Bradyarrhythmias

Bradyarrhythmias are defined as a heart rate below the normal range for the species ( < 60 bpm for dogs). Most bradyarrhythmias are either of a sinus-node or AV-node origin; however, bradyarrhythmias do not necessarily indicate a primary cardiac problem. In some cases, a systemic issue (hypothermia, hypothyroidism, medications) may be impacting the sinus and/or AV node. Determining the origin of the bradyarrhythmia can help one understand the underlying cause of the arrhythmia and the need for treatment.

Sinus Node Bradyarrhythmias

Common sinus-origin rhythms include sinus bradycardia, atrial standstill, sinus arrest, and sick sinus syndrome.

Sinus Bradycardia

Sinus bradycardia is most often a physiologic response to a systemic issue. This may include an increase in the parasympathetic nervous system. Sleeping animals can have a very low heart rate (30 bpm), but GI disease, hypothyroidism, increased intracranial pressure, respiratory disease, and hypothermia can also be involved. Additional considerations would include pharmacologic causes, such as beta blockers, digoxin, etc., or, uncommonly, true pathology of the sinus node.

**Diagnosis:** The heart rate is below the normal range and regular. There should be a regular relationship between the P wave for every QRS wave, and the relationship between the P wave and the QRS wave should be regular.

**Treatment:** Since sinus bradycardia is usually a rhythm that develops secondary to a primary disease process, it does not usually need to be treated. However, the animal should be carefully evaluated for the underlying systemic issues, and these should be addressed, if indicated.

Atrial Standstill

Two forms of atrial standstill are described: transient and permanent. The transient form is most often associated with hyperkalemia, also referred to as “sinoventricular rhythm” (paralysis of atrial myocytes, conduction through atrial pathways). The permanent form is fairly uncommon and is associated with myocardial diseases of the atria. This condition has been described in Siamese cats, and in the dog most frequently in Springer spaniels.

**Diagnosis:** There is a complete absence of P waves and a normal or decreased ventricular rate (QRS rate). Junctional or ventricular escape beats may be observed. Hyperkalemia can be a cause of transient atrial standstill, so potassium should always be evaluated. The permanent form of atrial standstill is typically due to an atrial cardiomyopathy, and atrial enlargement should be observed on the echocardiogram and possibly on the radiographs.

**Treatment:** In the case of the transient form, treat the hyperkalemia and identify the underlying cause of the hyperkalemia. In the case of the permanent form, the treatment of choice would be a pacemaker. However, because of significant myocardial disease, most cases will eventually develop congestive heart failure.

Sinus Arrest and Sinus Block

Periods of sinus arrest and sinus block may be an early sign of sinus node disease or can be induced by high vigil tone.
**Diagnosis:** Diagnosis can be based on intermittent periods without a P wave; an escape beat (QRS without a P wave that appears after a pause) may be observed. Sinus arrest or sinus block is an intermittent absence of P waves, as opposed to atrial standstill, in which there is a complete absence of P waves.

**Treatment:** Since the sinus arrest or block is typically intermittent, it does not usually result in significant bradycardia.

**Sick Sinus Syndrome**
Sick sinus syndrome (SSS) is a broad term used to describe an arrhythmia that contains a combination of all or some of the following: sinus bradycardia, periods of sinus arrest, AV block, and periods of supraventricular tachycardia. The most common presentation is syncope in older small-breed dogs—especially Schnauzers and dachshunds.

**Diagnosis:** The electrocardiogram may demonstrate any combination of the arrhythmias listed above. Since the syncope may be secondary to periods of bradycardia or tachycardia, it may be necessary to perform a Holter monitor or an event monitor before treatment to identify which one is causing the syncope. In most cases, it is the bradycardia.

**Treatment:** If the syncope is due to a bradyarrhythmias, terbuteline (2.5 mg/dog orally b.i.d.) or theophylline (Theodur, 10–15 mg/kg orally twice a day) is frequently very helpful and usually very reasonable to try.

If there is no response, it may be necessary to consider pacemaker implantation. If the patient is syncopal owing to tachyarrhythmias (uncommonly), the correct antiarrhythmic for a supraventricular tachyarrhythmia should be chosen.

**AV Node Bradyarrhythmias: Atrioventricular Block**

There are three types of atrioventricular (AV) block: 1st-, 2nd-, and 3rd-degree block. First-degree and sometimes 2nd-degree AV block can be caused by high vagal tone (sometimes normal in a dog, or associated with respiratory disease, GI disease, or central nervous system [CNS] disease); however, they may also be a sign of AV-node fibrosis associated with aging. Third-degree block is generally a sign of true nodal disease, which can be fibrosis, inflammation, or a tumor. High vagal tone would not be expected to cause third-degree AV block.

