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E-POINT SEPTAL SEPARATION

E-Point Septal Separation (EPSS) is the distance between the anterior mitral valve leaflet and the interventricular septum during ventricular diastole.

EPSS is a useful tool in the evaluation of Left Ventricular (LV) systolic function. When the LV function decreases or the chamber becomes enlarged, the distance between the mitral valve leaflet and interventricular septum increases. An increased EPSS may be suggestive of a decreased Ejection Fraction (EF). The validity of EPSS for systolic function evaluation may be limited by regional wall motion abnormalities, cardiomyopathies, and valvular disorders.

Measurement:

- E-point Septal Separation (EPSS)

Use the Cardiac exam type to perform the measurement:

- Obtain a Parasternal Long Axis (PLAX) view of the heart (Fig. 1).
- Press M to activate the M-Mode cursor, place it at the tip of the anterior mitral valve leaflet (Fig. 1), and press M or Update to start the M-Mode trace.

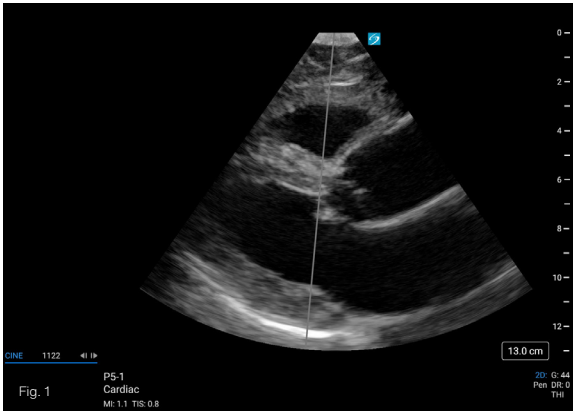

Fig. 1

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E-POINT SEPTAL SEPARATION

- Freeze the image ❄ after a full M-Mode display, including at least one cardiac cycle (Fig. 2).
- Navigate to Calcs, and select EPSS.
- Use the calipers to measure the distance from the peak E-wave (E-point) of the mitral valve to the interventricular septum in early ventricular diastole (Fig. 2).
- Save image 📷.

An EPSS > 7 mm may be suggestive of severely reduced LV systolic function

Reference:
McKaigney, C. et. al. (2014, Feb 3). E-point septal separation: a bedside tool for emergency physician assessment of left ventricular ejection fraction. Am J Emerg Med
https://pubmed.ncbi.nlm.nih.gov/24630604/

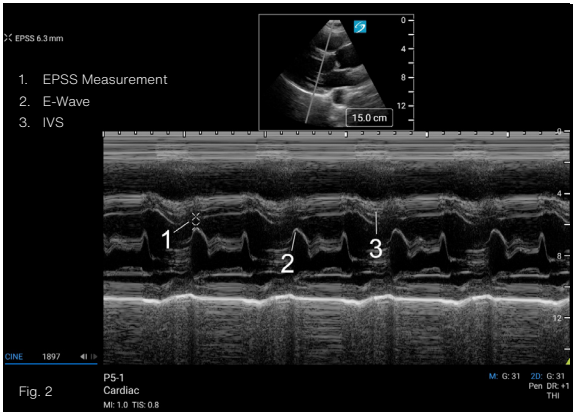

Fig. 2

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MAPSE AND TAPSE

MAPSE and TAPSE are quick M-Mode measurements to help evaluate systolic ventricular function.

During systole, the left ventricle contracts and shortens. This movement can be captured with M-Mode and measured as Mitral Annular Plane Systolic Excursion (MAPSE) and Tricuspid Annular Plane Systolic Excursion (TAPSE). These measurements may be used in the evaluation of systolic ventricular function by assuming the longitudinal movement of the annulus during systole represents the overall systolic function of the ventricle. M-Mode displays distance on the y-axis and time on the x-axis, so for the purposes of these measurements, we utilize the y-axis values only.

Measurements:

- TAPSE
- MAPSE

Use the Cardiac exam type to perform a TAPSE measurement:

- Obtain an Apical 4 Chamber (A4C) view.
- Press M to activate the M-Mode cursor, and place it through the base of the lateral tricuspid valve annulus (Fig. 1).
- Press M or Update to start the M-Mode trace.
- Freeze ❄ after a full M-Mode display, including at least one cardiac cycle.
- Press Calcs, and select TAPSE.
- Measure the annular movement by using the two calipers to mark the lowest point of ventricular diastole and the tallest point of ventricular systole (Fig. 1).
- Save image 📷.

TAPSE < 17 mm is highly suggestive of RV systolic dysfunction

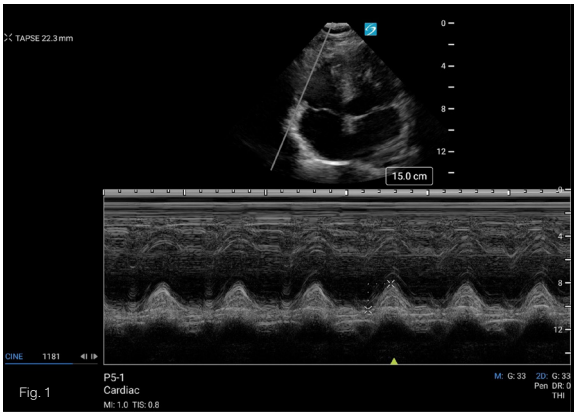

Fig. 1

Reference:
Lang, R. et. al. (2015, Jan). Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Journal of the American Society of Echocardiography. https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext

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MAPSE AND TAPSE

Use the Cardiac exam type to perform the measurement – MAPSE (lateral annulus):

- Obtain an Apical 4 Chamber (A4C) view.
- Press M to activate the M-Mode cursor, and place it through the base of the mitral valve annulus near the lateral wall (Fig. 2).
- Press M or Update to start the M-Mode trace.
- Freeze ❄ after a full M-Mode display, including at least one cardiac cycle.
- Press Calcs, and select MAPSE.
- Measure the annular movement by using the two calipers to mark the lowest point of ventricular diastole and the tallest point of ventricular systole (Fig 2).
- Save image 📷.

Use the Cardiac exam type to perform the measurement – MAPSE (septal annulus):

- Obtain an A4C view, place the M-Mode cursor through the base of the mitral valve annulus near the interventricular septal wall, and start the M-Mode trace.
- Freeze ❄ after a full M-Mode display, including at least one cardiac cycle.
- Repeat the MAPSE measurement for this view (Fig. 3).
- Save image 📷.

A MAPSE of ≥11 mm for women and ≥13 mm for men may be suggestive of a normal EF.

A MAPSE of <6 mm for both men and women may be suggestive of a severely reduced EF.

The above values use the averaged MAPSE value from the lateral and septal walls. The averaged value can be accessed in the patient report.

