Anesthesia for Patients with Co-Morbidities

ACVAA
FOUNDED IN 1975

AMERICAN COLLEGE OF VETERINARY ANESTHESIA AND ANALGESIA

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Acknowledgements

Objectives

- Recognize that it is possible to safely anesthetize patients with co-morbidities, including DM, renal, hepatic disease and brachycephalics
- Understand of both the pathophysiology of the disease itself, and anesthetic options available
- Recognize importance of vigilant monitoring!
- Know the anesthetic concerns and how best to prevent and manage potential complications...

Consult or Referral?

- Experience of clinician
- Client preference
- Referral location, cost, availability
- Available patient support
  - drugs, monitoring, staff
- Procedure to be performed?
- Options?
- Keep the case, get a consult, refer it…

Considerations for Case Management

- Does patient preparation need to be modified?
- What special drug considerations exist?
  - Pre-op: regular medications
  - Intra-op: need for “special” drugs
  - Post-op: avoid or add?
- Should the “regular” IV fluid rate be modified?
- Any special monitors/monitoring needed?
- Recovery considerations?
- TGH needs?

Anesthesia for Patients with Diabetes Mellitus

Patient Preparation

- Schedule anesthesia as early as possible in the day
- GOAL: minimize disruption to normal schedule
- Important to minimize stress
- Hydration status
- Repeat glucose monitoring available (glucometer)
- Additional supplies
  - Dextrose
  - Patient's insulin
  - Regular insulin

Patient Plan

- Fear-Free Approach
  - Reduce FAS!
- Oral meds to prevent stress PRN
- Trazodone 3-5 mg/kg PO q 8-12h
- Gabapentin 10 mg/kg PO q 8-12h
- When?
  - Night before visit and > 1h prior to arrival
  - At arrival if not given previously

Patient Plan: Fasting & Insulin at Home

- No insulin and no food (?)
- Full dose of insulin on a fast prior to d/o?
- Full or half dose of insulin with full or half dose of usual insulin (?)
- IT DEPENDS! Consider:
  - 3-4h prior to anesthesia
  - highly-digestible food (canned DM, baby food, canned chicken)
  - half to full amount of usual insulin
- GOAL: blood glucose 150-250 mg/dL (8.3-13.9 mmol/L)

Patient Plan at arrival: BG checks

- Check BG at MINIMUM: before anesthesia, during anesthesia, after anesthesia (short procedures)

Depends on BG:

- < 100 mg/dL (5.6 mmol/L) – q 30 min
- 100-200 mg/dL (5.6-11.1 mmol/L) – q 30-60 min
- > 200 mg/dL (>11.1 mmol/L) – q 30-60 min
- > 300 mg/dL (>16.7 mmol/L)– q 30-60 min
- Recommend PCV/TP recheck too if other recent labs done ok
  - CBC/Chem/lytes/UA

Patient Plan: fluid therapy

Depends on BG and hydration status (PCV/TP):

- < 100 mg/dL (<5.6 mmol/L) or up to 150 mg/dL (8.3 mmol/L)
  - Dextrose 0.25-0.5% at 1-2 mL/kg/h
  - BES to top up total volume to 3-5 mL/kg/h (cats), 5-10 mL/kg/h (dogs)
- > 200 mg/dL (> 11.1 mmol/L)
  - BES to top up total volume to 3-5 mL/kg/h (cats), 5-10 mL/kg/h (dogs)
- > 300 mg/dL (> 16.7 mmol/L)
  - BES to top up total volume 3-5 mL/kg/h (cats), 5-10 mL/kg/h (dogs)
  - Regular insulin IV at 0.25 U/kg

Patient Plan for Anesthesia

Drugs to avoid (if possible):

- Dexmedetomidine
  - Inhibits insulin release from pancreas
- Ketamine (induction doses)
  - Catecholamine release
  - Note: analgesic doses may be well-tolerated and use full for ↓ MAC

Use Preanesthetic medication

- Goals: ↓ anxiety without ↓ MAP, RBF
- Opioid + benzodiazepine (best option)

Consider for induction

- Propofol or alfaxalone
- Etomidate
- Box/Mask? NO! Stressful!!

Anesthetic Monitoring

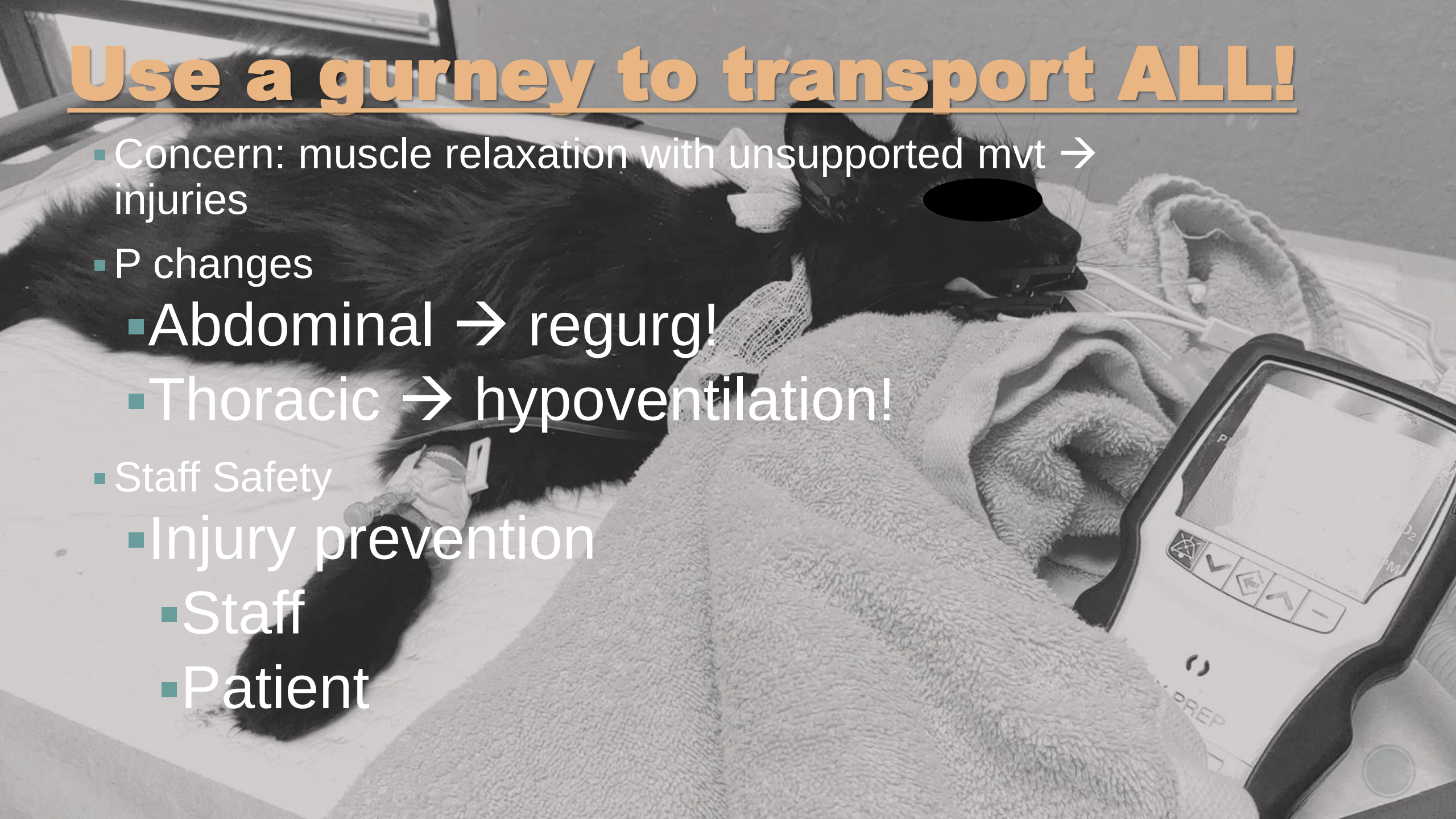
- End-tidal CO2
- Pulse oximetry
- NIBP
- +/- ECG
- +/- Arterial blood pressure
  - MAP > 60 mmHg
- BG q 30-60 m

Recovering the Diabetic Patient

- Manage stress and pain!
  - Consider the effects of stress and pain on BG
  - Pure mu opioids and local anesthetics maximize MAC reduction
- Offer feeding ASAP
- Check BG at least once in recovery, more PRN

Use a gurney to transport ALL!

- Concern: muscle relaxation with unsupported mvt → injuries
- P changes
  - Abdominal → regurg!
  - Thoracic → hypoventilation!
- Staff Safety
  - Injury prevention
    - Staff
    - Patient



AAHA Resource for DM anesthesia mgt

https://www.aaha.org/aaha-guidelines/diabetes-management/resource-center/tips-and-tricks-for-anesthetizing-diabetic-dogs-and-cats/

Tips and tricks for anesthetizing diabetic dogs and cats

Take away messages:

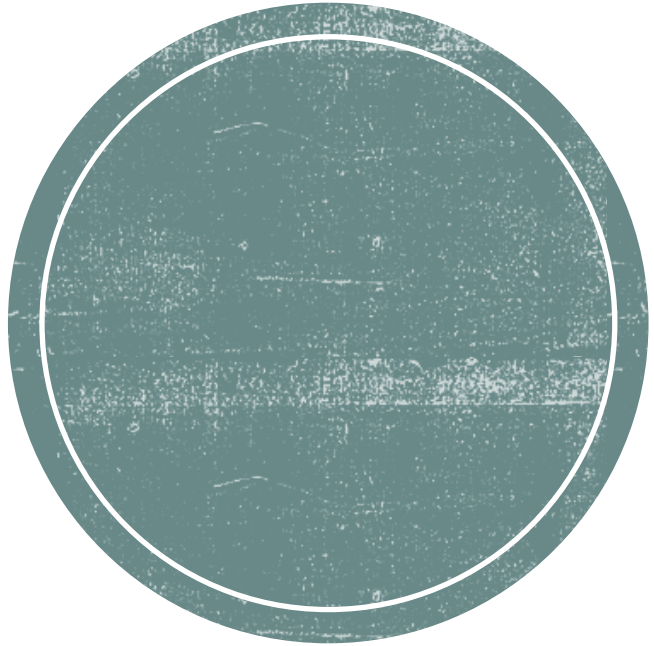
Anesthesia is not contraindicated in healthy diabetic dogs and cats and can even provide relief from complications or treat concurrent conditions that could be causing insulin resistance.

Adjusting insulin administration and dextrose supplementation based on frequent blood glucose monitoring is recommended.

Try to keep the patient "sweet, not sour." A mild hyperglycemia is preferred over hypoglycemia.

The goal is to provide minimal disruption to the pet's diet and insulin routine. Schedule the procedure in the morning, adopt outpatient anesthetic protocols, and encourage eating as soon as possible after recovery. Some experts advocate feeding a small meal prior to anesthesia

ANESTHESIA FOR PATIENTS WITH HEPATOBILLIARY DISEASE



The Liver

- Functions
  - Drug metabolism
    - detoxification
  - Gluconeogenesis
  - Protein synthesis
    - Albumin
    - Coagulation factors
  - Extramedullary hematopoiesis
  - large functional reserve and capable of regeneration
    - Insufficiency UNCOMMON → needs chronic/recurrent injury

The Liver

- Laboratory Findings
  - ↓albumin, BUN, glucose, cholesterol
  - Coagulopathies (↑ PT, PTT, fibrinogen)
  - ↑ bile acids (pre-,postprandial)
  - +/- ↑ALT, GGT, Alk-P
  - Icteric serum

The Liver

Hepatic dysfunction	Bilirubin	ALT/AST	ALP	Causes
Pre-hepatic	↑ unconjugated fraction	Normal	Normal	Hemolysis, bilirubin overload from whole blood
Intrahepatic (hepatocellular)	↑ conjugated fraction	Markedly ↑	Normal to slightly ↑	Infection, drugs, sepsis, hypoxemia, cirrhosis, lipidosis, neoplasia
Post-hepatic (cholestatic)	↑conjugated fraction	Normal to slightly ↑	Marked ↑	Stones, sepsis, pancreatitis

Courtesy Lisa Ebner, DVM, DACVAA

Clinical Signs of Liver Disease

- Clinical signs of hepatic disease:
  - Ascites
  - Depression
  - Seizures
  - Hepatic encephalopathy
  - Anorexia
  - Weight loss
  - Icterus/jaundice

Cases needing anesthesia:

- Portosystemic vascular malformations
- Acquired PSS
- Hepatic lipidosis
- Cholangiohepatitis (liths, mucocele)
- Liver Bx and Feeding Tube Placement
- Hepatotoxins
  - Chronic administration of drugs such as: phenobarbital, NSAIDs, steroids, acetaminophen
  - may need anesthesia for other reasons

The Anesthetic Plan

- Preanesthetic medication:
  - Sedative
    - AVOID:
      - Acepromazine – hypotension, inhibition of platelet-aggregation
      - Alpha-2 agonist - Δ plasma glucose, peripheral blood flow alterations
    - USE:
      - Benzodiazepine–diazepam or midazolam (0.1-0.2 mg/kg)
      - Minimal CV depression
      - CAUTION: patients with hepatic encephalopathy
  - Opioids are good
    - But, perhaps avoid morphine. WHY?!?

