Update in the management of heart failure: focus on treatment

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	ACUTE (IN HOSPITAL) MANAGEMENT OF SEVERE HEART FAILURE	CHRONIC (OUT PATIENT) MANAGEMENT OF HEART FAILURE
DOG	• **Furosemide**: 2-4 mg/kg IM or IV bolus +/- CRI (Max 12 mg/kg/day) • **Oxygen** • **Sedation**: butorphanol 0.1- 0.2mg/kg IV or IM • **Pimobendan**: 0.25 mg/kg PO BID – TID (when able to swallow) • ***Nitroglycerin:*** *¼-1" transdermal q 8-24 hr for 1-2 d* ***or Nitroprusside*** *1 - 10 ug/kg/min IV (careful BP monitoring)* • ***Dobutamine****: if cardiogenic shock (hypotensive, hypothermic, low output signs)* • ***Diltiazem/digoxin****: if concurrent atrial fibrillation*	• **Dietary Na+ restriction** (< 100 mg sodium / 100 Kcal or < 0.25 %) • **ACE-I**: 0.5 mg/kg PO q 12-24 hr ↓RAAS remodeling, ↓Na+ retention • **Furosemide**: Lowest effective dose ↓fluid retention/preload • **Pimobendan:** ↑contractility and ↓afterload • **Spironolactone**: 2 mg/kg PO q 24 hr ↓myocardial fibrosis • **Fish oils**: 40 mg/kg/day of EPA+DHA • ***Sildenafil****: 1 – 2 mg/kg PO q 8 – 12 hr if pulmonary hypertension* • ***Amlodipine****: 0.1-0.2 mg/kg PO q 12 – 24 hr for additional vasodilation* • ***Diltiazem/digoxin****: if A-fib* • ***Periodic abdominocentesis*** *for right HF*
CAT	• **MINIMIZE STRESS** • **Furosemide:** 1-4 mg/kg IM or IV bolus +/- CRI (Max 12 mg/kg/day) • **Oxygen** • **Nitroglycerin:** ¼" transdermal q 8 – 24 hr for 1-2 d or **Nitroprusside**: 0.5-5 ug/kg/min IV (careful BP monitoring) • **Sedation**: butorphanol 0.1-0.2mg/kg IM *(Minimize Stress!!!)* • **Thoracocentesis**: if pleural effusion • **Pimobendan:** Especially if refractory edema, LV systolic dysfunction or azotemia- 0.25 mg/kg PO BID (when able to swallow) • **Puff:** inhaled albuterol (2 puffs) or SQ terbutalline for peribronchiolar edema or refractory respiratory distress	• **Dietary Na+ restriction** • **ACE-I:** ↓RAAS remodeling, ↓Na+ retention • **Furosemide:** ↓fluid retention/preload • **Clopidogrel**: 1-2 mg/kg PO q 24 hr (1/4 of 75 mg tablet) • **Pimobendan**: same dose as in dog • *Diltiazem: if need additional rate control* • *Atenolol: usually lower dose if on BB preclinically* • *Sildenafil: same dose as in dog* • *Spironolactone: same dose as in dog* • *Periodic thoracocentesis*

CANINE HEART FAILURE

Pimobendan

The most important recent advancement in canine heart failure management is the addition of an ino-dilator, pimobendan. Over the past several years, NCSU cardiology has treated thousands of dogs and hundreds of cats with pimobendan. The use of pimobendan has evolved over the years from being a salvage, last-ditch medication to one that we use early in the management of heart failure, essentially first-time heart failure. Several clinical trials have shown improved quantity and quality of life in canine heart failure patients, due to both mitral valve disease and dilated cardiomyopathy. Pimobendan is labeled for use in NYHA class II, III, IV canine heart failure secondary to degenerative mitral valve disease (MVD) and dilated cardiomyopathy (DCM). It is not FDA approved for use in cats or humans in USA.

