Cardiac Ultrasound Mini Series

Session Two: Introduction to Doppler, Canine Cardiac Disease, Discussion of Clinical Cases

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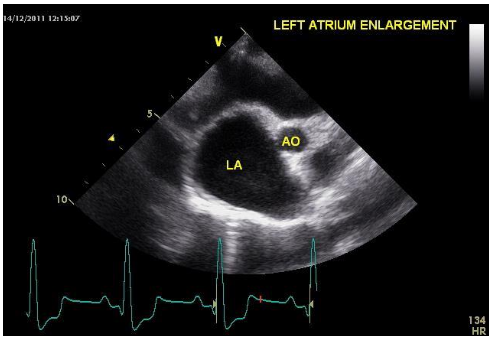

Echocardiography
in small animals
Part 2

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Abbreviations

ATE: Aortic thromboembolism

CHF: Congestive heart failure

DCM: Dilated Cardiomyopathy

HCM: Hypertrophic cardiomyopathy

HOCM: Hypertrophic obstructive cardiomyopathy

IVRT: Isovolumetric relaxation time

IVS: Interventricular septum

IVSW: Interventricular septal wall

LA: Left atrial enlargement

LV: Left ventricle

LVd: Left ventricular chamber dimension in diastole

LVs: Left ventricular chamber dimension in systole

LVFW: Left ventricular free wall

LVVd: Left ventricular volume in diastole

LVVs: Left ventricular volume in systole

LVVd: Left ventricular volume in diastole

PA: Pulmonary artery

PEP: Preejection period

ET: Ejection time

RV: Right ventricle

RVOT: Right ventricular outflow tract

SAM: Systolic anterior movement of the mitral valve

VSD: Ventricular septal defect

Doppler echocardiography

Doppler allows detecting and analysing moving blood or myocardium and provides information about the direction and speed of the flow and indirectly about the pressures within the cardiac chambers.

In **continuous-wave Doppler** the probe sends out and receives sound waves continuously. The advantage is that it can detect high velocities but the downside is that the transducer cannot detect the exact depth point of the reflected signal and blood flow is examined all along the sound beam.

In **Pulse-wave Doppler** the transducer sends out waves in a pulsatile manner and therefore it can detect flow at a particular area along the sound beam (sample depth of the cursor) but it is not able to detect high velocities.

Colour Doppler is a type of pulse-wave Doppler where the various velocities and direction of flow are coded in different colours. Usually red is for flow moving towards the transducer and blue away from the transducer.

In Doppler the time interval between pulses should be two times the sample depth and it is also referred as the pulse repetition frequency (PRF). Basically, for pulsed signals, the signal must be received before the next one is transmitted or ambiguity (aliasing) will occur. At which velocities ambiguity occurs (the nyquist limit) is directly correlated to the PRF and alising (mixed colour in Color Doppler and spectral broadening in pulse Doppler) can be minimised/resolved by using the lowest frequency probe possible (just the opposite to 2D echocardiography), adjusting your gain, eliminating real time image, finding an image plane where less depth is necessary, adjusting your PRF within the available PRF range or switching to continuous Doppler. In colour Doppler aliasing may occur at lower velocities than in pulse Doppler and it will occur even with laminar flows (it will depend on the PRF). To optimise further the colour flow image decreasing the colour sector width can be carried out.

In general, an important part of the Doppler equation is the cosine of the intercept angle. Therefore a paramount thing to do when you are using Doppler is to have your interrogation line (your sound waves emitted) as parallel (in line) as possible with the blood flow. Otherwise you will underestimate the flow velocities.

The main aims of Doppler are:

1. Assessing the direction, timing and velocity of flow within the heart.
2. Estimating the pressures in the different cardiac chambers (by the modified Bernoulli equation).

   PG: Pressure gradient (difference between Pressure in chamber 1 vs 2)

   V: Peak flow velocity

   $PG= 4V^2$

Further echocardiographic views

Right parasternal short axis view – Mitral valve level

Position:

1.From a right parasternal short axis view below the papillary muscles
2.Angle/slide the transducer dorsally
3.The typical “fish mouth” image will appear

This view can be used for:

1. M-mode across the mitral valve: Opening of the valve in early and late diastole
2.Calculation of EPSS
3.Evaluation of SAM in cats

Right parasternal short axis view – RVOT, pulmonic valve and PA

Position:

1.From a right parasternal short axis view at the level of the aorta
2.Angle/slide the transducer dorsally and cranially
3.Optimise the image to the pulmonary valve, pulmonary artery and then the bifurcation

This view can be used for:

1.PA/AO ratio is 0.8-1.2. Assess for pulmonary artery dilation.
2.Assess the RVOT
3.Assess the pulmonary valve
4.Assess the pulmonary artery
5.PDA
6.Assess PTE
7.Assess PTE
8.Assess flow through RVOT, PV, PA
9.Assess PDA flow
10.Assess severity of pulmonic stenosis
11.Assess severity of pulmonary hypertension

Right parasternal short axis view – TV, RVOT pulmonic valve

Position:

1. From the previous view move usually slightly ventrally (every dog is a bit different)

This view can be used for:

