Cedars-Sinai Medical Center
Department of Medicine
Artificial Intelligence in Medicine Program

QBS

Quantitative Blood Pool SPECT

Reference Manual

Version 2013.1

Options: ARG, PlusPack20

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Table of Contents

1 Introduction

QBS (Quantitative Blood Pool SPECT) is an interactive standalone application for the automatic segmentation and quantification of gated short axis blood pool (red blood cells, RBC) SPECT. It provides the following functionality:

- Automatic generation of left- and right-ventricular endocardial surfaces and valve planes from three-dimensional (3D) gated short axis blood pool images.
- Automatic calculation of left- and right-ventricular volumes and ejection fractions.
- Two-dimensional (2D) image display using standard American College of Cardiology (ACC) cardiac SPECT conventions.
- 3D image display. Ability to combine isosurfaces extracted from the data with the calculated endocardial surfaces in various ways (endocardial borders displayed as wireframes, shaded surfaces or both).
- Display of projection (raw) images in static and cine mode. Two-dimensional display of gated short axis SPECT images in 1 (single), 2 (dual), 3 (triple), or 4 (quadruple) mode. (2, 3, and 4 are displayed as interleaved or side-by-side). Three-dimensional parametric display of gated short axis SPECT images in 1 (single), 2 (dual), 3 (triple), or 4 (quadruple) mode. (2, 3, and 4 are displayed as interleaved or side-by-side).
- Display of planar images, raw projection images and snapshots (screen captures).
- Ability to support manual identification of the left-ventricular (LV) region, to separate it from the right ventricle (RV) in cases where the automatic algorithm fails or returns unsatisfactory results.
- Calculation of phase histograms from all gated images, including separate left-ventricular (LV) and right-ventricular (RV) histograms based on the program's ROIs for gated short axis SPECT images.
- Calculation and display of first Fourier harmonic (FFH) amplitude and phase images for all gated images.
- Computation of diastolic function metrics for the left and right ventricles including PER (peak emptying rate), PFR (peak filling rate), PFR2 (secondary peak filling rate), MFR/3 (mean filling rate over the first third of the ED to ES phase), and TTPF (time to peak filling from ES). HR (heart rate in beats per minute) is also displayed if available.
- Ability to rotate, zoom and cine surfaces.
- Calculation and display of polar maps representing wall motion, including FFH amplitude and phase.

1.1 New Features

1.1.1 Multiple language support

The Cedars-Sinai Cardiac Suite has been fully updated to support datasets that contain non-latin characters (e.g., Chinese, Japanese, etc…). The user interface is also now available in several languages. Chinese (Simplified), Czech, Danish, Dutch, English, Finnish, French, German,

Hungarian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish, Turkish. The automated reporting module (ARG) is only available in English. The user interface language is user-selectable.

1.1.2 Combined phase/amplitude displays

This feature allows the combined display of phase and amplitude data. Instead of separate images for phase and amplitude, displays are color-coded by phase angle and shaded to black as a function of the amplitude. This provides a more intuitive way to assess how much regional contraction may be occurring and how out of phase with normal contraction it may be.

1.1.3 Automated Report Generator (ARG) for Bloodpool studies

Integration of ARG (Automatic Report Generator) provides the ability within QBS to create, edit, sign, review, archive, and share customizable, consistency-checked, reports. A reporting pane and a few extra dialogs have been added to QBS for this purpose.

1.1.4 Integration enhancements

On a number of platforms QBS will better integrate with the host software. This covers dataset access, printing support as well as file output support.

1.2 Important Note

Because this application is licensed to a number of equipment manufacturers, the appearance of the screen may vary depending on the platform on which it is executed. The screen captures included in this manual may therefore vary slightly from what is observed on a given system. Similarly, features may vary as not all vendors provide support for all features of the software. This is most likely to occur in input/output features of the software.

2 Tutorial

2.1 Workflow

The QBS workflow is intentionally modeless. As such, no particular processing sequence is dictated to the user. A typical sequence might proceed as follows:

1. Select appropriate datasets and launch QBS.
2. Select **Process**. After processing, quantitative results are displayed in every page.
3. Select **Slices** (initial page) to view short axis slices.
4. Visually validate LV and RV contours (select **Manual** if contour refinement is required).
5. Select **Splash** to review data in the Splash Page.
6. If so desired, select **Surface** to review data in the Surface Page.
7. Select **Results** to review data in the Results Page.
8. Select **Exit** to exit QBS.

2.2 Patient Example

2.2.1 File selection

QBS is able to quantify parameters of global and regional LV and RV function using only a short axis gated blood pool dataset. For the purposes of this example, we'll assume to have selected a short axis gated blood pool dataset for the patient "BP_TEST01". All figures in this section refer to that patient, unless specifically indicated in the figure's caption.

2.2.2 Launching QBS

Launching QBS in its standard configuration will bring up the Main screen with the **Slice** page indicator and the **Label**, **LV** and **RV** toggles highlighted (Figure 2.1). Representative slices are shown, with the number to the top-left of each slice showing its order in the short axis dataset. Left-clicking on Label toggles that number and the slice reference lines on and off. The name of the folder (generally, a patient name) and that of the datafile are displayed in the horizontal section that also contains the color scales (Figure 2.4). Left-clicking on and dragging (in the **Slices** color scale) the vertical black stripe rightmost in the scale will "saturate" the scale and make the heart visible in cases where strong extra-cardiac activity exists. The **Parametric** color scale is functional only if FFH Phase images are displayed on the **Slice** page.

Left-clicking on the dataset selector will bring up a pull-down menu listing all selected datasets (Figure 2.5). The page control bar is shown in Figure 2.6. The number of controls on the page control bar is specific to the page selected on the Main screen toolbar.

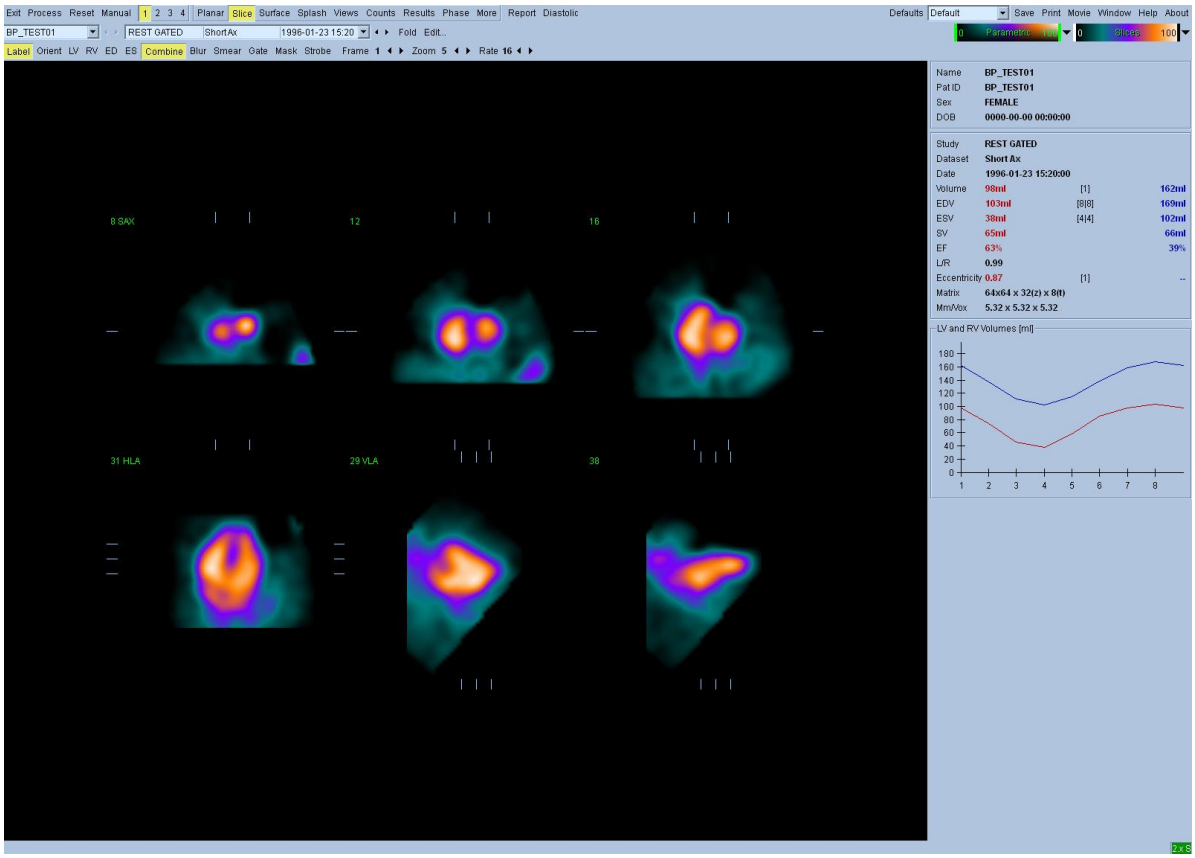


Figure 2.1. Main Screen with Slice Page selected (before processing). From the top: application control bar, folder/data selector and colorscales, page control bar, page

Six 2D images or "slices" are presented in standard ACC orientation, i.e., left to right = apex to base for three short axis images (top row), with the bottom row consisting of a horizontal and a vertical long axis image.