Anesthetic Induction

- Propofol/Alfaxalone
  - Rapid distribution and metabolism via glucuronidation and extrahepatic clearance (lung)
- Etomidate
  - Short duration of action
  - Rapid redistribution
  - Hepatic microsomal enzymes, plasmaesterases
- Dissociative Anesthetics
  - Tiletamine, ketamine (duration of action tiletamine > ketamine)
  - Acceptable if no seizure history

Maintenance: Inhalant anesthetics

- Isoflurane
  - ↑ hepatic blood flow
  - 0.2 % metabolized
  - Less CV depression than halothane → better CO → better perfusion
- Sevoflurane
  - 2-5% metabolized
  - Possibly reduces portal vein blood flow and O2 delivery more than isoflurane

Inhalants undergo metabolism mostly in the liver, also to a smaller degree in the lung, kidney, and GIT; however, most is exhaled!

Anesthetic Monitoring

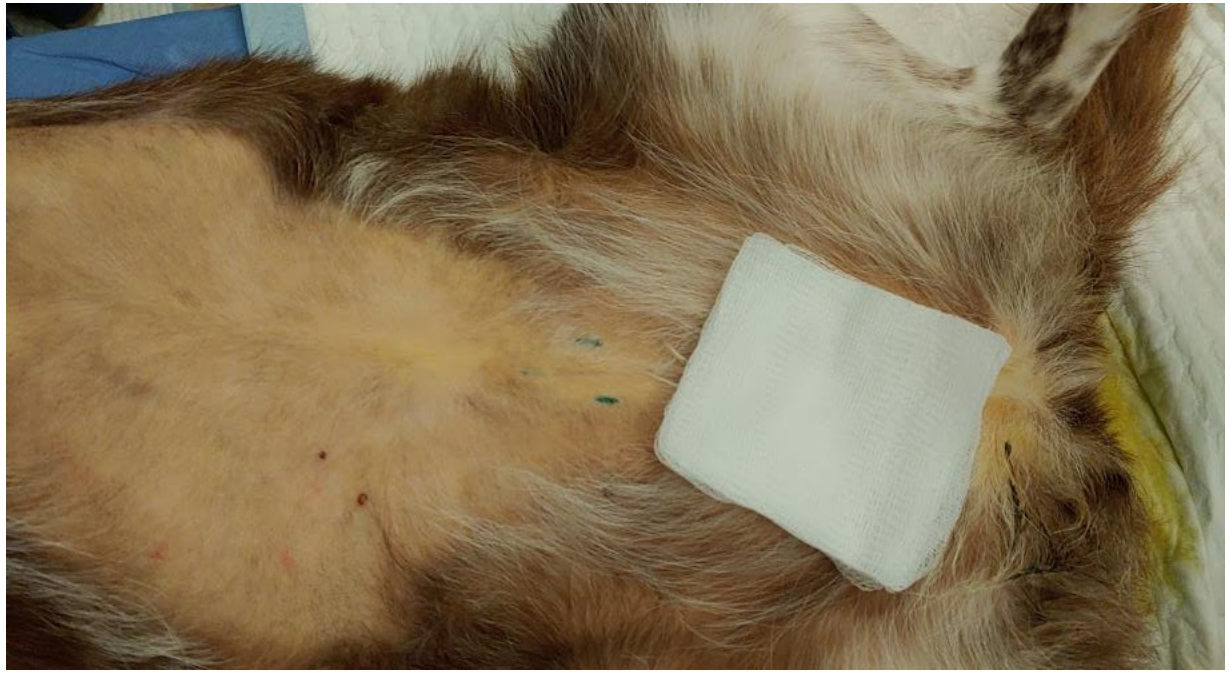
- End-tidal CO2
- Pulse oximetry
- Arterial blood-gas analysis
- +/- ECG
- +/- Arterial blood pressure
  - MAP > 60 mmHg
- +/- Central Venous Pressure (CVP)
  - Often hypoproteinemic
  - Hydration status

Other considerations:

- Maintain T
  - ↓ metabolism by liver during hypothermia
- Blood glucose
  - Check, recheck, & treat hypoglycemia PRN
  - 2.5 – 5% Dextrose in crystalloid
- Hypoproteinemia
  - Albumin ≤ 1.5 g/dL
  - ↓ plasma oncotic P
    - pulmonary edema with fluid administration
    - Hypotension
    - Tx. : Plasma transfusion (up to 20 mL/kg)
      Vetstarch/Hetastarch (10-20 mL/kg)
      Albumin (canine, human) @ 2.5-5 mL/kg

Meet Bailey

- 10 y/o FS
- Canine, Border CollieX
- PC: weight loss, inappetance
- Hx: persistently elevated LE
- Procedure:
  - Laparoscopic liver biopsy
  - Esophageal feeding tube
  - Urinary catheter



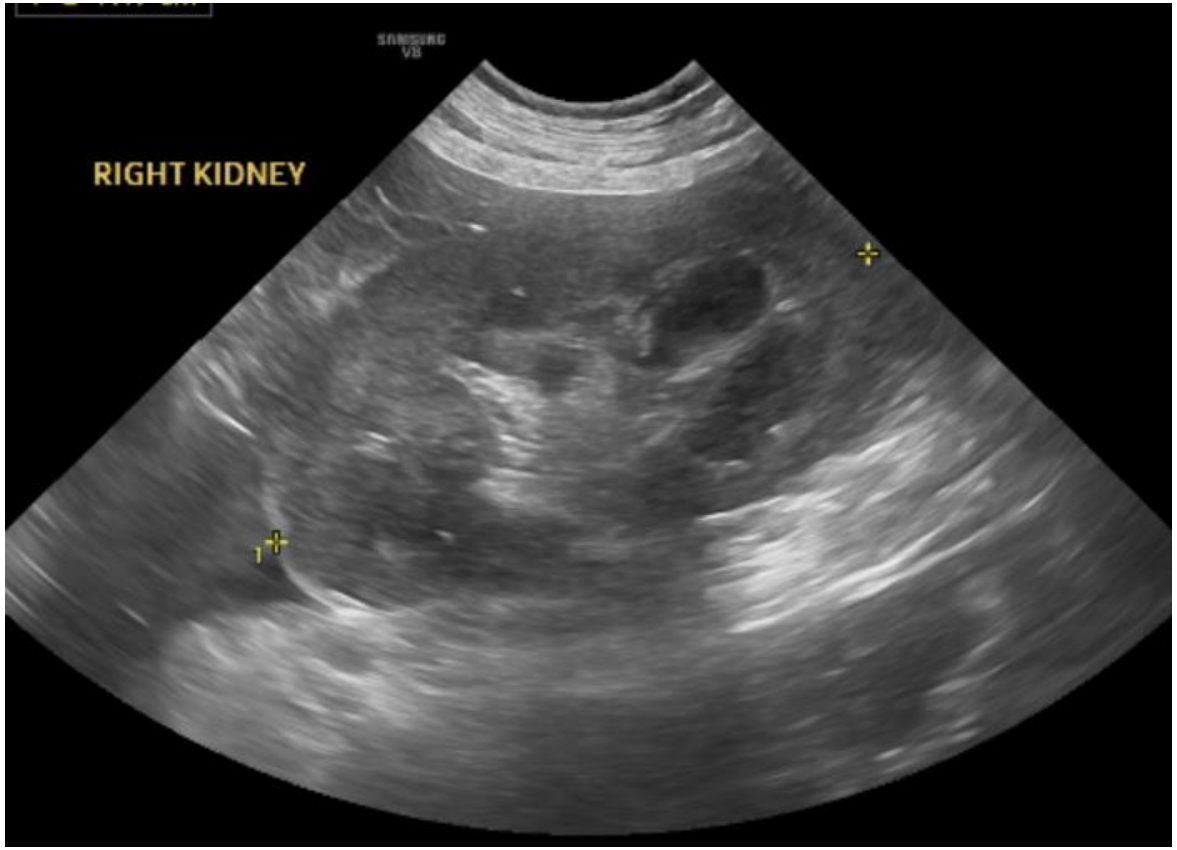
Bailey's Anesthetic Plan

Patient presents to CO Sx via IM dept for laparoscopic liver biopsy. Bailey has a history of persistently elevated LE and weight loss. She has been in hospital for past 3d with supportive care yielding minimal improvement. TBIL continues to be elevated at 12 (mg/dL), 205 µmol/L, mild anemia (35%), AUS showed hepatopathy w probable cholangiohepatitis. PT/PTT 10/110 (s). Current tx: Isolyte at maint, pantoprazole, sucralfate, fentanyl CRI, ampicillin-sublactam, enrofloxacin, maropitant
ASA: III
Anesthetic concerns: hypotension, hypoventilation, significant hypercarbia, hemorrhage (TBV 2187 mL, 10% 219 mL), hypoxemia, distension discomfort, prolonged recovery
Premed/Induce: fentanyl 5 mcg/kg, followed by midazolam 0.2 mL/kg then propofol up to 4 mg/kg IV slow
Maint: iso + O2, fentanyl CRI 5-10 mcg/kg/h, ampicillin-sublactam 22 mg/kg IV slow q 90 min, LE bupivacaine up to 0.4 mL/kg at close. IPPV up to 20 cmH2O to keep ETCO2 < 55 mmHg. MAP > 80 mmHg (fluid boluses, glyco 0.005 mg/kg IV if HR < 60 bpm, dopamine CRI (dilute to 5 mg/mL) 5-10 mcg/kg/min)
Recovery: as per surgeon preference. Recommend continue IVF at main, rest of meds as Rx. Avoid dexmed/ace. Give propofol 0.25 mL/kg if needed at recovery

ADDENDUM: very anxious and screaming after owner visit, gabapentin 200 mg PO +/- trazodone 50-100 mg PO q8h PRN. Central line (jugular catheter) to be placed pre-op. Triple lumen, 7Fr since peripheral veins have thrombosis from previous IVCs and blood draws

Anesthetic Summary: Hepatic Disease

- Start medical management for hepatic encephalopathy PRIOR to surgery
- Check coagulation profile (PT, PTT)
- Use short-acting and reversible drugs
- Monitor hydration, blood glucose, and plasma protein concentrations
- Hypotension and bradycardia (vasovagal reflex) may occur with biliary tree manipulation. Consider anticholinergic (atropine or glycopyrrolate) in the anesthestic plan
- Be prepared for postoperative complications, such as seizures
- Potential for thromboembolic complications



Anesthesia for Patients with Renal Disease

Patients with Renal Disease

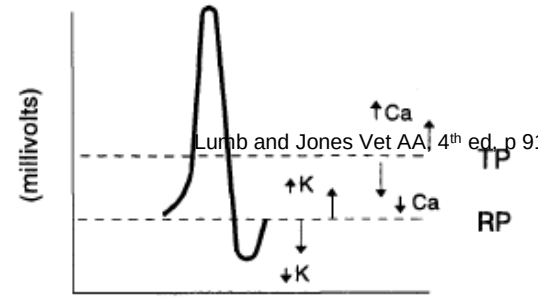
- Kidney Functions
  - Filtration
  - Reabsorption
  - Secretion
- Renal Blood Flow (RBF)
  - Receives ≈ 25% CO
  - autoregulated in MAP range of 80-180 mmHg
  - ALL anesthetics are likely to affect RBF

Patients with Renal Disease

- Patient Problems
  - Azotemia
    - ≥ 75% nephron loss for persistent azotemia
      - Signs of renal insufficiency: U/A, PCV, PU/PD
    - ∆ BBB → ↑ drug penetration into CNS
  - Acidosis
    - can↑ fraction of unbound drug

Patients with Renal Disease

- Electrolyte abnormalities
  - Hyperkalemia (>5.5 – 6 mEq/L)
    - Postpone anesthesia
    - Tx.: Ca^{++}; 0.9% saline +/- glucose, insulin, bicarbonate
    - What would your ECG look like? (≈ 8 mEq/L)
- Dehydration/Anorexia
- Anemia
  - Via bone marrow suppression, GI blood loss (ulceration), ↓ RBC lifespan, ↓ erythropoeitin production
  - Transfuse pRBC (cats <18%, dogs <20%)
- Hypertension



Lumb and Jones Vet AA, 4th ed. p 917

Fig. 39.1. Relationships between extracellular concentrations of potassium (K^+) and calcium (Ca^{2+}) and the resting potential (RP) and threshold potential (TP). An action potential is generated when there is sufficient depolarization to reach the TP. Increased extracellular potassium will result in raised (less negative) RP, whereas increased extracellular calcium will result in raised TP.

Common Concerns for Azotemic Patients

- Chronic Renal Failure
  - May be hyperkalemic, azotemic, acidemic, dehydrated, GI/oral ulceration, anemic, hypertensive, poor body condition
- Urethral Obstruction
  - Concerns: hyperkalemic, azotemic, acidemic
    - Cats may also be hypocalcemic, hyponatremic, and hyperglycemic
- Ruptured Urinary Bladder
  - Hyperkalemic, hyponatremic, hypochloremic, acidotic

Anesthetic Plan

STRESS-FREE!

- Stress → catecholamine release →↓RBF, ↓GFR → ↓ urine production
  - Also, release of aldosterone, renin, and vasopressin (contributing further to these issues)
- Preanesthetic medication
  - Goals: ↓ anxiety without ↓ MAP, RBF
  - Opioid + benzodiazepine (best option)
  - Acepromazine?: NO, likely to cause hypotension. Alpha-2 agonists?: No, likely to decrease CO → decreased renal perfusion
- Induction
  - Propofol or alfaxalone
  - Etomidate
  - AVOID ketamine in cats
  - Box/Mask? NO! Stressful!!

Maintenance: Inhalant Anesthesia

- GOAL: minimize inhalant use
  - ↓ CO, vasodilation → hypotension
- Isoflurane
  - Preferred inhalant?
- Sevoflurane
  - Breakdown into nephrotoxic inorganic fluoride
  - Compound A: nephrotoxic breakdown produce of sevoflurane degraded by CO2 absorbents
    - Avoid low fresh gas flows which would increase the concentration of Compound A

Anesthetic Monitoring

- End-tidal CO2
- Pulse oximetry
- Arterial blood-gas & electrolyte analysis
- ECG
- +/- arterial blood pressure
  - But, BP, BP, BP!

