Cardiac Viewer Slab Mode

Slab is the default view mode when you open the Cardiac Viewer. The window opens in the general axes mode. The axial image in the main viewport is active by default.

Slab mode functions specific to the Cardiac Viewer are described in this section. The following features are included in Cardiac Viewer's Slab mode (see section "Cardiac Viewer 2D Viewing Tools" on page 74).

Cardiac Axes

You can view heart images in the "cardiac axes" orientations, which are the horizontal long axis, the vertical long axis, and the short axis. (This is in addition to the standard axial, sagittal, and coronal orientations, which are referred to as the "general" axes.)

Rotation Center

You can rotate the volume image around a center point.

You can view the same image location over several heart phases. This shows the motion of the heart over the loaded heart phases.

You can view the same image location over several heart phases. This shows the motion of the heart over the loaded heart phases.

Multi-view Time Mode Batch

Multi-view Time Mode Batch can be created in the following modes:

- **Echo Mode.** In this mode the time mode batch is created on several viewports at once.
- **Planar Mode.** All viewports: 3 viewports with slab images. In the Planar mode, when you are using the Compare function, only a regular time mode batch of the active viewport can be created (not a multi-view time mode batch).

Cardiac Phases

You can simultaneously manipulate multiple heart cycle phases and move easily between phases by clicking phase indicator tabs along the top of the display window. (Phase tab manipulation is equivalent to switching between the series in the series list function tab.)

ECG Monitor Display

Allows you to view the ECG signal and measure time along the ECG wave.

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WARNING

Cross sectional images might rotate around the centerline. Please note orientation annotations on images.

In cases where the orientation annotations are not displayed on the image - you must not assume any specific orientation. For correct orientation information - use only the images which display such information.

One or more of the following image types may appear in this application: curved MPR, straightened MPR, volume images, and thick slab images. Measurements you make on such processed images can sometimes be misleading. When saving such images, make sure they are labeled properly.

Objects in thick curved MPR images may appear distorted. Use caution when making measurements on MPR images.

Load Multiple Studies in Application

To load multiple studies in the application:

1. Use the **Ctrl** key when selecting studies from the Directory list.
2. Select the application from the Applications menu.
3. Confirm the studies are from the same patient.

NOTICE

When loading data into an application, ensure the orientation shown on the images is consistent with the images' appearance. This precaution is required for data that contains wrong orientation information because the data will be incorrectly presented within the application.

Cardiac Viewer Slab Tools

Use the Cardiac Slab Viewer Tools to review images as acquired by the scanner.

See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

Orientation

At any time in the Slab viewing mode, you can change the image orientation between the General Axes and the Cardiac axes modes. Click the down arrow to switch between the two orientation modes. See section “General Axes” on page 78 and section “Cardiac Axes” on page 78.

General Axes

The general axes are the standard anatomical orientations: Axial; Coronal; and Sagittal.

Cardiac Axes

The cardiac axes orient the views of the heart as follows: Short axis; Horizontal long axis (4 Chamber View); and Vertical long axis (2 Chamber View). See also section “Cardiac Axes Display Layout” on page 85 and section “Step 3: Review Cardiac Axes Images” on page 87.

Flip

Use this button to flip all displayed images right to left. In the drop-down menu you can select the flip vertical function (up to down) of this tool.

Planar Mode

The Planar viewing mode displays the study in three orthogonal plane images. The planar mode is activated by the Planar button.

Activating the Planar mode shows the standard cardiac angles, in the lower right-hand corner, on the three orthogonal views (MPR images).

NOTICE

Rotate the MPR images and review the corresponding cardiac standard angle.

Each image can be manipulated independently, while the axes remain oriented at 90 degrees to each other. Changing the rendering and thickness in one Planar viewport affects all viewports. Crosshairs appear on all 3 planar viewports. The crosshairs form the rotation center, around which the views can be rotated. See also section “Rotation Center” on page 79.

Layouts

There are 2 factory layouts, the 1+2 layout, which consists of one main image and 2 reference images, and the 2x2 layout, which consists of 4 equal size viewports.

(In the Curve mode, the 1+3 layout replaces the 1+2 layout. The third reference viewport displays the results of the drawn curve in the upper right corner.)

The Layout Manager allows you to create and select various display layouts.

See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

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Compare

The Compare function allows you to perform a side-by-side review of selected images of selected series.

See **Report**, **Film**, **CT Common Processes**, and **CT Common Tools** for information on using common options, tools, functions, and processes.

Relate

The Relate function helps orient yourself in the viewer. Clicking a location in one viewport marks the same location in other viewports, and other viewing modes.

Paddlewheel

The paddle wheel mode allows you to rotate images around one axis, x or y. See section “Paddle Wheel” on page 31.

Show Crosshair

Click to show the crosshairs on the reference images.

Rotation Center

Click to show the center point (indicated by a green X) around which the volume can be rotated.

