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ACUSON Sequoia Ultrasound System

2D Heart^{AI}
3.5 (VB30)

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Objectives

- **Review cardiac strain principles**
- Explain image acquisition for cardiac strain
- Discuss 2D Heart^{AI} workflow
- Evaluate 2D Heart^{AI} analysis and report

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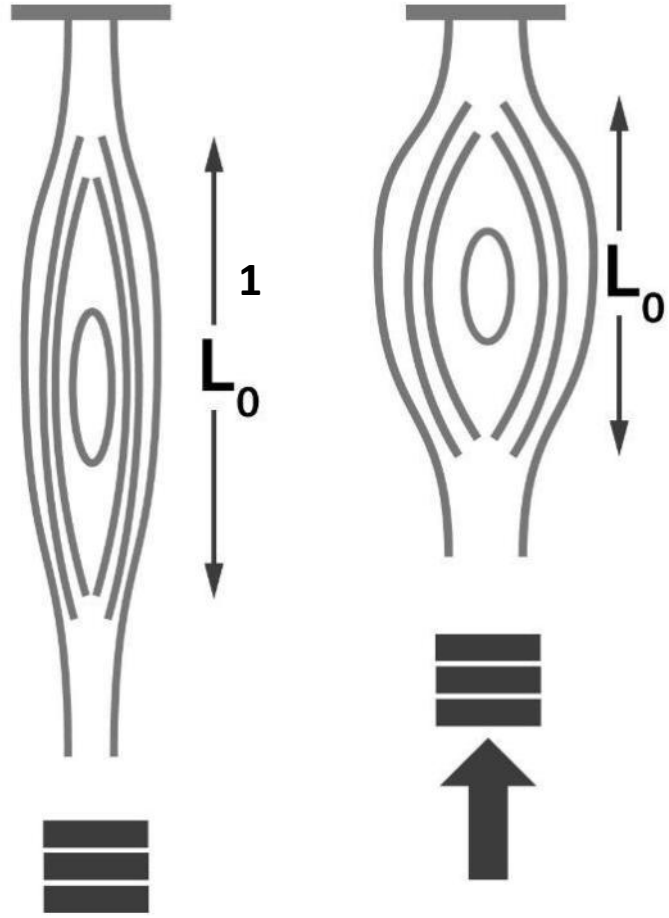
What is cardiac strain?

- Strain is a noninvasive technique which quantifies myocardial mechanics
- Strain is the change (deformation) in shape of a material (myocardium)
- Tracked via speckle-tracking echocardiography (STE)
- Expressed as percentage (%)
- Strain (€) = $\frac{L_1 - L_0}{L_0}$
- L_0 is length at baseline
- L_1 is length at a given point in time



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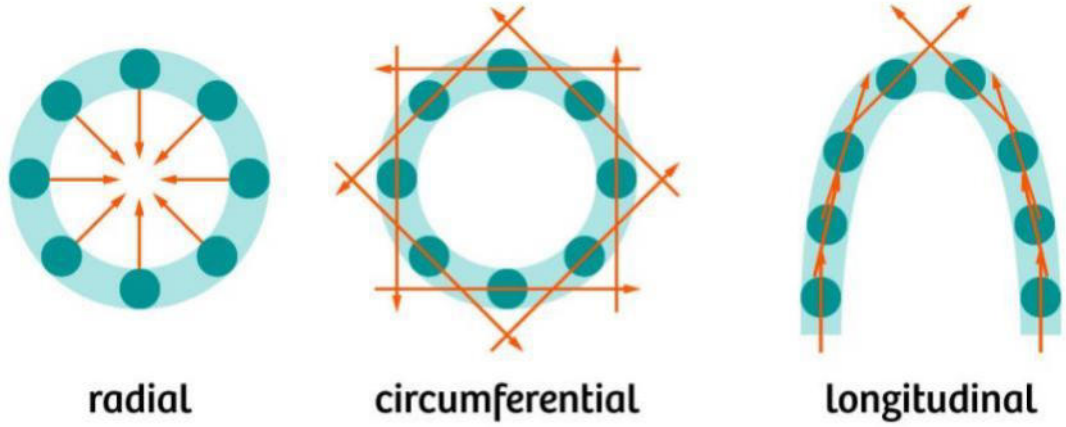
Three principles of left ventricular strain

- Radial or Transverse (47 ± 15%)[1]
  Global Radial Strain (GRS)
- Circumferential (-23 ± 3%)[1]
  Global Circumferential Strain (GCS)
- Longitudinal (-20 ± 3%)[1]
  Global Longitudinal Strain (GLS)



Sources | 1. Yingchoncharoen, Teerapat, et al., *JASE* (2013) 26: 185-91

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Parameters of myocardial function

Displacement

Displacement: distance that a certain feature, such as a speckle, has moved between two consecutive frames (cm)

Strain

Strain: describes myocardial deformation, or the fractional change in length of a myocardial segment (%)

Velocity

Velocity: reflects displacement per unit of time, or how fast the location of a feature changes (cm/s)

Strain Rate

Strain Rate: is the rate of change in strain and is expressed as 1/sec or sec-1

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Global longitudinal systolic strain (GLS)
Clinical relevance

- Studies suggest reduced strain is associated with mortality due to cardiovascular events
- GLS adds prognostic value in prediction of adverse cardiovascular outcomes

Prognostic value of global longitudinal strain in heart failure subjects: A recent prototype

Kumar Ashish [a], Mohammed Faisaluddin [b], Dhrubajyoti Bandyopadhyay [c,*], Adrija Hajra [d], Eyal Herzog [e]

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Heart failure (HF)

and HFpEF subgroups the strain has been found to have an important prognostic value that is independent of LVEF. Nonetheless, this study included only patients with acute heart failure, so it is unknown whether their findings would translate to those with chronic heart failure [3]. Another meta-analysis was done by Morris et al. with 2284 patients having HFpEF, and 2302 controls showed patients with HFpEF had significantly lower GLS than healthy subjects [4]. Another data pool collected from 16 studies (15 prospective and one retrospective) showed 1 SD change in absolute GLS was associated with decreased all-cause

Sources | *. Ashish, Kumar, et al., *IJC Heart & Vasculature* (2019) 22: 48-49

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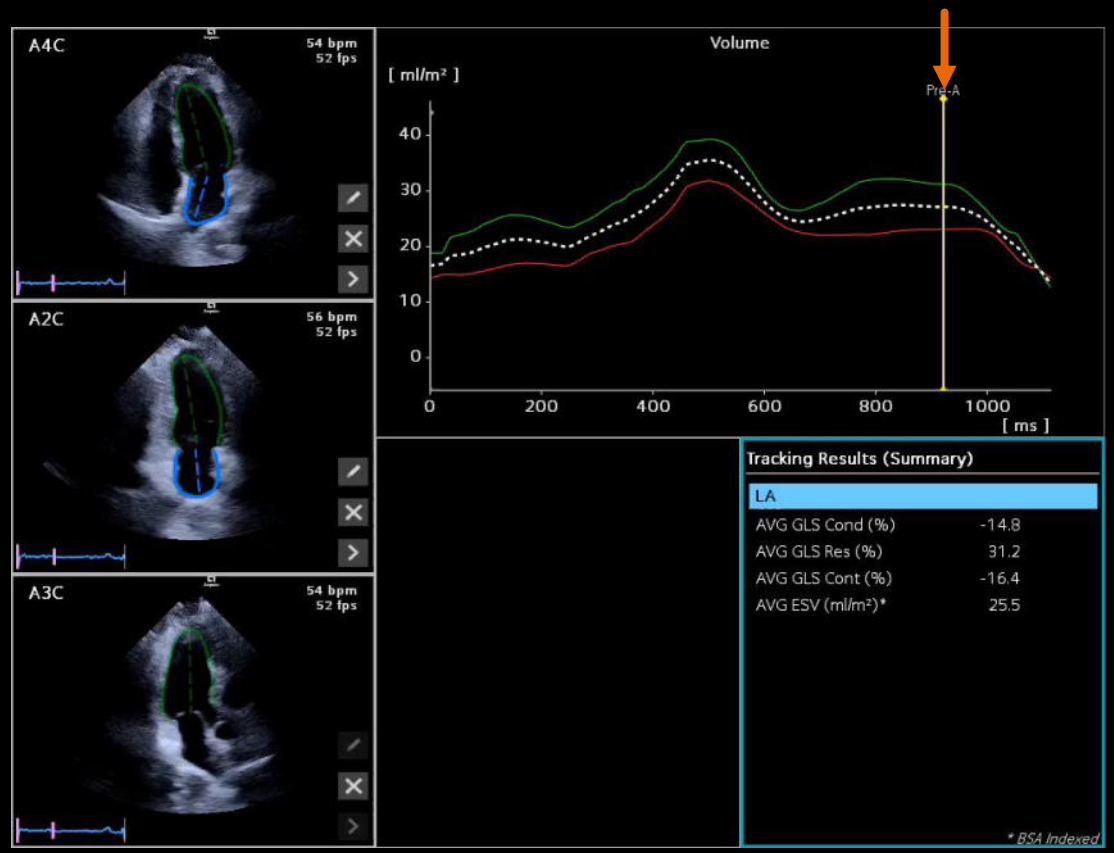
Left atrial strain

- Can potentially be used as an early indicator of diastolic dysfunction and elevated LV filling pressures*
- **Pre-A**: LA pre-systolic volume (just before the P wave on ECG) – higher number can indicate elevated LV filling pressures
- The following normal LA strain values were determined in a meta-analysis*
  - LASr: 39%
  - LAScd: -23%
  - LASct: -17%

Note: *Normal values are from studies performed on subjects with normal cardiac function and sinus rhythm.*



Sources | *. Espen Boe, Otto, et al., *European Heart Journal* (2022) 23;9: 1169-1170
*. Pathan, F., et al., *J Am Soc Echocardiography* (2017) 30; 1: 59-70

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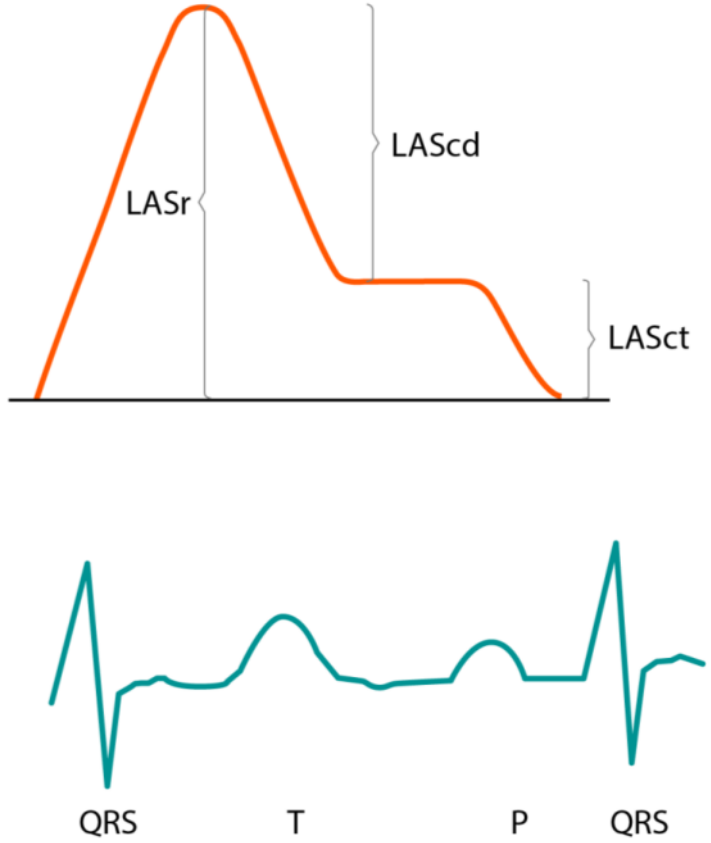
Left atrial strain phases

Left atrial strain consists of three phases*:

1. **Reservoir** (positive value) – left atrial filling during ventricular systole; also called the "peak" of LA strain and is measured at the end of the reservoir stage
2. **Conduit** (negative value) – passive emptying during early ventricular diastole; measured as the difference between peak reservoir and contractile strain
3. **Contraction** (negative value) – active emptying during late ventricular diastole; measured as the peak positive strain following the P wave (atrial contraction)



Sources | *. Gan, Gary C.H., et al., *JAHA* (2021) 10;1

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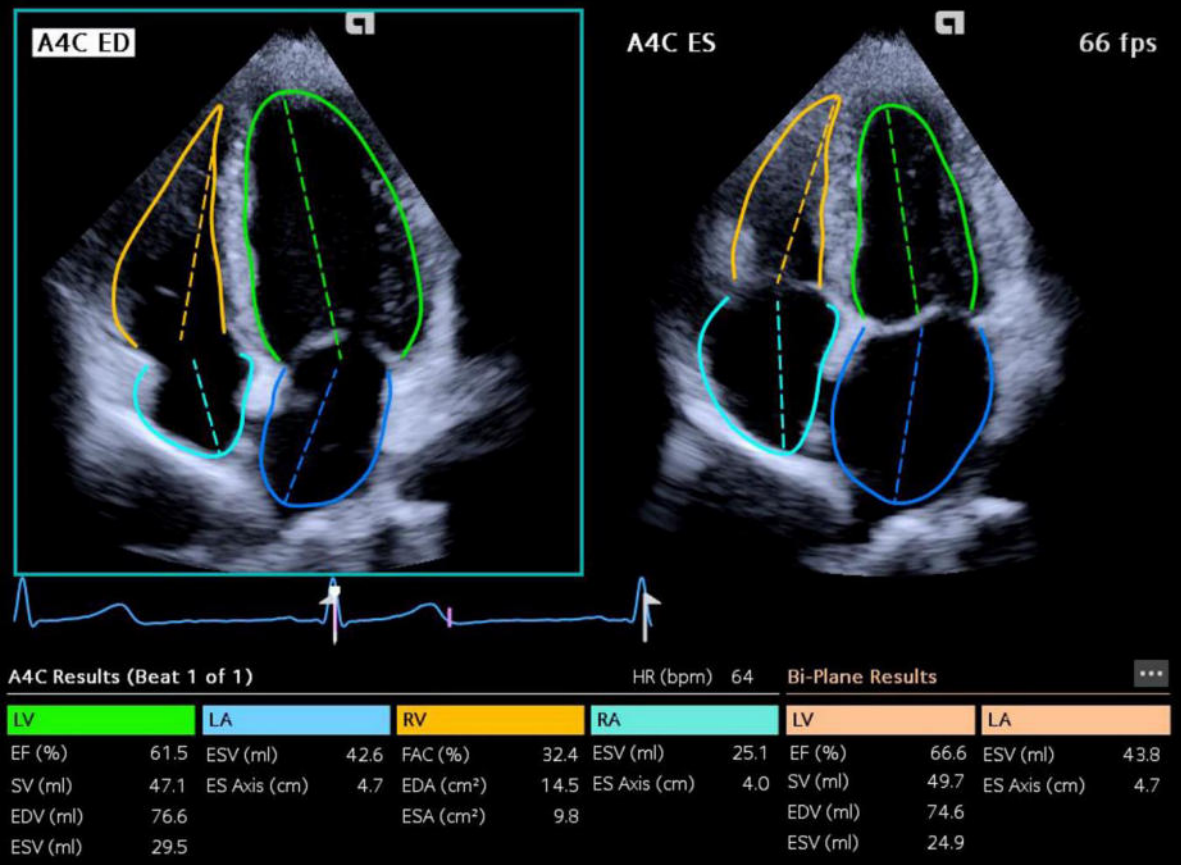
2D Heart^{AI} license

2D Heart (standard configuration): two-frame analysis only for LV, RV, LA, and RA

- Results include volumes, ejection fraction, cardiac output, stroke volume, area, and fractional area change (RV)
- Only ED and ES are contoured for analysis
- Analysis for up to five beats

Note: *Strain analysis (GLS) is not included in the standard configuration.*



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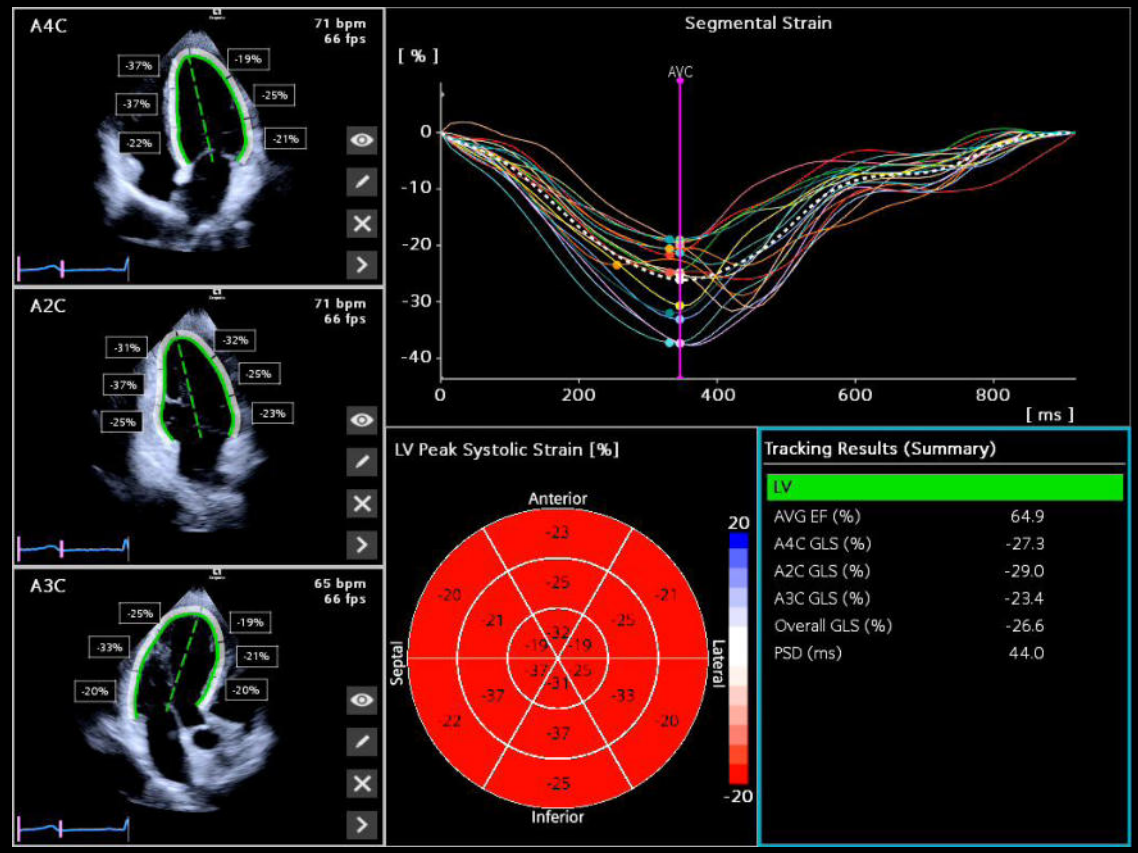
2D Heart^{AI}+ license

2D Heart^{AI}+ (full license): includes two-frame analysis and speckle tracking analysis

- Two-frame for LV, RV, LA, and RA
- Speckle tracking for LV and LA to include global longitudinal strain (every frame is tracked)
- Includes bullseye and curves



