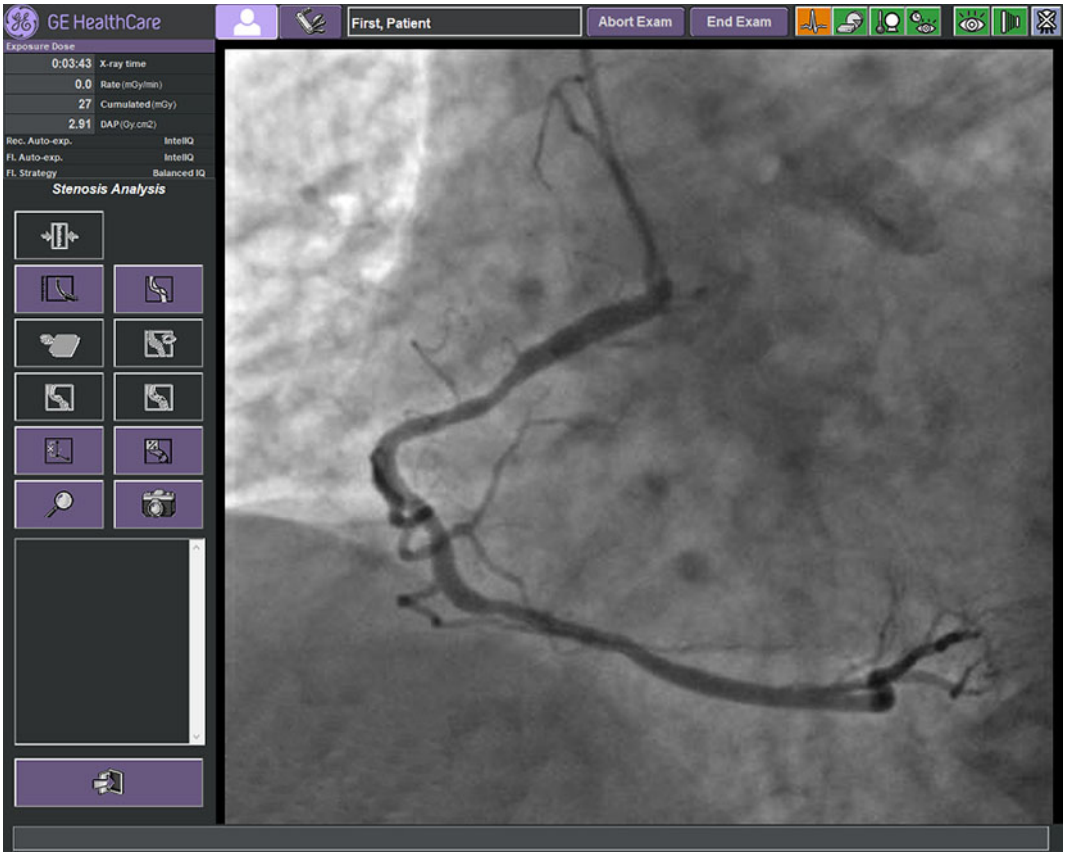
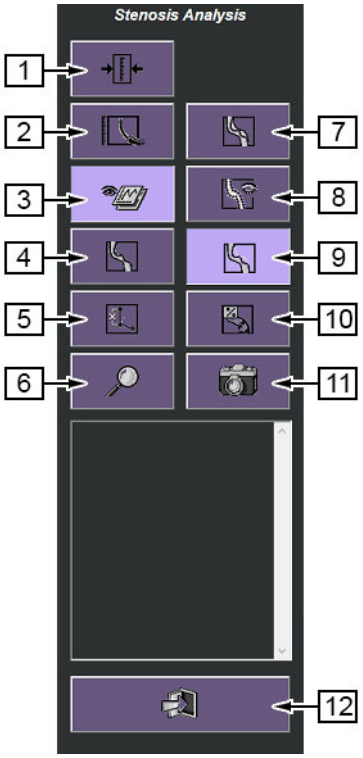
Figure 11-2 Stenosis Analysis Window



11.1.4 Reference Description for Stenosis Analysis Toolbar

The functions provided by the Stenosis Analysis Toolbar are:

	Item	Description
	**[1]**	Autocalibration
	[2]	Catheter Calibration
	[3]	Show/Hide Results
	[4]	Show Real Contours
	[5]	Multi Segments
	[6]	Zoom Image
	[7]	Stenosis Quantification
	[8]	Hide Contours
	[9]	Show Real and Ideal Contours
	[10]	Measure Distance
	[11]	Store Photo
	[12]	Exit

11.1.5 Calibrating on a Catheter Diameter

Calibration measures the pixel size at the vessel plane perpendicular to the X-Ray beam by using a catheter as a calibration device.

The user gives the external diameter of the catheter, which is supplied by the manufacturer (usually in French), and then indicates a portion of the catheter visible on the image.

The system automatically detects the external diameter of the catheter and computes the calibration factor for this acquisition and its associated accuracy. The calibration factor is reliable for all objects located at the same plane (+/- 1.5 cm) as the catheter and for all the images acquired with the same geometric parameters of the X-Ray system.

The catheter calibration can be performed on cardiac images or non-subtracted digital angiographic images. If in subtracted mode, the application will switch automatically to non-subtracted mode when clicking on the catheter calibration button. Automatic catheter detection may not work on subtracted frames.

The imprecision displayed below the calibration factor is the estimated confidence interval around the result returned by the application (in %).

For example, if you get a calibration factor of 0.1 mm/pixel with an imprecision of 10%, it means that the real factor is between 0.09 mm/pixel and 0.11 mm/pixel.

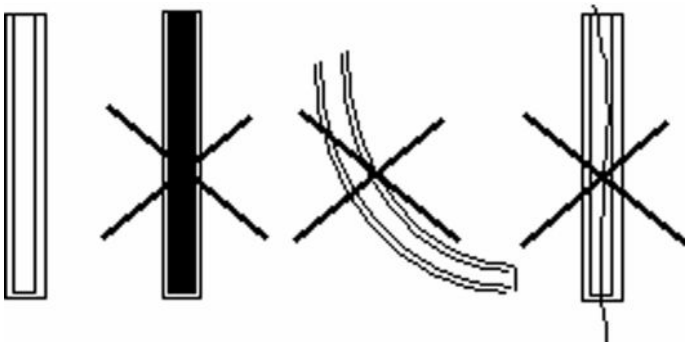
11.1.6 How to achieve an accurate catheter calibration

- Select a frame where the catheter is completely empty: no contrast media and no guide-wire or any kind of tool.
  Guide Line:

  Always calibrate on a completely empty catheter.

Watch the imprecision percentage displayed in the calibration result box: if higher than 20%, select another frame and redo the calibration in order to get the lowest imprecision as possible.

- Enter the exact size of the catheter used.

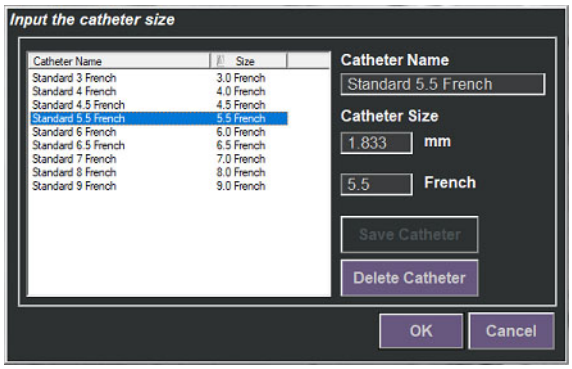


The catheter must be at the same distance from the detector than the vessel to be measured.

A difference in distance of 5 cm may cause a 5% error in the vessel dimension. The catheter must be as close as possible to the vessel to be measured in the image.

Reject those, which do not fit the external edges of the catheter.

- Select a catheter segment long enough (at least 2 cm on the screen) in the straight section of the catheter.
- Examine carefully the traced contours.
- Steps to calibrate a catheter.
- Click on the **Catheter Calibration** button  on the Stenosis Analysis Toolbar.
  The Input the Catheter Size dialog box appears.



A preloaded 10 lines catheter list is available from the Catheter list.

Default catheter names are between "Standard 3 French and Standard 9 French".

In the Input the Catheter Size dialog box, select one of the existing catheters from the catheter list, and click on the **OK** dialog button. To quit the dialog box without any change, click **Cancel**.

- If you do not find a catheter in the list with the appropriate size, define your own catheter and add it to the catheter list. Just enter the name of the new catheter in the Catheter Name field, specify the catheter size in either one of the two Catheter Size fields, and click on the Save Catheter dialog button. The minimum and the maximum value that can be saved for a catheter is 3 F (1 mm) and 9 F (3 mm), respectively. Both size fields are synchronized.
- It is also possible to use a catheter size without saving it. Enter the catheter size into the Catheter Size box and click **OK**.

- To delete a catheter from the list, select the intended catheter in the Catheter list and click on the Delete Catheter dialog button.
- To sort the catheter list by catheter name or catheter size in ascending or descending order, click on one of the dialog box located on top of the list, either Catheter Name or Size.

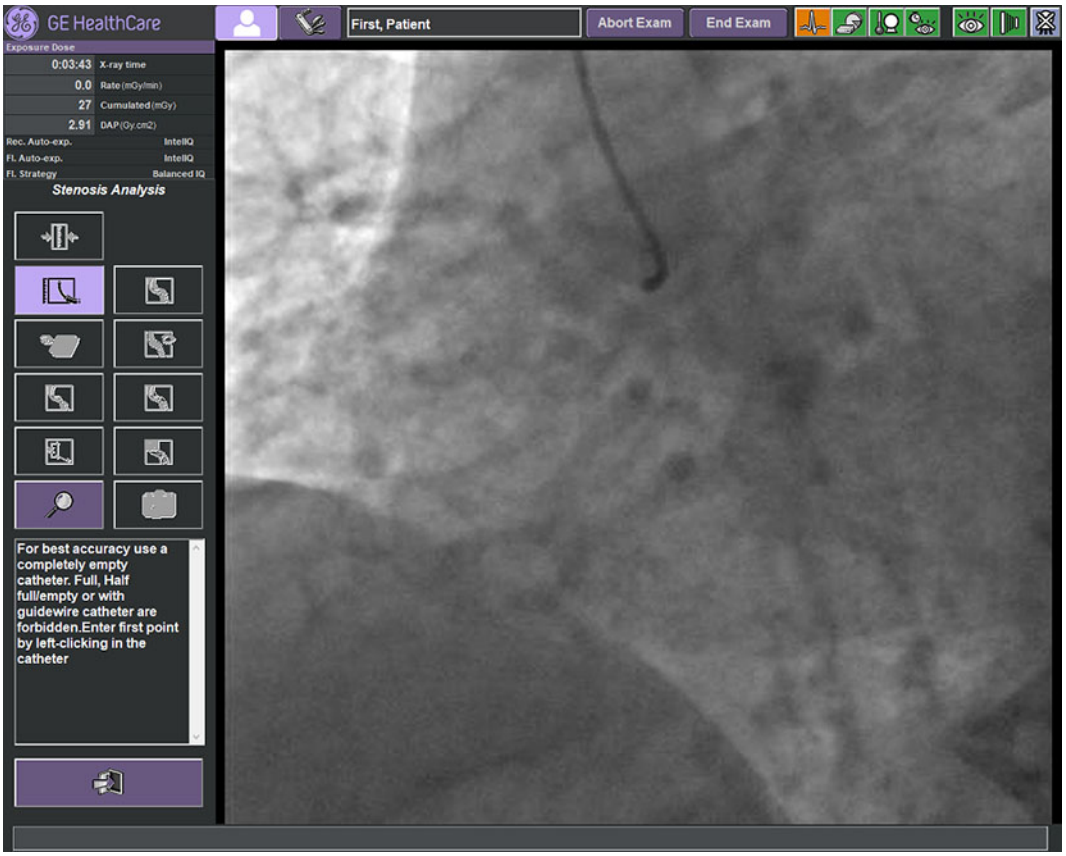
NOTE
To get the mm measurement of a catheter, divide the catheter French size by 3. Example: a 6 F catheter divided by 3 = 2 mm.

NOTE
The catheter list is sorted by catheter size from the smallest (3 F) to the largest (9 F).

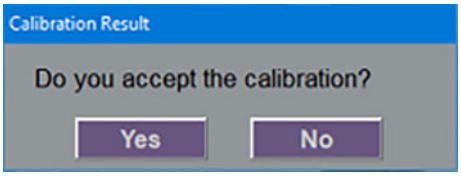
In all cases, you should ensure that the calibration was performed using the appropriate catheter size by checking the Object Size displayed in the calibration result box at anytime a sequence is calibrated.

Stenosis Analysis application shall only be used with catheter between 3 and 9 French (1-3 mm). Also, depending of the manufacturer, the given product catheter size may not be accurate, else the measurement results displayed will be wrong. In such case, you may possibly want to customize your catheter sizes. In all cases, it is recommended to check the displayed catheter size before accepting the calibration results.

- Place two points within the catheter, as close as possible to the end but not on a curve, to define the section for diameter detection.



- The system automatically finds and displays the catheter edges. The `Confirm the catheter detection` message appears.



NOTE
Before accepting any calibration by clicking on OK, in the "calibration results" pop-up window, always double-check catheter size displayed in the "calibration result" grey box, on the DL screen.

NOTE
The automatic edge detection program will show the detected border of the catheter. You shall check that the edges being displayed are matching the catheter border before accepting the calibration results. If the matching is not accurate, please cancel and restart a new calibration.

11.1.7 Stenosis Quantification (available for Dynamic, subtracted DSA, Single Shot, Bolus and subtracted 3D CT Modes only)

The basic principles of this functionality are the automatic detection of the vessel edges in a selected portion of the artery, then the quantitative measurement of the vessel length and diameters along the selected segment.

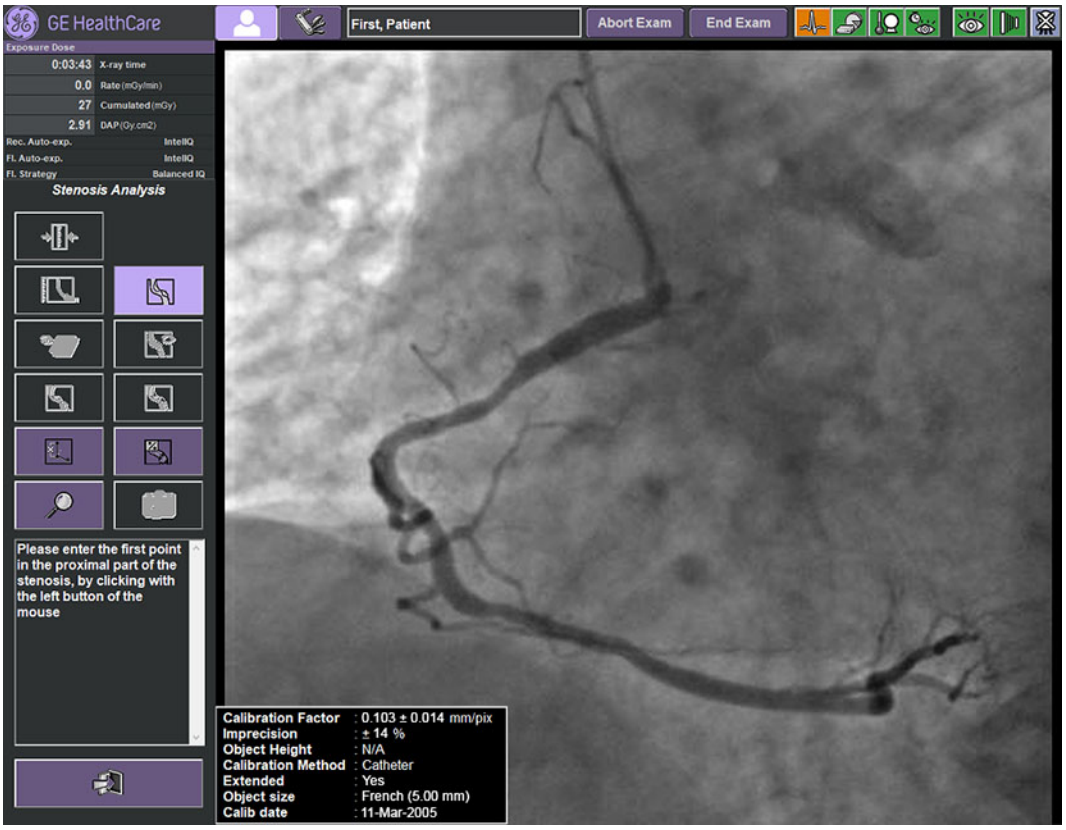
The application is able to quantify vessels up to 5 mm on Cardiac images acquired on Dynamic mode with FOV less than or equal to 20 cm and vessels up to 50 mm on subtracted DSA, Single Shot, Bolus and subtracted 3D CT images. T4

The contrast media used to differentiate the vessels from the patient background must be radio-opaque (iodine) so that vessels appear as dark structures with respect to the background. Quantification is not applicable on radio-transparent opacification (CO_2).

