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Vevo 770® Protocol-Based Measurements and Calculations

The Vevo software provides the operator with packages of tools to identify and label anatomic or physiological features on images and to make measurements of these features. This document lists the measurements and calculations that are available in the Cardiac, Embryology and Abdominal measurement packages. The measurement packages include the following protocols:

Cardiac Measurement Package

Aortic Valve Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Asc Ao	Ascending aorta diameter	mm	Linear	B-Mode
Trans Arch	Transverse aortic arch diameter	mm	Linear	B-Mode
Desc Ao	Descending aorta diameter	mm	Linear	B-Mode
LVOT	Left ventricular outflow tract diameter	mm	Linear	B-Mode
(Note 1)	Left ventricular outflow tract heart rate	BPM	Heart Rate	B-Mode
AV Peak V	Aortic valve peak velocity	mm/s	Vertical velocity	PW Doppler
AI PHT	Aortic insufficiency deceleration	mm/s^2	Acceleration	PW Doppler
(Note 1)	Aortic insufficiency half time	ms	Time	PW Doppler
Ao VTI	Aorta Velocity time integral	cm	VTI	PW Doppler
(Note 1)	Aorta mean velocity	mm/s	VTI	PW Doppler
(Note 1)	Aorta mean pressure gradient	mmHg	VTI	PW Doppler
(Note 1)	Aorta peak velocity	mm/s	VTI	PW Doppler
(Note 1)	Aorta peak pressure gradient	mmHg	VTI	PW Doppler
Desc Ao V	Descending aorta peak velocity	mm/s	Vertical velocity	PW Doppler
LVOT VTI	LVOT Velocity time integral	cm	VTI	PW Doppler
(Note 1)	LVOT mean velocity	mm/s	VTI	PW Doppler
(Note 1)	LVOT mean pressure gradient	mmHg	VTI	PW Doppler
(Note 1)	LVOT peak velocity	mm/s	VTI	PW Doppler
(Note 1)	LVOT peak pressure gradient	mmHg	VTI	PW Doppler
Desc Ao VTIp	Descending Aorta Velocity time integral, proximal	cm	VTI	PW Doppler
(Note 1)	Descending Aorta mean velocity, proximal	mm/s	VTI	PW Doppler
(Note 1)	Descending Aorta mean pressure gradient, proximal	mmHg	VTI	PW Doppler
(Note 1)	Descending Aorta peak velocity, proximal	mm/s	VTI	PW Doppler
(Note 1)	Descending Aorta peak pressure gradient, proximal	mmHg	VTI	PW Doppler
Desc Ao VTId	Descending Aorta Velocity time integral, distal	cm	VTI	PW Doppler
(Note 1)	Descending Aorta mean velocity, distal	mm/s	VTI	PW Doppler
(Note 1)	Descending Aorta mean pressure	mmHg	VTI	PW Doppler
(Note 1)	Descending Aorta peak velocity, distal	mm/s	VTI	PW Doppler
(Note 1)	Descending Aorta peak pressure gradient, distal	mmHg	VTI	PW Doppler

Note 1: Denotes an additional parameter that is displayed as part of the preceding measurement.

Aortic Valve Protocol - Calculation Definitions

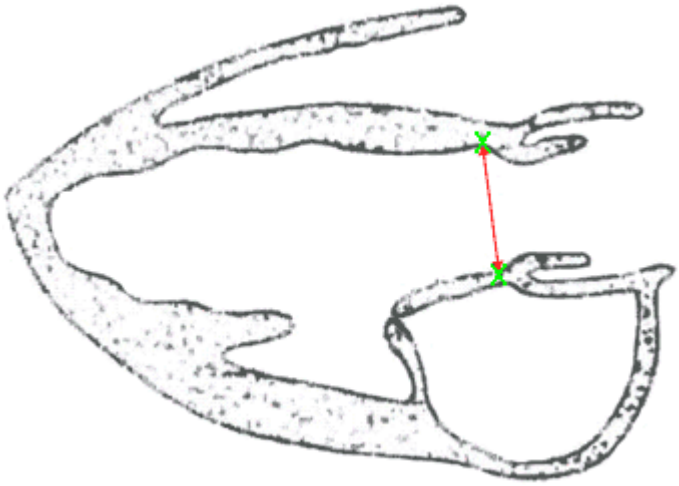
Name	Description	Units	Formula
AV Peak Press	Aortic valve peak pressure gradient	mmHg	4 * (Av Peak Velocity/1000)^2
AV Mean V	Aortic valve mean velocity	mm/s	Value is the mean velocity defined by the Ao VTI measurement.
SV	Stroke volume	ul	7.85 * LVOT^2 * Ao VTI
CO	Cardiac output	ml/min	(SV * HR(from LVOT)) / 1000
AVA	Aortic valve area	mm^2	((LVOT/2)^2 x π x LVOT VTI, peak vel)/Ao VTI, Peak V

HELP

2D Measurements

1. Obtain a parasternal long axis view at the level of the aortic root.
2. Place calipers from leading edge to leading edge as shown in the following illustration.

LVOT Diameter

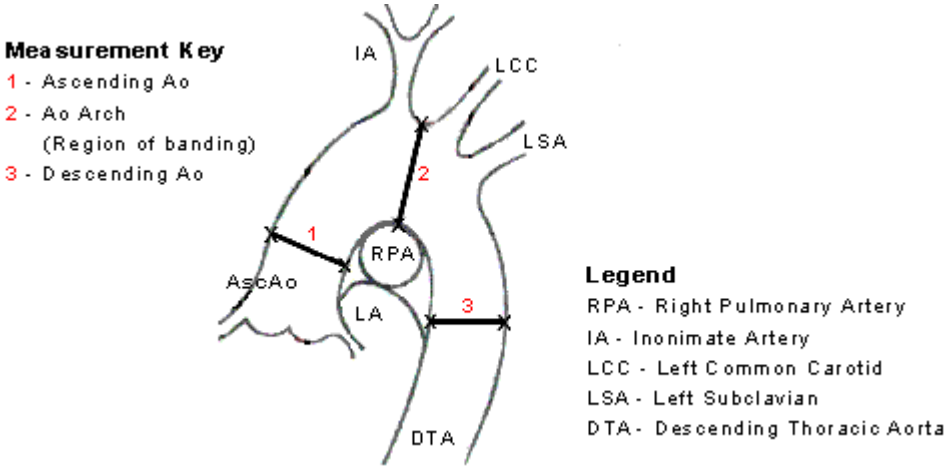


3. Obtain a right parasternal view of the long axis of the aorta with the ascending and descending arches in view.

4. To determine diameters, place calipers at:

   - the level of the ascending aorta
   - the aortic arch
   - the descending aorta

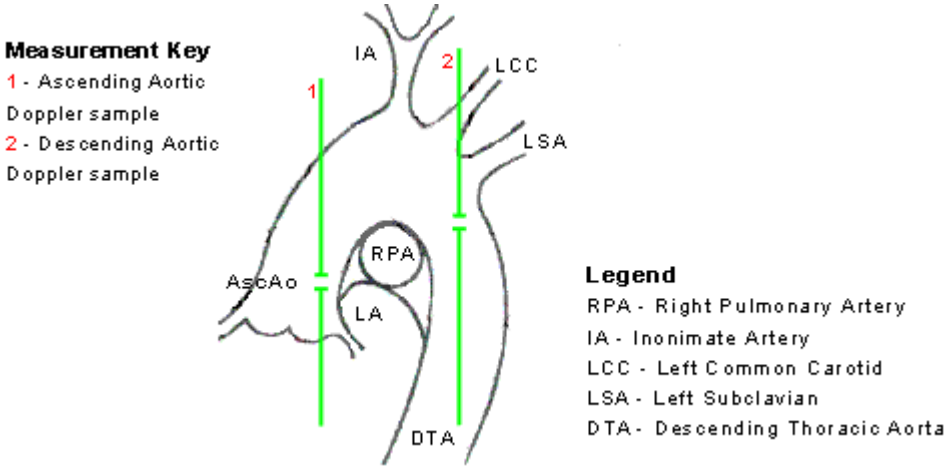
Aortic Arch



PW Doppler Measurements

1. Using the right parasternal view of the aortic arch, align the ascending aorta in a position that is as parallel as possible with the sound beam, as shown in the following illustration.

Aortic Arch



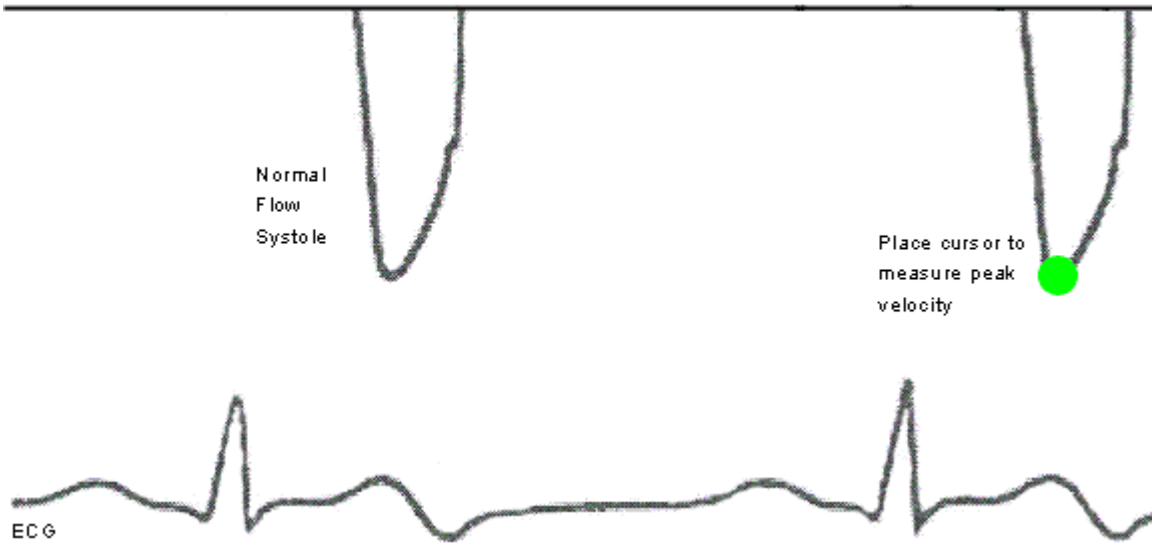
2. Press <Overlay> to determine the PW Doppler sample volume.

3. Place the sample volume as close as possible to the middle of the aortic outflow jet.

4. Press <PW> and adjust the velocity scale and baseline accordingly using the appropriate hot keys.

5. From the measurement package, select **AV Peak V.** and measure the peak velocity. The system will automatically calculate the mean velocity.

AV Peak Volume



6. When you have a clear PW Doppler trace of the aortic outflow:

    a. Select the AV VTI option from the measurement package.