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Objectives

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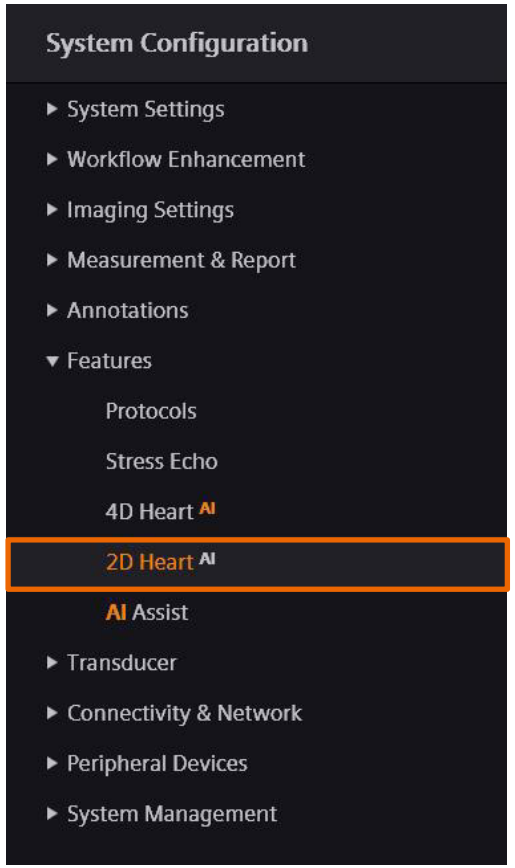
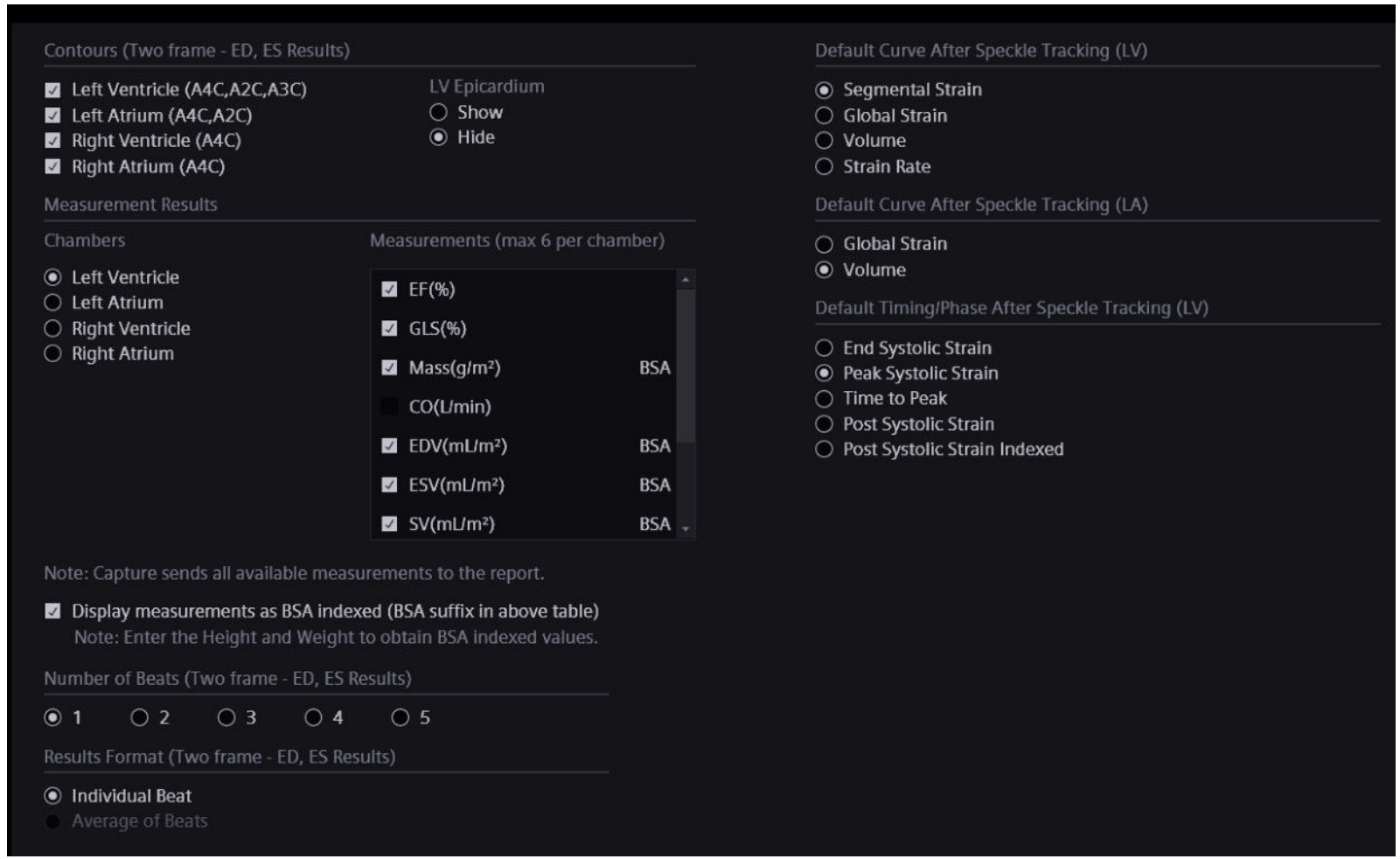
System configuration





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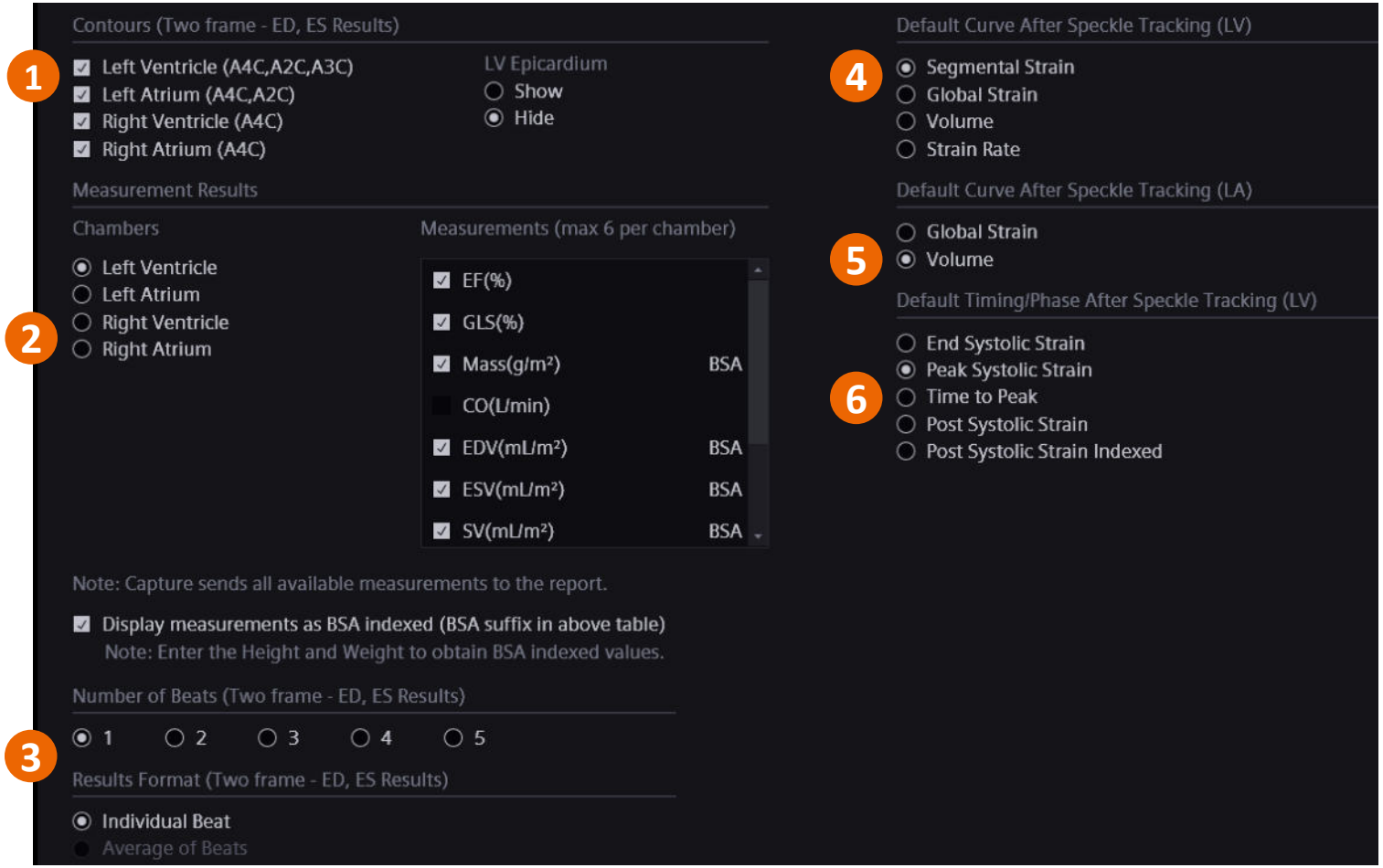
System configuration

1. **Contours** – select chambers to contour; select epicardium contour for LV
2. **Measurement Results** – select measurement results for each chamber
3. **Number of Beats** – select from options 1-5 and individual or average of beats
4. **Default Curve After Speckle Tracking for LV**
5. **Default Curve After Speckle Tracking for LA**
6. **Default Timing/Phase After Speckle Tracking for LV**



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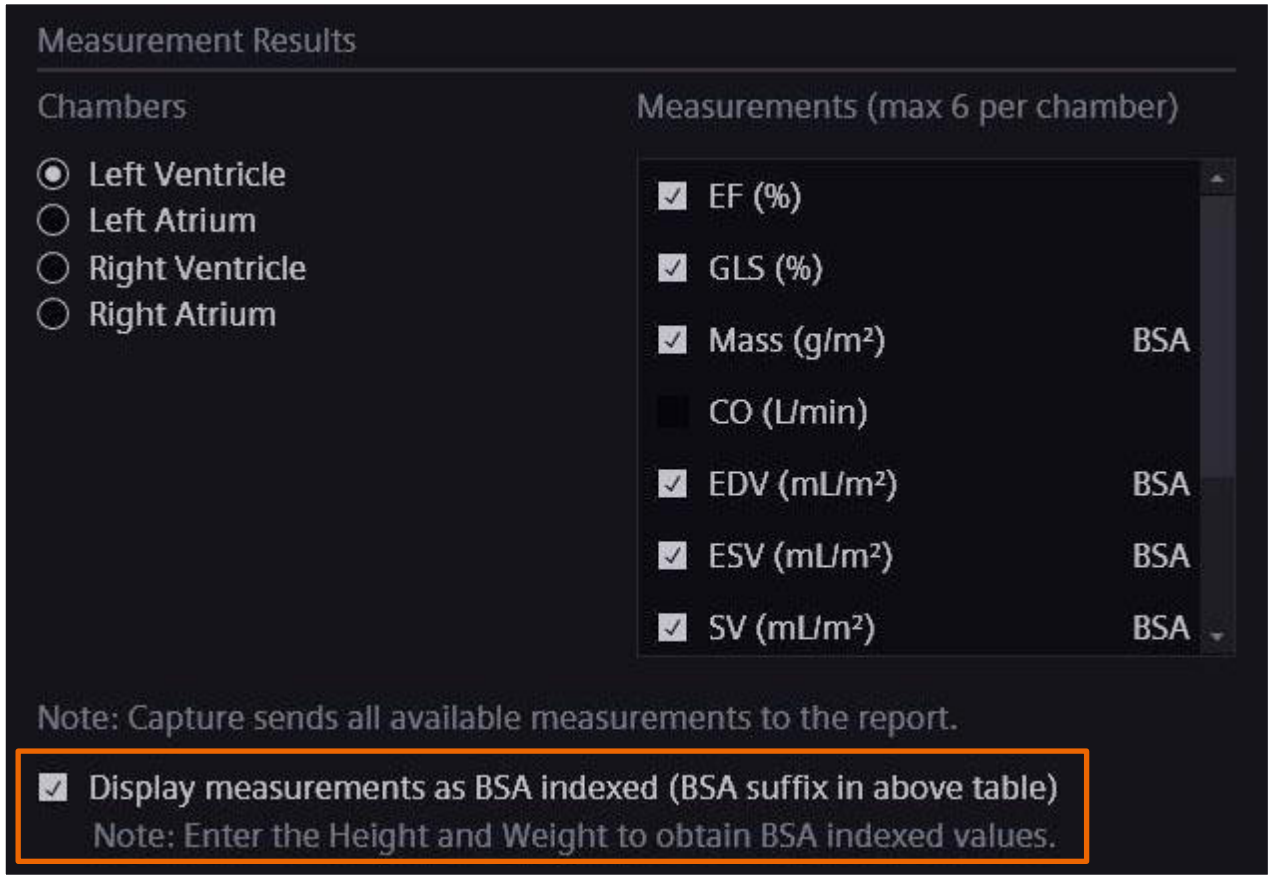
System configuration – LV chamber options



Measurements available for the left ventricle include:

- Ejection Fraction (EF)
- Global Longitudinal Strain (GLS)
- Mass
- Cardiac Output (CO)
- End Diastolic Volume (EDV)
- End Systolic Volume (ESV)
- Stroke Volume (SV)
- End Diastolic (ED) Axis
- End Systolic (ES) Axis

Note: *The maximum of 6 per chamber corresponds to values displayed on-screen on the ED-ES layout; all measured results will populate to the report.*

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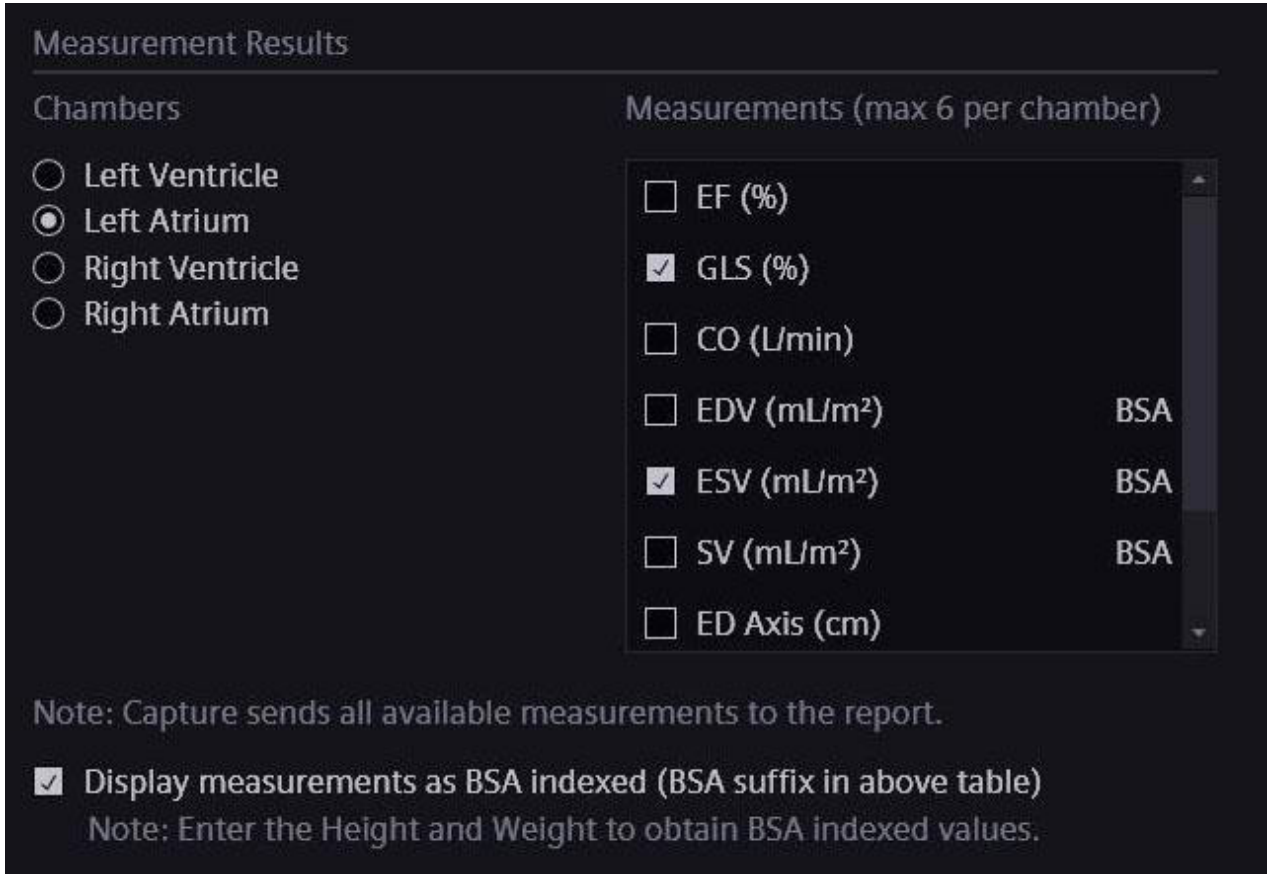
System configuration – LA chamber options



Measurements available for the left atrium include:

- Ejection Fraction (EF)
- Global Longitudinal Strain (GLS)
- Cardiac Output (CO)
- End Diastolic Volume (EDV)
- End Systolic Volume (ESV)
- Stroke Volume (SV)
- End Diastolic (ED) Axis
- End Systolic (ES) Axis

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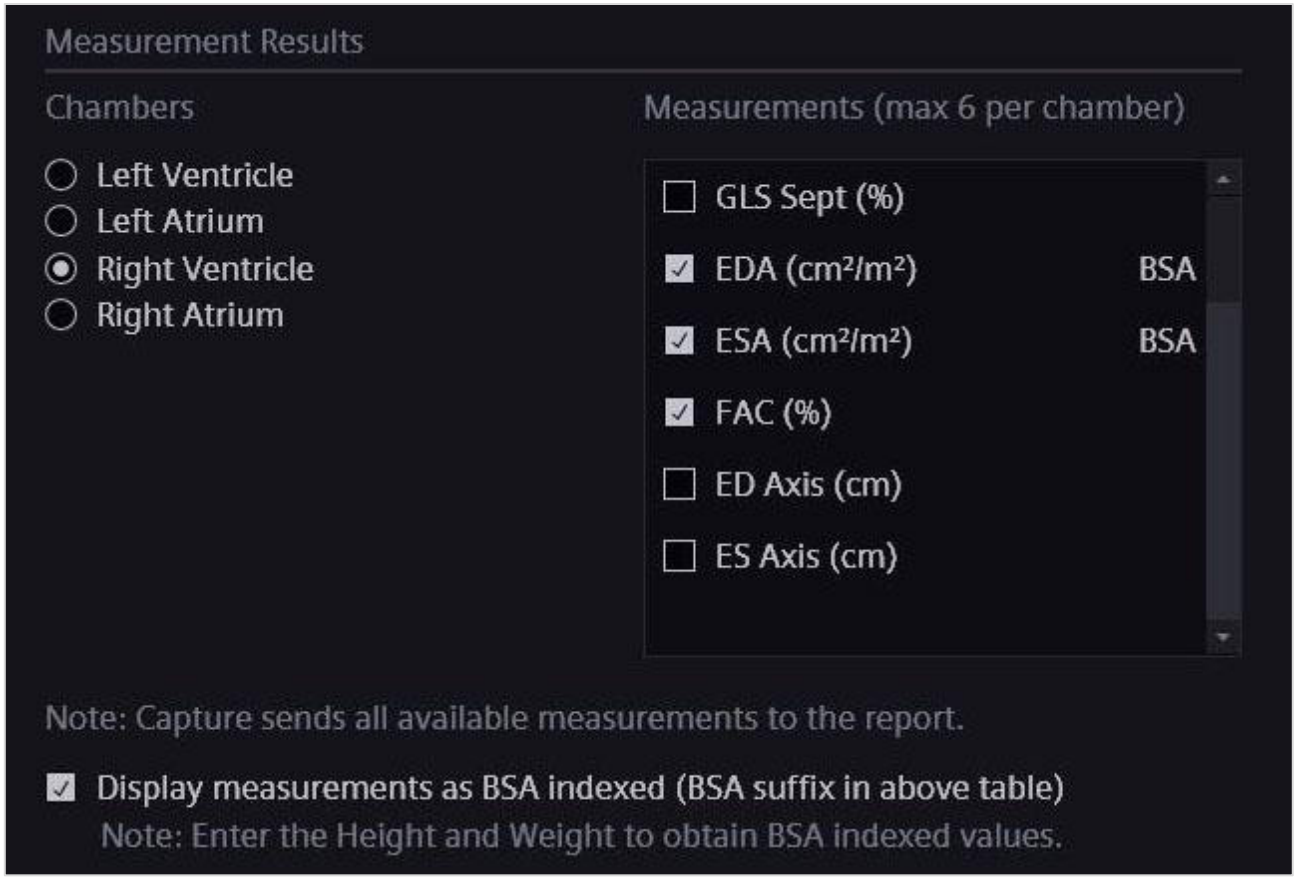
System configuration – RV chamber options



Measurements available for the left atrium include:

- Global Longitudinal Strain Sept (GLS)
- End Diastolic Area (EDA)
- End Systolic Area (ESA)
- Fractional Area Change
- End Diastolic (ED) Axis
- End Systolic (ES) Axis