The user has the option of placing only two points to start the automatic detection. For a tortuous vessel or one that is very close to another one, more points will increase the precision on the stenosis vessel path.

- Pick the image that best shows the area of interest.
  The user shall select the frame containing the vessel to be quantified before clicking on the Stenosis Analysis button in the SA toolbar.

- From the Stenosis Analysis Toolbar, click on the **Stenosis Quantification** button  .
  Guidelines appear in the dialog area, left of the screen:



- Place two or more points within the vessel from the proximal to the distal part of the stenosis to define the section for automatic detection. Double click the last point to start the calculation and get the results. To move a point, drag it with left mouse button. To delete a selected point, press the **Delete** key.

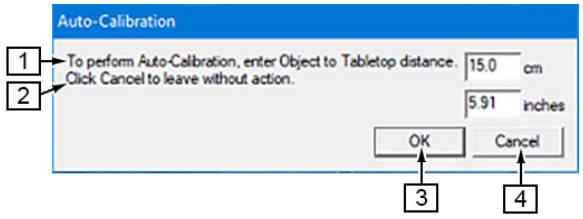
NOTE

The ability to accurately measure a vessel can be hindered by:

- The presence of a stent or guiding catheter in the vessel.
- A calibration or quantification performed on edge or corner of the image (conic deformation of X-Ray) can degrade the accuracy by up to 7.5%.

In case of Auto-calibration

If the image is not calibrated, the Auto-calibration dialog box opens asking you to enter the "object to table top distance".

	Item	Description
	**[1]**	To perform Auto-Calibration, enter Object to Table top distance.
	[2]	Click Cancel to leave without action.
	[3]	**OK** button
	[4]	**Cancel** button

The goal of auto-calibration is to allow the software to compute the pixel size in a given image without using any kind of reference object. Auto-calibration is entirely based on the known geometry of the imaging system. The only parameter that the user has to specify is the Object to

Table top distance defined as being the shortest distance between the center of the object to be measured and the top of the table.

As opposed to catheter calibration, auto-calibration is available only after a region of interest has been defined in the image. It means that auto-calibration can be launched only after vessel contours or segments are drawn in the image.

Calibration results are automatically saved at the sequence level. If you launch the application on a previously calibrated sequence, the calibration information will also be loaded as well as the sequence itself.

Enter the object (vessel) to table top distance or use the default value (15 cm for Cardiac image; 8 cm for Angio image), then click **OK** to get results in metric units.

WARNING

THE OBJECT (VESSEL) TO TABLE TOP DISTANCE IS DEFINED FROM THE TOP OF THE TABLE TOP AND NOT FROM THE TOP OF THE MATTRESS. IF THE DISTANCE ENTERED DIFFERS FROM THE ACTUAL DISTANCE, THE RESULTING MEASUREMENTS WILL BE INACCURATE OF ABOUT 1% PER CENTIMETER OF DIFFERENCE.

In case a new auto-calibration is needed, after points were dropped, it is always possible to launch it manually pressing on the **Auto-calibration** button  on the Stenosis Analysis toolbar.

Upon completion of auto-calibration, Stenosis Analysis report is displayed with the computed results.

NOTE

To accurately measure a vessel, note the followings:

- Input the correct distance of the anatomy from the table top.
- The greater the gantry angulation towards a lateral position, the higher the imprecision result will be. Avoid using Auto-calibration for lateral images; use catheter calibration instead.
- Always take into account the imprecision displayed with each measurement.

In case of Catheter Calibration

In case of use of catheter calibration, the quantification measurements shall only be taken into account when the catheter used for calibration and the quantified vessel are in the same plane, plane that shall be parallel to the flat panel detector. Any other cases will lead to underestimated imprecision.

NOTE

The ability to accurately measure a vessel can be hindered by a table panning between frame used for catheter calibration and frame used for quantification (increase the risk of catheter and vessel not in the same plane).

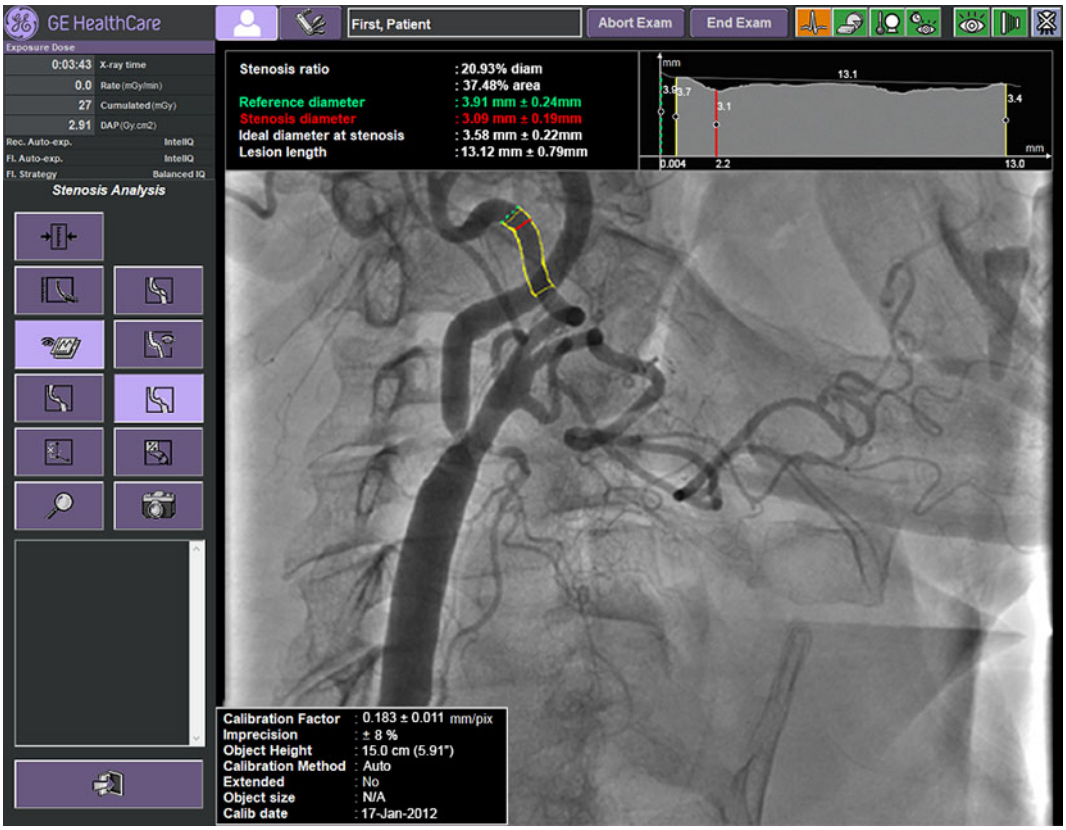
Situations such as described above will result in additional inaccuracy that will not be taken into account by the algorithm. So, the percentage of imprecision linked to results will be underestimated and will not reflect reality.

10.7

11

Advanced Tools (Options)

11.1.8 Stenosis Quantification Results (available for Dynamic, subtracted DSA, Single Shot, Bolus and subtracted 3D CT Modes only)



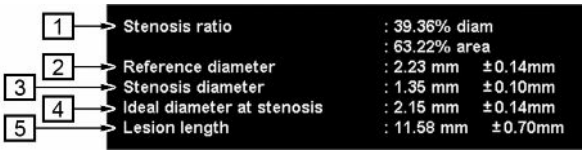
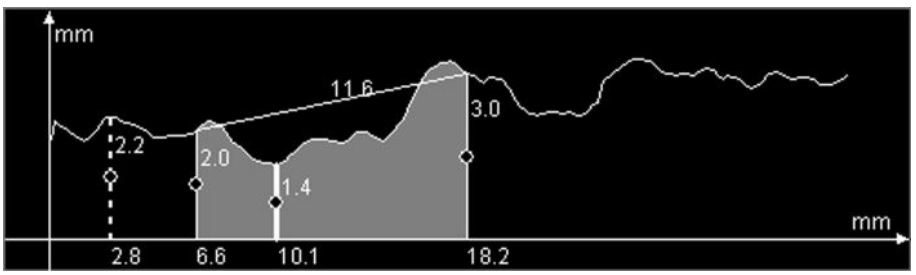
	Item	Description
Figure 11-3 Stenosis Quantification Results Box 	**[1]**	Stenosis ratio: 39.36% diam / 63.22% area
	[2]	Reference diameter: 2.23 mm ± 0.14 mm
	[3]	Stenosis diameter: 1.35 mm ± 0.10 mm
	[4]	Ideal diameter at stenosis: 2.15 mm ± 0.14 mm
	[5]	Lesion length: 11.58 mm ± 0.70 mm

Figure 11-4 Vessel Profile Box



The Results Box displays results of stenosis quantification and their imprecision.

The imprecision displayed after each measurement is the estimated confidence interval around the result returned by the application (in mm).

For example, if you get a Reference Diameter of 2 mm ± 0.2 mm, it means that the real reference diameter is between 1.8 mm and 2.2 mm.

The Vessel Profile Box shows the detected vessel diameters in mm versus the distance in mm along the vessel path from the beginning of the vessel portion. The profile corresponds to the vessel portion between the first and the last point entered by the user.

Once the calculation is finished and the results are displayed, you have several options on how to modify the results. In the Profile box, click and drag on any line to modify the placement. The edge detection of the vessel will be drawn in yellow. It will fill in where the vessel is over or under sized.

NOTE
Stenosis analysis shall never be taken as literal proof, but shall be double checked by the physician. Stenosis analysis is a reference tool only and is not intended as a means of making a diagnosis.

- Decide if the Reference segment is placed in the best area to represent the normal vessel size. If not, from the vessel profile, grabbing the black dot, move the segment to the desired area. Do the same with the stenosed segment representing the tightest lesion narrowing.
- Move the same way the lesion length segments (proximal and distal) to best represent the area of interest.
- Other modifications can be done to the drawing using the Stenosis Analysis Toolbar.
- Show/Hide Results  will remove and redisplay the Result and Profile windows.
- Hide Contours  will remove the vessel drawing temporarily. By clicking on icon  or  , the drawing will be returned.
- Show Real Contours  displays only the stenosis contours and will redisplay the vessel drawing if removed with Hide Contours.
- Show Real and Ideal Contours  displays the stenosis contours and the plaque area and will redisplay the vessel drawing if removed with Hide Contours.

  NOTE
  Hide and show the contours to visually verify the adequation between the edges detected and the actual vessel shape.

- To edit stenosis contour, right-click on any part of the contour. A line of seven crosses will appear on the edited contour area. Grab and move any points within this area to modify the contour. Double click with left button to confirm your modification. Each side of the stenosis can be edited separately.
- Zoom Image  will enlarge the image to double size in both directions. Click on it again to go back to the normal display.
- Store Photo  will save the SA results as a photo image in the Photo Browser. You will be asked to select whether this is a Pre- or Post- Interventional frame, and you might indicate the concerned region of interest, which will be displayed at the bottom of the taken photo.
- Exit  will close the Stenosis Analysis window. No Stenosis Quantification results will be saved except by using the Store Photo function.

11.1.9 Measure Distance

Distance Measurement is used to obtain up to 7 length only between two points and their ratio.

Click on the Measure Distance button  to activate the function.

Measuring a length:

- Position the cursor at the beginning for the first point and click. Move the mouse and draw the line to the second point and click. A length will be displayed.
- A maximum of 7 lengths can be displayed with their ratio relative to the first length measured taken as reference.

NOTE
The objects to measure may not be in a plane perpendicular to the X-Ray beam. Then, foreshortening in the length measurement may happen. The software is not able to detect or correct foreshortening. It is the user responsibility to interpret the results of the Distance Measurement function.

NOTE
When drawing a segment on an unzoomed frame, the user shall ensure to make no error of more than 1 pixel for each point defined.

The imprecision being displayed for each segment take into account a 1 pixel error for each click, no more. Also, when the distance is displayed in pixels, it is always displayed based on the non-zoomed image, even if zoomed.

NOTE
The Ratio between the segments is computed without taking into account the imprecision link to calibration or user error when clicking points. If the user error is at max 1 pixel for each segment, Ratio imprecision is less than 10.5% starting with 20 pixels segments. User shall be very careful with Ratio results taking into account smaller segments.

11.1.10 Multi Segments

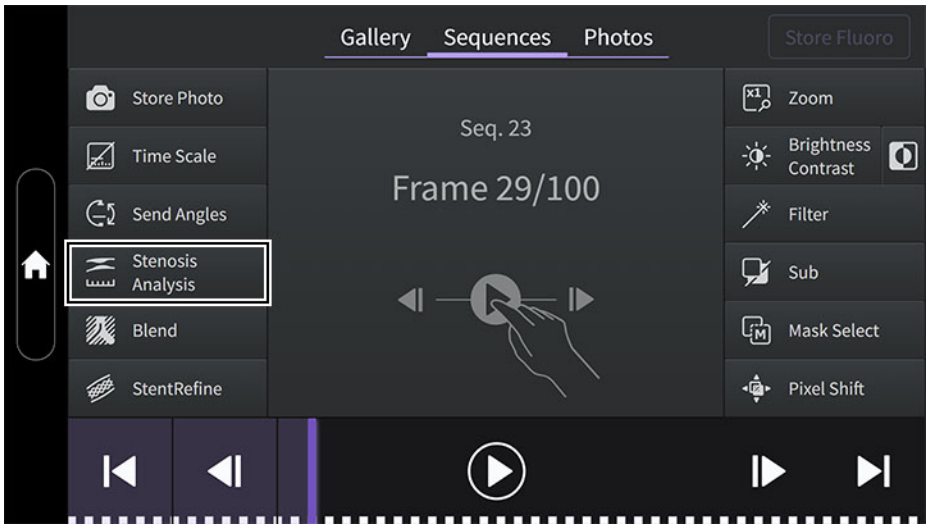
Clicking on the Multi Segments Icon  will allow to drop more than 2 points and to display the total length between the first and last point.

NOTE
Ensure that the measured object is in the same plane as the catheter, parallel to the detector, and take into account the imprecision found around the calibration factor.

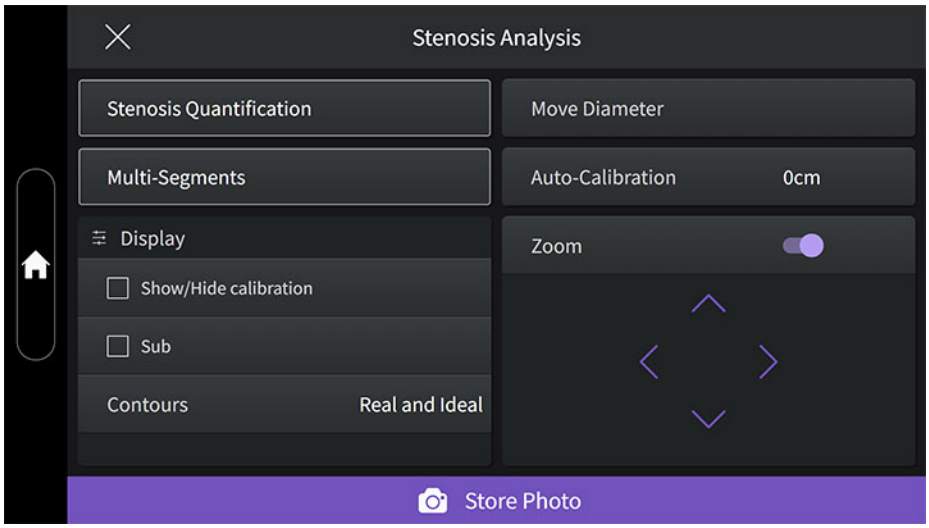
NOTE
Only one Multi-segments can be displayed at a time.

11.1.11 One Touch QA (option available on the Touch Panel)

Using the **Sequence** tab or the review widget on the home page of the Touch Panel, it is also possible to launch the Stenosis Analysis application.