Pimobendan, together with furosemide and an angiotensin converting enzyme inhibitor (ACE-I), has become standard of care for management of all cause canine heart failure. 85-90% of all canine heart failure is

due to MVD and DCM but we also use it to manage dogs with heart failure due to other etiologies such as heartworm disease, primary pulmonary hypertension with secondary right heart failure, infectious endocarditis and some congenital heart diseases. That said, there are a few exceptions where pimobendan may not be indicated in the setting of canine heart failure such as a dog with fixed or dynamic right ventricular or left ventricular outflow tract obstruction. For example, a dog with sub-aortic stenosis and signs of forward heart failure(syncope). To make things more confusing, in a dog with end stage sub-aortic stenosis and signs of both forward and congestive heart failure, pimobendan may be indicated.

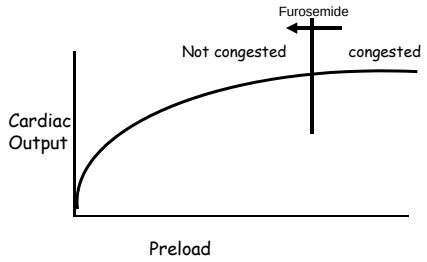
Pimobendan has a dual mechanism of action, an "inodilator". Specifically, it is a calcium-sensitizing drug that improves contractility (positive inotrope) with minimal effects on myocardial oxygen consumption. Pimobendan also does not lead to increased intracellular calcium concentrations. Digoxin and the IV catecholamines all lead to increase intracellular calcium levels which can lead to arrhythmias and cell death. The other mechanism of action is that of phosphodiesterase inhibition leading to a balanced vasodilation (arterial and venous) and as well as improving myocardial performance. Despites its vasodilation, our experience is that it has a neutral effect on blood pressure because of its combined inodilation property and improving cardiac output. Since the introduction of pimobendan, the use of digoxin in the management of canine heart failure has decreased dramatically. Pimobendan is an extremely well tolerated drug whereas digoxin has a narrow therapeutic window with a higher risk of complications. The most common scenario where we will still use **digoxin** (usually combined with diltiazem) is in the management of rapid atrial fibrillation in the setting congestive heart failure either due to DCM or MVD (and no evidence of renal insufficiency). We generally dose digoxin to achieve therapeutic concentrations of 0.5 – 0.9 ng/ml as this dose in humans has been shown to improve survival supposedly from its neurohumoral properties and minimize complications.

Knowledge of pimobendan's pharmacokinetics and pharmocodynamics is useful. Onset of action and peak blood levels of pimobendan and its metabolite, which requires liver metabolism, are reached within one hour of administration of a single oral dose. Because of its rapid onset of action, we have found it to be VERY USEFUL in the management of severe acutely decompensated heart failure. We will administer pimobendan as soon as the clinician feels that the dog can either swallow a pill or take the pill crushed in water via syringe. Pimobendan is highly protein bound and fortunately is tolerated well at high doses. Dose escalation is common in severe or recurrent heart failure if an owner has the financial resources. Pimobendan is moderately expensive especially in large breed dogs and dose escalation.The labeled dose is 0.5 mg/kg per day divided into two doses that are not necessarily equal. Dosing and frequency escalation are common with recurrent or refractory heart failure with good clinical response. The elimination half life is short (< 2 hrs) but its pharmacodynamic effects are prolonged (>8hrs). That said, we often will increase the frequency to TID when an owner is able as heart failure worsens. Pimobendan is primarily eliminated in feces via bile (95%) and only 5 % of the drug and its metabolites are renal excreted. Therefore it is extremely safe to use with concurrent renal disease and heart failure, which is not uncommon especially in older dogs with MVD. Furthermore, the renal venodilation together with improved cardiac output may actually improve GFR and improved renal perfusion. The addition of pimobendan allows lower doses of furosemide and ACE-inhibitors (enalapril, benazepril) as needed. We occasionally are able to wean a patient off furosemide with the addition of pimobendan.

Adverse effects are surprisingly few. Because of the human experience, there are still lingering concerns for tachycardia and pro-arrhythmia tendencies. These concerns have for the most part been greatly reduced by the clinical trials showing no increase in arrhythmias, but maybe a concern at high doses based on toxicity studies performed for FDA approval. In very early MVD (Stage B1), the use of chronic pimobendan (17 months) has been associated with worsening of valvular insufficiency. However, the use of pimobendan in asymptomatic dogs with advanced MVD (Stage B2, VHS > 10.5) has now been show to be beneficial in delaying onset of heart failure in the EPIC study.

