Diagnosis and management of common cardiac comorbidities.

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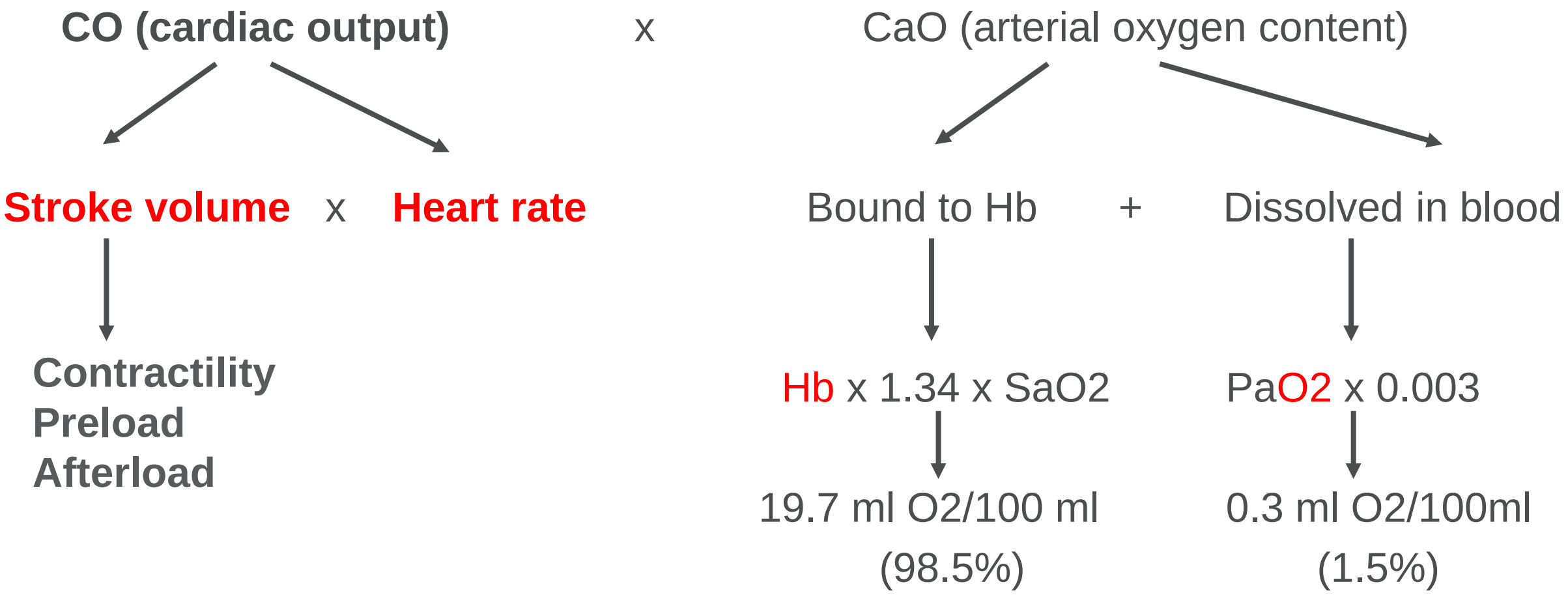
Conflict of Interest Disclosure:

Bill Saxon is a full-time IDEXX employee.

Oxygen delivery (DO2) =



Cardiac patients and:

Kidney disease
Hypertension
Endocrine disease
Anesthesia
Corticosteroids

Image courtesy Cardiac Education Group
www.cardiaceducationgroup.org

BSAVA BRITISH SMALL ANIMAL VETERINARY ASSOCIATION

PAPER

Cardiovascular–renal axis disorders in the domestic dog and cat: a veterinary consensus statement

J. L. Pouchelon*, C. E. Atkins†, C. Bussadori‡, M. A. Oyama§, S. L. Vaden†, J. D. Bonagura¶, V. Chetboul*, L. D. Cowgill||, J. Elliot**, T. Francey††, G. F. Grauer‡‡, V. Luis Fuentes§§, N. Sydney Moise¶¶, D. J. Polzin||||, A. M. Van Dongen*** and N. Van Israël†††