Reference:
Matos, J, Kronzon, I, et al. (2012, Sept) Mitral Annular Plane Systolic Excursion as a Surrogate for Left Ventricular Ejection Fraction. Journal of the American Society of Echocardiography. https://pubmed.ncbi.nlm.nih.gov/22795199/

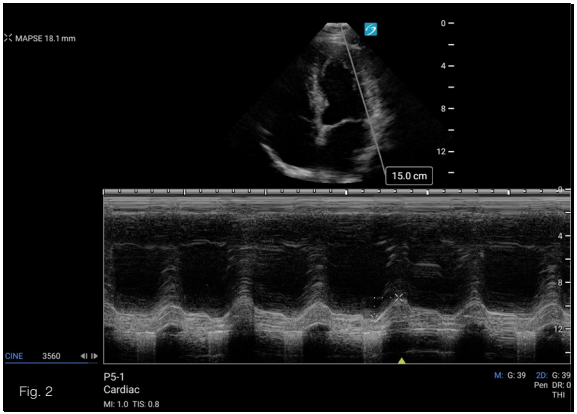

Fig. 2

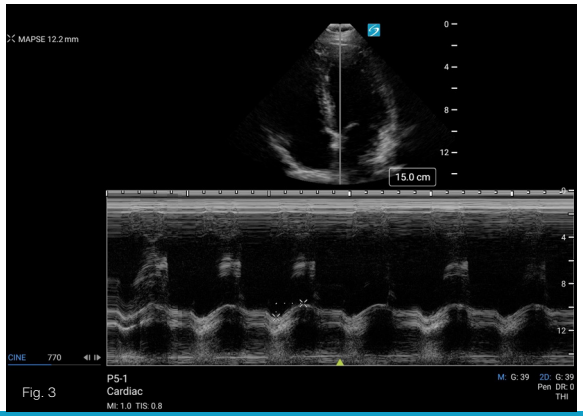

Fig. 3

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EJECTION FRACTION (EF) AND FRACTIONAL SHORTENING (FS)

Linear EF and FS calculations may assist in evaluating systolic heart function.

Linear EF and FS can both be calculated by measuring the Left Ventricle (LV) in systole and diastole. These can be performed in 2D or M-Mode. A decrease in the EF or FS may suggest pathologies such as coronary artery disease, cardiomyopathy, heart failure, valvular heart disease, or congenital heart diseases. Linear EF and FS measurements can be limited by regional wall and conductive abnormalities.

Measurements:

- Left Ventricular Dimension in Diastole (LVDd)
- Left Ventricular Dimension in Systole (LVDs)

Use the Cardiac exam type to perform the measurements in 2D:

- Obtain a Parasternal Long Axis (PLAX) view.
- Freeze ❄ the image after visualizing a complete cardiac cycle.
- Cine scroll to end-diastole or the frame with the largest LV dimension.
- Press Calcs, and select LVDd.
- Measure the LV from the inner edge of the interventricular septum to the inner edge of the posterior wall, disregarding the chordae tendinae (Fig. 1).
- Save image 📷.

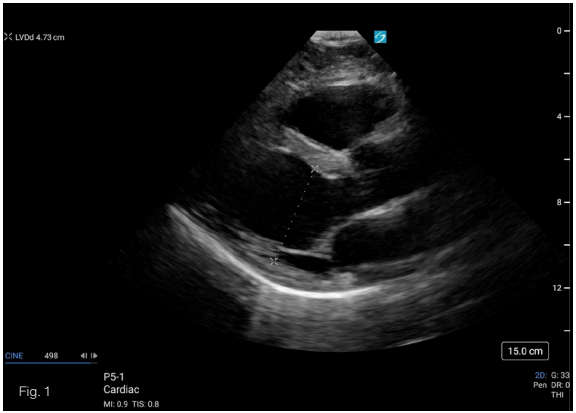

Fig. 1

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EJECTION FRACTION (EF) AND FRACTIONAL SHORTENING (FS)

- On the same heartbeat, cine scroll to end-systole or the frame with the smallest LV dimension.
- Select LVDs, and measure the LV from the inner edge of the interventricular septum to the inner edge of the posterior wall, disregarding the chordae tendinae (Fig. 2).
- Save image.

Use the Cardiac exam type to perform the measurement in M-Mode:

- Obtain a Parasternal Long Axis (PLAX) view.
- Press M to activate the M-Mode cursor, and place it just past the mitral valve leaflet tips. Press M or Update to start the M-Mode trace.
- Freeze after a full M-Mode display, including at least one cardiac cycle.
- Press Calcs, and select LVDd.
- Measure the LV at end-diastole from the inner edge of the interventricular septum to the inner edge of the posterior myocardium, disregarding the chordae tendineae (Fig. 3).
- Select LVDs, and measure the LV at end-systole from the inner edge of the interventricular septum to the inner edge of the posterior myocardium, disregarding the chordae tendineae (Fig. 3).
- Save image.

The ASE recommends using the Simpson's biplane (2D) for global assessment of LV function. See Biplane Ejection Fraction Quick Guide for reference.

Reference:
Lang, R. et. al. (2015, Jan). Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Journal of the American Society of Echocardiography. https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext

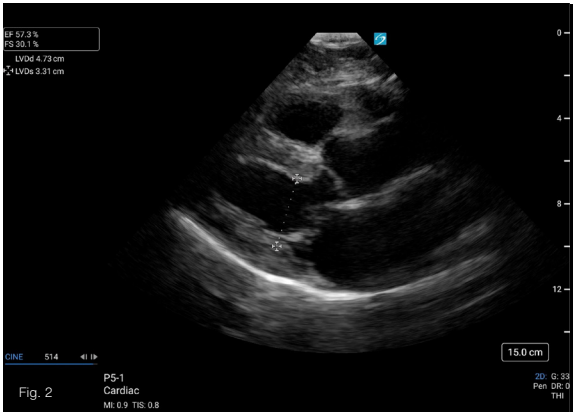

Fig. 2

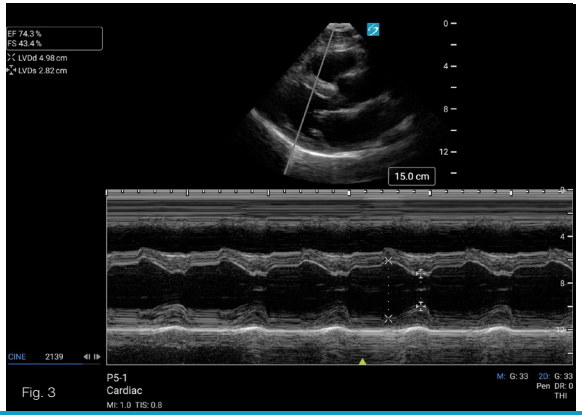

Fig. 3

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BIPLANE EJECTION FRACTION

Ejection Fraction (EF) measures the amount of blood being pumped out by the heart each time it contracts.