**1st-Degree AV Block**
At this level the block is usually asymptomatic.

**Diagnosis:** There will be an increased PR interval (> 0.13 seconds in the dog).

**Treatment:** No treatment is needed because it does not cause symptoms. However, it can progress to 2nd- or 3rd-degree AV block, so periodic evaluations may be considered.

**2nd-Degree AV Block**
At this level also the block is usually asymptomatic.

**Diagnosis:** Occasionally a P wave without a QRS complex and a normal to slow heart rate will be noted.

**Treatment:** The 2nd-degree block typically does not require treatment. If the block is frequent enough, it may cause a bradycardia, and a pacemaker may be indicated. Additionally, it can progress to a 3rd-degree block, so periodic evaluations may be considered.

**3rd-Degree AV Block (Complete Block)**
Third-degree AV block can be due to AV-node fibrosis, but it has also been associated with neoplasia and infectious diseases such as Chagas disease and Lyme disease. Dogs frequently have collapsing episodes or extreme lethargy due to the slow heart rate associated with 3rd-degree AV block.
Diagnosis: A complete disassociation of the P and QRS waves will be present. The PR interval is variable. Usually there are many more P waves than QRS waves. The heart rate (ventricular rate) is usually less than 60 bpm, and the QRS morphology may be abnormal.

Treatment: The only treatment is pacemaker implantation. Very little response is observed with medical therapy. These cases should be considered an emergency, and the pacemaker should be placed as soon as possible—sudden death can occur. The cost is usually between $2,000.00 and $3,000.00. Since neoplasia and infectious diseases can be the cause of 3rd-degree AV block (although not frequently), a thorough cardiac evaluation should be performed prior to pacemaker implantation, if possible.

Tachyarrhythmias
Tachyarrhythmias are defined as a heart rate above the normal range for the species. Most tachyarrhythmias arise from one of three places: the sinus node, the supraventricular region (atria or AV-node/junction), or the ventricle. Therefore, the three common forms of tachyarrhythmias include sinus tachycardia, supraventricular tachycardia, and ventricular tachycardia. Determining the origin of the tachyarrhythmia can help one understand the underlying cause of the arrhythmia and the need for treatment.

Sinus Tachycardia
Sinus tachycardia is typically a response to low blood pressure, pain, sepsis, fever, or low cardiac output. Note that many of these are systemic issues rather than a primary cardiac arrhythmia. Sinus tachycardia can be associated with congestive heart failure as a response to low cardiac output.

Diagnosis: Diagnosis is based on a normal P wave and QRS wave that appear to be consistently linked and have a regular rhythm with a heart rate above normal range.

Treatment: The primary cause should be addressed. Correct underlying problems; give fluids, if needed, to correct blood pressure; consider pain relief; attack primary infection, if fever is present; if the tachycardia is secondary to low cardiac output and heart disease, treat the heart disease.

Supraventricular Tachyarrhythmias
Supraventricular tachyarrhythmia is defined as a run of premature atrial beats leading to an increased heart rate. Supraventricular arrhythmias can look very similar to sinus tachycardias, since the QRS shape should be normal. It may be differentiated from a sinus tachycardia by the abruptness at which it starts up and turns off (sinus tachycardias should be more gradual). There is also a slightly different appearance to the P wave, if it is present.

Ectopic Atrial Tachycardia
This is an uncommon tachyarrhythmia defined by a run of atrial premature complexes in a row. In small animals it is most often associated with atrial enlargement.

Treatment: The first question to ask is whether treatment is necessary. This may be best determined by the heart rate, clinical signs, blood pressure, etc. Beta blockers (sotalol) or calcium channel blockers (diltiazem) may be beneficial, and, if the tachyarrhythmia is due to increased automaticity, may stop the arrhythmia. Digoxin may also be considered. Even if the rhythm is not broken with this regime, the ventricular response rate may be slowed by decreasing the AV node conduction rate.

Atrial Fibrillation
Atrial fibrillation is the most common form of supraventricular tachycardia in the dog. It is most commonly observed with severe atrial enlargement, usually secondary to cardiomyopathy or valvular disease.

Diagnosis: The diagnostic criteria for atrial fibrillation include a very rapid heart rate, an irregularly irregular rhythm, a normal-shaped QRS, and no obvious P waves. F waves may or may not be detectable, since in small animals they may be subtle.
Treatment: In small animals (as opposed to horses), atrial fibrillation has occurred because of a very dilated, stretched atria. It is unlikely that we will ever permanently convert these patients out of atrial fibrillation back to a sinus rhythm. Therefore, the goal is to decrease the heart rate to a normal range by slowing conduction through the AV node.

There are three options for antiarrhythmics: digoxin (0.005 mg/kg b.i.d. in the dog); beta blocker (sotalol 1.5–2.0 mg/kg b.i.d.); calcium channel blocker (diltiazem 0.5–1.0 mg/kg t.i.d.). In some cases more than one of these may be needed to maintain the heart rate within the normal range.

