tr>
<tr>
<td></td>
<td>Structural heart disease</td>
<td>Aortic and pulmonic stenosis, pericardial effusion, pulmonary hypertension due to pulmonary thrombosis/embolism, heartworm disease, advanced degenerative AV valve disease, DCM, hypertrophic obstructive cardiomyopathy</td>
</tr>
<tr>
<td>Reflex-mediated syncope</td>
<td>Vasovagal neurocardiogenic</td>
<td>Mediated by emotion: stress, fear, pain (not documented in veterinary patients)</td>
</tr>
<tr>
<td></td>
<td>Situational</td>
<td>Intense activity, excitement, coughing, urination/defecation, gagging/vomiting</td>
</tr>
<tr>
<td></td>
<td>Carotid sinus hypersensitivity</td>
<td>Primary dysfunction of baroreceptors in carotid arteries, neoplasia in cervical region</td>
</tr>
<tr>
<td>Orthostatic syncope</td>
<td>Drug-induced hypotension</td>
<td>Acepromazine, hydralazine, amlodipine, nitrates, beta-blockers, diuretics</td>
</tr>
<tr>
<td></td>
<td>Volume depletion</td>
<td>Dehydration, hemorrhage, redistribution</td>
</tr>
</tbody>
</table>

AVB, atrio-entricular block; DCM, dilated cardiomyopathy; OAVRT, orthodromic atrioventricular reciprocating tachycardia.
- Breed/species associated with syncope

<table>
<thead>
<tr>
<th>Breed or species-related cause of syncope</th>
<th>Associated conditions</th>
<th>ECG findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miniature schnauzer, American cocker spaniel, West Highland white terrier</td>
<td>Bradyarrhythmia +/- tachyarrhythmia</td>
<td>Sick sinus syndrome: brady tachy arrhythmia, junctional or ventricular escape rhythm, sinus arrest</td>
</tr>
<tr>
<td>Boxer/Doberman*</td>
<td>Tachyarrhythmia</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>Advanced cardiomyopathy in large breed dogs</td>
<td>Arrhythmia</td>
<td>Atrial fibrillation, ventricular tachycardia</td>
</tr>
<tr>
<td>Any dog with slow heart rate</td>
<td>Bradyarrhythmia</td>
<td>Advanced second or third degree atrioventricular block</td>
</tr>
<tr>
<td>English springer spaniel</td>
<td>KCNQ1 gene mutation</td>
<td>Long QT in sinus rhythm, biphasic T waves, presumed tachyarrhythmia as cause for collapse</td>
</tr>
<tr>
<td>Exercise-induced collapse syndrome (reported in Labrador retriever, Chesapeake Bay retriever, border collie, curly-coated retriever, Boykin spaniel and Pembroke Welsh corgi)</td>
<td>Dynamin-1 mutation, associated with acute hyperthermia</td>
<td>Presumed tachycardia</td>
</tr>
<tr>
<td>Cats with exertional syncope</td>
<td>Cardiomyopathy, left ventricular outflow tract obstruction, anemia</td>
<td>Normal to ventricular tachycardia</td>
</tr>
<tr>
<td>Cats or dogs with hypoglycemia</td>
<td>Hypoglycemia (insulin overdose), insulinoma, neonate</td>
<td>Normal</td>
</tr>
<tr>
<td>Older cats</td>
<td>Hyperthyroidism</td>
<td>Tachyarrhythmias to atrioventricular blocks</td>
</tr>
</tbody>
</table>

*Presumed to be ventricular tachycardia, but Boxers and Dobermans can collapse from reflex-mediated bradycardia and vasodilation as well. ECG, electrocardiogram; KCNQ1, potassium voltage-gated channel subfamily Q member 1.
• Drugs used for cardiac syncope associated with arrhythmias