The biplane method of disks (modified Simpson's rule) calculates the Left Ventricular Ejection Fraction (LVEF) from the diastolic and systolic volumes of both the Apical 4 Chamber (A4C) and Apical 2 Chamber (A2C) views. The result is a biplane EF that is reproducible and is one of the most accurate ways to assess systolic heart function using 2D ultrasound. An abnormal LVEF may suggest pathologies such as coronary artery disease, cardiomyopathies, heart failure, valvular heart diseases, or congenital heart diseases.

Measurements:

- Apical 4 Chamber Diastolic Volume (A4Cd Vol)
- Apical 4 Chamber Systolic Volume (A4Cs Vol)
- Apical 2 Chamber Diastolic Volume (A2Cd Vol)
- Apical 2 Chamber Systolic Volume (A2Cs Vol)

Use the Cardiac exam type to perform the measurements:

- Obtain an Apical 4 Chamber (A4C) view that does not foreshorten the ventricle.
- Freeze ❄ the image after visualizing at least one cardiac cycle.
- Cine scroll to end-diastole or the frame with the largest LV volume.
- Press Calcs, and select A4Cd Vol.
- Starting at the annulus, trace the endocardial border of the left ventricle, around to the opposite annulus, and adjust the apical length as needed (Fig 1).
- Save image 📷.
- Cine scroll to end-systole or the frame with the smallest LV volume (Fig. 2).
- Press Calcs, select the A4Cs Vol, trace the endocardial border of the LV, and adjust the apical length as needed.
- Save image 📷.

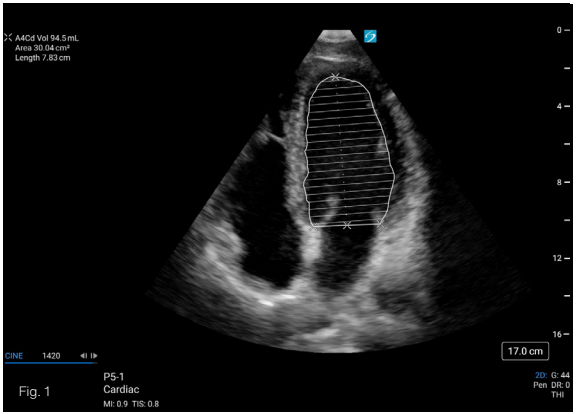

Fig. 1

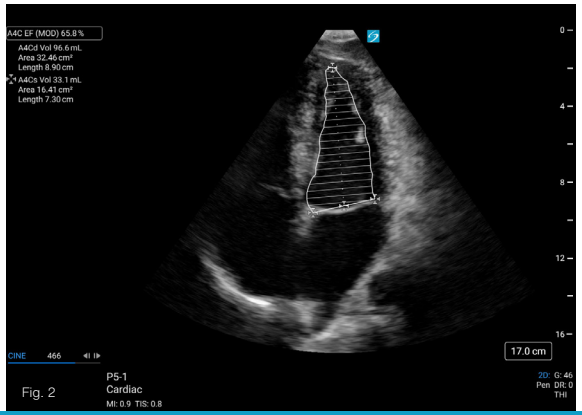

Fig. 2

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BIPLANE EJECTION FRACTION

- Repeat steps for the A2C view to calculate the biplane LVEF (Fig 3 and 4).

LV EFs of <52% for men and <54% for women are suggestive of abnormal LV systolic function.

Reference:
Lang, R. et. al. (2015, Jan). Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext

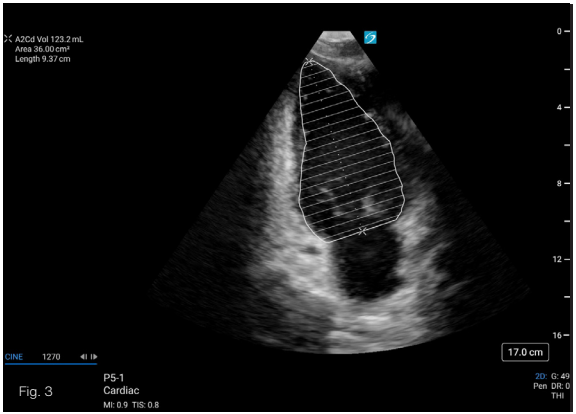

Fig. 3

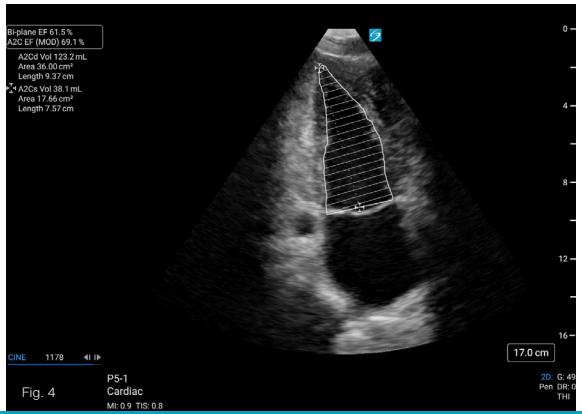

Fig. 4

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STROKE VOLUME (SV) AND CARDIAC OUTPUT (CO)

SV is the amount of blood ejected from the ventricle with each heartbeat.
CO is the amount of blood ejected from the ventricle per minute.

CO and SV values can both be used to evaluate how effectively the heart is meeting the demands of the human body, aiding in the assessment of the Left Ventricular (LV) systolic function and the overall volume status. CO is a more comprehensive evaluation, because it is adjusted for Heart Rate (HR). SV is more specific in evaluating systolic function, because it does not include HR.

$SV = (LVOT\ D)^2 \times 0.785 \times LVOT\ VTI$
$CO = SV \times HR.$

Measurements:

- Left Ventricular Outflow Tract Diameter (LVOT D)
- Left Ventricular Outflow Tract Velocity Time Integral (LVOT VTI)
- Heart Rate (HR)

Use the Cardiac exam type to perform the SV measurement:

- Obtain a Parasternal Long Axis (PLAX) view.
- Freeze ❄, and cine scroll to mid-systole when the aortic valve is at its widest excursion.
- Press Calcs.
- Select LVOT D, and measure at the insertion of the aortic valve leaflets (Fig. 1).

Fig. 1

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CARDIAC

STROKE VOLUME (SV) AND CARDIAC OUTPUT (CO)

- Save image.
- Obtain an Apical 5 Chamber (A5C) view (Fig. 2).
- Press D to activate the Pulsed Wave Doppler (PWD) gate, and place it in the LVOT at the insertion of the aortic valve leaflets - the same location that the LVOT D was measured (Fig. 2).
- Press D or Update to start the Doppler spectral trace. When in the correct location, the aortic valve closing click can be visualized on the spectral display (Fig 3).
- Freeze after a full spectral display.
- Press Calcs, select LVOT VTI, and trace the systolic waveform (Fig. 3). It is best to average 3 tracings, or 5 tracings if the patient has any arrhythmias.
- Save image.
- To see the averaged calculation for multiple saved measurements, access the patient report page.