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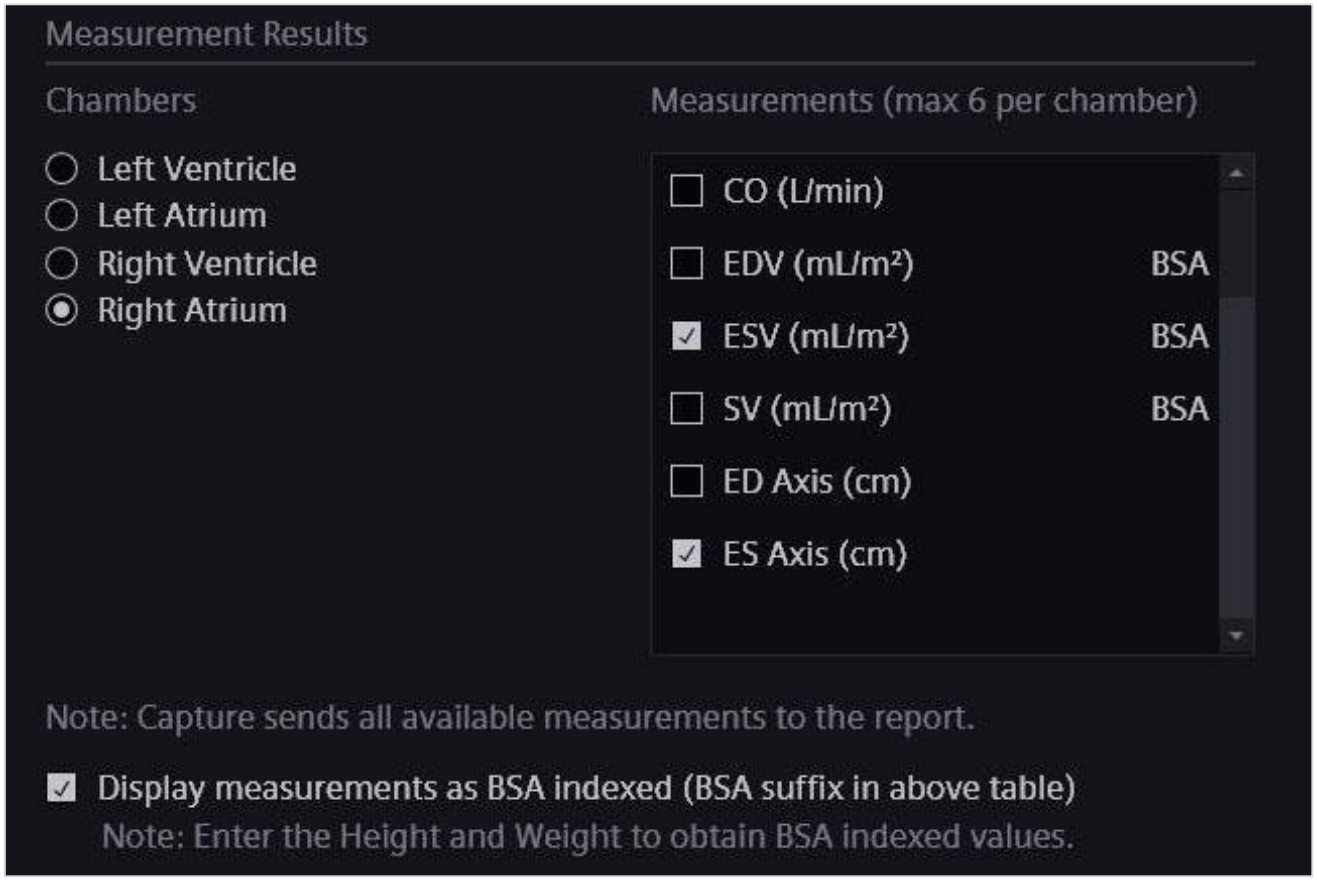
System configuration – RA chamber options



Measurements available for the left atrium include:

- Cardiac Output (CO)
- End Diastolic Volume (EDV)
- End Systolic Volume (ESV)
- Stroke Volume (SV)
- End Diastolic (ED) Axis
- End Systolic (ES) Axis

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Cardiac strain acquisition: physio vs. non-physio

Acquisition with ECG (physio)

- Use a beat capture – must have at least one full R-R capture
  - Acquire one extra beat or extended R-R acquisition
- Ensure ECG tracing is optimized and clear
- Multiple heart cycles can be analyzed and averaged (up to five)

Acquisition without ECG (non-physio)

- Use a time capture
- Only one beat can be analyzed
- Speckle tracking is still available for LV and LA
- ED/ES frames are detected as largest and smallest chamber sizes

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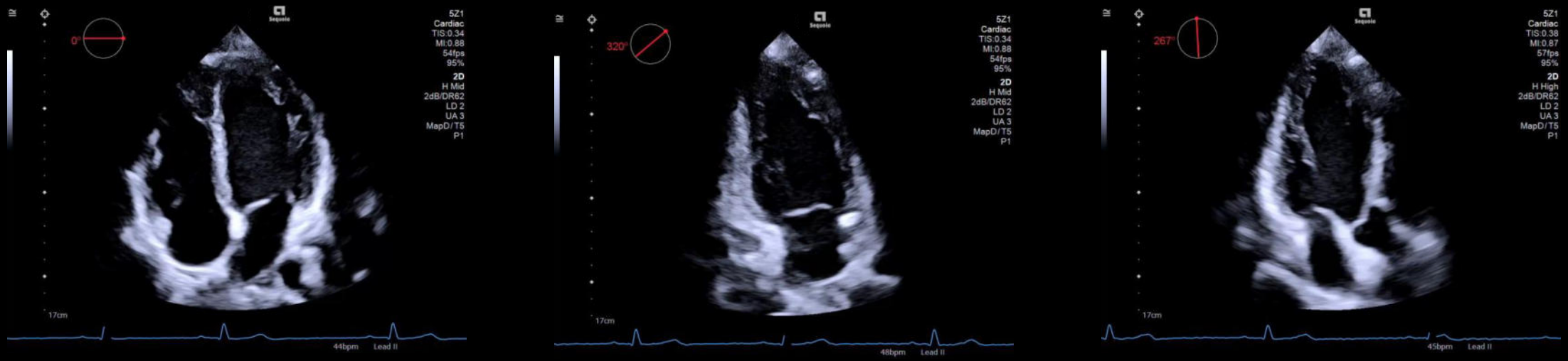
Cardiac strain acquisition: image optimization

- 40 – 80 frames per second (fps) is recommended for optimal speckle tracking results* (an elevated heart rate will require a higher frame rate)
- First, increase Line Density; next reduce depth; then reduce field of view when needed for increased frame rates
- Acquire steady beats, without any changes to field of view or depth – have patient hold breath if needed
- Obtain elongated (non-foreshortened) views of the LV



Sources | *. Mor-Avi, Victor, et al., *European Journal of Echocardiography* (2011) 12;3: 167-205

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Cardiac strain acquisition: image optimization

Challenges in LA strain

- LA is in the far field of the image
- Pulmonary veins and left atrial appendage orifices interrupt LA contouring (If approximately one-third of the atrial contour contains drop-outs, the analysis should be rejected)*
- Thin walls, compared to LV

Tips for LA strain acquisition

- Ensure frame rate is adequate – increase line density, then decrease field of view
- Have patient perform a breath hold to decrease motion of the heart
- Avoid foreshortened images of the LA – the long axis of the LA is slightly different than the long axis of the LV

Sources | *. Badano, et al., *European Heart Journal* (2018) 19; 591-600

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- **Discuss 2D Heart^{AI} workflow**
- Evaluate 2D Heart^{AI} analysis and report

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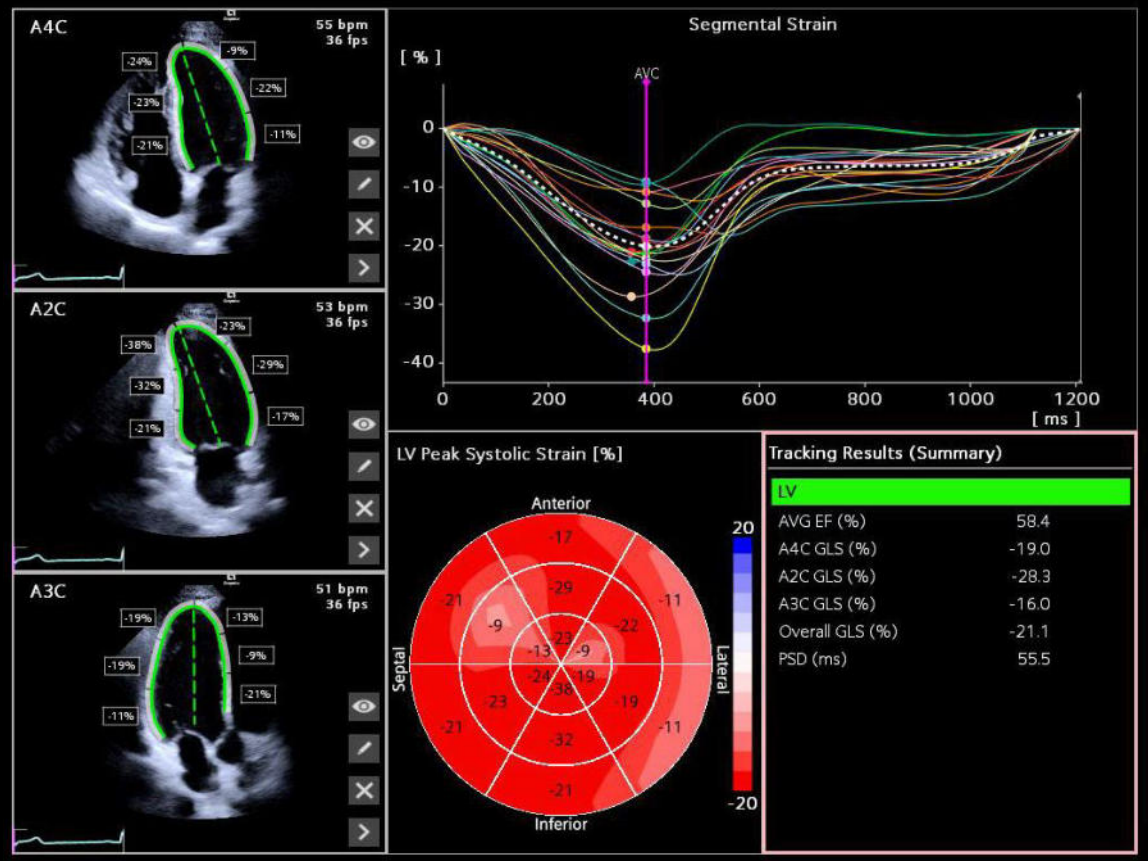
2D Heart^{AI} workflow overview

1. Launch software from live imaging (Cine) or Review
   - **From Cine** – two frame analysis (LV, LA, RV, RA)
   - **From Review** – tracking results for GLS (LV, LA)

2. Automated view detection will place contours and analyze

3. Analysis with contours and measurement results



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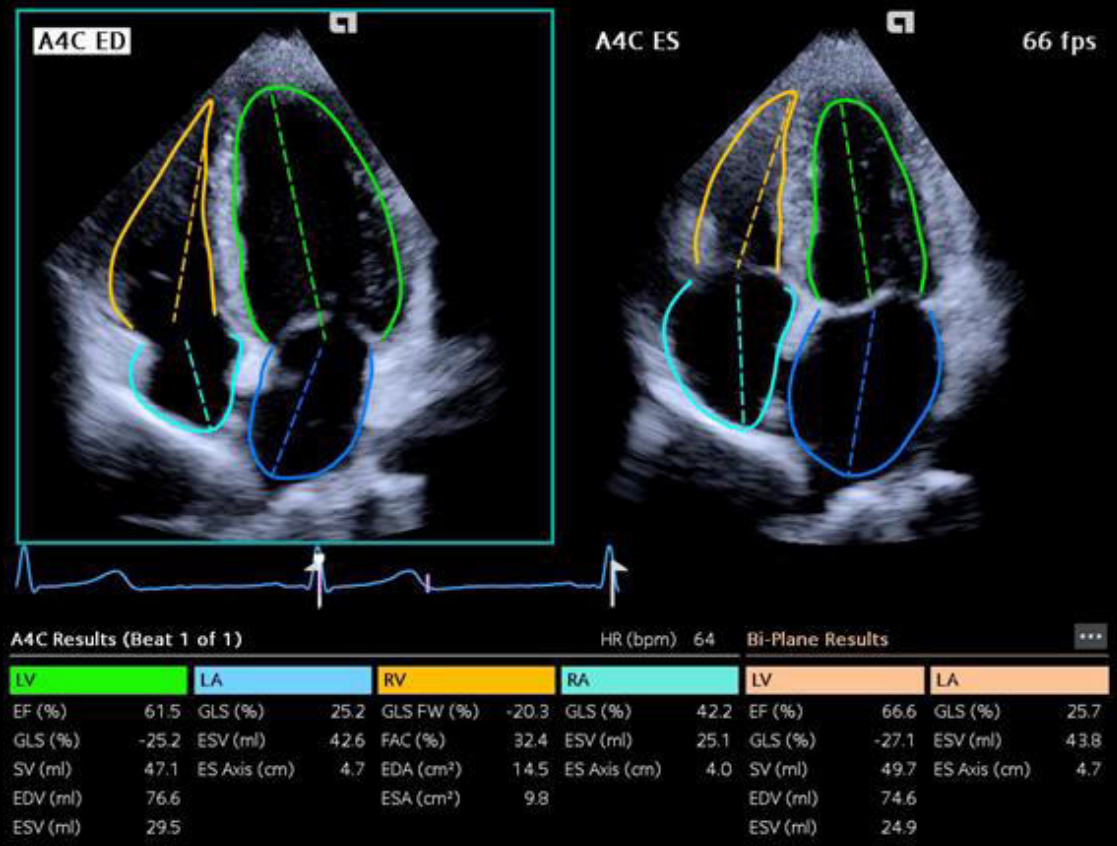
ED-ES View: two-frame (Edit) layout

Display at launch for Cine workflow or when a single clip/view has been selected for analysis

- Displays contours and results for configured chambers
- Select individual beat to analyze, or select multiple beats
- ***Only layout in which edits can be made to contours***
- ***Edits can only be performed on the ED and ES frames***



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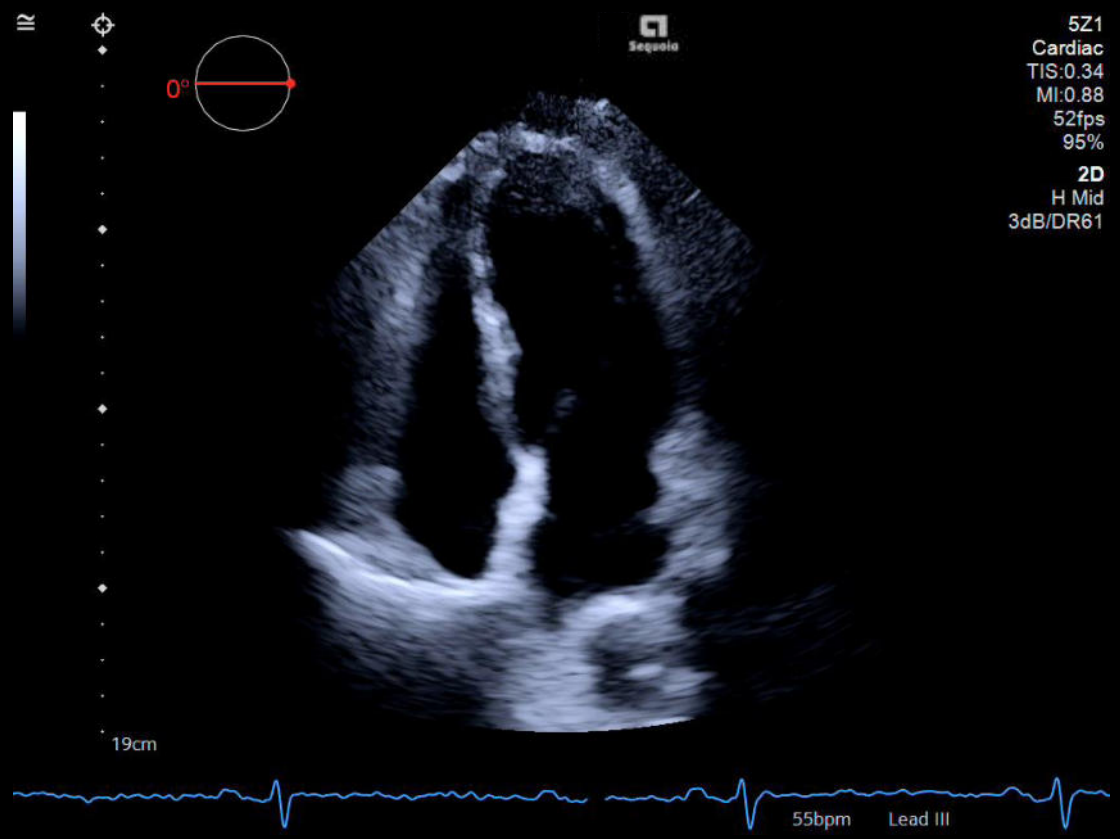
Launching 2D Heart^{AI} from Cine

- Enables user to select a view during live imaging for analysis
- Only one view at a time can be analyzed
- Includes two frame analysis only (no bullseye or curve analysis)
- All four chambers are analyzed (LV, LA, RV, RA)

Note: *Right heart analysis is only performed on a four chamber image in Cine or Review and does not include speckle-tracking results.*



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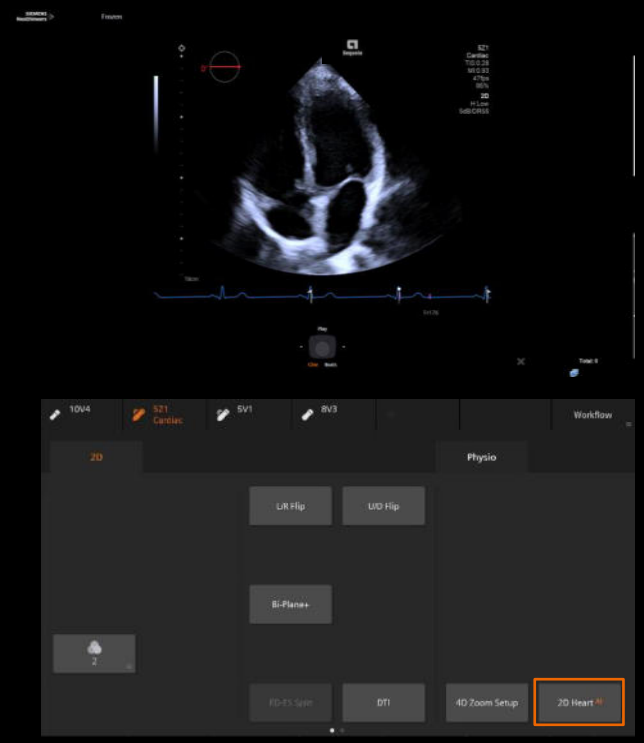
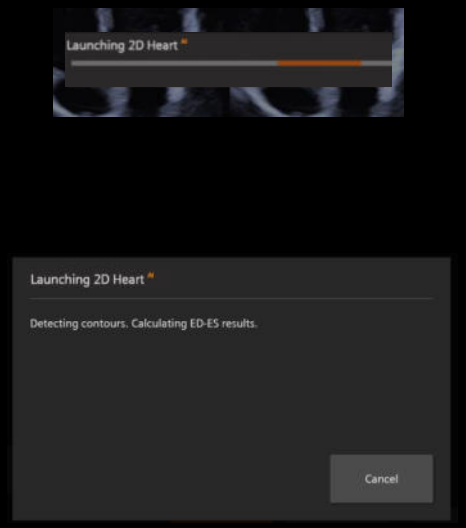
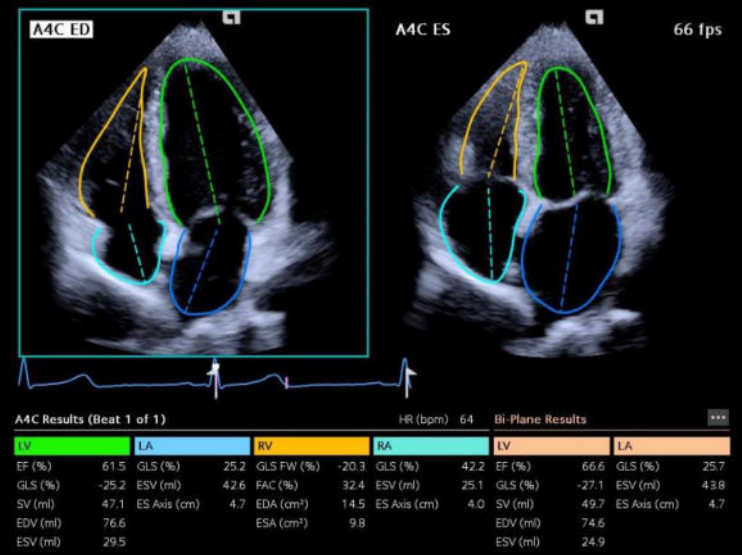
Launching 2D Heart^{AI} from cine



Freeze image and select **2D Heart^{AI}** from the touch screen



Contours are detected



Two frame analysis of all four chambers

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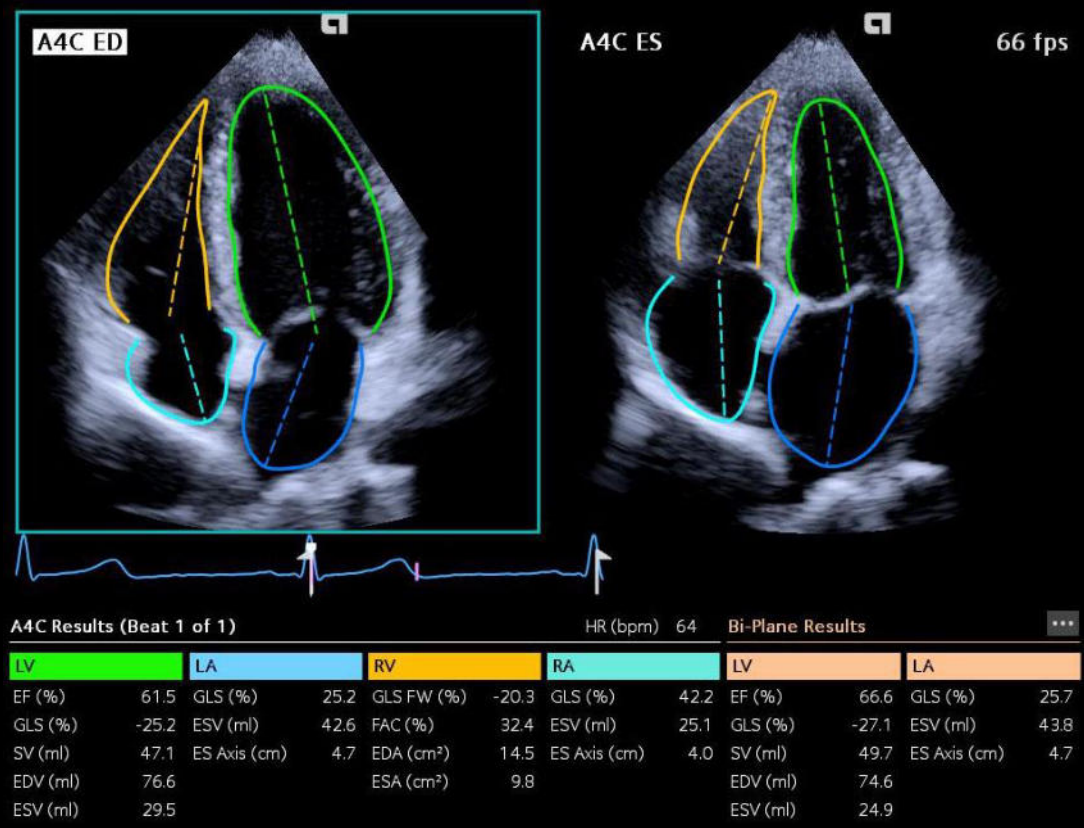
Launching 2D Heart^{AI} from cine

There are two suggested ways to effectively use Cine workflow:

1. Analysis for right heart only – once results for all chambers appear, remove LV/LA from the touch screen. The user can then complete GLS for left heart from Review using all three apical views.

