

TREATMENT OF CONGESTIVE HEART FAILURE

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Understanding Treatment

The aims of therapy, which applies to most causes of congestive heart failure (except pericardial effusion) are as follows:

Control volume load (congestive signs)

- Diuretics – should be used at the minimum effect dose
 - Furosemide – the most potent and commonly used diuretic
 - Spironolactone – a weak diuretic but more importantly has anti-aldosterone effects
 - Co-amilofide (hydrochlorothiazide + amiloride) – normally used in addition to furosemide when there is refractory ascites. This combination of diuretics act at different sites within the nephron: the concept of 'sequential nephron blockade'.
- ACE inhibitors
 - Have mild diuretic properties in addition to its anti-neurohormonal effects
- Low sodium diet
 - Excessive salt intake may exacerbate the 'fluid retention' that occurs in heart failure and therefore it is generally agreed that high salt diets and 'salty-treats' should be avoided.
- Remove fluids
 - Drainage of pleural and/or ascitic fluid – is unusually only performed when causing dyspnoea, but removal also removes proteins and potentially reduces oncotic forces which could exacerbate oedema fluid
- Restriction of water intake
 - This is not advised and water should be provided *ad lib*.

Reduce cardiac work

- Rest
 - Caged rest is important, especially in fulminant congestive failure cases
 - If oxygen administration causes stress, it should be avoided. Consider hands-free methods, eg. oxygen cage, anaesthetic chamber
 - Once congestive failure signs are controlled, exercise (within the limits of the animal's ability) is considered beneficial, but prevent excessive exercise.
- Reduce arterial pressure (afterload)
 - Arterial vasodilators
 - Pimobendan or levosimendan: useful in acute fulminant cases and it is also a positive inotrope
 - ACE inhibitor drugs – vasodilator benefits are mild and more long term
- Reduce the filling pressure (preload)

- Venodilators
 - Diuretics – furosemide reduces preload, but is also reported to have venodilator properties when given i/v
 - Glyceryl trinitrate
 - Pimobendan, levosimendan
 - ACE inhibitors (mild)
- Weight reduction in obese animals
 - Obesity is a recognised cause of increased cardiac workload, especially during exercise.

Improve cardiac efficiency

when myocardial failure is present

- Enhance contractility with positive inotropic drugs:
 - Pimobendan, levosimendan
 - Digoxin
 - Dobutamine
- Improve diastolic function
 - Improve ventricular relaxation
 - Beta blockers and calcium channel blockers may be useful in hypertrophic cardiomyopathy
 - Control arrhythmias such as:
 - Atrial fibrillation – digoxin would be the most commonly preferred drug
 - Frequent supraventricular premature complexes or ventricular premature complexes
- Improve myocardial or vascular remodelling
 - Counter the neurohormonal effects
 - ACE inhibitors
 - Angiotensin receptor antagonists
 - Beta blockers
 - Aldosterone antagonists, eg. spironolactone

Basic fundamentals of treatment

As a general rule, all dogs with congestive heart failure due left sided congestive heart failure (ie. MVD or DCM) will require the following:

- | | |
|--|---|
| 1. The anti-neurohormonal drugs: | ACE inhibitor
+ spironolactone |
| 2. Inodilator drug: | pimobendan |
| 3. Diuretic for congestion (and proportional to severity): | furosemide
+/- co-amilozide |

Note: There is some interest in the use spironolactone at sub-diuretic doses (one quarter normal dose) as part of the treatment medications to minimise/reduce myocardial fibrosis.

Cough

This is a common problem and often poorly managed. As a general rule, coughing in dogs with chronic MVD is most commonly due to compression of the airways by the huge left atrium. Thus is is a physical stimulus. Oedema can also cause coughing, but dyspnoea is also a more common symptoms in these cases.

Treatment

Oral medication with codeine linctus at 1-2mg/kg tid/qid (or a similar anti-tussive) given for a week and then reduced to the minimum effective dose or as required.