To add CO:

- Select HR CO, and use the two goalposts to mark the beginning of systole for the traced waveform and the beginning of systole for the next waveform (Fig. 3).
- Save image.

Because of the differences in body size of patients, it is useful to index both SV and CO by dividing the calculation result by the Body Surface Area (BSA). Enter the patient's height and weight in Patient Information, under the More Exam Info menu.

These measurements can also be done by using Assisted Cardiac Output (ACO). Please see ACO Quick Guide for more information.

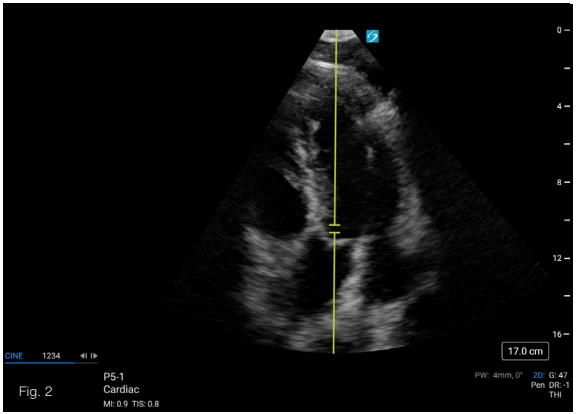

Fig. 2

Fig. 3

Arrow: Closing Click
Proper sample volume placement should include visualization of the closing click. If the closing click is not seen, move the sample gate towards the valve. If an opening click is seen, move the sample gate towards the ventricle.

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ASSISTED CARDIAC OUTPUT (ACO)

ACO removes steps and complexity from the manual Cardiac Output (CO) workflow.

CO can be used to assess how effectively the heart is meeting the demands of the human body and can aid in the evaluation of the left ventricular systolic function and volume status changes. CO is a more comprehensive evaluation compared to traditional surrogates such as Left Ventricular Outflow Tract Velocity Time Integral (LVOT VTI) or Stroke Volume (SV), because CO adjusts for Heart Rate (HR). ACO can be performed from a live or frozen image. Additionally, ACO may be used to quickly evaluate volume status changes with methods such as a passive leg raise or fluid challenge.

CO = SV x HR.

Measurements:

- Left Ventricular Outflow Tract Diameter (LVOT D)
- Cardiac Output (CO)
- Post CO

To use ACO, LVOT D must be measured and saved prior to LVOT Doppler trace.

Use the Cardiac exam type to perform the CO measurement:

- Obtain a Parasternal Long Axis (PLAX) view.
- Freeze ❄, and cine scroll to mid-systole when the aortic valve is at its widest excursion.
- Press Calcs.
- Select LVOT D, and measure at the insertion of the aortic valve leaflets (Fig. 1).
- Save image 📷.
- Obtain an Apical 5 chamber (A5C) view (Fig. 2).
- Press D to activate the Pulsed Wave Doppler (PWD) gate, and place it in the LVOT at the insertion of the aortic valve leaflets - the same location where the LVOT D was measured (Fig. 2).

Fig. 1

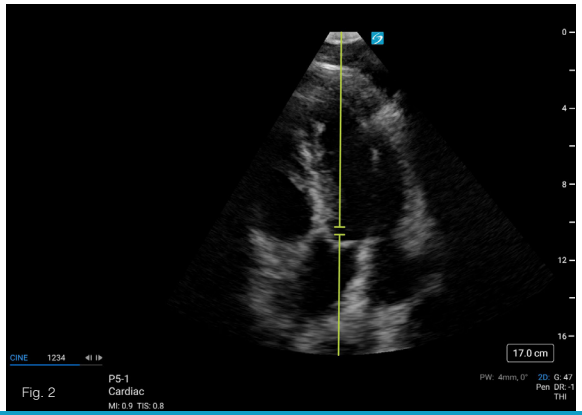

Fig. 2

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ASSISTED CARDIAC OUTPUT (ACO)

- Press D or Update to start the Doppler spectral trace. When in the correct location, the aortic valve closing click can be visualized on the spectral display.
- Press Calcs. CO, SV, VTI, and HR will update on the screen in live PWD.
- Freeze ❄ after obtaining a full spectral display.
- If needed, adjust the start and end points of the trace (Fig 3).
- Review the traced waveforms, and confirm each of the accurately traced waveforms (Fig. 3).
- Save image 📷.
- To see the averaged CO for multiple saved waveforms, access the patient report page.

When more than two confirmed measurements are saved, the VTI % variation will be displayed. Be sure to include both the maximum and minimum waveforms across a respiratory cycle for accurate results (Fig 4).

To then calculate a % change:

- Perform a fluid challenge or a maneuver such as a passive leg raise.
- Repeat the prior steps using the Post CO measurement.
- Save image 📷.

Because of the differences in body size of patients, it is useful to index both SV and CO by dividing the calculation result by the Body Surface Area (BSA). Enter the patient's height and weight in Patient Information under the More Exam Info menu.

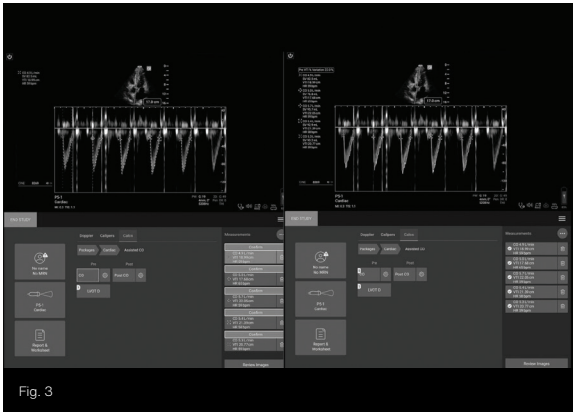

Fig. 3

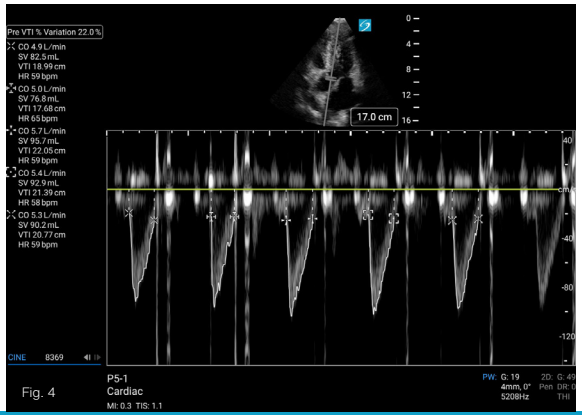

Fig. 4

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VOLUME STATUS: PERCENT CHANGE

Percent Change is a method used to help determine how responsive a patient may be to fluid administration and should be used in conjunction with other clinical indications.