Center Cursor

This function centers the image around the rotation center. Change the rotation center as follows:

1. Move mouse over the current rotation center (the green X) in the slab view. The mouse pointer turns into an arrow cross symbol.
2. Drag the rotation center to the desired region of interest.
3. Click **Center Cursor** and the slab view centers around the new rotation center location.

Any swiveling and rotating of the image will be performed around this new rotation center.

Reset Center and Axes

Clicking this button influences the rotation center and axis as follows:

Rotation Center

The center of rotation is reset to its original location upon loading the phases to the application.

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Orientation (if the image is in one of the general orientations)

The orientation of the main image is changed to axial.

Orientation (if the image is in one of the cardiac orientations)

he orientation of the main image is changed to short axis view.

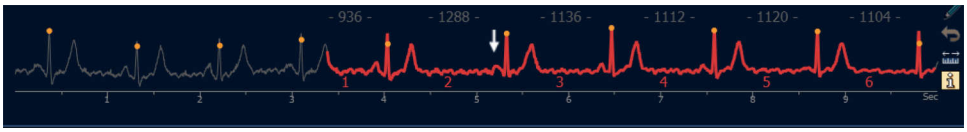
ECG

Click the Show ECG button to display the ECG strip along the bottom of the screen.

The ECG viewer displays, by default, data from 5 seconds before the start of the scan to 5 seconds after.

When scrolling through the axial images, the position of the ECG is continuously updated.

The ECG strip is colored red for the duration of the scan (while radiation was applied).

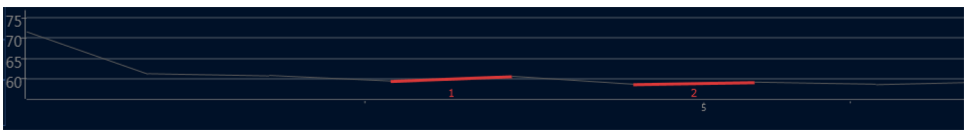


In the ECG mode, you can measure the time along the graph using this procedure:

Click the **Caliper** button. Click and drag from any starting point along the graph. Release the mouse button at the desired stopping point. The time between the start and end points displays.

Heart-rate Graph

Click the **HR graph** tab to switch to the Heart Rate graph, which displays the heart rate over time.



Magic Glass

The Magic Glass function displays a moveable, mini-window (3 cm default) which can be set with its own windowing, image enhancement and rendering parameters. With the Magic Glass function you can enhance visualization and assessment of certain elements of the image, such as calcium and stents, while maintaining optimal viewing parameters for the main viewport.

Cardiac Viewer Slab Functions

To access additional Slab Viewer functions, click the down arrow in the tab window, or hover the mouse over the tab window. The list of available functions displays.

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See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

Series

The Series list in Slab scene displays a list of the phase series loaded into the Viewer. It only contains original images.

Bookmarks

While using a viewer or an application, you can use a bookmark at any time to “save the current status” of your work.

Curve

The Curve function allows you to draw a curve (or load an existing curve to produce a curved path to produce a Curved Planar Reformat (cMPR) image, or a curved path for the Endo viewer’s fly through function.

The Curve function is not available in the Paddlewheel mode.

Clip

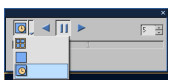
The Clip function is used to remove unwanted anatomy from the slab images.

Not all Clip functions are available in the Cardiac Slab viewing mode. Only the Bone Removal and Sculpting functions are available.

Batch

The Slab Batch function allows you to create a series of sequential slab images for viewing, saving, reporting and filming purposes.

Cine (Time Mode)



In the Slab mode, you can perform Cine (in the main viewport) in either the Location or the Time mode. Time mode cine performs only on the active viewport.

Multi-view Batch

In certain modes of the Cardiac Viewer and Comprehensive Cardiac Analysis applications (see the CT Analysis volume), you can create a time mode batch simultaneously in more than one viewport (a “multi-view batch”).

When playing a multi-view time mode batch, all viewports play the batch simultaneously. Changing the speed of the cine affects all viewports simultaneously.

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In the modes described below, when you save, film or send to report a time mode batch, the output is a single movie file showing the heart images of all viewports beating together.

Creating a Multi-view Time Mode Batch

A Multi-view time mode batch is created in the same way as a regular time mode batch:

- By activating one of the relevant viewports; and
- by either checking the Time mode option in the batch tab or by choosing and playing the Time mode option in the cine dialog.

In Cardiac Viewer – Slab Mode

Multi-view time mode batch can be created in the following modes:

- **Echo Mode.** All viewports: one viewport with short axis plane slab images, and 3 viewports with long axis plane slab images.
- **Planar Mode.** All viewports: 3 viewports with slab images. In the Planar mode, when you are using the Compare function, only a regular time mode batch of the active viewport can be created (not a multi-view time mode batch).

In Comprehensive Cardiac Analysis - Functional Stage

Multi-view time mode batch can be created in the following modes:

- **View Results Mode.** One viewport with short axis plane slab images, and 3 viewports with long axis plane slab images.
- **Correct Axis Mode.** All viewports: 1 viewport with short axis plane slab images, and 2 viewports with long axis plane slab images.