Journal of Small Animal Practice (2015) 56, 537–552 DOI: 10.1111/jsap.12387

IDEXX

How does heart disease affect kidneys? $CvRD_H$

Traditional

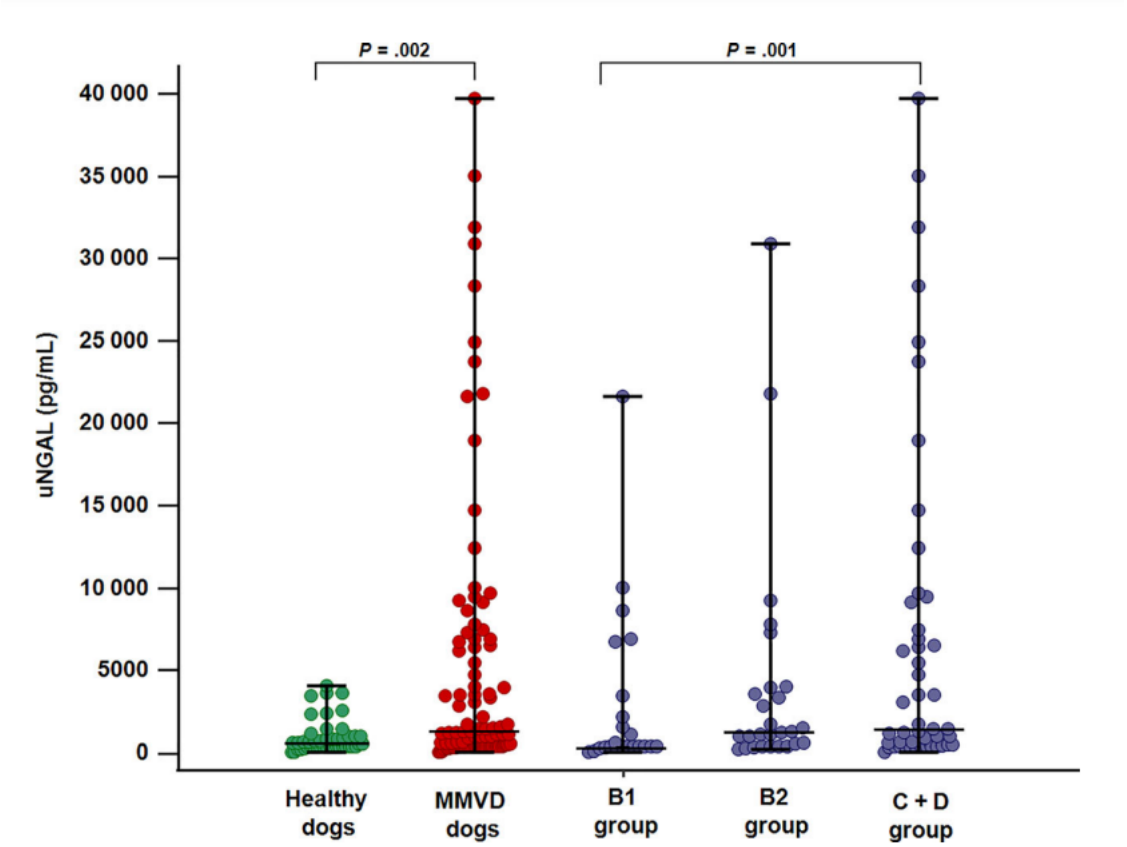
- Decreased cardiac output
- Decreased renal perfusion
- Decreased GFR
- Increased functional markers (blood)
  - BUN, creat, SDMA

Revised

- Renal congestion
- Inflammation
- Tubular damage
- Increased injury markers (urine)
  - Cystatin B, granular casts

Blood *and* urine needed to assess heart disease affect on kidneys.