First, calculate Cardiac Output (CO), Stroke Volume (SV), or Velocity Time Integral (VTI) at baseline. Then, perform a fluid challenge or a maneuver such as a passive leg raise. Finally, repeat the same calculation to compare with the baseline. A notable percent change in VTI, SV, or CO after fluid bolus or maneuver may suggest a higher probability of fluid response. Assisted CO (ACO) can also be used to simplify and expedite this workflow.

The quickest way to calculate the Percent Change is to measure Pre and Post using the LVOT VTI only. However, you can add LVOT D and HR to calculate SV and/or CO Percent Change.

Measurements:

- Left Ventricular Outflow Tract Diameter (LVOT D)
- Left Ventricular Outflow Tract Velocity Time Integral (LVOT VTI)
- Heart Rate (HR)

First, use the Cardiac exam type to measure the LVOT D, which is needed for SV or CO:

- Obtain a Parasternal Long Axis (PLAX) view (Fig. 1).
- Freeze ❄, and cine scroll to mid-systole when the aortic valve is at its widest excursion.
- Press Calcs.
- Select LVOT D, and measure at the insertion of the aortic valve leaflets (Fig. 1).
- Save image 📷.

Fig. 1

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VOLUME STATUS: PERCENT CHANGE

Next, calculate a Percent Change using a Passive Leg Raise (PLR) maneuver (see reference):

Start by placing the patient in a semi-recumbent position with the head of the bed 30-45° above the horizontal.

- Obtain an Apical 5 Chamber (A5C) view.
- Press D to activate the Pulsed Wave Doppler (PWD) gate, and place it in the LVOT at the insertion of the aortic valve leaflets - the same location that the LVOT D was measured (Fig. 2).
- Press D or Update to start the Doppler spectral trace. When in the correct location, the aortic valve closing click can be visualized on the spectral display (Fig 3).
- Freeze ❄ after a full spectral display.
- Press Calcs.
- Select Pre LVOT VTI, and trace the systolic waveform (Fig. 3).
- If calculating CO, select Pre HR, and adjust the goalposts to mark the start of systole of the traced waveform and the start of systole of the next waveform.
- Save image 📷.

Then, quickly adjust the bed to simultaneously elevate the lower limbs to 30-45° above the horizontal while lowering the head of the bed to 0 (supine). CO changes can be detected 1–2 minutes after the PLR maneuver.

- Repeat the prior steps using the Post LVOT VTI and Post HR measurements.

Because of the differences in body size of patients, it is useful to index both SV and CO by dividing the calculation result by the Body Surface Area (BSA). Enter the patient's height and weight in Patient Information under the More Exam Info menu.

Reference:
Boyd, J. et. al. (2016, December) Echocardiography as a guide for fluid management. Critical Care. https://www.researchgate.net/publication/307594435_Echocardiography_as_a_guide_for_fluid_management

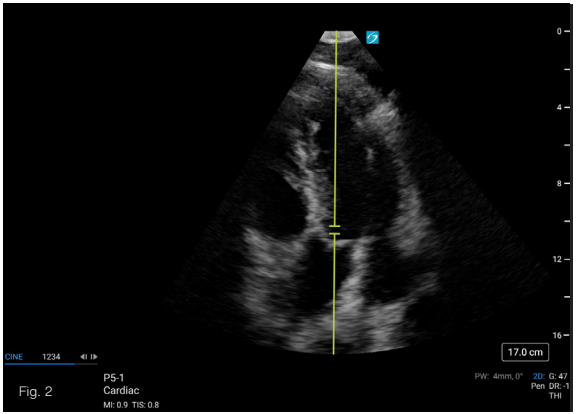

Fig. 2

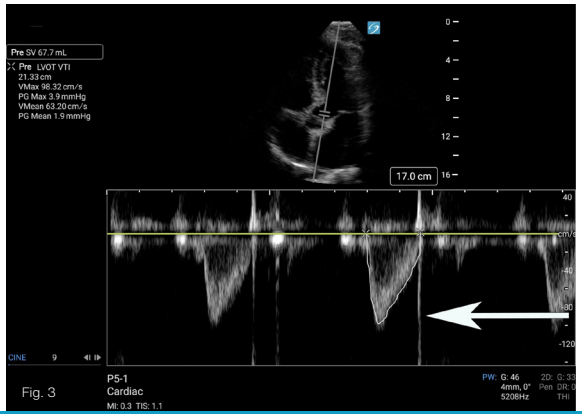

Fig. 3

Arrow: Closing Click
Proper sample volume placement should include visualization of the closing click. If the closing click is not seen, move the sample gate towards the valve. If an opening click is seen, move the sample gate towards the ventricle.

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VOLUME STATUS: PERCENT VARIATION

Percent Variation can be used to help assess a mechanically ventilated patient's volume status. It is calculated by comparing the change of Stroke Volume (SV) between inspiration and expiration using a single respiratory cycle. LVOT VMax variation or LVOT VTI variation can be used as surrogates for SV variation for a quick evaluation. The predictable shifts in pressure caused by mechanical ventilation affects the SV, but the degree of SV variation is dependent on the patient's volume status. When in a normovolemic state, there is little SV variation with inspiration and expiration compared to a hypovolemic state where there is greater SV variation. Assisted Cardiac Output (ACO) can also be used to simplify and expedite this workflow.

The quickest way to calculate the Percent Variation is to measure Min and Max LVOT Vmaxes only. However, you can trace the LVOT VTI instead or add the LVOT D to calculate SV Percent Variation.

Measurements:

- Maximum Left Ventricular Outflow Tract Maximum Velocity (Max LVOT VMax)
- Minimum Left Ventricular Outflow Tract Maximum Velocity (Min LVOT VMax)
- Maximum Left Ventricular Outflow Tract Velocity Time Integral (Max LVOT VTI)
- Minimum Left Ventricular Outflow Tract Velocity Time Integral (Min LVOT VTI)
- Left Ventricular Outflow Tract Diameter (LVOT D)

Use the Cardiac exam type to calculate an SV % Variation.

First, measure the LVOT D:

- Obtain a Parasternal Long Axis (PLAX) view (Fig. 1).
- Freeze ❄, and cine scroll to mid-systole when the aortic valve is at its widest excursion.
- Press Calcs.
- Select LVOT D, and measure at the insertion of the aortic valve leaflets (Fig. 1).
- Save image 📷.