Other Anesthetic Concerns

- Fluid therapy
  - BES
  - 3-10 ml/kg/h
    - If normal protein and CV status
- Blood pressure
  - MAP $\geq$ 80 mmHg
  - Fluid support
  - + inotrope
    - Dobutamine, dopamine
- Ventilation
  - Mild hyperventilation. WHY?
  - ETCO2 ≈ 35 mmHg

Post-operative care

- Avoid nephrotoxic drugs
  - NSAIDs (?)
  - Aminoglycoside antibiotics
- +/- urinary catheter placement
  - 0.5-1 ml/kg/h urinary output (dogs)

Meet Cassie

- 14.5 y/o FS
- Canine, Terrier X
- 10 kg
- Hx. Chronic renal disease
- PC: bilateral pelvic limb lameness, L>R
- Procedure: L TPLO
- Workup: CBC/Chem/AUS/pelvic limb rads
- AUS results: moderate degenerative changes in the kidneys with bilateral pyelectasia that appears more likely secondary to fibrosis and blunting of the renal papilla over pyelonephritis. No evidence for ureteral obstruction

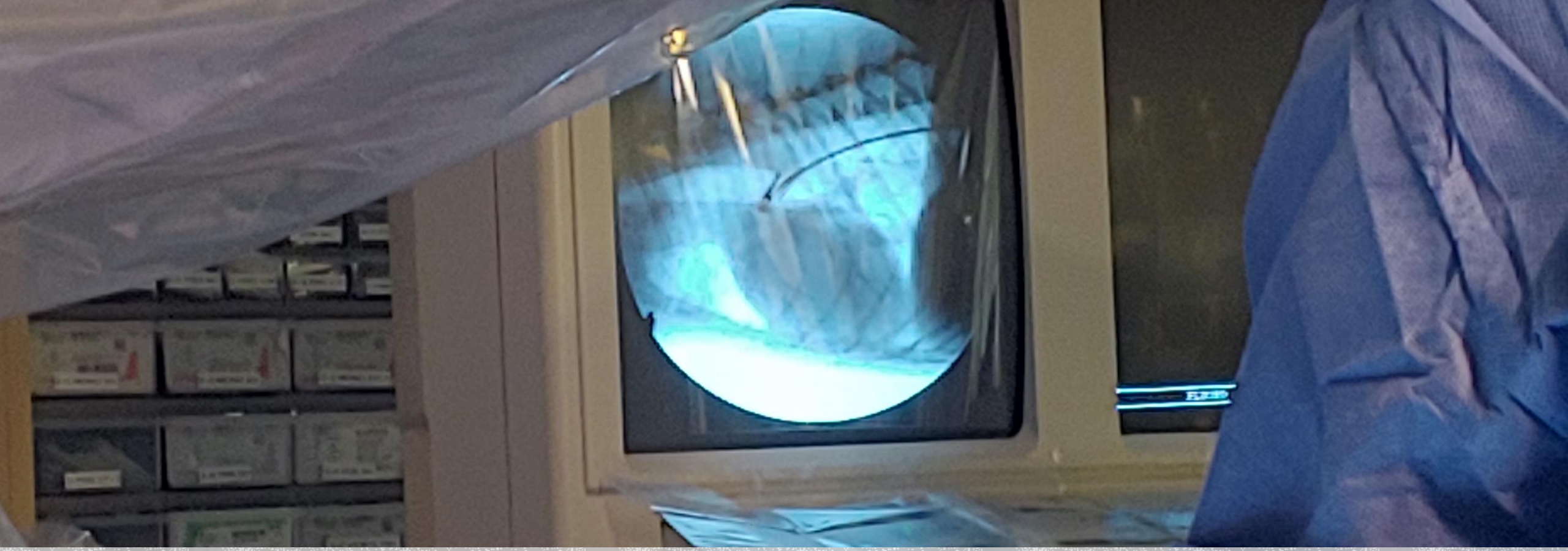
Cassie's Plan:

Patient presents to sx dept for L TPLO. Cassie has an extensive history, including R chronic cruciate injury, L acute. Chronic degenerative renal changes seen on AUS with azotemia and proteinuria. Heart murmur, intermittently ausculted (2/6) but not worked up to date. Labs (9.22) UA USG 1.019, prot 2+, SDMA 15, Creat 1.9 mg/dL (168 µmol/L), BUN 84 mg/dL (30 mmol/L)
ASA: III
Anesthetic concerns: hypotension v fluid volume overload, hypoventilation, pain, hypoxemia, progressive renal dysfunction, regurg/asp
Prior to anesthesia: PCV/TP/iSTAT, consider CXR w rad review if murmur present, maropitant 1 mg/kg IV slow, IV fluids (Isolyte or LRS)
Premed/Induce: hydro 0.1 mg/kg, followed by midazolam 0.2 mg/kg then propofol up to 4 mg/kg IVs slow
Maint: iso + O2, IVF 5 mL/kg/h, fentanyl CRI 5-10 mcg/kg/h, cefazolin 22 mg/kg IV slow q 90 min, LE bupivacaine up to 0.4 mL/kg at close. MAP > 80 mmHg at all times (judicious fluid boluses, glyco 0.01 mg/kg IV, dopamine CRI (dilute to 2 mg/mL) 5-10 mcg/kg/h
Locoreg: L F+S block, bupivacaine 2 mg/kg (4 mL), divided
Recovery: as per sx preference, likely fentanyl patch 25 mcg/h if no NSAIDs. Recommend continue IVF at 1-1.5x maint, F CRI 2-5 mcg/kg/h, AVOID ace/dexmed if possible. Give propofol 0.25-0.5 mg/kg IV if needed in recovery

- ADDENDUM: patient pre-op labs increased azotemia, procedure cancelled

Renal Patient Anesthesia Summary

- Correct hydration status PRIOR to anesthetic episode and maintain immediately post
- Minimize stress to avoid catecholamine release
- Maintain MAP ≥ 80 mmHg
- Avoid nephrotoxic drugs



Anesthesia for Patients with Cardiac Disease

The CVS

- Functions
  - Circulate blood
  - Maintain DO_2
- Concern
  - O2 needed to maintain life!
  - (Nearly) all anesthetic drugs compromise CVS
    - Effects can be greater in those with underlying cardiac disease
- Anesthetic goals
  - Maintain DO_2 and homeostasis: $DO_2 = CO \times CaO_2$
  - Individualized patient plan

Cardiac Patient Assessment

- Extensive workup recommended!
- ECG +/- Holter
- Echocardiogram
- CXR
- BP
- PE: cardiac and lung sounds; HR/RR, effort
  - mm color/CRT

Cardiac Patient Medications

HOLD ACE-inhibitors

Coleman AE, Shepard MK, Schmiedt CW, Hofmeister EH, Brown SA. Effects of orally administered enalapril on blood pressure and hemodynamic response to vasopressors during isoflurane anesthesia in healthy dogs. Vet Anaesth Analg. 2016 Sep;43(5):482-94. doi: 10.1111/vaa.12338. Epub 2016 Feb 5. PMID: 26848816

- **Clinical relevance:** Dogs receiving angiotensin-converting enzyme inhibitors on the day of anesthesia may exhibit clinically significant intra-anesthetic hypotension

GIVE PIMOBENDAN

Pagel PS, Hettrick DA, Warltier DC. Influence of levosimendan, pimobendan, and milrinone on the regional distribution of cardiac output in anaesthetized dogs. Br J Pharmacol. 1996 Oct;119(3):609-15. doi: 10.1111/j.1476-5381.1996.tb15716.x. PMID: 8894186; PMCID: PMC1915696

- **Clinical relevance:** increases in heart rate, cardiac output, and left ventricular +dP/dt and decreases in end-diastolic pressure and systemic vascular resistance

Cardiac Disease: Functional Classification

- Assists in assessing risk
- Class I
  - Nonclinical, no preanesthetic stabilization needed
- Class II
  - Mild to moderate clinical signs, significant stabilization prior to anesthesia
    - Medications +/- hospitalization
  - Aggressive and invasive monitoring recommended
- Class III
  - Ongoing, fulminant heart failure, anesthesia is contraindicated until stabilized (if possible)

Sedation versus Anesthesia?

- ↑ risk of mortality seen with increasing ASA status
  - Importance of patient evaluation and stabilization PRIOR to commencement of procedure
  - Identify risk factors and monitor carefully
- Largest proportion of deaths in post-procedure period
  - Continued patient monitoring & support vital
- Procedural sedation: may not be safer in cardiac patients (over GA)
  - Common sedatives may be contra-indicated
    - Acepromazine (?)
    - Dexmedetomidine (?)
  - Monitoring may be limited

Blood Pressure Monitoring

- Parameters:
  - Pulse rate (PR)
  - Arterial pressure (SAP, MAP, DAP in mmHg)
- Normal ranges:
  - *MAP > 60 mmHg*: normal, healthy, young pts
    - Doppler BP ≥ 90 mmHg
  - *MAP > 80 mmHg*: geriatric, renal, hypertensive pts
    - Or ideally, within 20 mmHg of awake BP if possible

Blood Pressure Monitoring

- Considered a major vital sign
  - Blood to peripheral tissue beds to carry O_2 and remove CO_2
- Indirectly indicates:
  - Perfusion
  - Circulation
  - Cardiac output
  - No clinically useful CO monitor on market

BP monitoring: Options

- **Direct Arterial Line**
  - Pros: gold-standard, accuracy, waveform analysis
  - Cons: higher skill level, ↑ equipment, set up time, +/- hemorrhage, hematoma, infection, and/or pain
- **Doppler + sphygmomanometer**
  - Pros: ↓$, reliable among a large range of pt size, HR, BP; real-time, audible
  - Cons: electrical interference of othr eqpt, ↑ set-up time vs oscillometric, manual inflation of the cuff needed
- **Oscillometric device**
  - Pros: easy to apply, automated, *can* be very accurate
  - Cons: ↓accuracy: hypotension, hypertension, tachycardia, bradycardia, very small patients

1. Check patient depth

Decrease inhalant!

- Inhalant: ↓ SV and ↓ SVR → ↓ CO & ↓MAP
  - Check depth
    - Eye position, palpebral reflexes, jaw tone
- Plan ahead: multi-modal plan
  - Opioid (pure mu agonist best for mod-sev pain)
  - Other analgesic drugs (consider CRIs)
  - Locoregional anesthesia

2. Check heart rate

Is the patient bradycardic?

- HR < 60 bpm (dogs), HR < 120 bpm (cats)
- Anticholinergic administration
  - Glycopyrrolate versus Atropine
  - Dexmedetomidine: HR < 40 bpm (dogs), HR < 80 bpm (cats)
    - AVOID anti-cholinergic drugs if HYPERtensive & bradycardic → ↓ cardiac index (Congon et al. JAVMA, 2011)
    - If patient stable → benign neglect
    - *Give anti-cholinergic if bradycardic **&** HYPOtensive*
    - Atipamazole? (Martin Flores et al. IVECCS, 2016)
- Hypothermia

3(A). Fluid therapy

- Is it under-hydrated in the face of anesthetic vasodilation?
  - Pre-op PCV/TP?
  - Vasodilating drugs? (i.e. acepromazine, inhalant)
  - Can patient tolerate a fluid bolus (with perhaps additional boluses)?
- Bolus = 3-10 mL/kg (BES crystalloid) – ok for heart?!?
  - < 15 minutes
  - Note: increasing the hourly fluid rate is unlikely to improve hypotension!
- Rule of thumb: 3-4 mL BES for every 1 mL blood lost
- What modifications are needed for cardiac disease?

3 (B). Transfusion or Substitute Tx (?)

GOAL = use supportive therapies in patients to correct deficiencies until the underlying cause or disease process can be treated

- CONCERNS
  - Volume overload
  - Electrolyte disturbances
  - Immunogenicity
  - Availability
  - $
  - Transmission of infection
    - Blood products

4. Positive Inotropes

- Dopamine CRI (5-10 mcg/kg/min)
  - Beta agonist → ↑SV
  - Alpha agonist →↑SVR
- Dobutamine CRI
  - Synthetic beta agonist →↑SV

Proper fluid resuscitation needed prior to start, otherwise tachyarrhythmias

Adrenergic Agonists: Dose-dependent effects of Dopamine

- Low dose: DA1 and DA2 receptors
  - 1-4 mcg/kg/min
  - Renal effects
- **Medium dose: β receptors**
  - **5-10 mcg/kg/min**
  - **↑CO**
- High dose: α1 receptors (along with β)
  - 10-20 mcg/kg/min
  - ↑ SVR, ↑HR & CO

Adrenergic Agonists: Dobutamine

Do**B**utamine

- Receptors:
  - α1: vasoconstriction (intense, peripheral)
  - **β1**: ↑ HR, BP, CO
  - β2: bronchodilation
- Clinical uses (CRI)
  - Management of hypotension
    - Especially in equine anesthesia
- Caution: tachyarrhythmias, seizures in cats (?)

5. Vasopressors

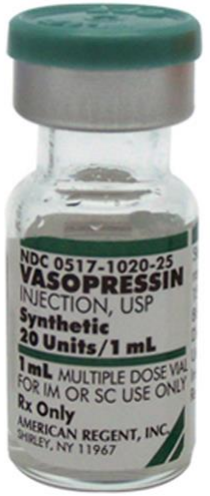
- Shock, significant underlying disease→ significant peripheral vasodilation
- Phenylephrine (2-5 mcg/kg), ephedrine (0.05-0.2 mg/kg), or norepinephrine (0.5-2 mcg/kg/min)
  - ↑ SVR
- Vasopressin (1–4 mU/kg/min)
  - patients with significant acidemia

* Patients with significant hemorrhage and/or needing use of vasopressors = high risk! Need intensive & O/N care!!

