6 Cardiac

This application allows you to perform gated planar (MUGA) analysis, first pass analysis, and quantify left-to-right shunts. It has these methods:

- Shunt
- MUGA Manual
- LV Muga GBP
- LV Muga C
- First PASS

The methods are used to create these preferences:

- Shunt
- MUGA Manual
- LV Muga GBP
- LV Muga C
- First PASS

For information on loading requirements, and on calculations and algorithms used in this application, see the appropriate section in the *NM Application Suite Reference Manual*.

NOTICE

In some preferences, you are required to draw background ROIs. When drawing these, be sure to capture an area that does not include high counts (an organ or blood vessel, for example). If you include high-count areas, the results may be incorrect

MUGA GBP and MUGA C

MUGA (Multi-Gated Acquisition) allows you to segment and quantify gated blood pool datasets semi-automatically, and create statistical information about the cardiac cycle. A Left Ventricle ROI is required for MUGA, but the Right Ventricle ROI is also selectable as a Method. By default, bounding regions are automatically drawn around the ventricles. From the regions obtained from the bounding regions the application determines ED and ES, and generates results using relevant corrections (for example, background correction).

NOTICE

The difference between the MUGA C Preference and the MUGA GBP Preference is in the edge detection algorithm. The quantitative results that are generated are based on the Odyssey GBP implementation for both preferences. The only difference is in the edge detection algorithm initially used to generate the regions. The MUGA C preference uses the MUGA C edge detection algorithm.

Using MUGA GBP and MUGA C

In the Define Regions workstep, this application draws a preliminary bounding region around one or more regions. By default the edge detection algorithm is GBP Multiple. You must then take these steps to create ROIs:

1. Move and adjust a bounding region so that it encloses the appropriate ventricle. Drag the line to move the bounding region; drag a handle to reshape it.
2. Click **Detect Region**.

   This creates an ROI for the ventricle and an ROI for the background (for preferences with that specify automatic background ROIs). To start over, click the detect region icon again; to draw the ROI by hand, click the eraser icon.

The ED and ES frames for LV and RV are automatically determined and the ROIs are automatically drawn. If you would like to change any of the ROIs:

1. In the Cine viewer, go to the correct frame (using the Scroll feature, for example).
2. If necessary, redraw the ROI by clicking on its eraser icon and using the ROI pencil tool.
3. Right-click in the Cine viewer, and use the Set As pop-up menu to select ED or ES.

   Results will be calculated based on the new ROIs.

NOTICE

The GBP Preference draws a background ROI on the ES frame. This ROI is automatically duplicated on the ED frame, even though it does not apply on that frame. When this happens, you may see it overlap the ED ROI. However, you can ignore the ED background ROI: only the background ROI on the ES image is used for calculations.

In the Review Results workstep, you can use the red timing marker in the Time Activity viewer to to get results values and EFs for the time range from start to the marker position. Drag the marker to a specific time to view the values; the precise time appears just above the marker.

CAUTION

If the count rate is significantly lower in the last few bins of the study, the Ejection Fraction value and the identification of the ED and ES frames can be wrong. To avoid this situation, use the timing marker in the Time Activity viewer to exclude the last bins from the calculations.

If you need to compare data from legacy workstations, you can calculate the slope and intercept for each system and compare the values. To perform the calculations, follow the steps below.

1. Process enough ejection fraction studies on your acquisition system to result in a total of at least 24 studies (60 studies is optimal) with the following characteristics:

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- 1/3 of the studies should have EF < 40%
- 1/3 of the studies should have 40% < EF < 60%
- 1/3 of the studies should have EF > 60%

2. Process the same studies on the IntelliSpace Portal system in this application using a **slope** value of 1.0 and **intercept** of 0. (For more information, see section “Preferences” on page 228).

Important

Be sure to use 1.0 and 0 as the slope and intercept values for this step. If you do not, you cannot establish a baseline for comparison with your legacy system.

3. Create a graph that plots the IntelliSpace Portal results on the x axis and your acquisition system’s results on the y axis.
4. Perform a linear regression on the plots.
5. Use the slope and intercept values of the resulting line (y = mx + b) as the values in the defaults dialog.