<table>
<thead>
<tr>
<th>Drug</th>
<th>Indication</th>
<th>Maintenance dosage</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine</td>
<td>Acute, life-threatening ventricular arrhythmias</td>
<td>2 mg/kg bolus IV, over 1–2 min followed by CRI at 40–80 µg/kg/min</td>
<td>Repeat up to 4 times, if no effect or the arrhythmia recurs</td>
</tr>
<tr>
<td>Atropine</td>
<td>Sinus bradycardia, high-grade AV block, atropine response test</td>
<td>0.02–0.044 mg/kg IV, IM, SQ</td>
<td>Repeat bolus 2 times (but negative inotropic and may cause hypotension)</td>
</tr>
<tr>
<td>Procainamide HCl</td>
<td>Life-threatening ventricular and supraventricular arrhythmias</td>
<td>2.4 mg/kg (up to 20 mg/kg) IV SLOWLY over 10 min followed by CRI at 20–50 µg/kg/min</td>
<td>Repeat 2 times PRN</td>
</tr>
<tr>
<td>Esmolol</td>
<td>Ventricular and supraventricular arrhythmias</td>
<td>25–100 µg/kg IV bolus followed by CRI at 10–200 µg/kg/min</td>
<td>Repeat 2 times PRN</td>
</tr>
<tr>
<td>Sotalol</td>
<td>Ventricular and supraventricular arrhythmias</td>
<td>Dog: 0.5–2.5 mg/kg PO Cat: 10–20 mg</td>
<td>q12–24h</td>
</tr>
<tr>
<td>Diltaizem HCl</td>
<td>Supraventricular arrhythmias</td>
<td>0.05–0.25 mg/kg IV bolus, followed by CRI at 2–6 µg/kg/min</td>
<td>Repeat up to 3 times</td>
</tr>
<tr>
<td>Diltaizem XR (Dilevor)</td>
<td>Supraventricular tachycardia, atrial fibrillation</td>
<td>Dog: 3–4 mg/kg PO Cat: 30–60 mg total dose</td>
<td>q12h</td>
</tr>
<tr>
<td>Cardizem</td>
<td>Supraventricular tachycardia</td>
<td>Dog: 0.5–1.5 mg/kg PO, increase PRN Cat: 7.5 mg/cat, increase PRN</td>
<td>q8h</td>
</tr>
<tr>
<td>Cardizem CD</td>
<td>Supraventricular tachycardia</td>
<td>Cat: 6–10 mg/kg PO</td>
<td>q6–12h</td>
</tr>
<tr>
<td>Amiodarone HCl</td>
<td>Ventricular and supraventricular arrhythmias</td>
<td>2 mg/kg IV bolus slowly over 10 min followed by CRI at 0.8 mg/kg/h for 6 h</td>
<td>q12h for 1 week (leading)* q24h* (maintenance)</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>Ventricular and supraventricular arrhythmias</td>
<td>Dog: 10 mg/kg PO</td>
<td>q12h</td>
</tr>
<tr>
<td>Mexiletine</td>
<td>Ventricular arrhythmias</td>
<td>5–8 mg/kg PO</td>
<td>q8h</td>
</tr>
<tr>
<td>Hyoscynamine sulfate</td>
<td>Sick sinus syndrome Advanced heart block</td>
<td>0.001–0.005*** mg/kg PO</td>
<td>q8–12h</td>
</tr>
<tr>
<td>Propantheline bromide</td>
<td>Sick sinus syndrome</td>
<td>0.2–0.5 mg/kg PO, increase PRN</td>
<td>q8–12h</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Atrial fibrillation</td>
<td>Dog: 0.005–0.01 mg/kg PO**</td>
<td>q12h BID</td>
</tr>
</tbody>
</table>
Look-a-likes

Seizure
Syncope Look-a-likes

- Seizure
  - Cerebral event
  - Hypoglycemia

- Narcolepsy
  - No cerebral hypoperfusion
  - Easily awakened

- Exercise intolerance

- Exercise induced collapse

- Border Collie collapse (BCC)

- Episodic falling syndrome
  - CKCS
Seizure

• Abnormal and excessive excitation and synchronization of cortical neuron population

• Epilepsy
  – Recurrent seizures

• Status Epilepticus (SE)
  – Seizure > 5 min
  – > 30 mins
    • Permeant brain injury

• Cluster
  – > 2 in 24 hour period

• Focal (Partial) Seizure
  – With or without loss of consciousness
  – Non convulsive (sensory)
  – Altered mentation
    • Hypersalivation
    • Jaw chomping (chewing gum)
    • Fly biting
    • Symmetric/asymmetric facial twitching
    • Rhythmic limb movement
Seizure

- Generalized seizure
  - Convulsive or non-convulsive
  - Tonic-clonic
    - Bilateral, symmetrical, violent muscle contractions
  - LOC
  - Autonomic phenomena
    - Hypersalivation
    - Urination
    - Defecation