2. Two frame analysis for all four chambers – results for all chambers are two frame results. The user will still need to complete the LV/LA from Review for tracked GLS results.

Note: *Two-frame GLS values will only be available with the advanced license.*



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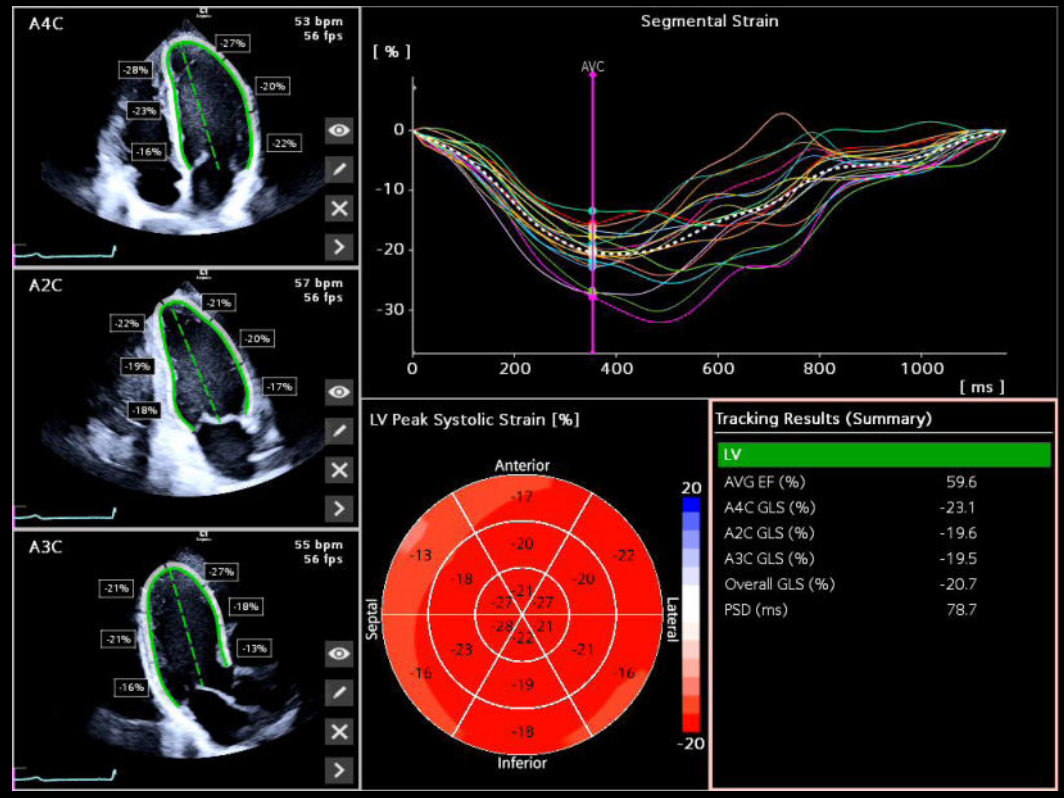
Launching 2D Heart^{AI} from review

- Enables users to select captured data to analyze cardiac chambers – includes GLS (bullseye and curve results) for LV and LA

- Two ways to launch:
  1. **Group selection** – select apical 4, 3, and 2 chamber views as a group in Review
  2. **Individual selection** – select apical 4, 3, and 2 chamber views one at a time



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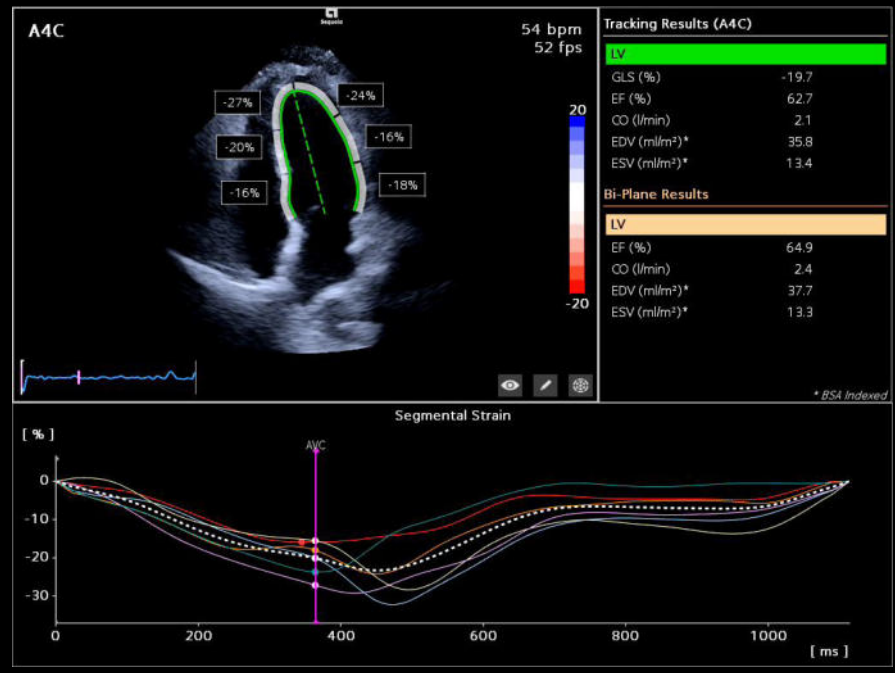
Review workflow: individual view selection

Use to analyze one clip / view at a time

- A single view selected from Review and analyzed
- Views can be selected in any order
- Bullseye View – displays bullseye results
- Single View – displays tracking results only for selected view



Why would individual selection be used over group selection?

- *User can't obtain all three apical views*
- *User only wants to analyze apical four chamber*

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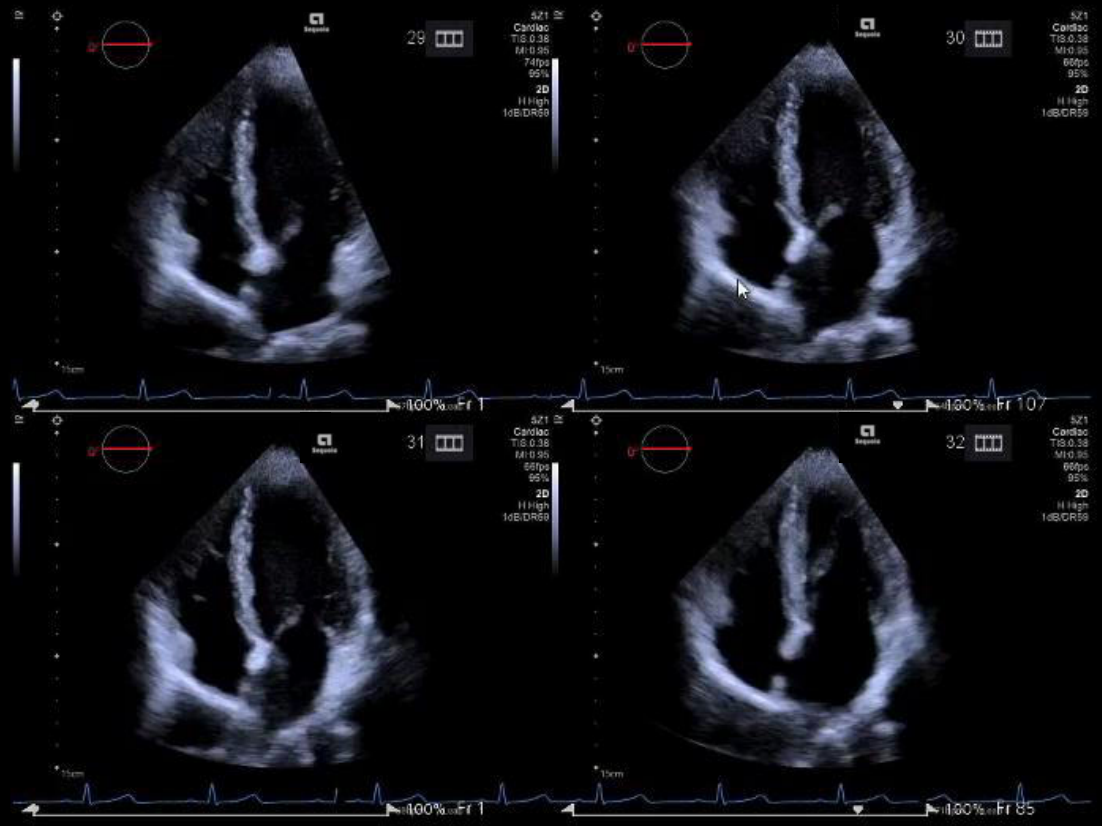
Review workflow: individual view selection

1. Select desired apical 4, 2, or 3 camber view
2. Select **2D Heart^{AI}**
3. ED-ES View will display; *user can edit from this screen only*
4. Select **Bullseye View** or **Single View** for analysis (once all three views are analyzed, bullseye will be completed)



Note: *If any non B-mode images are selected, 2D Heart^{AI} will not be available on the touch screen.*

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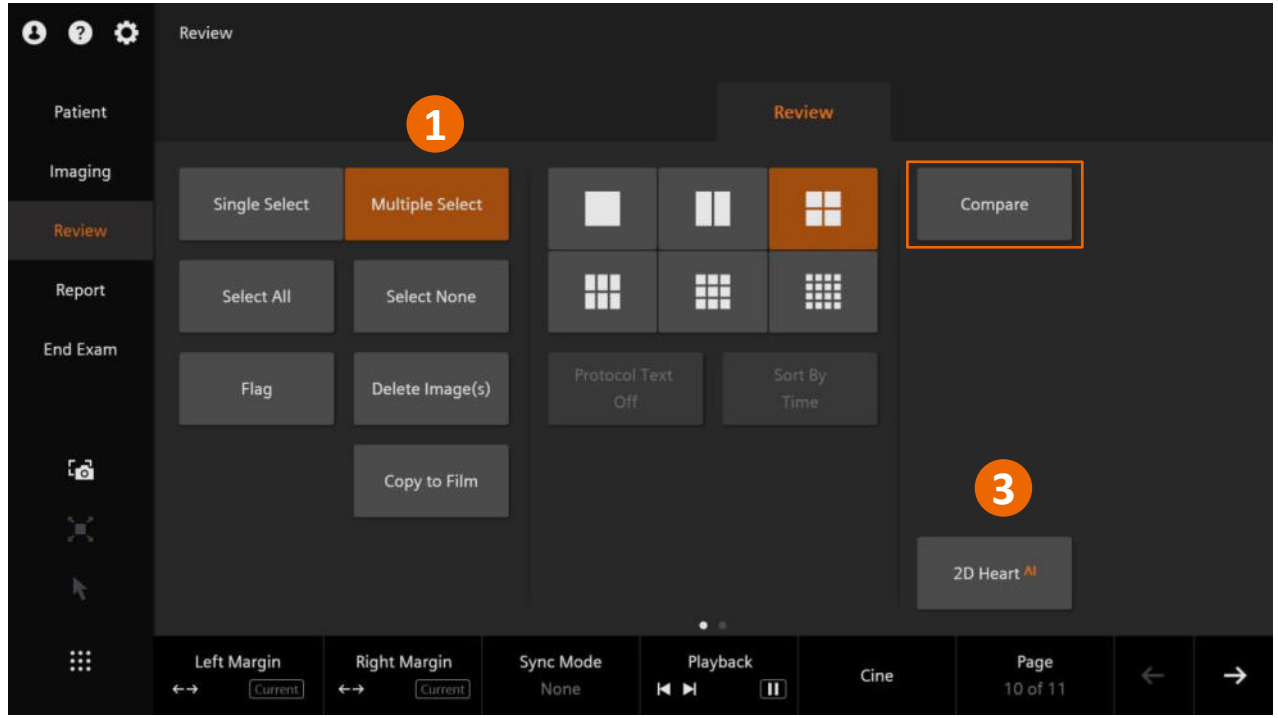
Review workflow: group selection

Use to analyze more than one clip / view at a time

1. Press **Select Multiple**
2. Select apical 4, 2, and 3 chamber views
3. Select **2D Heart^{AI}**



TIP: *Once all views are chosen, select* ***Compare*** *to review selected images prior to launching 2D Heart^{AI} to ensure all three apical views are included.*

NOTE: *If more than three clips are selected (or irrelevant clips are selected), the 2D Heart^{AI} option on the touchscreen will be unavailable, and analysis will not launch.*

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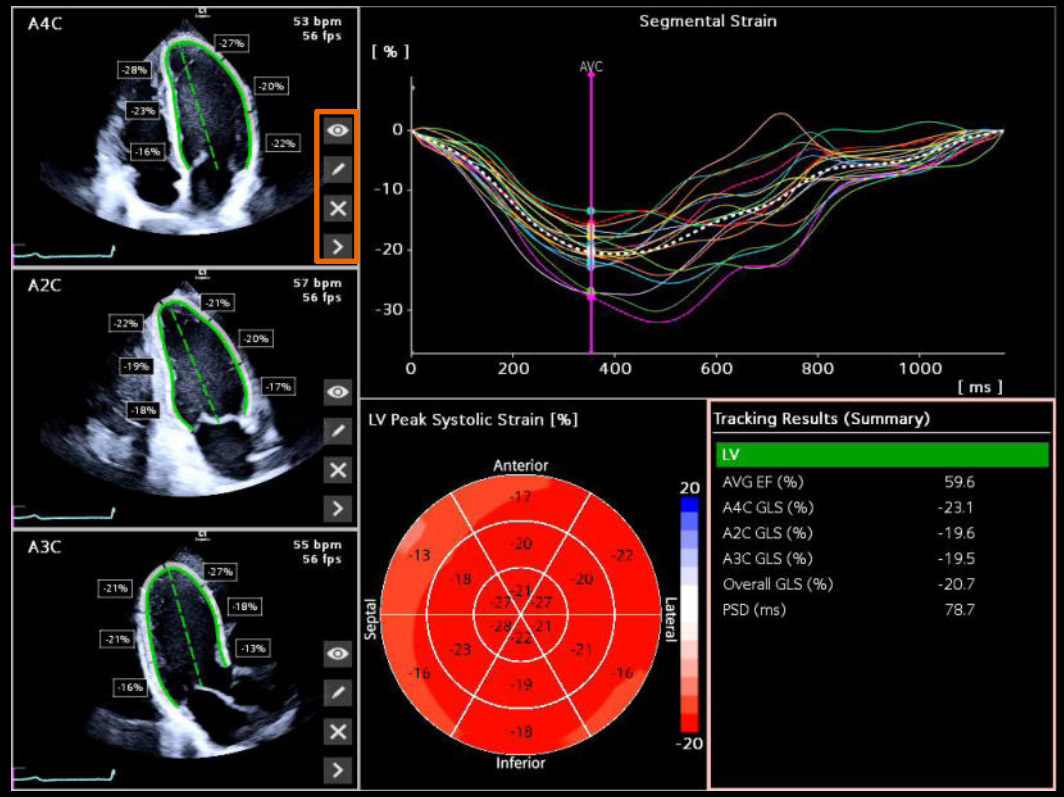
Review workflow: group selection

- Bullseye View is the default analysis layout when more that one apical view is selected
- Select the **Single View** icon within a viewport to view an individual apical 4, 2, or 3 chamber image
- Select the **Edit** icon in Single View to edit current view
- Select the **Bullseye** icon to return to the Bullseye layout
- Select **Hide Segment Values** to remove the segment values from the viewport images



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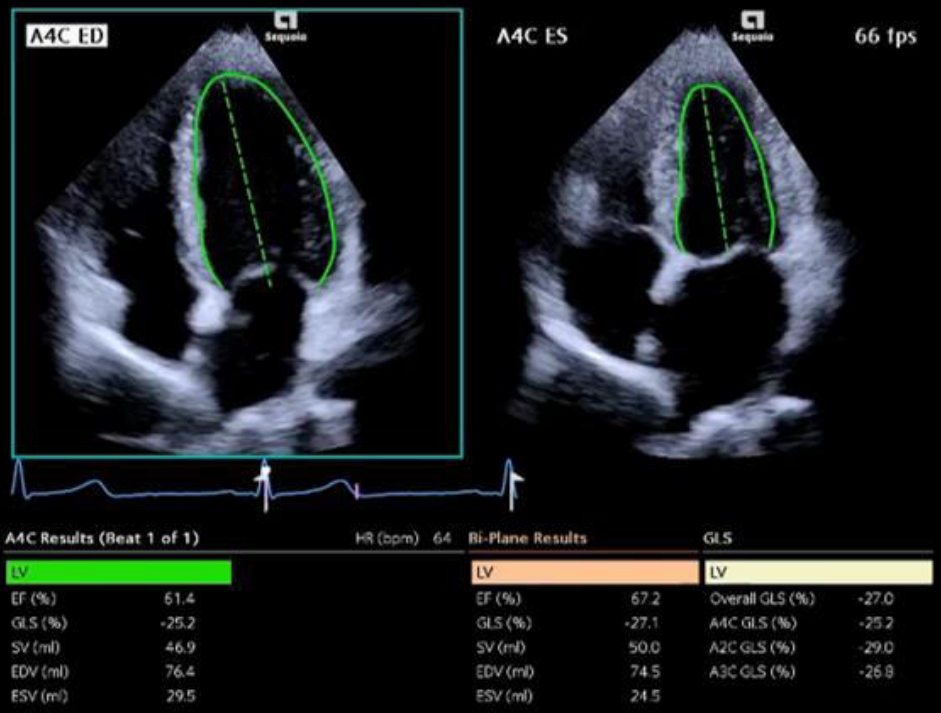
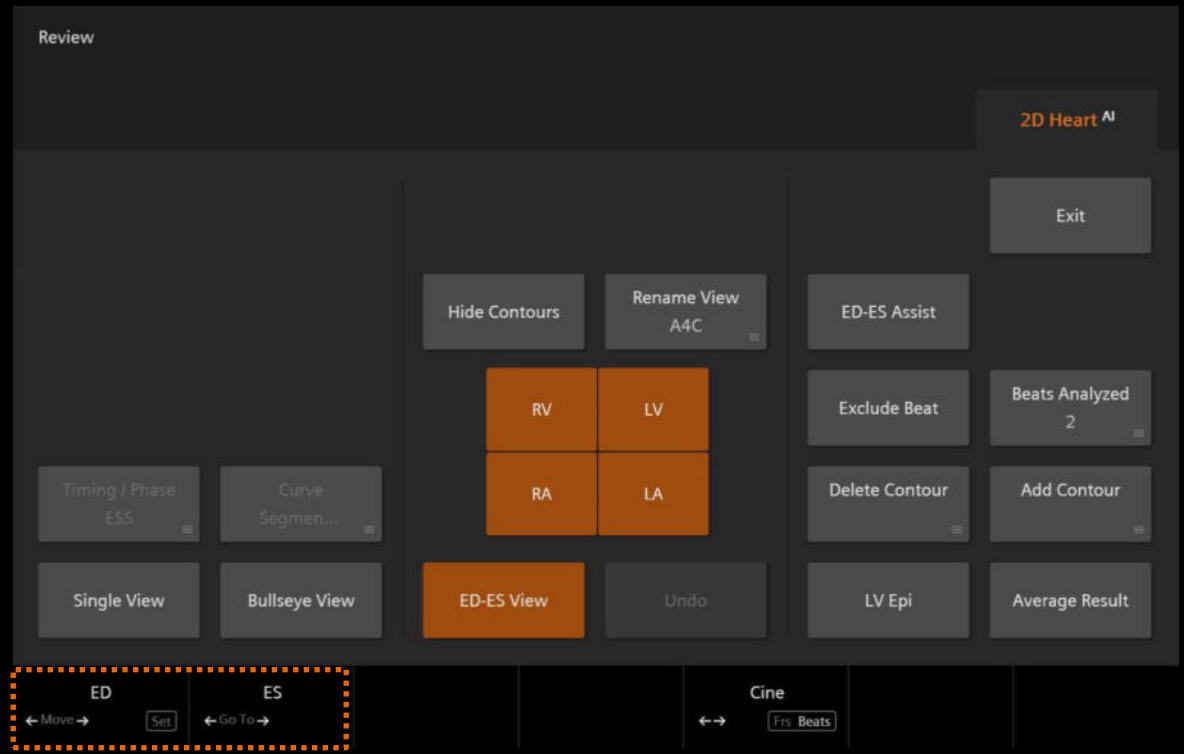
Review workflow: view detection and contours