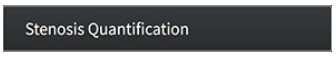


From the Touch Panel, select **Stenosis Analysis** to enter the application.

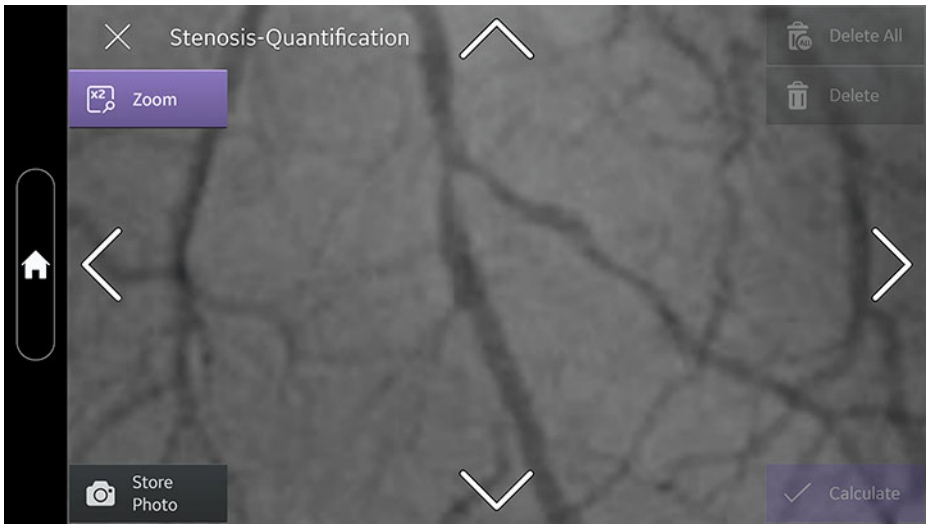


The most useful functions are available to quantify a vessel or measure a distance.

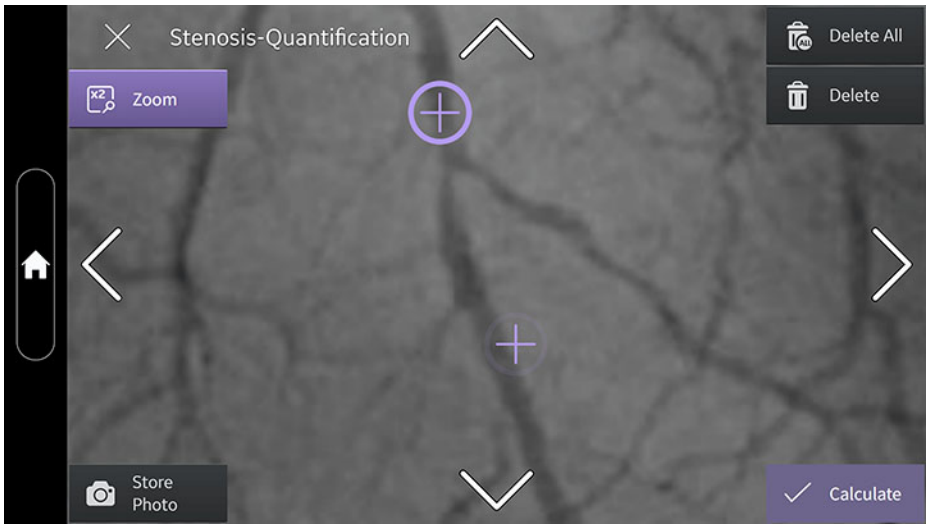
NOTE
Only Autocalibration is available at table side. In case of catheter calibration required, perform the calibration from the control room console.



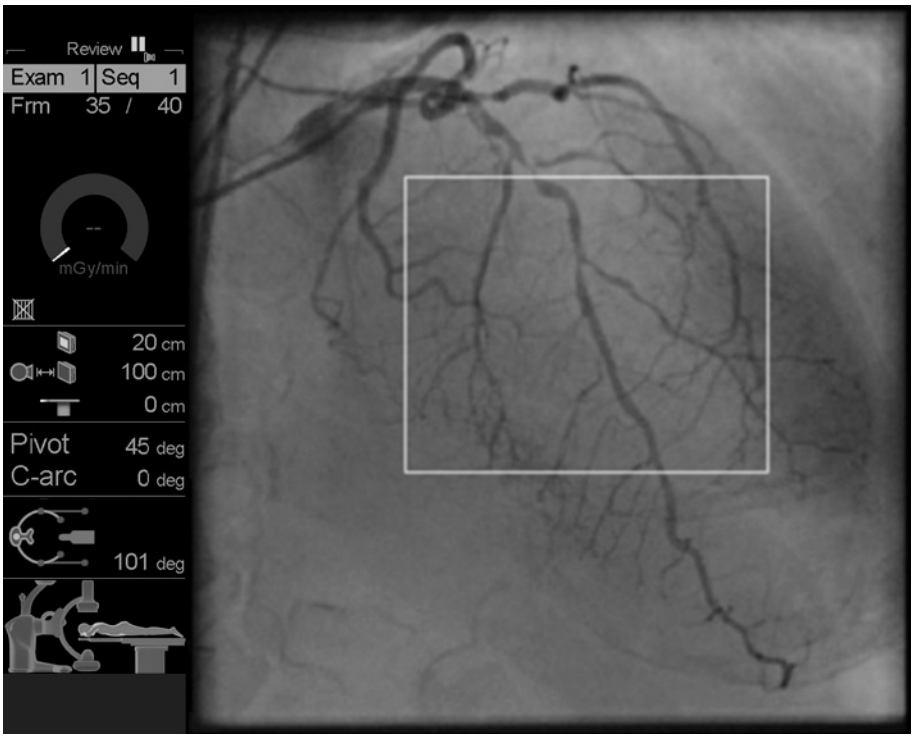
Launch the transfer of the image displayed on the live display in the Touch Panel.



After the completion of the transfer, the central part of the image appears on the Touch Panel.



And the displayed Region Of Interest (ROI) is visualized on the live display.



Use the Touch Panel to roam the image:

Use the Zoom/Roam functions to better visualize and center the part of vessel to quantify.

The **Zoom** button on the Touch Panel switches zoom state on both images. The zoom can also be performed with a double tap on the image area.

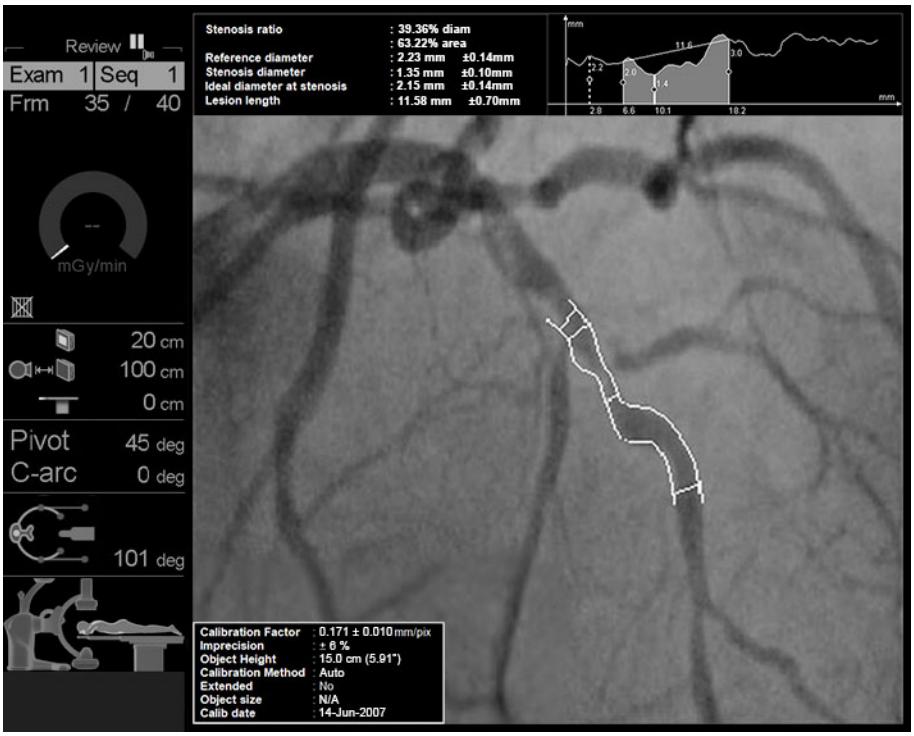
Drop points apart of the stenosis to quantify from proximal to distal by just touching the vessel (at least 2 points must be dropped).

All dropped points can be deleted by using the **Delete All** button.

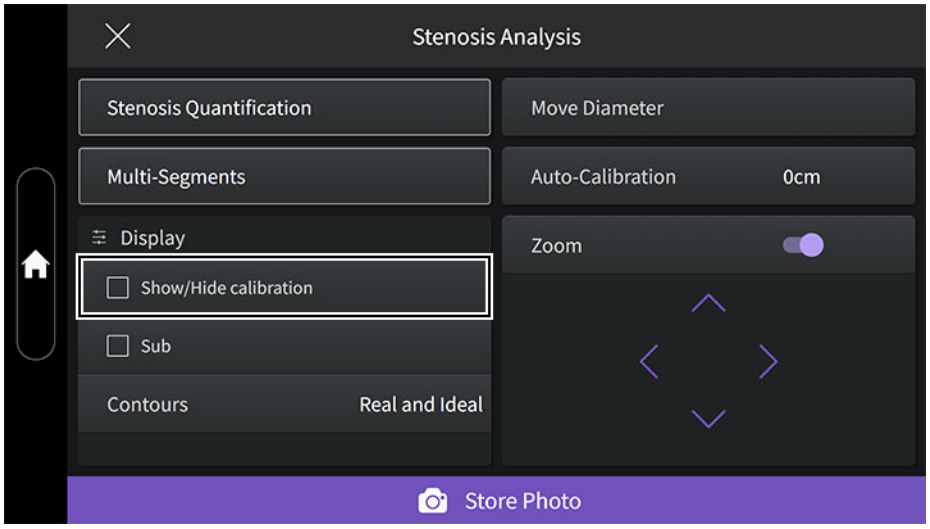
One single point can be selected by just touching it, moved by just dragging it or deleted by pressing on the **Delete** button.

After all points are dropped, press on the **Calculate** button to launch the quantification.

After completion of the quantification, results are displayed on the live display.



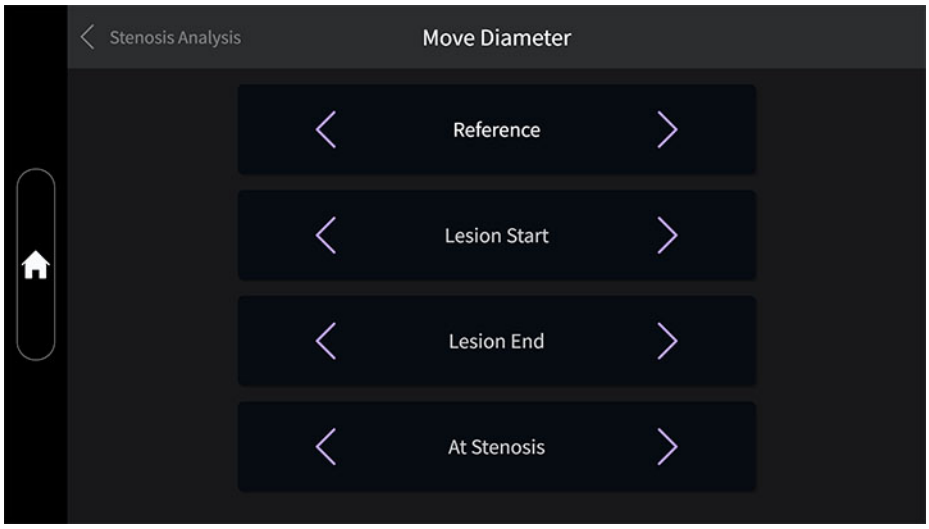
The image can be zoomed using the **Zoom** button and roamed using the Touch Panel.



The **Calibration Result** window can be hidden by ticking the **Show/Hide Calibration** box.

NOTE
The **Stenosis Analysis Results** and **Vessel Profile** windows cannot be hidden.

Vessel diameters along the vessel can be moved by using the **Move Diameter** button.



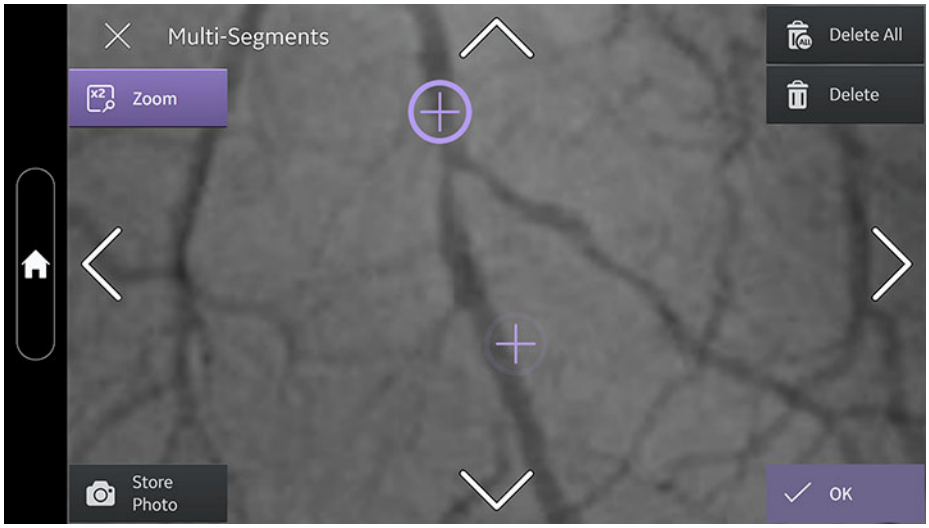
Select the prev and next arrows of the diameter which needs to be moved between **Reference**, **At Stenosis**, **Lesion Start** or **Lesion End**.

The selected diameter is highlighted on the live display. Use both arrows on the Touch Panel to adjust its position. When the optimum position is found, another diameter can be moved similarly.

To end diameter movement and go back to the **Stenosis Analysis** page, select the back arrow: Stenosis Analysis.

Launch the transfer of the image displayed on the live display in the Touch Panel.

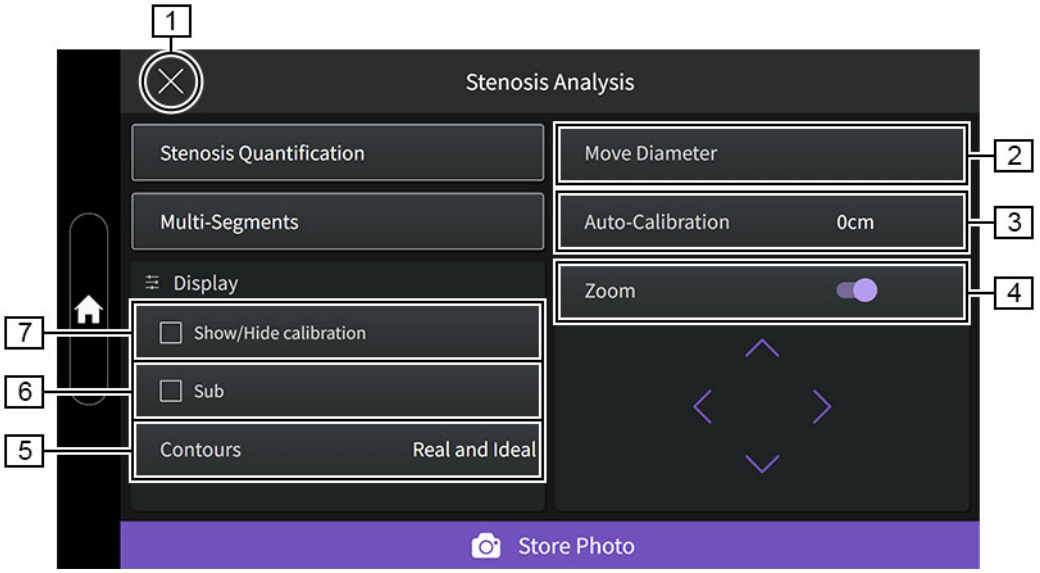
After the completion of the transfer, the central part of the image appears on the Touch Panel.



If needed, zoom and roam the same way as for Stenosis Quantification by using the Touch Panel. Drop points (at least two) by touching the image displayed on the Touch Panel. All points or any selected point can always be deleted.