- Post ictal
  - Rhythmic movement noted
    - Eyelids
    - Face
Seizure

• Signalment
• Past pertinent HX
  – 1st time vs pre-existing?
  – What, where, when, how long, how many?
  – Conscious, unconscious or hard to say?
  – Otherwise healthy?
  – Travel, vaccination, trauma, toxin
  – Medications
  – Indoor vs outdoor
• Cats
Seizure

- **PE**
  - Ideally before medications
- **Preictal**
  - Agitation
  - Clingy
  - Hiding
- **Postictal**
  - Impaired vision
  - Disoriented
  - Hyperactive
  - Aggression
Seizure – Differential
Seizure - Differential

- Hypoglycemia
- Electrolyte abnormalities
- Severe liver or kidney disease
  - PSS
  - Toxin
  - Polycythemia

Requires diagnostics: blood, urine, imaging
Seizure - Differential

- Brain tumor
- Meningitis/encephalitis
- Hemorrhage or ischemia
- Hydrocephalus
- Congenital
- Storage disease
- Infection

MRI, CSF, other
Seizure - Differential

Idiopathic

1st seizure 1-5 yrs old
- Generalized
- Tonic/Clonic
- Normal between seizure
- Normal NE

Rule out diagnosis:
- CBC/Chem/UA
- Radiographs
- +/-MRI
- +/-CSF
Seizure – minimum data base

- PCV
- BG
- BUN
- Metabolic profile
  - NOVA
  - ISTAT
- ECG
Seizure – extended diagnostics

- CBC/Chem/UA
- Tick/vector borne disease profile
- FeLV/FIV
- Thoracic radiographs
- CT
  - Head trauma and unstable patients
- MRI
  - Post ictal
- CSF

- Lead
  - Once stable
  - If suspected
- Cholinesterase levels
  - Once stable
  - If suspected
Seizure - Anticonvulsants

- Benzodiazepines
  - Fast acting
  - IV, PR, IN
    - Not the compounded suppositories
  - Diazepam
    - IV 0.5-1 mg/kg
    - PR 0.5-2 mg/kg
    - IN 0.5 mg/kg
    - CRI 0.5-2 mg/mg/h

- Midazolam
  - IV 0.07-0.22 mg/kg
  - IM 0.07-0.22 mg/kg
    - Not ideal in acute setting
  - IN gel [50 mg/mL, dogs]; 0.2 mg/kg

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Bioavailability of a novel midazolam gel after intranasal administration in dogs.

Pharmacokinetic evaluation of novel midazolam gel formulations following buccal administration to healthy dogs.
Aldawari ME, Lau VW, Babu RJ, Arnold RD, Platt SR.
Seizure - Anticonvulsants

• Phenobarbital
• SE, clusters
• PO, IV, IM
• Loading dose
  – 4-6 mg/kg IV
    • q 30 min up to 4-6 hr
    • Patient directed
    • Max 24 mg/kg over 24 hr

• Refractory seizures
  – After 24 hrs of combined BZD/PB
  – Likely a structural lesion
  – More aggressive therapy needed
    • Levetiracetum
    • Propofol CRI
    • BZD CRI
Levetiracetum
– PO, IV
– Minimal metabolism, renal excretion
– Limited drug interactions
– Short half-life
  • 3-4 hrs in dogs
– IV 20 mg/kg q8h
– Loading dose: 60 mg/kg IV once

In cats
– Therapeutic range after 10 mins; maintained for 9 hrs
– Can be combined with other drugs
– Good safety margin
– Minimal side-effects
Seizure - Anticonvulsants

• Propofol
  – GA
  – Hypnotic/amnestic
  – Similar to PB and BZD
  – Apnea, vasodilation, myocardial depression common
  – Suppresses gag reflex
    • Aspiration pneumonia
    • Be prepared to intubate and ventilate

• Efficacy is controversial
  – Anticonvulsant and proconvulsant qualities
  – Antiepileptogenic qualities are dose dependent and high
• Epileptic dogs under Propofol
  – Exhibit epileptiform activity on EEG
• Study in PSS dogs
  – Showed promise of seizure control using PB and Propofol for refractory seizure
Seizure - Anticonvulsants

• Ketamine
  – NMDA receptor antagonist
  – Experimental
    • Management of refractory seizure in humans and rodents
    • NMDA activation results in a loss of GABAergic inhibition
    • May be beneficial
Bond. James Bond.

Thank You!

Questions?

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