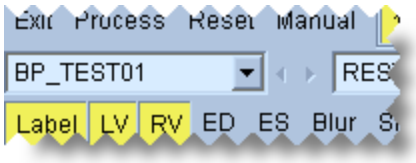


Figure 2.2. Folder Selector

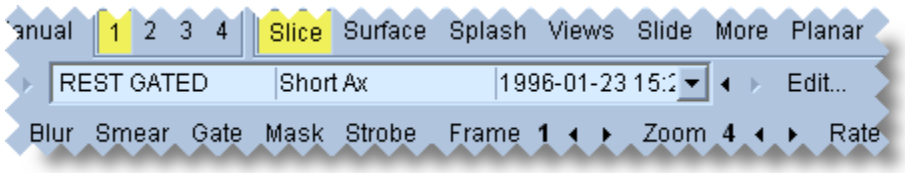


Figure 2.3. Dataset Selector (and Editor button)

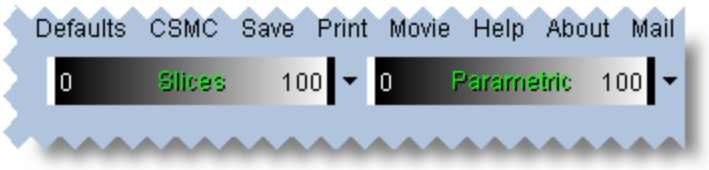


Figure 2.4. Color Scales

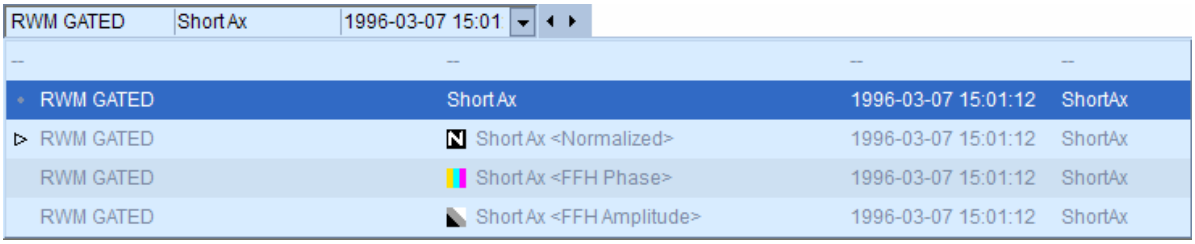


Figure 2.5. Dataset Selector pull-down menu

Figure 2.6. Page control bar (for the Slice Page)

2.2.3 Reviewing the rotation projection images

Clicking the **Planar** page indicator will bring up the Planar page (Figure 2.7). The Planar page consists of four display areas; the raw Counts projection area, the FFH Amplitude area, the FFH Phase area, and the Phase Histogram area (FFH = First Fourier Harmonic).

Prior to processing the data, it is always a good idea to view the raw projection data in cine fashion to assess patient motion. Clicking the **Lines** toggle brings up two horizontal lines, that should be manually positioned so that they tightly straddle the heart (Figure 2.7). Clicking the **Controls** toggle will bring up individual color scale and projection slider adjustment controls for the Counts, FFH Amplitude and FFH Phase display areas. A continuous loop cine display of the projection dataset(s) can then be started by clicking the **Spin** toggle (continuous rotation). Clicking the **Rock** toggle (in addition to the **Spin** toggle) will display an alternating, back-and-forth cine. The cine speed can be adjusted by clicking the ◄ ► symbols on the right side of the **Rate** label. Any sudden movement of the heart's perceived boundaries towards, or away from the lines should be noted. Major motion may affect the quantitative parameters measured by QBS; if such motion is detected, it would be prudent to repeat the gated acquisition.

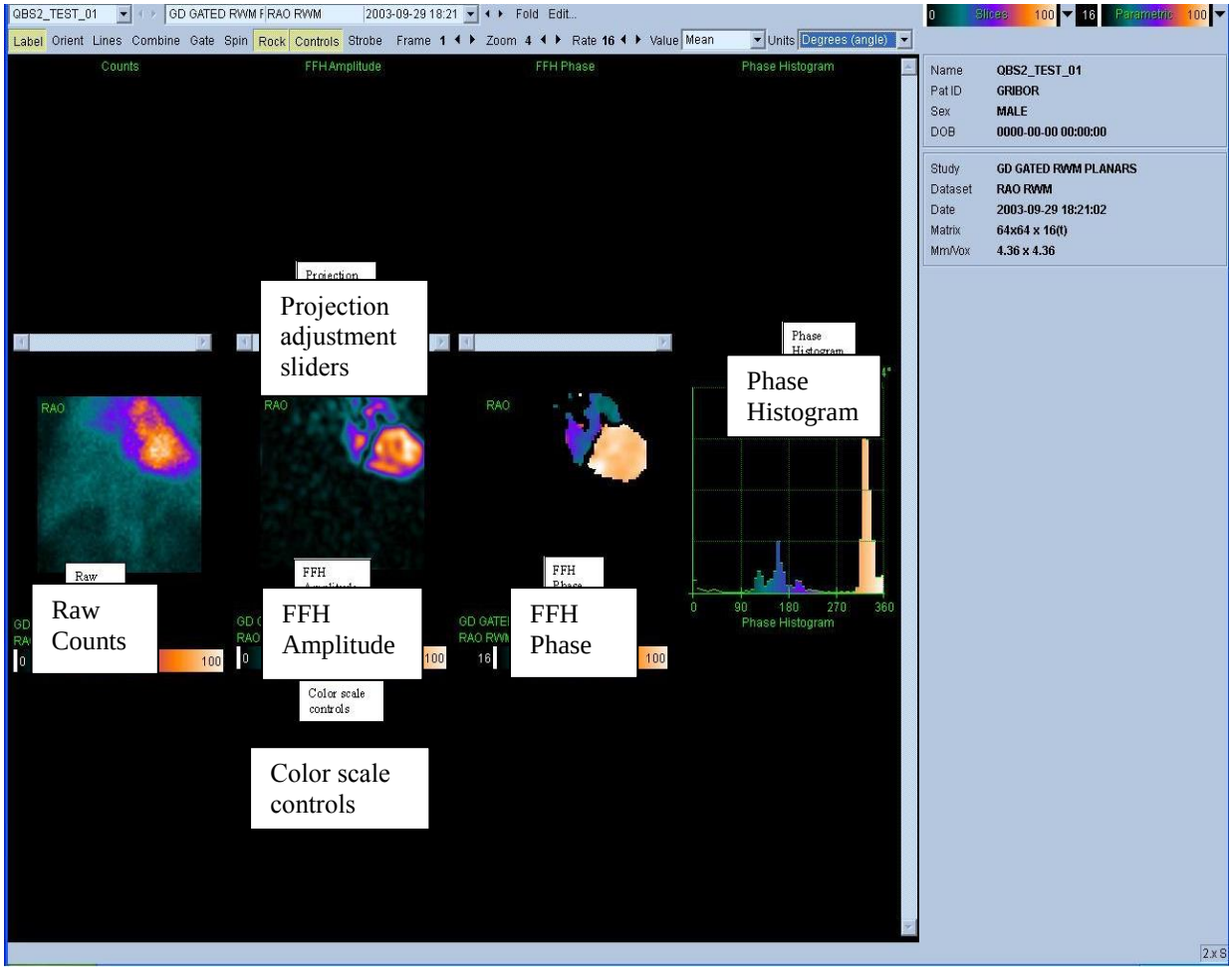


Figure 2.7. Planar page with Lines and Controls enabled

In addition to patient or organ motion, flickering (sudden variations in brightness between adjacent projections) can be assessed by reviewing the projections cine. Flickering is often an indication of gating errors, and can be accompanied by alterations of the time-volume curves shown in the Results page.

2.2.4 Processing the images

Clicking on the **Slice** page indicator will highlight it and advance QBS to the **Slice** page view. Clicking the **Process** button will automatically apply the QBS algorithms to the data, segmenting the LV and RV, calculating the endocardial 3D surfaces, and determining all the global and regional quantitative cardiac parameters. The intersection of the 3D surfaces with the 2D slices planes are displayed as "contours" overlaid onto the six slices (yellow = RV, white = LV), which are now representative of equally spaced (short axis images) or mid-ventricular (long axis images) portions of the LV and RV. Moreover, all quantitative parameter fields in the right portion of the screen should now be filled with numeric values (Figure 2.8). We'll examine and discuss the quantitative measurements in more detail later.