NOTICE

You can perform this procedure for as many acquisition systems as you have and create a defaults file for each one.

Results

- Cine
- ED/ES images
- Phase/Amplitude images and Phase Histogram
- Ejection Matrix/Stroke images
- Ejection Fraction
- Background Counts
- Peak Filling Rate
- Peak Ejection Rate
- Time to Peak Filling
- Time to Peak Ejection
- Filling for 25%, 33%, 50%, and 75%
- RR Interval Window
- Acquired Beats

- Rejected Beats
- Skipped Beats
- Volume Time Activity Curve
- Regional Ejection Fractions
- First Derivative Time Activity Curve
- High R-R
- Low R-R

If you do not see all the result images in the Review Results workstep, it may be that one or more viewers are hidden. If you suspect this, try using the **Show Hidden Viewers** tool in the **Utilities Data Manager**. For more information, see section “Review Results” on page 231.

Preferences

To change the Preferences for this application:

1. Select the **Preferences** Data Manager
2. Click **Open Preference Editor** at the bottom of the Preferences section (the second icon ).
3. Make changes in the preferences window using the information in the table below.

For details on editing Preferences, see section “Creating and Editing Preferences” on page 59.

You can save these parameters as Preferences:

Parameter	Default	Description
Slope	1.0	Slope of the line fit to points in a calibration plot
Intercept	0.0	Y intercept of the line fit to points in a calibration plot
Muga Algorithms	GBP Multiple	This is the algorithm used for edge detection
Scale Volume Curves	False	This sets the units for the y axis of the volume curve to counts when False, and to % EDV when True
View Smoothed Image	True	This determines whether the cine images are smoothed (using the Fourier algorithm)

MUGA Tutorial

In this tutorial you will learn how to perform a MUGA C analysis. You will learn how to load MUGA data, draw the necessary ROIs, and review the results and images.

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The Preference used in this tutorial (LV Muga C) calculates the left ventriclular ejection fraction only. If you needed to calculate both ventricles you would need to create a custom Preference that included both.

NOTICE

This tutorial is designed to use a particular sample patient that works well to illustrate certain features of the software. Nothing prevents you from substituting your own patient, but be aware that it may not load the same way or produce similar results. If you try to load your own data and it fails because of automatching, see section “Editing Auto Matches” on page 27.

If you would like to start this tutorial over at any time, just click **Restart** in the application. This reloads the data as it does in the first workstep, as long as the default Preference has not been changed.

Setup

1. In the IntelliSpace Portal Patient Directory’s Local Devices list, select the NM Demo Data studies.
2. From the list of patients, select the Patient Name **NM Cardiac** with Patient ID **Heart, MUGA PLANAR**.
3. Click on the arrow in the Analysis menu and select the NM Cardiac application.
4. Open the Preferences Data Manager and if the LV Muga C Preference is not selected, select it now by clicking on its **Apply Preference** icon ( ).

   Depending on your defaults, the patient data may automatch with the Preference. If so, you do not need to load data into buckets individually. When this happens, the application proceeds directly to the next workstep (Define Regions) automatically.

   If you wanted to load different data, you would have to go back to the Setup workstep. By way of example, we will do that next.
5. Click the Previous Workstep button to go back to the Setup workstep.

6. Open the MUGA bucket by clicking on the double down arrows.
7. Click on the LAO dropdown list and select Clear Bucket at the bottom.

   Notice that both the MUGA and LAO buckets have a red exclamation point. This indicates that they are required data.
8. Click on the LAO dropdown list again and select LAO.

   This clears the exclamation point and allows you to proceed to the next workstep.
9. Click the Next Workstep button to proceed to the Define Regions workstep.

Define Regions

When the workstep loads, you can see that the Next Workstep button is grayed out:

This indicates that a requirement for the workstep has not been met. Different applications may have different requirements: drawing certain ROIs, setting parameters, etc. When all requirements have been met, the button becomes available.