Subclinical *tubular* damage in all MMVD stages



Troia et al. JVIM 2022

Azotemia and kidney injury in cats with CHF

- Azotemia present in 44% at diagnosis, up to 75% during treatment
- “Kidney injury” (creat increase ≥0.3 mg/dL over any time frame) in 66%
- KI risk highest during initial treatment in hospital (diuretics)
- ACEi - fewer life-time KI events, smaller increase in creatinine
  - At least safe if not renoprotective
  - Ameliorates RAAS-induced renal hypertension
- Azotemia and KI did not influence survival
  - Relieving renal congestion more important?
- Only age correlated with outcome

Rogg S, et al. JVIM. 2025;39(1):e17254. doi:10.1111/jvim.17254

Your cardiac patient needs fluids…

Hypovolemia vs dehydration

Hypovolemia (rapid)

- Loss from vascular space
- Impaired tissue perfusion
- Parameters
- Balanced crystalloid IV, IO
  - No additives
- Correct 1-2 hr

Dehydration (gradual)

- Loss from interstitial space
- Volume normal unless severe (10-12%)
- Parameters
- Balanced crystalloid IV, SC
  - Additives (e.g., KCl prn)
- Correct 4-24 hr

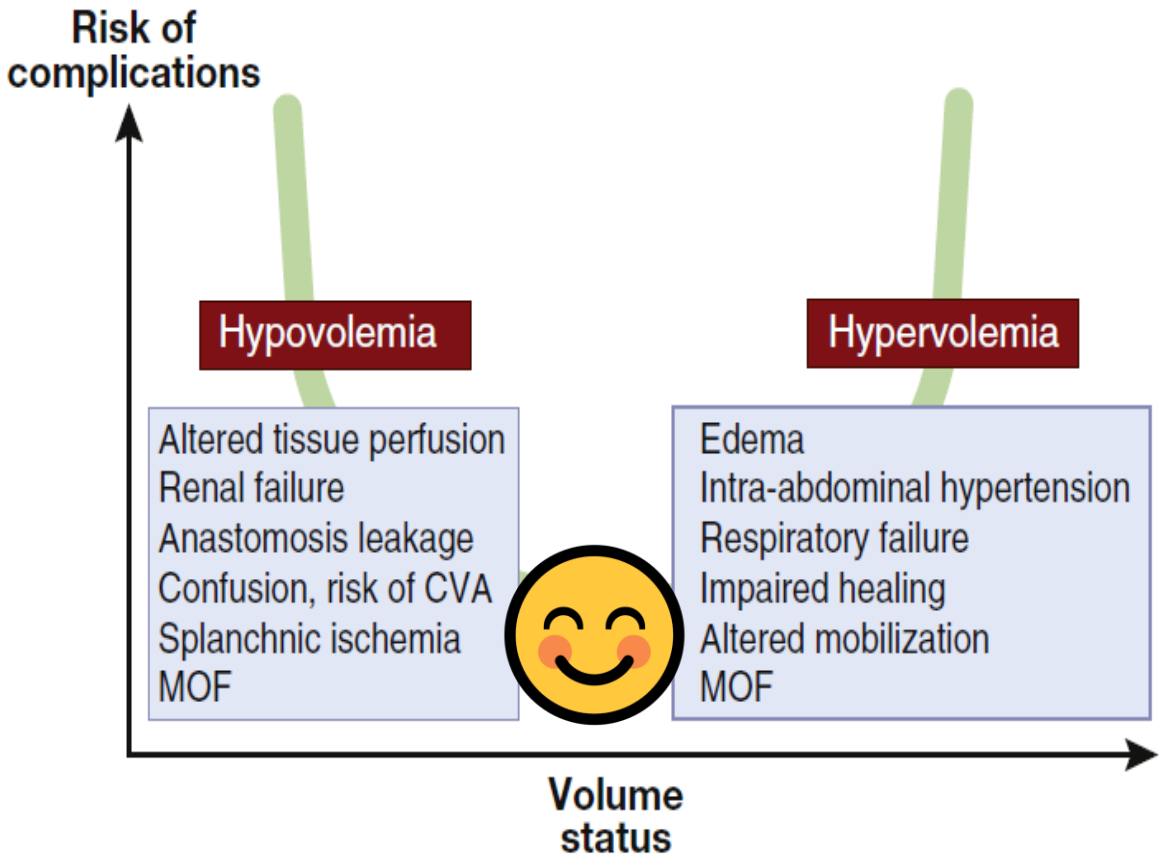