Adrenergic Agonists: Norepinephrine

- Receptors:
  - **α1**, α2: intense vasoconstriction
    - May see reflex bradycardia as a result
  - β1: mild ↑ HR, BP, CO
  - β2: mild bronchodilation
- Clinical uses (CRI)
  - Refractory shock
  - Significant, tx non-responsive hypotension
- Caution: extravasation → tissue necrosis

Vasopressin



- a.k.a. anti-diuretic hormone (ADH)
- Receptor:
  - V1, V2, V3 agonist
- Clinical uses (CRI)
  - CPR!
  - Septic/vasodilatory shock
  - Intra-op hypotension
  - Von Willebrand's disease
- ACE-inhibitor-related hypotension mgt?

Hedman KF, Mann CL, Spulecki C, Castner J. Low-Dose Vasopressin and Analogues to Treat Intraoperative Refractory Hypotension in Patients Prescribed Angiotensin-Converting Enzyme Inhibitors Undergoing General Anesthesia: A Systematic Review. AANA J. 2016 Dec;84(6):413-419. PMID: 28235174

Adrenergic Agonist Organ System Effects

Drug	Heart Rate	MAP	CO	Peripheral Vascular R	Broncho-dilation	Renal BF
Dobutamine	↑	↑	↑↑↑	↓	-	↑
Dopamine	↑/↑↑	↑	↑↑↑	↑	-	↑↑↑
Ephedrine	↑↑	↑↑	↑↑	↓↓	-	↑↑↑
Epinephrine	↑↑	↑	↑↑	↑/↓	↑↑	↓↓
Isoproterenol	↑↑↑	↓	↑↑↑	↓↓	↑↑↑	↓/↑
Norepinephrine	↓	↑↑↑	↓/↑	↑↑↑	-	↓↓↓
Phenylephrine	↓	↑↑↑	↓	↑↑↑	-	↓↓↓

Cardiac Patient Problems

- Autoregulation of BP: MAP ≈ 60-160 mmHg
  - CO = HR x SV
  - MAP = CO x SVR
- Perfusion
- Hypotension
- Fluid volume overload

Meet Marlo!

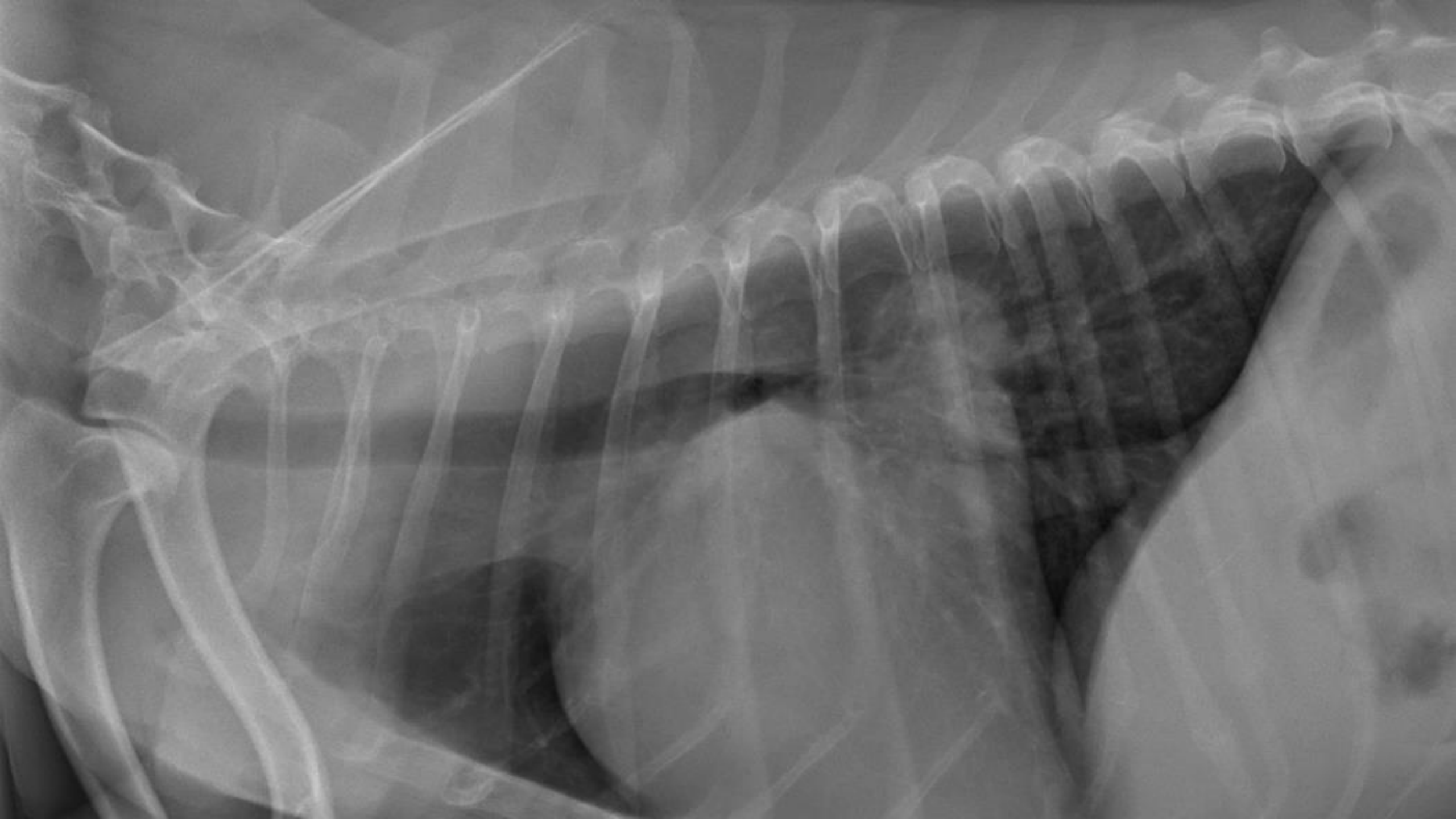
- 9 y/o MN
- Canine terrier X
- 6 kg
- PC: L TPLO
- Hx: CHF 7.2022, cardiologist mgt, now 3 months later
- Current meds: pimobendan, enalapril, furosemide, hydrocodone, meloxicam
- Temperament = nervous but nice

Marlo's Pre-op Plan

ASA: III

Anesthetic concerns: hypotension v fluid volume overload, hypoventilation, pain, ventricular arrhythmias
Prior to anesthesia: CXR 2v (w rad review), maropitant 1 mg/kg IV slow, CXR (2v) with rad review. Gabapentin 50 mg + trazodone 25 mg PO at arrival


R



Marlo's Intra- & Post- Op Plan

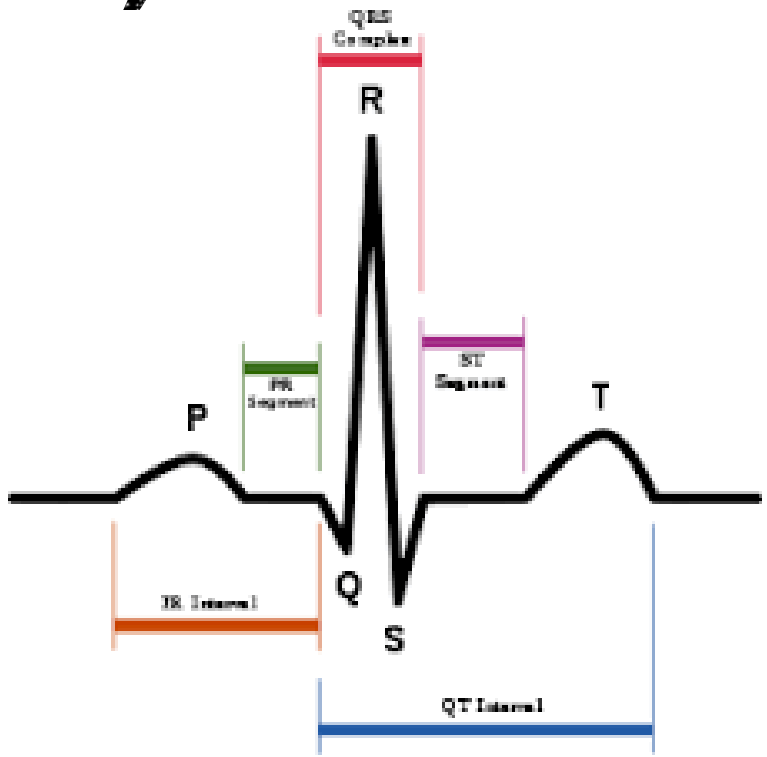
Premed/Induce: hydro 0.1 mg/kg, followed by midazolam 0.2 mg/kg then propofol up to 4 mg/kg IVs slow
Maint: iso + O2, IVF (LRS) 3 mL/kg/h, fentanyl CRI 5-10 mcg/kg/h, cefazolin 22 mg/kg IV slow q 90 min, LE bupivacaine up to 0.4 mL/kg at close. MAP > 80 mmHg at all times (fluid boluses, glyco 0.01 mg/kg IV, dopamine CRI (dilute to 2 mg/mL) 5-10 mcg/kg/h
Locoreg: F+S block, bupivacaine 2 mg/kg (2.6 mL), divided
Recovery: as per surgeon preference. Recommend continue IVF at 0.25x maint, F CRI 2-5 mcg/kg/h, AVOID ace/dexmed. Give propofol 0.25-0.5 mg/kg IV if needed in recovery. ***Respiratory watch in CCU***

What about cardiac arrhythmias?

- Source: abnormal cardiac contraction(s)
- Detection: helpful monitors -
  - Pulse oximeter (with waveform)
  - Doppler
  - ECG

Electrocardiogram (ECG)

- Parameters:
  - Cardiac electrical activity
  - HR
    - Canine: 60-160 bpm
    - Feline: 120-220 bpm
- When to use?
  - Normal pts: after the “big 3”: pulse oximeter, capnogram/graph, BP monitor
  - Place in advance of anesthetic induction in patients where cardiac arrhythmia concern
    - i.e., hx cardiac dz, hemoabdomen, GDV, septic shock



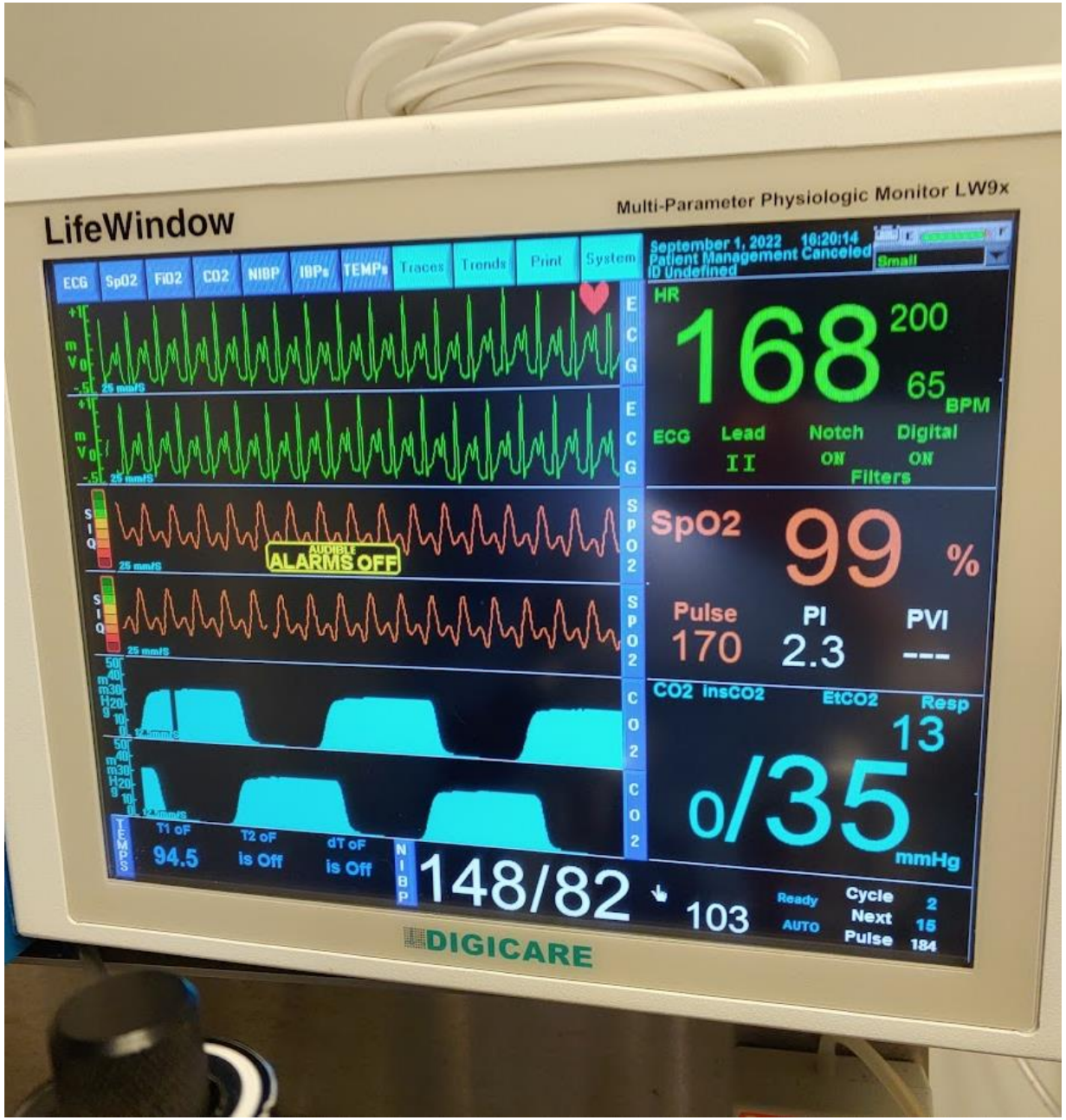

26-JAN-2017 11:27:38
DOG
AUDIO OFF
28
ECG
CO2
SPO2
NIBP
PRESS THE ROTARY KNOB TO FREEZE THE WAVEFORM AREA
ALARMS
TRENDS
SETUP
QUICKSET
SUSPEND
NIBP MODE: MANUAL
FREEZE