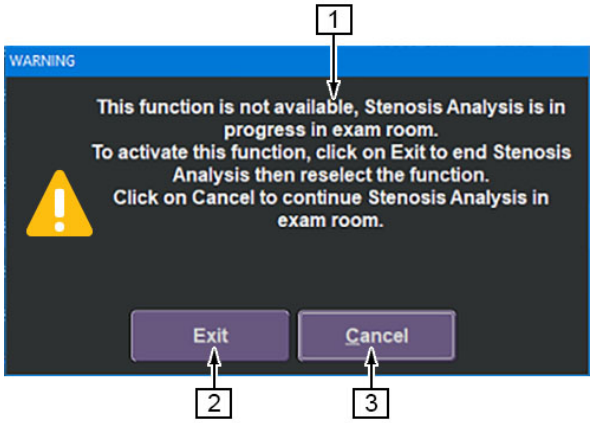
Touch and drag a point in the image to move it.

Press the **OK** button to end the drawing.



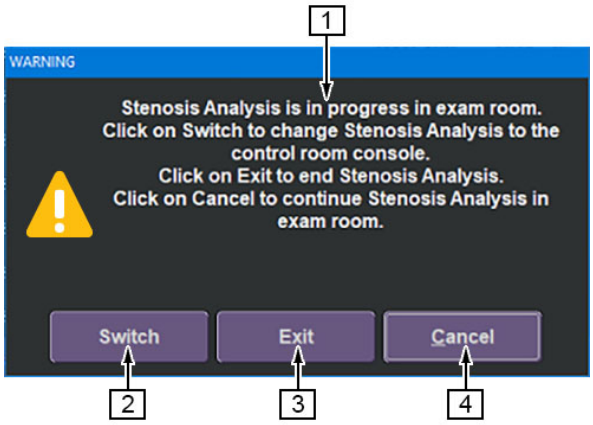
Item	Description
[1]	Allows to exit from the in-room Stenosis Analysis application.
[2]	During a vessel quantification, allows to move the **Reference** or **At Stenosis** or **Lesion Start** or **Lesion End** vessel diameter.
[3]	If needed, select one of the preloaded Object to table top distance from the pull down list.
[4]	The Zoom button on the Touch Panel switches between zoom and unzoom on both images, Touch Panel and live display. The zoom can also be performed with a double tap on the image area. The image on the Touch Panel can be roamed by using a one finger slide on the image area.
[5]	Select the **Contours** button and then one of the predefined displays from the pull down list. This function is only available after a Stenosis Quantification has been performed.
[6]	When possible, allows to toggle between Sub and NoSub image display.
[7]	When available, allows to display or not the calibration result window.

After In-room Stenosis Analysis is launched, it is always possible to launch the review of the selected sequence or of another one from the DL screen. In that case, the in-room Stenosis analysis will be exited after user confirmation:

	Item	Description
	**[1]**	This function is not available, Stenosis Analysis is in progress in exam room. To activate this function, click on **Exit** to end Stenosis Analysis then reselect the function. Click on **Cancel** to continue Stenosis Analysis in exam room.
	[2]	Click on **Exit** to end Stenosis Analysis.
	[3]	Click on **Cancel** to continue Stenosis Analysis in exam room.

Double click again on the sequence to review in the Sequence Browser to launch the review.

While In-room Stenosis Analysis is on going, it is also possible to continue the analysis from the control room. Click the **Stenosis Analysis** button on the Control room. A user confirmation will be required.

	Item	Description
	**[1]**	Stenosis Analysis is in progress in exam room. Click on **Switch** to change Stenosis Analysis to the control room console. Click on **Exit** to end Stenosis Analysis. Click on **Cancel** to continue Stenosis Analysis in exam room.
	[2]	Click on **Switch** to change Stenosis Analysis to the control room console.
	[3]	Click on **Exit** to end Stenosis Analysis.
	[4]	Click on **Cancel** to continue Stenosis Analysis in exam room.

11.2 Ventricular Analysis (Option)

Ventricular Analysis (VA) is an application designed for analyzing and quantifying the left ventricle (LV). The user can perform two types of quantification: Global Ejection Fraction (GEF) analysis and Wall Motion (WM) analysis.

The output of the Global Ejection Fraction quantification provides the user with information on left ventricle volumes and the ejection fraction. This set of information gives the user a good idea about how well the entire left ventricle is functioning.

From the results of Wall Motion analysis, the user can estimate the adequacy of blood supply to each distinct region of the left ventricle.

In addition to these two major functions, a "Multi-segments" feature allows to draw a multi-segment line to estimate segments lengths.

NOTE
Ventricular Analysis is only an estimation tool, and is not intended as a means of making a diagnosis.

NOTE
Ventricular quantification and Distance measurement cannot be performed on a fluoro image such as Fluoro LIH or a fluoro sequence created using the Fluorostore function. A message will be displayed and the application will fail.

NOTE
Before starting acquisition, exit the Ventricular Analysis (VA) application to have access to the display of the X-Ray technique factors on the DL Screen.

Contrast media

For ventricular analysis to be successful, the contrast media injected in the left ventricle should have enough volume to fill the entire ventricle during multiple cardiac cycles and to visualize the end diastolic and end systolic phases of the cycles.

Quantification

Based on the end-diastolic and end-systolic contour of the left ventricle defined manually by the user, Ventricular Analysis provides a means to perform Wall Motion (WM) and Global Ejection Fraction (GEF) calculations. Wall Motion analysis is built upon the Sheehan's centerline method. Global Ejection Fraction analysis provides results calculated with both the Simpson's rule method and the Dodge-Sandler Area-Length method.

Ventricular Analysis at a glance

Using the Ventricular Analysis application involves the five activities summarized below.

1. Select study image.

   Review patient LV-gram.

2. Launch Ventricular Analysis application.

   The VA application can be launched while in review or paused.

3. Select two frames and manually draw LV contour:

   The one that most clearly shows the end of Diastolic contour.

   The one that most clearly shows the end of Systolic contour.

4. Generate the Global Ejection Fraction and Wall Motion report.

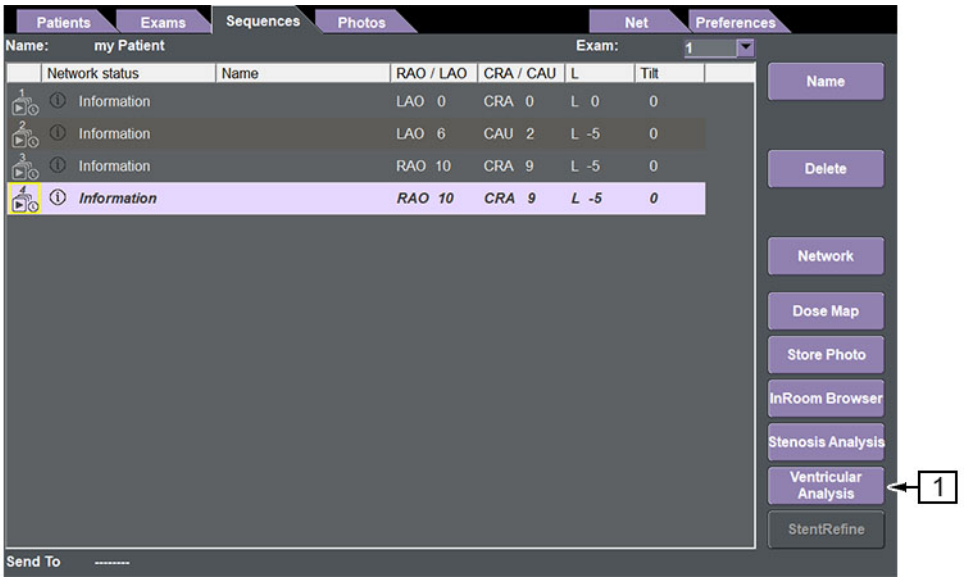
   On application request, enter the object to table top distance (or use default value) to perform the automatic calibration. The distance entered shall be determined from the center of the measured object to the top plane of the table without mattress.

5. Save the GEF and WM report.

   When the report is saved, it is added in the Photo Browser as a standard photo.

Performing Ventricular Analysis

1. Once need for analysis has been established, select the desired sequence from the SEQUENCE BROWSER and begin playback.
2. Review the images that most clearly show the end of Diastolic and end of Systolic contours.
3. Click the **Ventricular Analysis** button **[1]** on the SEQUENCE BROWSER to start the analysis. The **Ventricular Analysis** button can be selected while in a review or paused mode.



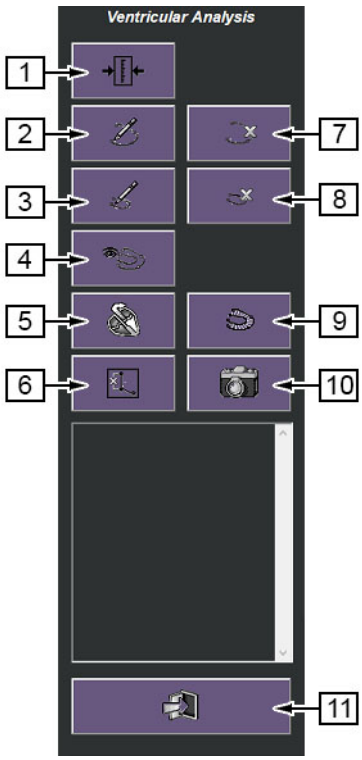
If selected during a review, it will stop and then:

- The selected image and the Ventricular Analysis toolbar will appear on the flat panel.

NOTE
Any X-Ray acquisition will exit the Ventricular Analysis application.

Reference description for Ventricular Analysis Tool Menu

The functions provided by the Ventricular Analysis tool menu are:



Item	Description	Function
[1]	Auto-calibration	select to manually launch a new autocalibration
[2]	Draw Diastole	select to start to draw End-Diastolic Contour
[3]	Draw Systole	select to start to draw End-Systolic Contour
[4]	Show/Hide contours	select to show/hide graphics/reports already performed on the image
[5]	Generate GEF report	select to launch the Global Ejection Fraction report
[6]	Multi-segments	select to draw a multi-segment line and get length measurements
[7]	Delete Diastole	select to delete the Diastolic contour
[8]	Delete Systole	select to delete the Systolic contour
[9]	Generate WM report	select to launch the Wall Motion report
[10]	Store photo	select to save the image/graphic/report as a standard photo
[11]	Exit	select to exit from the Ventricular Analysis application

Draw Diastolic Contour

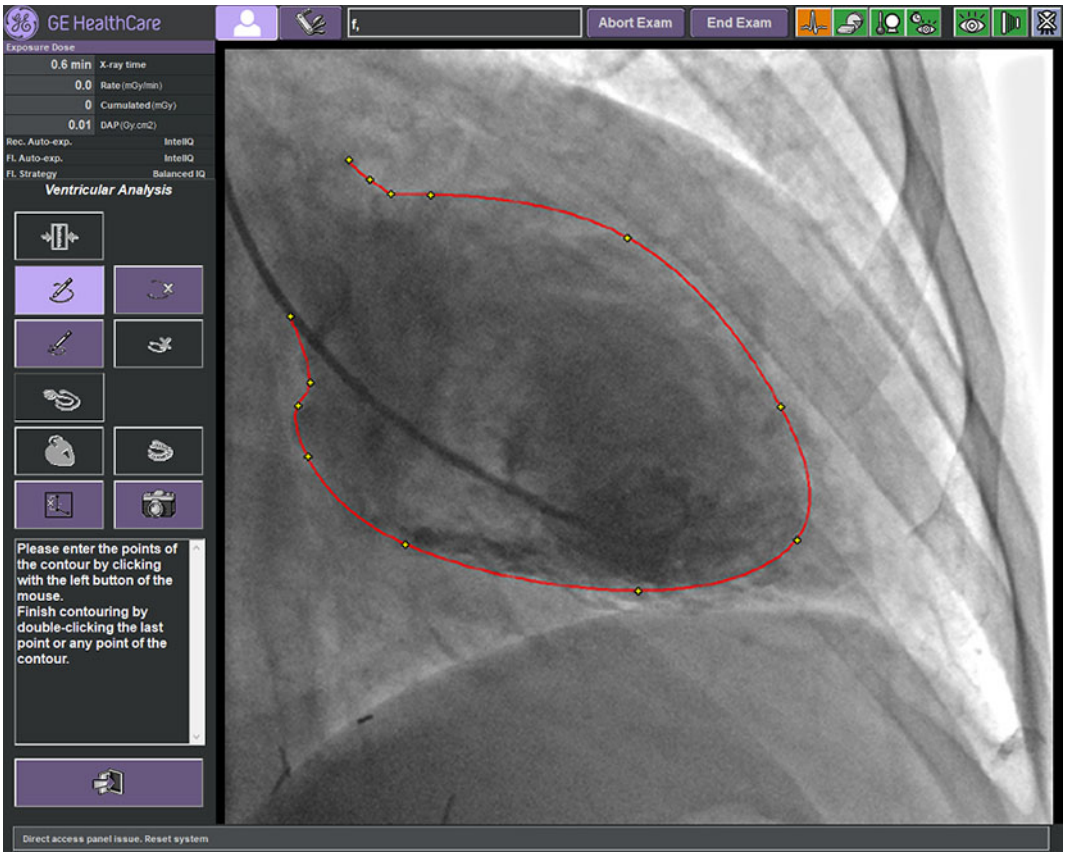
Using the Play/Pause and/or Next/Previous Frame keys, select the frame which most clearly shows the end of Diastolic contour.

Click on the **Draw Diastole** icon  on the Ventricular Analysis tool menu.

Following the instructions in the hint window, enter the points of the diastolic contour by clicking with the left mouse button. The LV diastolic contour shall contain at least 3 points.

Each point entered is represented by a yellow cross.

The application builds up the LV diastolic contour by connecting the user-specified LV edge points using a bicubic spline interpolation. The diastolic contour is represented by a red curve.



To edit a point already entered, move over the point, click on it, and drag it to the correct position with the left mouse button kept pressed.

To insert a new point in the contour, click on the contour with the left mouse button.

To delete a selected point, press the **Delete** key on the keyboard.

If you do not get an acceptable curve using the editing functions, the **Delete Diastole** icon allows you to easily delete and redraw the curve.

During the modifications, the contour is updated real-time in the screen.

To end the drawing, double-click the last point or any point of the contour, or click on the **Draw Diastole** button. The contour becomes thinner (**Draw Diastole** button OFF).

To insert a new point to the contour, click on it with the left mouse button. The contour becomes active again (**Draw Diastole** button ON).

To modify the location of any point after finishing the curve, click on the point with the left mouse button, and drag it to the right place. The contour becomes active again (**Draw Diastole** ON).

When you finish with the modifications, press **Draw Diastole** again (OFF).

The LV contour is automatically saved at the sequence level. It means that if you already drew a contour in the past, then launching Ventricular Analysis again later on that same sequence will display the frame selected in the viewer with the LV contour drawn on it.

It is possible to change the frame during the diastolic contour edition. The diastolic frame will be the one on which the contour edition is finished.

Draw Systolic Contour

As for the Diastolic contour, using the Play/Pause and/or Next/Previous Frame keys, select the frame which most clearly shows the end of Systolic contour.

NOTE
The Systolic frame must be selected in the same heart cycle as the Diastolic frame to preserve the best result accuracy.

Click on the **Draw Systole** icon on the Ventricular Analysis tool menu.