VETERINARY PRACTICE GUIDELINES

2024 AAHA Fluid Therapy Guidelines for Dogs and Cats

Mariana Pardo, BVSc, MV, DACVECC†, Erin Spencer, MEd, CVT, VTS (ECC)†,
Adesola Odunayo, DVM, MS, DACVECC, Mary L. Ramirez, DVM, DABVP (Canine and Feline),
Elke Rudloff, DVM, DACVECC, cVMA, Heidi Shafford, DVM, PhD, DACVAA, Ann Weil, DVM, MS, DACVAA,
Ewan Wolff, DVM, PhD, DACVIM (Small Animal Internal Medicine)

Stage	Formula	Rate of Administration	Comments
Resuscitation	**Cat:** 5–10 mL/kg **Dog:** 15–20 mL/kg	15 min	Assess perfusion parameters after bolus. May repeat bolus as needed.
Rehydration	Total Fluid deficit (L) = Body weight (kg) × % Dehydration (as a decimal)	Over 12–24 hr	Ongoing losses should be assessed through inputs and outputs and incorporated into the fluid plan.
Maintenance	**Dog:** a. 60 mL/kg/day b. 132 × BW $(kg)^{0.75}$ c. 30 × BW (kg) + 70 = mL/day **Cat:** a. 40 mL/kg/day b. 80 × BW $(kg)^{0.75}$ c. 30 × BW (kg) + 70 = mL/day **Pediatric:** Dog: 3 × adult dose Cat: 2.5 × adult dose	Over 24 hr	Also incorporate enteral water, liquid diets, and IV medications into the total volume of the fluid plan.