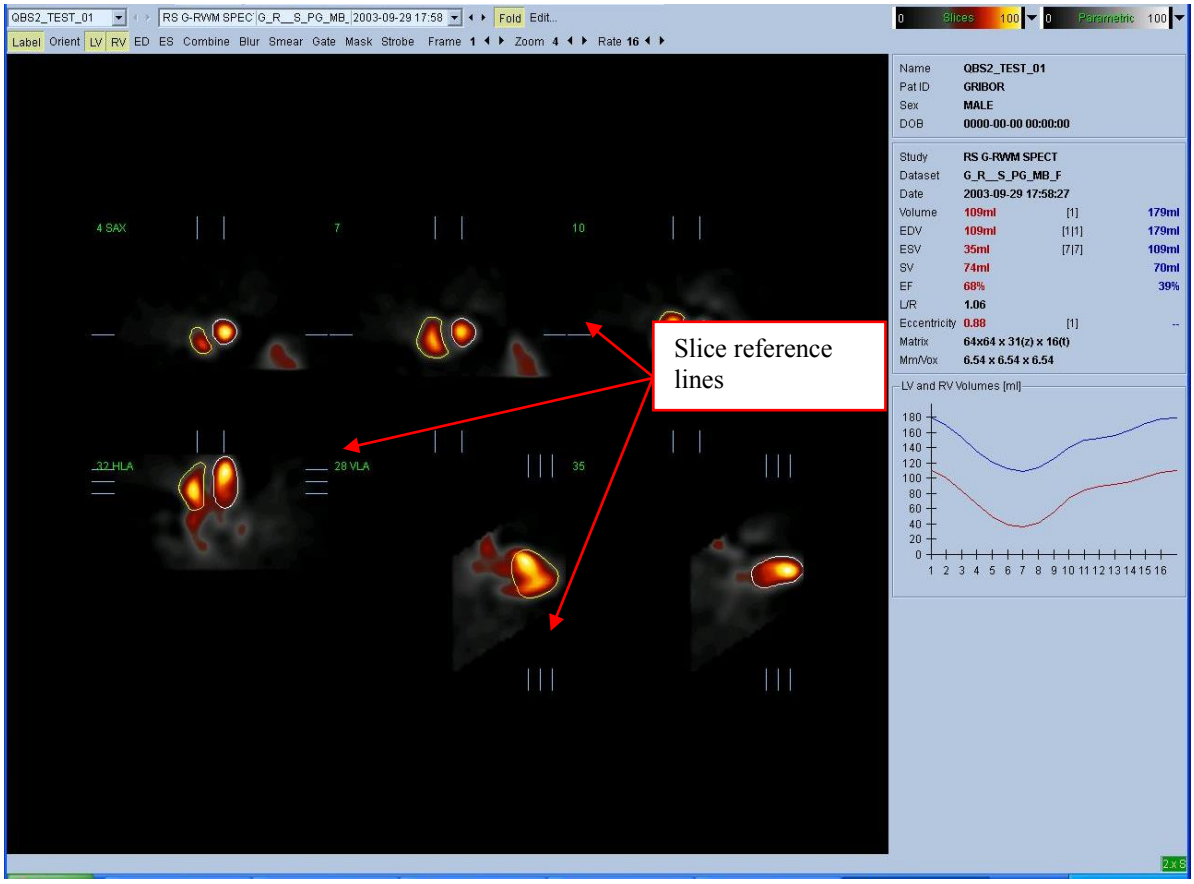


Figure 2.8. Slice page after processing

2.2.5 Checking the QBS contours

The location of the six slices displayed can be interactively adjusted by moving their corresponding slice reference lines in orthogonal views (Figure 2.8); however, in most patient studies this will not be necessary.

At this point, a visual check for obvious inaccuracies in the way the contours follow the LV and RV must be performed. This will likely involve toggling the LV and RV contour toggles on and off, and setting the images in motion (cine) by left-clicking the Gate toggle. Most major inaccuracies are due to the presence of extra-cardiac activity. In particular, one would expect to a) see the contours centered on a structure other than the heart, or b) see the contours "pulled away" from the ventricles to follow closely adjacent activity. These occurrences are infrequent, and should be dealt with using the Manual option discussed in the next section.

Another potential source of error is excessive blurring of the short axis data. If the dataset was over filtered during reconstruction, it is possible that the algorithm will fail to differentiate between the left and right ventricles correctly. The ventricular contours may interpenetrate, or be completely erroneous.

Note Since the algorithm requires a phase difference between the ventricles and atria to correctly identify these structures, at this time it is not possible to obtain measurements from a static phantom, even if a gated acquisition was performed.

2.2.6 Modifying the contours (Manual page)

Clicking the Manual toggle will bring up a modified version of the Slice page, with 4 slices for the ED interval and 4 slices for the ES interval, as well as masking graphics superimposed upon the slices. It is possible to modify the shape and position of the masking graphics by left-clicking and dragging the masking graphic handles, small squares and circles placed at various points on the masking graphics.

For each interval, two short-axis slices (mid-ventricular and apical), one mid-ventricular long axis and one mid-RV vertical long axis slice. Because of constraints imposed between the various points that constitute the mask, selection of the slices may be limited (as compared to slice selection in other pages).

The masking graphics are designed to achieve:

- masking of extra-cardiac activity (Figure 2.9);
- separation between the LV and RV (Figure 2.10);
- separation of the ventricles from the atria (i.e., mitral and tricuspid valves, Figure 2.11);
- separation of the RV from the pulmonary trunk (optional, Figure 2.12).

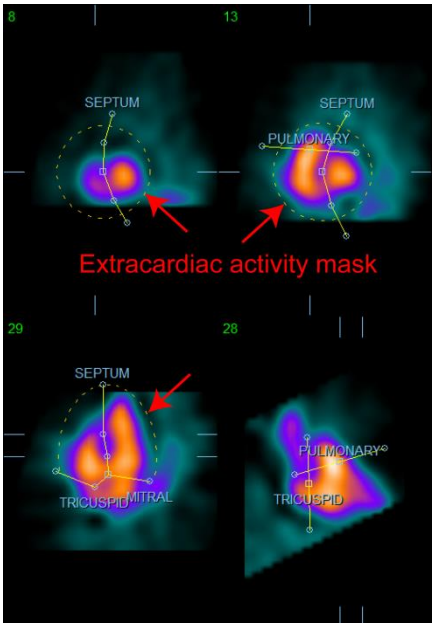


Figure 2.9. Extracardiac activity mask

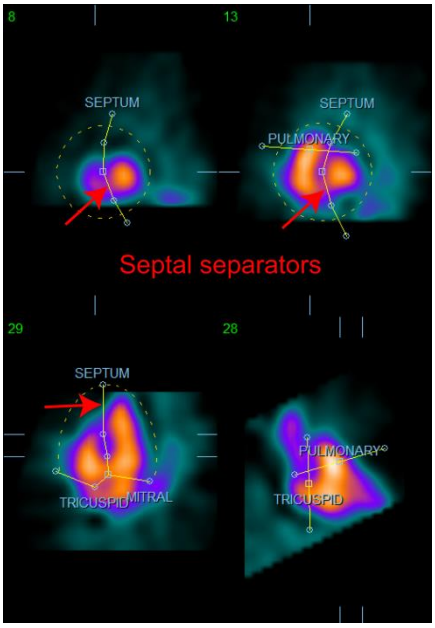


Figure 2.10. Septal separators

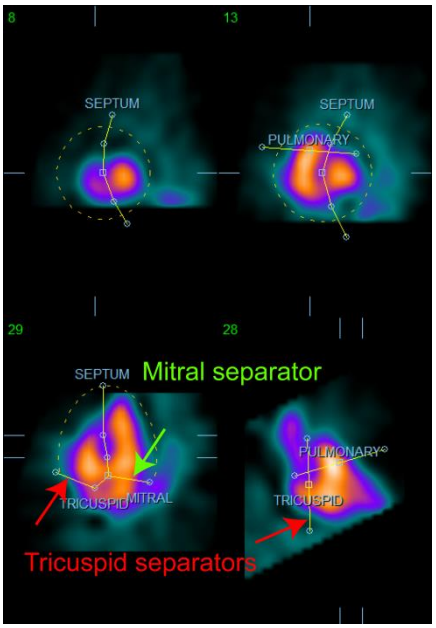


Figure 2.11. Tricuspid and mitral separators

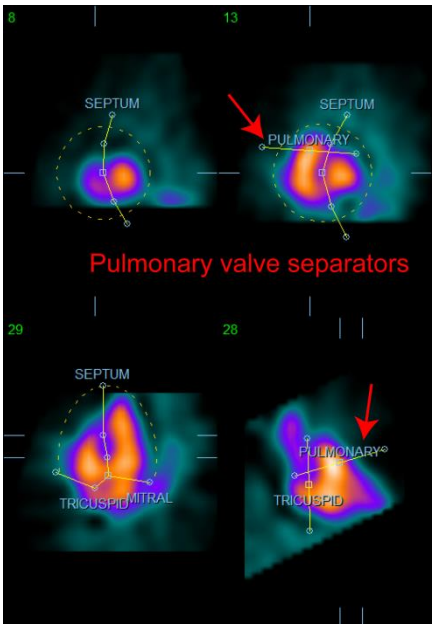


Figure 2.12. Pulmonary valve separator

In general, the following sequence should be followed for optimal placement of the mask:

1. start with the ED interval (left half of the page);
2. adjust the HLA guide in the basal SAX slice to select a mid-ventricular HLA slice;
3. move the whole mask in the HLA slice by dragging the square handle;
4. adjust the circular handles for the septal and mitral separators in the HLA slice (this process may cause the selection of different SAX slices, just place the handles and slices in a way that allows for a good delineation of the septum in SAX and HLA views);
5. adjust the circular handles for the septal separators in the SAX slices
6. in addition adjust the circular handle for the mitral valve separator to limit the mask (represented by the dashed lines) to exclude any non cardiac activity (otherwise segmentation algorithm may fail to return RV contours);
7. adjust the VLA guide in the basal SAX slice to select a mid-RV VLA slice, this will automatically adjust the first tricuspid handle in the HLA view;
8. adjust the second tricuspid handle in the HLA view to correctly separate the RV from the RA;
9. if RV Truncation is on, move the square pulmonary valve handle to the appropriate location;
10. adjust the orientation of the pulmonary and tricuspid valves in the SAX and VLA slices using the circular handles.