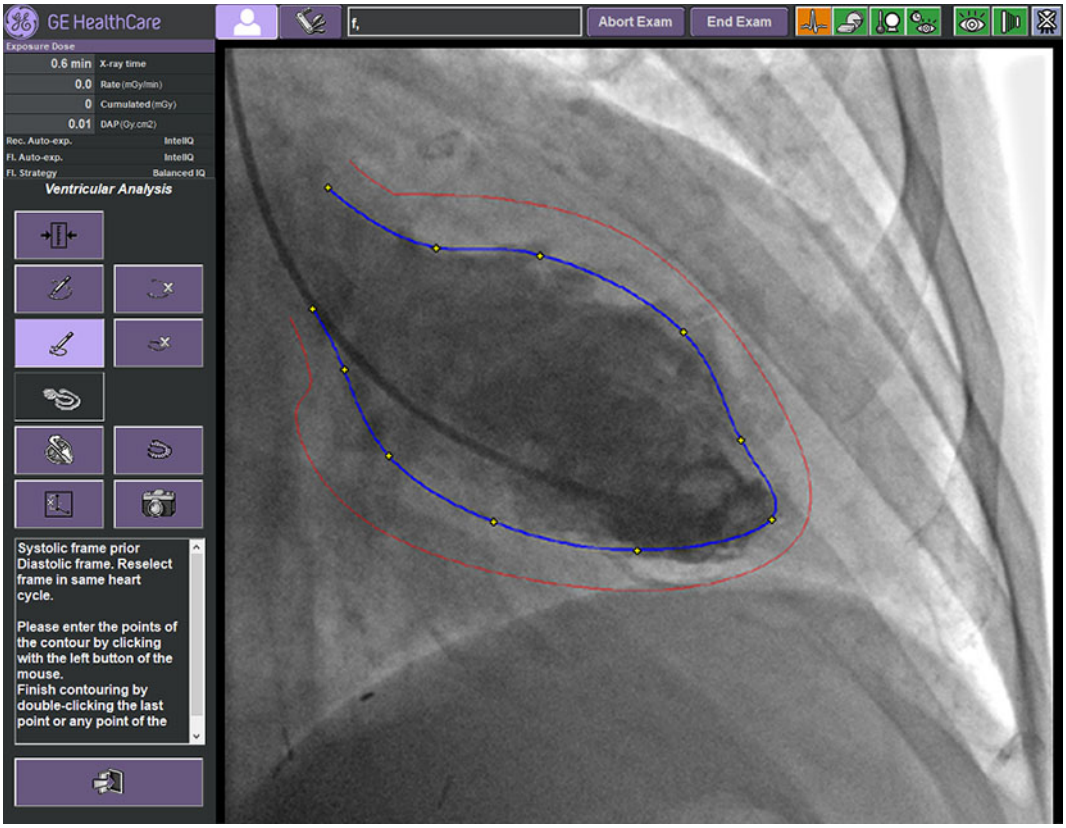
Follow the same process to draw/edit/delete the Systolic contour.

The Systolic contour is represented by a blue curve.

After the Systolic contour is ended by double clicking on it or clicking again on the **Draw Systole** button, both Diastolic and Systolic contours connected with the 100 equidistant chords are displayed.

Click on **Show/Hide contours** icon to display or not the Diastolic and/or Systolic contour.

It is possible to change the frame during the systolic contour edition. The systolic frame will be the one on which the contour edition is finished.



Global Ejection Fraction Analysis

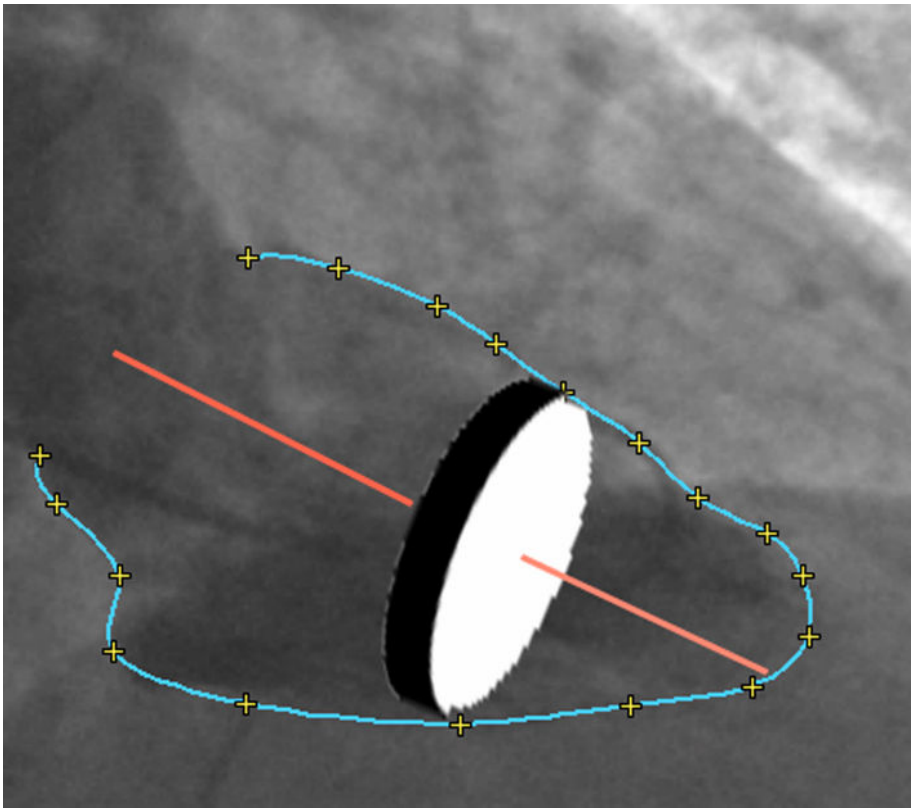
The GEF analysis uses two different methods for estimating Left Ventricular (LV) volumes: the Simpson's Rule and the Dodge-Sandler Area-Length Method. Both methods aim at modeling the left ventricle in 3D, based on the accurate determination of the LV border on the diastolic and the systolic frame. Both methods also require the determination of the long axis of the LV.

Ventricular Analysis uses linear correction formulas with coefficients varying between X-Ray systems so as to counterweight the errors exhibited by the mathematical models during the 3D modeling process.

NOTE
These two methods are validated for LV acquired in RAO 30° angulation. So, if the sequence was not acquired in RAO 30° +/- 10°, or with a CRA or CAU angulation greater than 10°, or with more than 5° difference between the end of Diastolic and end of Systolic frame, a warning message about the loss of result accuracy will be displayed.

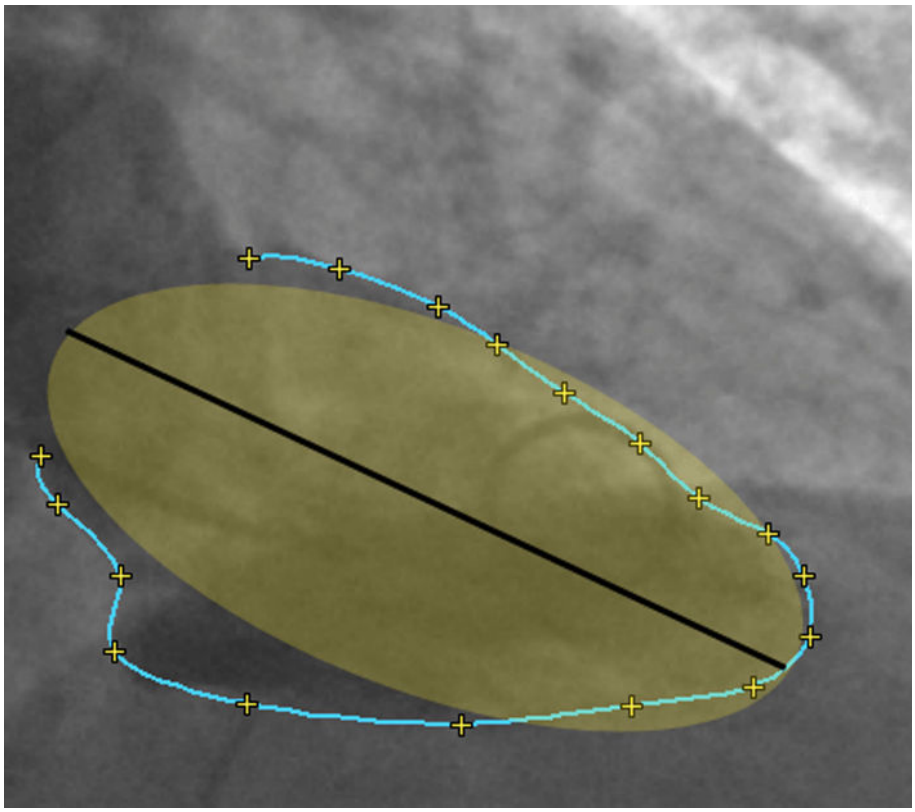
Simpson's Rule Method

Simpson's Rule is based on the idea that the volume of an object can be determined by "cutting" the object into thin "slices", measuring the volume of each slice and summing the volumes of all slices. Simpson's Rule is applied to the left ventricle by slicing it into "discs" along the long axis, as shown in the illustration below. The area of each disc is calculated and multiplied by the disc's thickness to determine its volume.



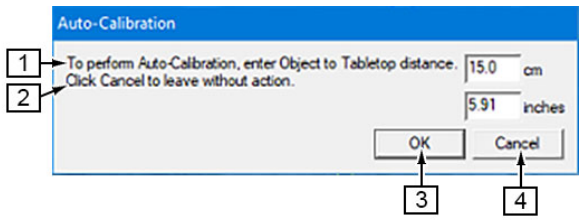
Dodge's method

The left ventricle is approximated by a prolate ellipsoid with its long axis in the 30° RAO projection. The calculation of the volume of a prolate ellipsoid only requires knowledge of the length of the longest axis and the area of the ellipse. The axis of revolution length is the long axis of the LV. The computation of the ellipse area is based on the mechanical tracing of the LV projection border.



After both end of Diastolic and Systolic contours are drawn, click on **Generate GEF report** icon  on the Ventricular Analysis tool menu.

If needed, the Auto-calibration dialog box opens asking you to enter the "object to table top distance".

	Item	Description
	**[1]**	To perform Auto-Calibration, enter Object to Table top distance.
	[2]	Click Cancel to leave without action.
	[3]	**OK** button
	[4]	**Cancel** button

The goal of auto-calibration is to allow the software to compute the pixel size in a given image without using any kind of reference object. Auto-calibration is entirely based on the known geometry of the imaging system. The only parameter that the user has to specify is the Object to Table top distance defined as being the shortest distance between the center of the object to be measured and the top of the table.

As opposed to catheter calibration, auto-calibration is available only after a region of interest has been defined in the image. It means that auto-calibration can be launched only after LV contours or segments are drawn in the image.

For images acquired on system with universal table top or with headrest (adjustable), skull clamp or horseshoe, to get the distances in mm, ventricular analysis can be performed using catheter calibration only.

Calibration results are automatically saved at the sequence level. If you launch the application on a previously calibrated sequence, the calibration information will also be loaded as well as the sequence itself.

Enter the object (heart) to table top distance or use the 15 cm default value, then click **OK** to get results in metric units.

WARNING

THE OBJECT (HEART) TO TABLE TOP DISTANCE IS DEFINED FROM THE TOP OF THE TABLE TOP AND NOT FROM THE TOP OF THE MATTRESS. IF THE DISTANCE ENTERED DIFFERS FROM THE ACTUAL DISTANCE, THE RESULTING VOLUMES WILL BE INACCURATE OF ABOUT 3% PER CENTIMETER OF DIFFERENCE.

In case a new auto-calibration is needed, it is always possible to launch it manually pressing on the **Auto-calibration** icon on the Ventricular Analysis toolbar.

Upon completion of auto-calibration, centerline computation and GEF quantification, the GEF report is displayed with the computed results.

Hospital: Unknown
Report Date: 27-Jun-2007

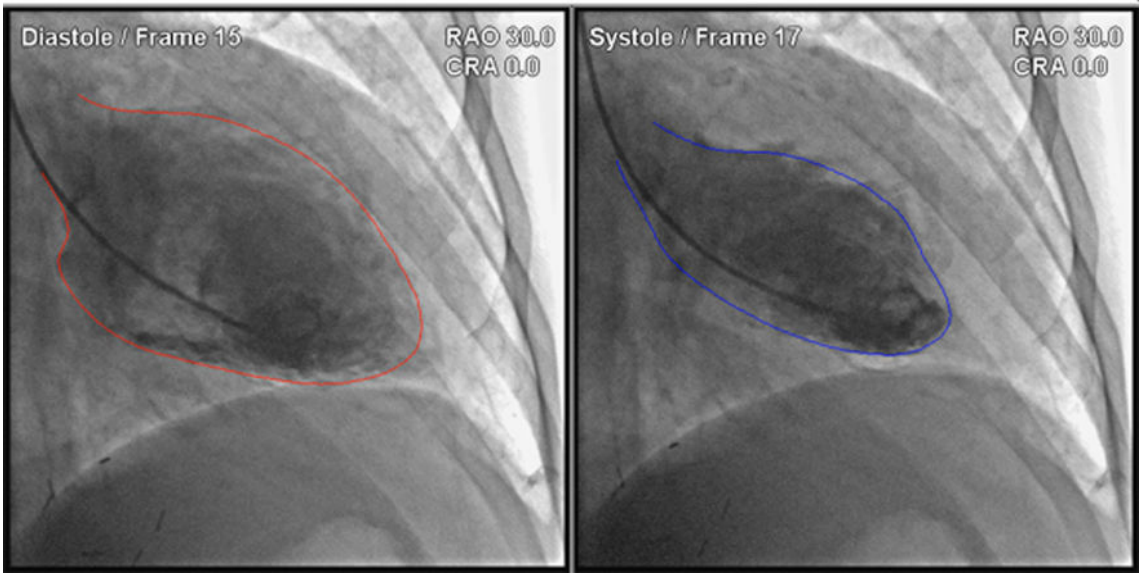
Global Ejection Fraction

Name	: LastName, FirstName
Patient ID	: PatientId
Date of Birth	: 24-Jun-1990
Sex	: M
Height	: 185 cm (6'1")
Weight	: 80.0 kg (176 lbs)
Body surface area	: 2.04 m2
Study ID	: 1
Study date	: 26-Jun-2007
Performing physician	:
Sequence	: 5
Calibration Factor	: 0.17 mm/pixel
Imprecision	: +/- 5 %
Calibration object height	: 15.0 cm (5.91")

Results

		Dodge's Method	Simpson's Method
End diastolic volume	ml	280.2	288.0
	ml/m2	137.6	141.4
End systolic volume	ml	117.4	119.3
	ml/m2	57.7	58.6
Stroke Volume	ml	162.7	168.8
	ml/m2	79.9	82.9
Global Ejection Fraction		58 %	59 %

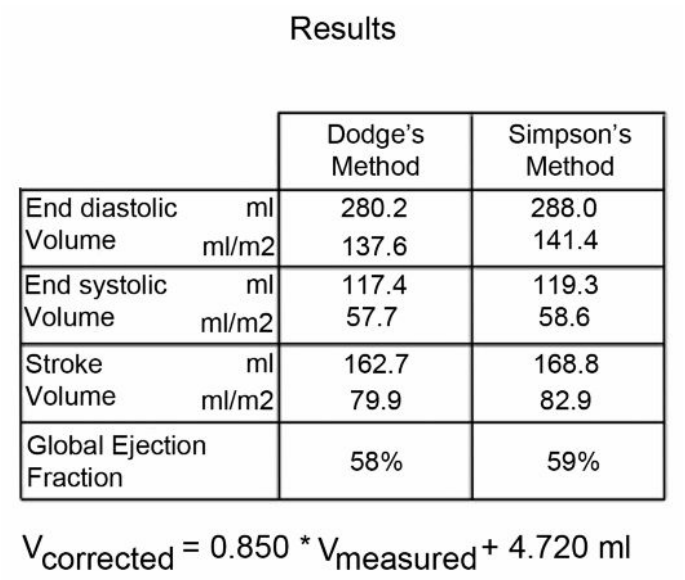
$V_{corrected} = 0.850 * V_{measured} + 4.720$ ml



The GEF analysis results report includes the report header, patient and exam information, the Diastolic and Systolic image, and the results table.

The results table provides the end diastolic, end systolic and stroke volumes of the left ventricle computed in two ways (Dodge's method and Simpson's method). These volumes are provided in both ml and ml/m^2 (normalized by the body surface area. Patient weight and height must be entered). Also, the table contains the Global Ejection Fraction value expressed in %.

If the sequence has not been calibrated for Ventricular Analysis, then the resulting units of ml or ml/ m^2 are not displayed. In this case, only percentage values appear.