Get started and monitor, monitor, monitor…



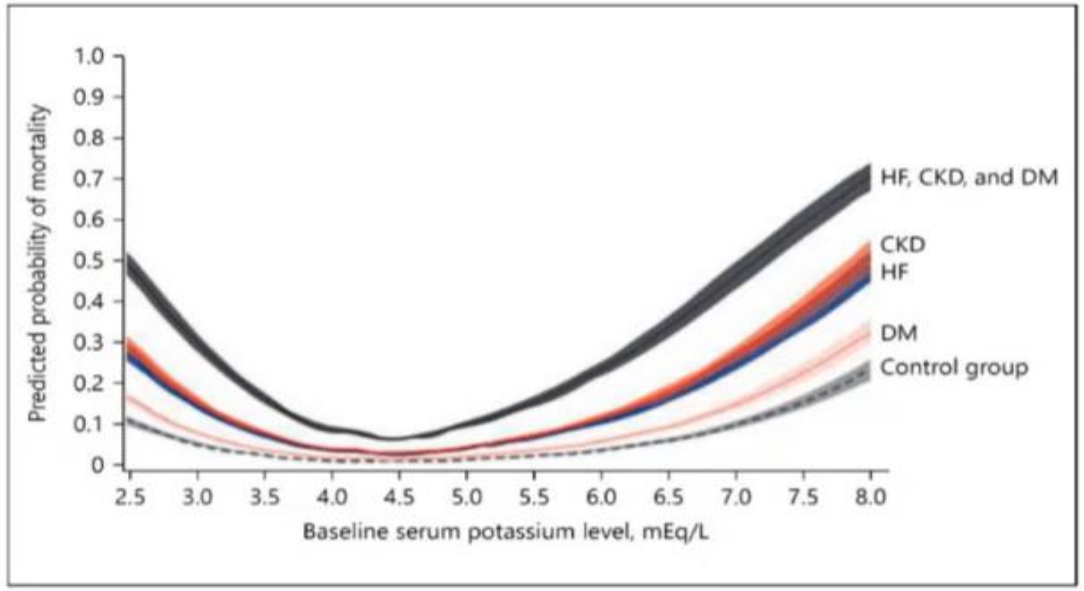
Fluid therapy with cardiac disease

- Stable heart patient needs fluids (e.g., general anesthesia)
  - LRs at 2-5 ml/kg/hr
  - 0.45% NaCl in 2.5% dextrose with KCl if more severe heart disease or you're worried
- CHF patient is hypovolemic (e.g, trauma, severe vomiting, diarrhea)
  - LRs to restore volume
  - 0.45% NaCl in 2.5% dextrose with KCl for ongoing fluids
- CHF patient is dehydrated (e.g., cat on furosemide)
  - Water via NE or NG tube
  - SC fluids
  - LRs or low sodium fluid

  } Mild, 5-7%
- Pericardial effusion with hypotension
  - LRs to increase volume to overcome increased filling pressure

Monitor for hypo- not just hyperkalemia

(Mortality increased with every 0.1 mEq/L change <4 mEq/L and >5 mEq/L)



Collins et al Am J Nephrol 2017

Hypokalemia with heart disease: prevent and manage

- K supplementation in 1/3-1/2 cats and 1/3 dogs in heart failure (referral)
- K <4 prior to diuretics → supplement
- K normal prior to diuretics → recheck lytes 7 days
  - ≥4 no supplementation
  - <3.7 supplement
- K at 4 week recheck
  - ≥4.5 on supplementation stop
  - <3.7 start or increase supplement

Potassium gluconate:
Cats 2-6 mEq/d divided q8-12
Dogs 2.2 mEq/10 kg

How does kidney disease affect the heart? $CvRD_K$

- AKI
  - Hypovolemia → ↓ preload
  - Electrolyte, acid-base, electrolyte abnormalities, cytokines → ↓ contractility, arrhythmia
  - Acute decompensation → CHF

- CKD
  - Systemic hypertension → ↑ afterload
  - Electrolyte, acid-base, electrolyte abnormalities, uremia → ↓ contractility
  - Progressive cardiac ‘stress’

Detect *pre-azotemic* kidney disease: protects heart too

- AKI
  - **Injury markers in urine up to 48 h before increased functional (GFR) markers in blood**
  - Complete urinalysis (cysto not necessary) evaluate for:
    - Granular casts, euglycemic glucosuria, proteinuria
    - Cystatin B

- CKD
  - Creatine, SDMA trending up but within reference interval
  - USG decreasing over time
  - Body weight decreases early with CKD in cats (up to 3 years before diagnosis)
  - Persistent renal proteinuria = proteinuric CKD (no azotemia in Stage 1)

CONSENSUS STATEMENT | Open Access

ACVIM consensus statement: Guidelines for the identification, evaluation, and management of systemic hypertension in dogs and cats

Mark J. Acierno, Scott Brown, Amanda E. Coleman, Rosanne E. Jepson, Mark Papich, Rebecca L. Stepien, Harriet M. Syme

First published: 24 October 2018 | https://doi.org/10.1111/jvim.15331

Normotensive (minimal TOD risk)	SBP <140 mm Hg
Prehypertensive (low TOD risk)	SBP 140-159 mm Hg
Hypertensive (moderate TOD risk)	SBP 160-179 mm Hg
Severely hypertensive (high TOD risk)	SBP ≥180 mm Hg

New normal

Assess kidneys, endocrine

Treat here

Target organ damage

Acclimate 5-20 minutes out of carrier, cuff width 30-40% circumference forelimb, tail base.