ED-ES View: only page where edits can be made to contours

ED and ES timing can be changed from the soft keys

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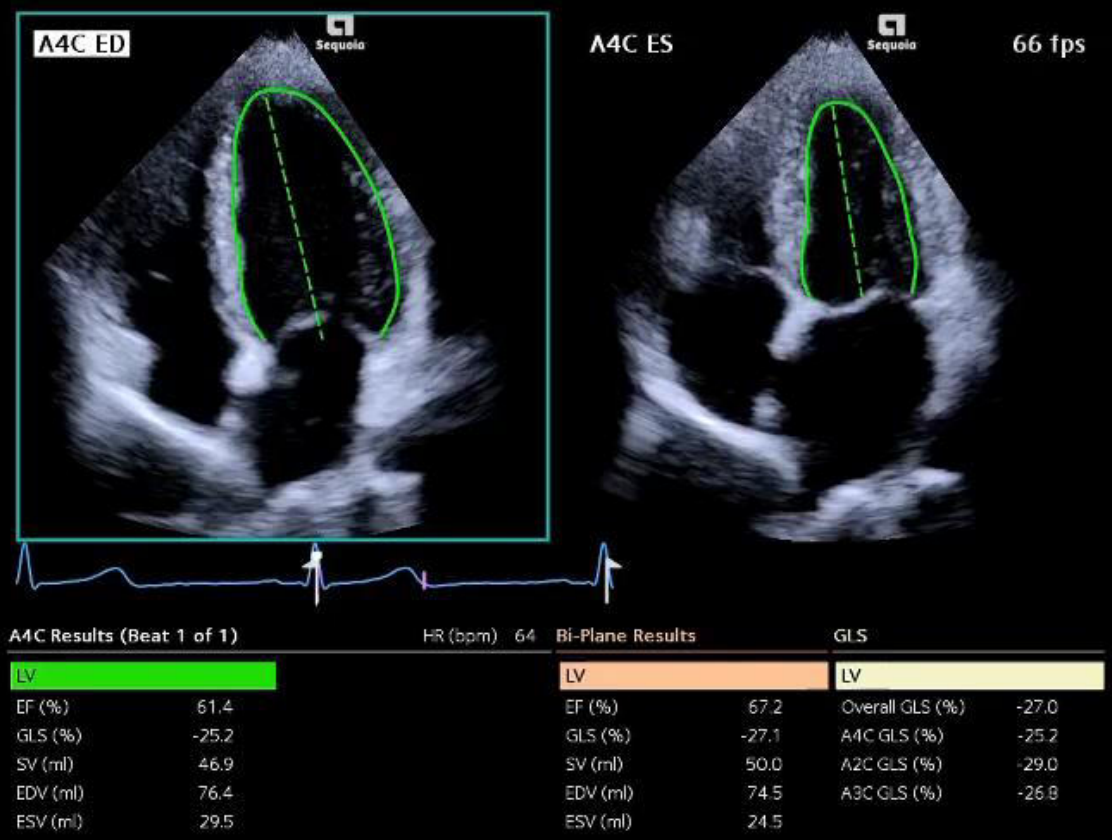
Editing contours

ED-ES View

Contours can be edited by entering *ED-ES View* from the touch screen

- Cursor becomes available when user clicks on the ED or ES image to activate the viewport – *edits can only be made in ED-ES View on the displayed ED or ES frame*

- Active region of contour becomes highlighted
  - When pointer is closer to contour, a smaller region becomes active
  - When pointer is further from contour, a larger region becomes active



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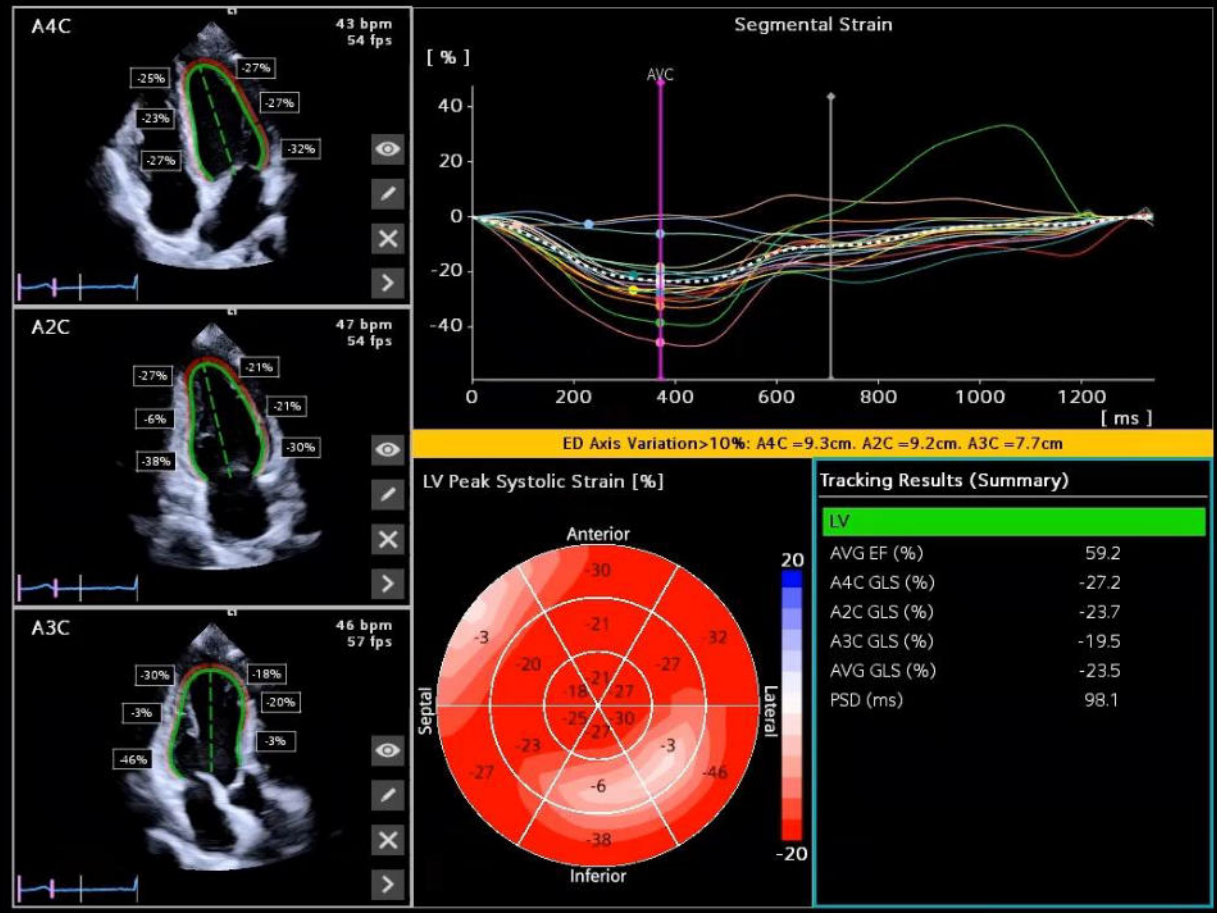
Editing the second ED frame in a single beat

1. Edit contours on first ED and ES frames
2. Cine to the second ED in the current beat and apply edits
3. Select Bullseye View to re-analyze with new contours

Note: *Editing of the second ED will not change bullseye and GLS; It only affects timing analysis (e.g. time-to-peak, post systolic strain, etc).*



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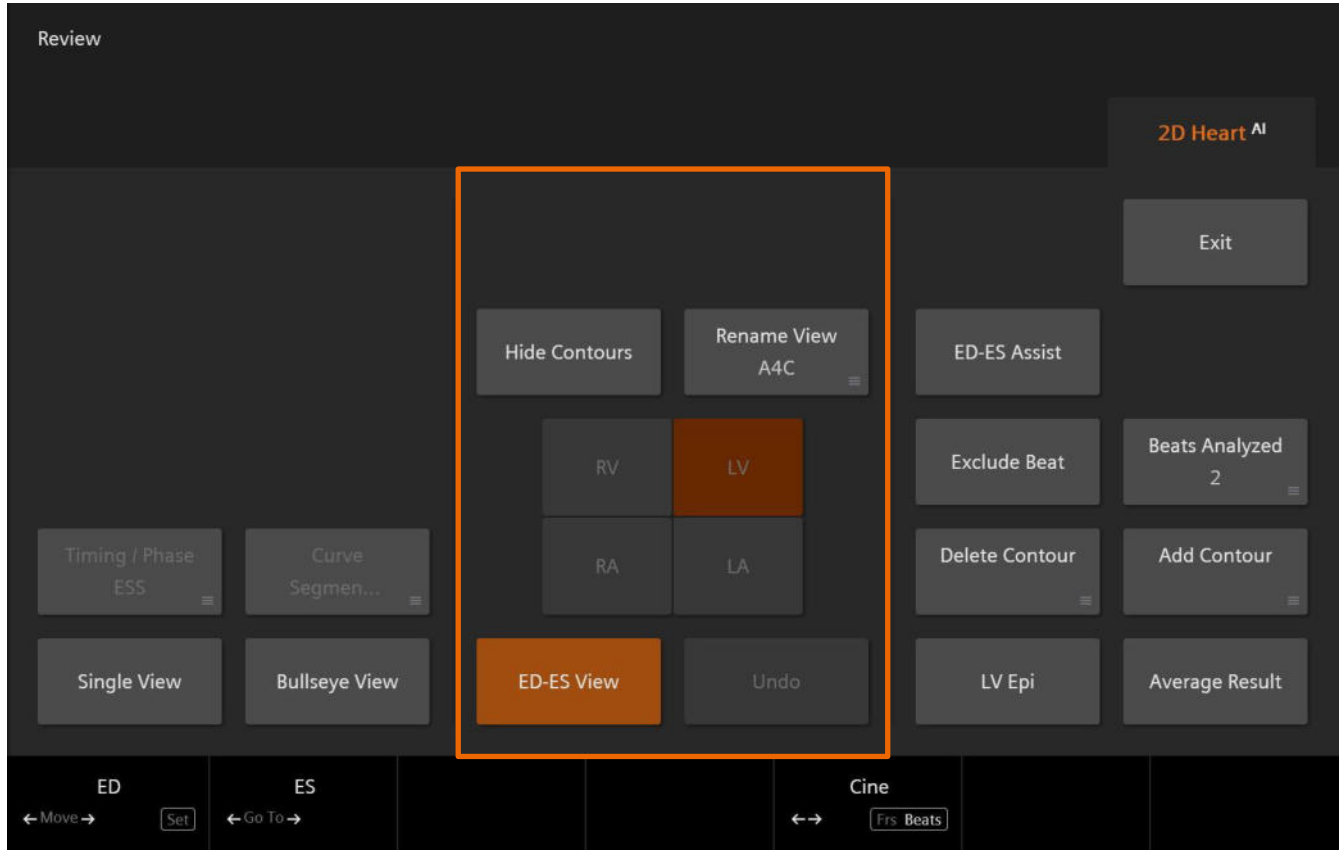
Touch screen – ED-ES View

- **Hide Contours** – select to hide contours across both views
- **Rename View** – Rename analyzed view (or undetected view)
- **Chamber Selection** – select to enable or disable a chamber
- **Undo** – reverts up to 10 edits performed by the user

Note: *when a user chooses a new view, the stored edits will start over for the Undo function.*



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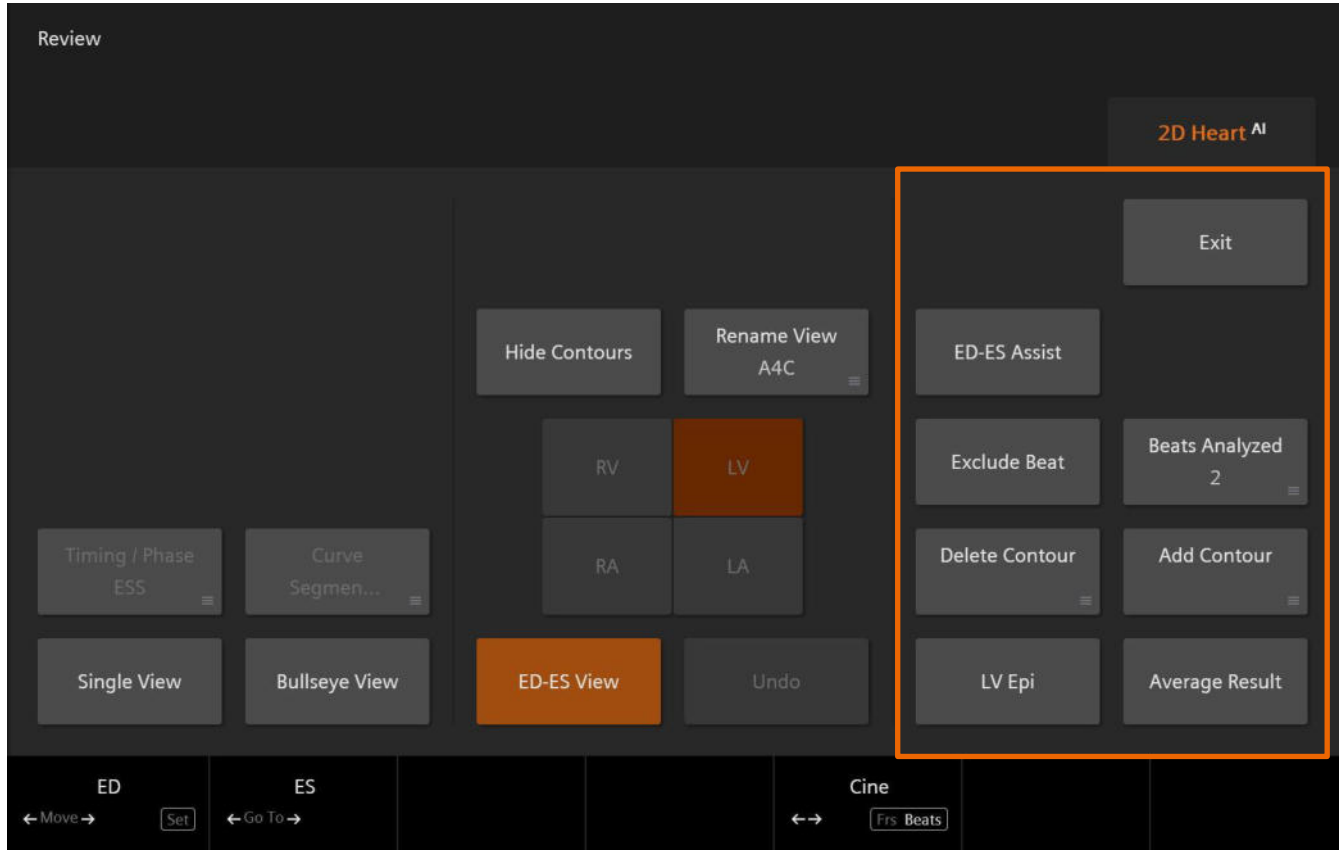
Touch screen – ED-ES View

- **ED-ES Assist** – chooses frames that may be better than the ones selected based off the ECG
- **Exclude Beat** – excludes contours of selected beat; also excludes the beat from averaged results
- **Beats Analyzed** – changes number of beats analyzed (choose from 1-5)
- **Delete Contour** – select to delete and redraw a contour



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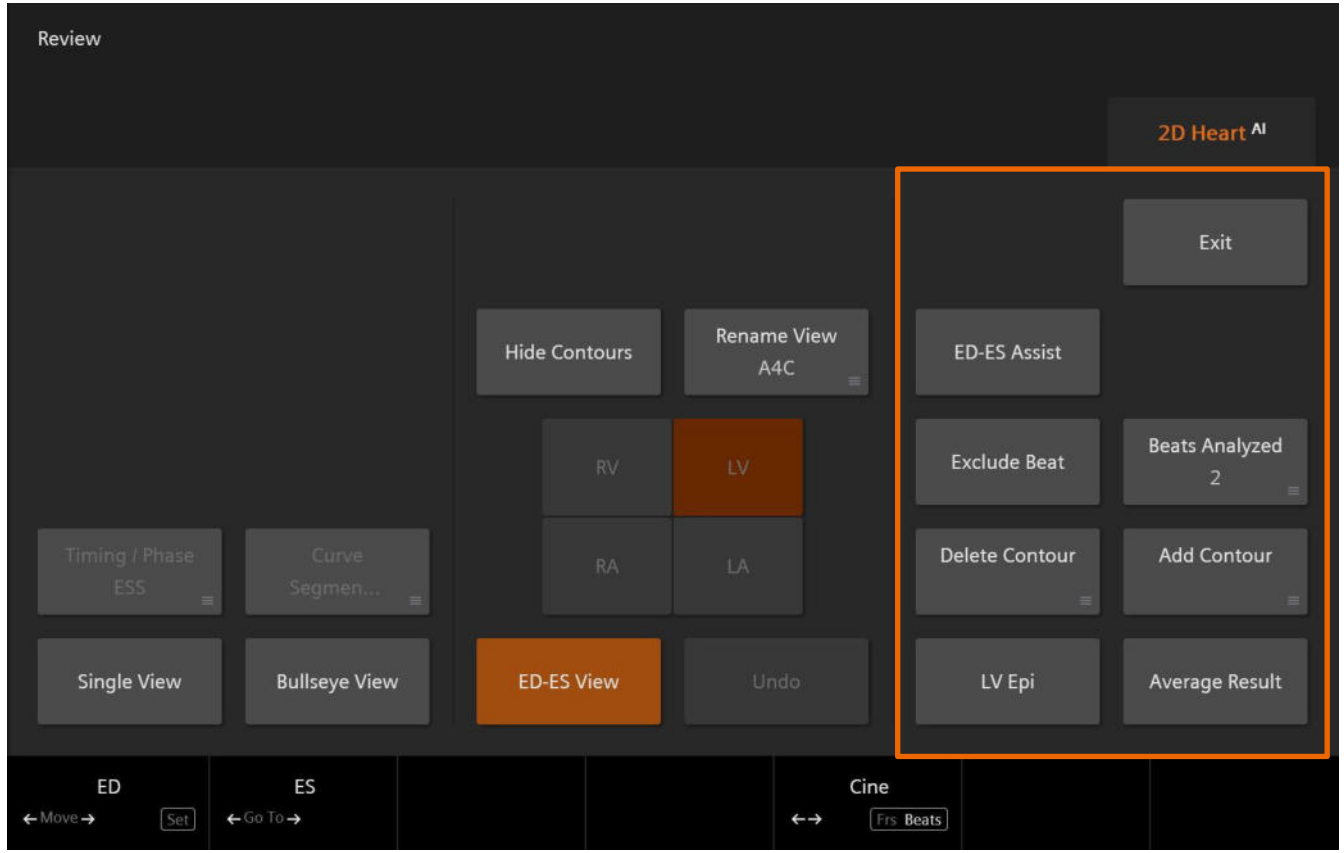
Touch screen – ED-ES View

- **Add Contour** – select to add missing contour on a key frame
- **LV Epi** – enables or disables the LV epicardium and associated result (LV mass)
- **Average Result** – select to average results for more than one beat

Note: *The user must add contours for both the ED and ES views to obtain results*



