

## ANESTHETIC MANAGEMENT OF SPECIFIC CARDIOVASCULAR DISEASES

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Small animal patients that need general anesthesia may have preexisting cardiovascular diseases. To ensure oxygen delivery to the tissue, the cardiac output and oxygen content of the blood should be optimized. Cardiac output is the product of stroke volume and heart rate. Patients with cardiovascular diseases may have reduced cardiac output due to decreased stroke volume. The determinants of stroke volume are preload, afterload, and myocardial contractility. The hemodynamic goals for patients with cardiovascular diseases involve targeting these factors with the ultimate objective of providing adequate cardiac output to the anesthetized patients.

The main objective of this presentation is to present the anesthetic management of specific cardiovascular diseases. The cardiovascular conditions that will be discussed in this presentation are the more commonly encountered problems in practice.

### *Dogs with Mitral Regurgitation (MR)*

MR in dogs is due mainly to endocardiosis. The clinical consequences of mitral valve endocardiosis are seen in elderly small-breed dogs. The anesthetic risk associated with MR depends on its severity. Mild MR does not have hemodynamic consequence. Dogs with untreated congestive heart failure will have the highest risk. Dogs being treated with an ACE inhibitor and diuretics for congestive heart failure can be anesthetized but extreme care should be taken. Anesthesia should not be performed in dogs with untreated congestive heart failure.

With MR, part of the left ventricular stroke volume is ejected through the incompetent mitral valve into the left atrium. It creates a volume load on the left atrium and left ventricle resulting in increased pressure in those chambers. With these increased pressures, the LA and LV dilate and develop hypertrophy. Later in the disease process, the increased pressures will be reflected back upon the pulmonary venous circulation and ultimately results in pulmonary edema.

The hemodynamic goals for MR include: (1) reduce preload slightly to reduce regurgitant flow (preload); (2) avoid acute increases in afterload; (3) maintain contractility; (4) avoid bradycardia; (5) maintain sinus rhythm; and (6) do not increase myocardial oxygen requirement by avoiding severe tachycardia and hypotension.

To accomplish the above mentioned goals, there are specific steps that can be done. Do not overload the patient with fluids. Do not use fluid boluses to treat hypotension during anesthesia. Fluid should be given at a lower rate of 3.0-5.0 ml/kg/hour. Those patients with compensated CHF should receive fluid with lower sodium load like 2.5% dextrose and half-strength LRS. Avoid sinus bradycardia. Maintain normal heart rate. Slight tachycardia is acceptable. Atropine (0.02 mg/kg IV) or glycopyrrolate (0.01 mg/kg IV) should be given to correct sinus bradycardia. Maintain myocardial contractility. Treat hypotension using beta-1 agonist like dobutamine or dopamine. Dobutamine and dopamine can be given at 5.0-10.0 µg/kg/min. Slight vasodilation is acceptable. Avoid peripheral vasoconstriction. Alpha<sub>2</sub>-agonists should not be used in dogs with MR. Minimize excitement. Increased catecholamine release may cause vasoconstriction.

### *Anesthetic Considerations*

*Premedication:* Low dose of acepromazine is acceptable. This will reduce the afterload. It will provide sedation and minimize catecholamine-induced dysrhythmias. It can be administered at 0.01-0.02 mg/kg IM, SC. Opioids are indicated if there will be pain involved. Most opioids maintain cardiac contractility. However, they may cause sinus bradycardia. An anticholinergic (atropine or glycopyrrolate) can be added to the preanesthetic protocol if the patient has preexisting bradycardia or if a relatively high dose of an opioid is used. The opioids that are commonly used for premedication are morphine, hydromorphone, butorphanol, and buprenorphine. These are the recommended dosages for the different opioids: (1) morphine: 0.2-0.5 mg/kg IM, SC, (2) hydromorphone: 0.05-0.1 mg/kg IM, SC, (3) butorphanol: 0.2-0.4 mg/kg IM, SC, and (4) buprenorphine: 0.01-0.02 mg/kg IM, SC. Benzodiazepines are acceptable premedicants for MR. They produce minimal cardiopulmonary depression. They can produce paradoxical agitation in dogs if given alone or with an opioid. Instead of sedation, the dog may show restlessness and dysphoria. It is best to avoid the use of benzodiazepines in dogs that are not depressed. Diazepam and midazolam are the two most commonly used benzodiazepines in dogs. Midazolam is water soluble and can be administered IM, SC or IV. Diazepam is not water soluble and when given IM will result in unpredictable absorption. These are the dosages for the benzodiazepines: (1) diazepam: 0.2-0.4 mg/kg IV and (2) midazolam: 0.2-0.4 mg/kg IM, SC, IV.