Tissue Management

When playing a multi-view time mode batch, all viewports play the batch simultaneously. Changing the speed of the cine affects all viewports simultaneously.

Functional Analysis

Functional Analysis allows you to analyze a variety of heart functions, including left ventricle volumes, ejection fraction, stroke volume, and cardiac output. See section “Functional Analysis” on page 83.

Fusion

The Fusion Viewer employs standard CT Viewer functions, allowing you to view PET and SPECT images, and to fuse NM images with CT images. See section “CT Viewer Fusion Mode” on page 61.

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Functional Analysis

The basic purpose of Functional Analysis in the Cardiac Viewer is to determine the proportion of (contrasted) blood ejected by the left ventricle during one heart cycle. This proportion is called the Ejection Fraction.

The Ejection Fraction (expressed in percentage) is calculated by subtracting the ventricle's minimum blood volume (ES, end systolic) from the ventricle's maximum blood volume (ED, end diastolic), and dividing by the ventricle's maximum blood volume (ED).

NOTICE

Two factors affect the accuracy of Functional Analysis calculations:

- Whether the phases that have been loaded include those closest to the actual ED and ES volumes.
- How accurately the user draws the ventricle volume contours and the ventricle length lines.

The various calculations obtained by Functional Analysis are shown in the Functional Results table.

By entering the patient's weight and height, you can have the Functional Results normalized by Body Surface Area. Display the normalized BSA Functional Results table by selecting it from the "Show table" drop-down menu.

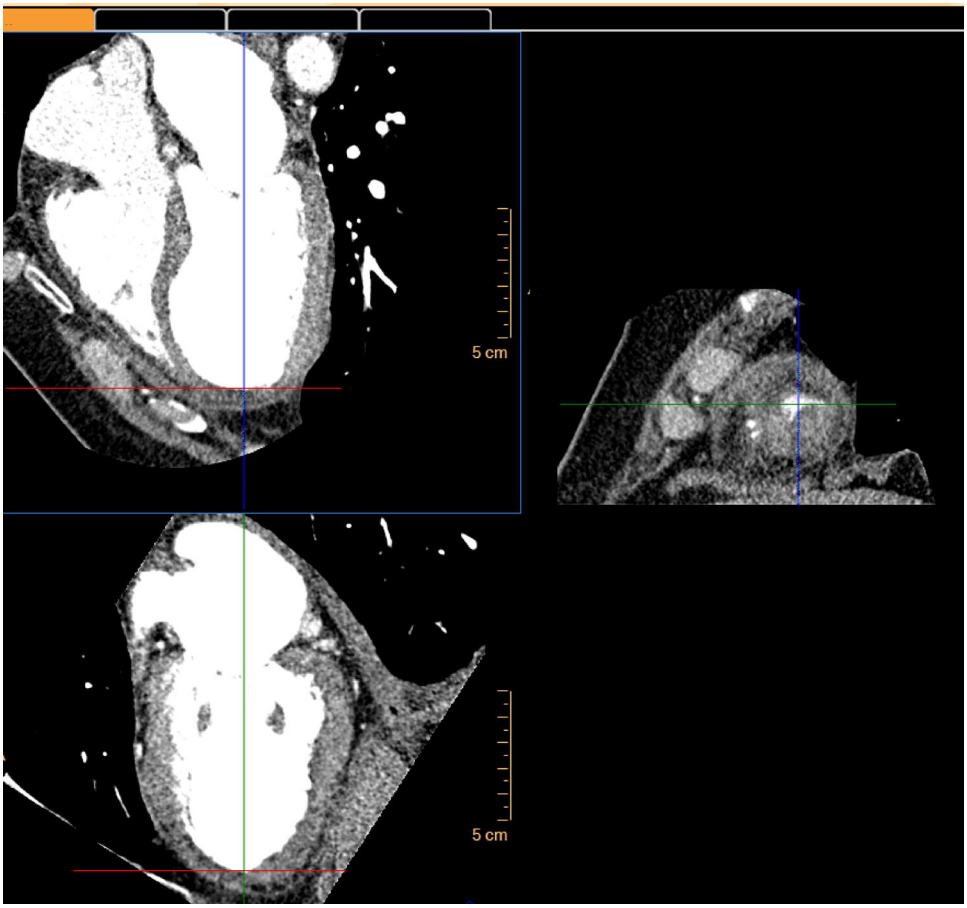
The Functional Analysis feature provides several functional parameters calculated based on Area-Length method. Following is the summary of workflow steps required to use Functional Analysis:

1. **Load Study.** From the Directory, load the desired study into the Cardiac Viewer application, including sufficient cardiac phases, and the ECG data, if available. See section "Cardiac Viewer Requirements" on page 68.
2. **Activate Functional Analysis.** From the Slab viewer's tab menu activate Functional Analysis. The application automatically enters the Correct Axis mode.
3. **Review the Cardiac Axes images.** The red cross-hair should be located at the apex. The green and the blue cross-hairs should be located along the middle of the left ventricle and should cross the apex and the mitral valve.
4. **Correct Axes, if necessary.** Correct the axes if necessary by rotating and moving the cross-hairs on the phases you consider as the ED and ES phases. It is recommended to determine the ED and ES phases before you enter the Functional Analysis tab.
5. **Set the ED and ES phases.** Click the Area Length Ejection Fraction button. From the "Set ED/ES" dialog, which opens automatically, choose the ED and ES phases. The system will recommend settings of ES at 40%, and ED at 0%. (If the 40 and 0 phases are not loaded, the system will recommend the phases closest to 40 and 0).
6. **Draw the endocardial contours** of the left ventricle on all 4 images. Once the contours are drawn the left ventricular long axis diameter is displayed automatically along the long axis.