Using a non-linear color lookup table may help in determining the best location for the various mask separators (in the example images, the “Cool” colormap is used). Figure 2.13 gives a graphical depiction of the mask placement steps.

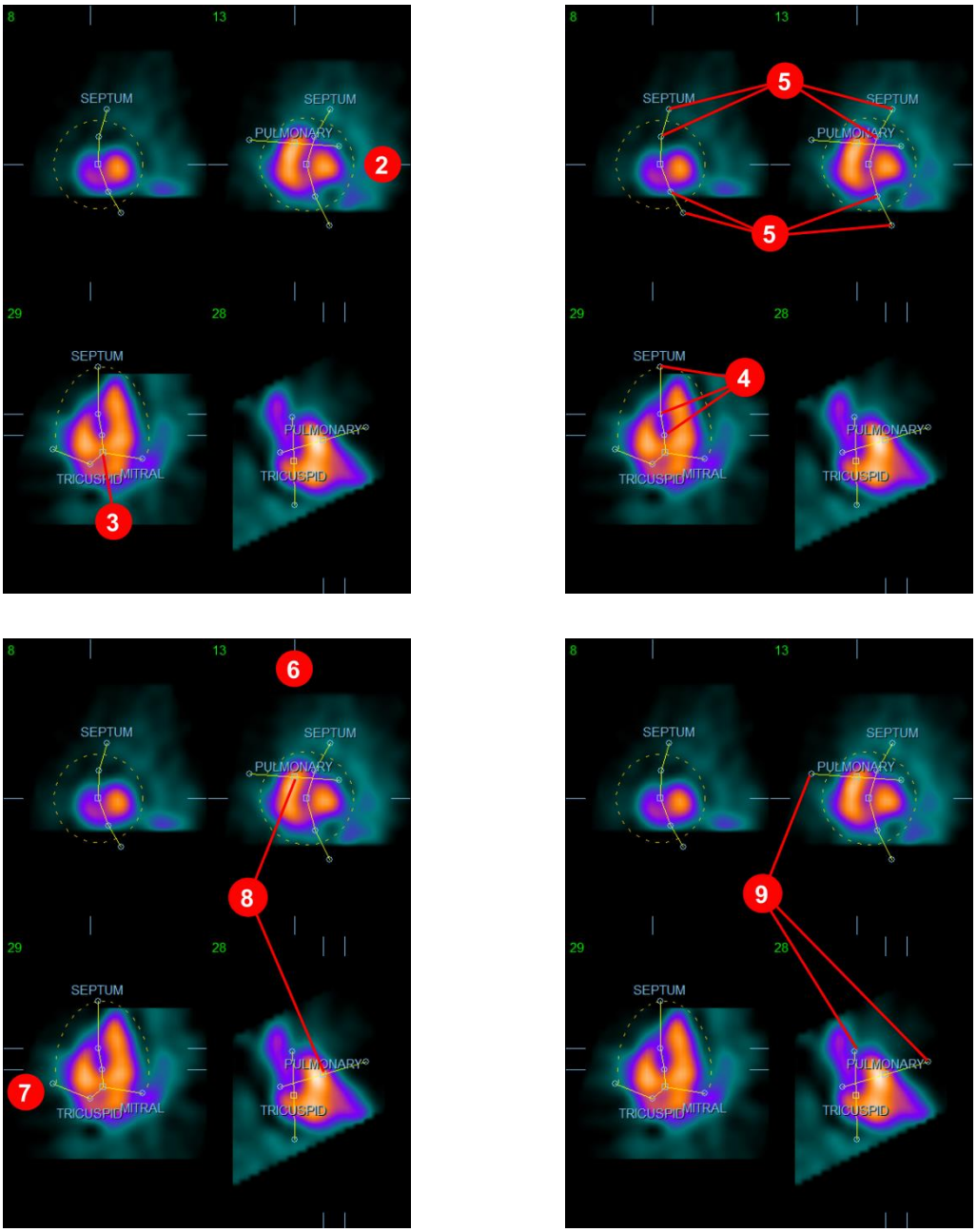


Figure 2.13. Sequence of steps to correctly position the mask

Having correctly positioned the ED mask, use the **Copy to ES** >> button to copy the mask's position to the ES interval. The correct ES interval should be selected manually by examining the image and visually determining in which frame the ventricles seem fully contracted. The program will automatically attempt to select the appropriate interval, but manual adjustment may be required. Is so desired, the mask can also be adjusted in the ES interval and copied back to the ED interval using the << **Copy to ED** button (note that the ES mask will completely replace the ED mask).

When the mask has been copied and the interval adjusted, repeat the above procedure for the ES interval.

Figure 2.14 shows the whole manual page after positioning the ED and ES masks.