DOG
ALARM
AUDIO OFF
37
ECG
CO2
ART1
SPO2
NIBP
TEMP
PRESS THE ROTARY KNOB TO FREEZE THE WAVEFORM AREA
ALARMS
TRENDS
SETUP
QUICKSET
SUSPEND
NIBP MODE: MANUAL
FREEZE

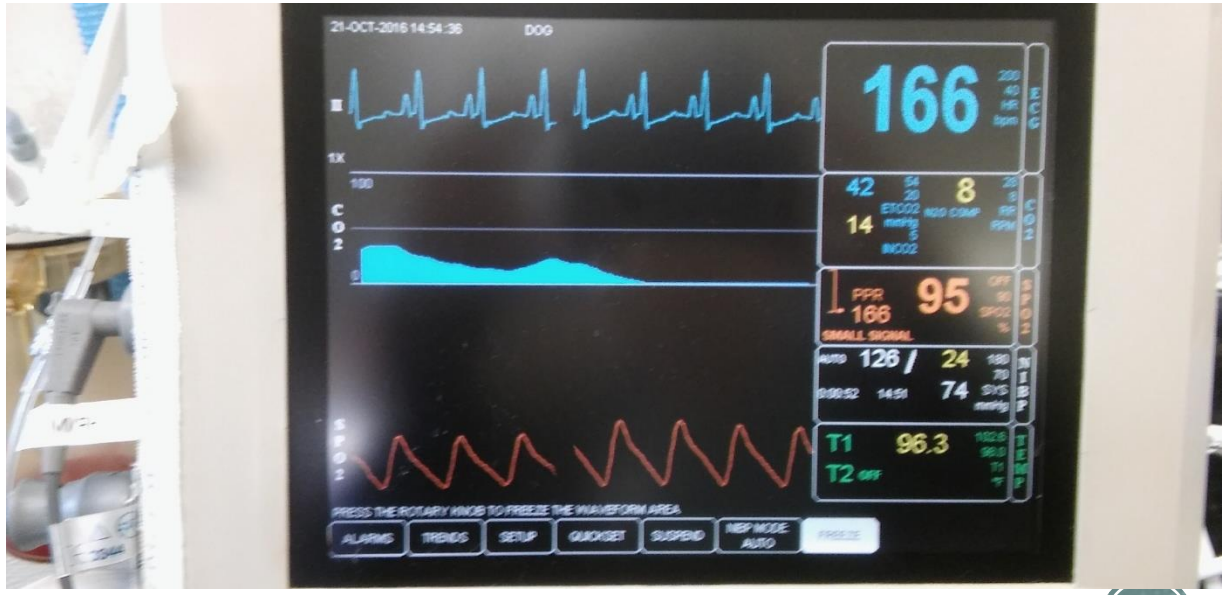

midmark
Multiparameter Monitor
bruno
SpO2 Pulse Search
** ART Sys Too Low
II
x1
Notch On(60Hz)
Surgery
HR BPM
48
from ECG
TEMP
T1 99.6
T2
TD
25 mm/s
SpO2 %
98
PR BPM
0
SPO2
IBP<1,2>
ART1 101 / 60 72
CVP2
ART1(0,120)
NIBP 14:12:22 00:00:56
2min
102 / 58 75
Auto measuring
CVP2(0,400)
CO2
EtCO2 36
iCO2 0
RR 9
80 mmHg
12.5 mm/s
03/29/2022
14:12:36
Tuesday
Pat.Set
Settings
Alarms
Pause
NIBP
Suspend
Freeze
Displays
Trend
Print
Lock

Sinus Bradycardia

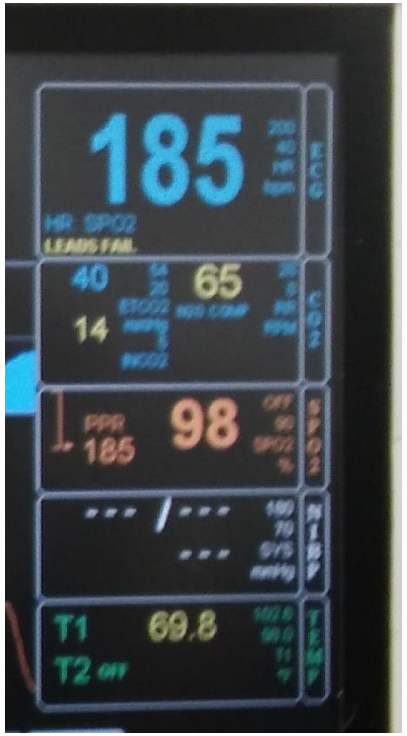
- Rate low, rhythm regular
- Dogs < 60 bpm, Cats < 100-120 bpm
  - Dexmed use: Dogs < 40 bpm, Cats < 80 bpm
- Causes:
  - ↑ vagal tone
  - Hypothermia
  - Drugs, esp opioids, dexmedetomidine
- Treatment: anticholinergic
  - Atropine (urgent, emergent), glycopyrrolate (↑ time)


LifeWindow
Multi-Parameter Physiologic Monitor LW9x
ECG SpO2 FiO2 CO2 NIBP IBPs TEMPs Traces Trends Print System
September 1, 2022 16:20:14
Patient Management Canceled
ID Undefined
Small
HR
168
200
65
BPM
ECG Lead II
Notch ON
Digital ON
Filters
AUDIBLE ALARMS OFF
SpO2
99
%
Pulse 170
PI 2.3
PVI ---
CO2 insCO2 EtCO2 Resp
13
0/35
mmHg
T1 oF 94.5
T2 oF is Off
dT oF is Off
NIBP
148/82
103
Ready
AUTO
Cycle
Next
Pulse
2
15
184
DIGICARE


SurgiVet
SX
24-JAN-2017 16:02:06 CAT
173
HR SPO2
ETCO2
INCO2
PPR 173
96
SMALL SIGNAL
153 / 117
129
T1 96.3
T2 OFF
PRESS THE ROTARY KNOB TO FREEZE THE WAVEFORM AREA
ALARMS PRINTER TRENDS SETUP QUICKSET SUSPEND NIBP MODE: AUTO FREEZE

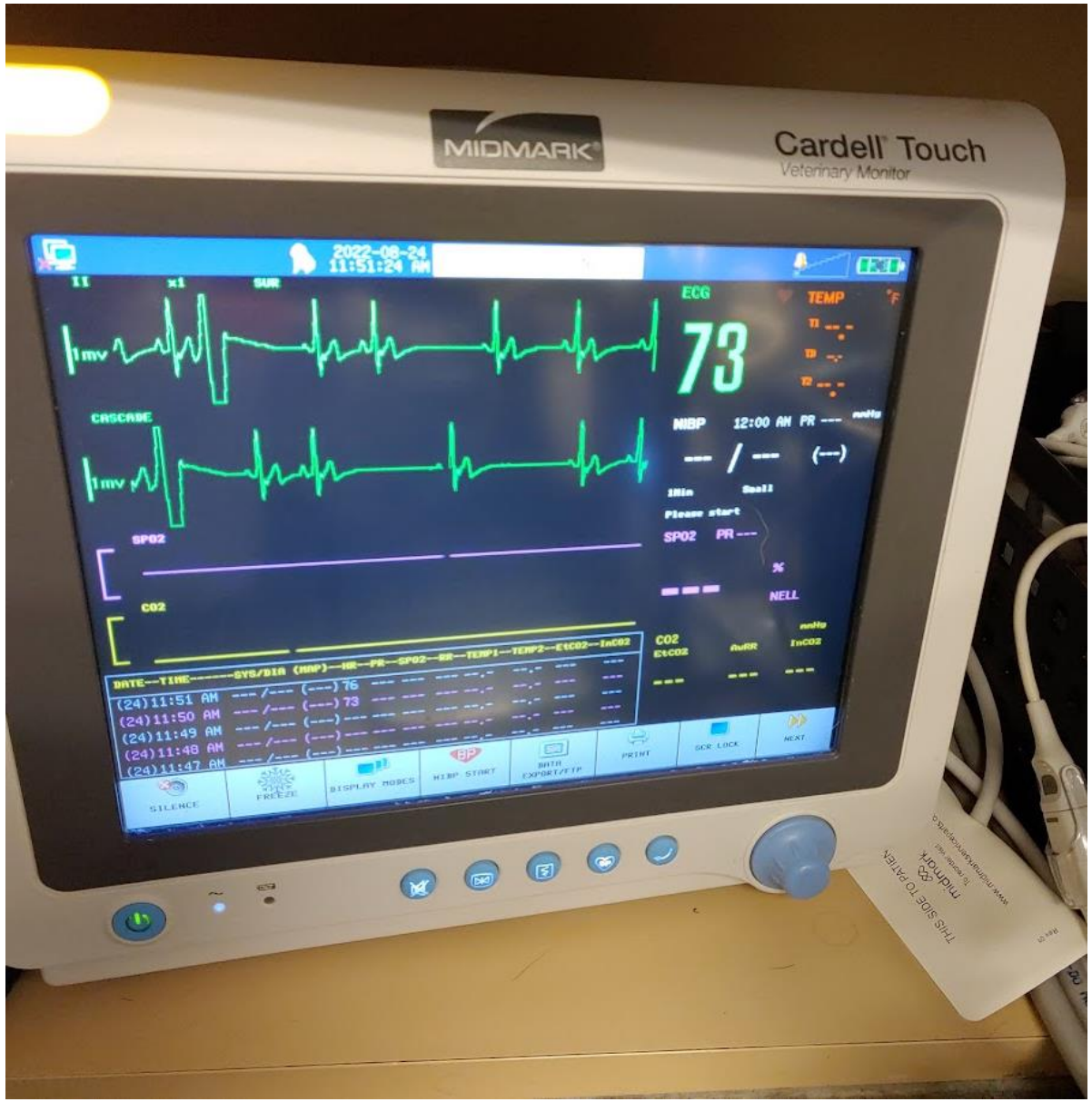

21-OCT-2016 14:54:36 DOG
166
42
14
8
PPR 166
95
SMALL SIGNAL
126 / 74
T1 96.3
T2 OFF
PRESS THE ROTARY KNOB TO FREEZE THE WAVEFORM AREA
ALARMS TRENDS SETUP QUICKSET SUSPEND NIBP MODE: AUTO FREEZE

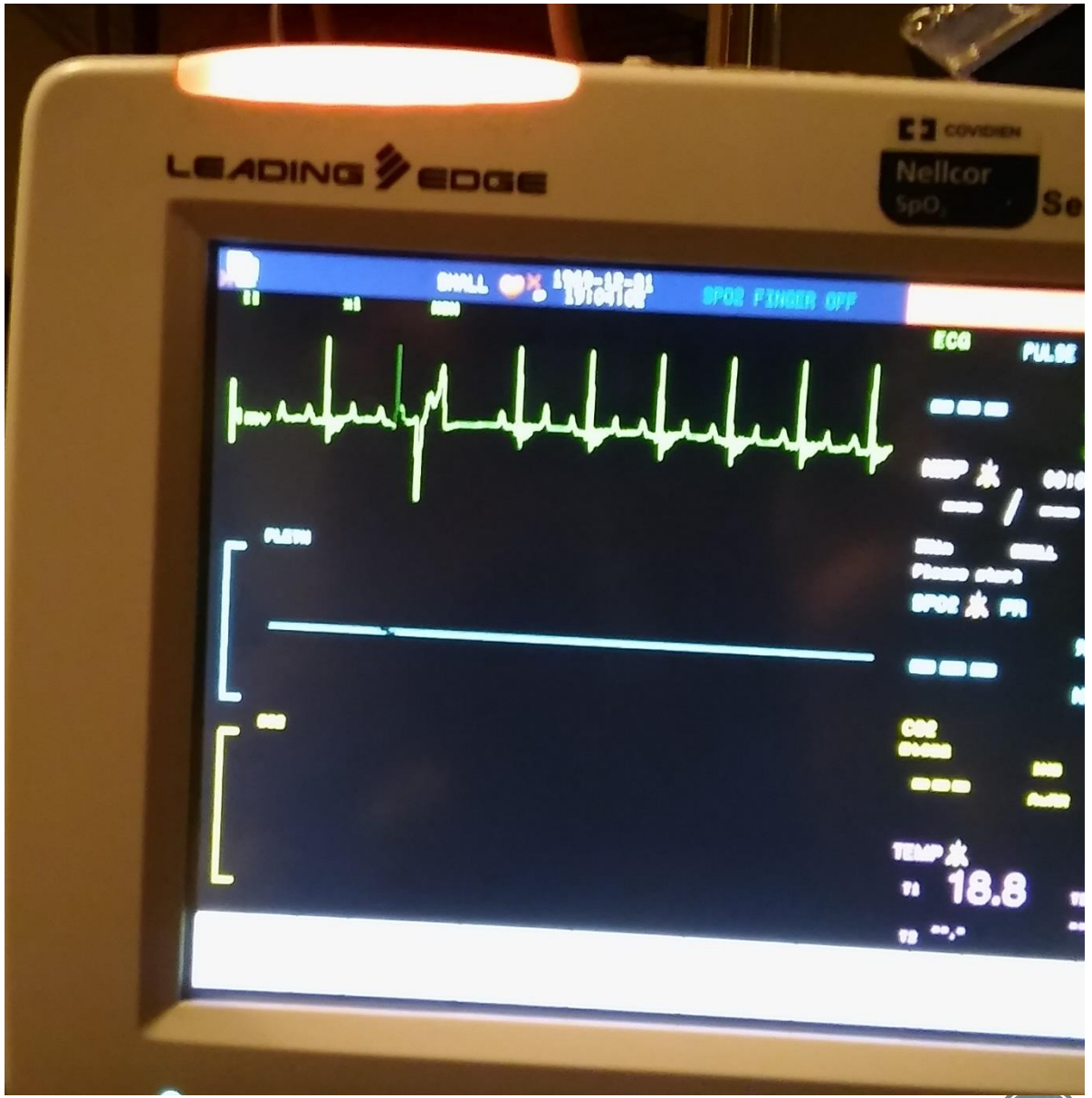
Sinus Tachycardia



- Rate high, rhythm regular
- Dogs > 140-160 bpm, Cats > 240 bpm
- Causes:
  - Light anesthetic plane, pain
  - Shock
  - Iatrogenic
- Treatment
  - Diagnose and address underlying cause