*Induction:* Propofol is an acceptable choice for dogs with mitral regurgitation. It causes some degree of vasodilation, which will be beneficial for this heart condition. When used in these cases, it should be given slowly following premedication. The dose of propofol is 4.0 mg/kg IV; half of the dose should be given over 40-60 seconds and the remaining dose is given to effect.

A combination of diazepam-ketamine or midazolam-ketamine can be used in MR. The combination will result in transient sinus tachycardia. Ketamine, by itself, does not result in significant increase in peripheral vascular resistance. Diazepam is given at 0.25 mg/kg IV and ketamine at 5.0 mg/kg IV. Lower doses should be used in dogs that have profound sedation from the premedicants and are depressed. Etomidate is the most heart-friendly induction agent. However, it is still expensive. It is the drug of choice in patients with enlarged heart and showing signs of congestive heart failure before presentation. The dose of etomidate is 0.5-1.0 mg/kg IV. If etomidate is not available, a neuroleptanalgesic combination can be used. This combination maintains myocardial function. Bradycardia may occur due to the opioid's effect on the vagal tone. Anticholinergic can be added to the protocol to prevent sinus bradycardia. The two most common combinations used in practice are diazepam-hydromorphone and diazepam-fentanyl. The doses for diazepam and hydromorphone are 0.25 mg/kg IV and 0.2 mg/kg IV, respectively. When fentanyl is chosen, instead of hydromorphone, the dose is 10 ug/kg IV.

*Maintenance:* Anesthesia should be maintained with either isoflurane or sevoflurane. Dogs that develop hypotension and tend not to respond to the positive inotrope should be managed by "balancing" the anesthetic technique. A fentanyl CRI at 0.2-2 ug/kg/min can be added to the inhalant administration. This will allow the use of the lower concentration of the inhalant.

The drugs that need to be avoided in dogs with MR are xylazine, medetomidine, dexmedetomidine, and phenylephrine (vasoconstrictor).

*Postoperative:* Provide external heat support. Hypothermia can result in increased oxygen demand. Provide oxygen until the patient is ventilating adequately. Hypoventilation will result in hypoxemia when breathing room air. Provide optimal recovery conditions. Minimize stress, which can increase catecholamine release. Provide pain control when painful procedure is

performed. It is not recommended to give NSAID in patients with compensated congestive heart failure.

### *Cats with Hypertrophic Cardiomyopathy*

Many cats with hypertrophic cardiomyopathy may be asymptomatic. These cats can have mild to severe left ventricular thickening. Cats with hypertrophic cardiomyopathy can live longer than two years after a bout of pulmonary edema. Anesthesia should not be performed in cats with definite signs of congestive heart failure due to hypertrophic cardiomyopathy.

Left ventricular myocardium thickens (concentric hypertrophy). This results in stiff chamber. The basic problem in hypertrophic cardiomyopathy is the diastolic dysfunction of the left ventricle. It is characterized by delayed or incomplete myocardial relaxation and reduced compliance of the left ventricle. The stiff chamber leads to increased diastolic intraventricular pressure and then left atrial enlargement. The increased pressure in left atrium will be transmitted to the pulmonary veins and pulmonary edema will follow. Mitral regurgitation will develop as a result of the distortional change in the mitral valve apparatus caused by the hypertrophy of the left ventricle. In those cats with asymmetric hypertrophic cardiomyopathy, left ventricular outflow obstruction can develop when the anterior leaflet of the mitral valve moves to contact the septum during systole.

Hemodynamic goals for hypertrophic cardiomyopathy include: (1) maintain preload in cats without congestive heart failure; (2) increase afterload, if possible; (3) do not increase myocardial contractility; (4) maintain normal heart rate and avoid sinus tachycardia; (5) maintain sinus rhythm; and (6) avoid increase in myocardial oxygen consumption. To accomplish these goals, there are specific steps that should be considered. Adequate diastolic filling can be accomplished by large ventricular volume and sinus rhythm. Increased contractility, reduced afterload and preload will decrease the ventricular volume. Ketamine should be avoided because it increases contractility and heart rate. It also increases the myocardial oxygen demand. Acepromazine at the higher dose will cause vasodilation resulting in augmentation of the outflow obstruction. Dysrhythmias should be controlled before anesthesia. Minimize stress and excitement because of the catecholamine release that will increase heart rate and contractility. The drugs (beta blocker or calcium channel blocker) being taken by the patient for hypertrophic cardiomyopathy should be administered up to and including the day of anesthesia.