7. **View the results.** Results are displayed in the Functional Results table. You can save and film the results, and send them to Reporting.

Start Functional Analysis

With an appropriate cardiac study loaded into the Cardiac Slab viewer, click the down arrow in the tab window and then select **Functional Analysis** from the menu. There is a delay while the application processes the study. When processing is complete, the Functional Analysis opening window appears, as shown below, in a 2x2 layout showing the Short Axis and the two Long Axis images.



Functional Analysis Tools

When you first start Functional Analysis, the tool panel appears. (Some tools are grayed out and unavailable until later.)

See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

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Correct Cardiac Axes

This mode is active when you start Functional Analysis. The Correct Axis function allows you to more accurately position the colored crosshairs onto the apex of the left ventricle in the 3 Cardiac Axes viewports.

NOTICE

You can skip the Correct Axis function if the crosshair positions look OK. Click the Ejection Fraction button to continue.

Set ED/ES

Use this function after you are satisfied with where the apex of the left ventricle is located by the crosshairs. Clicking this button to opens a dialog box where you can designate the ED and ES phases.

Area/Length Ejection Fraction

You can use this function at any time: if you have not set the ED and ES phases, you will be prompted to do so before you can continue. When the ED and ES phases are set, clicking the Ejection Fraction button updates the 2x2 layout window with 4 new viewport images: 2 Horizontal Long Axis images and 2 Vertical Long Axis images, depicting the ED and ES phases for each axis.

Draw/Edit/Delete Contours

The Draw/Edit/Delete Contours buttons become active after the ED and ES phases are set. Use these tools to draw (and edit or delete) contours in the ventricles in all 4 viewports: in both horizontal and vertical views, and at both maximum (ED) and minimum (ES) ventricle volumes.

Show Table

The Show Table button toggles the Functional Result table on and off. The drop down menu allows you to select a table normalized by Body Surface Area factor.

Cardiac Axes Display Layout

After Functional Analysis processes the study into cardiac axes orientation, the opening window consists of the following components:

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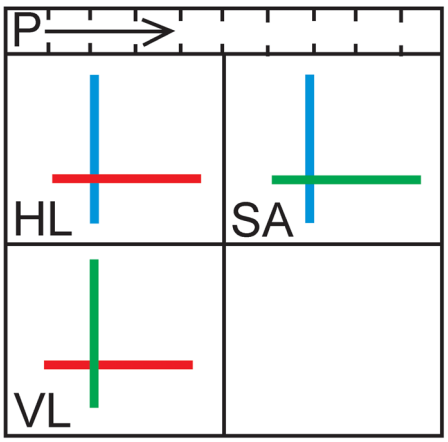

- HL - Horizontal Long Axis viewport.
- VL - Vertical Long Axis viewport.
- SA - Short Axis viewport.
- P - Phase tabs.

Axis Lines

The opening window viewports display Cardiac Axis images that show the heart according to the left ventricle's long axis. Each viewport has colored lines that intersect at the apex of the left ventricle. The colors are assigned this way:

- red represents the short axis;
- green represents the horizontal long axis; and
- blue represents the vertical long axis.

Also shown in the viewports are 3D orientation boxes in the lower-left corners.

Phase Tabs

Tabs representing all the loaded cardiac phases appear above the upper viewports. Click a tab and, after a short delay, the viewports are refreshed with Cardiac Axis images that correspond to the selected phase.

Step 1: Load Valid Study

From the Directory, load the desired study into the Cardiac Viewer application.

Phases are defined according to the percentage of heart contraction during a heart cycle.

Functional Analysis can only work with contrast enhanced studies that were acquired concurrently with an ECG signal.

The series of images are identified in a row of tabs above the viewports identifying to the cardiac phase during which they are acquired (0%, 10%, 20%, etc.). See section "Cardiac Viewer Requirements" on page 68.

See section "Step 2: Activate Functional Analysis" on page 87.

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Step 2: Activate Functional Analysis

After the study has been loaded, activate Functional Analysis from the Slab viewer's tab menu. The study is processed and Cardiac Axes images are created and displayed (see section "Cardiac Axes Display Layout" on page 85).

See section "Step 3: Review Cardiac Axes Images" on page 87.

Step 3: Review Cardiac Axes Images

Click the phase tabs to examine the various heart cycle phases. Determine which phases are the ED and ES by examining each phase separately.