Ventricular Premature Complexes (VPCs)
Premature beats that originate in the ventricle are ventricular premature beats (VPCs). They may occur as single beats or occur in pairs, triplets, or runs. VPCs are never normal in the dog. So although we may or may not treat them, we should always try to identify the cause.

Diagnosis: Ventricular premature beats may be characterized by tachycardia with wide and bizarre QRS complexes that occur early.

Importance
Ventricular premature complexes are not a normal finding in most domestic animal species. Normal dogs have an average of two VPCs per day out of 100,000 heartbeats. Since VPCs may lead to sudden death and syncope, they are always of some concern. However, the relationship between risk of sudden death and the numbers of ventricular premature beats is poorly understood.

VPCs may be caused by cardiac or noncardiac causes. Cardiac disease can include cardiomyopathy, cardiac tumors, and chronic valvular disease. Noncardiac disease can include splenic disease, gastric dilation and volvulus (GDV), and shock.

Choosing to Treat
All ventricular antiarrhythmics are proarrhythmic, so the benefits and risks of treatment should be weighed. The ability of any drug to decrease the risk of symptoms and sudden death is questionable. Many antiarrhythmics may have additional side effects (dermatologic, immune, ocular, etc.). Sometimes considering whether the arrhythmia is “benign” or “malignant” is helpful and may be used to guide treatment options.

Benign Ventricular Arrhythmias
Benign ventricular arrhythmias could be thought of as one of two types: isolated ventricular premature beats or an accelerated idioventricular rhythm. If they are isolated VPCs, they probably do not need to be treated if the heart rate is normal, they are asymptomatic, and there is no underlying cardiac disease. But remember to evaluate the underlying cause of arrhythmia.

Accelerated idioventricular rhythm is often thought of as slow ventricular tachycardia. This is a very regular rhythm that is often similar or slightly higher than sinus rate. It often disappears when the animal is aroused. Generally, these patients do not need to be treated if they are hospitalized animals without underlying heart disease, since the rate is slow and they generally resolved in 48 to 72 hours. However, again, one must always be sure to try to identify the cause (splenic disease, hypoxia, anemia, etc.).

Malignant Ventricular Arrhythmias
Malignant arrhythmias are generally ones that should be treated. This group includes those with severe underlying cardiac disease and complex ventricular premature beats (paroxysms, bigeminy, etc.); sustained ventricular tachycardia (usually longer than 30 seconds); the R on T phenomenon; syncope related to VPCs; and rapid ventricular tachycardia.
**Acute/Emergency Therapy**

*Lidocaine*

In a dog, a bolus of 2 mg/kg should be given slowly IV to determine effect. If a response is noted, one can switch to a constant rate infusion (CRI) (50 ug/kg/min). If there is no response, the dose can be repeated two more times in a 10-minute period. Most dogs tolerate this dose very well.

If there is a poor response to Lidocaine, consider reevaluation of the serum potassium level. Potassium levels should be in the high normal range for maximum Lidocaine effect. Additionally, sometimes decreased levels of myocardial magnesium may be associated with ventricular arrhythmias. Serum levels are not necessarily accurate indicators of magnesium levels. So, one may consider supplementation with magnesium sulfate or chloride if suspicion exists.

*Procainamide*

In some cases, procainamide may be more effective than Lidocaine. If there is no response to Lidocaine and potassium is appropriate, consider an IV bolus slowly; if there is a response to this, consider CRI.

*Oral Therapy*

The response to therapy is probably dependent on the mechanism of arrhythmia, and usually this is not known. Unfortunately, the mechanism of the arrhythmia cannot be detected from the case.

*Sotalol*

Sotalol, a combination beta blocker and potassium channel blocker, is an excellent antiarrhythmic. We use a dose of 2 to 2.5 mg/kg orally twice a day. We may use it more carefully in cases with CHF and severe myocardial dysfunction, since it has weak negative inotropic abilities. It has a very low risk of proarrhythmia.

*Mexiletine*

Mexiletine is very similar to an oral Lidocaine. It can be an excellent ventricular antiarrhythmic. Some gastrointestinal disturbances may be seen, although this is significantly decreased if given with food. It *must* be given with at least a small meal. The dose is 5 to 6 mg/kg orally three times a day.

*Amiodarone*

Canine experience with this drug is limited. Hepatotoxicity (severe) and neutropenia can develop, but may resolve with discontinuation of drug.

**Monitoring Treatment**

In hospital electrocardiography, 2 to 3 minutes is highly specific for evidence of ventricular arrhythmias but poorly sensitive for monitoring response to therapy, because arrhythmias can be so intermittent. Therefore, ideally a Holter monitor is performed 10 to 14 days after starting oral therapy. The goal would be at least an 85% reduction in VPC number and a reduction in complexity (for example, from runs to singles).

In conclusion, one must carefully evaluate the benefits and risks of treatment. The perfect ventricular antiarrhythmic does not exist, and you may need to try more than one to get a response.