IDEXX

Hypertension: ≥80% secondary to kidney or endocrine disease

- Cat
  CKD, hyperthyroidism, primary hyperaldosteronism, glomerulopathy, pheochromocytoma

- Dog
  CKD, AKI, Cushing's, diabetes mellitus, glomerulopathy, pheochromocytoma, hypothyroidism (rare)

Cats:
Amlodipine:
<200 mm Hg 0.625 mg SID
≥200 mm Hg 1.25 mg SID

Telmisartan:
2 mg/kg once daily

Dogs:
Benazepril:
0.25-0.5 mg/kg SID

Amlodipine:
0.125-0.25 mg/kg SID

Telmisartan:
1-2 mg/kg SID

Some endocrine comorbidities

Primary hyperaldosteronism (PHA) in cats

- Most common adrenocortical disease in cats
- Hypertension, hypokalemia
- Progressive renal / cardiac damage due to aldosterone AT1 receptor effects
- Unilateral adrenal carcinoma or adenoma most common
- Diagnosis → adrenal mass, ↑ basal aldosterone + hypokalemia usually sufficient
- Treatment
  - Surgery → Adrenalectomy
  - Medical → Spironolactone 2 mg/kg q12h, amlodipine 0.1–0.2 mg/kg q24 h, K gluconate 1–6 mEq/cat q12h

Is it PHA or CKD?

- PHA more likely if:
  - Phosphorous normal or low
  - Metabolic alkalosis
  - Increased CK
  - Hypertension and hypokalemia disproportionate to degree of azotemia
    - Hypokalemia unresponsive to oral potassium supplementation is a clue
  - Adrenal mass vs small irregular kidneys on abdominal ultrasound

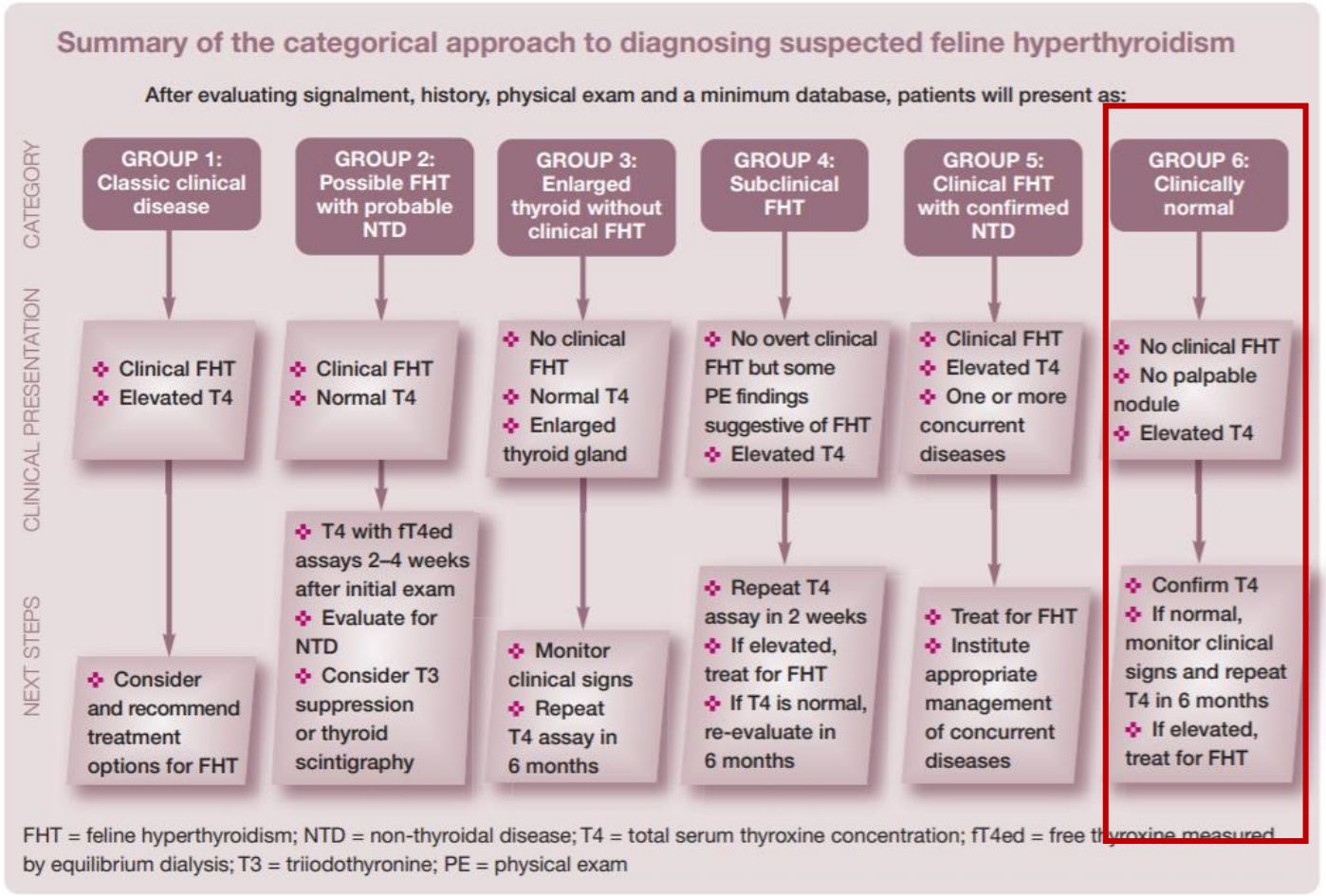
PHA and CKD can co-exist. Maintain awareness.