See section "Step 4: Correct Axes" on page 88.

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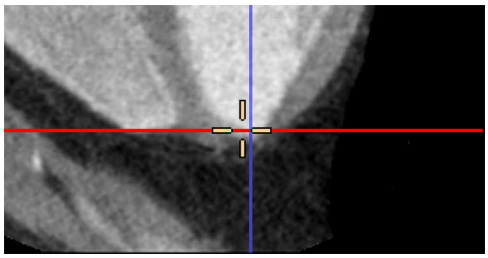
Step 4: Correct Axes

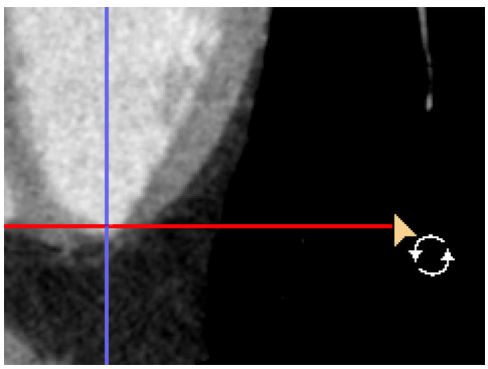
The Cardiac Axes are generated so that the cross-hairs of the long axes views cross the left ventricle through the apex and the mitral valve. After you examine the Cardiac Axes, if you want to adjust the crosshairs, use the Correct Axis function.

You can zoom and pan the viewport to better observe the crosshairs. You can also expand any viewport to full size by double-clicking in it. Double click again to return to the original layout.

1. With the Correct Axis function active (the button appears depressed), move the mouse pointer toward the crosshairs you want to adjust.
2. The pointer changes to a crosshair pointer.



3. Holding down the left mouse button, drag the crosshairs to the desired position.
4. Repeat the Correct Axis procedure in other viewports, as needed.
5. If correcting the cross-hairs requires rotating them, move the mouse pointer to the edges of the cross-hairs. The cursor changes to a rotation cursor, making it possible to rotate the cross-hair.



See section “Step 5: Set ED and ES Phases” on page 88.

Step 5: Set ED and ES Phases

The specific phases at which ED and ES occur must be indicated (“set”) before the next work stage can start. You must set the ED and ES phases by either manually clicking on the Set ED/ES button, or by witching to Area Length Ejection Fraction mode, where the dialog opens automatically.

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Manually Open Dialog

1. Click **Set ED/ES** to open the dialog manually, where you can designate the ED and ES phases. The phases are set to 0.
2. Click the down arrow of each phase box and select the desired phase. You can only select a phase that has been loaded - you cannot enter your own values.
3. Click **OK** when finished and proceed to the next step.

Automatically Open Dialog

By default the ED shall be 0%. If the 0% phase is not loaded then ED is set to the largest phase loaded. By default the ES shall be 40%. If the 40% phase is not loaded then ES shall be set to the loaded phase closest to 40%.

1. Click the **A/L (Ejection Fraction)** button. The display changes to the Ventricle contour drawing display (see Step 6). The Set ED/ES dialog box also opens.
2. Check the automatic recommendations and change if necessary.
3. Click **OK** to close the dialog.

See section “Step 6: Area/Length Ejection Fraction” on page 89.

Step 6: Area/Length Ejection Fraction

Click the Area/Length Ejection Fraction button to see the measurements layout.

The contour drawing buttons are activated when you enter the Contour drawing work stage. (From left to right, they are Draw contour, Edit contour, Delete contour.)

When finished editing and drawing contours, see section “Step 7: Adjust Length Dimension” on page 92.

Measurements Display Layout

ED Ver. Ax %	This viewport shows the End Diastolic phase (maximum volume phase) in Vertical long axis orientation.
ES Ver. Ax %	This viewport shows the End Systolic phase (minimum volume phase) in Vertical long axis orientation.
ED Hor. Ax %	This viewport shows the End Diastolic phase (maximum volume phase) in Horizontal long axis orientation.
ES Hor. Ax %	This viewport shows the End Systolic phase (minimum volume phase) in Horizontal long axis orientation.

Draw Contour

The procedure to draw a contour is the same as drawing an ROI in the Common Tools.

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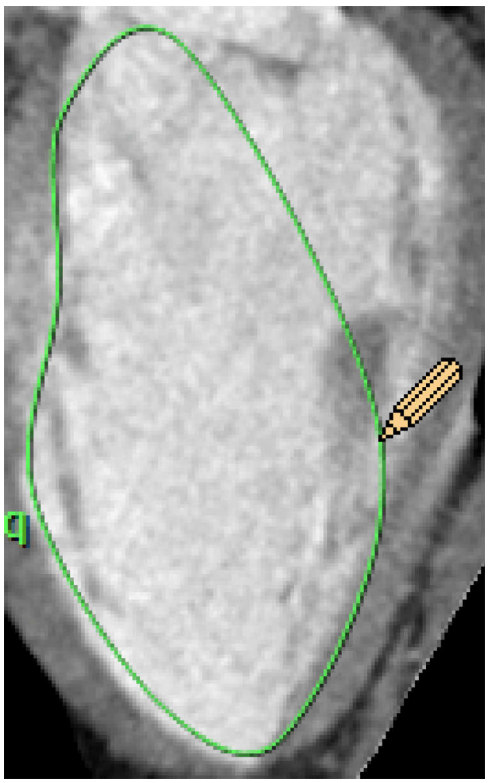
You can zoom and pan a viewport to better observe the ventricle. You can also expand any viewport to full size by double-clicking in it. Double click again to return to the original layout.