By default, there is a bounding ellipse around the left ventricle in the LAO Filtered Image viewer (on the left). This defines the area in which autodetection will occur. To increase the accuracy of the autodetection, you will need to increase the contrast of the MUGA and adjust the ellipse according to the new image information.

This application also automatically identifies the ED and ES images, though you can change them using the Set As feature in the context menu.

1. To use a larger window, click the viewer's Maximize button.

   

2. Control-click on the left viewer to make it active.
3. Slide the black bar in the Image Colorbar to the left to increase the contrast.

   Notice that the ellipse could be a little smaller and tilted to the left slightly.
4. Use the handles on the ellipse (visible when you hover over it) to adjust it so it more closely encloses the ventricle.
5. Click Detect All Regions.

   

   The LV ROIs are drawn automatically, but you should confirm that it appears correctly. Use the Phase and Amplitude images for reference. If you are not satisfied with the ROI, you can go back and edit the size or shape of the ellipse and use Detect All Regions again.

   Additionally, the ED and ES frames are also found. In the ED frame, the ventricle ROI is purple, while the ES ROI is blue. You can see that these colors correspond to those set for ED and ES in the ROI controls in the Control Panel. You can find the ED and ES frames by scrolling.
6. Following the direction at the top of the viewer, draw the background ROI.
7. Click Next Workstep.

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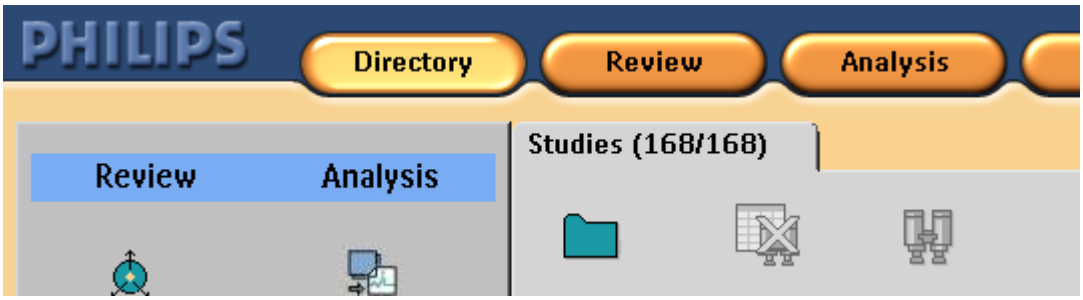
Review Results

In this workstep, you can review the quantification results. For a list of the results displayed, see section “Results” on page 227. You can also save the page as a Secondary Capture (as you can in any workstep). Secondary Captures can be either single-frame or multi-frame. Multi-frame allows you to embed a cine.

Create a Secondary Capture:

1. If it is not already selected, click the **Scroll** button ( ) and drag upward in the cine viewer to scroll to the first frame. The frame number is displayed in the lower right of the viewer.
2. In the Image Tools Manager, click the arrow on the **Save all images** button ( ) and select **Secondary Capture**.
3. Type in a description for the Secondary Capture.
4. Check the **RGB** option.
5. Click **Save**.
6. Click on the orange IntelliSpace Portal **Directory** button at the top of the screen (the active button in the image below) to display the Patient Directory and notice that the saved image is listed in the Series list at the bottom, and also in the NM Images list (which is the tab next to Series)



7. Return to the application by clicking on the orange IntelliSpace Portal **Analysis** button at the top.
8. Advance to the next workstep by clicking the Next Workstep button.

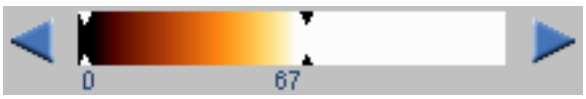
Review Images

This workstep provides multiple layouts to view the images. Click on each layout to view its contents. Layouts with a dark blue background are unavailable. You can also hide and show individual viewers:

1. Click the triangular Remove button in the upper left viewer to remove the viewer from the display area.

2. From the Global Image Tools, select the **Utilities** tab.

3. Click **Show Hidden Viewers** ( ) to list currently hidden viewers.
4. Select the hidden viewer to redisplay it.
5. Use the Image Colorbar in the Image Tools Manager to adjust the background (white bar) and brightness (black bar).
6. Right-click on the Image Colorbar to open a menu that lets you select Colormap, Intensity, and Pixel Values



When you are done, click **Exit** to exit to the Patient Directory. If you are prompted to save images, click **No** unless you want to save any new images.