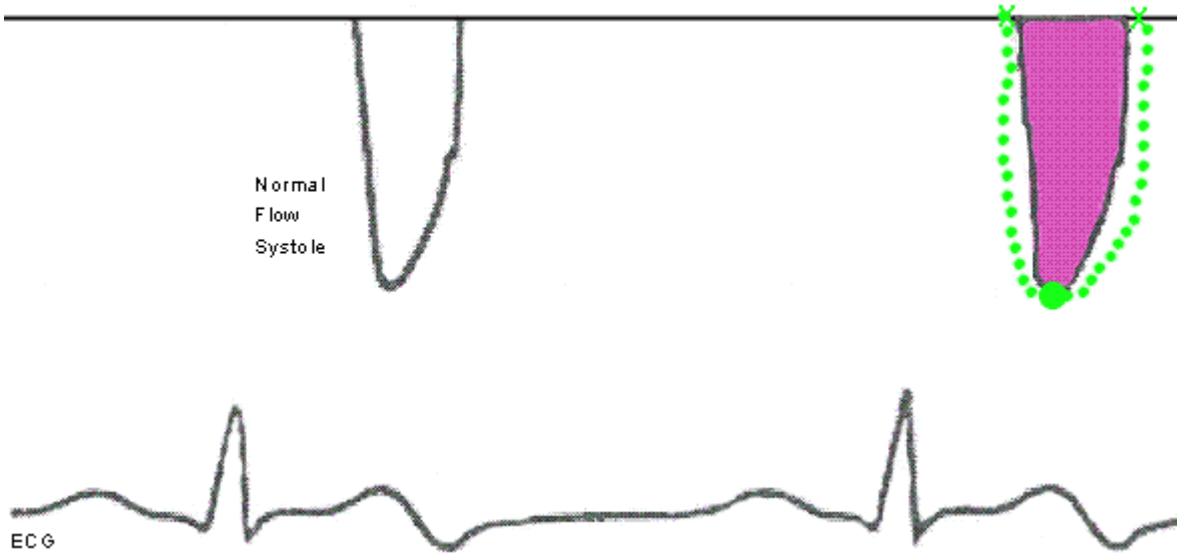
    b. Place your cursor on the baseline, where the envelope starts.

    c. Trace the envelope.

    d. When you have reached the baseline, right click to set the measurement. If you have performed a 2D measurement of the LVOT and the VTI, the system will automatically calculate Stroke Volume.

    e. Measure the heart rate to automatically calculate the Cardiac Output.

Velocity Time Interval



Cardiac Measurement Package

Mitral Valve Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
MV E/A	Mitral valve E velocity	mm/s	Vertical velocity	PW Doppler
MV A	Mitral valve A velocity	mm/s	Vertical velocity	PW Doppler
MV Decel Time	Mitral valve deceleration time	mm/s^2	Acceleration	PW Doppler
(Note 1)	Mitral valve deceleration time	ms	Time	PW Doppler
IVRT	Isovolumic relaxation time	ms	Time	PW Doppler
IVCT	Isovolumic contraction time	ms	Time	PW Doppler
MV PHT	Mitral valve pressure half time	mm/s	Acceleration	PW Doppler
(Note 1)	Mitral valve pressure half time	ms	Time	PW Doppler
MV VTI	Mitral valve velocity time integral	cm	VTI	PW Doppler
(Note 1)	Mitral valve mean velocity	mm/s	VTI	PW Doppler
(Note 1)	Mitral valve mean pressure gradient	mmHg	VTI	PW Doppler
(Note 1)	Mitral valve peak velocity	mm/s	VTI	PW Doppler
(Note 1)	Mitral valve peak pressure gradient	mmHg	VTI	PW Doppler

Note 1: Denotes an additional parameter that is displayed as part of the preceding measurement.

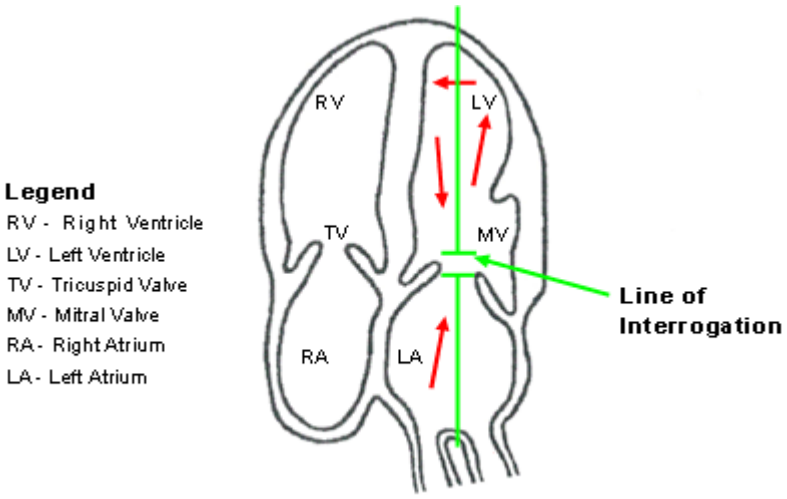
Mitral Valve Protocol - Calculation Definitions

Name	Description	Units	Formula
MV E/A			MV E/ MV A
MVAmm^2	MV area	mm^2	220/(MV PHT, pressure half time)

HELP

1. Obtain an apical 4 chamber view of the heart from lateral to the midline of the animal.

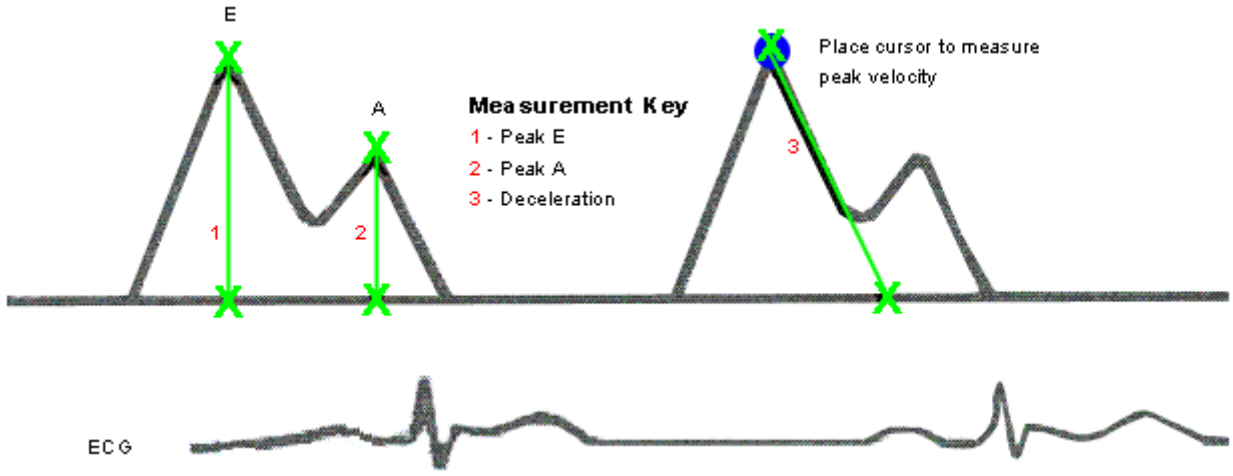
Mitral Valve Doppler



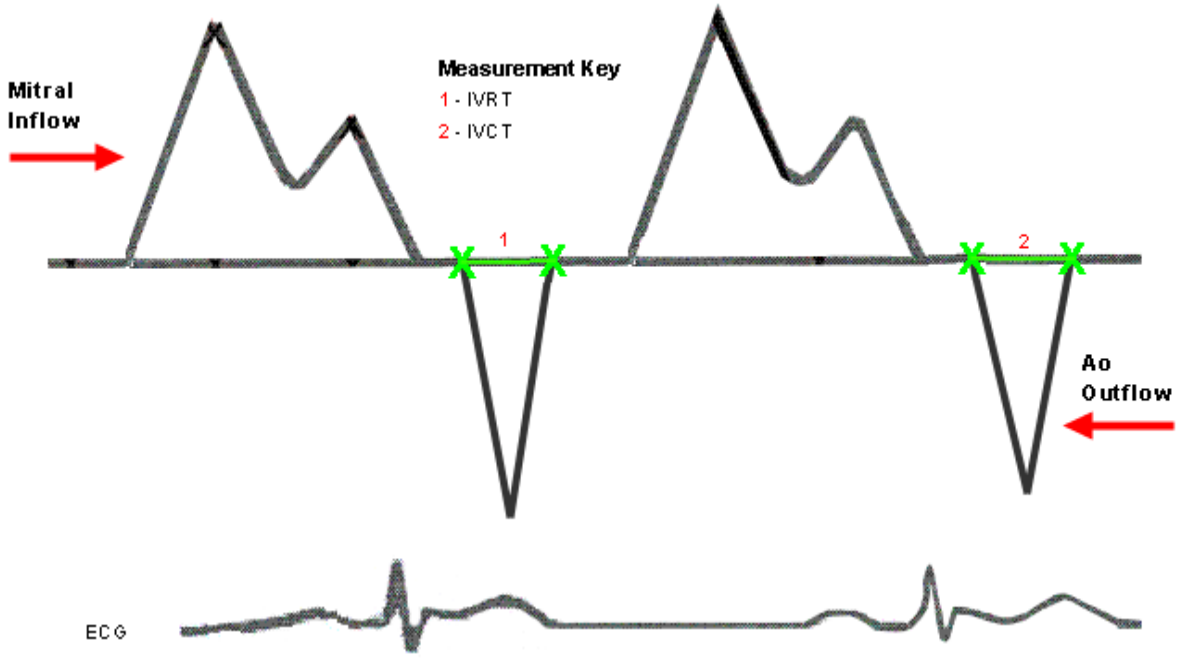
2. Press <Overlay> to view the Doppler sample volume.
3. Place the sample volume just distal to the mitral valve leaflet tips, where blood will be entering the ventricle.
4. Press <PW>.
5. If the Doppler Spectrum does not represent an adequate MV inflow waveform pattern, press <Toggle Scout> and adjust the sample volume.
6. Press <Toggle Scout> to return to the PW Doppler trace, then reassess.
7. When an adequate Doppler trace is acquired, press <Cine Store>.
8. Complete measurements of the MV inflow as shown in the following illustrations (the system automatically calculates the E/A ratio):

Note: To measure IVRT and IVCT, view both the mitral valve inflow as well as the aortic outflow Doppler tracings by moving the sample volume closer to the area of aortic outflow.

Measuring Peak Velocity



Doppler Trace of Mitral Inflow and Aortic Outflow



Cardiac Measurement Package

Pulmonary Valve Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Peak V	Pulmonary valve peak velocity	mm/s	Velocity	PW Doppler
PV Peak V	Pulmonary regurgitation peak velocity	mm/s	Velocity	PW Doppler
PV VTI	Pulmonary Velocity time integral	cm	VTI	PW Doppler
(Note 1)	Pulmonary mean velocity	mm/s	VTI	PW Doppler
(Note 1)	Pulmonary mean pressure gradient	mmHg	VTI	PW Doppler
(Note 1)	Pulmonary peak velocity	mm/s	VTI	PW Doppler
(Note 1)	Pulmonary peak pressure gradient	mmHg	VTI	PW Doppler

Note 1: Denotes an additional parameter that is displayed as part of the preceding measurement.