### *Anesthetic considerations*

*Premedication:* Opioids are considered good choices because they have minimal effects on myocardial contractility, preload and afterload. The opioids that are commonly used for premedication are hydromorphone, morphine, methadone, butorphanol, and buprenorphine. The premedicant doses for the opioids are as follows: hydromorphone (0.03-0.05 mg/kg IM SC), morphine (0.1 mg/kg IM SC), methadone (0.1 mg/kg IM SC), butorphanol (0.2 mg/kg IM SC), and buprenorphine: (0.01-0.02 mg/kg IM SC).

Benzodiazepines are also suitable for these cases. They produce minimal cardiopulmonary depression. However, they can produce paradoxical agitation and restlessness in cats. To minimize these side effects, midazolam or diazepam can be given with the IV induction agent. Small amount of the induction agent is given first. The dose of midazolam or diazepam is given next. The induction is completed with the primary induction agent given to effect. The dose for diazepam and midazolam is 0.2-0.4 mg/kg. Diazepam is preferably given IV while midazolam can be given by IM, SC, or IV route.

Medetomidine has been shown to eliminate outflow tract obstruction in cats with dynamic left ventricular outflow obstruction. The dose used in the study is 20 ug/kg IM. It appears that medetomidine or now dexmedetomidine may be used in cats with HCM that are not amenable to physical restraint during examination.

*Induction:* The use of propofol in cats with hypertrophic cardiomyopathy is debatable. There is a study that showed that it impairs regional myocardial function in ischemic myocardium. It also causes peripheral vasodilation. If used, it should be given very slowly and with a benzodiazepine. The calculated dose is 4.0 mg/kg IV; half of the dose should be given over 40-60 seconds and the remaining dose is given to effect.

Etomidate is the most heart-friendly induction agent. However, it is very expensive. It is the author's drug of choice in patients with enlarged heart and had shown signs of congestive heart failure before presentation. The dose is 0.5-1.0 mg/kg IV. Half of the calculated dose is given as a slow bolus and the rest of the dose given to effect.

Neuroleptanalgesic combination is another option in cats with HCM. The combination maintains myocardial function. Diazepam and hydromorphone are given at 0.25 mg/kg IV and 0.2 mg/kg IV, respectively. The fentanyl can replace the hydromorphone and is given at 10 ug/kg IV.

Mask induction using sevoflurane or isoflurane should be avoided because of the stress and excitement associated with this induction method. The outflow obstruction will be worse because of the increased heart rate and myocardial contractility due to the sympathetic stimulation.

The drugs that should be avoided are high to moderate dose of acepromazine, ketamine, atropine, glycopyrrolate, and thiopental.

*Maintenance:* Anesthesia should be maintained with either isoflurane or sevoflurane. Cats that develop hypotension should be managed by administering phenylephrine CRI at 1-5 µg/kg/min. It is advisable to avoid dobutamine and dopamine. A fentanyl CRI at 0.2-2 µg/kg/min can be added to the inhalant administration. This will allow the use of the lower concentration of the inhalant.

The patient should be monitored closely during anesthesia. The monitoring tools should include pulse oximetry, blood pressure measurement, capnography, ECG, and temperature probe.

*Postoperative:* The measures taken postoperatively will minimize mortality and morbidity in these cases. Provide external heat support. Hypothermia can result in increased oxygen demand. Provide oxygen until the patient is ventilating adequately. Hypoventilation will result in hypoxemia when breathing room air. Minimize stress, which can increase catecholamine release. Provide pain control when painful procedure is performed. It is advisable not to give NSAID in patients with compensated congestive heart failure.

### *Dilated cardiomyopathy (DCM)*

DCM is common in large-breed dogs. The main concerns in this condition are the reduction in myocardial contractility and dysrhythmias. The hemodynamic goals these patients that need anesthesia include: (1) maintain preload, (2) avoid increases in afterload, (3) maintain or increase contractility, (4) maintain normal heart rate, (5) control dysrhythmias, and (6) do not increase myocardial oxygen requirement by avoiding severe tachycardia and hypotension. These goals are almost similar to those set for mitral regurgitation. Therefore, a detailed discussion of the management of DCM is not included in these notes.

*References*

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