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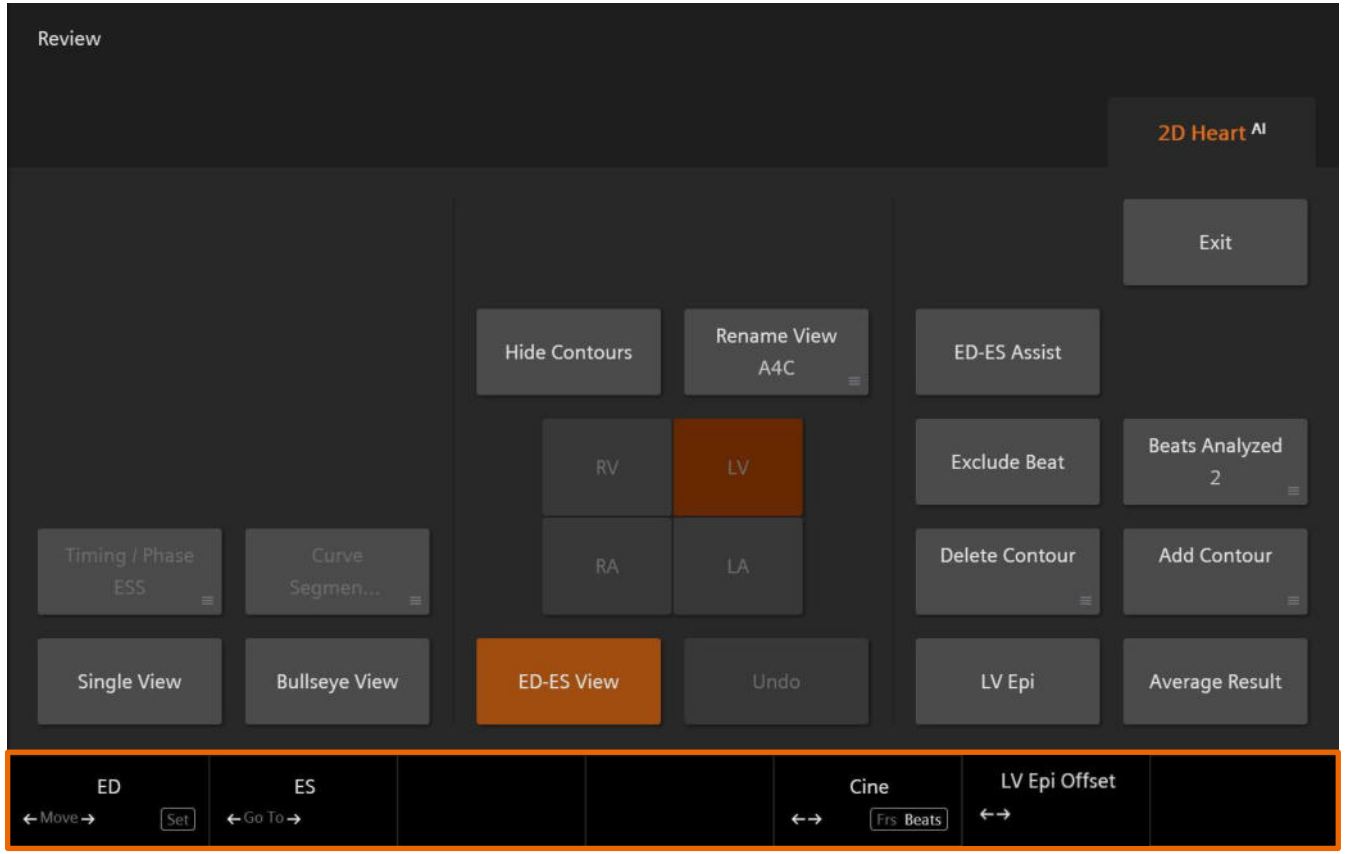
Soft keys – ED-ES View

- **Move / Set ED** – use to alter ED frame (rotate to Move, press to Set)
- **Move / Set ES** – use to alter ES frame (rotate to Move, press to Set)
- **Cine (Frs / Beats)** – physio navigation by beats or frames (defaulted to beat)
- **LV Epi Offset** – adjust offset (thickness) of LV Epi contour; available on apical 4 and 2 chamber views for the LV



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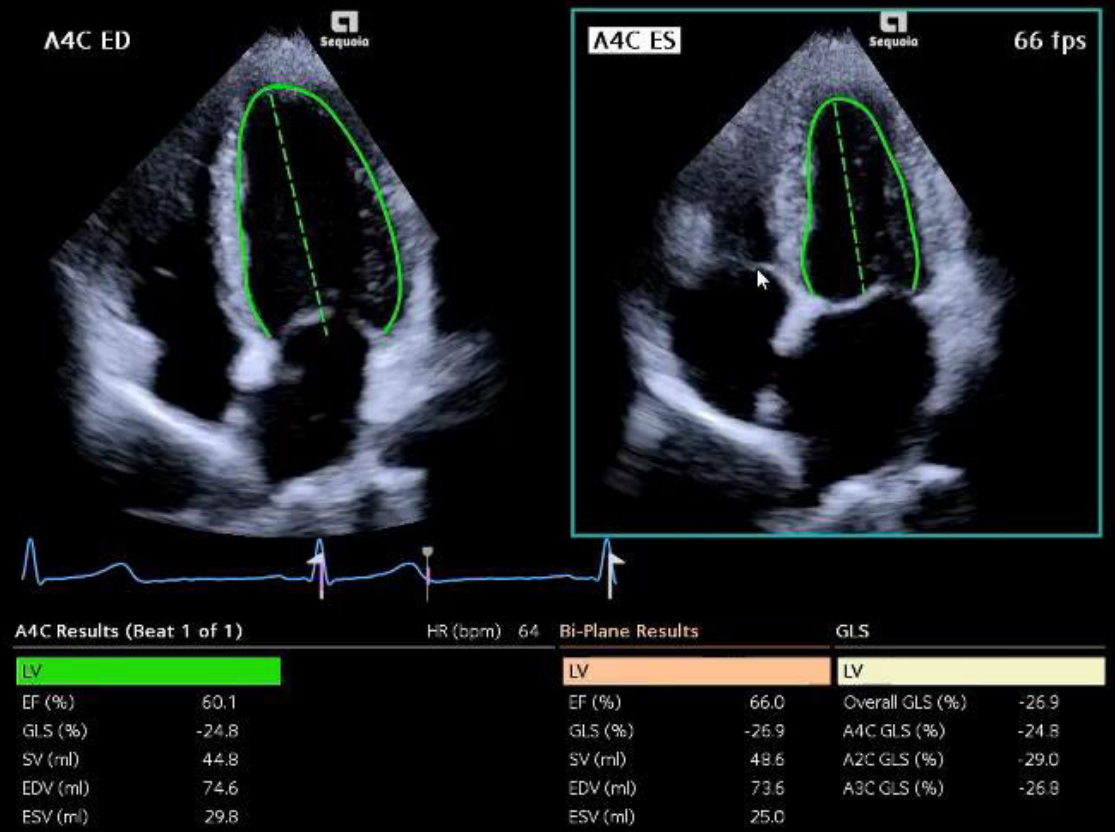
Changing ED and ES Frames

- ED and ES frames are labeled as purple markers on the ECG tracing as well as labels on viewports

- Move and set ED or ES frames with softkeys
  - Rotate soft key to move – active frame on ECG tracing will have a yellow marker when moving; when inactive, will return to gray
  - Press soft key to set – new ED or ES frame will be set (purple marker will move)
  - New contours will populate, results will update



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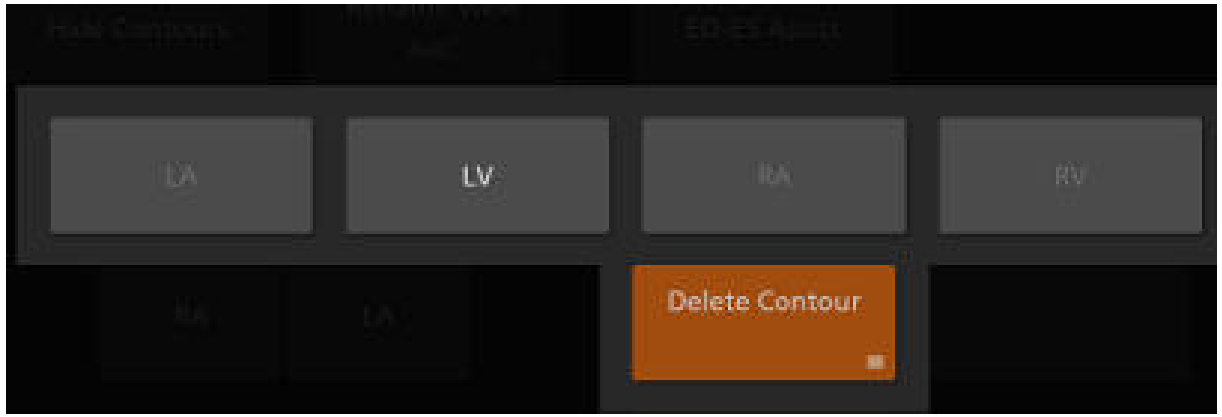
Deleting a contour

- **Delete Contour** removes contours of the selected chamber from the ED or ES frame within the active viewport; also removes the analysis from the results table and the report (Available for chambers that are enabled / detected)

- Available for chambers which are enabled (can be changed from the touch screen)

- After deletion, a manual contour becomes available for the deleted chamber; the user will be prompted to place contour points or can cancel placement of a new contour



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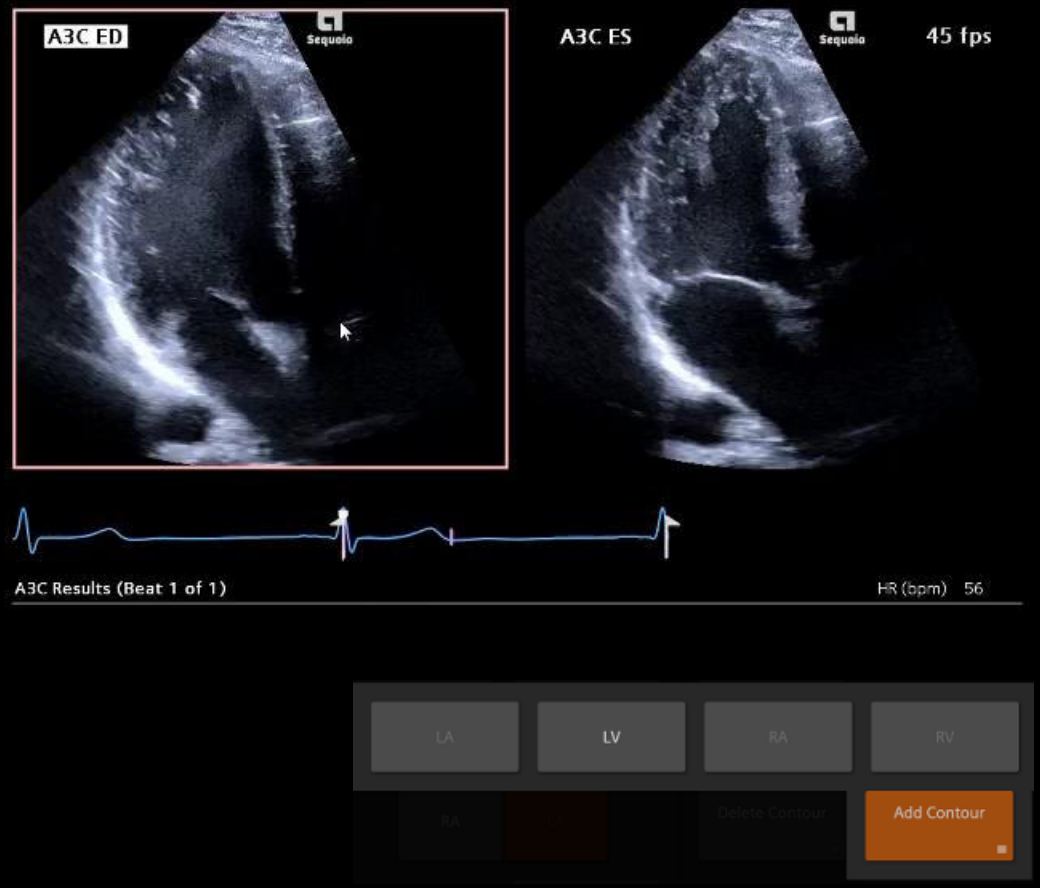
Adding a contour

- **Add Contour** places a new contour on the selected chamber from the ED or ES frame within the active viewport with manual placement of contour points
- Only available when viewport is on ED or ES frame
- Will only be available for the active viewport
  - Select inside of the ED or ES frame or use the trackball to alternate between the two
- For each cardiac view, a guide is in the bottom left-hand corner of the monitor for the order in which to place the three points

Place Post, AntSept, Apex points to draw LV contour



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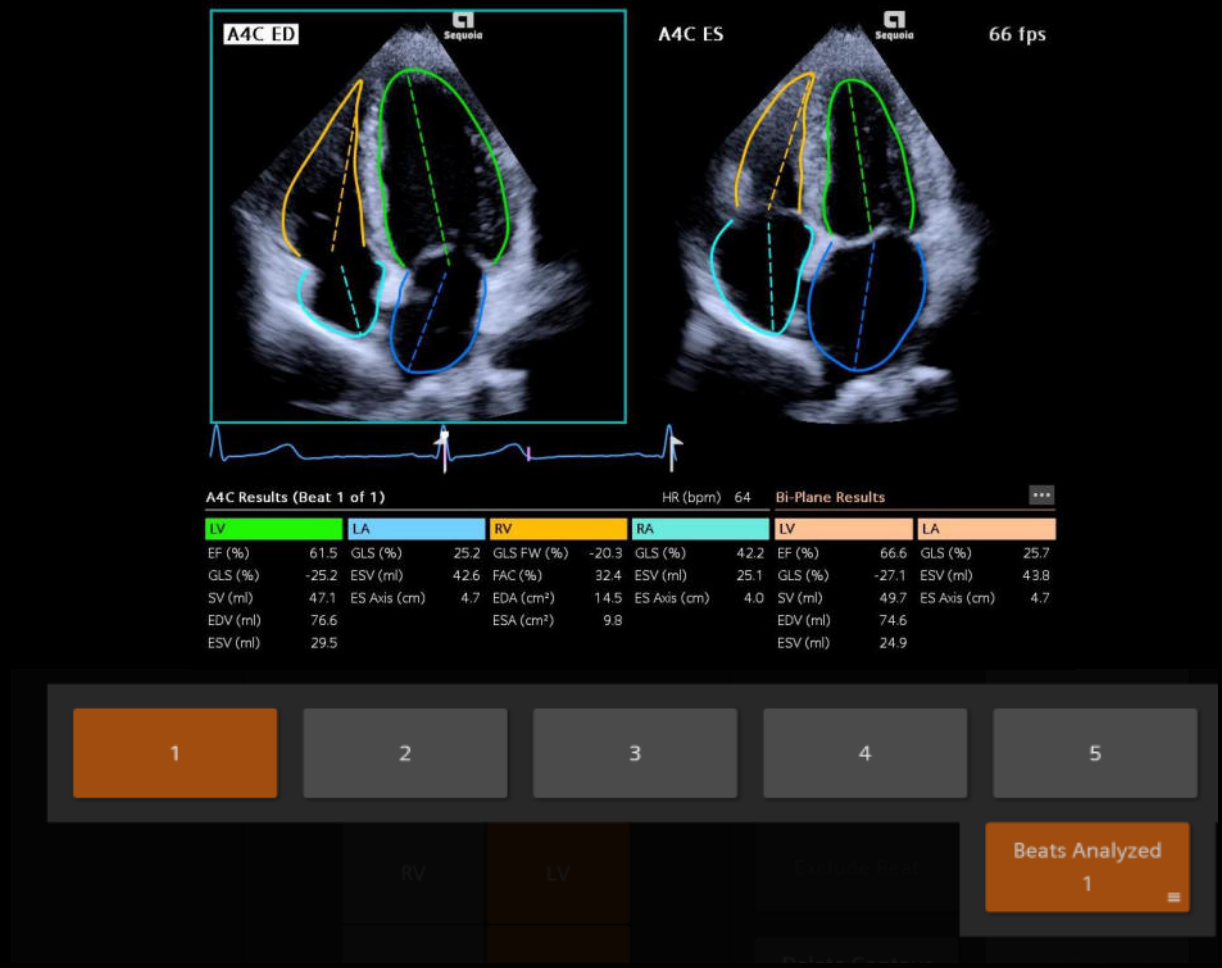
Multiple beats analysis

- 1 – 5 beats can be analyzed, depending on how many beats are available
- Increasing beats analyzed will move the ECG margin to the left to include prior beats
- Viewports will display current beat that is being analyzed
- Rotate the **Cine** soft key to scroll to different beat(s)



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Non-physio workflow

Ability to perform analysis in cine and review workflows on non-physio data (no ECG)

- Launch the same way as with physio
- ED and ES frames are determined by largest and smallest LV size
- Editing can still be performed from ED-ES View
- Only one beat can be analyzed without physio

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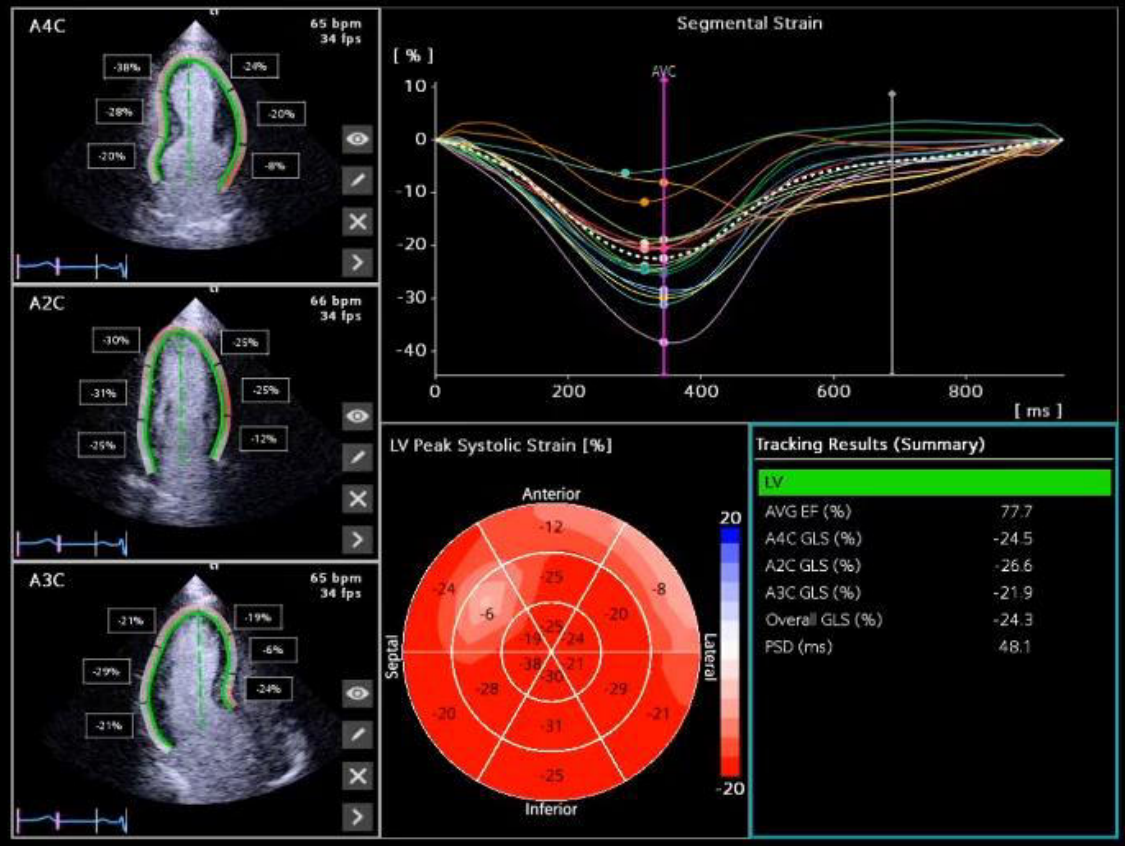
2D Heart^{AI} with contrast

- **F**ully automated tracking analysis is available for the left ventricle – view classification and contour placement
- Includes GLS and bullseye results
- ***The ACUSON Origin ultrasound system is the only cardiac ultrasound system in its class to have this feature!***



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Objectives

- Review cardiac strain principles
- Explain image acquisition for cardiac strain
- Discuss 2D Heart^{AI} workflow
- **Evaluate 2D Heart^{AI} analysis and report**

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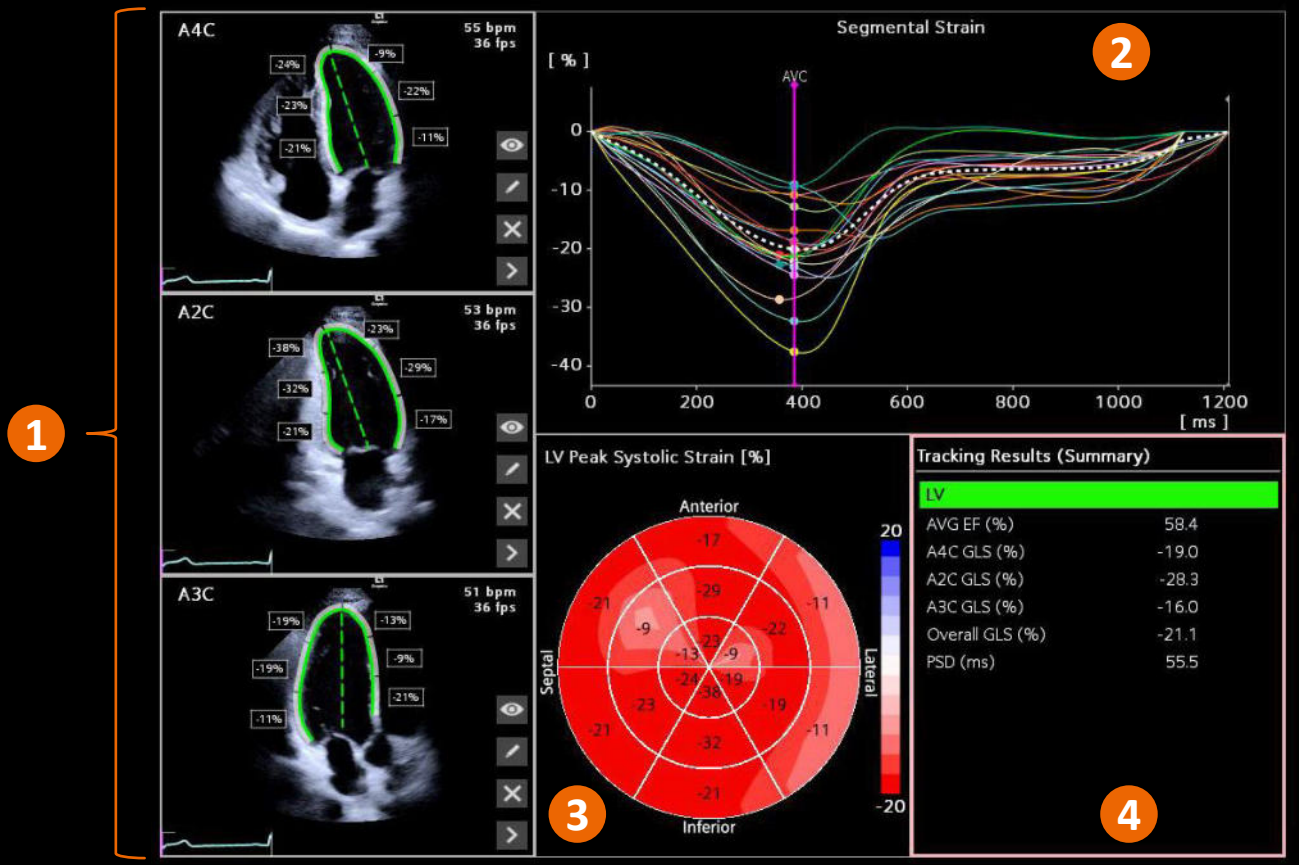
Tracking analysis – bullseye view

