Congenital Heart Disease: What Can I Tell from Radiographs?

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General principles of cardiac radiography

Radiographs are essential for the evaluation of cardiac disease. They are easy to perform and useful for evaluation of the cardiac silhouette, pulmonary vessels, and pulmonary parenchyma. Proper positioning and technique are essential for evaluation of the cardiac silhouette and pulmonary vessels. This includes at least two orthogonal views (lateral and ventrodorsal or dorsoventral). Often the dorsoventral is preferred for cardiac evaluation and better visualization of the caudal lobar vasculature. The underlying cause of the cardiac disease may not always be evident on radiographs; therefore, echocardiography may be necessary to determine the etiology or further define congenital cardiac diseases.

Cardiac anatomy

There is a wide range of normal size and shape of the cardiac silhouette in dogs. In breeds with a deep chest the trachea will diverge from the spine acutely, while in brachycephalic breeds the trachea may parallel the spine. A line drawn from the carina to the apex of the heart on the lateral view should divide the heart into approximately 3/5 on the cranial side (right heart) and 2/5 on the caudal side (left heart). On the lateral view the cardiac silhouette should be 2.5-3.5 intercostal spaces at the widest dimension. These are not absolute values and are highly variable between breeds. In a brachycephalic dog 3.5 intercostal spaces would be normal, while in a very deep-chested dog 3.0 intercostal spaces may signify enlargement.

A cranial and caudal cardiac waist may be (but is not always) visible in normal dogs on the lateral view. The degree of cardiosternal and cardiophrenic contact is highly variable and subjective. On the ventrodorsal view the widest width of the cardiac silhouette should be < 50-66% of the widest width of the thorax. The vertebral heart score (VHS) provides a useful objective measurement of cardiac size. In the dog the VHS is < 10.5, with slight variations based on breed.

The cat heart should be very petite on both views. There is usually 1 intercostal space between the apex of the heart and diaphragm. The normal VHS is < 7.8 in the cat.

The clock face anatomy applied to the cardiac silhouette is very helpful in evaluating specific chamber and vascular anatomy abnormalities. Don't forget to evaluate the diameter of the caudal vena cava (CVC), which should be less than the diameter of the aorta. Evaluation of the pulmonary arteries and veins is an essential part of the overall assessment. A general rule of thumb for dogs is the cranial lobar vessels (evaluated on the lateral view) should be less in diameter, where they cross the 4th rib, than the proximal third of that same rib. On the ventrodorsal view the caudal lobar vessels are evaluated at the level of the 9th rib and should be less in width than the rib width.

Radiographic abnormalities associated with patent ductus arteriosis (PDA)

The abnormal communication between the proximal descending aorta and pulmonary artery leads to left to right shunting and radiographic changes depend on the severity/size of the shunt and patient age. A focal bulge in the descending aorta is considered pathopneumonic for PDA. Additional changes that are often seen are left atrial/auricular and left ventricular enlargement, main pulmonary artery enlargement, and over circulation (both arteries and veins enlarged). In severe cases pulmonary cardiogenic edema is present. Left ventricular enlargement results in elevation of the carina due to increased height of the cardiac silhouette on the lateral view. Increased convexity of the left border and rounding of the cardiac apex with elongation of the heart is seen on the VD/DV view. Left atrial enlargement results in elevation of the trachea and left mainstem bronchus due to increased height of the cardiac silhouette and loss of the caudal cardiac waist on the lateral view. Bowing of the mainstem bronchi and an enlarged left auricle (at the 3 o'clock position) is seen on the DV/VD view. Increased opacity in the perihilar region can be present on all views.

In rare cases increased pulmonary vascular resistance will result in elevated right ventricular pressure (Eisenmenger's syndrome) in which case the PDA will shunt from right to left. In these cases there will be right ventricular enlargement and dilation of the main pulmonary artery.

Radiographic abnormalities associated with pulmonic stenosis (PS)

Typically pulmonic stenosis is caused by an abnormality at the level of the pulmonic valve, which leads to restriction of flow from the right ventricle into the main pulmonary artery. Occasionally the abnormality may be subvalvular, but radiographic findings are similar in both cases. The three main radiographic findings are a prominent main pulmonary artery, right ventricular enlargement, and normal to under circulation (decreased size of arteries and veins).

Right ventricular enlargement is identified by increased sternal contact, increased intercostal space width (increased craniocaudal dimension), and elevation of the apex of the heart from the sternum all seen on the lateral view. On the ventrodorsal view there is

rounding and prominence of the right ventricle resulting in a reverse D shape of the cardiac silhouette. With severe RV enlargement the height of the heart may also become elevated, although this is more commonly seen with left-sided heart enlargement.

Main pulmonary artery enlargement is identified by at bulge or prominence at the 1-2 o'clock position on the VD/DV view. On the lateral view there may be loss of the cranial cardiac waist.

Radiographic abnormalities associated with aortic stenosis

Aortic stenosis is most commonly subvalvular, caused by a fibrous ring below the valve. The hallmark radiographic features are enlargement of the aortic arch with or without left ventricular enlargement. An enlargement of the aortic arch will result in an elongate heart on the ventrodorsal view and loss of the cranial cardiac waist/bulge at the craniodorsal heart margin on the lateral view. There is potential for left atrial enlargement if mitral insufficiency occurs.

Radiographic abnormalities associated with ventricular septal defects

Ventricular septal defects are generally located in the dorsal part of the septum. Because the pressure in the left ventricle is greater than the right ventricle during systole blood shunts from left to right. Depending on the age and severity of the shunting the cardiac silhouette may be normal or range to severe generalized (both right and left side) cardiac enlargement. Variability from normal size to over circulation of pulmonary vessels can be seen.

Radiographic abnormalities associated with atrioventricular dysplasia

Both mitral and tricuspid dysplasia will result in atrial overload. If the mitral valve is affected left atrial enlargement and pulmonary venous congestion can be seen. With tricuspid valve dysplasia the right atrium will enlarge with concurrent enlargement of the caudal vena cava and ascites as common radiographic findings. Right atrial enlargement is seen as focal elevation of the trachea cranial to the carina and loss of the cranial cardiac waist on the lateral view. There is rounding and enlargement of the right atrium (9-11 o'clock) on the VD/DV view.

Radiographic abnormalities associated with Tetralogy of Fallot

The four cardiac abnormalities seen with tetralogy are PS, VSD, overriding aorta, and RV hypertrophy (secondary to the PS). These will result in a mildly enlarged right ventricle as described above in the PS section, or a boot-shaped heart on the VD view. As with PS pulmonary vessels are generally decreased in size.

Radiographic abnormalities associated with peritoneopericardial diaphragmatic hernia

Communication between the abdomen and pericardial space will result in a globoid or abnormal shape to the cardiac silhouette. Because the liver, falciform fat, spleen, and gastrointestinal tract can all be present within the pericardial sac there is often a mixed opacity to cardiac silhouette. Lack of visualization of an intact diaphragm (cardiac silhouette and cupula of diaphragm blend together) is a key finding. A dorsal peritoneal pericardial remnant extending from the diaphragm to the caudodorsal pericardium is sometimes recognized.