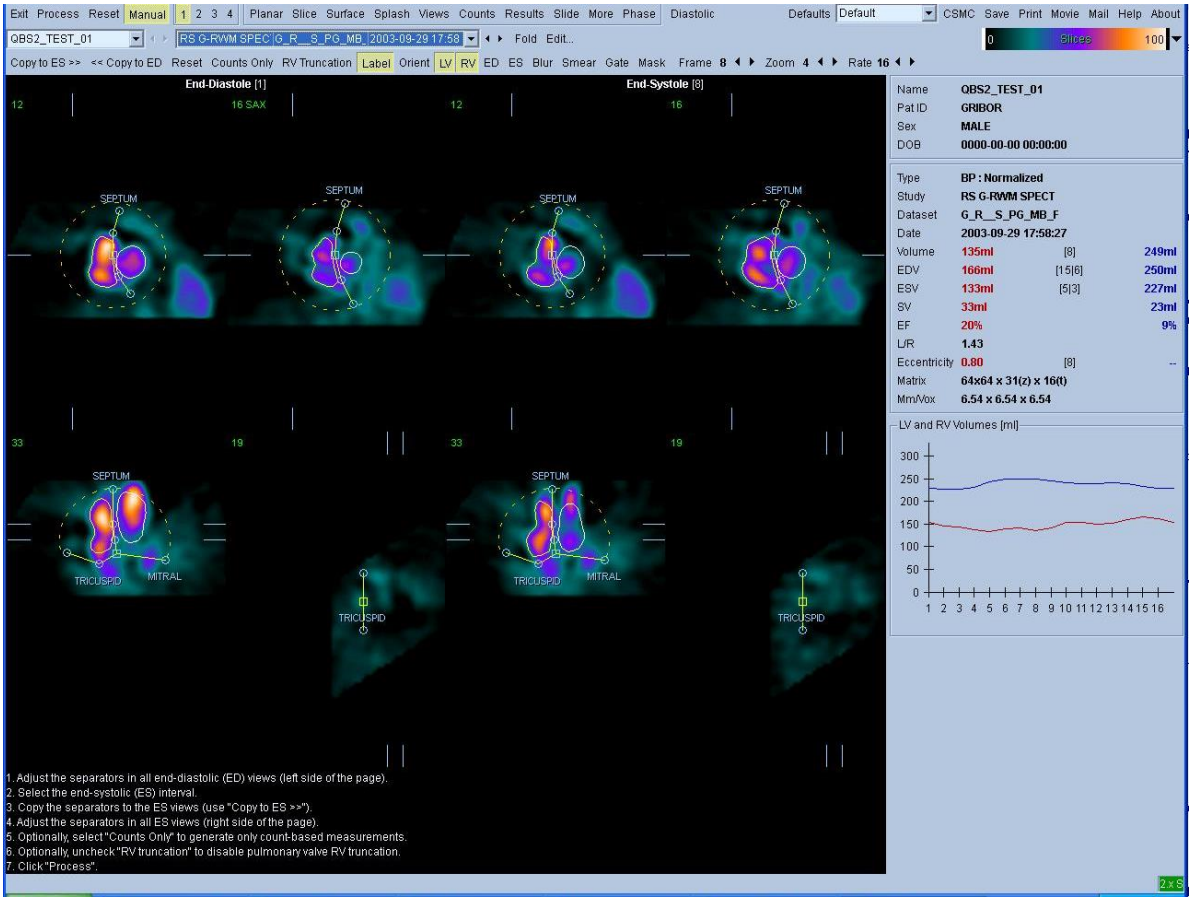


Figure 2.14. Manual page with pulmonary truncation off

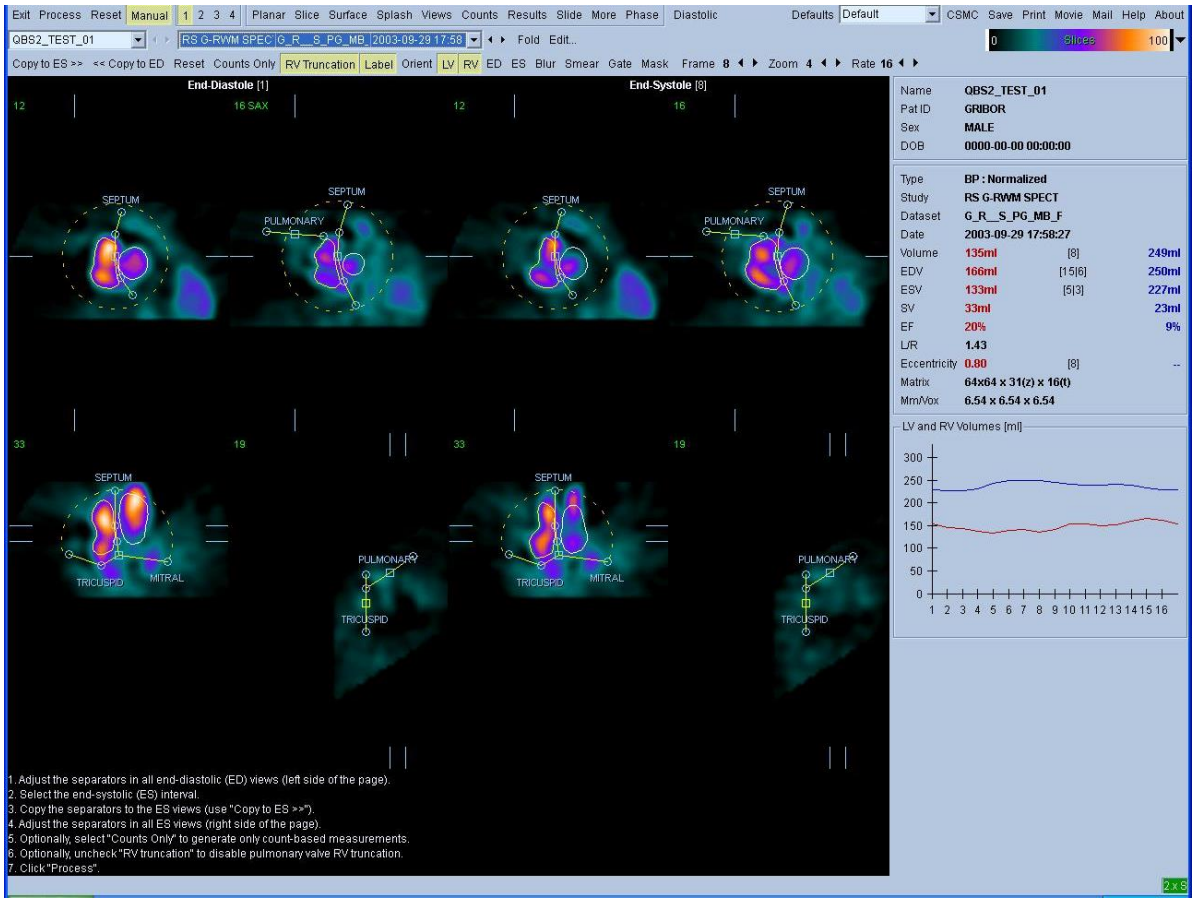


Figure 2.15. Manual page with pulmonary truncation on. Note the pulmonary valve separators in the basal SAX and mid-RV VLA

Once the mask has been correctly positioned, click Process to process the data using the mask, or select Counts Only then click Process to perform count-based calculations only. Note that if Counts Only is selected, no surfaces will be generated and limited information only will be available in the Counts page.

If the RV Truncation toggle is off, no RV truncation will be performed. At any time, use the Reset button to reset the mask to its original (non dataset-specific) configuration. This will void all user changes.

The remaining page controls (LV, RV, ED, ES, Blur, Smear, Gate, Mask, Frame, Zoom, and Rate) perform the same function as they do in the Slice page.

2.2.7 Reviewing Gated SPECT Blood Pool images in the Slice page

A first visual assessment of LV and RV function can be performed by left-clicking the Gate toggle to display a cine of the six slices while clicking the LV and RV toggles on and off. The cine speed can be adjusted by clicking the ◄► symbols on the right side of the Rate label. Moreover, a temporal and spatial smoothing filter can be applied to the images by clicking the Blur and Smear toggles, respectively. This is especially useful to reduce statistical noise in low-counts images for visual assessment, and it will not affect the quantitative results. Figure 2.16 shows the Slice page set for review of gated images.

Note: The “Blur” and “Smear” functions only affect image display. The QBS algorithms operate on the original, unsmoothed data regardless of Blur and Smear settings.

At Cedars-Sinai Medical Center (CSMC), a gray or thermal scale is typically used to visually assess wall motion.

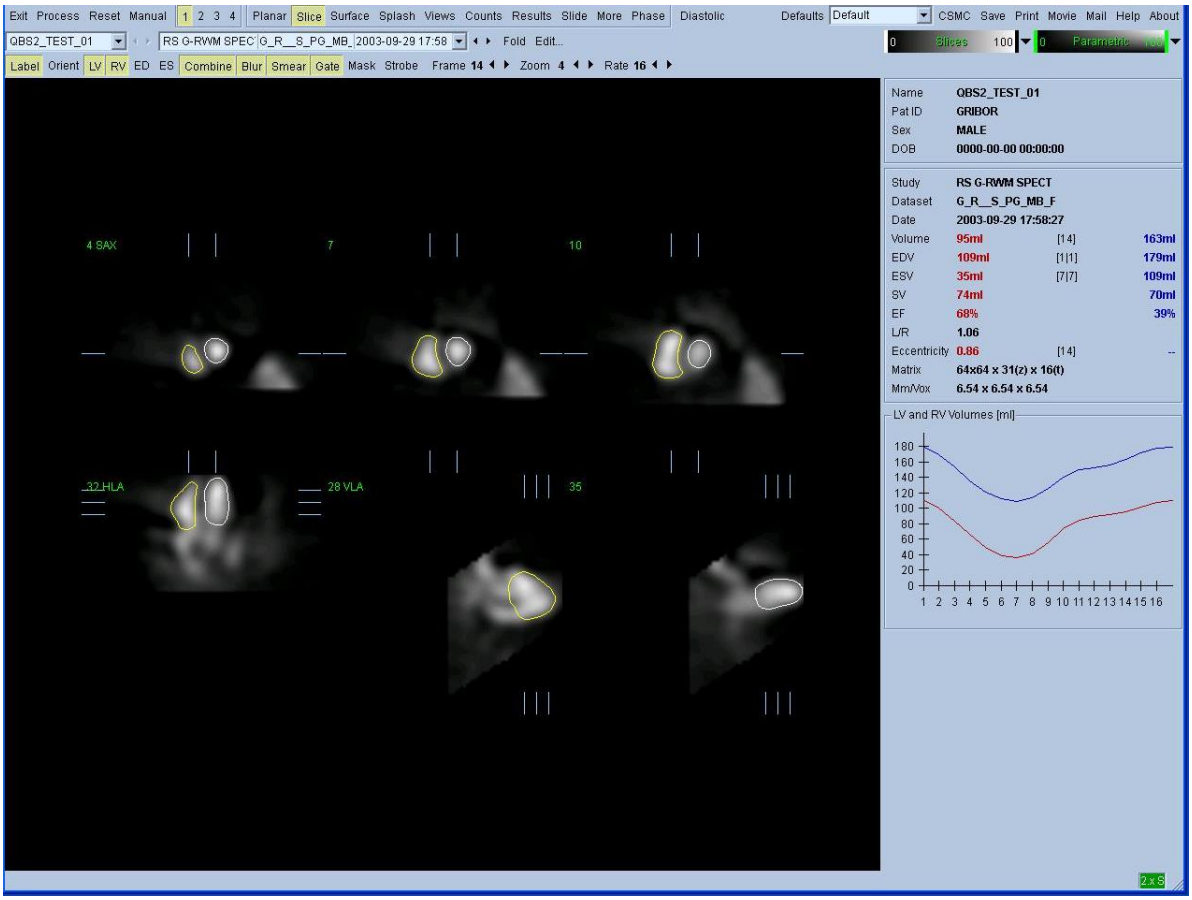


Figure 2.16. Slice Page with Blur, Smear, and Gate toggles enabled for cine review

2.2.8 Reviewing Gated SPECT Blood Pool images in the Splash page

Clicking on the **Splash** page indicator will bring up the Splash page (Figure 2.17) with all the available short images, which can be then gated simultaneously by left-clicking the **Gate** toggle. At times, a user may want to select images for closer inspection. This is accomplished by using the “popout” feature. This is performed by right-clicking on the desired images (Figure 2.18) to select/deselect them (the corners of the selected items are highlighted in blue), then left-clicking on the **Popout** toggle. Figure 2.19 shows how four short axis, four horizontal and four vertical long axis images can be displayed using the **Popout** toggle in the Splash page. The **Clear** button can be used to deselect all selected slices.