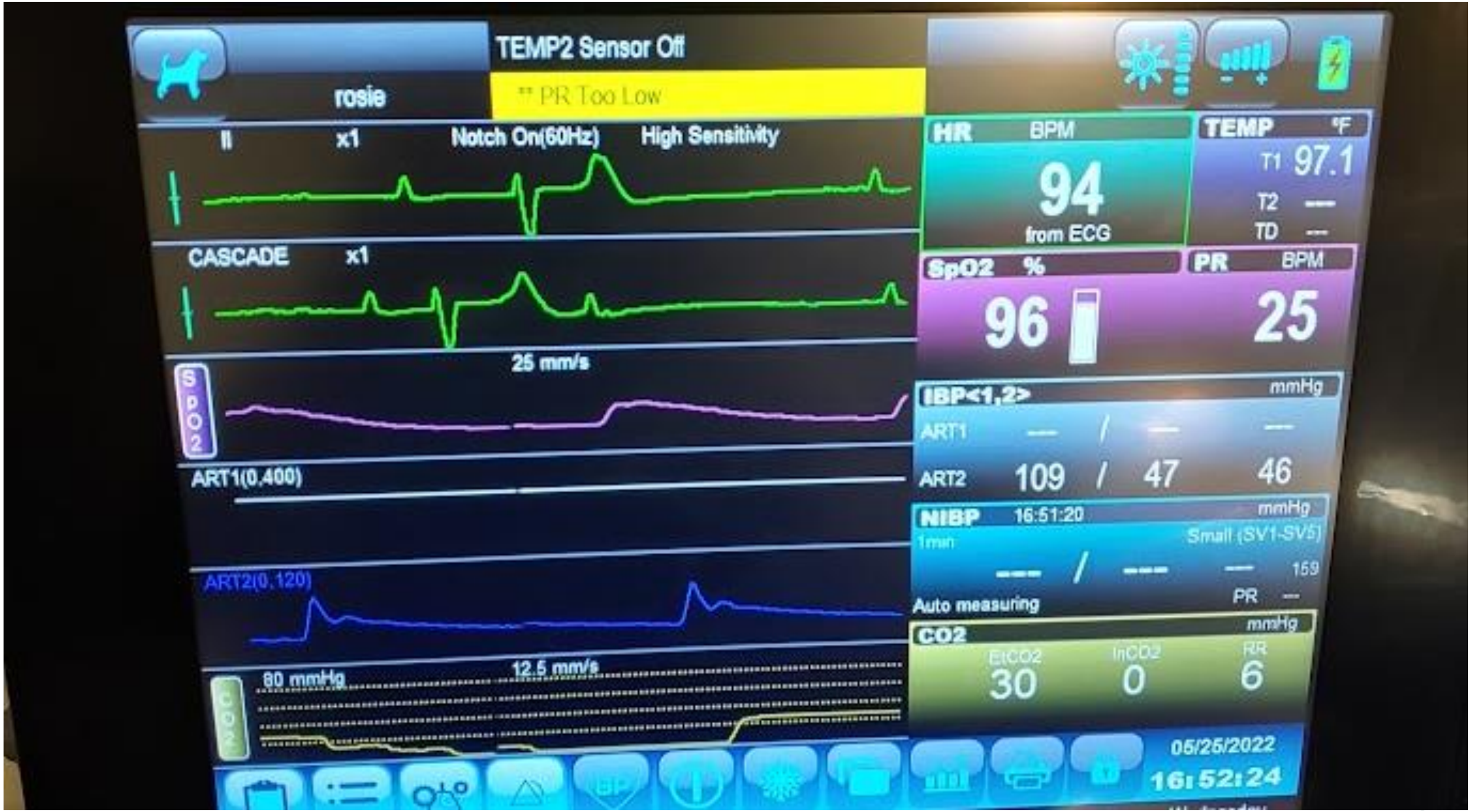
- hypoxemia anemia


MIDMARK
Cardell Touch
Veterinary Monitor
2022-08-24
11:51:24 AM
ECG
73
TEMP
NIBP
12:00 AM PR
SPO2
CO2
DATE--TIME SYS/DIA (MAP) HR PR SPO2 RR TEMP1 TEMP2 EtCO2 InCO2
(24)11:51 AM
(24)11:50 AM
(24)11:49 AM
(24)11:48 AM
(24)11:47 AM
SILENCE
FREEZE
DISPLAY MODES
NIBP START
PRINT
SCR LOCK
NEXT

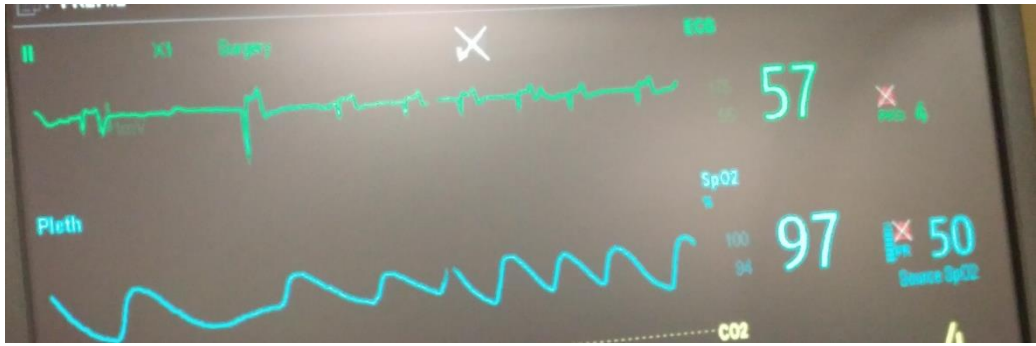

LEADING EDGE
COVIDIEN
Nellcor
SPO2 FINGER OFF
ECG
PULSE
PLETH
TEMP
18.8

Ventricular Premature Complex (VPC)

- Ventricular origin of cardiac impulse, early
- QRS w/o preceding P wave
- QRS complex = wide, bizarre, EARLY
- Causes:
  - Pain
  - Shock, trauma
  - hypoxemia, anemia
  - underlying cardiac dz
  - GDV, hemoab
- Treatment
  - Runs w/ ↑ *f*, multi-form, hypotension, pulse def, RonT
  - Lidocaine (2-4 mg/kg) +/- CRI (35-100 mcg/kg/min), procainamide, esmolol


TEMP2 Sensor Off
rosie
** PR Too Low
II x1 Notch On(60Hz) High Sensitivity
CASCADE x1
25 mm/s
SPO2
ART1(0,400)
ART2(0,120)
80 mmHg
12.5 mm/s
ECG
HR BPM
94
from ECG
TEMP °F
T1 97.1
T2 —
TD —
SpO2 %
96
PR BPM
25
IBP<1,2> mmHg
ART1 — / — —
ART2 109 / 47 46
NIBP 16:51:20 mmHg
1min
Small (SV1-SV5)
— / — — 159
Auto measuring
PR —
CO2 mmHg
EtCO2 InCO2 RR
30 0 6
05/25/2022
16:52:24

Ventricular Escape Beats



- Ventricular in origin
  - No P wave ahead of complex
- Looks like VPC but occurs LATE
  - Low intrinsic rate
    - Dogs < 40 bpm, Cats < 80 bpm
- Treatment:
  - Avoid treating ventricular rhythm, it is protective!
  - Increase intrinsic HR via anticholinergic
    - Atropine v glycopyrrolate


ECG
RESP
SpO2
TEMPs
Traces
Trends
Print
Main Sys
TeleVue 1
HR
140
140
60 BPM
ECG
Lead II
Notch On
Mode Mon
Filters
is Off
ALARM Silence
FREEZE
PRINT ECG
TeleVue3


IN LOCKBOX
ECG
RESP
SpO2
TEMPs
Traces
Trends
Print
System
Charlie
TeleVue2
HR
63
140
60 BPM
ECG
Lead II
Notch On
Mode Mon
Filters
is Off
FREEZE
PRINT ECG
TeleVue4
TeleVue3

Accelerated Idioventricular Rhythm (AIVR)

- Ectopic ventricular foci (wide, bizarre)
- Looks like > 3 VPCs in a row (but it's NOT)
  - Too regular/fast to be VPC, to slow to be V Tach
- HR < 150 bpm (dogs)
- Perfusion usually well-maintained
- Treatment:
  - Underlying cause, AVOID lidocaine
  - Monitor carefully
  - ↑ intrinsic HR? (i.e. anticholinergic)