1. Click the **Draw Contour** button to activate the drawing function. The mouse pointer becomes a pencil.

2. To start, point to any point of the ventricle wall and click on it.
3. Move the pencil pointer along the wall to another point and click. The image below shows the contour line in the process of being drawn.



4. Continue contouring the ventricle wall until it is well defined.
5. Double-click on the last point to finish. (The image below shows a finished contour.)

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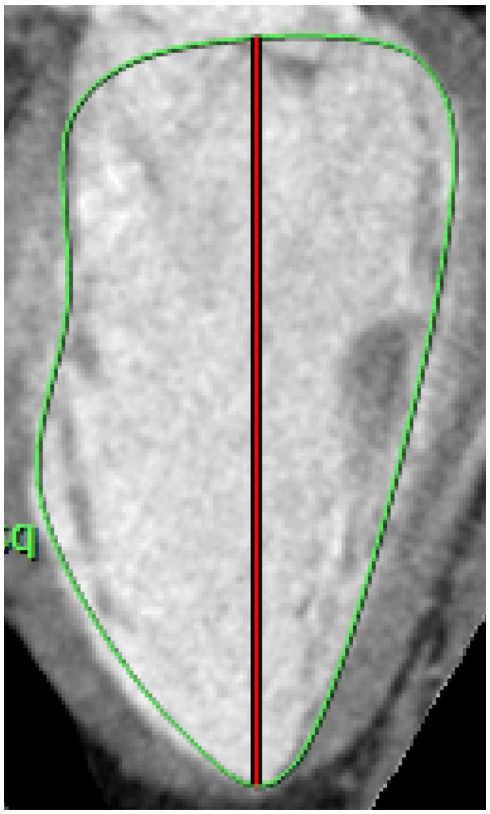

When you finish drawing the contour the left ventricular diameter is drawn automatically.

This diameter is located along the long axis line, so if the long axis line was set correctly in the Correct Axis mode, there is no need to edit this diameter's position. Editing of the diameter position is described in the next section.

When finished editing and drawing contours, see section “Step 7: Adjust Length Dimension” on page 92.

Edit Contour

If you want to correct the contour, use the following procedure.

Click the **Edit Contour** button to activate the contour drawing function.

As you move the mouse pointer near the green contour line, it turns yellow. Control points (small squares) appear around the contour.

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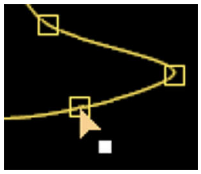
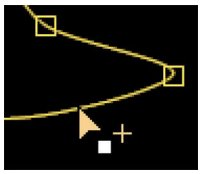
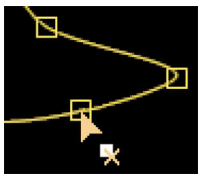
	To edit the shape of the contour : • Point the mouse to the control point you want to move. The cursor becomes an arrow head with a white square. • Drag the control point to the desired location. • Move additional control points as needed.
	To add new control points: • Click on the graphic. • Move the mouse onto the contour where you want a new control point (not on an existing control point). The pointer changes to an arrow head with a white square and a plus sign (+). • Left click to add a new control point.
	To delete a control point: • Hold down the <Ctrl> key. • Move the mouse over the control point that you want to delete. The cursor changes to an arrow head with a white square with an X symbol. • Click on the control point. It is deleted.

When finished editing and drawing contours, see section “Step 7: Adjust Length Dimension” on page 92.

Step 7: Adjust Length Dimension

When you finish creating contours, a vertical line is automatically added, as shown below.

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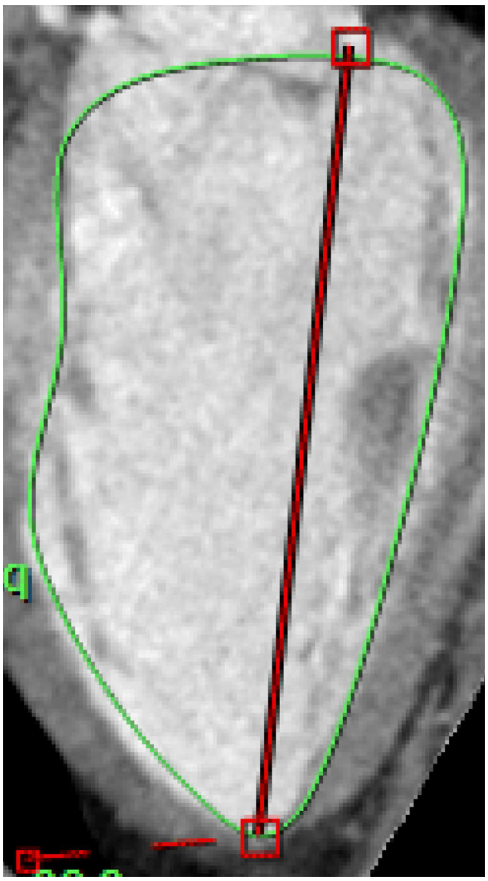

You must reposition this preliminary line to create the Ventricle Length line. The Length line is used (in conjunction with the ventricle area inscribed by the contour) to determine the ventricle volume.