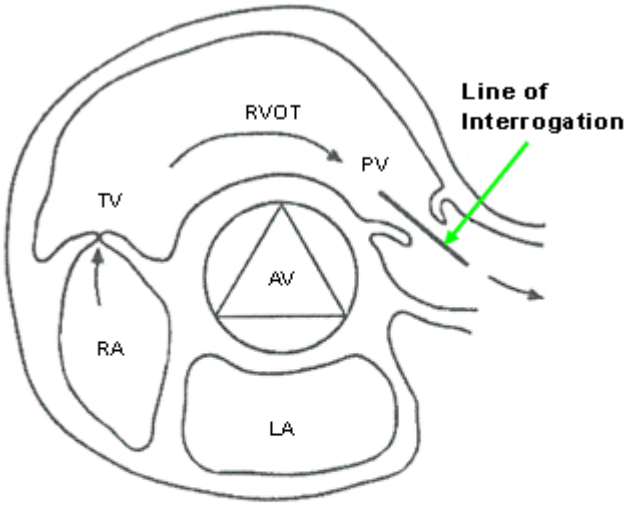
Pulmonary Valve Protocol - Calculation Definitions

Name	Description	Units	Formula
PV Peak Gradient		mmHg	$4 * (\text{PV Peak Velocity} / 1000)^2$

HELP

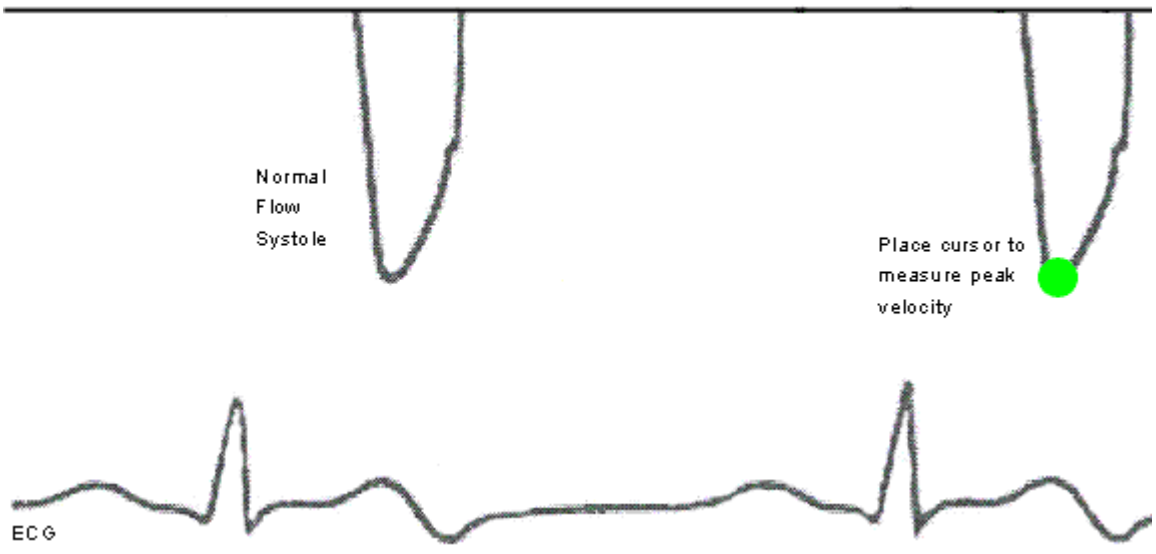
1. Obtain a parasternal short axis view of the heart and angle slightly towards the left shoulder of the animal until the opening and closing of the pulmonary valve is visible.
2. Press <Overlay> to position the sample volume, just beyond the pulmonary valve.
3. Press <PW> button and adjust the sample volume until a clear trace of the pulmonary outflow is visible.
4. From the measurement package, select Pulmonary Valve and place one caliper at the peak of the pulmonary outflow trace.
5. Select the PR peak velocity caliper to measure the pulmonary regurgitation if there is some present.
6. Trace the PV outflow envelope to obtain the VTI measurement.

Doppler PV Flow - Systole



Legend

PV - Pulmonic Valve
TV - Tricuspid Valve
RA - Right Atrium
LA - Left Atrium
RVOT - Right Ventricular Outflow Tract
AV - Aortic Valve



Cardiac Measurement Package

Tissue Doppler Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
E’	Velocity at E’	mm/s	Velocity	Tissue Doppler
A’	Velocity at A’	mm/s	Velocity	Tissue Doppler
MV E	Velocity at MV E	mm/s	Velocity	PW Doppler
SR Vel 1	First strain rate measurement	ms	Time	Tissue Doppler
SR Vel 2	Second strain rate measurement	ms	Time	Tissue Doppler

Tissue Doppler Protocol - Calculation Definitions

Name	Description	Units	Formula
E’ / A’	Ratio of E’ velocity to A’ velocity	none	E’ / A’
A’ / E’	Ratio of A’ velocity to E’ velocity	none	A’ / E’
MV / E’	Ratio of MV E velocity to E’ velocity	none	MV E / E’
Strain Rate	Strain rate calculation	1/s	(SR Vel 1 - SR Vel 2)/Distance between sample volume positions

For more information on strain rate measurements, see **Tissue Doppler Mode Measurements** in the **Measurements** chapter in the *VisualSonics Vevo 770® High-Resolution Imaging System Operator Manual*.

Cardiac Measurement Package

Tricuspid Lateral Wall - Measurement Definitions

Label	Description	Units	Generic Type	Mode
TLW E'	Velocity at E'	mm/s	Velocity	Tissue Doppler
TLW A'	Velocity at A'	mm/s	Velocity	Tissue Doppler

Tricuspid Lateral Wall - Calculation Definitions

Label	Description	Units	Generic Type	Mode
TLW E' / A'	Ratio of E' velocity to A' velocity	none	TLW E' / TLW A'	
TLW A' / E'	Ratio of A' velocity to E' velocity	none	TLW A' / TLW E'	

Mitral Lateral Wall - Measurement Definitions

Label	Description	Units	Generic Type	Mode
MLW E'	Velocity at E'	mm/s	Velocity	Tissue Doppler
MLW A'	Velocity at A'	mm/s	Velocity	Tissue Doppler

Mitral Lateral Wall - Calculation Definitions

Label	Description	Units	Generic Type	Mode
MLW E' / A'	Ratio of E' velocity to A' velocity	none	MLW E' / MLW A'	
MLW A' / E'	Ratio of A' velocity to E' velocity	none	MLW A' / MLW E'	

Mitral Septal Wall - Measurement Definitions

Label	Description	Units	Generic Type	Mode
MSW E'	Velocity at E'	mm/s	Velocity	Tissue Doppler
MSW A'	Velocity at A'	mm/s	Velocity	Tissue Doppler

Mitral Septal Wall - Calculation Definitions

Label	Description	Units	Generic Type	Mode
MSW E' / A'	Ratio of E' velocity to A' velocity	none	MSW E' / MSW A'	
MSW A' / E'	Ratio of A' velocity to E' velocity	none	MSW A' / MSW E'	

Cardiac Measurement Package

Tricuspid Valve Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
TV E	Tricuspid valve E wave velocity	mm/s	Vertical velocity	PW Doppler
TV A	Tricuspid valve A wave velocity	mm/s	Vertical velocity	PW Doppler
TR Peak V	Tricuspid regurgitation peak velocity	mm/s	Vertical velocity	PW Doppler
TV VTI	Tricuspid Velocity time integral	cm	VTI	PW Doppler
(Note 1)	Tricuspid mean velocity	mm/s	VTI	PW Doppler
(Note 1)	Tricuspid mean pressure gradient	mmHg	VTI	PW Doppler
(Note 1)	Tricuspid peak velocity	mm/s	VTI	PW Doppler
(Note 1)	Tricuspid peak pressure gradient	mmHg	VTI	PW Doppler

Note 1: Denotes an additional parameter that is displayed as part of the preceding measurement.

Tricuspid Valve Protocol - Calculation Definitions

Name	Description	Units	Formula
TR Peak Gradient	Tricuspid regurgitation peak gradient	mmHg	$4 * (\text{TV Peak V} / 1000)^2$

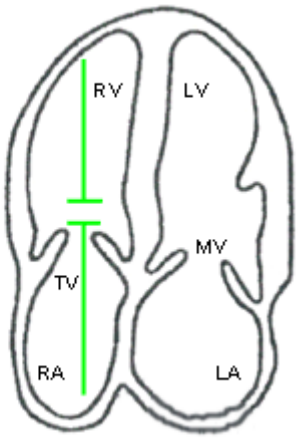
HELP

1. Obtain a 4-chamber or parasternal short axis view of the heart that displays the tricuspid valve.
2. Press <Overlay> on the right ventricle side of the tricuspid valve to place the calipers.
3. Press <PW>.
4. Press <Toggle Scout> and position the sample volume until a clear inflow trace is obtained.
5. From the Protocol menu, select Tricuspid Valve and measure the E and A waves.

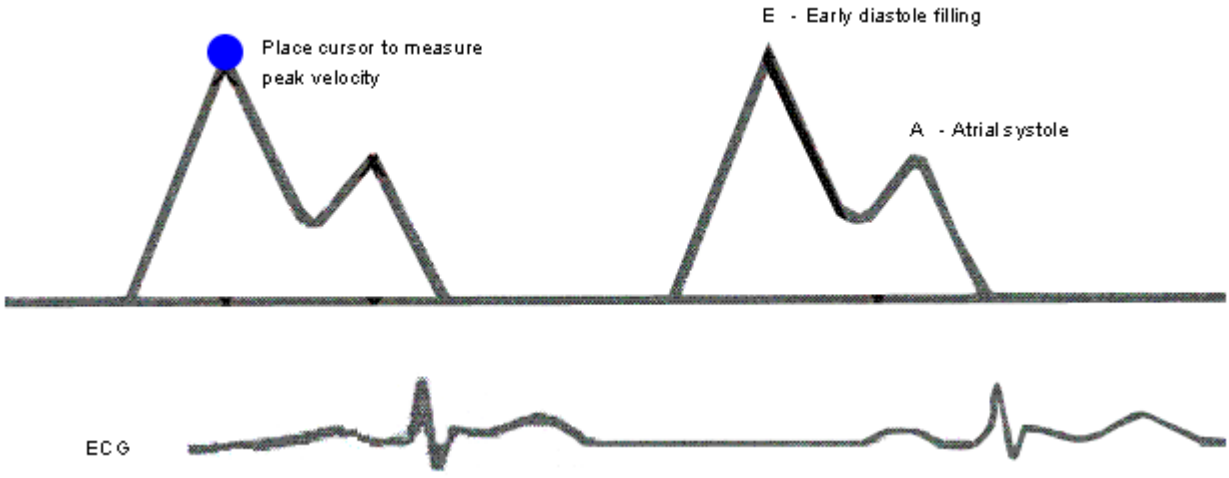
Doppler Tricuspid Valve

Legend

RV - Right Ventricle
LV - Left Ventricle
TV - Tricuspid Valve
MV - Mitral Valve
RA - Right Atrium
LA - Left Atrium



Measuring Peak Velocity



Cardiac Measurement Package

Vascular Valve Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
LCCA Vel a	Left Common Carotid Artery velocity	mm/s	Velocity	PW Doppler
LCCA Vel b	Left Common Carotid Artery velocity	mm/s	Velocity	PW Doppler
LCCA Diam	Left Common Carotid Artery diameter	mm	Linear	B-Mode
LCCA VTI	Left Common Carotid Artery VTI	cm	VTI	PW Doppler
(Note 1)	Left Common Carotid Artery VTI; Mean Vel	mm/s	Velocity	PW Doppler
RCCA Vel a	Right Common Carotid Artery velocity	mm/s	Velocity	PW Doppler
RCCA Vel b	Right Common Carotid Artery velocity	mm/s	Velocity	PW Doppler
RCCA Diam	Right Common Carotid Artery diameter	mm	Linear	B-Mode
RCCA VTI	Right Common Carotid Artery VTI	cm	VTI	PW Doppler
(Note 1)	Right Common Carotid Artery VTI; Mean Vel	mm/s	VTI	PW Doppler
LICA Vel a	Left Internal Carotid Artery velocity	mm/s	Velocity	PW Doppler
LICA Vel b	Left Internal Carotid Artery velocity	mm/s	Velocity	PW Doppler
LICA Diam	Left Internal Carotid Artery diameter	mm	Linear	B-Mode
LICA VTI	Left Internal Carotid Artery VTI	cm	VTI	PW Doppler
(Note 1)	Left Internal Carotid Artery VTI; Mean Vel	mm/s	VTI	PW Doppler
RICA Vel a	Right Internal Carotid Artery velocity	mm/s	Velocity	PW Doppler
RICA Vel b	Right Internal Carotid Artery velocity	mm/s	Velocity	PW Doppler
RICA Diam	Right Internal Carotid Artery diameter	mm	Linear	B-Mode
RICA VTI	Right Internal Carotid Artery VTI	cm	VTI	PW Doppler
(Note 1)	Right Internal Carotid Artery VTI; Mean Vel	mm/s	VTI	PW Doppler
LECA Vel a	Left External Carotid Artery velocity	mm/s	Velocity	PW Doppler
LECA Vel b	Left External Carotid Artery velocity	mm/s	Velocity	PW Doppler
LECA Diam	Left External Carotid Artery diameter	mm	Linear	B-Mode
LECA VTI	Left External Carotid Artery VTI	cm	VTI	PW Doppler
(Note 1)	Left External Carotid Artery VTI; Mean Vel	mm/s	VTI	PW Doppler
RECA Vel a	Right External Carotid Artery velocity	mm/s	Velocity	PW Doppler
RECA Vel b	Right External Carotid Artery velocity	mm/s	Velocity	PW Doppler
RECA Diam	Right External Carotid Artery diameter	mm	Linear	B-Mode
RECA VTI	Right External Carotid Artery VTI	cm	VTI	PW Doppler