Diuretics

Frank-Starlings Law



Furosemide is a loop diuretic and a mainstay in the management of congestive heart failure regardless of etiology. Despite its usefulness in HF management it's important to remember that furosemide does not improve cardiac output or activation of the Renin Angiotensin Aldosterone System. The dose of furosemide is usually the most challenging issue with this drug because it needs to be tailored to the individual patient. Too high of a dose can have deleterious effects on renal perfusion and electrolytes. Conversely, too low of a dose can lead to unnecessary hospitalization, expense and potential euthanasia because of recurrent decompensations.

The current debate about furosemide in human medicine is repeated bolus dosing v. continuous rate infusions (CRI). Clinical trials have shown mixed results. That said, at NCSU we use a combination of repeat bolus dosing and CRIs to manage our hospitalized severe acutely decompensated HFs. For an inpatient HF, the initial furosemide dose is typically ~ 2 – 4 mg/kg IV or IM with repeated doses q 1- 12 hrs as needed, not to exceed 12 mg/kg/day. After the initial bolus dose, we commonly use a furosemide CRI of 1-4 mg/kg over 2-8 hrs after initial bolus. The combination of a furosemide bolus followed by a CRI has a better diuretic effect. For an outpatient heart failure patient, the dose is usually lower such as 1-2 mg/kg once to twice daily. The initial furosemide dose is usually higher than the long-term dose. The best dose chronically is the lowest effective dose as overzealous furosemide therapy can lead to low effective circulating volume, hypokalemia (hypomagnesemia). These electrolyte abnormalities in humans have been shown to predispose to serious arrhythmias. The lowest effective dose is achieved with the aid of the patient's owner. After the first episode of HF, I will teach the owner to take resting respiratory rate and to keep a "cough" diary. Together we will try (if possible) to lower the furosemide dose gradually over time. I will also give the owner a "flex" dose of furosemide based on the dog's clinical status and food/water intake. I always remind the owner if the dog is not eating or drinking, the diuretic need may be greatly reduced. Periodic chest radiographs are also helpful to determine the best dose of furosemide.

Torsemide: Another loop diuretic that is starting to get some attention is Torsemide. Torsemide has a longer duration of action, decreased susceptibility to diuretic resistance, and adjunctive aldosterone antagonist properties compared with furosemide. Generally the torsemide dose is one tenth of the daily furosemide dose divided into twice daily dosing. We have limited experience with this new drug in the dog and none in the cat to date.

Spironolactone is a potassium sparing diuretic that works by blocking aldosterone at the collecting ducts. Spironolactone is used together with furosemide as a diuretic and for its anti-aldosterone effects in most causes of chronic CHF. It is not considered an "ER" drug, as its onset of action is slow. In humans with severe CHF, spironolactone improved survival as compared to placebo when added to conventional CHF treatment (furosemide, ACE-inhibitor, Digoxin). Its improved survival benefit is thought to be primarily due to reduced hypokalemia and arrhythmic death. A clinical trial in dogs with mild to moderate heart failure due to mitral valve disease was recently performed in Europe which suggests a survival benefit in dogs receiving the spironolactone vs. placebo. The most common adverse effect is hyperkalemia, which is rare and dose dependent. Like all other diuretics, it has the potential to cause effective hypovolemia and azotemia, albeit less likely than furosemide or hydrochlorthiazide. The dose may be important in the use of spironolactone in dogs. Survival benefit in dogs with HF due to MVD was conferred at a 2 mg/kg/day dose but not at the lower "neurohumoral dose" used in humans (0.3 mg/kg/d) . We

currently recommend adding spironolactone to all dogs with heart failure (stage C). The use of spironolactone has not been easy to implement in the feline heart failure. This is likely due to a combination of the difficulty in medication administration in cats and the occasional side effect of facial excoriation and dermatitis that has been recognized. NCSU has not experienced the facial dermatitis side effect.