1. If you are not already in the Edit contour mode, click the **Edit Contour** button to activate it. Move the mouse pointer near the Length line. It turns yellow. Control points (small squares) appear at each end of the line.

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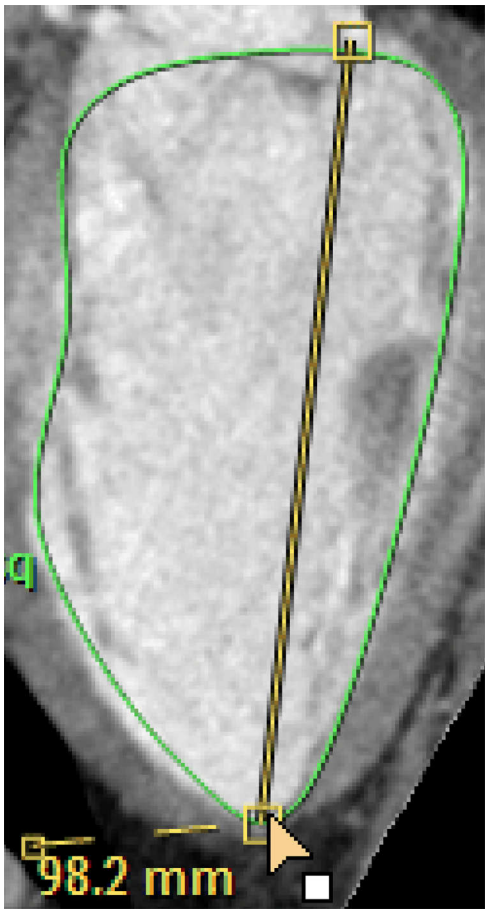

2. Drag one or both control points as appropriate to form a line that approximates the length of the ventricle, as shown below.

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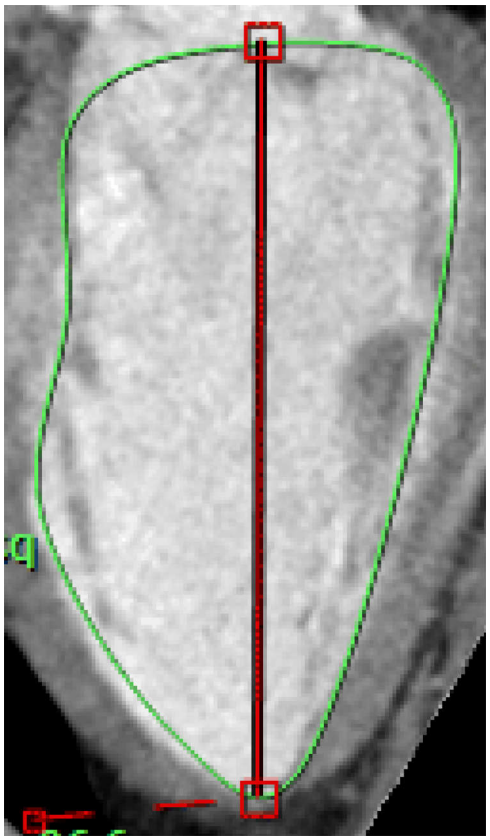

3. When finished, see section “View Results” on page 95.

View Results

After you have finished drawing the ventricle contours and ventricle lengths, the Functional Analysis results can be viewed in the Functional Results table at the bottom of the display. The display may be turned on and off by clicking the **Show Table** button. (All volumes are expressed in milliliters.)

ED Volume

This is the volume of the left ventricle at the End Diastolic phase, the phase with the maximum ventricular volume.

ES Volume

This is the volume of the left ventricle at the End Systolic phase, the phase with the minimum ventricular volume.

Stroke Volume

he volume at ED minus the volume at ES.

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Cardiac Output

The Stroke volume times the Heart rate (expressed in milliliters per minute).

EF (Ejection Fraction)

The volume at ED minus the volume at ES, divided by the volume at ED, times 100.