(Note 1)	Right External Carotid Artery VTI; Mean Vel	mm/s	VTI	PW Doppler
Inno Vel	Innominate Artery velocity	mm/s	Velocity	PW Doppler
Inno Diam	Innominate Artery diameter	mm	Linear	B-Mode
Subcl Vel	Subclavian Artery velocity	mm/s	Velocity	PW Doppler
Subcl Diam	Subclavian Artery diameter	mm	Linear	B-Mode
C Iliac Vel	Common Iliac artery velocity	mm/s	Velocity	PW Doppler
C Iliac Diam	Common Iliac artery diameter	mm	Linear	B-Mode
I Iliac Vel	Internal Iliac artery velocity	mm/s	Velocity	PW Doppler
I Iliac Diam	Internal Iliac artery diameter	mm	Linear	B-Mode
E Iliac Vel	External Iliac artery velocity	mm/s	Velocity	PW Doppler
E Iliac Diam	External Iliac artery diameter	mm	Linear	B-Mode
R Femoral Vel	Right femoral artery velocity	mm/s	Velocity	PW Doppler
R Femoral Diam	Right femoral artery diameter	mm	Linear	B-Mode
L Femoral Vel	Left femoral artery velocity	mm/s	Velocity	PW Doppler
L Femoral Diam	Left femoral artery diameter	mm	Linear	B-Mode
L Saph Vel	Left Saphenous artery velocity	mm/s	Velocity	PW Doppler
L Saph Diam	Left Saphenous artery diameter	mm	Linear	B-Mode
R Saph Vel	Right Saphenous artery velocity	mm/s	Velocity	PW Doppler
R Saph Diam	Right Saphenous artery diameter	mm	Linear	B-Mode

Note 1: Denotes an additional parameter that is displayed as part of the preceding measurement.

Vascular Valve Protocol - Calculation Definitions

Name	Description	Units	Formula
LCCA RI	Left Common Carotid Artery Resistive index	None	(LCCA Vel a – LCCA Vel b)/LCCA Vel a
LCCA PI	Left Common Carotid Artery Pulsatility index	None	(LCCA Vel a - LCCA Vel b)/LCCA VTI; mean
RCCA RI	Right Common Carotid Artery Resistive index	None	(RCCA Vel a - RCCA Vel b)/ RCCA Vel a
RCCA PI	Right Common Carotid Artery Pulsatility index	None	(RCCA Vel a - RCCA Vel b)/ RCCA VTI; mean
LICA RI	Left Internal Carotid Artery Resistive index	None	(LICA Vel a - LICA Vel b)/ LICA Vel a
LICA PI	Left Internal Carotid Artery Pulsatility index	None	(LICA Vel a - LICA Vel b)/ LICA VTI; mean
RICA RI	Right Internal Carotid Artery Resistive index	None	(RICA Vel a - RICA Vel b)/ RICA Vel a
RICA PI	Right Internal Carotid Artery Pulsatility index	None	(RICA Vel a - RICA Vel b)/ RICA VTI; mean
LECA RI	Left External Carotid Artery Resistive index	None	(LECA Vel a - LECA Vel b)/ LECA Vel a
LECA PI	Left External Carotid Artery Pulsatility index	None	(LECA Vel a - LECA Vel b)/ LECA VTI; mean

RECA RI	Right External Carotid Artery Resistive index	None	(RECA Vel a - RECA Vel b)/ RECA Vel a
RECA PI	Right External Carotid Artery Pulsatility index	None	(RECA Vel a - RECA Vel b)/ RECA VTI; mean

Cardiac Measurement Package

LV B-Mode Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
LV Trace	Traces the LV wall over one or more cardiac cycles	mm^2	BLVArea	B-Mode
(Note 1)	Volume	µl	BLVArea	B-Mode
(Note 1)	Area;s	mm^2	BLVArea	B-Mode
(Note 1)	Area;d	mm^2	BLVArea	B-Mode
(Note 1)	Volume;s	µl	BLVArea	B-Mode
(Note 1)	Volume;d	µl	BLVArea	B-Mode
(Note 1)	Stroke Volume	µl	BLVArea	B-Mode
(Note 1)	Ejection Fraction	%	BLVArea	B-Mode
(Note 1)	Fractional Shortening	%	BLVArea	B-Mode
(Note 1)	Cardiac Output	ml/min	BLVArea	B-Mode
Epicardial Area; d	The area defined by the outer wall of the LV in diastole.	mm^2	Polygon	B-Mode
Epicardial Major; d	The outer length defined by the major axis of the LV in diastole.	mm	Linear	B-Mode
Epicardial Area; s	The area defined by the outer wall of the LV in systole.	mm^2	Polygon	B-Mode
Epicardial Major; s	The outer length defined by the outer wall of the LV in systole.	mm	Linear	B-Mode
Endocardial Area; d	The area defined by the inner wall of the LV in diastole.	mm^2	Polygon	B-Mode
Endocardial Major; d	The inner length of the major axis of the LV in diastole. Heart rate is recorded as part of the measurement for Use in the CO calculation.	mm	Linear	B-Mode
Endocardial Area; s	The area defined by the inner wall of the LV in systole.	mm^2	Polygon	B-Mode
Endocardial Major; s	The inner length of the major axis of the LV in systole.	mm	Linear	B-Mode
Simpson Are; d	The 4 Simpson area measurements of the LV in diastole.	mm^2	Polygon	B-Mode

Simpson Are; s	The 4 Simpson area measurements of the LV in systole.	mm^2	Polygon	B-Mode

Note 1: Denotes an additional parameter that is displayed as part of the preceding measurement.

LV B-Mode Protocol - Calculation Definitions

Name	Description	Units	Formula
LV Vol;d	The volume of the LV endocardium in diastole.	µl	$\frac{4\pi}{3} \times \frac{End\ Major;\ d}{2} \times \left(\frac{End\ Area;\ d}{\pi\left(\frac{End\ Major;\ d}{2}\right)} \right)^2$
LV Lov;s	The volume of the LV endocardium in systole.	µl	$\frac{4\pi}{3} \times \frac{End\ Major;\ s}{2} \times \left(\frac{End\ Area;\ s}{\pi\left(\frac{End\ Major;\ s}{2}\right)} \right)^2$
SV	LV stroke volume.	µl	$Endocardial\ Vol;\ d - Endocardial\ Vol;\ s$
EF	LV ejection fraction.	%	$\frac{Endocardial\ SV}{Endocardial\ Vol;\ d} \times 100$
FAC	LV fractional area change.	%	$\frac{Endocardial\ Area;\ d - Endocardial\ Area;\ s}{Endocardial\ Area;\ d} \times 100$
CO	Cardiac output of The LV.	µl /min	$Endocardial\ SV$ x $Heart\ Rate$
T	Average wall thickness of the LV myocardium.	µl	$\sqrt{\frac{EpicardialArea;d}{\pi}} - \sqrt{\frac{EndocardialArea;d}{\pi}}$
LV Mass	The mass of LV myocardium.	mg	$1.05 \times \left(\left(\frac{5}{6} \times EpicardialArea;d \times (EpicardialMajor;d + T) \right) - \left(\frac{5}{6} \times EndocardialArea;d \times EndocardialMajor;d \right) \right)$
Simpson Vol;d	The volume of the LV in diastole calculated using the Simpson method.	µl	$(SimpsonArea1;d + SimpsonArea2;d + SimpsonArea3;d)$ x $Height + SimpsonArea4;d$ x $Height/2 + \pi / 6$ x $Height^3$

Simpson Vol;s	The volume of the LV in systole calculated using the Simpson method.	µl	$(SimpsonArea1;s+SimpsonArea2;s+SimpsonArea3;s) \times Height + SimpsonArea4;s \times Height/2 + \pi / 6 \times Height^3$
Simpson SV	The stroke volume of the LV.	µl	$SimpsonVolume;\ d - SimpsonVolume;\ s$
Simpson EF	The Ejection Fraction of the LV.	%	$100 \times SimpsonSV / SimpsonVolume;\ d$
Simpson FAC	The Fractional Area Change of the LV.	%	$((SimpsonArea2;\ d + SimpsonArea2;\ s) / SimpsonArea2;\ d) \times 100$
Simpson CO	The Cardiac Output of the LV.	µl/min	$(SimpsonSV \times EndocardialMajor;\ d.HeartRate)$

Cardiac Measurement Package

LV M-Mode Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode	Chain
LA	Left Atrium	mm	Linear	M-Mode	
Ao Root	Aortic root	mm	Linear	M-Mode	
RVID;d	Right ventricular internal diameter (diastole)	mm	Linear	M-Mode	IVS;d
IVS;d	Inter ventricular septum (diastole)	mm	Linear	M-Mode	LVID;d
LVAW;d	Left ventricular anterior wall (diastole)	mm	Linear	M-Mode	LVID;d
LVID;d	Left ventricular internal diameter (diastole)	mm	Linear	M-Mode	LVPW;d
LVPW;d	Left ventricular posterior wall (diastole)	mm	Linear	M-Mode	
IVS;s	Inter ventricular septum	mm	Linear	M-Mode	LVID;s
LVAW;s	Left ventricular anterior wall (systole)	mm	Linear	M-Mode	LVID;s
LVID;s	Left ventricular internal diameter (systole)	mm	Linear	M-Mode	LVPW;s
LVPW;s	Left ventricular posterior wall (systole)	mm	Linear	M-Mode	
LVET	Left ventricular ejection time (systole)	ms	time	M-Mode	
LVID Trace	Trace of the inside dimension of the LV	n/a	MLVArea	M-Mode	
LVOD Trace	Trace of the outside dimension of the LV	n/a	MLVArea	M-Mode	

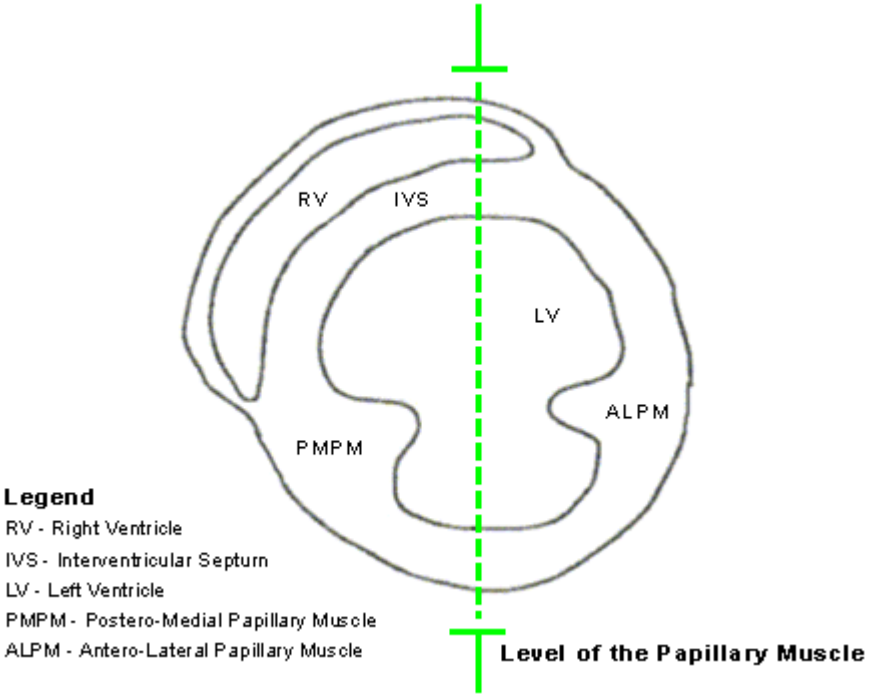
LV M-Mode Protocol - Calculation Definitions