MUGA Manual

MUGA Manual allows you to determine ED and ES frames manually to create statistical information about the cardiac cycle.

Using MUGA Manual

NOTICE

If an edge detection method is used in another preference and then you change the preference to MUGA Manual, the ROIs for ED and ES are copied to MUGA Manual, where you can edit them.

In the Define Regions workstep you must draw ROIs on frames that you determine are the ED and ES frames.

1. Scroll through the frames and determine which one is the ED frame.
2. Draw the ED ROI on that frame.

   A candidate for the ES frame is automatically displayed, but you can go to a different frame by scrolling.
3. Draw the ES ROI on the appropriate frame.
4. To change a frame, draw the ROI on a new frame and right-click to select **Set As** from the menu.

Results

- Cine display
- ED/ES images
- Phase/Amplitude images, and Phase Histogram

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- Stroke/Ejection Matrix images
- Ejection Fraction
- Background Counts
- RR Interval Window
- Acquired Beats
- Rejected Beats
- Skipped Beats
- Volume Time Activity Curve
- High R-R
- Low R-R

First Pass

This calculates right or left ventricular ejection fractions from a First Pass dynamic study. It requires rapid framing rate studies (30-40 sec acquisitions of 0.03 to 0.04 secs per frame) of the first transit through the heart to obtain a 16-frame gated study.

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Using First Pass

In the Define Regions workstep, after drawing the ROIs, use the timing markers in the Whole Heart Time Activity curve to specify the time to analyze.

In the Review Results workstep, define frame pairs in the Ventricle curve:

1. Click on the **FramePair 1** radio button to select the first pair to define.
2. Drag the red and green timing markers to define the beginning and end frames.
3. Click **Add Frame Pair** to confirm the settings.
4. Identify other frame pairs similarly.
5. Use the **Delete Frame Pair** button to delete a pair.

NOTICE

The first defined frame pair must be the farthest pair to the left in the displayed curve and the pairs must continue in numerical order. This means that you should not add new frame pairs to the left of any others, only to the right.

Results

- Cine display
- Gated study display
- Ejection Fractions for each frame pair

- Average Ejection Fraction
- Ventricle Time Activity Curve
- Splash display

If you do not see all the result images in the Review Results workstep, it may be that one or more viewers are hidden. If you suspect this, try using the **Show Hidden Viewers** tool in the **Utilities** Data Manager. For more information, see section “Review Results” on page 237.

Preferences

To change the Preferences for this application:

1. Select the **Preferences** Data Manager.
2. Click **Open Preference Editor** at the bottom of the Preferences section (the second icon ).
3. Make changes in the preferences window using the information in the table below.

See section “Creating and Editing Preferences” on page 59 for details on editing Preferences.

You can save these parameters as Preferences:

Parameter	Default	Description
Review Compress Factor	0	Number of frames to compress for review data
No. of Frames Pairs	6	This determines the max number of frame pairs to be identified in the Ventricle Time Activity curve in the Results step

First Pass Tutorial

In this tutorial you will learn how to perform a First Pass analysis. You will learn how to load First Pass data, draw the necessary ROIs, and review the results and images.

NOTICE

This tutorial is designed to use a particular sample patient that works well to illustrate certain features of the software. Nothing prevents you from substituting your own patient, but be aware that it may not load the same way or produce similar results. If you try to load your own data and it fails because of automatching, see section “Editing Auto Matches” on page 27.

If you would like to start this tutorial over at any time, just click **Restart** in the application. This reloads the data as it does in the first workstep, as long as the default Preference has not been changed.

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Setup

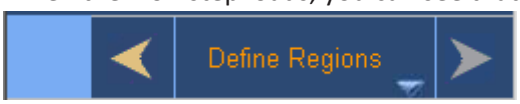
1. In the IntelliSpace Portal Patient Directory's Local Devices list, select the NM Demo Data studies.
2. From the list of patients, select the Patient Name **NM Cardiac** with Patient ID **Heart, First Pass** .