Ventricle Volume Calculations

The results are displayed as separate vales for Horizontal LA (long axis), Vertical LA, and Biplane (the average volume using the horizontal and vertical long axes). The ventricle volumes are calculated using these formulas:

Horizontal LA Volume	8/3pi * area (squared) / Long axis length.
Vertical LA Volume	8/3pi * area (squared) / Long axis length.
Biplane Volume	8/3pi * area (Vertical LA) * area (Horizontal LA) / Long axis length. The shortest of the two long axes is taken.
Stroke Volume	ED volume minus ES volume (ml).
Cardiac Volume	Stroke volume times heart rate (ml/min).
EF (ejection fraction)	The difference between ED volume and ES volume, divided by ED volume, times 100. (The result is a percentage.)
HR (heart rate)	The mean HR from ECG (if ECG is loaded); otherwise, initial HR from DICOM tag.
BSA (body surface area)	The square root of product of the weight (in kG) times the height in cm divided by 3600. (Reference: Mosteller RD. Simplified calculation of body-surface area. N Engl J Med 1987;317:1098)

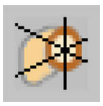
Body Surface Area

The body surface area is the total surface area of the human body. (BSA may be used to produce the cardiac index, which is a measure of cardiac output divided by the BSA, giving a better approximation of the required cardiac output. The BSA is calculated as described in the table on the previous page.)

To apply BSA to the Functional Analysis calculations:

1. Click the down arrow of the **Show Table** function.
2. Select **Show Table/BSA**. The BSA Calculation dialog box appears.
3. Type in the patient's weight and height (in kG and cm) and click **OK**.

Echo Viewing Mode



Click the **Echo** button to display the four Echo views, which are conventionally used in echocardiography.

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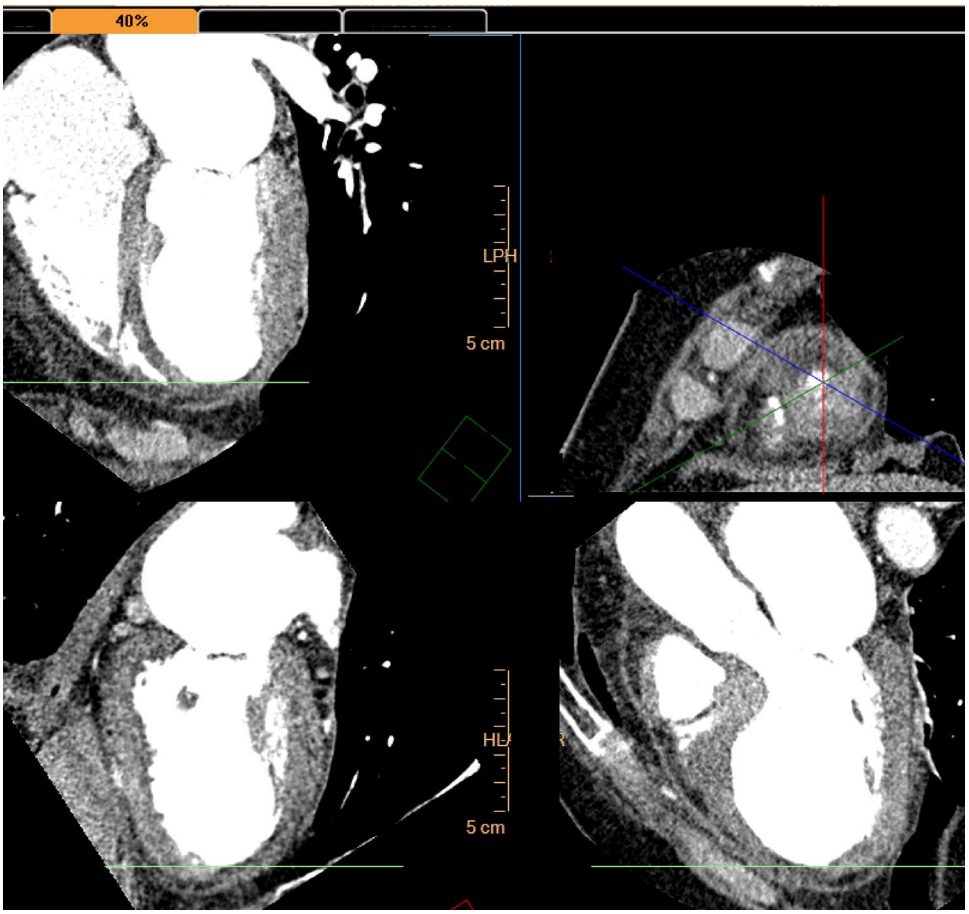

The upper right viewport displays the Short Axis view (with variable position along long axis) and three long axis views separated by 60 degrees around the ventricle's long axis.

The upper left viewport displays the 4-chamber view.

The lower right viewport displays the 2-chamber view.

The lower left viewport displays the 3-chamber or long-axis view (this is characterized by passing through the aortic root and left ventricular outflow tract)

You can rotate the cutting planes of the three Echo long axis views for viewing relative to the short axis view. Rotation is done by dragging a spoked wheel. The spoked wheel can be rotated by dragging the ends of the spokes to change the position of the various long-axis planes.

Each spoke represents a long-axis view and is colored to correspond with the orientation box in the viewport.

WARNING

When you use the Echo Views In the Cardiac Viewer application, verify axes correctness. If necessary, correct the axes using correction tools in the Functional Analysis tab in the Slab stage.

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