Fig. 1

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VOLUME STATUS: PERCENT VARIATION

To calculate VTI % Variation or SV % Variation when combined with prior LVOT D steps:

- Obtain an Apical 5 Chamber (A5C) view.
- Press D to activate the Pulsed Wave Doppler (PWD) gate, and place it in the LVOT at the insertion of the aortic valve leaflets - the same location that the LVOT D was measured (Fig. 2).
- Press D or Update to start the Doppler spectral trace. When in the correct location, the aortic valve closing click can be visualized on the spectral display (Fig 3).
- Adjust the sweep speed to display an entire respiratory cycle on the spectral display. A slow sweep speed may be helpful.
- Freeze ❄.
- Press Calcs.
- Find the waveform with the maximum velocity during mechanical inspiration.
- Select Max LVOT VTI, and trace the systolic waveform (Fig. 3).
- Find the waveform with the minimum peak velocity during mechanical expiration.
- Select Min LVOT VTI, and trace the systolic waveform (Fig. 3).
- Save image 📷.

To calculate VMax % Variation:

- Perform the steps above using the Max LVOT VMax and Min LVOT VMax measurements to mark the maximum and minimum peak systolic velocities (Fig. 3).

Reference:
Miller, A. et. al. (2016, June) Predicting and Measuring Fluid Responsiveness with Echocardiography. Echo Research and Practice. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4989101/

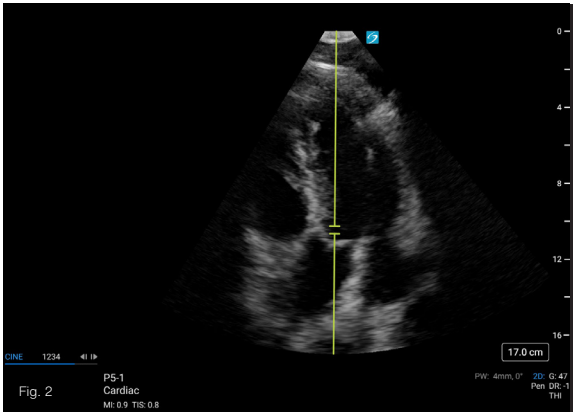

Fig. 2

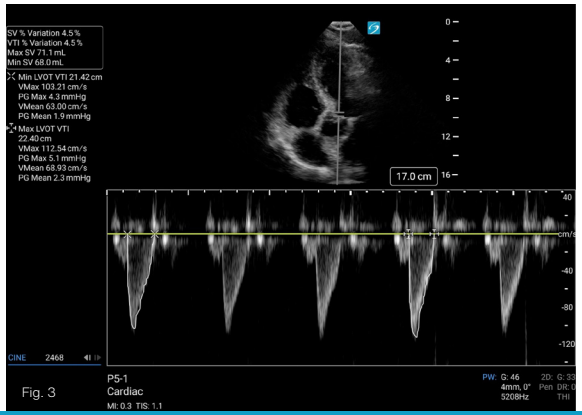

Fig. 3

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IVC DISTENSIBILITY INDEX

The Inferior Vena Cava (IVC) distensibility index is measured in mechanically ventilated patients.

During mechanical ventilation, the movement of the IVC is opposite of a spontaneously breathing patient; the IVC diameter increases with positive inspiratory pressures. The amount of distension can be measured to help assess volume status and to aid in predicting fluid responsiveness.

Distensibility Index = (Max IVC Diameter – Min IVC Diameter) / Min IVC Diameter X 100.

Measurements:

- IVC Maximum Diameter (IVC Max D)
- IVC Minimum Diameter (IVC Min D)

Use the Cardiac exam type to perform Distensibility Index in M-Mode:

- This can be performed on a mechanically ventilated patient.
- Obtain a subxiphoid (subcostal) view of the IVC in the long axis as it enters the Right Atrium (RA). The maximum dimension of the IVC should be visualized (Fig. 1).
- Press M to activate the M-Mode cursor, and place it through the IVC about 1-2 cm from the RA, ensuring it is perpendicular to the long axis of the IVC (Fig. 1).
- Press M or Update to start the M-Mode trace.
- Adjust the sweep speed to display an entire respiratory cycle on the M-Mode display. A slow sweep speed may be helpful.
- Freeze ❄ the image after a full M-Mode display.

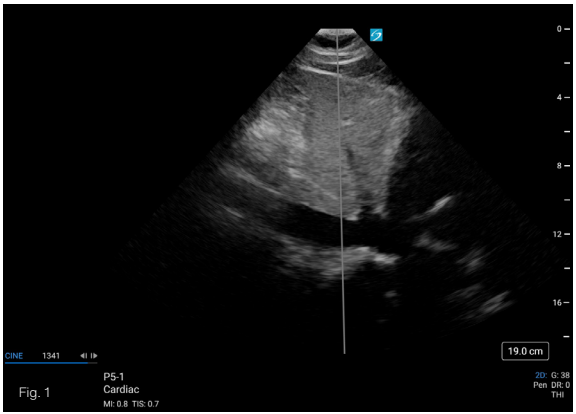

Fig. 1

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IVC DISTENSIBILITY INDEX

- Under Distensibility, select IVC Max D to measure the maximum diameter during inspiration (Fig. 2).
- Under Distensibility, select IVC Min D to measure the minimum diameter during expiration (Fig. 2).
- Save image.

Use the Cardiac exam type to perform Distensibility Index in 2D:

- Obtain a subxiphoid (subcostal) view of the IVC in the long axis as it enters the RA. The maximum dimension of the IVC should be visualized.
- Freeze the image after visualizing at least one respiratory cycle.
- Cine scroll to expiration.
- Press Calcs.
- Under Distensibility, select IVC Max D, and measure the maximum diameter during inspiration about 1-2 cm from the RA.
- Save image.
- Cine scroll to inspiration.
- Under Distensibility, select IVC Min D, and measure the minimum diameter during expiration about 1-2 cm from the RA.
- Save image.

Distensibility Index > 18% may be suggestive of a higher probability of fluid responsiveness.

Reference:
Barbier, C., et al. (2004, March 18) The system shall provide distensibility index of IVC (dIVC) based on "Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients." Intensive Care Med. https://doi.org/10.1007/s00134-004-2259-8

Fig. 2

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IVC COLLAPSE

The Inferior Vena Cava (IVC) collapse is measured in spontaneously breathing patients.

IVC size and collapsibility can aid in the assessment of conditions such as shock, sepsis, hypovolemia, heart failure, and other abnormal volume states. For example, a small, flattened IVC may be suggestive of reduced central venous pressure (CVP) and/or hypovolemia. Conversely, a distended, non-collapsible IVC may be suggestive of elevated CVP and/or hypervolemia. IVC collapse can aid in the estimation of Right Atrial Pressure (RAP) but is less reliable when there are intermediate or inconclusive findings.