TREATMENT STRATEGIES

Acute fulminant congestive failure (pulmonary oedema)

Can occur in any dog or cat with rapidly progressing or uncontrolled congestive failure, but some common causes of acute failure are:

- Ruptured chordae tendineae secondary to mitral valve disease
- Acute onset dilated cardiomyopathy, particularly Dobermanns and Cocker Spaniels
- Cardiomyopathies in cats can present acutely, which may be associated with recent steroid administration or a salt load
- Strict rest and stress-free handling – cannot be over emphasised
- Gentle sedation results in:
 - Reduction in anxiety
 - Slower deeper respiration
 - Dogs: morphine at 0.1 – 0.2mg/kg i/m
 - Cats: butorphanol at 0.1mg/kg i/m
- Oxygen supplementation – without stressing the animal, using hands free methods
- **Furosemide** : 3 (- 4) mg/kg in dogs and 2mg/kg in cats
 - administered i/v if it is not stressful to the animal, otherwise i/m
 - given every 1-2 hours until there is evidence of :
 - diuresis (urination)
 - improvement in respiration (reduction in pulmonary oedema)
 - at which time the frequency of administration is reduced to every 6 hours

Note: Excessive dosing can potentially be counterproductive and may result in

- Dehydration
- Reduced cardiac output
- Circulatory collapse
- Electrolyte depletion
- Renal failure

- Venodilators

Essentially redistribute blood volume away from the lungs to the large capacitance veins, thereby reducing pulmonary oedema

- **Glyceryl trinitrate** – ¼” to 1” in dogs tid, ¼” in cats tid/qid
 - Simpler to use than sodium nitroprusside, although may be less effective
 - Applied to a hairless part of the body: inner ear or inside thigh (not rubbed in)
 - Caution: Need to use gloves when using or handling dog

- Positive inotropes / inodilators

Beneficial in dogs with dilated cardiomyopathy, but also useful in dogs in acute failure due to mitral valve disease. Generally not used in cats in acute failure.

- **Pimobendan** at 1 – 3 mg/kg bid, *per os*. (on an empty stomach)
 - Simpler to use than dobutamine
 - Additionally provides arterial & venous vasodilation
 - Absorbed rapidly from gut
- **Digoxin** – not normally used as an emergency drug
 - It is a weak positive inotrope
 - Steady state levels take 5- 7 days to achieve, which is not appropriate in emergency cases
 - The intravenous preparation is difficult to use and has a narrow margin of safety

Summary: Treatment strategies for the management of acute fulminant congestive heart failure in dogs

Option 1 - Intensive therapy

- Rest
- Gentle sedation
- Oxygen supplementation
- Furosemide
- Sodium nitroprusside CRI
- Dobutamine CRI

Option 2 – Less intensive (more likely to be an option in general practice)

- Rest
- Gentle sedation
- Oxygen supplementation
- Furosemide i/v or i/m
- Glyceryl trinitrate percutaneous
- Pimobendan orally

Chronic congestive failure (out-patient treatment)

The majority of heart failure patients will fall into this category.

The general rule is that treatment should not be initiated until there are clinical signs.

- Exercise – considered important, but should be well within the capabilities of the patient
- **ACE inhibitors** – indicated in all dogs with heart failure (due to mitral valve disease or dilated cardiomyopathy) due to the importance of inhibiting the adverse neuroendocrine responses that are induced by CHF. Being increasingly used in cats.
 - There are a large number of ACE inhibitors available, none has a particular advantage or benefit compared to others
 - Start at standard manufacturer recommended dose
 - Dose can be doubled to bid in long standing or advanced cases
- Diuretics – dose should be adjusted and optimised in each case
 - **Furosemide** – dose range is $\frac{1}{2}$ – 3 mg/kg bid in dogs, 1 – 2mg/kg sid/bid in cats
 - Initial dose is proportional to severity
 - Oral furosemide solution is often a more convenient medication for cats and more accurately titrated when the dose is small.
 - Following a response the dose should be reduced to the minimum effective dose
 - In many cats (without concurrent pleural effusion) the furosemide can often be weaned off, being maintained on an ACE inhibitor.