Bullseye View displays a summary page with bullseye and curve display for all segments (GLS)

1. **Viewports** – display of each view analyzed
2. **Curves** – LV curve display (choose value from touch screen)
3. **Bullseye** – completed bullseye with segment values (choose value from touch screen)
4. **Summary** – list of LV chamber results from analysis

TIP: *Press the **Update** key on the control panel to change the currently selected viewport.*



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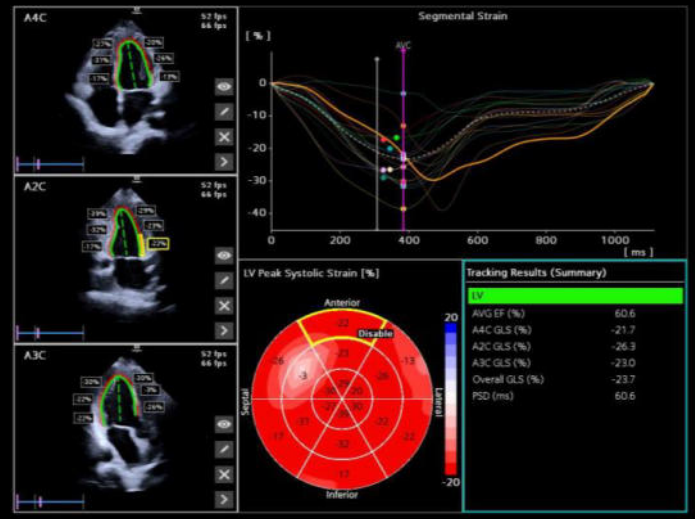
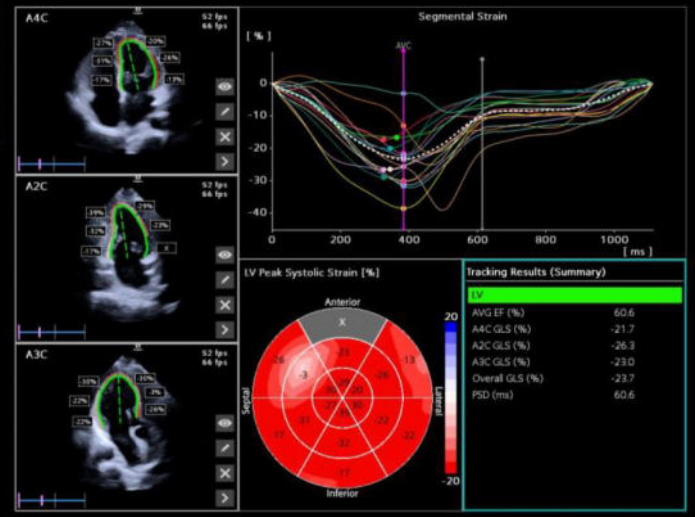
Tracking analysis – bullseye view

- Hovering the cursor over a segment on the bullseye highlights the associated curve and segment within the viewport(s)
- Hovering the cursor over a curve will display the X and Y values
- Remove a segment by selecting from the bullseye
- Heart rate variation message when the variation is greater than 10%

HR Variation > 10% : A4C = 61 bpm, A2C = 61 bpm, A3C = 45 bpm





Note: *Removing a segment from the bullseye does not change GLS values.*

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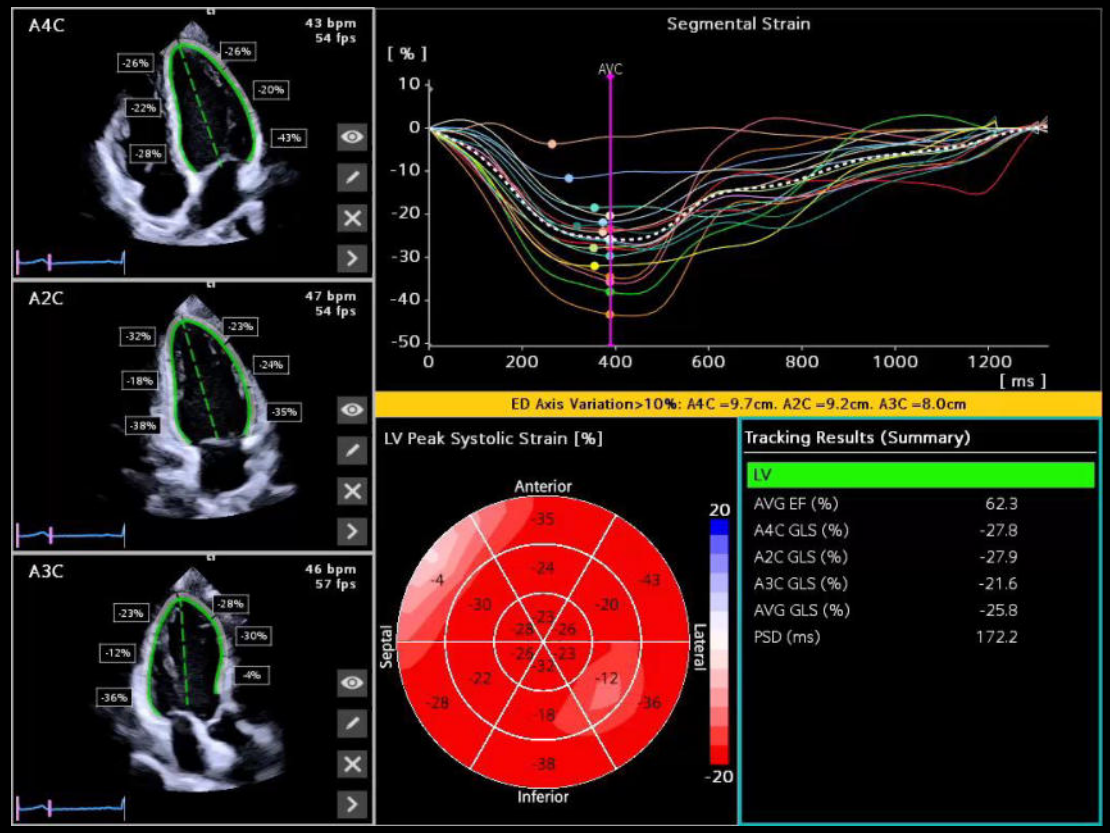
2D Heart^{AI}
LV length variation message

- Length variation message appears on Bullseye View page
- Available when more than one view is analyzed
- Alerts the user if there is more than a 10% variation in LV ED Axis (length)
- Quality check to ensure LV is not foreshortened for more accurate analysis
- LV ED Axis **does not** need to be selected in system configuration for the message to appear on the bullseye page



ED Axis Variation>10%: A4C =9.7cm. A2C =9.2cm. A3C =8.0cm

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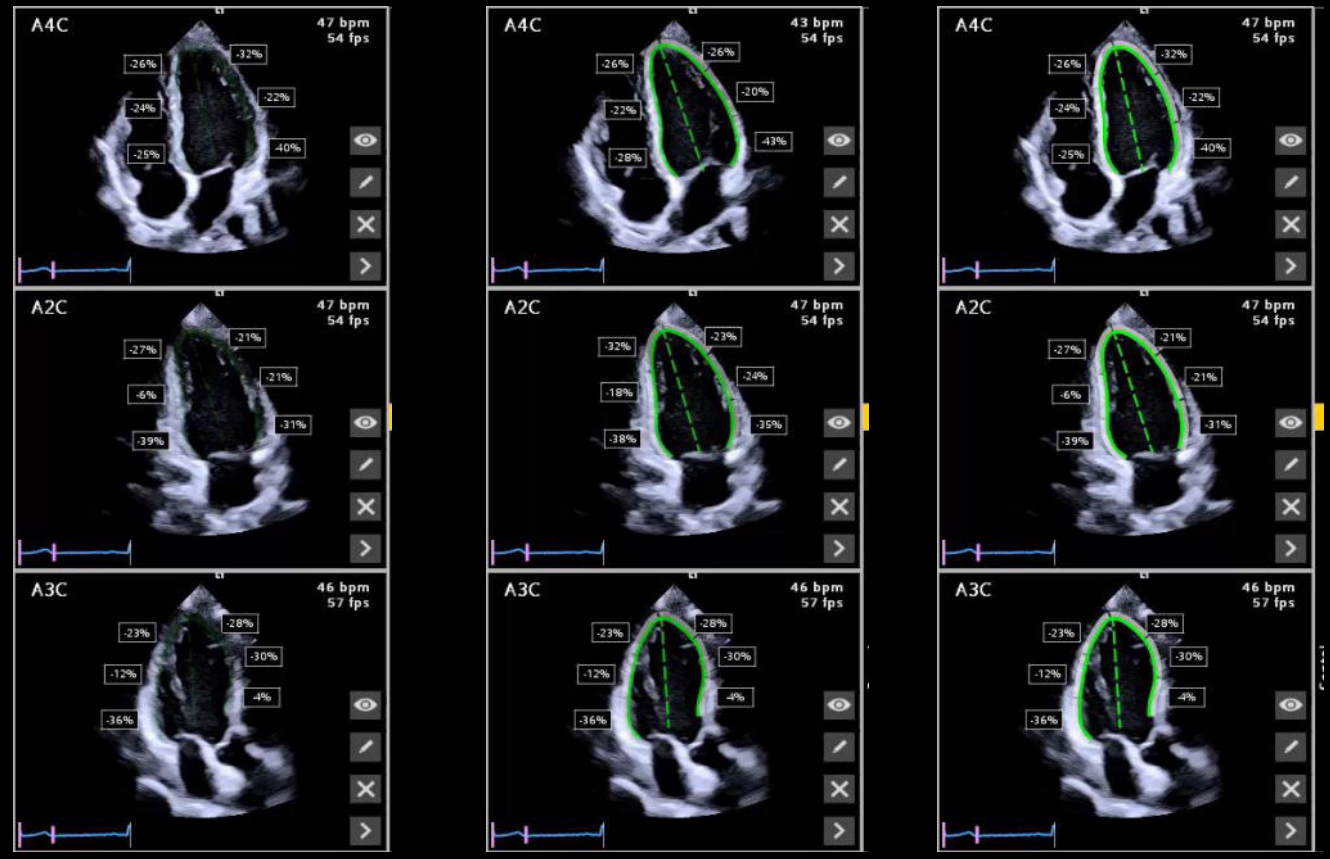
2D Heart^{AI}
Contour brightness

- Allows users to control the transparency of the contours
- Enables visualization of underlying anatomy
- Available in ED-ES View, Single View, and Bullseye View
- 10 – 100% (transparency – opacity); located on the soft keys
- Value chosen is retained for subsequent exams



10% **70%** **100%**

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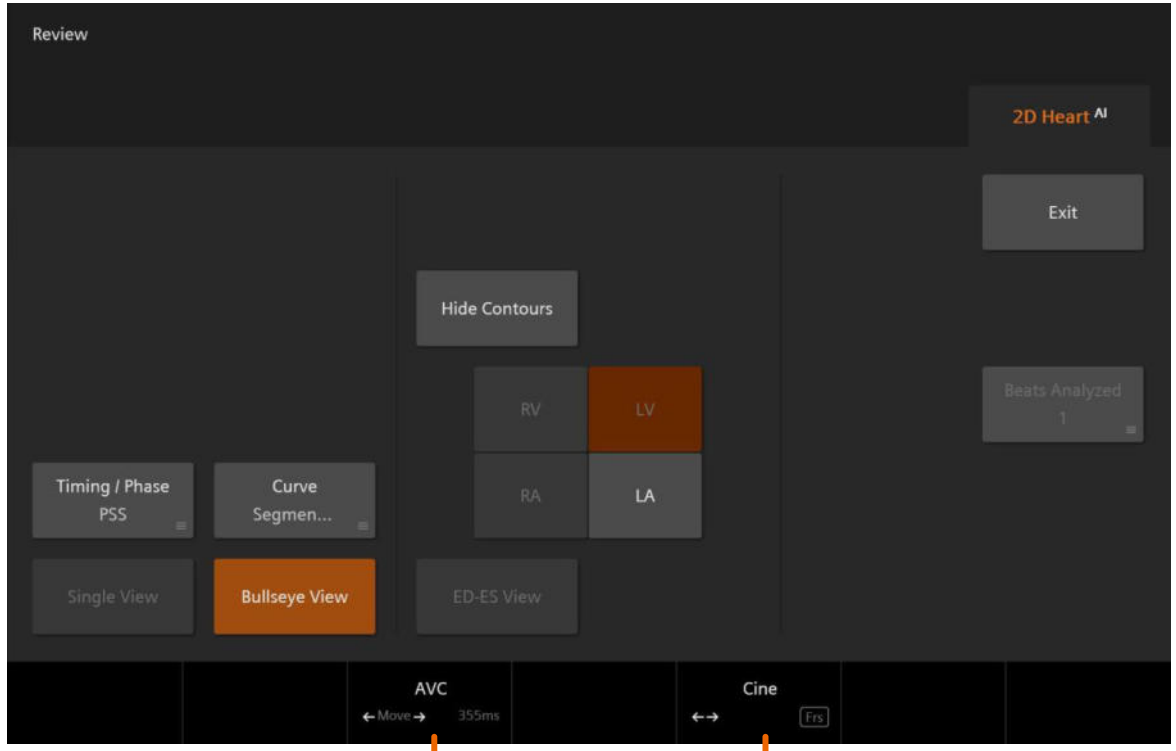
Bullseye view touch screen

The Bullseye View touch screen includes the following options:

- **Timing / Phase** – changes timing / phase parameters displayed
- **Curve** – changes Curve parameters displayed
- **Hide Contours** – removes contour display from all views
- **Chamber selection** – select currently displayed chamber results
- **Exit** – select to come out of 2D Heart^{AI} and back to active imaging
- **AVC** – rotate to adjust aortic valve closure time; press to set
- **Cine** – rotate to cine through frames



Rotate to adjust aortic valve closure

Rotate to Cine through frames

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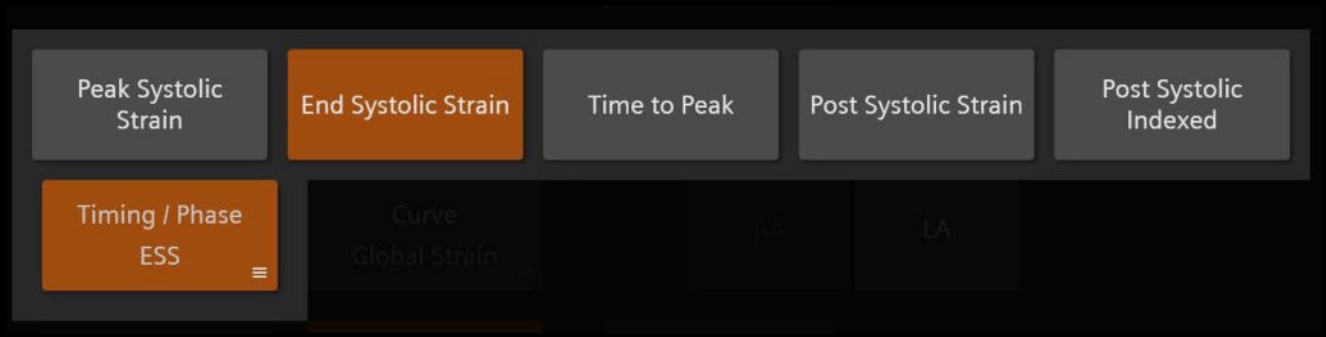
Timing / phase options

Timing / Phase options available for the bullseye summary include:

- **Peak Systolic Strain** – peak strain value during systole, measured before aortic valve closure (AVC)
- **End Systolic Strain** – strain value at end systole, measured at AVC
- **Time to Peak** – time it takes to reach peak strain
- **Post Systolic Strain** – strain value after end system, measured after AVC
- **Post Systolic Indexed** – ratio between deformation (strain) after end systole divided by total deformation



Note: *End Systolic Strain is the parameter recommended by the EACVI / ASE / Industry Task Force for routine exams.*[*]

Sources | *. Voigt, et al., *JASE* (2015) 28;2: 183-193

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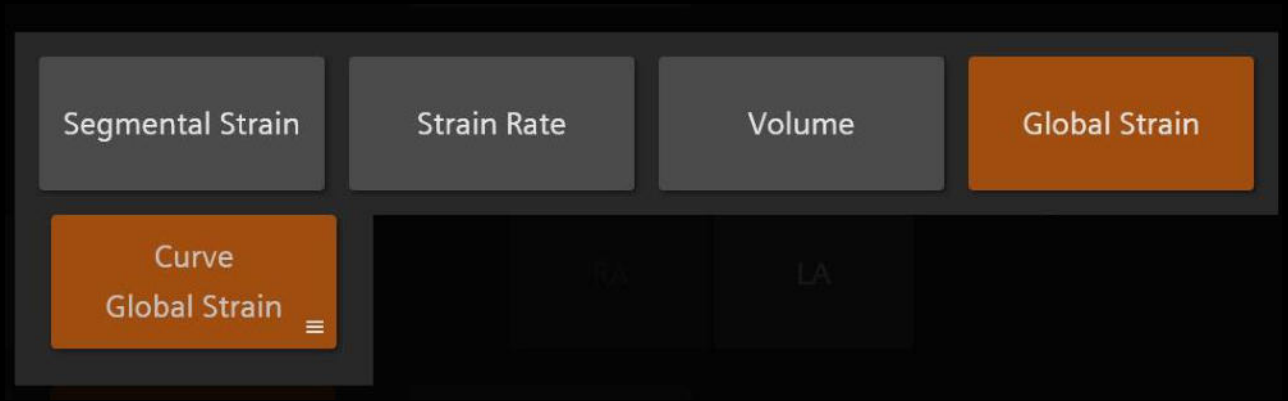
Curve options

Curve options available for the bullseye summary are:

- **Segmental Strain** – average value in each segment of the cardiac chamber
- **Strain Rate** – rate of deformation (how fast the deformation occurs)
- **Volume –** change in chamber volume from ED to ES
- **Global Strain** – strain calculated by using the entire myocardial line length to calculate deformation; can also be computed by averaging the values from the segments



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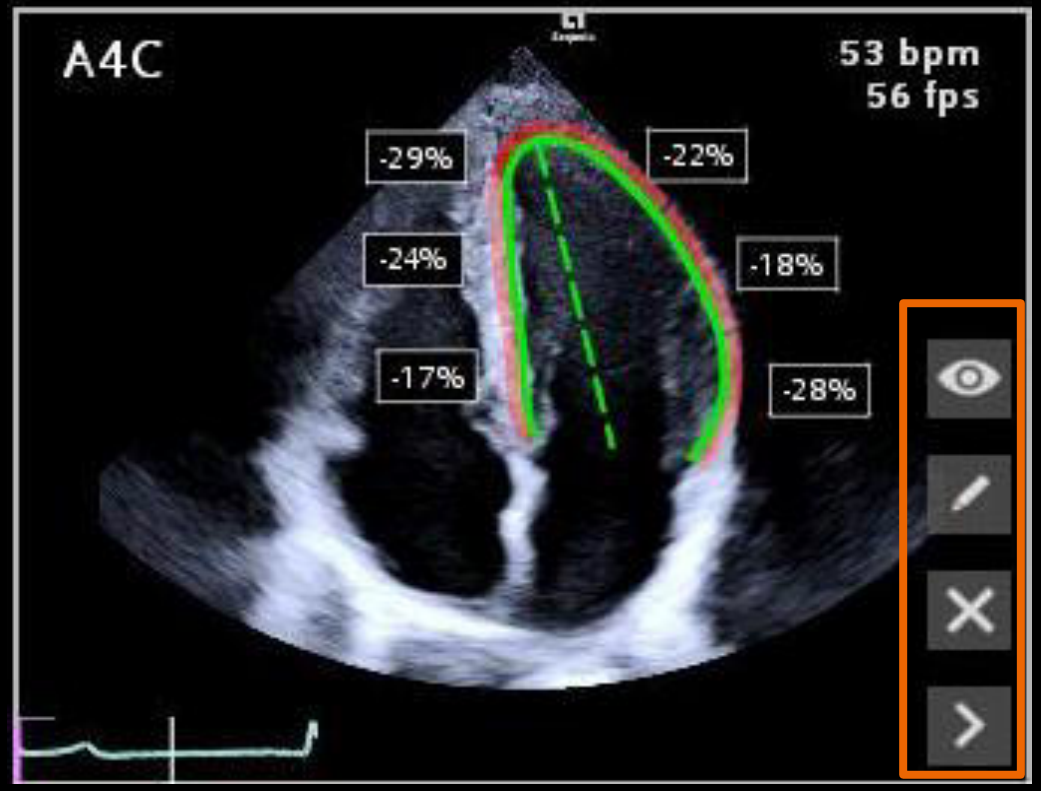
Monitor controls

Hide/Show Segment Values – show or hide segment values on tracked clips

Edit Contours – brings user to ED-ES layout for editing

Delete View – removes view within viewport; removes view, curves, and analysis
Cannot undo after deletion!