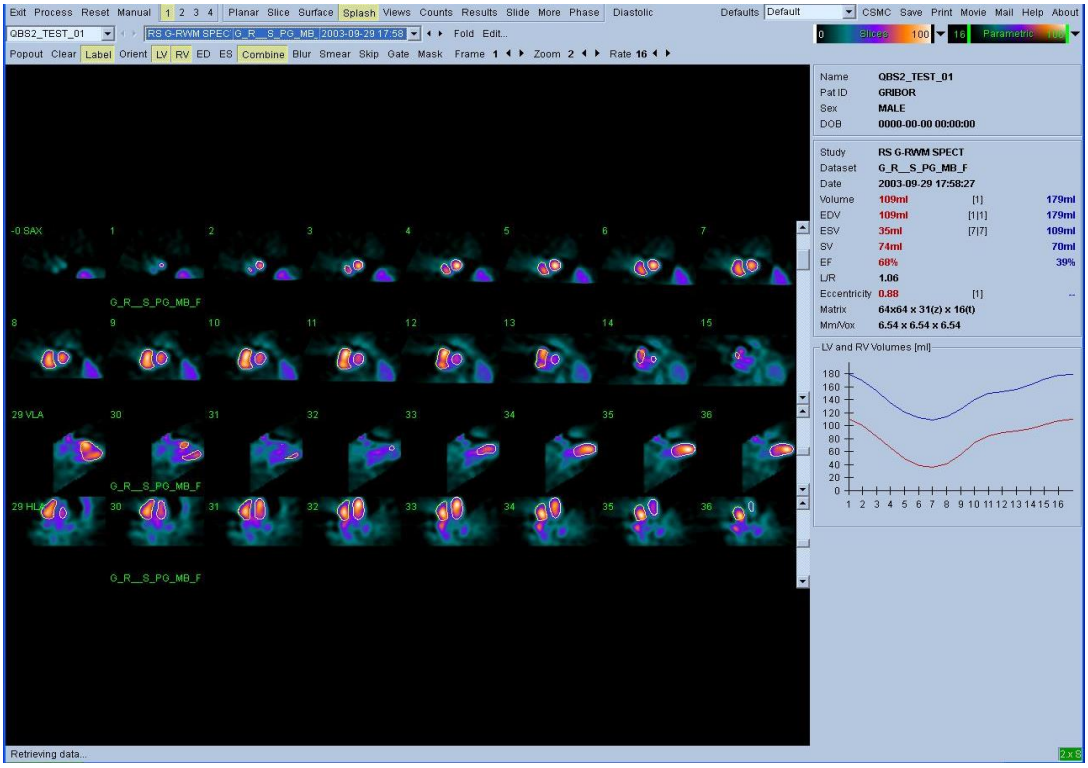


Figure 2.17. Splash page

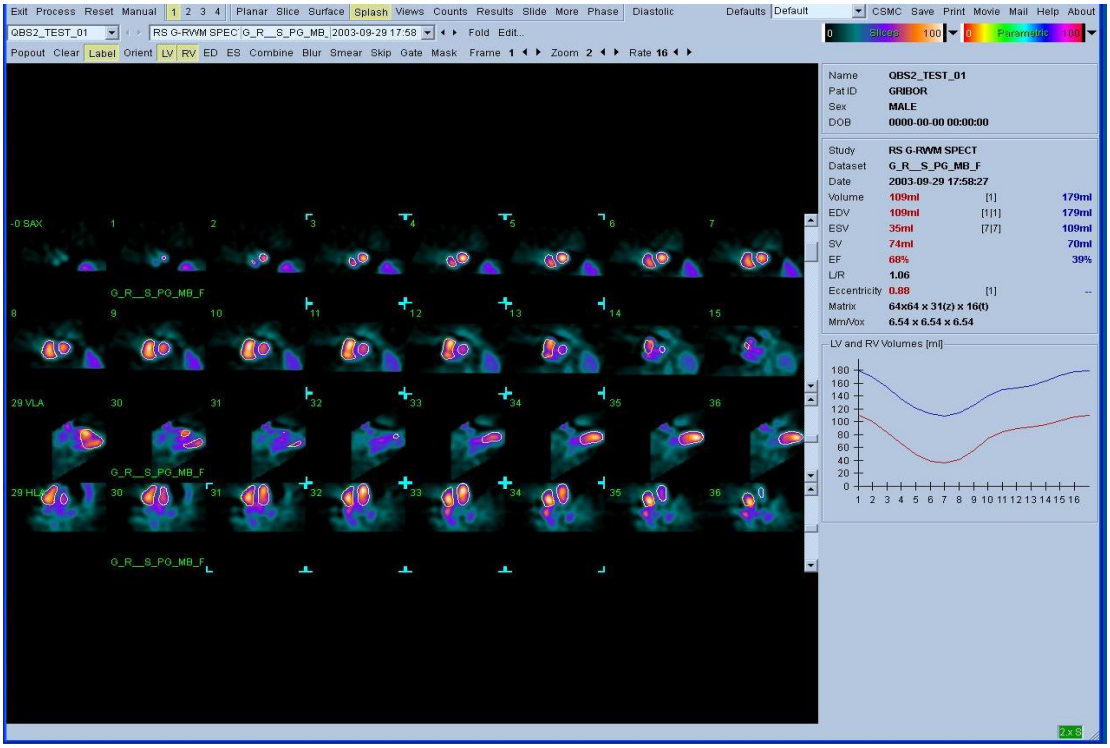


Figure 2.18. Splash page with popout items selected (marked by ‘blue’ corners)