   This patient contains only shunt data, but because the framing rate meets the specifications for First Pass the data is compatible.
3. Click on the arrow in the Analysis menu and select the NM Cardiac application.
4. When the application comes up, the Preferences Data Manager is open; click on the First Pass Preference.
5. Notice that the First Pass bucket has a red exclamation point. This indicates that it requires data

6. Click on the bucket dropdown list. This brings up a list of available images.
7. Select the SHUNT dataset.
8. Click the Next Workstep button to proceed to the Define Regions workstep.

Define Region

When the workstep loads, you can see that the Next Workstep button is grayed out:



This indicates that a requirement for the workstep has not been met. Different applications may have different requirements: drawing certain ROIs, setting parameters, etc. When all requirements have been met, the button becomes available.

This application provides a composite image of the data so you can be sure to enclose all the pixels in all the images at once. The composite viewer includes a slider at the bottom so you can exclude some of the beginning or ending frames. It also displays a cine so you can refer to the whole sequence of images if necessary.

In the steps below, you are instructed to draw an ROI incorrectly. This is intentional, as it also illustrates how to recover from such a mistake.

1. Adjust the slider at the bottom of the composite viewer so only the frames you need are used (drag the markers at the ends of the slider).
2. Following the instruction to "Draw Ventricle" near the top of the composite image window, use the pencil to draw an approximate ROI (you will draw a more precise one later). When you reach the last point, double-click to end the drawing.

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Notice that the Ventricle Draw Region icon is now an eraser:

3. Click the eraser to delete the ROI. The eraser changes back to a pencil, indicating that you can redraw the ROI.
4. Click the **Maximize** button. This allows you to use a larger window.

5. Redraw the ventricle ROI, and then follow the instruction to draw the whole heart. Here is one example of ROIs (your ROIs may be very different).

6. Hover the cursor over an ROI outline and notice that the control points are indicated by boxes.
7. Edit the ROIs so they are exactly correct, however you define that, by dragging the control points. (Remember, if you need to redraw the whole ROI, click the region's eraser.)
8. Click the Restore icon (same location as the Maximize button above) to restore the default view.

   On completing the second ROI, a Time Activity curve appears. In the Time Activity viewer, the green and red timing markers define the segment of the curve to analyze.
9. If necessary, reposition the timing markers as appropriate.
10. Advance to the next workstep by clicking the Next Workstep button.

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Review Results

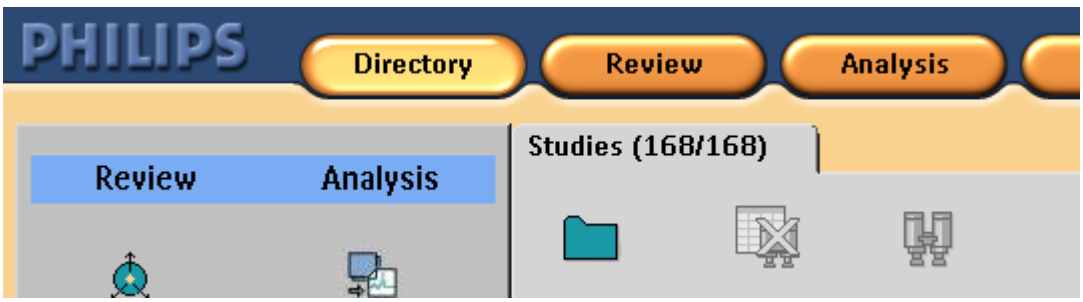
In this workstep, you can review the quantification results. For a list of the results displayed, see section “Results” on page 233. You can also save the page as a Secondary Capture (as you can in any workstep). Secondary Captures can be either single-frame or multi-frame. Multi-frame allows you to embed a cine.

This workstep also displays results based on frame pairs that you define. The results will be more complete if we add some pairs.