Name	Description	Units	Formula
LV Vol;d	Left ventricle volume diastole	ul	$((7.0 / (2.4 + LVID;d)) * LVID;d^3$
LV Vol;s	Left ventricle volume systole	ul	$((7.0 / (2.4 + LVID;s)) * LVID;s^3$
%EF	LV ejection fraction	%	100 * ((LV Vol;d – LV Vol;s) / LV Vol;d)
%FS	LV Fractional Shortening	%	100 * ((LVID;d – LVID;s) / LVID;d)
LV Mass	LV Mass Uncorrected	mg	$1.053 * ((LVID;d + LVPW;d + IVS;d)^3 – LVID;d^3)$
LV Mass Cor	LV Mass corrected	mg	LV Mass * 0.8
LV Mass (AW)	LV Mass Uncorrected	mg	$1.053 * ((LVID;d + LVPW;d + LVAW;d)^3 – LVID;d^3)$
LV Mass Cor (AW)	LV Mass corrected	mg	LV Mass (AW) * 0.8
LV Mass (Wall)	LV Mass Uncorrected	mg	$1.053 * ((LVOD, Systolic Depth)^3 – (LVID, Systolic Depth)^3)$
LV Mass (Wall) Cor	LV Mass corrected	mg	LV Mass (Trace) * 0.8

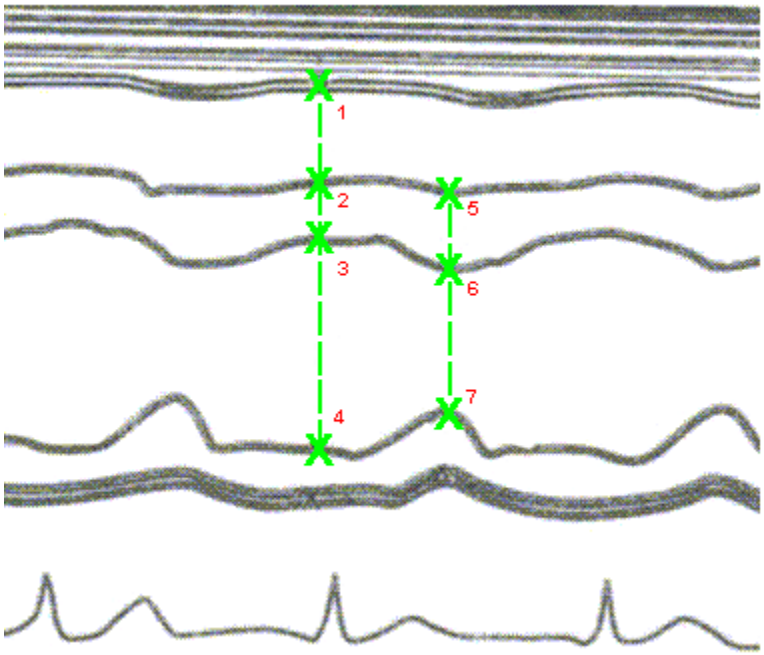
HELP

1. Obtain a parasternal short axis view of the left ventricle at the level of the papillary muscles.
2. Press <Overlay> twice to view the M-Mode sample.
3. Place the sample cursor to the center of the left ventricle and across the anterior and posterior pericardium.
4. Press <M-Mode>.
5. Complete the trace.
6. When a satisfactory trace with endocardial definition is acquired, press <Cine Store> to save.

Parasternal Short Axis - LV



M-Mode of the Left Ventricle



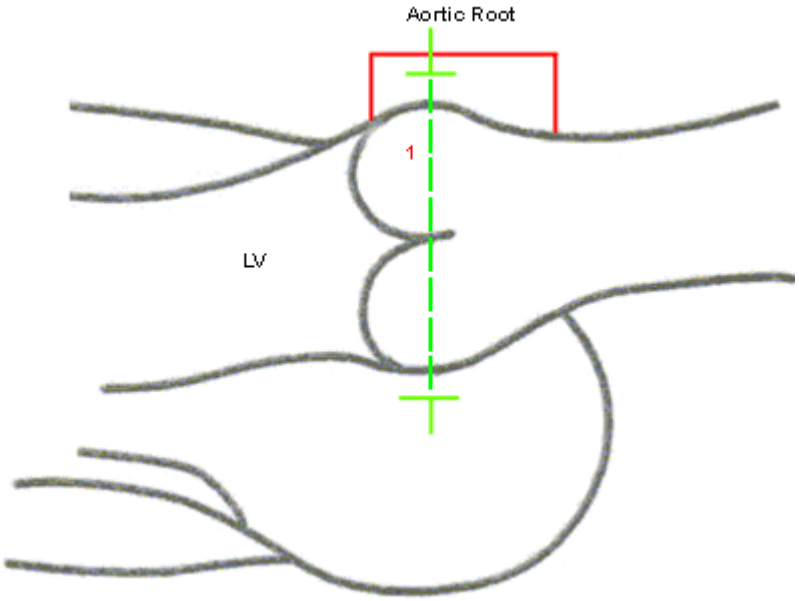
7. Obtain measurements as shown in diagram.

Other

- AO Root(d)
- LVET (ms)

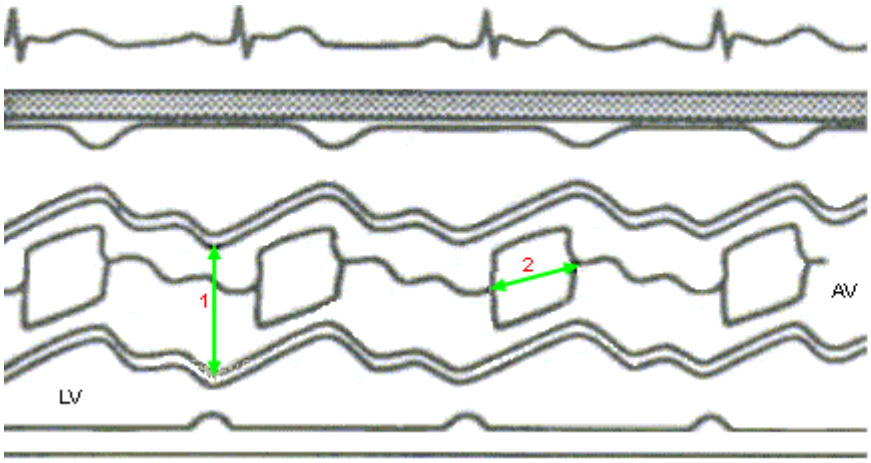
1. Obtain a parasternal long axis view of the left ventricle including the aorta.

Aortic Root and Ascending Aorta Measurements



2. Press <Overlay> twice to view the M-Mode sample volume.
3. Place the sample cursor through the center of the aortic root and across both walls.
4. When you have a good trace, press <M-Mode> and <Scan/Freeze>.
5. Complete the measurement of the AO root and aortic leaflets as shown in the following illustration:

M-Mode of the AO Root



Measurement Key

1 - AO Root

2 - LVET (LV ejection time)

Abdominal Package

Adrenal Glands Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
RAG Sag	Right Adrenal Glands sagittal length	mm	Linear	B-Mode
RAG Trans	Right Adrenal Glands transverse length	mm	Linear	B-Mode
RAA Vel	Right Adrenal artery velocity	mm/s	Velocity	PW Doppler
RAA Diam	Right Adrenal artery diameter	mm	Linear	B-Mode
RAA Diam	Right Adrenal artery diameter	mm	Linear	M-Mode
RAV Vel	Right Adrenal vein velocity	mm/s	Velocity	PW Doppler
RAV Diam	Right Adrenal vein diameter	mm	Linear	B-Mode
RAV Diam	Right Adrenal vein diameter	mm	Linear	M-Mode
LAG Sag	Left Adrenal Glands sagittal length	mm	Linear	B-Mode
LAG Trans	Left Adrenal Glands transverse length	mm	Linear	B-Mode
LAA Vel	Left Adrenal artery velocity	mm/s	Velocity	PW Doppler
LAA Diam	Left Adrenal artery diameter	mm	Linear	B-Mode
LAA Diam	Left Adrenal artery diameter	mm	Linear	M-Mode
LAV Vel	Left Adrenal vein velocity	mm/s	Velocity	PW Doppler
LAV Diam	Left Adrenal vein diameter	mm	Linear	B-Mode
LAV Diam	Left Adrenal vein diameter	mm	Linear	M-Mode

Abdominal Package

Abdominal Aorta & IVC Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
AA Vel	Abdominal Aorta velocity	mm/s	Velocity	PW Doppler
AA Diam	Abdominal Aorta diameter	mm	Linear	B-Mode
AA Diam	Abdominal Aorta diameter	mm	Linear	M-Mode
CrMA Vel	Cranial Mesenteric artery velocity	mm/s	Velocity	PW Doppler
CrMA Diam	Cranial Mesenteric artery diameter	mm	Linear	B-Mode
CrMA Diam	Cranial Mesenteric artery diameter	mm	Linear	M-Mode
CaMA Vel	Caudal Mesenteric artery velocity	mm/s	Velocity	PW Doppler
CaMa Diam	Caudal Mesenteric artery diameter	mm	Linear	B-Mode
CaMa Diam	Caudal Mesenteric artery diameter	mm	Linear	M-Mode
CIA Vel	Common Iliac artery velocity	mm/s	Velocity	PW Doppler
CIA Diam	Common Iliac artery diameter	mm	Linear	B-Mode
CIA Diam	Common Iliac artery diameter	mm	Linear	M-Mode
IVC Vel	IVC velocity	mm/s	Velocity	PW Doppler
IVC Diam	IVC diameter	mm	Linear	B-Mode
IVC Diam	IVC diameter	mm	Linear	M-Mode

Abdominal Package

Female Reproductive Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Uterus Sag	Uterus sagittal length	mm	Linear	B-Mode
Uterus Trans	Uterus transverse length	mm	Linear	B-Mode
UA Vel	Uterine artery velocity	mm/s	Velocity	PW Doppler
UA Diam	Uterine artery diameter	mm	Linear	B-Mode
UA Diam	Uterine artery diameter	mm	Linear	M-Mode
UV Vel	Uterine vein velocity	mm/s	Velocity	PW Doppler
UV Diam	Uterine vein diameter	mm	Linear	B-Mode
UV Diam	Uterine vein diameter	mm	Linear	M-Mode
RO Sag	Right Ovary sagittal	mm	Linear	B-Mode
RO Trans	Right Ovary transverse	mm	Linear	B-Mode
RO Art Vel	Right Ovarian artery velocity	mm/s	Velocity	PW Doppler
RO Art Diam	Right Ovarian artery diameter	mm	Linear	B-Mode
RO Art Diam	Right Ovarian artery diameter	mm	Linear	M-Mode
RO Vein Vel	Right Ovarian vein velocity	mm/s	Velocity	PW Doppler
RO Vein Diam	Right Ovarian vein diameter	mm	Linear	B-Mode
RO Vein Diam	Right Ovarian vein diameter	mm	Linear	M-Mode
LO Sag	Left Ovary sagittal	mm	Linear	B-Mode
LO Trans	Left Ovary transverse	mm	Linear	B-Mode
LO Art Vel	Left Ovarian artery velocity	mm/s	Velocity	PW Doppler
LO Art Diam	Left Ovarian artery diameter	mm	Linear	B-Mode
LO Art Diam	Left Ovarian artery diameter	mm	Linear	M-Mode
LO Vein Vel	Left Ovarian vein velocity	mm/s	Velocity	PW Doppler
LO Vein Diam	Left Ovarian vein diameter	mm	Linear	B-Mode
LO Vein Diam	Left Ovarian vein diameter	mm	Linear	M-Mode