Hydrochlorthiazide is a potassium wasting diuretic that works by blocking sodium and water resorption at the distal tubule. It is occasionally used in end stage heart failure for its additional diuretic effect. At NCSU, we often use a combination diuretic tablet (Spironolactone and hydrochlorothiazide). These oral diuretics can be useful to-go-home medications in a non-azotemic refractory or recurrent heart failure cases who are already on high dose furosemide. By adding a diuretic with a different and more distal site of action (hydrochlorothiazide – distal tubule, spironolactone – collecting ducts), the diuretics will have a synergistic diuretic effect.

Vasodilators

ACE-Inhibitors: Enalapril and Benazepril, block the conversion of angiotensin I to angiogensin II. Ag II has several negative effects in the setting of heart failure leading to vasoconstriction, resorption of sodium and water as well as direct myocardial toxic effects. Many previous studies in dogs have shown that ACE-I improves survival and quality of life in dogs with congestive heart failure secondary to both dilated cardiomyopathy and chronic valvuar heart disease. The recommended dose for Enalapril is 0.5 mg/kg PO q 12-24 hr while the dose of Benazepril is generally once daily. Athough the 2 ACE-I are very similar, benazepril is less dependent on renal clearance and doesn't accumulate in the setting of renal insufficiency as does enalapril. Although both ACE-I are very similar, benazepril may have an advantage in cats in that it is a little longer acting than enalapril allowing for more ACE inhibition with once daily dosing. Moreover, the route of excretion is 50% via the biliary system (85% in cats) so it may be safer in a dog with concern with renal impairment. The benefit of the ACE-I seems to involve more than just its vasodilator effects. It's proposed that its inhibition of local RAAS may protect the myocardium from deleterious remodeling effects. Although enalapril has been shown to reduced pulmonary venous pressures acutely in HF, ACE-I are typically withheld in the peracute management of severely decompensated HF because of the possibility of lowering intra renal perfusion and GFR. Furthermore, in humans there is a new recommendation to withhold ACE-I on the morning of an anesthestic episode because of an increased risk of hypotension. There is no evidence in dogs yet but it would be a reasonable recommendation. Because we have an alternative therapy that is safe in renal disease (pimobendan), I find that we are more cautious using ACE-I in dogs with creatinine > 2 g/dl. I personally withhold (possibly just temporarily) the ACE-I in an animal in HF and a creatinine > 3.0 g/dl. That said, for the average HF with a creatinine < 2.0 g/dl, ace-inhibition is recommended as soon as the patient is eating and able to take oral medications.

Sildenafil: Based on anecdotal experience and a couple of small cohort studies, sildenafil is useful adjunctive vasodilator in the setting of symptomatic and severe pulmonary hypertension and in refractory HF associated with pulmonary hypertension. Sildenafil is a phosphodiesterase V inhibitor and has greater affinity for certain vascular beds including the pulmonary arteries. It is dosed at 1 – 2 mg/kg PO q 8- 12 hrs. There is now a generic 20 mg Sildenafil tablet that is a fraction of the price of the brand name.

Amlodipine is a calcium channel blocker that acts primarily as an arterial vasodilator. We use amlodipine commonly in the refractory or recurrent congestive heart failure in dogs, especially if their systolic blood pressure is 120 mmHg or above. Amlodipine is especially helpful in dogs with severe mitral valve regurgitation and to decrease regurgitant fraction.

FELINE HEART FAILURE:

Etiologies and precipitating factors : Heart failure is defined as a clinical syndrome that results from any structural or functional disorder that impairs the ability of the ventricle to fill with or eject blood. The clinical heart failure diagnosis is made from a careful review of a combination of historical, physical examination, imaging, and biomarker findings as well as response to therapy There is no single diagnostic test for heart failure. Most cats (not all) presenting with heart failure have myocardial dysfunction, usually due to a cardiomyopathy.