Single View – brings user to single view layout



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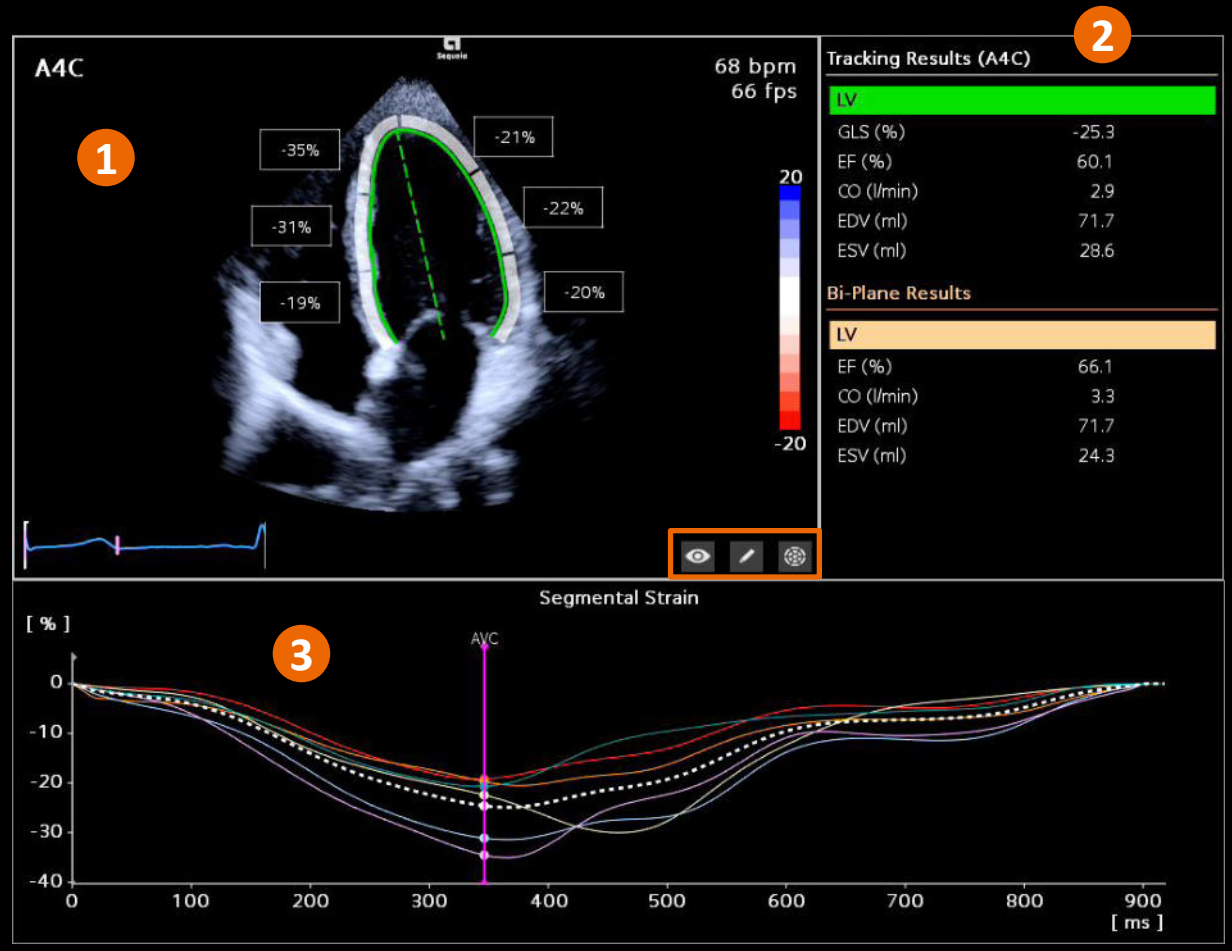
Tracking analysis – single view

Single View displays a summary page for an individual view, as opposed to all three views and the completed bullseye.

1. **Viewport** – display of currently selected view with contour and segment values; other display options are listed on the bottom right-hand corner
2. **Summary** – list of results for currently selected chamber
3. **Curves** – curve display for currently selected view (choose results displayed from touch screen)

*TIP: Press the **Update** key on the control panel to change the currently displayed view.*



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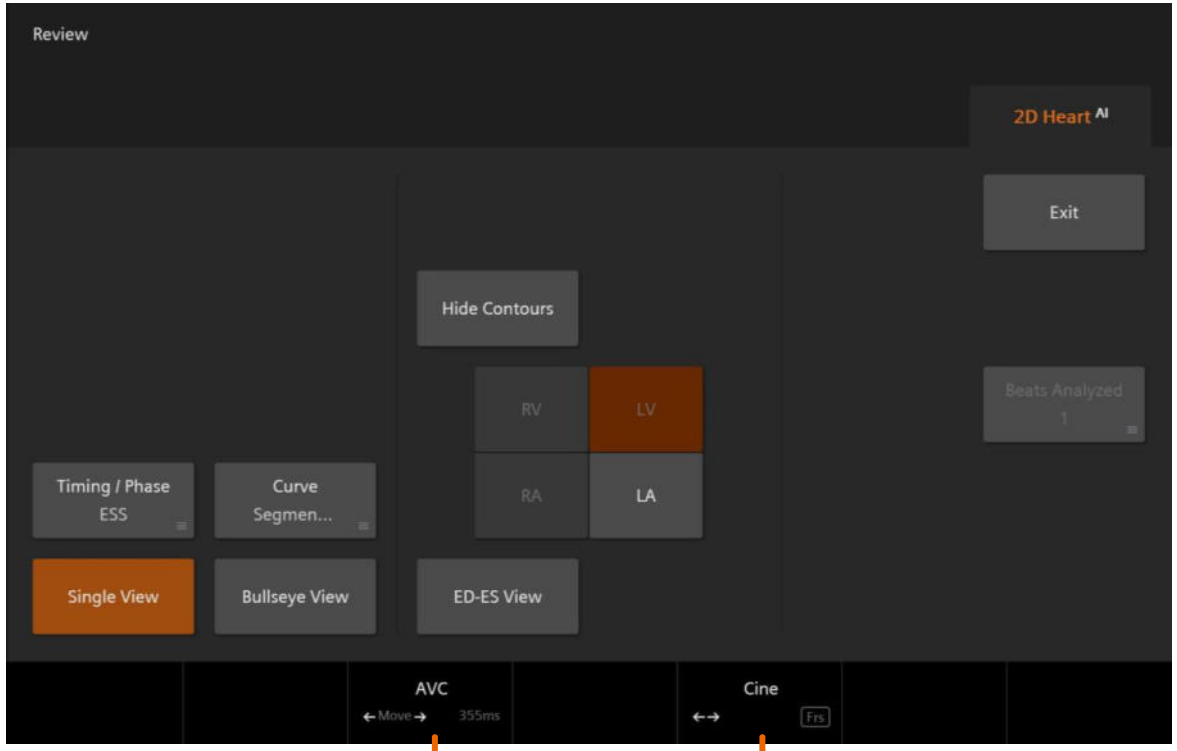
Single view touch screen

Options available on the Single View touch screen include:

- **Timing / Phase** – changes timing / phase parameters displayed
- **Curve** – changes Curve parameters displayed
- **Hide Contours** – removes contour display from all views
- **Chamber selection** – select currently displayed chamber results
- **Exit** – select to come out of 2D Heart^{AI} and back to active imaging
- **ED-ES View** – return to ED-ES View layout to edit contours for current view



Rotate to adjust aortic valve closure

Rotate to Cine through frames

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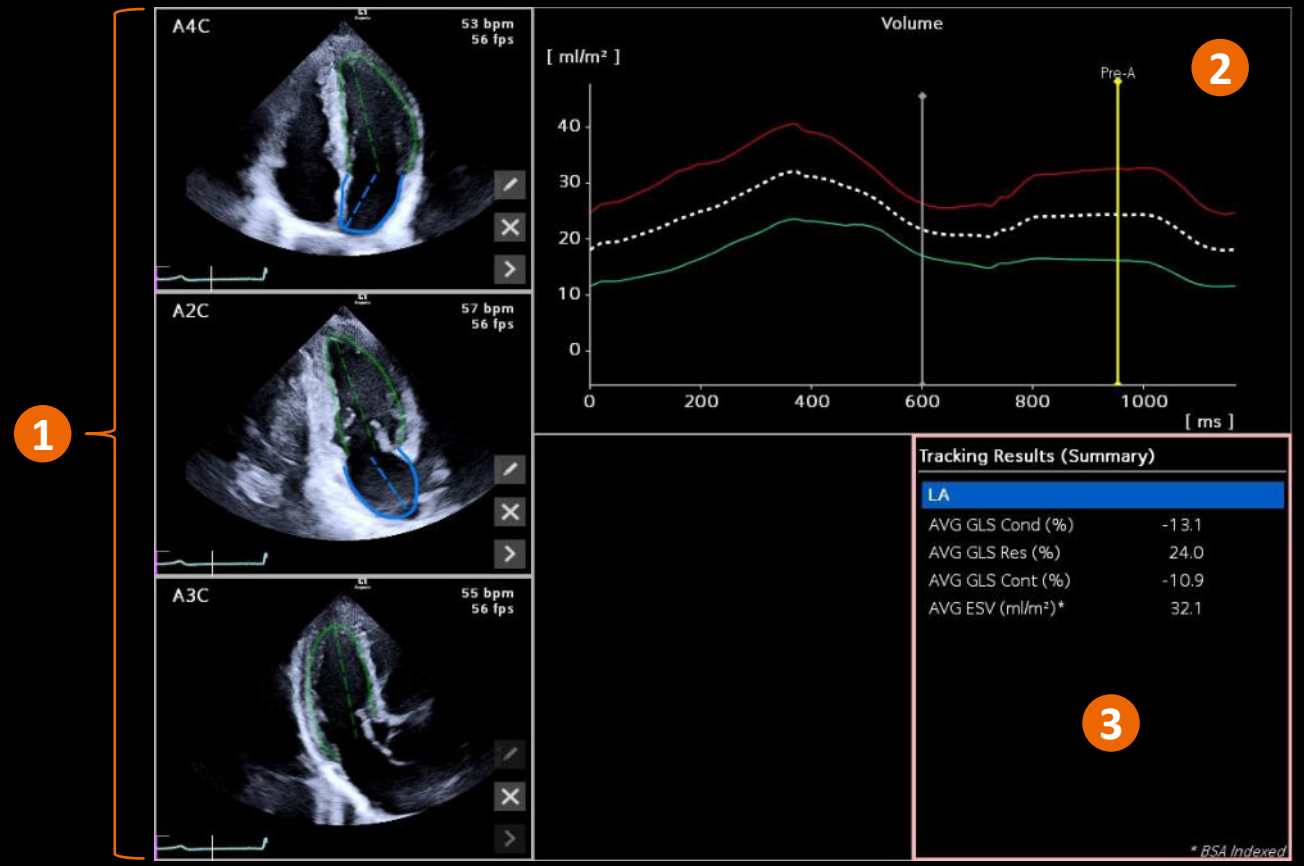
Tracking – Bullseye View for the LA

To obtain the tracking results for the left atrium, select the LA option on the touch screen while in Bullseye View

Tracking results for the LA includes the following:

1. **LA viewports** – the LA is only tracked in the apical 4 and 2 chamber views
2. **Curve** – LA curve display (choose value from touch screen)

3. **Summary** – list of LA chamber results from analysis



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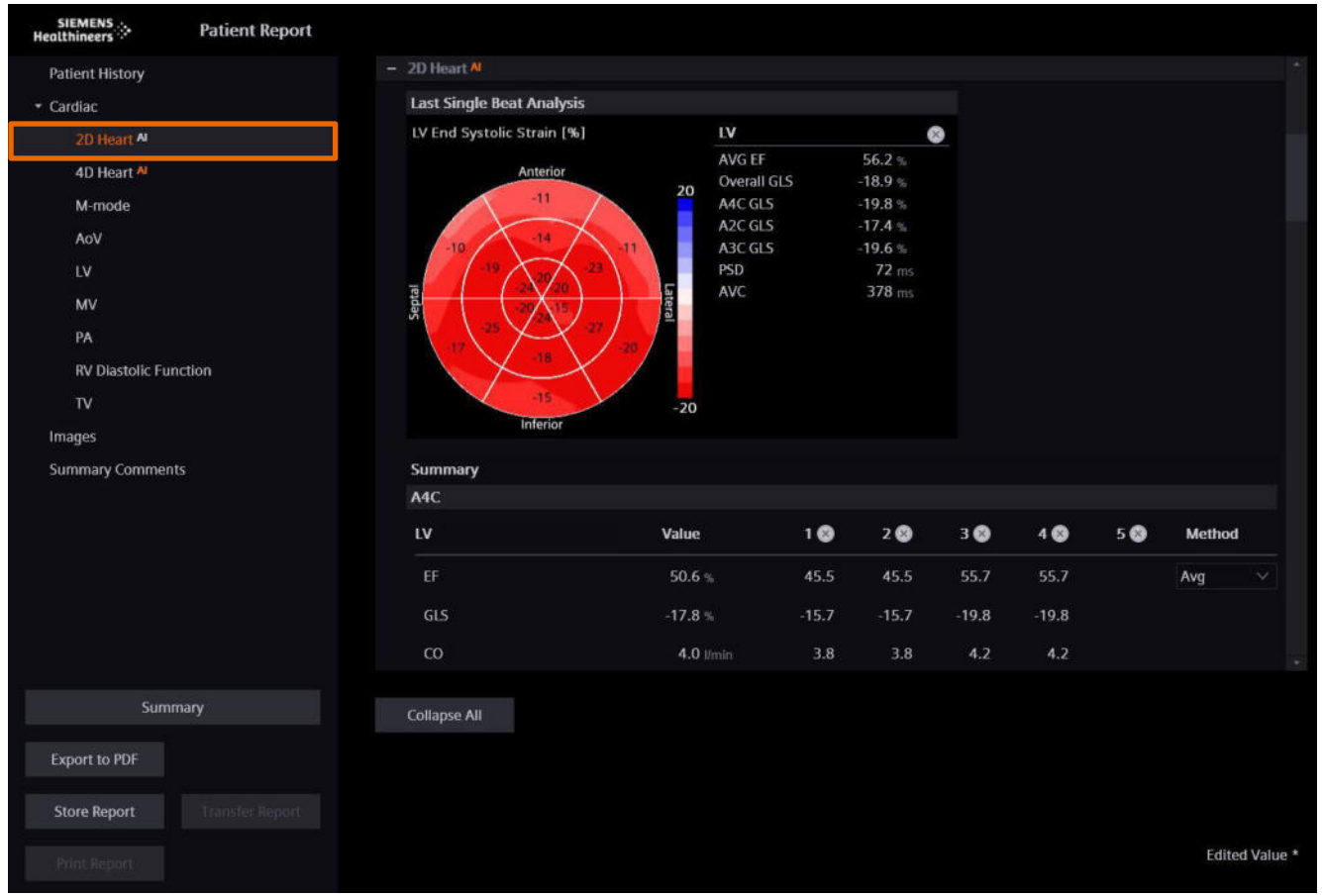
Report layout - bullseye

For results, select the 2D Heart^{AI} option on the left-hand side of the report

- The last *captured* analysis is displayed on the report bullseye
- Bullseye displays the Timing / Phase value selected in system configuration or during the exam from the touch screen
- Segments cannot be removed from the bullseye in the report
- A GLS value for all three chambers and the Overall GLS are listed in the LV summary with the bullseye

Note: *If an analysis is not captured during the exam, the bullseye results will not populate to the report.*



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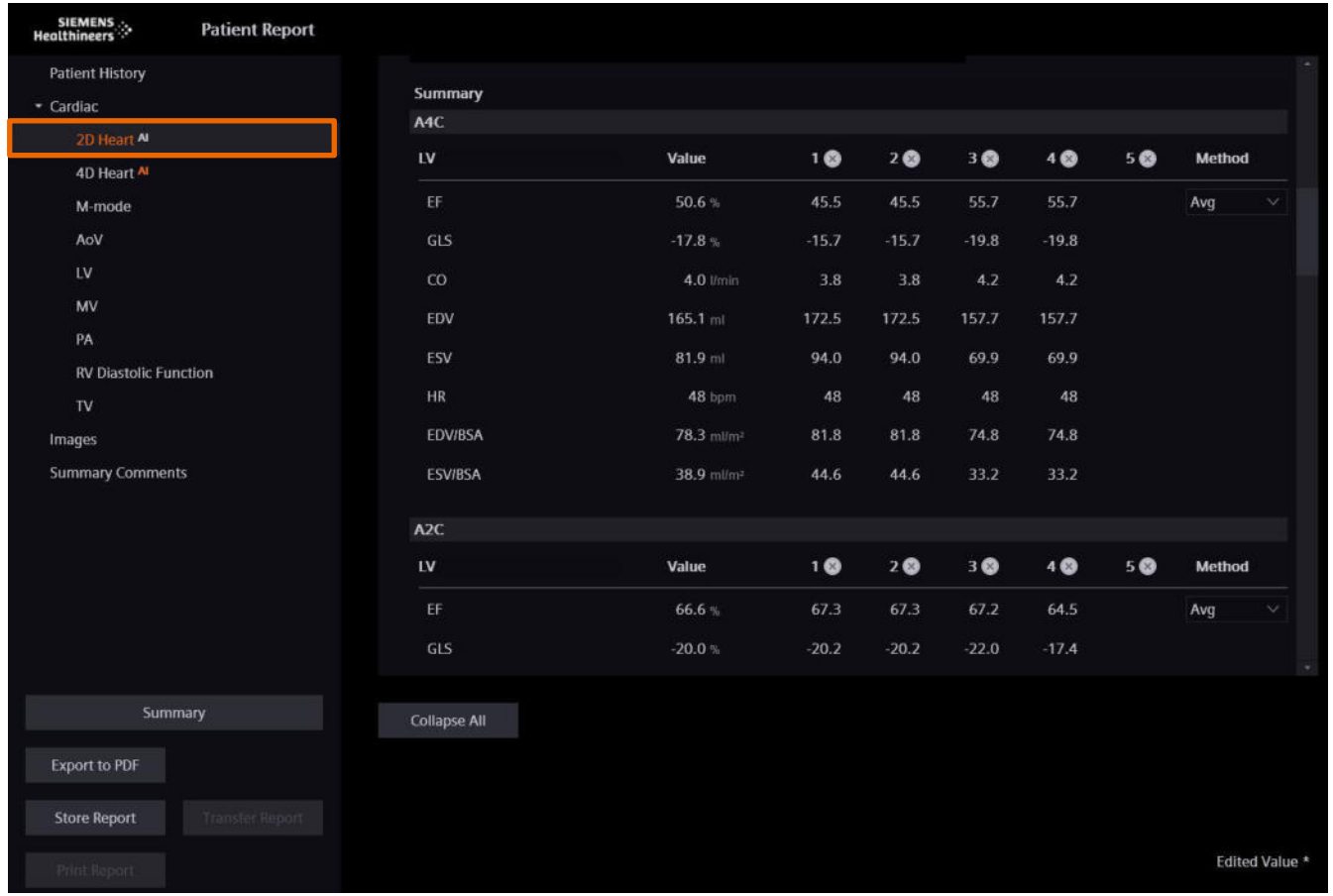
Report layout - worksheet

The worksheet includes the last five instances captured

- Result values can not be edited, only deleted
- Method can be set to Average, Last, First
- Results are listed by chamber (A4C, A2C, A3C)
- **Store Report** – saves an image of the entire report
- **Export to PDF** – exports a pdf version of the report to a USB
- **Print Report** – prints the report to the configured printer



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Report layout - Summary

The Summary page is displayed when Summary is selected from the Report page or the touch screen

- GLS, EF, and Volume measurements listed for each chamber
- Bi-Plane results from apical 4 and 2 chamber views
- Select **Edit Report** to return to the report worksheet

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Summary

- Review cardiac strain principles
- Explain image acquisition for cardiac strain
- Discuss 2D Heart^{AI} workflow
- Evaluate cardiac strain analysis and report

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Resources

1. Yingchoncharoen, Teerapat, et al., *JASE* (2013) 26: 185-91
2. Ashish, Kumar, et al., *IJC Heart & Vasculature* (2019) 22: 48-49
3. Espen Boe, Otto, et al., *European Heart Journal* (2022) 23;9: 1169-1170
4. Pathan, F., et al., *J Am Soc Echocardiography* (2017) 30; 1: 59-70

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Questions?

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