1.RVOT anatomy (hypertrophy, aneurisms)
2.TV-RVOT-PA flow
3.RVOT dynamic or fixed obstructions
4.VSDs

Subcostal view

Position:

1.Transducer caudal to the xiphisternum
2.Cranial angle
3.Increase greatly the depth of field
4.The Ao can be seen beyond the diaphragm (and liver)

This view can be used for:

1. The main use is to assess Aortic velocities by Spectral Doppler as the aorta is usually in a straight line with the Doppler cursor

Left parasternal apical view – 4-chambers view

Position:

1.Where is the cardiac apex?
2.30-45 degrees to the intercostal space, towards the head, angling dorsally
3.You can also start from the liver and move cranially
4.Optimise for a straight heart
5.Optimise for the tricupid valve after assessing the left side

This view can be used for:

1. Measurement of volumes
2. Evaluation of the mitral and tricuspid valve
3. Evaluation of mitral and tricuspid inflows (Doppler)
4.Evaluation of mitral regurgitation (Doppler)

Left parasternal apical view – 5 chambers view

Position:

1.From a left apical 4 chamber view
2.Rotate 10-20 degrees anti-clock wise

This view can be used for:

1.Assessing aortic and subaortic flow
2.Assessing SAM
3.Assessing obstruction gradients (SAM and SAS)

Assessment of systolic and diastolic function

Systolic function is first assessed subjectively by observing the left ventricular myocardium in a right parasternal four-chamber view and a short parasternal short axis view for example. Basic measurements for systolic function include:

1. Calculation of LVs (normals previously discussed) or LVVs (normal < 30-50mls/m^2) or left ventricular systolic volume.
2. Fractional shortening or ejection fraction.
   FS=LVd-LVs/LVd x 100   EF=LVVd-LVVs/LVVd x 100
3. E-point to septal separation
4. Systolic times intervals (PEP/ET< 0.44)
   On a subcostal or left parasternal view; Spectral Doppler flow of the aorta
   PEP: From the begining of the QRS to the begining of the flow
   ET: From the begining to the end of the flow

Diastolic function is first assessed by evaluating mitral inflow with Doppler (pictures can be found in the presentation). A normal E A pattern with an normal IVRT will become a reverse EA pattern (A wave taller than the E wave) and a prolonged IVRT with impaired relaxation (mild diastolic dysfunction). As the diastolic function worsens the atrial pressures will increased and the initial pattern will return (pseudonormal pattern).

Other techniques such as tissue Doppler or pulmonary venous flow are needed to differentiate between a normal or pseudonormal pattern. As the diastolic disease advances further a restrictive patter will become obvious with a tall E wave and a short A wave (ratio above 2) and a short IVRT.

Echocardiography in mitral valve disease

1. In the initial phase of mitral valve disease (Stage B1; murmur but absence of clinical signs and absence of cardiac enlargement) the findings will be as follows:
-Mitral valve thickening
-Mitral valve prolapse
-Mitral regurgitation as seen with Colour Doppler

2. As the disease progresses mitral valve disease will enter stage B2 (murmur, cardiac enlargement, but absence of heart failure). The extra findings, which may be observed, will be:
-Left atrial enlargement of varying severity.
-Early pulmonary hypertension may be observed at this stage
-Rupture of chorda tendinae may be observed at this stage

3. As the disease progresses into stage C (congestive heart failure) extra features may be seen as follows:
-Marked dilation of pulmonary veins
-Usually the left atrium is severely enlarged
-A restrictive filling pattern on mitral inflow may be seen
-Systolic function usually is normal or increases in this disease but it may be low in very late stages of the disease (cardiomyopathy of overload)

Tricuspid regurgitation (concurrent tricuspid valve disease) may be observed at any stage of the disease.

In general, you should diagnosed pulmonary oedema (stage C) with radiographs and use echocardiography for confirming the disease, differentiating stage B1 from B2 and if possible diagnosing pulmonary hypertension.

Echocardiography in dilated cardiomyopathy

During the preclinical phase of dilated cardiomyopathy the main echocardiographic findings will be:

1.Systolic dysfunction (as discussed above)
2.Increase cardiac sphericity
3.Left ventricular and possibly right ventricular enlargement
4.Possible mild, centrally orientated regurgitation jet but with normal valve appearence
5.Possible left atrial enlargment

During the overt phase there will be pulmonary oedema on radiographs and extra findings to the ones mentioned above would include:

1.Severe left atrial enlargment
2. Restrictive filling pattern on mitral inflow

An algorithm to diagnose DCM was suggested by the European society of Veterinary Cardiology. More than 6 points will make a diagnosis of DCM likely. However, it should be born in mind that systemic disease, tachycardiomyopathies, myocarditis and potentially normal variations (e.g. athletic heart) may also depressed systolic function.

MAJOR CRITERIA (3 POINTS)

-Ventricular dilatation in diastole and systole
-Sphericity index increased (>1.6)
-Decreased FS or EF

MINOR CRITERIA (1 POINT)

-Ventricular arrhythmia if Boxer or Doberman
-Atrial fibrillation
-Increased EPSS
-Altered systolic time intervals (0.44 PEP/ET)
-FS below 30% or 25% in large breeds but above 20%
-Atrial dilatation