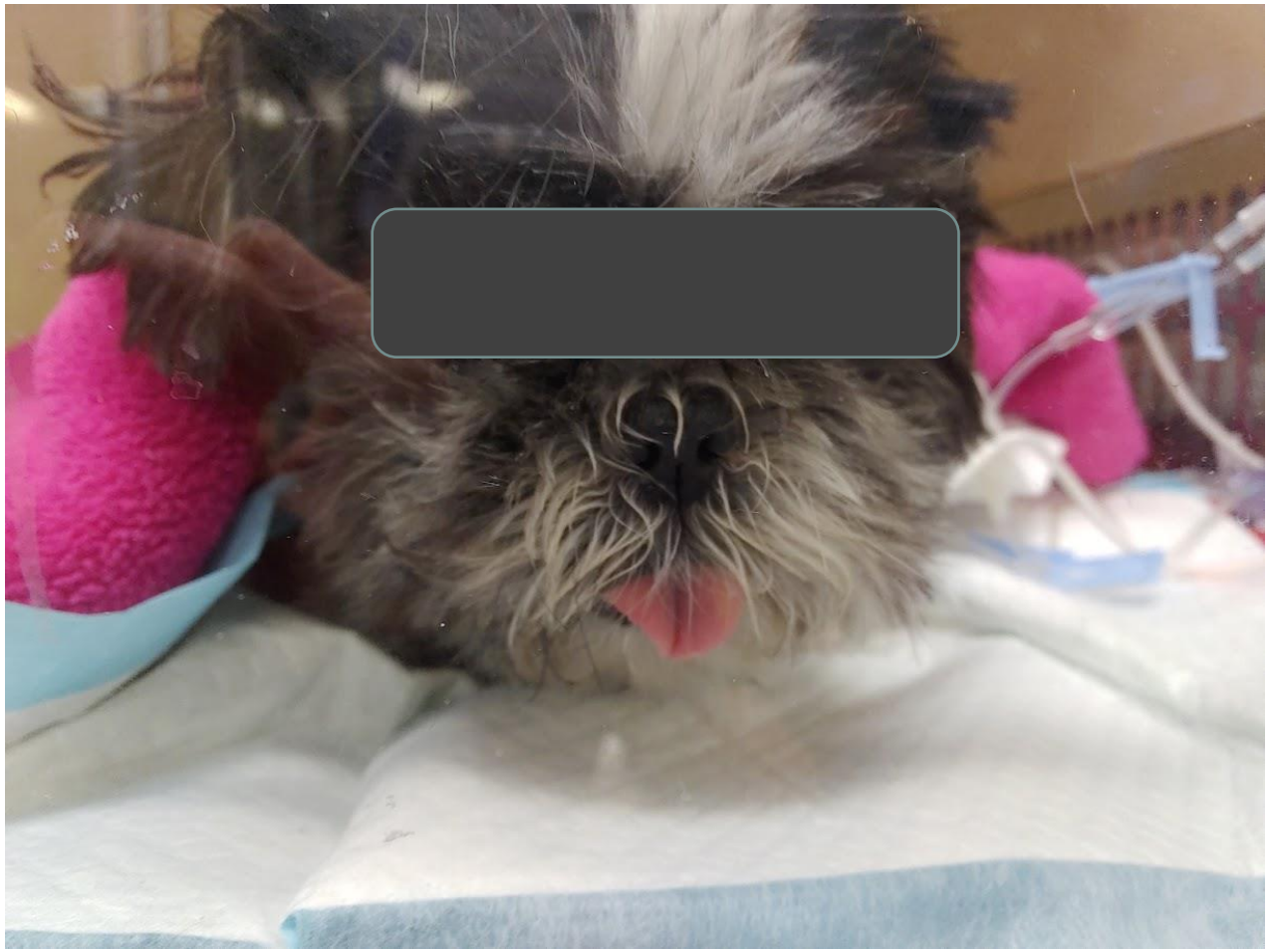
Anesthesia for Brachycephalic Breeds

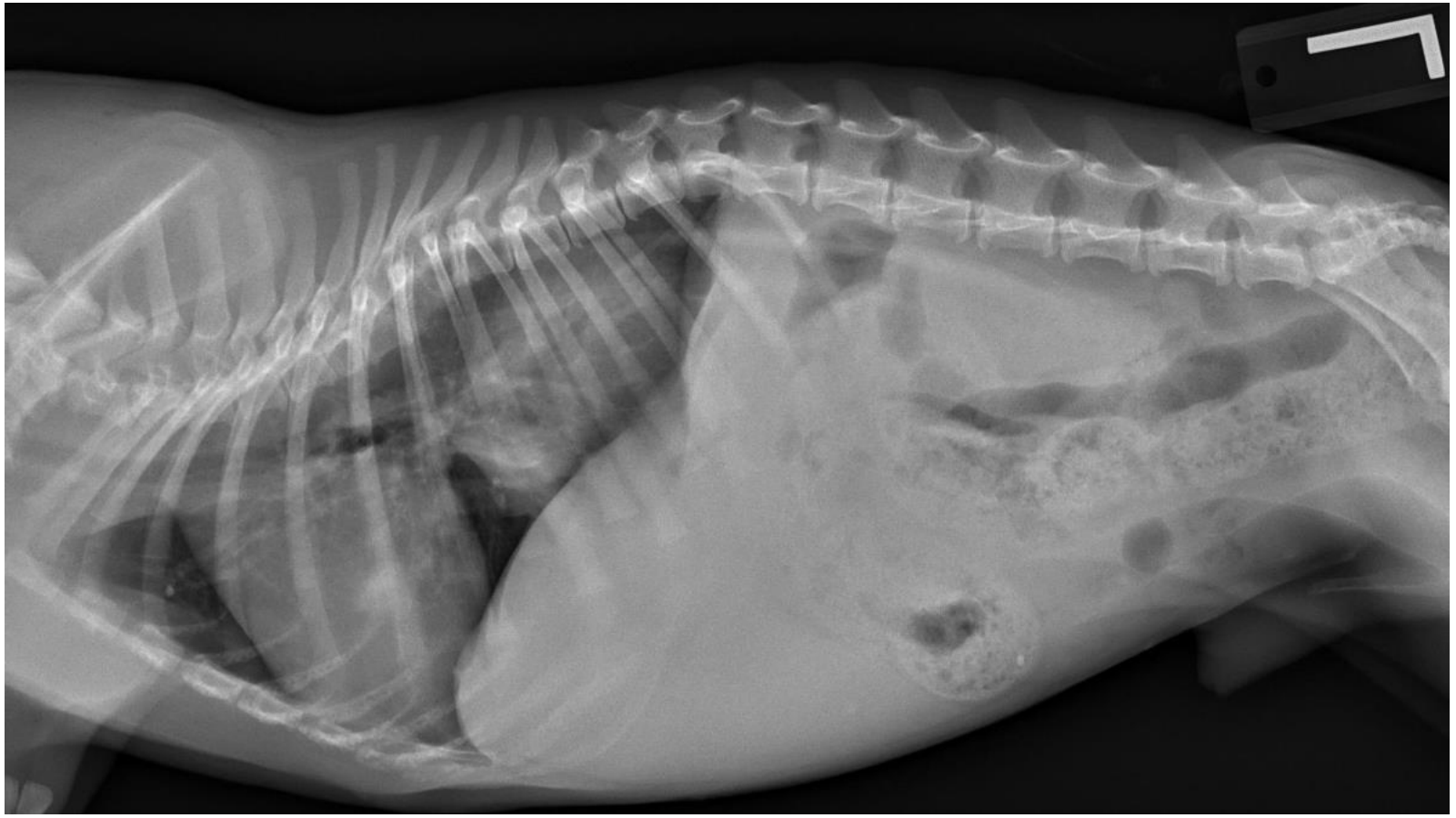
Components of BOAS

1. Stenotic nares
2. Hypoplastic trachea
3. Elongated soft palate
4. +/- Everted laryngeal saccules

Anesthetic concerns

- Hypoxemia
- Hypoventilation – obstructive airway
- Regurgitation/Aspiration
- Prolonged recovery
- Inadequate v profound sedation
- Hyperthermia





Hiatal hernia

Pre-operative Preparation

- Gastroprotectants (?)
  - Anti-nausea
    - maropitant 1 mg/kg SQ or IV > 1h before premed (or at home night b4)
  - Acid reducers
    - Famotidine 0.5-1 mg/kg IM or IV SLOW
    - Pantoprazole 1 mg/kg IV SLOW
  - Prokinetic agents
    - Cisapride
    - Metoclopramide

Pre-Operative Considerations

- Decrease stress, facilitate restraint
  - Oral medications
    - Gabapentin 10 mg/kg
    - Trazodone 3-5 mg/kg
  - Lidocaine-prilocaine cream for IVC site
- Sedate, but not too much
- Preoxygenate
  - Mask +/- diaphragm
  - High O2 flow
  - 3-5 min → IND

Induction Concerns

Airway secured rapidly!

- Sufficient muscle relaxation
- Rapid onset induction agent – which ones?
- Supplies
  - Many sizes of ETT
  - Tongue depressor
  - LARYNGOSCOPE ALWAYS!
- Bradycardia preparation
  - High vagal tone in brachycephalic dogs
  - Monitors
  - Anticholinergics – atropine 0.02-0.04 mg/kg or glycopyrrolate 0.005 – 0.01 mg/kg

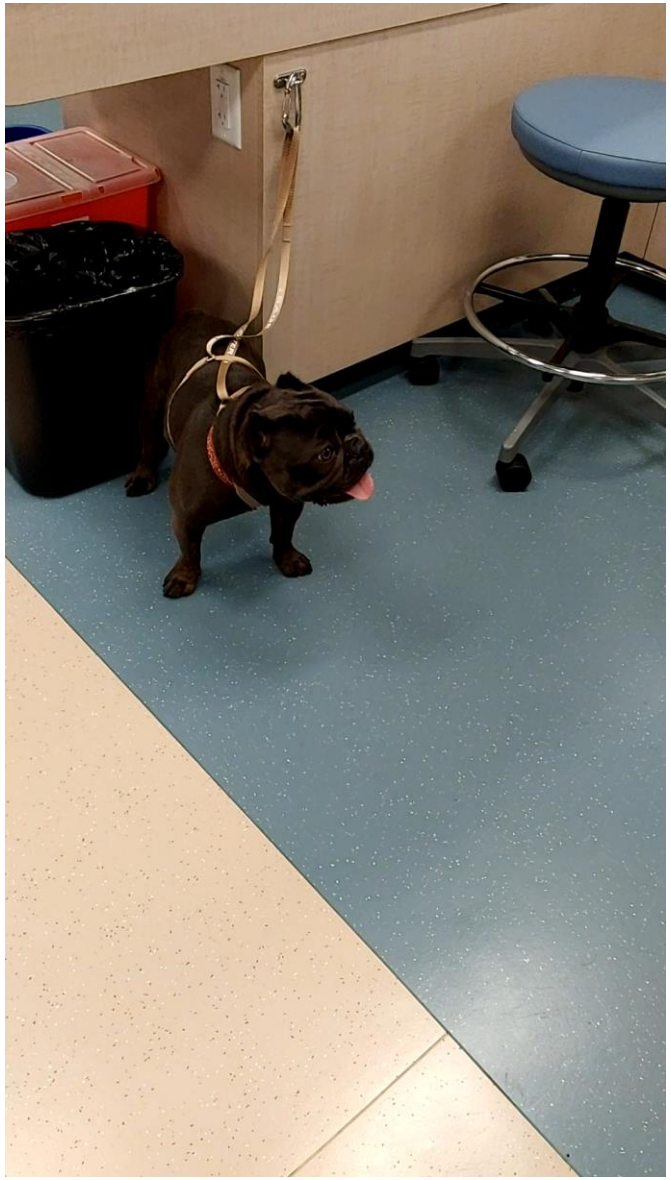
Recovery Concerns

- Hypoventilation
- Hypoxemia
- Regurgitation/aspiration
- Prolonged recovery
- Airway obstruction/emergency
  - Inflammation – steroid v NSAID?
- Hypothermia vs hyperthermia

Recovery Plan

LONG recoveries!

- O2 and monitors ON
- Plan these cases earlier in the day
- Manage pain pre-emptively
- Sedate, but not too much
- RECOVERY is the most DANGEROUS time!
  - Monitor diligently

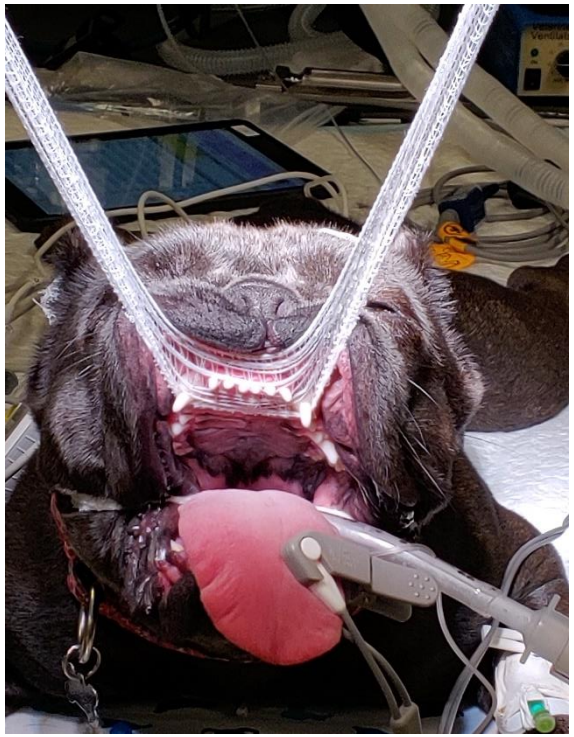
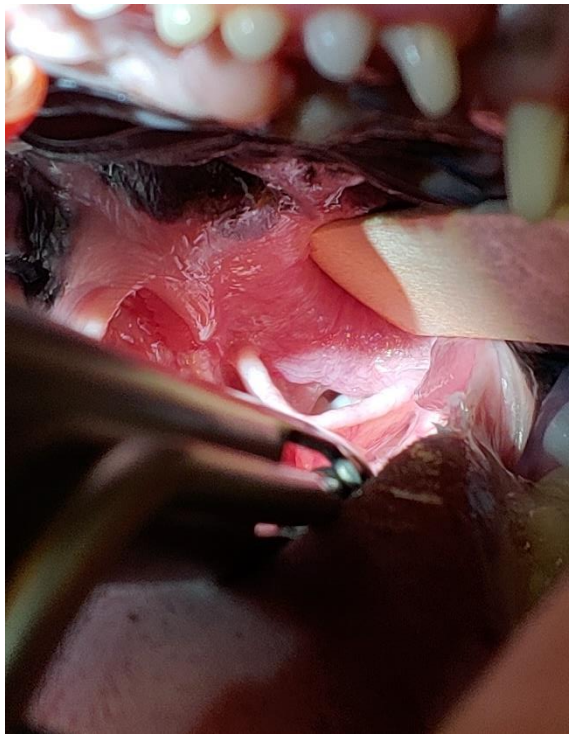


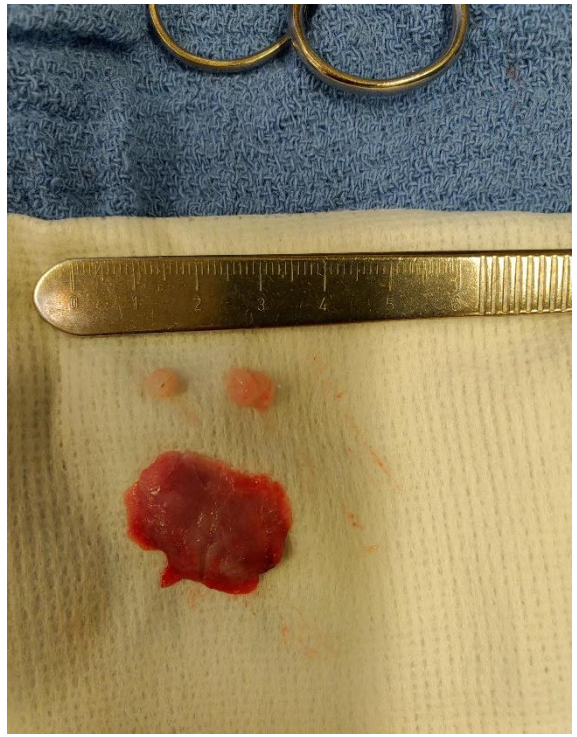
Meet Nino

- 1 y/o
- MI Canine, French Bulldog
- PC: BOAS and cryptorchid neuter
- History: becoming increasingly exercise intolerant