<p>Note: Diuretic over dosage can lead to: subclinical dehydration, inappetance, lethargy, pre-renal azotaemia, depletion of electrolytes, polydipsia/polyuria.</p>
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Management of Atrial fibrillation (AF)

- Important when the ventricular response rate exceeds 150/min
- May not be necessary in giant breed dog with lone AF
- **Digoxin** would be the most commonly used drug
 - Primarily used in dogs, indications for use in cat are rare and not discussed
 - Dose = $0.22\text{mg}/\text{m}^2$ every 12 hours, however the boxed text below provides a simple guideline for a starting dose

Digoxin starting dose in dogs

Body weight	Tablet size	Tablet dose	
1 – 5 kg	62.5µg (PG)	½	q12 hours
6 – 13 kg	62.5µg (PG)	1	q12 hours
14 – 23 kg	125µg	1	q12 hours
24 – 36 kg	125µg	1 ½	q12 hours
> 37 kg	250µg	1	q12 hours

Note: Dobermann dose is 125µg tablet 1 q12 hours

- Steady state levels are achieved in 5-7 days
- Serum digoxin levels should be measured (approximately 6 hours post pill, day 5-7) to confirm the dose is correct, as it varies between individual patients.
- Therapeutic serum levels are between 0.8 – 2.5ng/ml; between 1 – 2 ng/mg is a reasonable target
- Therapeutic aims are to reduce the resting heart rate to less than 150 – 160/min, however judging the heart rate in-clinic may result in falsely high heart rates, so clinical judgement needs to be made, but Holter monitoring is recommended.
- Causes of a persistent high heart rate listed in the boxed text below

Causes of a persistently high heart rate in dogs with atrial fibrillation receiving digoxin

- Elevation of the heart rate in-clinic due to nervousness at the time of examination – may require 24 hour Holter to determine average heart rate at home
- Inadequate control of the congestive failure signs - sympathetic drive is still high
- Dehydration / hypotension due to over diuresis / vasodilation
- Inadequate serum therapeutic levels of digoxin
- Concurrent medical disease, e.g. renal failure
- Advanced myocardial failure and end stage heart disease
- Heart rate poorly responsive to digoxin - needs additional antiarrhythmic drugs

- Bioaccumulation of digoxin may occur with azotaemia, low serum albumin, cachexia
- Signs of over dosage are: depression, anorexia, vomiting/diarrhoea, arrhythmias, in which case the drug should be stopped and re-introduced at a lower dose when signs have completely resolved.

Positive inotropic drugs

Pimobendan.

- Indications:
 - dogs with dilated cardiomyopathy or mitral valve disease
 - may be of benefit in cats with cardiomyopathy where there is reduced wall motion
- **Pimobendan** at 0.1 – 0.3 mg/kg bid, on an empty stomach
 - Also has arterial vasodilator properties
 - Positive lusitropic properties
 - Additional effects are: improvement in the animals demeanour, alertness and activity, and sometimes an improvement in appetite
 - Inhibits platelet aggregation
 - Note: Calcium channel antagonists may reduce the efficacy of pimobendan

Summary: Treatment strategy for treatment of chronic congestive heart failure (out-patient treatment) in dogs

- Exercise – yes, but within animals capability
- ACE inhibitor (ACE I)
- Pimobendan
- Furosemide – to minimum effective dose
- Digoxin – primarily in cases with atrial fibrillation

Refractory chronic heart failure in dogs (often with ascites)

This occurs primarily in dogs with dilated cardiomyopathy, but eventually is seen in dogs with mitral and tricuspid valve disease.

- Ascites (+/- pleural effusion) becomes refractory to the above treatment, including top-doses of furosemide (3mg/kg bid).
- In these cases the dose of ACE inhibitors should be doubled to bid and the dose of pimobendan maximised.
- If ascites remains refractory then additional diuresis is required:
 - Co-amilozide (hydrochlorothiazide + amiloride) at 1- 3mg/kg (combined dose rate)
 - a potent and useful diuretic
 - amiloride is a potassium sparing diuretic.

Monitoring of acquired heart failure in dogs and cats

Once heart disease and congestive failure has been diagnosed it is imperative that there is ongoing, life-long, monitoring of the heart failure with constant adjusting of drug doses to ensure these are optimised for each individual animal. This is a guideline that may be of benefit, but needs to be adapted to each patient's circumstances.