IVC Collapse = (Max IVC Diameter – Min IVC Diameter) / Max IVC Diameter X 100

Measurements:

- IVC Maximum Diameter (IVC Max D)
- IVC Minimum Diameter (IVC Min D)

Use the Cardiac or Abdomen exam type to perform IVC Collapse in M-Mode:

- Obtain a subxiphoid (subcostal) view of the IVC in the long axis as it enters the Right Atrium (RA). The maximum dimension of the IVC should be visualized (Fig. 1).
- Press M to activate the M-Mode cursor, and place it through the IVC about 1-2 cm from the RA, ensuring it is perpendicular to the long axis of the IVC (Fig. 1). Press M or Update to start the M-Mode trace.
- Advise the patient to sniff, if able.
- Adjust the sweep speed to display the sniff or an entire respiratory cycle on the M-Mode display. A slow sweep speed may be helpful.
- Freeze ❄ the image after a full M-Mode display.
- Press Calcs.
- Under IVC Collapse, select IVC Max D, and measure the maximum diameter during expiration (Fig. 2).
- Under IVC Collapse, select IVC Min D, and measure the minimum diameter during the sniff (inspiration) (Fig. 2).
- Save image 📷.

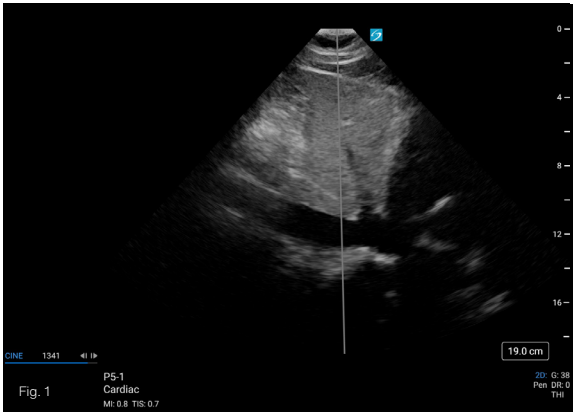

Fig. 1

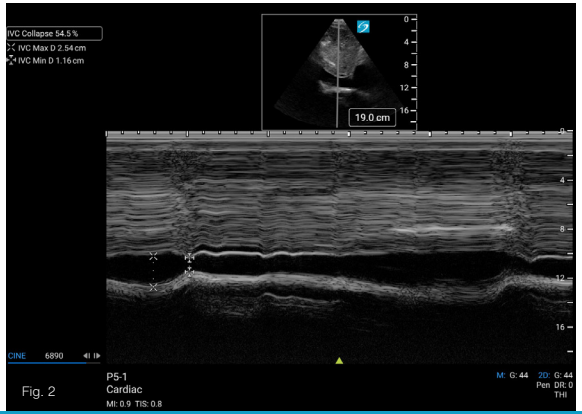

Fig. 2

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IVC COLLAPSE

Use the Cardiac or Abdomen exam type to perform IVC Collapse in 2D:

- Obtain a subxiphoid (subcostal) view of the IVC in the long axis as it enters the RA. The maximum dimension of the IVC should be visualized.
- Advise the patient to sniff, if able.
- Freeze ❄ the image after visualizing the sniff or at least one respiratory cycle.
- Cine scroll to expiration - the frame with the largest IVC dimension.
- Press Calcs.
- Under IVC, select IVC Max D, and measure the maximum diameter during expiration about 1-2 cm from the RA.
- Save image 📷.
- Cine scroll to the sniff (inspiration) - the frame with the smallest IVC dimension.
- Under IVC, select IVC Min D, and measure the minimum diameter during inspiration about 1-2 cm from the RA.
- Save image 📷.

IVC size and collapsibility may aid in the evaluation of RAP:

IVC Size	Percent (%) Collapse with sniff	RAP
<2.1 cm	**>50%**	**3 mmHg (0-5 mmHg)**
>2.1 cm	**<50%**	**15 mmHg (10-20 mmHg)**

When findings do not fit this paradigm, an intermediate value of 8 mmHG (5-10 mmHg) may be used. However, it is recommended other indices of RAP should be used to upgrade or downgrade the intermediate RAP value.

Reference:
Lang, R. et. al. (2015, Jan). Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext

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ATRIAL VOLUME

Atrial volume of the left and right atria can be measured to assess cardiac function and evaluate for certain cardiac pathologies.

Atrial enlargement may be suggestive of cardiovascular diseases such as atrial fibrillation, valvular disorders, hypertension, heart failure, and other cardiomyopathies. The indexed left atrial biplane volume is part of diastolic function evaluation.

The Right Atrial (RA) and Left Atrial (LA) volumes can be performed using the method of disks. The RA volume is performed using a single plane, Apical 4 Chamber (A4C) view. For LA volume calculations, it is recommended to measure the LA in both the A4C and the Apical 2 Chamber (A2C) views to create an LA biplane volume. Once these RA and LA volumes are obtained, it is recommended to use the indexed values by entering the patient's height and weight.

Measurements:

- Left Atrial Volume from the Apical 4 Chamber view (LA Vol A4C)
- Left Atrial Volume from the Apical 2 Chamber view (LA Vol A2C)
- Right Atrial Volume from the Apical 4 Chamber view (RA Vol A4C)

Use the Cardiac exam type to perform a biplane left atrial volume:

- Obtain an A4C view that does not foreshorten the atrium.
- Freeze ❄ after visualizing at least one cardiac cycle.
- Cine scroll to the end of ventricular systole, just prior to mitral valve opening where the atrium is at its largest.
- Press Calcs, and select LA Vol A4C.
- Trace the LA from one annulus around to the other annulus. Do not include the pulmonary veins or the LA appendage in the tracing. Adjust the chamber length axis as needed (Fig. 1).
- Save image 📷.

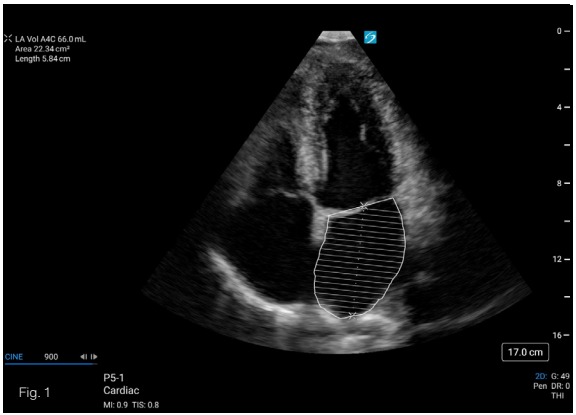

Fig. 1

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ATRIAL VOLUME

- Obtain an A2C view that does not foreshorten the atrium.
- Select the LA Vol A2C measurement, and trace the LA using the technique outlined above (Fig. 2).
- Save image.
- To calculate an LA volume index, enter the patient's height and weight into Patient Information under the More Exam Info menu.

Normal indexed LA volume range for men and women: 16-34 mL/m².