Abdominal Package

Gallbladder Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
GB Sag	Gallbladder sagittal length	mm	Linear	B-Mode
GB Trans	Gallbladder transverse length	mm	Linear	B-Mode
GB Wall Thickness	Gallbladder wall thickness	mm	Linear	B-Mode
CBD	Common Bile Duct diameter	mm	Linear	B-Mode

Abdominal Package

Kidney Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
R Kidney Sag	Right Kidney sagittal length	mm	Linear	B-Mode
R Kidney Trans	Right Kidney transverse length	mm	Linear	B-Mode
RRA Vel	Right Kidney Renal artery velocity	mm/s	Velocity	PW Doppler
RRA Diam	Right Kidney Renal artery diameter	mm	Linear	B-Mode
RRA Diam	Right Kidney Renal artery diameter	mm	Linear	M-Mode
RRV Vel	Right Kidney Renal vein velocity	mm/s	Velocity	PW Doppler
RRV Diam	Right Kidney Renal vein diameter	mm	Linear	B-Mode
RRV Diam	Right Kidney Renal vein diameter	mm	Linear	M-Mode
L Kidney Sag	Left Kidney sagittal length	mm	Linear	B-Mode
L Kidney Trans	Left Kidney transverse length	mm	Linear	B-Mode
LRA Vel	Left Kidney Renal artery velocity	mm/s	Velocity	PW Doppler
LRA Diam	Left Kidney Renal artery diameter	mm	Linear	B-Mode
LRV Vel	Left Kidney Renal vein velocity	mm/s	Velocity	PW Doppler
LRV Diam	Left Kidney Renal vein diameter	mm	Linear	B-Mode
LRV Diam	Left Kidney Renal vein diameter	mm	Linear	M-Mode

Abdominal Package

Liver Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Liver Sag	Sagittal length	mm	Linear	B-Mode
Liver Trans	Transverse length	mm	Linear	B-Mode
Hepatic Vel	Hepatic Vein velocity	mm/s	Velocity	PW Doppler
Hepatic Diam	Hepatic Vein diameter	mm	Linear	B-Mode
Hepatic Diam	Hepatic Vein diameter	mm	Linear	M-Mode
RHV Vel	Right hepatic vein velocity	mm/s	Velocity	PW Doppler
RHV Diam	Right hepatic vein velocity	mm	Linear	B-Mode
RHV Diam	Right hepatic vein diameter	mm	Linear	M-Mode
LHV Vel	Left hepatic vein velocity	mm/s	Velocity	PW Doppler
LHV Diam	Left hepatic vein diameter	mm	Linear	B-Mode
LHV Diam	Left hepatic vein diameter	mm	Linear	M-Mode
CHA Vel	Common Hepatic artery velocity	mm/s	Velocity	PW Doppler
CHA Diam	Common Hepatic artery diameter	mm	Linear	B-Mode
CHA Diam	Common Hepatic artery diameter	mm	Linear	M-Mode
RHA Vel	Right hepatic artery velocity	mm/s	Velocity	PW Doppler
RHA Diam	Right hepatic artery diameter	mm	Linear	B-Mode
RHA Diam	Right hepatic artery diameter	mm	Linear	M-Mode
LHA Vel	Left hepatic artery velocity	mm/s	Velocity	PW Doppler
LHA Diam	Left hepatic artery diameter	mm	Linear	B-Mode
LHA Diam	Left hepatic artery diameter	mm	Linear	M-Mode
MPV Vel	Main Portal vein velocity	mm/s	Velocity	PW Doppler
MPV Diam	Main Portal vein diameter	mm	Linear	B-Mode
MPV Diam	Main Portal vein diameter	mm	Linear	M-Mode
RPV Vel	Right Portal vein velocity	mm/s	Velocity	PW Doppler
RPV Diam	Right Portal vein diameter	mm	Linear	B-Mode
RPV Diam	Right Portal vein diameter	mm	Linear	M-Mode
LPV Vel	Left Portal vein velocity	mm/s	Velocity	PW Doppler
LPV Diam	Left Portal vein diameter	mm	Linear	B-Mode
LPV Diam	Left Portal vein diameter	mm	Linear	M-Mode

Gast Vel	Gastroduodenal artery velocity	mm/s	Velocity	PW Doppler
Gast Diam	Gastroduodenal artery diameter	mm	Linear	B-Mode
Gast Diam	Gastroduodenal artery diameter	mm	Linear	M-Mode

Abdominal Package

Male Reproductive Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Prostate Sag	Prostate sagittal	mm	Linear	B-Mode
Prostate Trans	Prostate transverse	mm	Linear	B-Mode
RVG Sag	Right Vesicular glands sagittal	mm	Linear	B-Mode
RVG Trans	Right Vesicular glands transverse	mm	Linear	B-Mode
RVA Vel	Right Vesicular artery velocity	mm/s	Velocity	PW Doppler
RVA Diam	Right Vesicular artery diameter	mm	Linear	B-Mode
RVA Diam	Right Vesicular artery diameter	mm	Linear	M-Mode
RVV Vel	Right Vesicular vein velocity	mm/s	Velocity	PW Doppler
RVV Diam	Right Vesicular vein diameter	mm	Linear	B-Mode
RVV Diam	Right Vesicular vein diameter	mm	Linear	M-Mode
LVG Sag	Left Vesicular glands sagittal	mm	Linear	B-Mode
LVG Trans	Left Vesicular glands transverse	mm	Linear	B-Mode
LVA Vel	Left Vesicular artery velocity	mm/s	Velocity	PW Doppler
LVA Diam	Left Vesicular artery diameter	mm	Linear	B-Mode
LVA Diam	Left Vesicular artery diameter	mm	Linear	M-Mode
LVV Vel	Left Vesicular vein velocity	mm/s	Velocity	PW Doppler
LVV Diam	Left Vesicular vein diameter	mm	Linear	B-Mode
LVV Diam	Left Vesicular vein diameter	mm	Linear	M-Mode
R Test Sag	Right Testicle sagittal	mm	Linear	B-Mode
R Test Trans	Right Testicle transverse	mm	Linear	B-Mode
RTA Vel	Right Testicular artery velocity	mm/s	Velocity	PW Doppler
RTA Diam	Right Testicular artery diameter	mm	Linear	B-Mode
RTA Diam	Right Testicular artery diameter	mm	Linear	M-Mode
RTV Vel	Right Testicular vein velocity	mm/s	Velocity	PW Doppler
RTV Diam	Right Testicular vein diameter	mm	Linear	B-Mode
RTV Diam	Right Testicular vein diameter	mm	Linear	M-Mode
L Test Sag	Left Testicle sagittal	mm	Linear	B-Mode
L Test Trans	Left Testicle transverse	mm	Linear	B-Mode
LTA Vel	Left Testicular artery velocity	mm/s	Velocity	PW Doppler

LTA Diam	Left Testicular artery diameter	mm	Linear	B-Mode
LTA Diam	Left Testicular artery diameter	mm	Linear	M-Mode
LTV Vel	Left Testicular vein velocity	mm/s	Velocity	PW Doppler
LTV Diam	Left Testicular vein diameter	mm	Linear	B-Mode
LTV Diam	Left Testicular vein diameter	mm	Linear	M-Mode
Epid Head	Epididymis head length	mm	Linear	B-Mode
Epid Head	Epididymis head depth	mm	Linear	M-Mode
Epid Tail	Epididymis tail length	mm	Linear	B-Mode
Epid Tail	Epididymis tail depth	mm	Linear	M-Mode

Abdominal Package

Mammary Glands Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Cervical Diam	Mammary Glands	mm	Linear	B-Mode
Thoracic Diam	Thoracic diameter	mm	Linear	B-Mode
Abdominal Diam	Abdominal diameter	mm	Linear	B-Mode
Inguinal Diam	Inguinal diameter	mm	Linear	B-Mode
Mammae Papillae Diam	Mammae Papillae diameter	mm	Linear	B-Mode

Abdominal Package

Pancreas Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Pancreas Sag	Pancreas sagittal length	mm	Linear	B-Mode
Pancreas Trans	Pancreas transverse length	mm	Linear	B-Mode
Duct	Pancreatic duct diameter	mm	Linear	B-Mode

Abdominal Package

Spleen Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Spleen Sag	Sagittal length	mm	Linear	B-Mode
Spleen Transverse	Transverse length	mm	Linear	B-Mode
Splenic Artery Vel	Splenic artery velocity	mm/s	Velocity	PW Doppler
Splenic Artery Diam	Splenic artery diameter	mm	Linear	B-Mode
Splenic Artery Diam	Splenic artery diameter	mm	Linear	M-Mode

Embryology Measurement Package

Placenta Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
Placenta Sag	Sagittal length	mm	Linear	B-Mode
Placenta Trans	Transverse length	mm	Linear	B-Mode

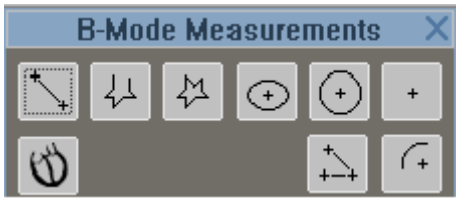
Embryology Measurement Package

Uterine Horn Protocol - Measurement Definitions

Label	Description	Units	Generic Type	Mode
UA Vel	Umbilical artery velocity	mm/s	Velocity	PW Doppler
UA Diam	Umbilical artery diameter	mm	Linear	B-Mode
UA Diam	Umbilical artery diameter	mm	Linear	M-Mode
UV Vel	Umbilical vein velocity	mm/s	Velocity	PW Doppler
UV Diam	Umbilical vein diameter	mm	Linear	B-Mode
UV Diam	Umbilical vein diameter	mm	Linear	M-Mode
VA Vel	Vitelline artery velocity	mm/s	Velocity	PW Doppler
VA Diam	Vitelline artery diameter	mm	Linear	B-Mode
VA Diam	Vitelline artery diameter	mm	Linear	M-Mode
VV Vel	Vitelline vein velocity	mm/s	Velocity	PW Doppler
VV Diam	Vitelline vein diameter	mm	Linear	B-Mode
VV Diam	Vitelline vein diameter	mm	Linear	M-Mode

Generic Protocol (B-Mode)

In B-Mode, the following generic measurements are available:



	Linear distance (mm)
	Traced distance (mm)
	Polygon ROI (mm2)
	Ellipse ROI (mm2)
	Circle ROI (mm2)
	Single point (x,y)
	Wall trace
	Angle (degrees)
	Radius (mm)

Generic measurements will be labeled with a sequence number that increments with each measurement of that type made in the study (i.e Point 1, Point 2, Point 3...). The sequential numbering will not be affected by deletion of measurements. If the last created measurement is Point1 and it is deleted, the next measurement will be Point2.

The options enabled in Measurement Display Options in the Operator Preferences dialog will be displayed on the image and in the Data Browser.

To place a linear distance measurement:

1. On the B-Mode Measurements Tool, click the Linear Distance measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.
   The system updates the measured distance between the initial caliper and the current trackball cursor position as the cursor is moved across the image.

3. Click to place the second caliper.
   The system labels the measurements sequentially in the form **Linear#**.

To place a traced distance measurement:

1. On the B-Mode Measurements Tool, click the Traced Distance measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the trace. There is no limit to the number of calipers that can be placed for this measurement.
   The system updates the cumulative measurement value of the line segments as the trackball cursor is moved across the image.

4. Right-click to place the last caliper and complete the measurement.
   The system labels the measurements sequentially in the form **Traced Distance#**.

To place a polygon ROI (region of interest) area measurement:

1. On the B-Mode Measurements Tool, click the Polygon ROI Area button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the polygon.
   The measurement values for the polygon will be updated as the trackball cursor is moved over the image.