SPECIAL ARTICLE

Journal of Feline Medicine and Surgery (2016) **18**, 400–416

2016 AAFP Guidelines for the Management of Feline Hyperthyroidism

Treat asymptomatic cats with persistent increased T4



How would **you** confirm hyperthyroidism in a cat with borderline TT4?

Repeat TT4
Free T4
Free T4 ED
TSH

Feline hyperthyroidism → cardiac disease, hypertension

- T4 direct and indirect affects on cardiovascular system
  - Hypertension in ≈ 35%, esp if concurrent renal
  - Direct → inotropy, chronotropy
  - Indirect → adrenergic, volume overload (↑ preload, ↓ afterload), systemic hypertension
    - ↑ CO x ↑ HR = ↑ BP
  - Myocardial hypertrophy from volume and pressure overload
- Hypertension develops median 5.3 mo post treatment in ≈20%
  - Monitor BP minimum 6 mo after starting tx
- Clinically relevant thyrotoxic heart disease rare <6 yr of age, CHF uncommon
- Thyrotoxic heart disease indistinguishable from primary cardiomyopathy
- BNP, cTnI normalize 3 months after euthyroid with thyrotoxic heart disease

Tachyarrhythmias with hyperthyroidism

- Atrial tachycardia
- VPC, multiform
- Ventricular tachycardia

- Atenolol: 6.25-12.5 mg/cat q12h
- Diltiazem (if asthma): 7.5 mg/cat q8h (standard formula), 30-60 mg/cat q12-24h (sustained release)

Heads up—Brooklyn is doing some open mouth breathing here. Doesn't seem dyspneic. Minimal B lines. Giving torb. HR 276. Injection is supposed to be at 1 and can't get in touch with owner. I really think this is the thyroid. So we're gonna give some atenolol and move forward with treatment unless you have a gut feeling that owner would rather delay and do a cardio consult. I really think he needs his thyroid to stabilize.

I think owners would trust your judgement for sure. I'll try to call him also.

Thank you!