Hypertrophic cardiomyopathy (HCM) is the most common etiology of myocardial dysfunction in cats. HCM is defined as left ventricular hypertrophy in the absence of diseases causing left ventricular hypertrophy, such as hypertension, hyperthyroidism or infiltrative disease. Most veterinary cardiologists define left ventricular hypertrophy as either diffuse or segmental echocardiographic left ventricular hypertrophy of either the LV free wall or interventricular septum of 6 mm or greater. However, some cats with HCM and heart failure can have significant remodeling when they decompensate and they may not have the classic left ventricular hypertrophy. We believe that these cats that remodel over time do so because of myocyte loss due to ischemic injury with replacement fibrosis. These cats with "end-stage", "burnt-out" or remodeled HCM have both diastolic and systolic dysfunction. Other types of cardiomyopathies such as dilated, restrictive, tachycardia-induced or unclassified cardiomyopathies are also possible. Dilated cardiomyopathy is rarely diagnosed and is usually not associated with taurine deficiency. That said, all cases of dilated cardiomyopathy should still be given taurine regardless of dietary history until proven to be ineffective. Despite the differences in the types of cardiomyopathies, the main treatment strategies for heart failure is typically the same (see below).

Although cardiomyopathies are the most common cause of heart failure in cats, other etiologies can be observed. Congenital defects, degenerative valvular disease, myocarditis, pericarditis and endocarditis have been reported. Congenital diseases such as a Patent Ductus Arteriosus (PDA) or a Cor Triatriatum Sinister may be optimally treated with a surgical or minimally invasive intervention. Systemic disease can also affect the heart resulting in heart failure. Chronic normovolemic anemia, hyperthyroidism, hypertention or hyperviscosity syndrome can either cause or contribute to heart failure.

It's important to emphasize that many cats with acute heart failure have an antecedent event that may have precipitated the decompensation of its heart disease. Usually these cats have pre-existing heart disease (mostly commonly HCM) that get "pushed" into heart failure with a stressful event, steroid injection, or aggressive IV fluid therapy.

Treatment

Minimizing stress : For a cat with acute severely decompensated heart failure (HF), minimizing stress is of the upmost importance. Often times, stress may have even precipitated the episode of heart failure. Giving the cat small breaks in between diagnostic and therapeutic interventions is wise and potentially lifesaving. Many times, one should start empiric therapy for presumptive heart failure if history, physical exam and preliminary low stress diagnostic testing are most suggestive for HF. Initial treatment typically includes oxygen, sedation, IV or IM furosemide and thoracocentesis if indicated. Another low risk empiric treatment option in cats in which the diagnosis of heart failure is uncertain and feline asthma is also being considered in inhaled bronchodilation. The bronchodilation may help some cats with heart failure as they can develop peri-bronchiolar pulmonary edema with associated bronchoconstriction. Generally, one or two puffs of albuterol are administered with a mask and spacer chamber. An additional one or two puffs could be repeated in 15-30 minutes to ensure delivery of the drug to the smaller airways. Bronchodilators should be used with caution, as they can cause tachycardia and tachyarrhythmias, especially at higher doses.

Sedation : Despite a small risk of depressing respiratory drive, mild sedation and oxygen before any prolonged handling of the cat is recommended. Mild anxiolysis with low dose butorphenol [0.05-0.2 mg/kg IV, SQ or IM] often times improves respiratory rate and effort. If a cat is on the verge of respiratory fatigue and failure, then it is

possible that sedation will make the cat more hypoventilatory. One should watch the cat's respiratory rate and effort carefully. Buprenorphine [0.005 – 0.02 mg/kg] is longer acting opioid with stronger analgesic effects making it a good choice in a cat with concurrent HF and aortic thromboembolism. Heavier sedation may be needed for thoracocentesis. The author often combines a second dose of butorphenol with midazolam [0.1 mg/kg IV or IM] to accomplish a therapeutic thoracocentesis. Sometimes a tiny dose of ketamine [5 mg/cat usually IM, or IV] may be needed in a particularly fractious cat.

Thoracocentesis : In cats with large volume pleural effusion and respiratory difficulties, medical therapy alone will not result in clinical benefit necessitating a therapeutic thoracocentesis. The risk to benefit ratio is most favorable with large volume effusion. Most cats can be tapped effectively via just one hemithorax as most have an incomplete mediastinum. In general, the entry site is the 7-8th intercostal space just above the costochondral junction entering the pleural space on the front side of the rib. The author prefers an over-the-needle catheter technique for a therapeutic centesis but the butterfly catheter technique also works well.