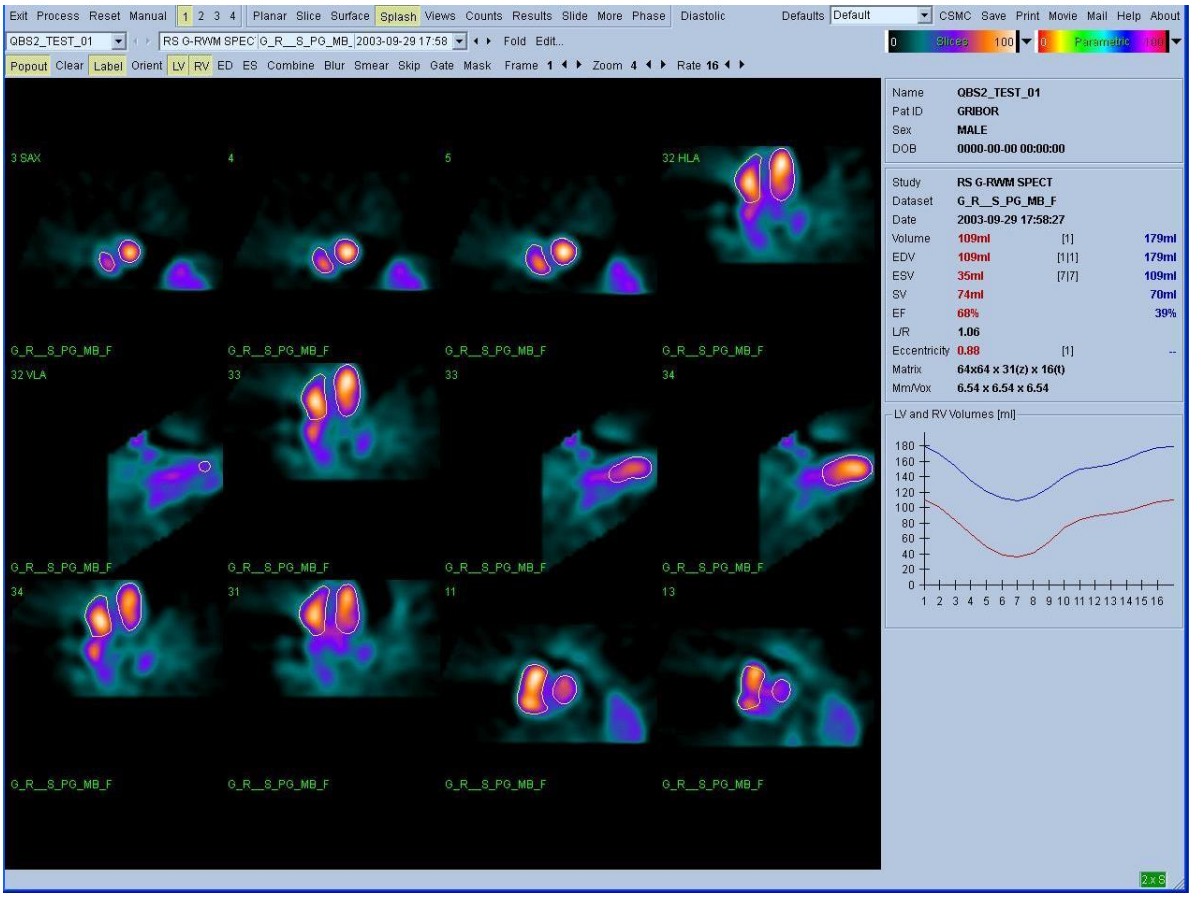


Figure 2.19. Splash page after Popout enabled

2.2.9 Reviewing Gated SPECT Blood Pool images in the Surface page

Clicking on the **Surface** page indicator will bring up the Surface page (

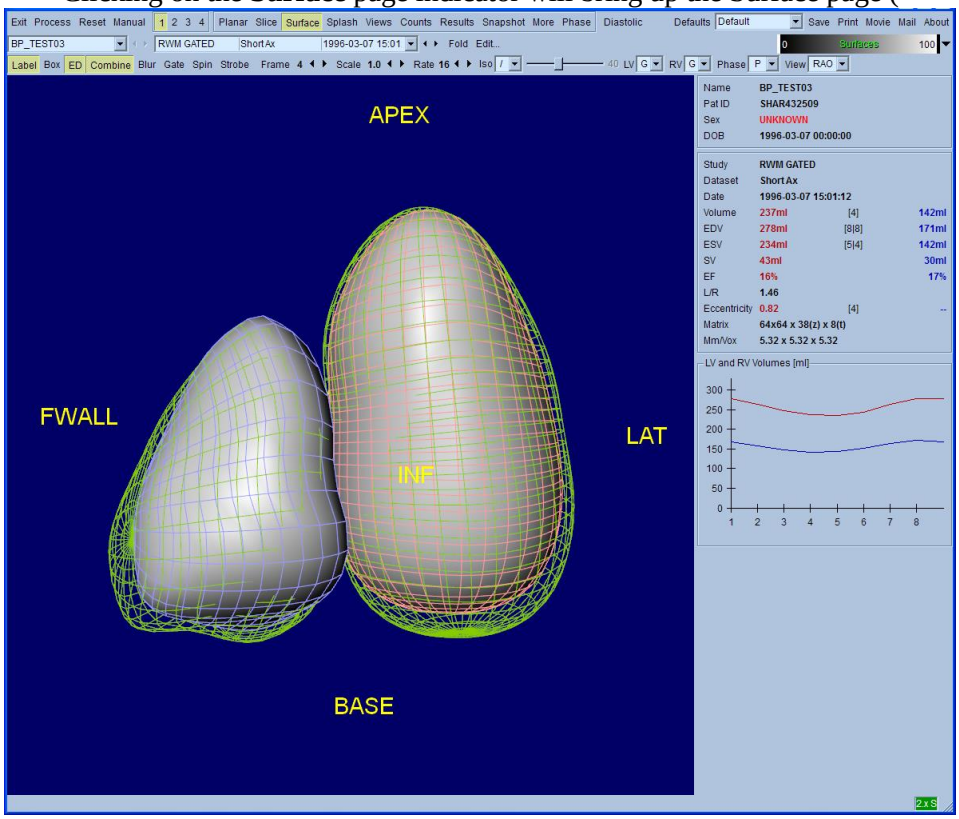


Figure 2.20), a parametric representation of the ventricles, consisting of green wireframe surfaces (ventricular ED endocardium) and shaded surfaces (ventricular endocardium). The **Gate** toggle allows the user to follow the 3D wall motion throughout the cardiac cycle, while clicking and dragging on the image will interactively and in real time position it to the observers liking.

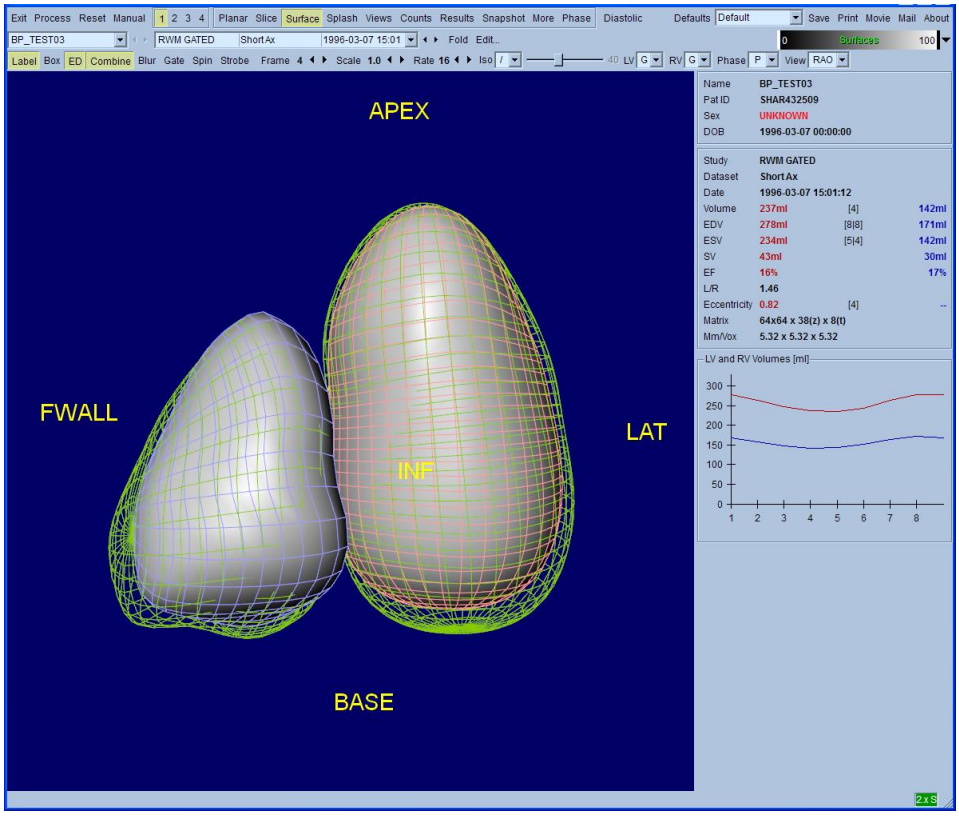


Figure 2.20. Surface page with ED wireframe

It is also possible to display an isosurface extracted from the counts data. This surface can potentially be used to visually assess wall motion as well, though no isosurface (at any level) gives the location of the endocardium. The user can then superimpose the calculated surfaces onto the isosurface display. The best way to do this is to display the LV and RV surfaces as wireframes (red and blue, respectively) along with the shaded isosurface (Figure 2.21). To minimize noise effects in the isosurface extraction, it is recommended to toggle on temporal smoothing by clicking the **Blur** toggle.

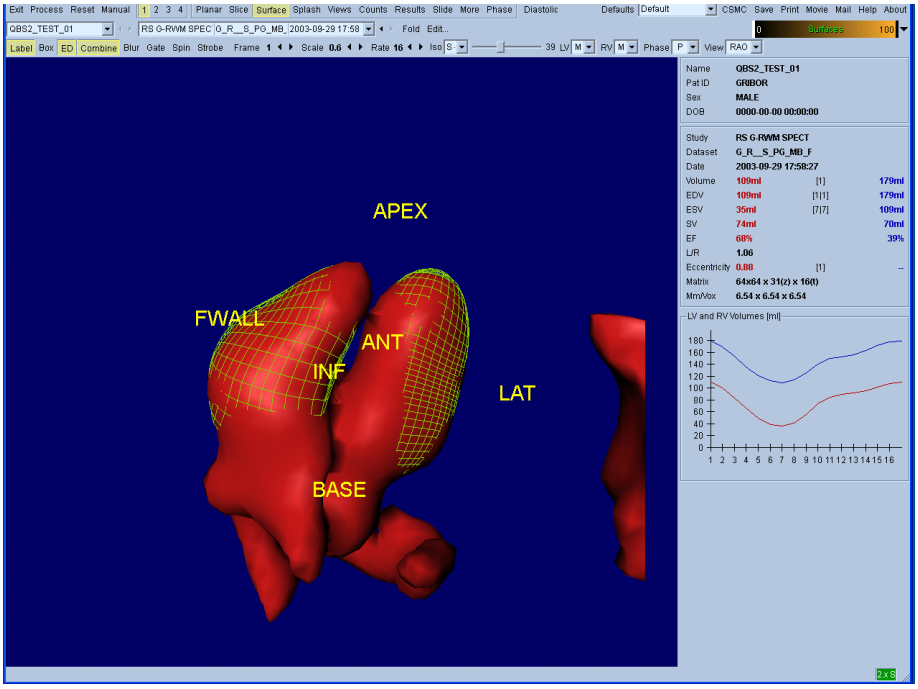


Figure 2.21. Surfaces page with wireframe endocardial surfaces

Display characteristics can be set separately for the LV and RV using the appropriate option menus.