Results

		Dodge's Method	Simpson's Method
End diastolic Volume	ml	280.2	288.0
	ml/m2	137.6	141.4
End systolic Volume	ml	117.4	119.3
	ml/m2	57.7	58.6
Stroke Volume	ml	162.7	168.8
	ml/m2	79.9	82.9
Global Ejection Fraction		58%	59%

$V_{corrected} = 0.850 * V_{measured} + 4.720$ ml

The volumes displayed are calculated from the following equation:

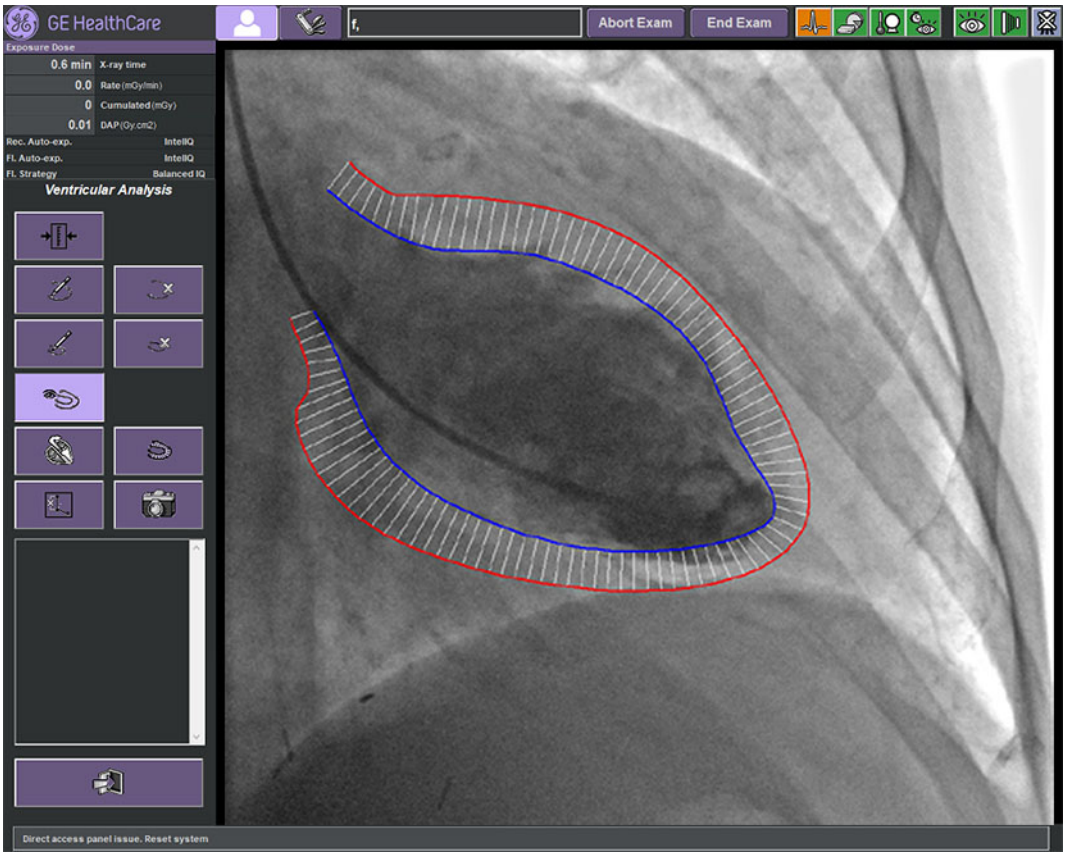
$V_{corrected} = A * V_{measured} + B$

The $V_{measured}$ is the volume in ml resulting directly from the Dodge's and Simpson's methods. Because these methods overestimate the actual left ventricle volumes, the coefficients A (slope) and B (intercept) are applied to obtain the actual volume $V_{corrected}$ in ml, which is the volume displayed in the Results table.

The Global Ejection Fraction (GEF) is calculated as the ratio of the End diastolic and End systolic volumes.

NOTE
If the sequence has not been calibrated for ventricular analysis, this correction is not applied, which leads to a less accurate value of the GEF.

If you hide the GEF report by pressing again the Generate GEF report button, you will see both Systolic and Diastolic contours in the image connected with the 100 equidistant chords.



In case you are not satisfied by results delivered in the GEF report:

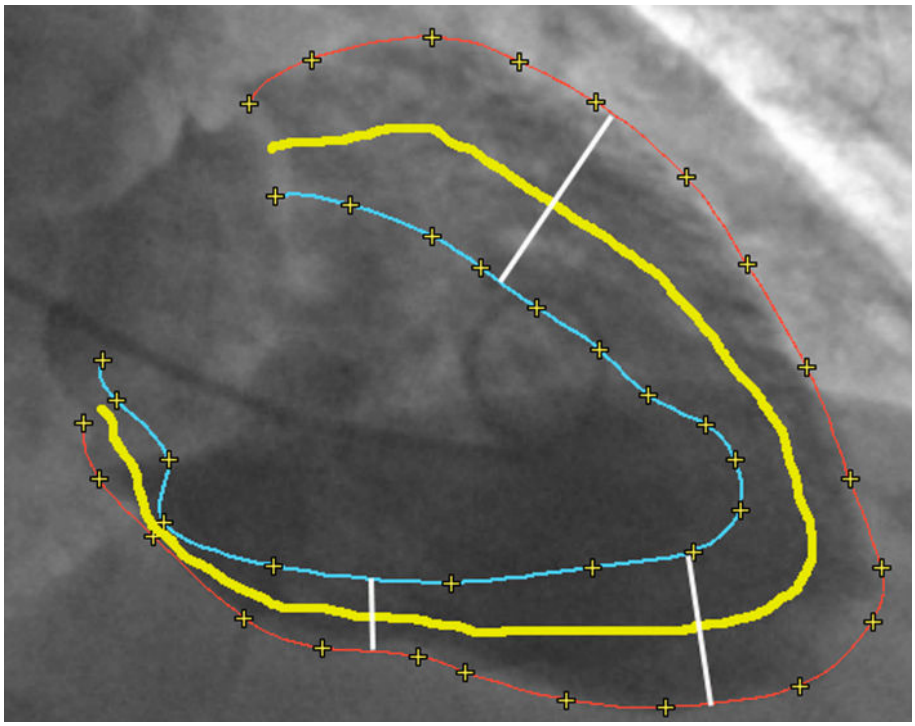
1. Hide the current GEF report by pressing again the Generate GEF report button.
2. Modify the position of the existing points on the Diastolic or Systolic contour, add new points, or delete the contours and draw new ones.
3. Press the Generate GEF Report button. (If requested, perform auto-calibration.)

   The new GEF report appears in the screen.

Before exiting the GEF report, click on **Store Photo** icon  to save the report in the Photo Browser as a standard photo.

Wall Motion Analysis

Wall Motion Analysis analyzes the wall motion dynamics of the left ventricle using the Sheehan's centerline method. This method computes the lengths and locations of 100 chords equally spaced between the user-defined heart contours.



According to the Sheehan's centerline method, each chord is drawn perpendicular to the centerline which is constructed midway between the End-Diastolic (ED) and the End-Systolic (ES) contour. The length of the chord represents the wall motion at a given location of the ventricle contour. The value will be negative if, at a given point of the contour, the ES contour is located outside the ED contour.

Since the heart size varies from patient to patient, the absolute extent of motion will vary even in normal hearts of different size. To normalize for heart size, each chord length is divided by the length of the ED perimeter. The normalized chord data can then be standardized.

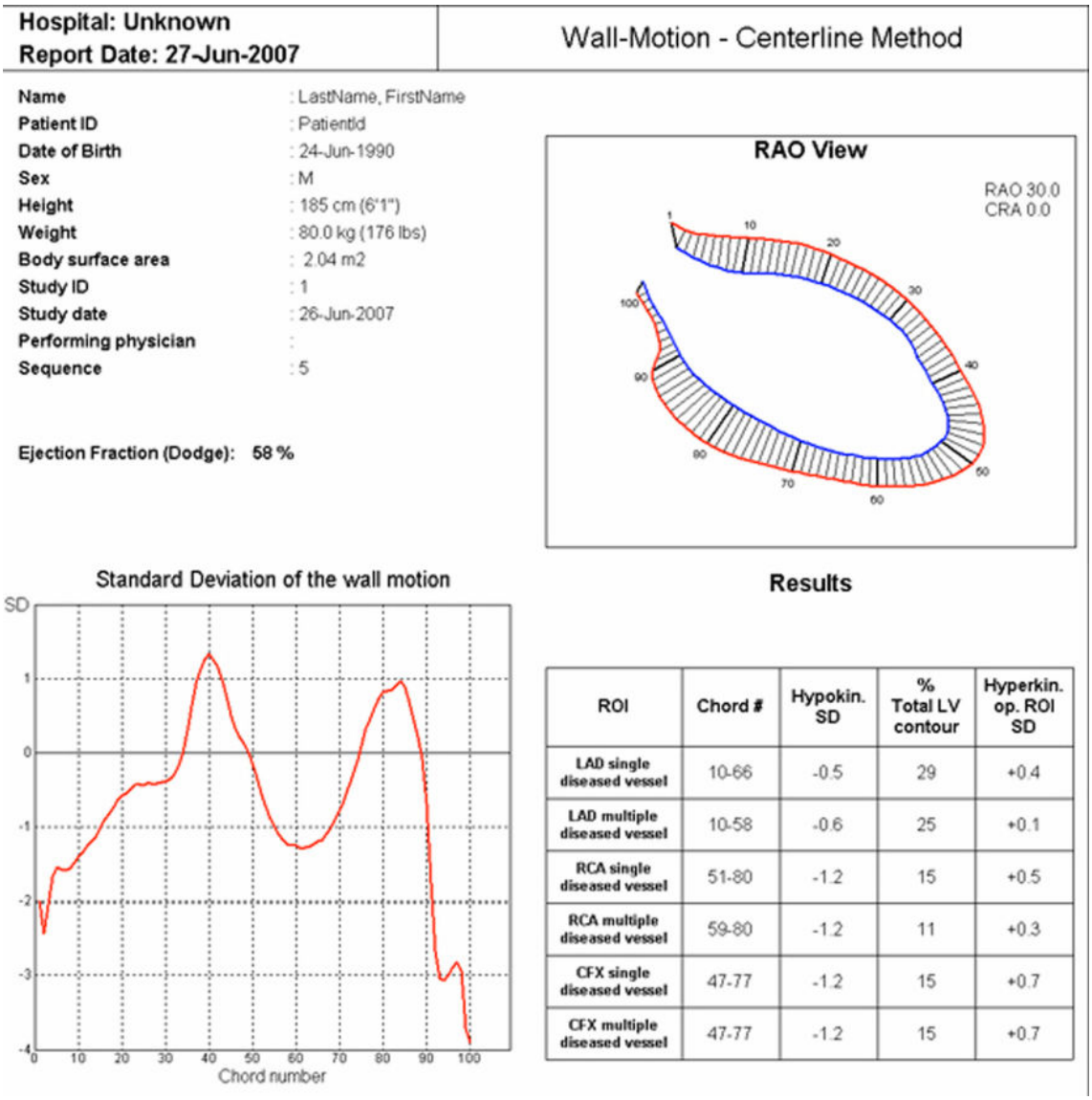
This is done by subtracting from each chord the average of a group of normal patients (called the normal mean), and dividing the result by the standard deviation from the normal mean for that chord.

NOTE
This method is validated for LV acquired in RAO 30° or LAO 60° angulations. So, if the sequence was not acquired in RAO 30° +/- 10° or LAO 60° +/- 10°, or with a CRA or CAU angulation greater than 10°, or with more than 5° difference between the end of Diastolic and end of Systolic frame, a warning message about the loss of result accuracy will be displayed.

After both end of Diastolic and Systolic contours are drawn, click on **Generate Wall Motion report** icon on the Ventricular Analysis tool menu.

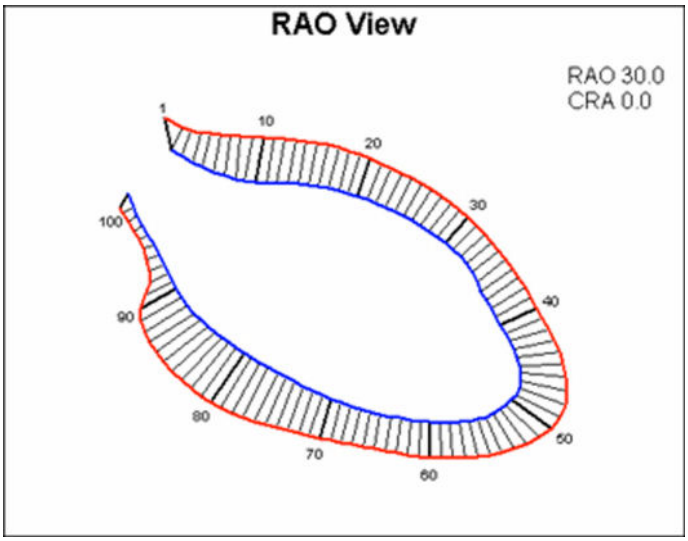
If needed, the Auto-calibration dialog box opens asking you to enter the "object to table top distance" (refer to GEF analysis for Auto-calibration procedure).

Upon completion of auto-calibration, centerline computation and Wall Motion quantification, the Wall Motion report is displayed with the computed results.



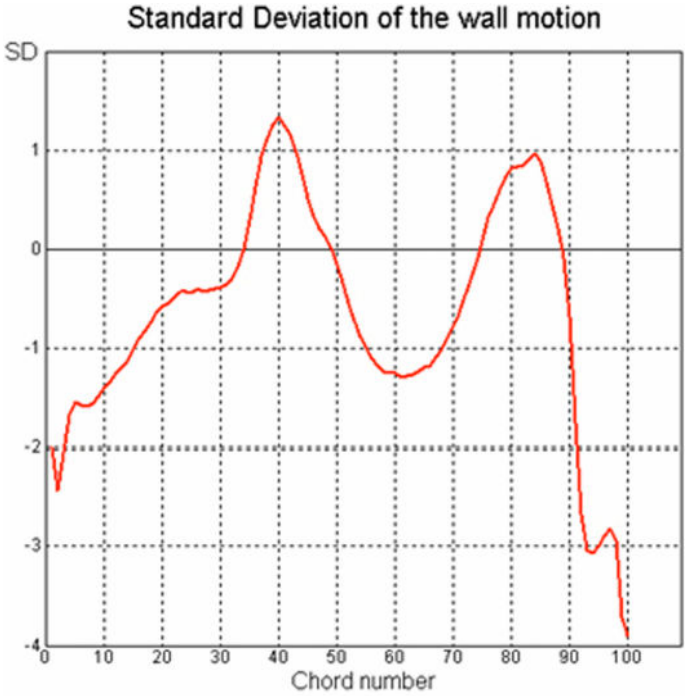
The Wall Motion analysis report includes a report header, patient and exam information, a heart graph, a standard deviation graph, and a results table.

The Heart graph field (top right of the WM report) contains the Systolic and Diastolic contours previously drawn by the user, together with the corresponding RAO/LAO values. Also, the 100 chords representing the current wall motion of the left ventricle are displayed (current patient chords).



To gather precise and relevant information on hypokinesia and hyperkinesia in different ROIs, study the Standard deviation graph and the Results table.

The standard deviation graph (bottom left of the WM report) shows the normalized wall motion as a function of chord number, based on Wall Motion computation.



In the case of hypokinesia, the normalized wall motion is a negative value. For hyperkinesia, the normalized wall motion is positive.

Left ventricle with normalized motion between -2 and +2 can be considered as normal.

The Results table field (bottom right of the WM report) contains a table with the results of Wall Motion Regional analysis.

Results

ROI	Chord #	Hypokin. SD	% Total LV contour	Hyperkin. op. ROI SD
LAD single diseased vessel	10-66	-0.5	29	+0.4
LAD multiple diseased vessel	10-58	-0.6	25	+0.1
RCA single diseased vessel	51-80	-1.2	15	+0.5
RCA multiple diseased vessel	59-80	-1.2	11	+0.3
CFX single diseased vessel	47-77	-1.2	15	+0.7
CFX multiple diseased vessel	47-77	-1.2	15	+0.7

The results provide information about the impact on the wall motion of the three main coronary arteries (LAD, RCA, and CFX) affected with single or multiple diseases. Also, the chord interval is specified for each vessel ROI in the 'Chord #' column. The chord interval associated with a main coronary territory is different in the case of RAO 30° +/- 10° and LAO 60° +/- 10° acquisition. The table below shows the chord intervals for each ROI in both cases.

Table 11-1 Chord intervals associated with different coronary territories

Region of Interest (ROI)	Chord interval for RAO 30°	Chord interval for LAO 60°
CFX single	10 - 80	19 - 67
CFX multiple	10 - 80	19 - 67
LAD single	10 - 66	50 - 67
LAD multiple	10 - 58	50 - 67
RCA single	51 - 80	38 - 74
RCA multiple	59 - 80	38 - 74

The 'Hypokin. SD' column displays the average of hypokinesia severity in standard deviation unit in a certain ROI. If the average of the hypokinesia value is lower than -2, then it is displayed in bold. Negative values in this column refer to hypokinesia. Wall motion is considered normal, if it is between -2 and +2.