Physical examination

By the owner at home:

- Monitor the resting respiratory rate - this increases when there is pulmonary oedema or pleural effusion.
- Monitoring the heart rate is sometimes useful - but this can be difficult especially when there is an arrhythmia such as atrial fibrillation (AF) and thus less reliable.
- Keep rechecking response for example - is the quality of life satisfactory? In particular is there an improvement, or not, in coughing, respiratory character, appetite, thirst, etc.

By the vet:

- Check general demeanour and attitude, respiratory effort, mucosal colour, heart and pulse rates (particularly when there is an arrhythmia such as AF), presence of ascites, body weight.

Blood tests

1. As a baseline a full blood profile should be performed before administering therapy in virtually all cases.
2. The first follow-up profile should ideally be performed within 1 to 2 weeks of instituting cardiac therapy, with the aims of monitoring renal and hepatic parameters, protein levels, electrolytes and haematology. For example dehydration or electrolyte imbalance may occur and may dictate reduction in diuretic dosage. Mild elevations in urea and creatinine are acceptable in most cases when on therapy.
3. Further follow-up profiles should be considered within 4 weeks and then at 3 - 4 month intervals to monitor long term, depending upon each individual case and the type of underlying heart disease.

Serum Digoxin

- Measure initially within 7 to 10 days of introducing digoxin, ideally 8 -10 hours post morning pill (or 'mid-way' between tablets).
- Ongoing digoxin levels should be assessed every 6 months. Serum levels may increase due to chronic renal failure or weight loss for example.

Thoracic Radiography

- The purpose of follow-up chest radiographs is to check if any pulmonary oedema or pleural effusion is adequately controlled - this cannot be reliably performed by clinical examination alone. Thus ensuring that the dose of diuretics used is not too much (or too little).
- If there is uncertainty as to the cause of any change in symptoms, such as deterioration in coughing, then chest radiographs can help to decide if the cough is due to progressing cardiomegaly or not.
- If heart disease has been detected before the onset of symptoms, such as a murmur due to mitral valve disease, then monitoring for the development of cardiomegaly can help to decide when treatment should be instituted.

Echocardiography

- In dogs the main value is monitoring for the progression or development of myocardial failure (reduced ventricular contractility). For example occult dilated cardiomyopathy will progress and lead to signs of heart failure, or long standing mitral valve disease may lead to secondary myocardial failure. Suspected acute rupture of a chordae tendineae is another indication for a repeat echocardiographic examination.
- In cats, repeat echocardiography after 4 to 6 months of therapy is useful, particularly with hypertrophic cardiomyopathy to document the response to therapy, degree of left ventricular hypertrophy or outflow tract obstruction. Alterations in therapy may be required according to findings.

Recommended Reading

Notes on Cardiorespiratory Diseases of the Dog and Cat,

2nd edition. Martin & Corcoran (2006) Blackwell Science. ISBN 0-632-03298-7

Small Animal ECGs: An Introductory Guide, 2nd edition. Mike Martin (2007), Blackwell. ISBN 978-1-4051-4160-4

DRUG GLOSSARY

For detailed information regarding uses, contra-indications and side-effects the reader should consult appropriate formularies and the product data sheets.

Amlodipine	Cat: 0.625 – 1.25mg per cat q24hr (to q12hr) Dog: Starting dose of 0.5mg/kg q12hr increasing to effect to a maximum of 2mg/kg q12hr
Aspirin	Dogs: 5mg/kg daily Cats: 5 – 20mg per cat twice a week
Atenolol.	Dog 0.25-2.0mg/kg q12hr orally. Cat 1-2mg/kg q12-24hr orally.
Atropine	Dog/cat: 20 - 60µg/kg q6-8hr orally Dog/cat: 40µg/kg s/c
Benazepril.	Dog 0.25mg/kg q24hr orally. Cat 0.5mg/kg q12-24hr orally.
Bromohexine.	Dog 2mg/kg q12hr orally. Cat 1mg/kg q24hr orally.
Butorphanol (anti-tussive)	Dogs: 0.5 – 1.0mg/kg q6-12hrs orally.
Co-amilozide (amiloride + hydrochlorothiazide)	Dogs/cats: 1-3mg/kg q12hr
Codeine.	Dogs: 0.5-2mg/kg q8-12/hr orally.
Clenbuterol	Dog: 1-5µg/kg q8-12hr Cat: 1µg/kg q12-24hr
Dalteparin (low-molecular weight heparin)	100-200iu/kg s/c q12hr
Dextromethorphan.	Dogs 0.1-5mg q8-12hr orally.
Digoxin	Dog: (0.22mg/m ² q12 hrs) for recommended starting dose see above Cat: < 4kg - 0.0625mg tablet 1/2 q48 hours & > 4kg - 0.0625mg tablet 1/2 q24 hours
Diltiazem.	Dog 1-3mg/kg q8hr orally, start low and titrate up Cat 1.6-3.3mg/kg q8hr orally. Slow release (Dilacor XR) 30mg per cat q24 hr
Dobutamine	Dog: 5.0 – 10µg/kg/min i/v