Furosemide : Furosemide is a loop diuretic and a mainstay in the management of congestive heart failure regardless of etiology. The dose of furosemide is challenging because it needs to be tailored to the individual patient. Too high of a dose can have deleterious effects on renal perfusion and electrolytes. Conversely, too low of a dose can lead to unnecessary hospitalization, expense and potential euthanasia because of recurrent decompensations.

The author uses a combination of repeat bolus dosing and CRIs to manage our hospitalized severe acutely decompensated HFs. For an inpatient HF, the initial furosemide dose is typically ~ 2 – 4 mg/kg IV or IM with repeated doses q 1- 12 hrs as needed, usually not exceeding 12 mg/kg/day. If the cat is severely dyspneic due to pulmonary edema, we commonly use a furosemide CRI of 0.66 mg/kg/hg until improvement in respiratory rate (< 60 per minute) after the initial bolus. The combination of a furosemide bolus followed by a CRI has a better diuretic effect. For an outpatient heart failure patient, the dose is usually lower such as 1-2 mg/kg once to twice daily. The initial furosemide dose is usually higher than the long-term dose. The best dose chronically is the lowest effective dose as overzealous furosemide therapy can lead to low effective circulating volume, and electrolyte disturbances such as hypokalemia.

Torsemide is a newer oral loop diuretic with greater potency and longer duration of action than furosemide. A few studies have shown that torsemide is well tolerated in dogs with advanced congestive heart failure. A recent 2013 ACVIM abstract showed that torsemide was also well tolerated in cats with HF and a high diuretic requirement (furosemide > 6 mg/kg/day). The typical dose is a tenth of the furosemide dose give q 12 hrs. Torsemide is more likely to cause azotemia and hypokalemia than furosemide.

Pimobendan : Although not licensed for use in cats (or humans in the US), there has been an increased use of pimobendan in the management of feline congestive heart failure. Pimobendan has a dual mechanism of action, an "inodilator". Specifically, it is a calcium-sensitizing drug that improves contractility (positive inotrope) with minimal effects on myocardial oxygen consumption. The other mechanism of action is that of phosphodiesterase inhibition leading to a balanced vasodilation (arterial and venous) and as well as improving myocardial performance. Because of its calcium sensitizing mechanism of action, pimobendan not only has positive inotropic but also positive lusitropic properties (relaxation) that may be beneficial in cats with diastolic dysfunction due to HCM.

Over the past several years, NCSU cardiology has treated hundreds of cats with pimobendan. The use of pimobendan has evolved over the years from being salvage, last-ditch medication to one that we are using earlier in the management of heart failure. Pimobendan is typically added when a heart failure cat has left ventricular systolic dysfunction, significant pleural effusion, concern for renal insufficiency, or severe refractory pulmonary edema. That said, my current impression is that most of our feline heart failure cases are being managed with pimobendan in combination with an ACE-Inhibitor and furosemide. There are no prospective randomized clinical trials in cats with heart failure evaluating pimobendan but 4 recent retrospective case series have suggested that it is safe at similar doses used in the dog (0.5 mg/kg/day). One of these studies recently demonstrated the safety and

potential benefit in cats with heart failure and preserved LV systolic function due to HCM with and without LV outflow tract obstruction. In this historical case-controlled retrospective case series, the median survival time of cats receiving pimobendan was 626 days, whereas median survival time for control cats was 103 days. No adverse effects were reported in this study which is different than 2 other case series that described adverse effects of hypotenion in cats with dynamic outflow tract obstruction. A recent pharmacokinetic study in healthy cats suggests that pimobendan has a favorable absorption profile for acute management of heart failure with peak plasma levels achieved within one hour (~0.3 hrs) after single oral dose pimobendan. This study also showed that pimobendan given as similar mg/kg doses as in the dog resulted in mean plasma elimination half-life that was almost three times as long as reported in dogs (1.3 h vs. 0.5 h) and that the mean Cmax was greater than ten times that reported in dogs. Despite these results, most using pimobendan in the cat will use similar doses as in the dog based on clinical studies.