4. Right-click (or left-click near the first point) to place the last caliper. The system creates a line that joins the last point in the polygon with the first point. Note: If the trackball cursor is positioned within five pixels of the previous caliper when the right-click occurs, the previously placed caliper will be considered to be the last caliper for the measurement. This applies to B-

Mode and 3D-Mode polygon measurements and for 3D-Mode volume contours.
The system labels the measurements sequentially in the form **Polygon#**.

To place an ellipse ROI area measurement:

1. On the B-Mode Measurements Tool, click the Ellipse ROI Area button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the center point of the ellipse.
3. Click again to define the size of the ellipse. The system initially draws the ellipse as a circle with a radius that is equal to the length of the axis indicator.
   The system updates the measurement value of the ellipse as the trackball cursor is moved over the image to define the size of the ellipse.
4. To adjust the eccentricity, click on the ellipse circumference and drag the edge in or out.
5. Click to commit the new shape.
6. To rotate the orientation of the ellipse, click on the axis indicator (the line that the system draws from the center of the ellipse to the circumference).
7. Click to commit the new shape.
   The system labels the measurements sequentially in the form **Ellipse#**.

To place a circle ROI area measurement:

1. On the B-Mode Measurements Tool, click the Circle ROI Area button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the center point of the circle.
3. The system updates the measurement value of the circle as the trackball cursor moves across the image to set the size of the circle and define the circle's radius.
4. Click to commit the circle radius.
   The system labels the measurements sequentially in the form **Circle#**.

To place a single point measurement:

1. On the B-Mode Measurements Tool, click the Point measurement button. This button will remain pressed until the measurement is completed. The system updates the (x, y) coordinate of the current trackball cursor position as it is moved across the image.

2. Click to place the caliper.

3. The system labels the measurements sequentially in the form **Point#**.

To add a semi-automatic B-Mode LV wall contour:

1. Select the appropriate view from the LV Options panel on the Measurements Tool (long axis or short axis).

2. On the Measurements Tool, click the LV Trace measurement button.

3. Click along the wall boundary to add caliper points. If in long axis view, the first two caliper points added define the annulus line.

4. After adding three caliper points, a dashed contour will be drawn connecting the points.

5. Caliper points may be added anywhere along the contour, or moved by clicking on a point and dragging it.

6. Right click to complete the contour.

Once a contour is drawn on a frame, it can be moved, resized, and modified.

- To add points to the contour click anywhere on the contour line, and drag the newly added caliper to the new position.

- To move an existing caliper point, click on the point and drag it to the new position.

- To drag the entire contour, click on the control point located in the center of the contour volume.

- To resize the entire contour, while pressing Shift, click on the contour edge and drag the contour edge.

- To delete a contour point, right click on the point and select Delete Point from the context menu.

To copy the contour to additional frames, use the refine feature. Right click on an existing contour then select one of the four refine options. Some options may be unavailable if it is not suitable for the current frame.

The following options exist:

Refine to Next	Refines the current contour to the next frame

Refine to Previous	Refines the current contour to the previous frame.
Refine Forward	Refines the current contour in the forward time direction by the number of cycles (or frames if in EKV) as set by the Cardiac Cycles field of the Measurements Tool (Cine Frames field if in EKV).
Refine Reverse	Performs the same functions as Refine Forward but in the reverse time direction.

Best results are obtained if a small number of images is refined at one time. Manually correct any refine errors during the process.

For example:

1. Select Refine to Next or Refine Forward with 1 cycle chosen as the number of Cardiac Cycles.
2. Correct any refine errors.
3. Continue this process until the entire range is complete.

To place an angle measurement:

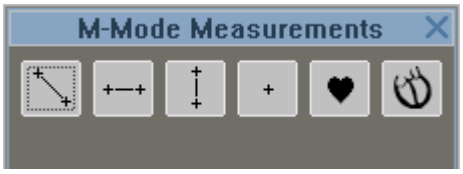
1. On the B-Mode Measurements Tool, click the Angle measurement button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.
3. Click to place the second and third calipers.
4. The system labels the measurements sequentially in the form of **Angle#.**

To place a radius measurement:

1. On the B-Mode Measurements Tool, click the Radius measurement button. This button will remain pressed until the measurement is completed.
2. Click to place the caliper at one end of the curvature.
3. Click to place the caliper at the middle of the curvature.
4. Click to place the caliper at other end of the curvature.
5. The system will draw the arc between the points specified along with the center of the curvature and labels the measurements sequentially in the form of **Radius#.**

Generic Protocol (M-Mode)

In M-Mode, the following generic measurements are available:



	Velocity (mm/s)
	Time Interval (ms)
	Depth Interval (mm)
	Single Point (x,y)
	Heart Rate (BPM)
	Wall trace

Generic measurements are labeled in sequence increments based on each measurement of that type made in the study (i.e Point 1, Point 2, Point 3...). Sequential numbering is not affected by the deletion of measurements. If the last created measurement is Point1 and it is deleted, the next measurement continues to be labelled Point2.

The options enabled in Measurement Display Options in the Operator Preferences dialog are displayed on the image and in the Data Browser.

To place a velocity measurement:

1. On the M-Mode Measurements Tool, click the Velocity measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the velocity caliper.
   The measurement value between the initial caliper and the current trackball cursor position will be updated as the trackball cursor is moved across the image.

3. Click to place the second caliper.
   The velocity at the indicated point is displayed and the system labels the measurements sequentially in the form **M-Mode Velocity#**.

To place a depth measurement:

1. On the M-Mode Measurements Tool, click the Depth measurement button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.
3. Click on the image to place the second caliper.
4. The system labels the measurements sequentially in the form **Depth#**.

To place a time interval measurement:

1. On the M-Mode Measurements Tool, click the Time Interval measurement button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.
   The difference between the initial caliper and the current trackball cursor position will be updated as the trackball cursor is moved across the image.
3. Click to place the second caliper.
4. The system labels the measurements sequentially in the form **Time#**.

To place a single point measurement:

1. On the M-Mode Measurements Tool, click the Point measurement button. This button will remain pressed until the measurement is completed. The system updates the (x, y) coordinate of the current trackball cursor position as it is moved across the image.
2. Click to place the caliper.
3. The system labels the measurements sequentially in the form **Point#**.

To place a heart rate measurement:

1. On the M-Mode Measurements Tool, click the Heart Rate measurement button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.

3. Click to place the next caliper in the sequence of heart beats.
   Note: The measured heart rate will be the average heart rate (averaged over the number of beats measured) if this measurement value has been checked in the Operator's Preferences.
   Note: Place each caliper at the same point in the cardiac cycle for each heart beat.

4. Right-click on the last heart beat of the sequence to complete the measurement.

5. The system labels the measurements sequentially in the form **Heart Rate#**.

To add a semi-automatic M-Mode LV wall trace:

Three methods are available: manual, semi-automatic, and automatic segmentation.

Manual Segmentation

1. On the Measurements Tool, click the LV Trace measurement button.

2. Click on the top heart wall to place the initial caliper.

3. Segment the wall by clicking along the boundary. Adding a caliper point to the peaks and troughs of the boundary is often sufficient.

4. Right click to finish drawing the wall trace. Trace the lower heart wall in the same way as the top wall.

5. Right click again to complete the measurement.

6. Adjust the position of any caliper by clicking and dragging it to a new position.

7. Click between two existing points to add a new caliper.

Semi-Automatic Segmentation

1. On the Measurements Tool, click the LV Trace measurement button.

2. Complete the manual segmentation as described previously; however, less emphases needs to be placed on getting the curve to follow the boundary perfectly, the auto-segmentation will optimize the position.

3. Ensure the two end calipers of each wall boundary are positioned correctly. These points are used to help fit the curve to the wall.

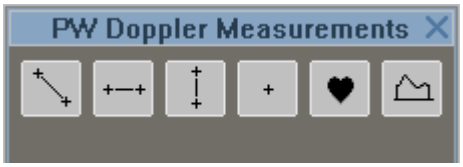
4. Right click on one of the traces and select either Refine or Refine All.

Automatic Segmentation

1. On the Measurements Tool, click the LV Trace measurement button.
2. Click on the top-right heart wall to place the initial caliper.
3. Right click where you want the contour to end. The in-between points will be automatically generated and positioned along the wall boundary.
4. Complete the lower heart wall in the same way.
5. Please note, it is important to get the end caliper points positioned correctly on the wall boundaries. These points are used to help fit the curve to the wall.

Generic Protocol (PW Doppler)

In PW Doppler Mode, the following generic measurements are available:



	Acceleration/Deceleration (mm/s)
	Time Interval (ms)
	Velocity (mm/s)
	Single Point (x,y1,y2)
	Heart Rate (BPM)
	VTI (cm)

Generic measurements will be labeled with a sequence number that increments with each measurement of that type made in the study (i.e Point 1, Point 2, Point 3...). The sequential numbering will not be affected by deletion of measurements. If the last created measurement is Point1 and it is deleted, the next measurement will be Point2.

The options enabled in Measurement Display Options in the Operator Preferences dialog will be displayed on the image and in the Data Browser.

To place an acceleration measurement:

1. On the PW Doppler Measurements Tool, click the Acceleration measurement button. This button will remain pressed until the measurement is complete.

2. Click on the image to place the initial caliper.
   Note: Press Ctrl+Click to place the caliper on the baseline at the desired time value.
   The measurement value between the initial caliper and the current trackball cursor position will be updated as the trackball cursor is moved across the image.

3. Click to place the second caliper.
   Note: Acceleration measurements will be constrained to either the positive portion of the Doppler spectrum or the negative portion depending on the placement of the initial caliper. The measurement cannot straddle the baseline.

4. The system labels the measurements sequentially in the form **Acceleration#**.

To place a time interval measurement:

1. On the PW Doppler Measurements Tool, click the Time Interval measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.
   The difference between the initial caliper and the current trackball cursor position will be updated as the trackball cursor is moved across the image.

3. Click to place the second caliper.

4. The system labels the measurements sequentially in the form **Time#**.

To place a velocity measurement:

1. On the PW Doppler Measurements Tool, click the Velocity measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the velocity caliper.

3. The velocity at the indicated point is displayed and the system labels the measurements sequentially in the form **Doppler Velocity#**.

To place a single point measurement:

1. On the PW Doppler Measurements Tool, click the Point measurement button. This button will remain pressed until the measurement is completed. The system updates the (x, y1, y2) value of the current trackball cursor position as it is moved across the image.

2. Click to place the caliper.

3. The system labels the measurements sequentially in the form **Point#**.

To place a heart rate measurement:

1. On the PW Doppler Measurements Tool, click the Heart Rate measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place the next caliper in the sequence of heart beats.
   Note: The measured heart rate will be the average heart rate (averaged over the number of beats measured) if this measurement value has been checked in the Operator's Preferences.
   Note: Place each caliper at the same point in the cardiac cycle for each heart beat.

4. Right-click on the last heart beat of the sequence to complete the measurement.

5. The system labels the measurements sequentially in the form **Heart Rate#**.

To manually trace a VTI measurement:

1. On the PW Doppler Measurements Tool, click the VTI button. This button will remain pressed in until the measurement is completed.
   Note: To activate the real-time frequency trace options, select **None**.

2. Click on the image to place the initial caliper.
   Note: Press Ctrl+Click to place a caliper on the baseline at the desired time value.

3. Click to place the next caliper to trace the Doppler spectrum. A running value is displayed as the points are placed. The system calculates the velocity time integral for the region between the baseline and the traced spectrum.

4. Right-click to place the last caliper and complete the measurement.

5. The system labels the measurements sequentially in the form **VTI#**.

The VTI measurement can be drawn automatically over a selected area when a real-time frequency trace has been selected.

To auto-trace a VTI measurement:

1. Select a real-time frequency trace (Peak or Mean).

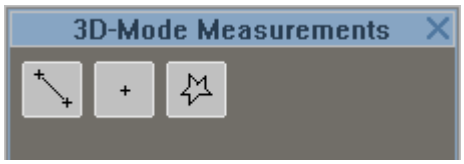
2. On the PW Doppler Measurements Tool, click the VTI button. This button will remain pressed in until the measurement is completed.