Enalapril.	Dog 0.5mg/kg q12hr orally.
Enoxaparin (low-molecular weight heparin)	100iu/kg s/c q12hr
Esmolol	Dog/cat: 0.25-0.5mg/kg slow i/v
Fenbendazole <i>Treatment of lungworm</i>	Mild infection: 100mg/kg daily for 5 – 7 days Moderate infection: 50mg/kg daily for 7 - 10 days Severe infection: 20mg/kg daily for 10 – 14 days
Fish oils	Eicosapentaenoic acid (EPA) = 40mg/kg per day Docosahexaenoic acid (DHA) = 25mg/kg per day
Furosemide (frusemide)	Starting dose: Dog: 0.5-2mg/kg q12hr (up to 4mg/kg q8hr) Cat: 0.5-1mg/kg q12-24hr (up to 2mg/kg q12hr) Acute failure: Dog: 3-4mg/kg q2hr i/v or i/m Cat: 1-2mg/kg q2 hr i/v or i/m
Glyceryl Trinitrate (2% ointment).	Dog 0.5 - 5.0cm (small-large breed) q6-8hr for 3d topically. Cat 0.5cm q8hr for 3d topically.
Heparin	250iu/kg q8hours
Imidapril.	Dog 0.25mg/kg q24hr orally.
L-carnitine	Dogs: 50mg/kg q8hr
Lidocaine (Lignocaine)	Dog 2-3mg/kg slowly iv, every few minutes to a max. of 9mg/kg in 20 – 30 minutes. Dog 25-75µg/kg/min iv infusion. Cat: 0.25-0.75mg/kg, can repeat after 20 minutes
Magnesium amino chelate (200mg tablets)	Dog: 10mg/kg daily with food
Mexilitine.	Dog 5-8mg/kg q8hr orally.
Morphine	Dogs: 0.3 – 0.5mg/kg q4-6hr Cats: 0.1mg/kg q6-8hr
Pimobendan.	Dog 0.1-0.3mg/kg q12hr orally, on empty stomach
Propantheline bromide.	Dog 0.5-2mg/kg q8hr orally. Cat: 7.5mg q8-12hr

Propranolol.	Dog 0.2-2mg/kg q8hr orally, start low and titrate up. Cat 2.5mg q8hr orally, up to 5mg q8hr. Dog/cat: 0.01-0.1mg/kg i/v, start low and titrate up
Ramapril.	Dog 0.125mg/kg q24hr orally, increasing to 0.25mg/kg.
Sodium nitroprusside	Dog: 1.0 – 5.0µg/kg/min i/v
Sotalol.	Dog: 0.5-2mg/kg q12hr orally.
Spironolactone.	Dog: Diuretic dose: 1-2mg/kg q12-24hr Cat: Diuretic dose: 1-2mg/kg q12-24hr
Streptokinase	Cat: 90000iu over 30 minutes; then 45000iu per hour for 3-6 hours
Taurine	Dogs: 500mg q12hr Cats: 250mg q12hr
Terbutaline.	Dog 1.25-5mg per dog q8-12hr orally. Cat: 0.625-1.25mg per cat q8-12hr orally.
Theophylline.	Dog 10-20mg/kg q12hr orally. Cat: 20mg/kg q12-24hr

SUMMARY