If a cat with severely decompensated heart failure is unable to take oral medications and has signs of low cardiac output, dobutamine could be used. The typical cat that could benefit from dobutamine is one in cardiogenic shock often with relative bradycardiac, hypothermia and hypotension. Dobutamine is an IV adrenergic positive inotrope with primarily beta-1 effects. The dose ranges from 1-5 mcg/kg/min CRI, starting at a lower dose and titrating upward based on blood pressure and ECG monitoring. Tachyarrhythmias are the main adverse effect.

ACE-Inhibitors : Enalapril and benazepril block the conversion of angiotensin I to angiogensin II. No published studies exist in cats with HF that show improved survival and quality of life with ACE-I. Conversely, there are many such studies in both dogs and humans with congestive heart failure. For this reason and a small unpublished multicenter study, ACE-I are generally added to a stable and eating cat with congestive heart failure. Although both ACE-I's are very similar, benazepril may have an advantage in cats in that it is a little longer acting than enalapril allowing for more ACE inhibition with once daily dosing. Moreover, the route of excretion is 85% via the biliary system (50% in dogs) so it may be safer in the cat with concern with renal impairment. The recommended dose for enalapril and benazepril in the cat is 0.25 to 0.5 mg/kg PO q 24 hr. ACE-I's are typically withheld in the per-acute management of severely decompensated HF because of the possibility of acutely lowering intra renal perfusion and GFR without significant afterload reduction.

Anti-thrombotics / Anticoagulants : Because HF cats have enlarged atria, they are at higher risk for aortic thromboembolism and should ideally be receiving some anti-thrombotic prophylaxis. Because oral medication administration is often problematic in cats, the anti-thrombotic medication is often omitted because it is prioritized lower than the diuretic, pimobendan and ACE-I. However, the risk of thromboembolism is even higher if spontaneous echo constrast or echo "smoke" is visualized. The most commonly used anti-thrombotic administered at our institution is clopidogrel, an ADP receptor inhibitor resulting in decreased platelet aggregation. The usual dose is a ¼ of 75 mg tablet once daily. Clopidogrel is now available as a generic which has lowered the cost dramatically. A recent abstract presentation of the Morris Animal Foundation FAT-CAT clinical trial demonstrated improved survival in cats receiving clopidogrel as compared to aspirin. Other newer anti-thrombotics such as apixaban and rivaroxiban are currently being investigated in cats.

Antiarrhythmics : In general, the author is a bit more conservative about managing arrhythmias in cat than in dogs. However, if hemodynamically significant supraventricular or ventricular tachyarrhythmias are present, then specific antiarrhythmic treatment is recommended. For rapid atrial fibrillation (> 240 / min), diltiazem is usually recommended. Oral diltiazem is given either as a non-sustained-release formulation [7.5 mg/cat PO q8h] ; or as a sustained-release oral formulation [Cardizem CD® at 10 mg/kg PO q24h or Dilacor® 30 mg/cat [or ½ of an inner 60 mg tablet] PO q 12h].

For rapid and sustained ventricular tachycardia, lidocaine slow IV 0.2–0.5 mg/kg (repeat once or twice max) or sotalol PO 2 mg/kg q12h is recommended. Risks of diltiazem and sotolol are related to their potential to decrease cardiac output because of its negative inotropic and chronotropic effects. Serious adverse effects of lidocaine affect the central nervous system and the cardiovascular system. Clinically, these are manifested as

lethargy, unconsciousness, coma, convulsions, seizures, hypotension, bradycardia, and cardiovascular collapse and could even result in death.

Some cats with HCM are treated with atenolol prior to their first episode of heart failure. Generally, the author will dose reduce the atenolol especially if the cat is showing any signs of low cardiac output manifested with low heart rate, blood pressure or body temperature. Additionally, one should refrain from starting a beta blocker in a cat with active congestive heart failure even if dynamic left ventricular outflow tract is present. The beta blocker may worsen the cat's signs of congestive heart failure.

References available upon request and questions: Teresa_defrancesco@ncsu.edu