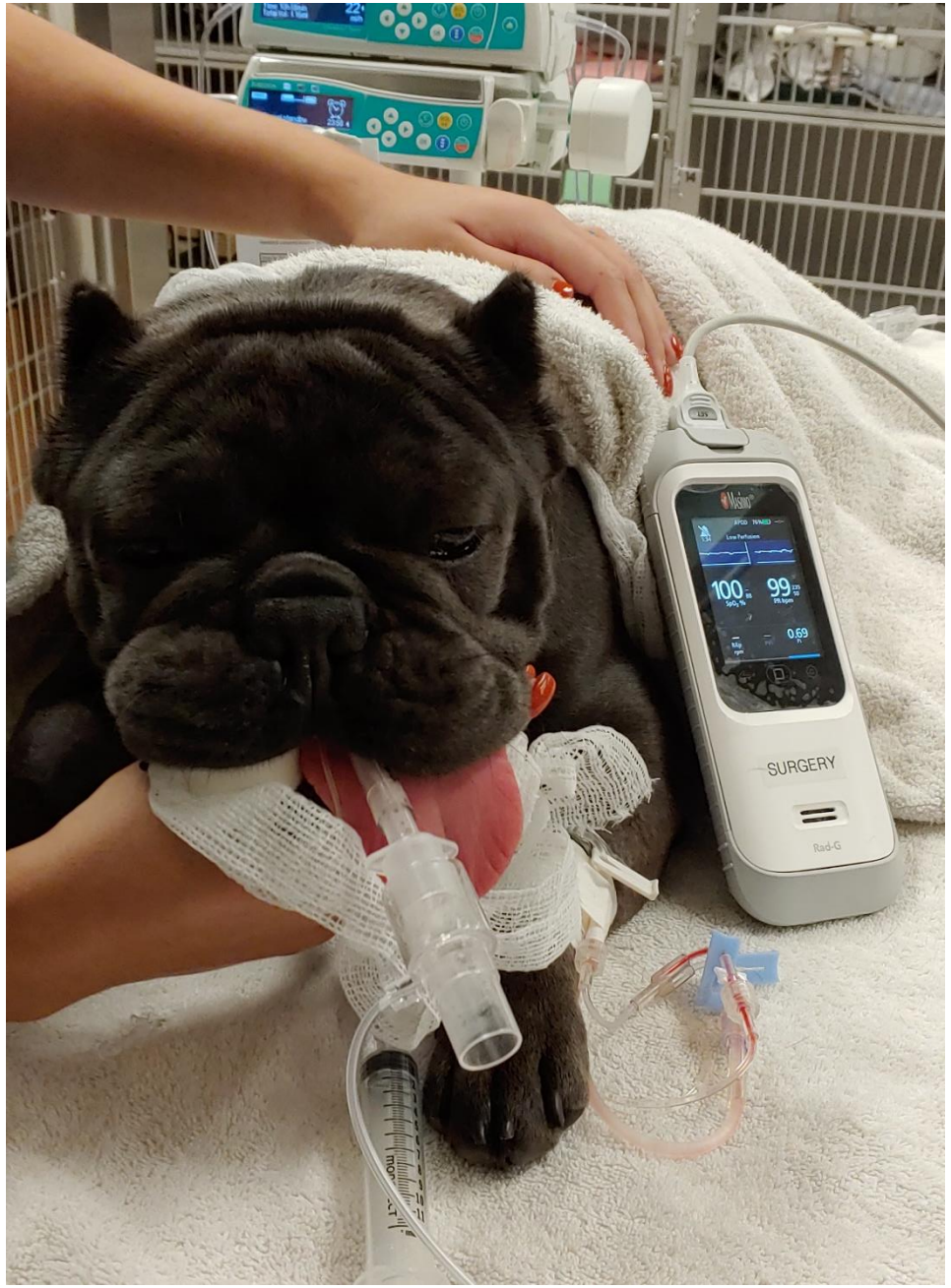
Anesthesia Plan for Nino

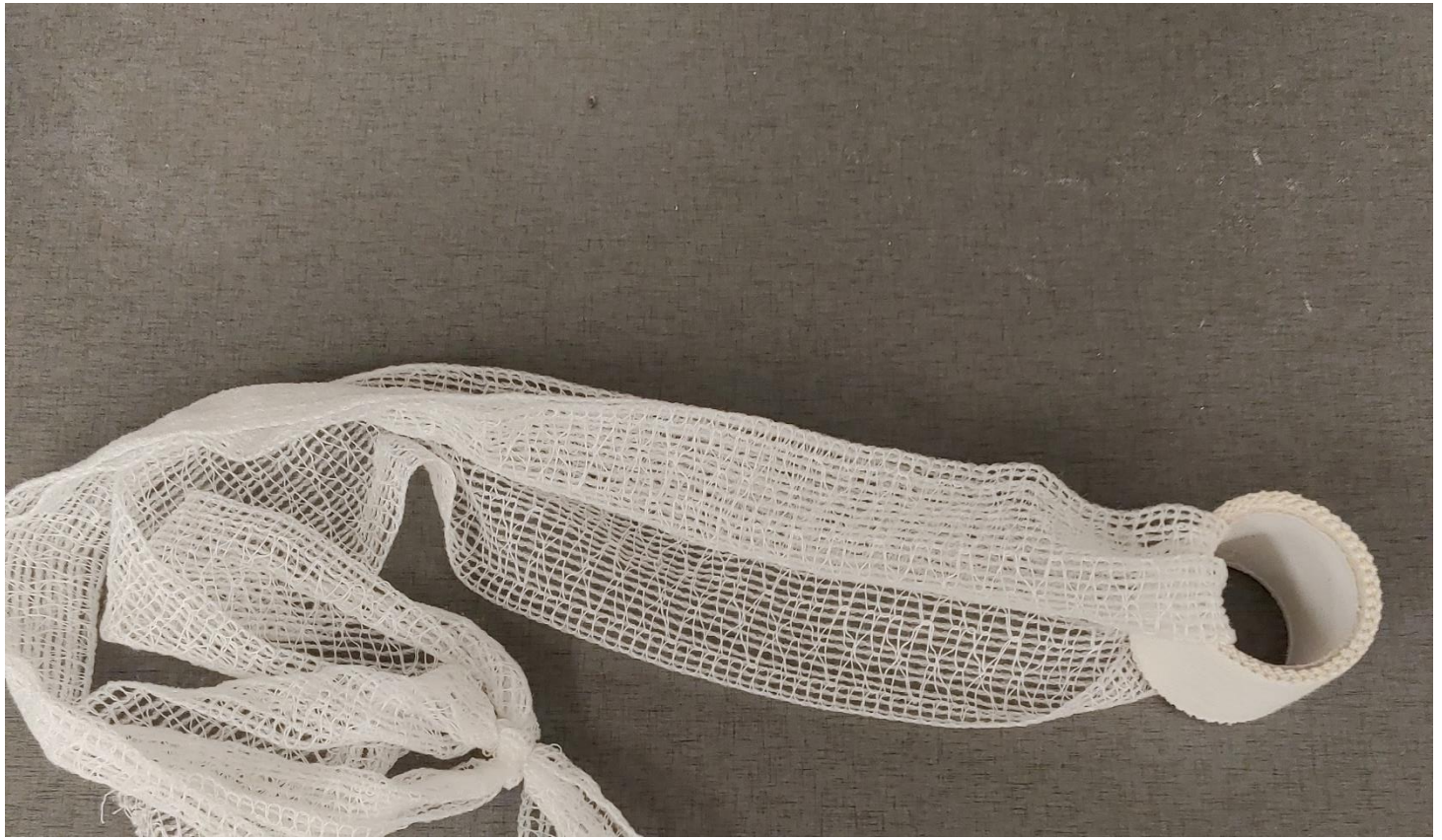
- ANESTHESIA PLAN FOR BOAS, L neuter, and R cryptorchid neuter (inguinal)
- Patient presents to CO sx (MD to MA) for BOAS corrective surgery and neuter. Nino has a history of loud upper respiratory noises, cryptorchidism (R), and retained deciduous teeth. Vaccines UTD, 10 p pDVM records available for review. His temperament is nice until handled, then he attempts to bite and has respiratory difficulty
  ASA: III
  Anesthetic concerns: hypoxemia, hypoventilation, pain, regurg/asp, BOAS complications (airway swelling/obstruction, aspiration pneumonia, O2 dependence)
  Prior to anesthesia: CXR (3v), maropitant 1 mg/kg SQ, famotidine 0.5 mg/kg IV SLOW or IM, dexamethasone SP 0.1 mg/kg IV. PreO2: mask, high flow, 3-5 m to IND, Masimo SpO2 flat probe on premed thru recovery
  Premed: acepromazine 0.02 mg/kg + butorphanol 0.2 mg/kg IM. Gabapentin 100 mg + trazodone 50 mg rectally once sedate
  Induce: fentanyl 5 mcg/kg IV bolus + propofol up to 4 mg/kg IV slow
  Maint: iso + O2, IVF (LRS) 5 mL/kg/h, fentanyl CRI 5-10 mcg/kg/h, cefazolin 22 mg/kg IV slow q 90 min
  Locoreg: L IT block, bupivacaine 0.5 mg/kg (1.2 mL); bilateral maxillary block (IO approach) bupivacaine 2 mg/kg (2.4 mL), divided
  Recovery: as per MA preference. Recommend buprenorphine 10 mcg/kg when F CRI D/C. Flowby O2 by mask, SpO2 monitoring, O2 cage, airway supplies ready, ***respiratory watch in CCU***



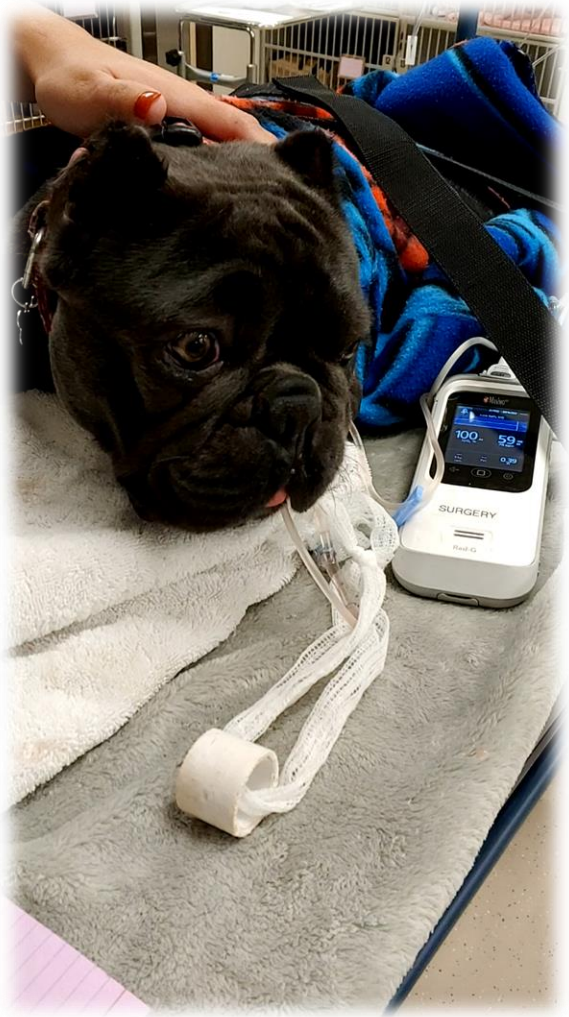
Nino's Procedure





Nino’s Recovery

Nino's Recovery...



A great resource for BOAS anesthesia!

- https://todaysveterinarypractice.com/anesthesiology/anesthesia-and-analgesia-in-brachycephalic-dogs/
- Tammy Grubb, DVM, DACVAA

Scholarly Articles on Brachycephalic Dogs

- Ellis J, Leece EA. Nebulized Adrenaline in the Postoperative Management of Brachycephalic Obstructive Airway Syndrome in a Pug. J Am Anim Hosp Assoc. 2017 Mar/Apr;53(2):107-110. doi: 10.5326/JAAHA-MS-6466. PMID: 28282230.
- Hughes JR, Kaye BM, Beswick AR, Ter Haar G. Complications following laryngeal sacculectomy in brachycephalic dogs. J Small Anim Pract. 2018 Jan;59(1):16-21. doi: 10.1111/jsap.12763. Epub 2017 Oct 19. PMID: 29047114.
- Riecks TW, Birchard SJ, Stephens JA. Surgical correction of brachycephalic syndrome in dogs: 62 cases (1991-2004). J Am Vet Med Assoc. 2007 May 1;230(9):1324-8. doi: 10.2460/javma.230.9.1324. PMID: 17472557.
- Cantatore M, Gobbetti M, Romussi S, Brambilla G, Giudice C, Grieco V, Stefanello D. Medium term endoscopic assessment of the surgical outcome following laryngeal saccule resection in brachycephalic dogs. Vet Rec. 2012 May 19;170(20):518. doi: 10.1136/vr.100289. Epub 2012 Apr 2. PMID: 22472536.
- Torrez CV, Hunt GB. Results of surgical correction of abnormalities associated with brachycephalic airway obstruction syndrome in dogs in Australia. J Small Anim Pract. 2006 Mar;47(3):150-4. doi: 10.1111/j.1748-5827.2006.00059.x. PMID: 16512847.

Considerations for Comorbidity Case Management

- Does patient preparation need to be modified?
- What special drug considerations exist?
  - Pre-op: regular medications
  - Intra-op: need for “special” drugs
  - Post-op: avoid or add?
- Should the “regular” IV fluid rate be modified?
- Any special monitors/monitoring needed?
- Recovery considerations?
- TGH needs?

Questions? Comments?

Thank you!

NAVAS 2023 Symposium Program - May 6th and 7th

mynavas.org

Saturday: Advanced Stream

- Management of the Difficult Airway Rachel Reed
- Fluid Therapy: Lydia Love
- CPR and Anesthesia: Veronica Salazar
- Anesthesia for Advanced Cardiac Procedures: Khursheed Mama
- Capnography: Waveform Interpretation & Troubleshooting Abnormalities - Alyssa Ann Stair
- ECG Interpretation & Common Dysrhythmias - Tracey Lawrence

Sunday: General Stream

- Pain Physiology & Pathophysiology: Tami Grubb
- Regional Anesthesia for the Abdomen: Diego Portela
- Alternative Analgesic Modalities: Cornelia Mosley
- New & Updated Drugs: Odette O
- Pulse Oximetry: Claire Woolford
- Blood Pressure Monitoring & Hypotension: Bonnie Lockridge

Veterinary Anesthesia Consultations

- https://www.nancybrockvetservices.com/
- https://vetanesthesiaspecialists.com/
- https://evolutionvet.com/services/pain-management-anesthesia/
- https://www.dispomed.com/new-veterinary-anesthesia-consultation-service/
- https://veterinaryanaesthesiaconsultants.com/