For each ROI, the '% Total LV contour' column displays what percentage of the entire length of the left ventricle contour can be characterized with hypokinesia outside the -2; +2 range.

For each ROI, the 'Hyperkin. op. ROI SD' column displays the possible hyperkinesia compensation in the opposite ROI. It corresponds to a significant hyperkinesia if it is positive and outside the range -2; +2.

If you hide the WM report by pressing again on the Generate WM report button, you will see both Systolic and Diastolic contours in the image connected with the 100 equidistant chords.

In case you are not satisfied by results delivered in the WM report:

1. Hide the current WM report by pressing again the Generate WM report button.
2. Modify the position of the existing points on the Diastolic or Systolic contour, add new points, or delete the contours and draw new ones.

3. Press the Generate WM Report button. (If requested, perform auto-calibration.)

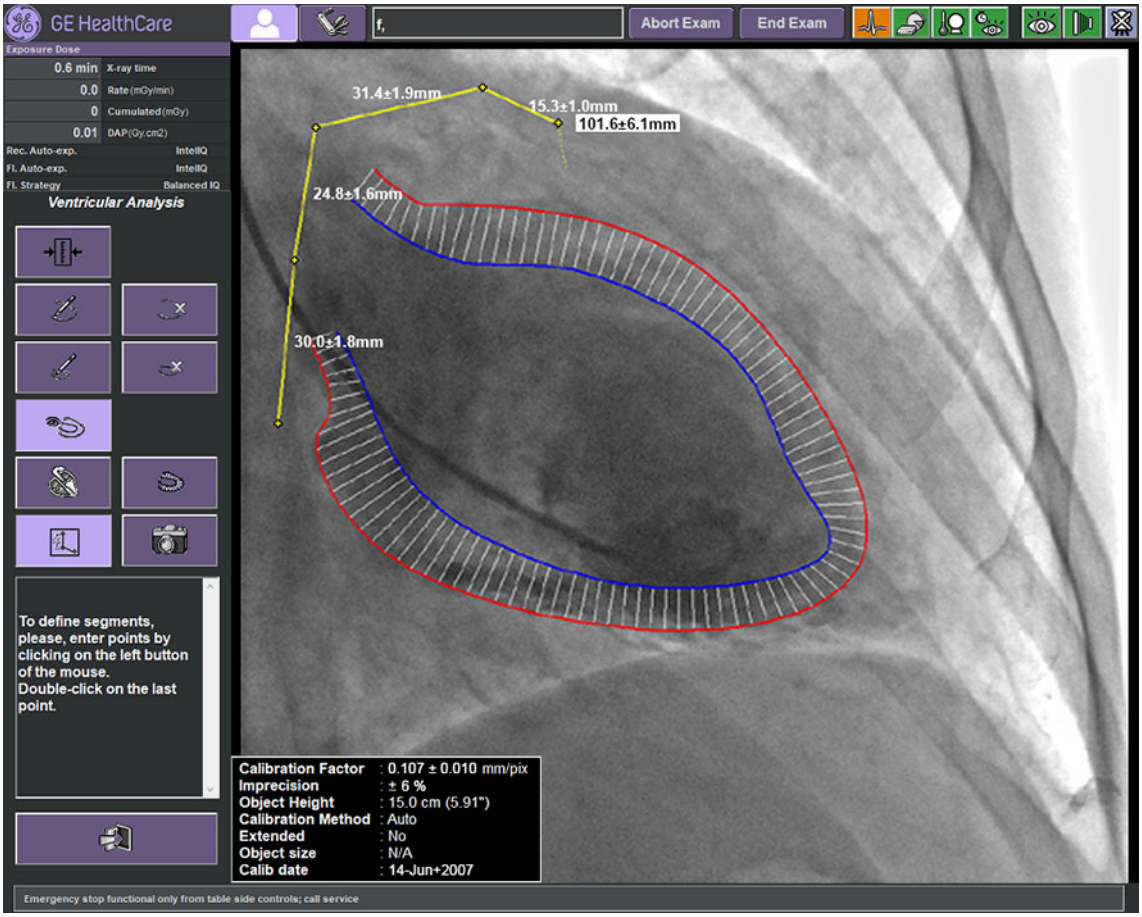
   The new WM report appears in the screen.

Before exiting the WM report, click on **Store Photo** icon to save the report in the Photo Browser as a standard photo.

Multi Segments

Click on the **Multi-segments** icon on the Ventricular Analysis tool menu to draw a link made of multiple segments (multi-segments) on a single frame of a sequence, and to estimate the length of the segments.

NOTE
Only one Multi-segments can be displayed at a time.



Following the instructions in the Hint window, enter the points of the multi-segment by clicking with the left mouse button.

Before you place the first point, you can perform frame navigation using the Play/Pause or Next/Previous frame functions.

The adjacent points of the multi-segments can be as close as you want from each other. However, remember that the smaller the distance between the points is, the higher the imprecision will be.

While creating the multi-segments, you can edit any of the points already entered. Move over a point, the pointer will change to a crosshair cursor, and then click and drag with the left mouse button to the intended position.

You can also insert points between two points already entered. Move over the intended position on the segment line (the pointer will change to a crosshair cursor), and click with the left mouse button.

Double-click the last or any existing point to indicate that the multi-segment is finished.

To draw a new multi-segment on the selected frame, repeat the above procedure.

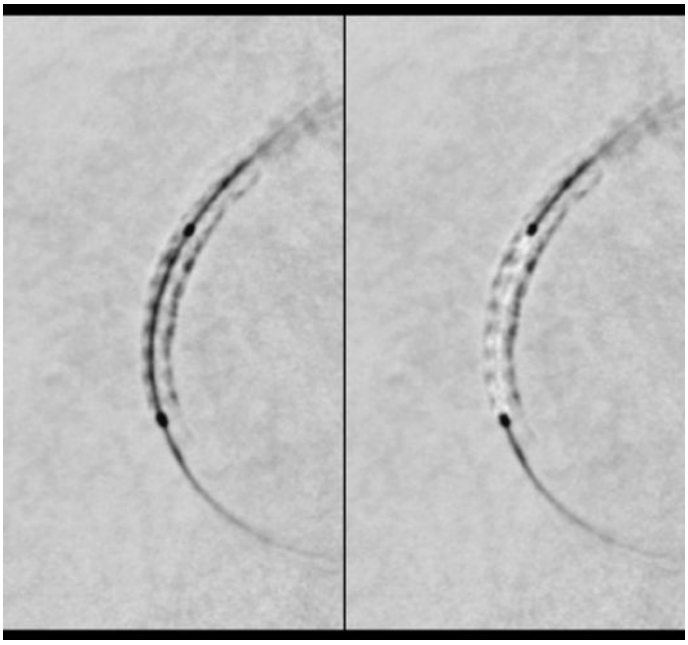
Before exiting, click on **Store Photo** icon  to save the image with measurements in the Photo Browser as a standard photo.

After all analysis are performed and all images/graphics/reports saved, click on the **Exit** icon  to exit the Ventricular Analysis application.

11.3 StentViz (Option)

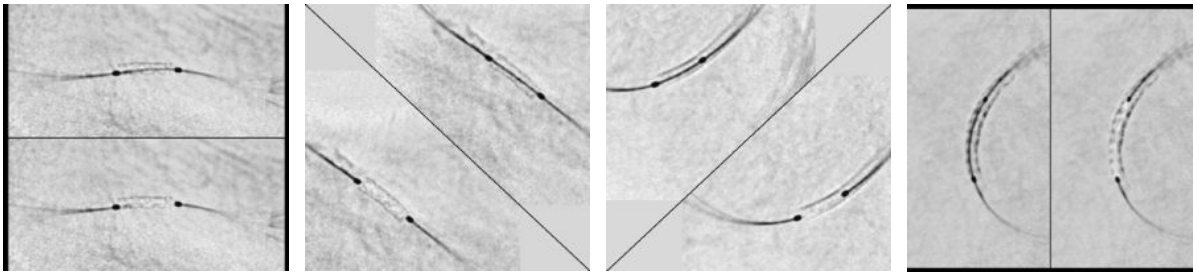
The StentViz application is designed to enhance the visibility of a stent placed during an interventional Cardiac procedure. Additionally, StentViz may help the cardiologist assess the correct deployment of the stent in the vessel. If a stent was already placed, it may also be used to verify the positioning of a new balloon before the deployment of the second adjacent stent, or before re-dilatation of the stent.

The result is shown on the static image below detailing the enhanced image image quality and contrast of the stent.



There are two StentViz images displayed on the reference display. One where the full guidewire is displayed and a second where the portion of the guidewire between the balloon marker-balls has been subtracted. The subtracted guidewire is intended to ease the visualization of the stent.

The image will be divided into four different displays depending on the original direction the vessel was imaged.



NOTE
This application is restricted to heart anatomy only and can be launched only on images acquired using the automatic StentViz workflow described below.

The success of the StentViz application might be altered by the poor quality of the images (high noise level…), the type of balloon used (low marker radio-opacity), the radio-opacity of the guidewire, and or high radio-opacity structures in the vicinity of the markers.

NOTE
The StentViz resulting photo is a recomputed image. Always associate it with the original recorded sequence for interpretation.

Automatic StentViz Workflow

To launch the StentViz application acquisition to image a deployed stent the following is required:

1. Deflate the balloon and leave it in position inside the stent. StentViz will detect and focus on both markers of the balloon and on the guidewire to perform the image processing.
2. A cardiac related protocol needs to be selected. On the DL screen or on the Touch Panel, select Dynamic and then StentViz to launch the application. An icon will be displayed on Live monitor to indicate the StentViz acquisition mode is set for the next single dynamic acquisition.

   When StentViz application starts, frame rate automatically switches to 30fps to optimize image processing.

   The message `READY FOR STENTVIZ` is displayed at the bottom left of the Live monitor in the Status area.

Figure 11-5 DL record acquisition

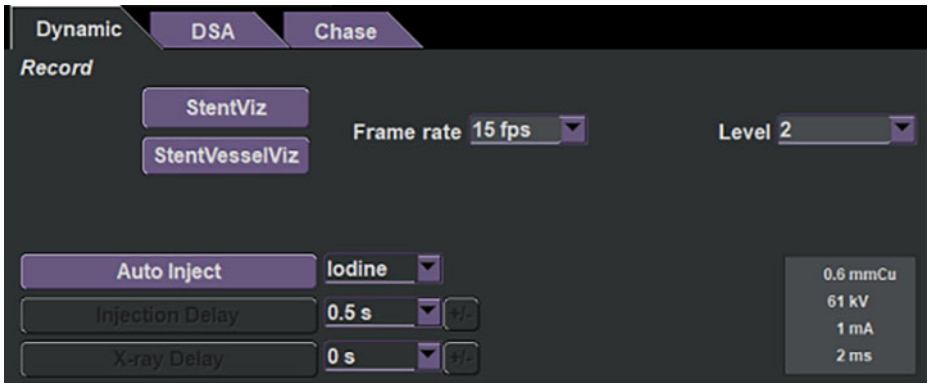


Figure 11-6 Touch Panel - X-Ray settings page

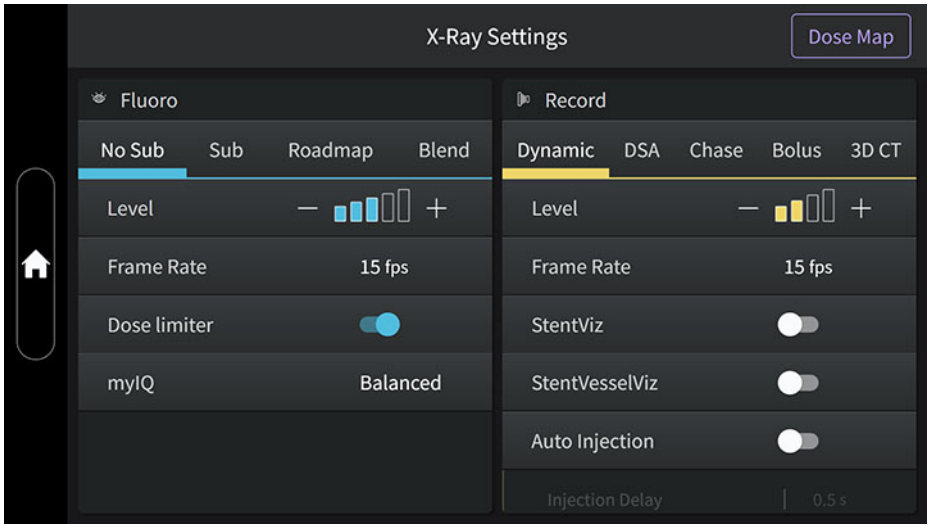
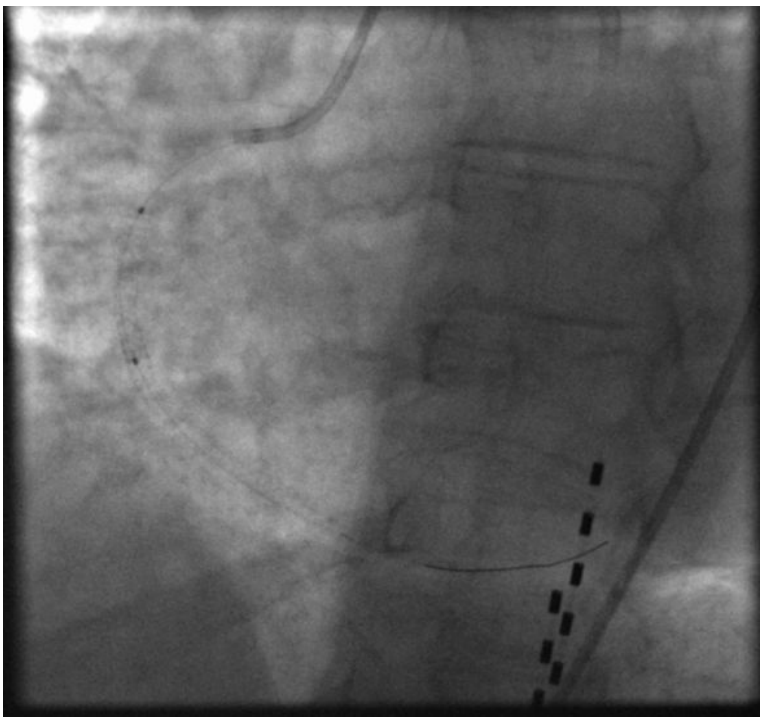


Figure 11-7 StentViz acquisition mode icon

3. Perform a short Record acquisition centered on the display stent and deflated balloon. Acquisition automatically stops and review starts when enough frames are acquired. You can release the pedal at this stage.

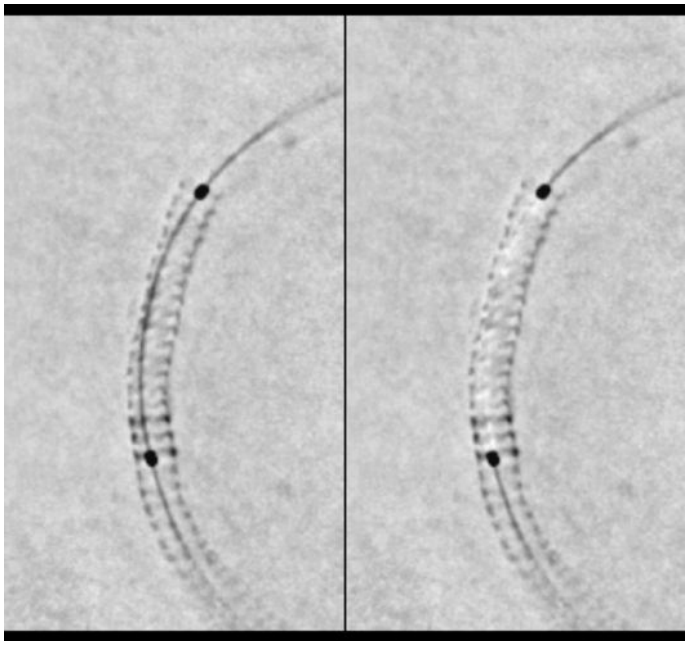
   The acquired sequence is stored in the DL Sequence browser with a specific default **Pre-StentViz** label.