My call was forwarded :(

He says proceed with I 131

Brilliant—thank you!!!

iMessage

Wed, Dec 17 at 2:17 PM

TREATMENT

- Atenolol: 6.25-12.5 mg/cat q 12 h
- (and treat for hyperT4)

Canine hypothyroidism

- Cardiac signs uncommon unless prior heart disease
- PE abnormalities +/-
  - Muffled heart sounds, weak apex beat, weak pulse, bradycardia
- Treatment precautions with heart disease
  - Start ¼ standard thyroxine dose
  - Increase by ¼ weekly
  - HypoT4 decreases digoxin clearance
    - 8h post pill digoxin level
    - Target range 0.5-1.0 ng/mL

Cushing's syndrome in dogs

- Rarely causes heart disease – can exacerbate
- Cortisol
  - ↑ SVR by ↑ catecholamine sensitivity and angiotensin production
  - ↑ volume due to mineralocorticoid activity
- Hypertension in 57-82%
  - Increases regurgitant fraction with valvular disease
- Pulmonary hypertension/thromboembolism
  - Right-sided CHF
  - Acute onset respiratory signs
  - Monitor and treat proteinuria

Your cardiac patient needs anesthesia

- Preoperative
  - Correct dehydration prior to general anesthesia
  - Minimize stress-induced tachycardia (premed, fear free)
  - Preoxygenate
- Intraoperative
  - LRs (lowest Na concentration, 140 mEq/L, of balanced crystalloids)
    - 0.45% NaCl in 2.5% dextrose if severe cardiomegaly
  - Max 5 ml/kg/hr dog, 3 ml/kg/hr cat
    - Furosemide 1-2 mg/kg IV and lower fluid rate if volume overload
  - Use agents that maintain cardiac output (no dexmedetomidine)
  - Inotropes (dobutamine) and lower vaporizer setting for hypotensive episodes
  - No fluids if short procedure with IV anesthetics (patient euvolemic, euhydrated)
- Postoperative
  - No fluids with quick return to eating/drinking
  - 0.45% NaCl in 2.5% dextrose at maintenance prn

Corticosteroid-induced CHF in cats

- Injectable and oral forms
- Increased preload (volume)
  - Up to 50% with IM intermediate/long-acting formulations
  - Mineralocorticoid effects
  - Insulin resistance-mediated hyperglycemia causing osmotic fluid shift
- Increased afterload
- NT-proBNP baseline and during therapy?
  - Prednisolone 2 mg/kg/d x 7 d to cats with no prior signs of heart disease
  - >60% increase from baseline in 60%; from normal to >100 pmol/L in 38%
- Increase >60% while monitoring → alternate drug, budesonide

Block CL, Oyama MA. Echocardiographic and biomarker evidence of plasma volume expansion after short-term steroids administered orally in cats. J Vet Intern Med. 2020;34:29–34.

SNAP proBNP

- Consider with
  - Respiratory signs, murmur/gallop, prean, yearly screening >6 y, before fluids/steroids
- Normal rules out moderate to severe heart disease
- Not sensitive enough to screen at risk breeds…

SNAP Feline proBNP Test	Normal	Abnormal	
	 Sample spot is lighter than reference spot.	 Sample spot is the same color as reference spot.	 Sample spot is darker than reference spot.
Cardiopet proBNP Test	<150 pmol/L	150–200 pmol/L	>200 pmol/L

Ranges: Sensitivity (65%-84%) and Specificity (83%-100%)

Hannas et al, JVIM 2020
Harris et al, JVIM 2017
Machen et al, JVC 2014

Causes of CHF in cats with better potential outcomes

Precipitating event common in cats in CHF.

- Consider baseline and serial NT-proBNP (SNAP or quantitative) with:
- Stress
  - Tachycardia-induced CHF
  - Cat friendly, gabapentin before visit…
- IV fluid therapy
  - Especially large volume, e.g., diabetic ketoacidosis, post urethral obstruction diuresis
  - Body weight using gram scale minimum bid
  - Serial BNP
- General anesthesia
  - Adjust anesthetic protocol, careful fluid administration, +/- postpone procedure
  - Minimize stress in perianesthetic period with multimodal therapy
- Corticosteroid-induced CHF

Luis Fuentes V et al. ACVIM consensus statement guidelines for the classification, diagnosis, and management of cardiomyopathies in cats. J Vet Intern Med. 2020;34:1062–1077

Thank you!