1. In the Ventricle curve viewer, click the **FramePair1** button to define the first frame pair.
2. Adjust the green and red timing markers so they define the first frame pair.
3. Click **Add Frame Pair** to confirm the points.
4. Add two more frame pairs similarly.
5. Review the numerical results.

Now create a Secondary Capture:

1. If it is not already selected, click the **Scroll** button () and drag upward in the cine viewer to scroll to the first frame. The frame number is displayed in the lower right of the viewer.
2. In the Image Tools Manager, click the arrow on the **Save all images** button () and select **Secondary Capture**.
3. Type in a description for the Secondary Capture.
4. Check the **RGB** option.
5. Click **Save**.
6. Click on the orange IntelliSpace Portal **Directory** button at the top of the screen (the active button in the image below) to display the Patient Directory and notice that the saved image is listed in the Series list at the bottom, and also in the NM Images list (which is the tab next to Series).



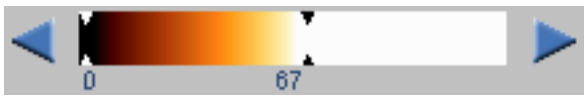
7. Return to the application by clicking on the orange IntelliSpace Portal **Analysis** button at the top.
8. Advance to the next workstep by clicking the Next Workstep button.

Review Images

This workstep provides multiple layouts to view the images. Click on each layout to view its contents. Layouts with a dark blue background are unavailable. You can also hide and show individual viewers:

1. Click the triangular Remove button in the upper left viewer. This removes the viewer from the display area.

2. From the Global Image Tools, select the **Utilities** tab.
3. Click **Show Hidden Viewers** (). This displays a list of all viewers that are currently hidden.
4. Select the hidden viewer to redisplay it.
5. Use the Image Colorbar in the Image Tools Manager to adjust the background (white bar) and brightness (black bar).
6. Right-click on the Image Colorbar to open a menu that lets you select Colormap, Intensity, and Pixel Values.



When you are done, click **Exit** to exit to the Patient Directory. If you are prompted to save images, click **No** unless you want to save any new images.

Shunt

This calculates the pulmonary-to-systemic flow ratio to determine if a left to right cardiac shunt is present. Given a fast dynamic cardiac study (usually a 30 sec acquisition of 0.5 secs per frame), Shunt processing requires fitting of the pulmonary curve with a gamma variate fit, subtraction of the fit and subsequent fitting of the remaining curve data with a second gamma fit to determine the pulmonary-to-systemic flow ratio. Superior Vena Cava quality control time is also computed to evaluate the bolus quality.

Using Shunt

In the Define Regions workstep, after defining the ROIs, use the timing markers in the Right Lung Time Activity curve to define the points to use to fit the gamma curve to the data as closely as possible. The Recirculation curve is generated automatically by subtracting the raw lung curve and the fit curve. Use the timing markers in the Recirculation curve to fit its gamma curve as well.

Results

- Composite image
- Cine with all ROIs

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- SVC Control Time
- Pulmonary Transit Time
- Qp/QS ratio
- SVC (superior vena cava) Time Activity curve
- Time Activity curves for right lung, gamma fit, recirculation, and recirculation fit
- Splash display

If you do not see all the result images in the Review Results workstep, it may be that one or more viewers are hidden. If you suspect this, try using the **Show Hidden Viewers** tool in the **Utilities** Data Manager. See section “Review Results” on page 231 for details.

Preferences

To change the Preferences for this application:

1. Select the **Preferences** Data Manager.
2. Click **Open Preference Editor** at the bottom of the Preferences section (the second icon: ).
3. Make changes in the preferences window using the information in the table below.

See section “Creating and Editing Preferences” on page 59 for details on editing Preferences.

You can save this parameter as Preferences:

Parameter	Default	Description
Review Compress Factor	0	Number of frames to compress for review data

Review Layouts

Below are the layouts in the Review workstep:

- MUGA Splash
- MUGA Cine
- MUGA Raw Splash
- MUGA Raw Cine
- Shunt Dynamic
- Shunt Splash
- First Pass Splash
- First Pass Dynamic
- Gated FirstPass
- SC images

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