3. Click on the image to place the initial caliper.

4. Move the trackball cursor along the trace. A line will follow the trackball cursor movement and update the VTI value.

Generic Protocol (3D-Mode)

In 3D-Mode, the following generic measurements are available within the Cube view:



	Linear distance (mm)
	Single point (x,y,z)
	Polygon ROI (mm2)

Generic measurements will be labeled with a sequence number that increments with each measurement of that type made in the study (i.e Point 1, Point 2, Point 3...). The sequential numbering will not be affected by deletion of measurements. If the last created measurement is Point1 and it is deleted, the next measurement will be Point2.

The options enabled in Measurement Display Options in the Operator Preferences dialog will be displayed on the image and in the Data Browser.

To place a linear distance measurement:

1. On the 3D Measurements Tool, click the Linear Distance button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper. The measured distance between the initial caliper and the current trackball cursor position will be updated as the cursor is moved on the image.
3. Click to place the second caliper.
   The system labels the measurements sequentially in the form **Linear#**.

To place a polygon ROI (region of interest) area measurement:

1. On the 3D Measurements Tool, click the Polygon ROI Area button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the polygon. The system updates measurement values for the polygon as the trackball cursor moves across the image.

4. Right-click (or left-click near the first point) to place the last caliper. The system creates a line that joins the last point in the polygon with the first point. Note: If the trackball cursor is positioned within five pixels of the previous caliper when the right-click occurs, the previously placed caliper will be considered to be the last caliper for the measurement. This applies to B-Mode and 3D-Mode polygon measurements and for 3D-Mode volume contours.
   The system labels the measurements sequentially in the form **Polygon#**.

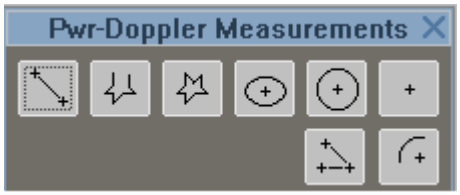
To place a single point measurement:

1. On the 3D Measurements Tool, click the Point measurement button. This button will remain pressed until the measurement is completed. The system updates the (x, y, z) coordinate of the current trackball cursor position as it is moved across the image.

2. Click to place the caliper.
   The system labels the measurements sequentially in the form **Point#**.

Generic Protocol (Power Doppler Mode)

In Power Doppler Mode, the following generic measurements are available:



	Linear distance (mm)
	Traced distance (mm)
	Polygon ROI (mm2)
	Ellipse ROI (mm2)
	Circle ROI (mm2)
	Single point (x,y)
	Angle (degrees)
	Radius (mm)

Generic measurements will be labeled with a sequence number that increments with each measurement of that type made in the study (i.e Point 1, Point 2, Point 3...). The sequential numbering will not be affected by deletion of measurements. If the last created measurement is Point1 and it is deleted, the next measurement will be Point2.

The options enabled in Measurement Display Options in the Operator Preferences dialog will be displayed on the image and in the Data Browser.

To place a linear distance measurement:

1. On the Pwr-Doppler Measurements Tool, click the Linear Distance measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.
   The system updates the measured distance between the initial caliper and the current trackball cursor position as the cursor is moved across the image.

3. Click to place the second caliper.
   The system labels the measurements sequentially in the form **Linear#**.

To place a traced distance measurement:

1. On the Pwr-Doppler Measurements Tool, click the Traced Distance measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the trace. There is no limit to the number of calipers that can be placed for this measurement.
   The system updates the cumulative measurement value of the line segments as the trackball cursor is moved across the image.

4. Right-click to place the last caliper and complete the measurement.
   The system labels the measurements sequentially in the form **Traced Distance#**.

To place a polygon ROI (region of interest) area measurement:

1. On the Pwr-Doppler Measurements Tool, click the Polygon ROI Area button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the polygon.
   The measurement values for the polygon will be updated as the trackball cursor is moved over the image.

4. Right-click (or left-click near the first point) to place the last caliper. The system creates a line that joins the last point in the polygon with the first point. Note: If the trackball cursor is positioned within five pixels of the previous caliper when the right-click occurs, the previously placed caliper will be considered to be the last caliper for the measurement. This applies to B-Mode and 3D-Mode polygon measurements and for 3D-Mode volume contours.
   The system labels the measurements sequentially in the form **Polygon#**.

To place an ellipse ROI area measurement:

1. On the Pwr-Doppler Measurements Tool, click the Ellipse ROI Area button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the center point of the ellipse.

3. Click again to define the size of the ellipse. The system initially draws the ellipse as a circle with a radius that is equal to the length of the axis indicator.
   The system updates the measurement value of the ellipse as the trackball cursor is moved over the image to define the size of the ellipse.

4. To adjust the eccentricity, click on the ellipse circumference and drag the edge in or out.

5. Click to commit the new shape.

6. To rotate the orientation of the ellipse, click on the axis indicator (the line that the system draws from the center of the ellipse to the circumference).

7. Click to commit the new shape.
   The system labels the measurements sequentially in the form **Ellipse#**.

To place a circle ROI area measurement:

1. On the Pwr-Doppler Measurements Tool, click the Circle ROI Area button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the center point of the circle.

3. The system updates the measurement value of the circle as the trackball cursor moves across the image to set the size of the circle and define the circle's radius.

4. Click to commit the circle radius.
   The system labels the measurements sequentially in the form **Circle#**.

To place a single point measurement:

1. On the Pwr-Doppler Measurements Tool, click the Point measurement button. This button will remain pressed until the measurement is completed. The system updates the (x, y) coordinate of the current trackball cursor position as it is moved across the image.

2. Click to place the caliper.

3. The system labels the measurements sequentially in the form **Point#**.

To place an angle measurement:

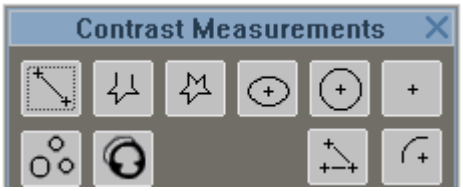
1. On the Pwr-Doppler Measurements Tool, click the Angle measurement button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.
3. Click to place the second and third calipers.
4. The system labels the measurements sequentially in the form of **Angle#.**

To place a radius measurement:

1. On the Pwr-Doppler Measurements Tool, click the Radius measurement button. This button will remain pressed until the measurement is completed.
2. Click to place the caliper at one end of the curvature.
3. Click to place the caliper at the middle of the curvature.
4. Click to place the caliper at other end of the curvature.
5. The system will draw the arc between the points specified along with the center of the curvature and labels the measurements sequentially in the form of **Radius#.**

Generic Protocol (Contrast Mode)

In Contrast Mode, the following generic measurements are available:



	Linear distance (mm)
	Traced distance (mm)
	Polygon ROI (mm2)
	Ellipse ROI (mm2)
	Circle ROI (mm2)
	Single point (x,y)
	Contrast region
	Cardiac region
	Angle (degrees)
	Radius (mm)

Generic measurements will be labeled with a sequence number that increments with each measurement of that type made in the study (i.e Point 1, Point 2, Point 3...). The sequential numbering will not be affected by deletion of measurements. If the last created measurement is Point1 and it is deleted, the next measurement will be Point2.

The options enabled in Measurement Display Options in the Operator Preferences dialog will be displayed on the image and in the Data Browser.

To place a linear distance measurement:

1. On the Contrast Measurements Tool, click the Linear Distance measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.
   The system updates the measured distance between the initial caliper and the current trackball cursor position as the cursor is moved across the image.

3. Click to place the second caliper.
   The system labels the measurements sequentially in the form **Linear#**.

To place a traced distance measurement:

1. On the Contrast Measurements Tool, click the Traced Distance measurement button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the trace. There is no limit to the number of calipers that can be placed for this measurement.
   The system updates the cumulative measurement value of the line segments as the trackball cursor is moved across the image.

4. Right-click to place the last caliper and complete the measurement.
   The system labels the measurements sequentially in the form **Traced Distance#**.

To place a polygon ROI (region of interest) area measurement:

1. On the Contrast Measurements Tool, click the Polygon ROI Area button. This button will remain pressed until the measurement is completed.

2. Click on the image to place the initial caliper.

3. Click to place each successive caliper in the polygon.
   The measurement values for the polygon will be updated as the trackball cursor is moved over the image.

4. Right-click (or left-click near the first point) to place the last caliper. The system creates a line that joins the last point in the polygon with the first point. Note: If the trackball cursor is positioned within five pixels of the previous caliper when the right-click occurs, the previously placed caliper will be considered to be the last caliper for the measurement. This applies to B-

Mode and 3D-Mode polygon measurements and for 3D-Mode volume contours.
The system labels the measurements sequentially in the form **Polygon#**.

To place an ellipse ROI area measurement:

1. On the Contrast Measurements Tool, click the Ellipse ROI Area button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the center point of the ellipse.
3. Click again to define the size of the ellipse. The system initially draws the ellipse as a circle with a radius that is equal to the length of the axis indicator.
   The system updates the measurement value of the ellipse as the trackball cursor is moved over the image to define the size of the ellipse.
4. To adjust the eccentricity, click on the ellipse circumference and drag the edge in or out.
5. Click to commit the new shape.
6. To rotate the orientation of the ellipse, click on the axis indicator (the line that the system draws from the center of the ellipse to the circumference).
7. Click to commit the new shape.
   The system labels the measurements sequentially in the form **Ellipse#**.

To place a circle ROI area measurement:

1. On the Contrast Measurements Tool, click the Circle ROI Area button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the center point of the circle.
3. The system updates the measurement value of the circle as the trackball cursor moves across the image to set the size of the circle and define the circle's radius.
4. Click to commit the circle radius.
   The system labels the measurements sequentially in the form **Circle#**.

To place a single point measurement:

1. On the Contrast Measurements Tool, click the Point measurement button. This button will remain pressed until the measurement is completed. The system updates the (x, y) coordinate of the current trackball cursor position as it is moved across the image.

2. Click to place the caliper.

3. The system labels the measurements sequentially in the form **Point#**.

To add a contrast region:

1. On the Contrast Measurements Tool, click the Contrast Region measurement button. This button will remain pressed until the measurement is completed.

2. Click along the tissue boundary to add caliper points. After adding three caliper points, a dashed contour connects the points.

3. Continue to click along the tissue boundary to add additional caliper points. To modify the position of a caliper, drag a caliper point.

4. Right-click to complete the contour.

5. The system labels the measurements sequentially in the form **Contrast Region#**.

To add a cardiac region:

1. On the Contrast Measurements Tool, click the Cardiac Region measurement button. This button will remain pressed until the measurement is completed.

2. In the Cardiac Region Analysis area, select the appropriate number of cardiac cycles, if desired.

3. Click along the boundary of the outer wall of the myocardium to add caliper points. After adding three caliper points, a dashed contour will be drawn connecting the points. You can add caliper points anywhere along the contour. Drag a point to move it.

4. Right-click to complete the outer wall contour.

5. Click on the boundary of the inner wall of the myocardium, and add caliper points using the same procedure you used to create the outer wall contour.

6. Right-click to complete the inner wall contour.

7. The system labels the measurements sequentially in the form **Cardiac Region#**.

To place an angle measurement:

1. On the Contrast Measurements Tool, click the Angle measurement button. This button will remain pressed until the measurement is completed.
2. Click on the image to place the initial caliper.
3. Click to place the second and third calipers.
4. The system labels the measurements sequentially in the form of **Angle#.**

To place a radius measurement:

1. On the Contrast Measurements Tool, click the Radius measurement button. This button will remain pressed until the measurement is completed.
2. Click to place the caliper at one end of the curvature.
3. Click to place the caliper at the middle of the curvature.
4. Click to place the caliper at other end of the curvature.
5. The system will draw the arc between the points specified along with the center of the curvature and labels the measurements sequentially in the form of **Radius#.**