Use the Cardiac exam type to perform a single plane RA volume:

- Obtain an A4C view that does not foreshorten the atrium.
- Freeze after visualizing a full cardiac cycle.
- Cine scroll to the end of ventricular systole where the RA is the largest.
- Press Calcs, and select RA Vol.
- Trace the RA from one annulus around to the other annulus, excluding the surrounding structures (Fig. 3).
- Save image.
- To calculate an RA volume index, enter the patient's height and weight into Patient Information under the More Exam Info menu.

Normal indexed RA volume range in men: 25 +/- 7 mL/m²

Normal indexed RA volume range in women: 21 +/- 6 mL/m²

Reference:
Lang, R. et. al. (2015, Jan). Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext

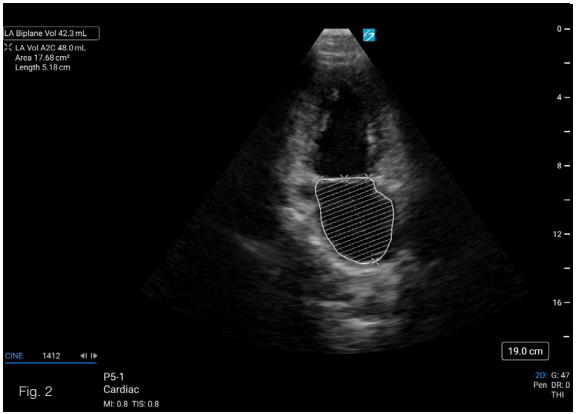

Fig. 2

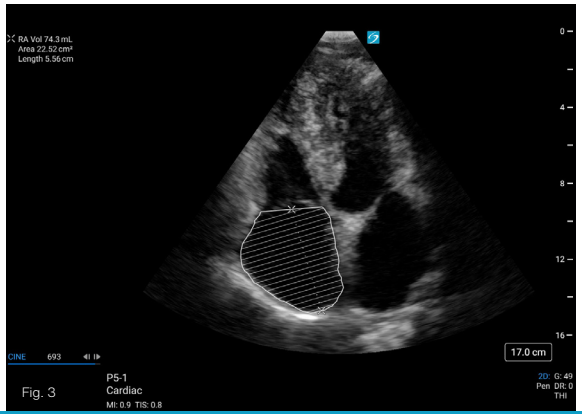

Fig. 3

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TISSUE DOPPLER IMAGING (TDI)

TDI is optimized for lower tissue velocities.

- E' and a' can be used to evaluate cardiac function. For a more comprehensive assessment, measure from multiple locations (i.e., septal and lateral).
- E/e' can be useful in the assessment of diastolic function. This ratio compares the TDI e' measurement to Pulsed Wave Doppler (PWD) mitral valve inflow (E).
- RV s' can be used in the evaluation of right ventricular systolic function by measuring the right ventricular annular movement with TDI.

Measurements:

- e' (e prime) – Early diastolic peak velocity
- a' (a prime) – Late diastolic peak velocity
- s' (s prime) – Systolic peak velocity

Use the Cardiac exam type to perform the Septal e' and a' measurements:

- Obtain an Apical 4 Chamber (A4C) view.
- Press D to activate the PWD gate.
- On the touchscreen, change the Doppler mode to Tissue Doppler imaging (TDI) using imaging controls. TDI is only available in Cardiac exam types.
- Place the sample gate on the septum near the mitral valve annulus (Fig. 1). When placing the sample gate, the cursor should be aligned with the associated basal wall segment. Press D or Update to start the Doppler spectral trace.
- Freeze ❄ after obtaining a full spectral display.
- Press Calcs.
- Select and measure the Sep e' and Sep a' velocities (Fig. 1).
- Save image 📷.

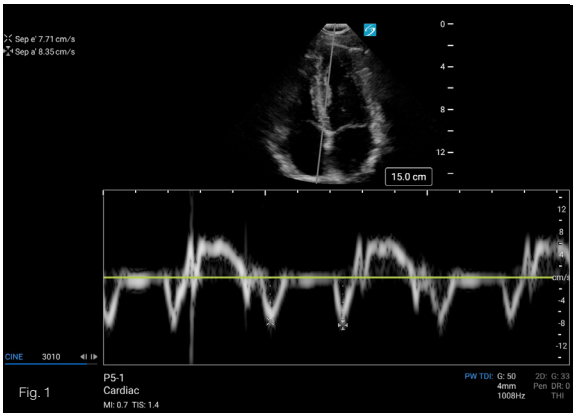

Fig. 1

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TISSUE DOPPLER IMAGING (TDI)

These steps can be repeated for the lateral (Lat e' and Lat a') wall by placing the sample gate on the lateral wall near the annulus (Fig. 2).

To measure the RV s', place the TDI sample gate near the tricuspid valve annulus on the right ventricular free wall. Measure the systolic velocity (Fig. 3).

S' velocity < 9.5 cm/s may be suggestive of RV systolic dysfunction.

Reference:

Nagueh, S. et. al. (2016, April 1) Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Journal of the American Society of Echocardiography. https://www.onlinejase.com/article/S0894-7317(16)00044-4/fulltext

Rudski, L. et. al. (2010, July) Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. Journal of the American Society of Echocardiography. https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext

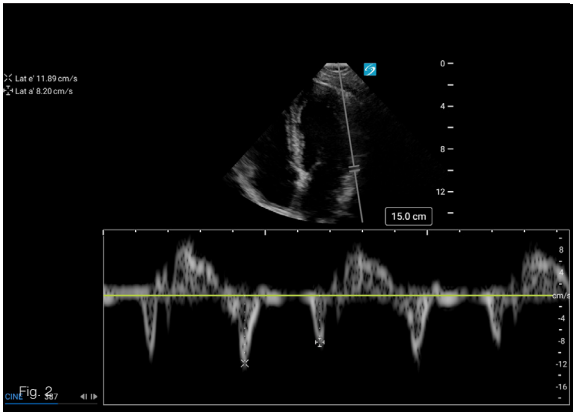

Fig. 2

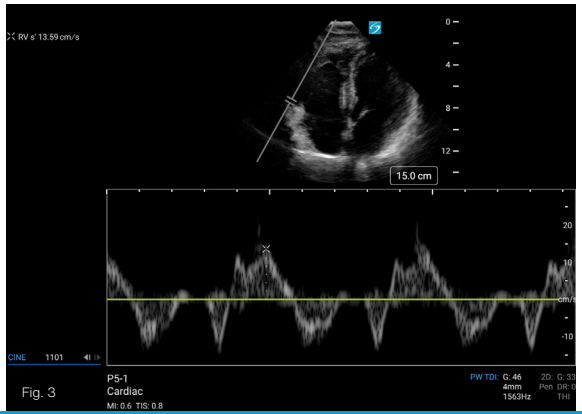

Fig. 3

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