Figure 11-8 "Pre-StentViz" sequence displayed on Live monitor



4. At the end of acquisition, StentViz processing is automatically launched. The message STENTVIZ IN PROGRESS is displayed at the bottom left of the Live monitor in the Status area. The typical processing time is less than 10 seconds. Because image processing is performed in the background, fluoro, record, review and image processing are always available.
5. At the end of StentViz processing time, the message STENTVIZ IN PROGRESS is replaced by STENTVIZ PHOTO READY at the bottom left of the Live monitor and the resulting image is automatically displayed on the reference display as a photo showing the stent with enhanced image quality and contrast. As for other photos, this photo is stored in the DL Photo browser with a specific default **StentViz** label.

Figure 11-9 StentViz photo displayed on Reference monitor



NOTE
In case of fluoro or record acquisition, or image review in progress at the completion of the StentViz processing, the resulting photo is displayed only at the end of the fluoro or when the review switches to Pause mode.

NOTE
The next Dynamic acquisition will be performed without StentViz processing. In case a new StentViz acquisition is required, reselect the **StentViz** button on the DL screen or Touch Panel.

Manual StentViz Workflow

If the StentViz processing is not successful, StentViz can be manually launched on previously acquired StentViz sequence:

1. Select the StentViz native sequence (labeled **Pre-StentViz**) and launch the review. Zoom the image and center it on the stent. This will increase the success rate and decrease the processing time.
2. Launch StentViz through the **StentRefine** button from the DL sequence browser **[1]** on the DL screen, the DL remote control using the Menu key, or from the Touch Panel.

NOTE

StentRefine is used indifferently for StentViz or StentVesselViz post-processing. The selection of StentViz or StentVesselViz post-processing is automatically done by the system depending of the acquisition setting of the native sequence.

Figure 11-10 DL sequence browser

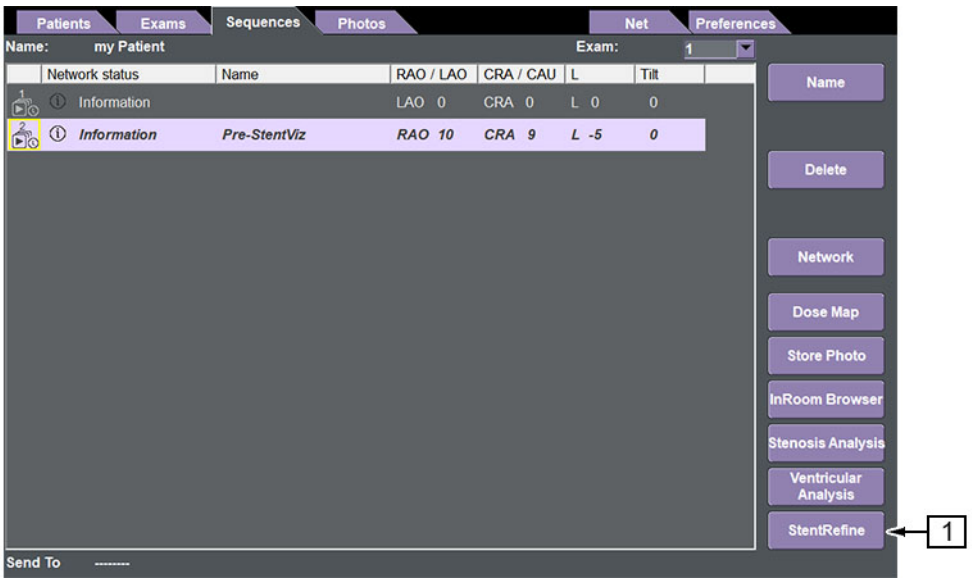
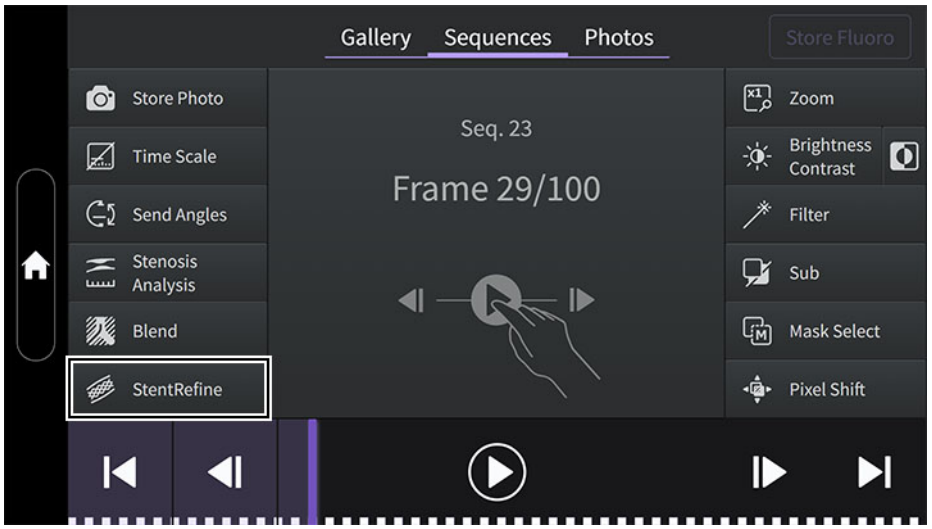


Figure 11-11 Touch Panel in sequence page



3. Refer to steps 4 and 5 of Automatic StentViz Workflow.

StentViz Best Practice

- Before performing the StentViz short record acquisition, perform fluoroscopy to:
  - Verify that the balloon has only 2 marker-balls. StentViz will fail if the balloon shows 1 or 3 markers.
  - Management of stent positioning to insure overlap: in case 2 adjacent stents are required and the first one is already deployed, position the balloon with the second non deployed stent next to the first one.

- Verify that the pair of markers and the stent are in the same vessel and/or as close as possible to each other. The closer the stent is to the markers, the sharper the stent will be displayed on the StentViz resulting image.
- Verify that the markers are not super-imposed to highly radio-opaque objects (like metallic staples or injected catheter).
- Verify that the stent is radio opaque. The more radio opaque the stent is the higher the StentViz image quality will be.

- During the StentViz short record acquisition:
  - Make sure that the markers are visible in every frame.
  - Do not move the balloon during the StentViz acquisition. The only allowable motion is from anatomy.
  - Do not move the table or gantry during the StentViz acquisition.

StentViz User Messages

Location	Message	Description
Live and Reference monitor	`StentViz already running. Restart it manually later`	The previous StentRefine or StentViz post-processing is still running
	`This is not an eligible sequence for StentRefine`	The sequence selected for the StentRefine post-processing has not been acquired using a StentViz workflow
	`Not enough frames. Reselect StentViz to proceed`	The acquired sequence or selected sequence does not have enough frames for StentViz post-processing. Redo StentViz acquisition and wait until `X-Ray Stop` is displayed.
	`StentViz failure, apply zoom and launch StentRefine`	StentViz processing has failed. Select the StentViz native sequence (labeled **Pre- StentViz**) and launch the review. Zoom on the sequence and center it on the stent. Launch StentViz through the **StentRefine** button.

11.4 StentVesselViz (Option)

The StentVesselViz application is designed to enhance the visibility of a stent placed during an interventional Cardiac procedure. Additionally, StentVesselViz may help the Cardiologist assess the correct deployment of the stent in relation with the vessel wall of the artery.

If a stent was already placed, it may also be used to verify the positioning of a new balloon before the deployment of the second adjacent stent.

The result is shown on:

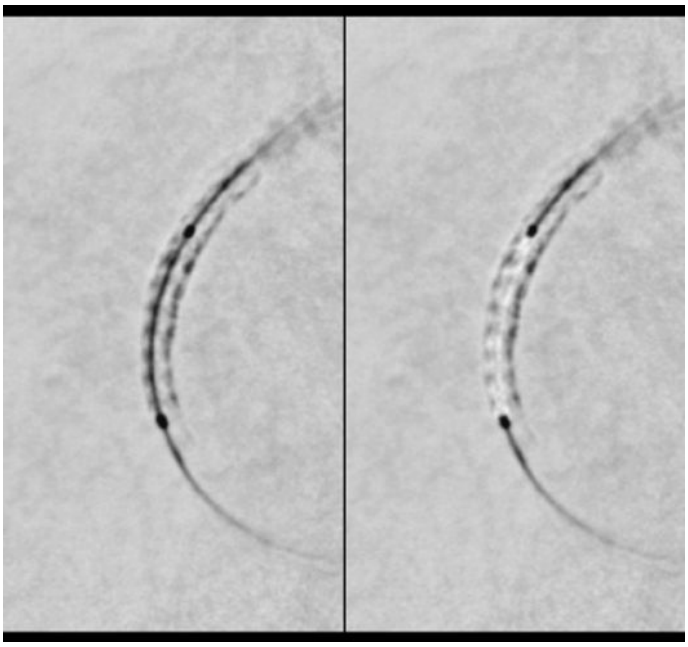
1. The static image below detailing the enhanced image quality and contrast of the stent (StentViz).
2. A dynamic zoomed image sequence which displays a progressive fading between the enhanced stent image and an injected vessel image.

NOTE
The StentVesselViz application includes the StentViz processing.

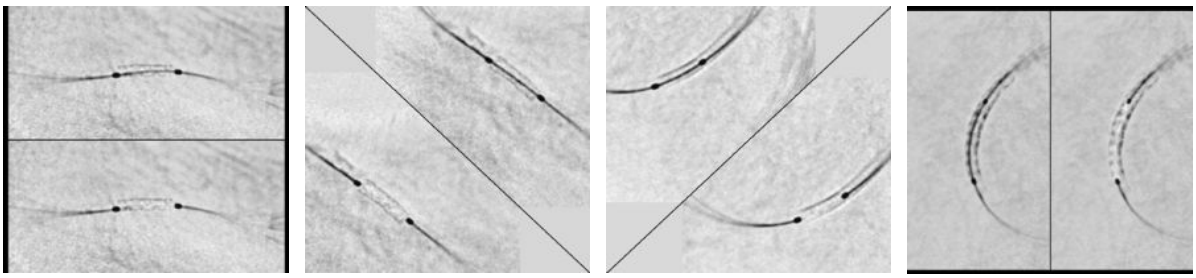
11.4.1 Output Description

StentViz Images

There are two StentViz images displayed on the reference display. One where the full guidewire is displayed and a second where the portion of the guidewire between the balloon marker-balls has been subtracted. The subtracted guidewire is intended to ease the visualization of the stent.



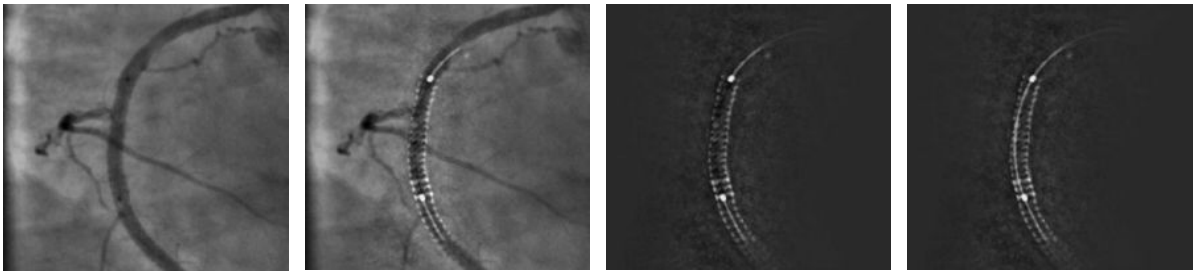
The image will be divided into four different displays depending on the original direction the vessel was imaged.



NOTE
The StentViz resulting photo is a recomputed image. Always associate it with the original recorded sequence for interpretation.

StentVesselViz Sequences

The StentVesselViz outputs a sequence of images that displays a video fading between a stent enhanced image (StentViz image) and the lumen of the vessel it is deployed in. The sequence starts by displaying the injected vessel. Then the stent enhanced image (with subtracted guidewire) progressively appears over the vessel. The stent enhanced image is registered so that the balloon marker-balls are at the same location as in the vessel image. In a third phase, the vessel disappears to leave the full stent enhanced image. Finally the guidewire is displayed over the stent image.



NOTE
This application is restricted to heart anatomy and can be launched only on images acquired using the Automatic StentVesselViz workflow described below.

The success of the StentVesselViz application might be altered by poor quality of the images (high noise level…), the type of balloon used (low marker radio-opacity), the radio-opacity of the guidewire, and/or high radio-opacity structures in the vicinity of the markers.

11.4.2 Automatic StentVesselViz Workflow

NOTE
The automatic StentVesselViz process is launched at the end of acquisition sequences.

StentVesselViz generates an image of a deployed stent by combining non-injected and injected images. Follow these steps:

1. Select a protocol containing the Dynamic acquisition mode. On the DL screen or on the Touch Panel, select Dynamic and then StentVesselViz. An icon is displayed on Live monitor to indicate the StentVesselViz acquisition mode is set for the upcoming acquisition.
2. Deflate the balloon and leave it in position. StentVesselViz will detect and focus on both markers of the balloon, and on the guidewire to perform the image processing.
   The message `READY FOR STENT VESSEL VIZ` is displayed at the bottom left of the Live monitor in the Status area.

Figure 11-12 DL record acquisition

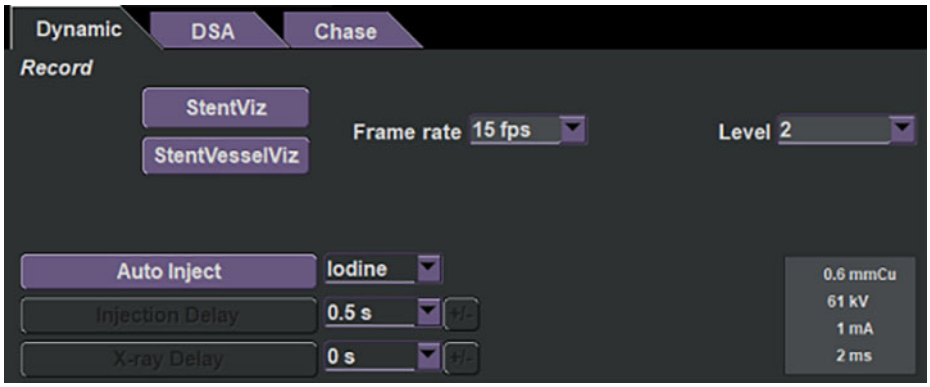


Figure 11-13 Touch Panel - X-Ray settings page

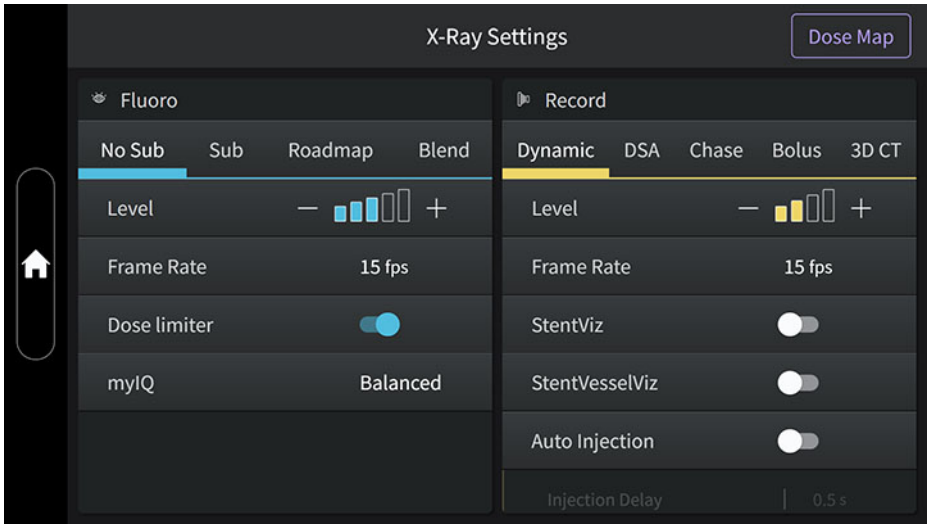


Figure 11-14 StentVesselViz acquisition mode icon

3. Perform a single and continuous Record acquisition centered over the deployed stent and deflated balloon, first part without injection of contrast media, second part with injection of contrast media:
   - Non-injected frames: an "inject" blinking message will be displayed on the Live monitor when enough non injected frames are acquired.
   - Injected frames: proceed as usual for an injected acquisition - standard injection-.

   The acquired sequence is stored in the DL Sequence browser with a specific default **Pre-StentVesselViz** label.