2.2.10 Reviewing Gated SPECT Blood Pool images in the Views page

Clicking on the **Views** page indicator will bring up the Views page with six 3D viewports (

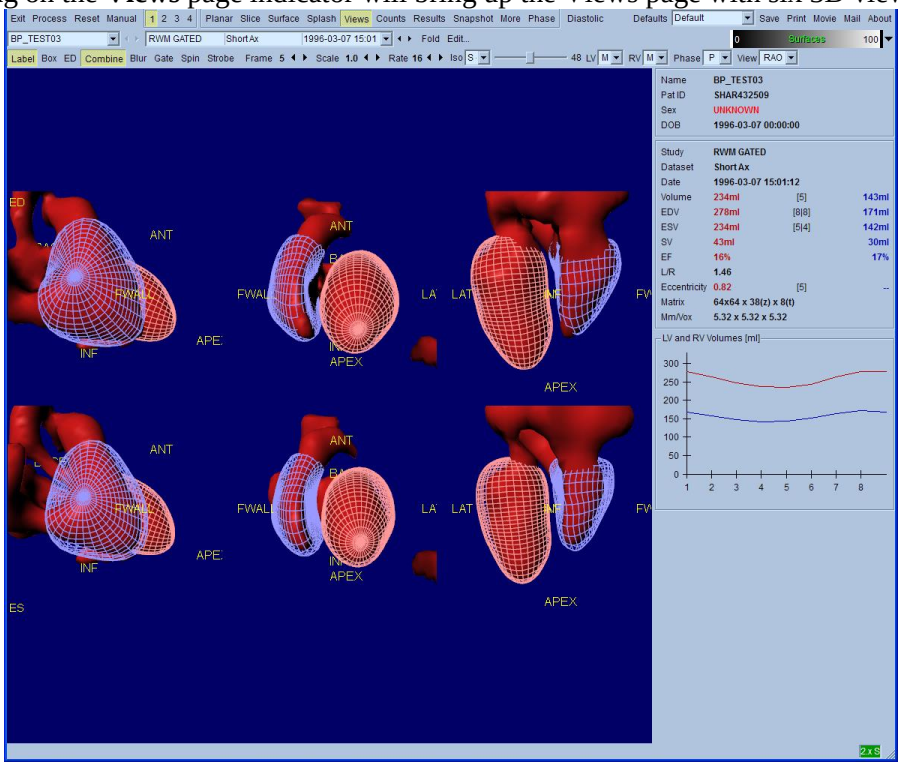


Figure 2.22) very similar to that in the **Surface** page. In fact, the main purpose of this page is to allow full coverage of the LV and RV, albeit with smaller images compared to the one in the **Surface** page.

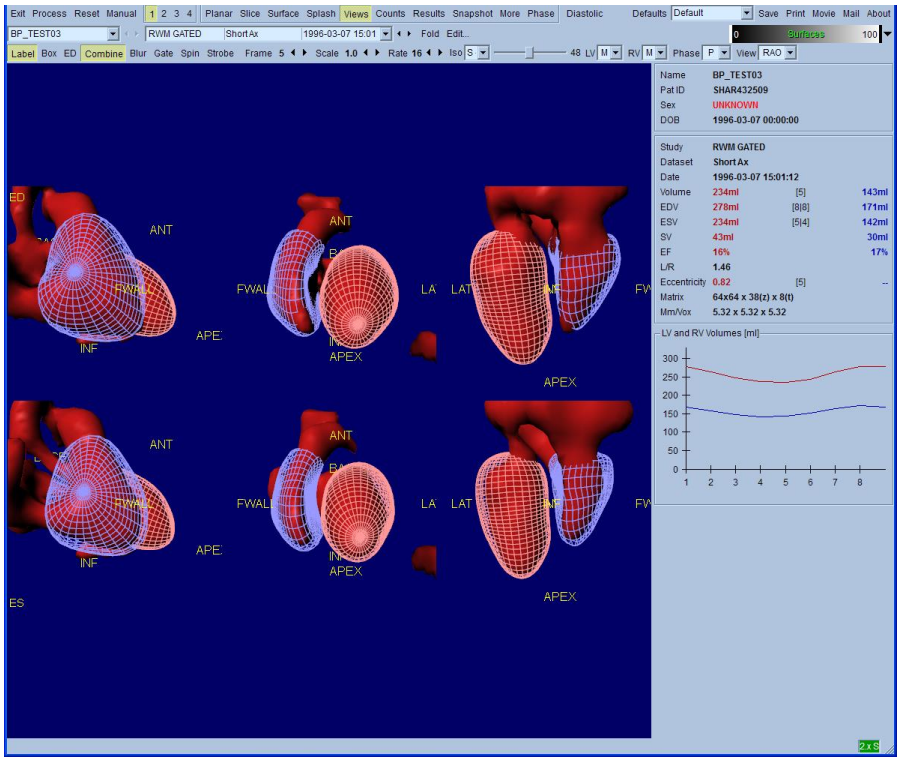


Figure 2.22. Views page

2.2.11 Putting it all together: the Results page

Clicking on the **Results** page indicator will bring up the Results page (Figure 2.23), which aims at presenting, in synthetic format, all information related to the gated SPECT blood pool study in this patient. If a screen capture is taken of this page with the LV and RV contour toggles off, it would represent a good image to send the referring physician.

The **Results** page will be discussed in further detail in Section 11 of this manual.

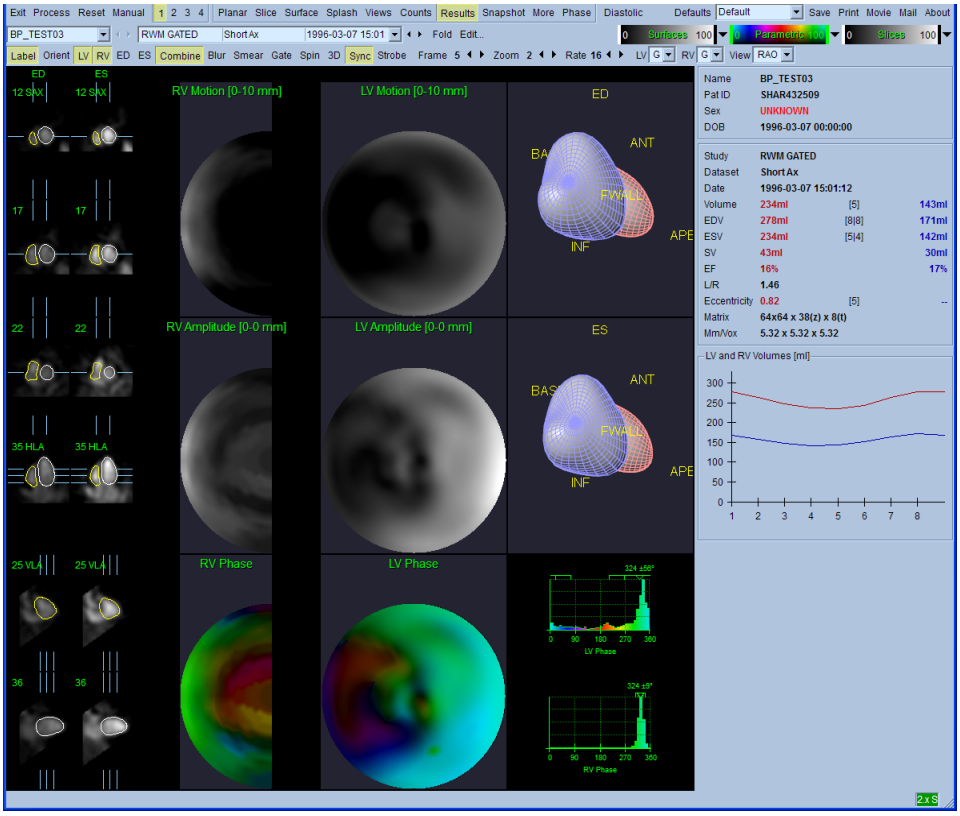


Figure 2.23. Results page

2.2.12 Assessing the time-volume curve

A valid time-volume curve would be expected to have its minimum (end-systole) at frame 3 or 4, and its maximum (end-diastole) at frame 1, 7 or 8 of an 8-frame gated acquisition. For a 16-frame gated acquisition, the minimum (end-systole) would be expected to be at frame 7 or 8 and its maximum (end-diastole) at frame 1 or 16. If major deviations from this expected behavior occur, the prudent assumption is that gating or processing was unsuccessful and the study needs to be repeated. An example of a correct curve is shown in Figure 2.23.

Note In the time-volume curve graph, the volumetric value for interval 1 is also “appended” to the curve after interval 8 or 16, respectively, for 8-frame and 16-frame gated acquisitions.

2.2.13 Assessing the polar maps

QBS provides two wall motion polar maps, one each for the LV and RV.

Mapping of the endocardial motion in the motion polar map follows a linear model from 0 mm to 10 mm. Motion greater than 10 mm is assumed to be = 10 mm (the scale "saturates" at 10 mm), while motion <0 mm (dyskinesia) is assumed to be = 0 mm. The parametric surfaces displayed on the Results page are not normalized to this 10 mm limit but to the maximum wall motion value instead. The FFH Amplitude polar maps and surfaces are not normalized in any way. The FFH Phase polar maps and surfaces are displayed in such a manner than angles between 0 and 360^{o} span the color stripe (negative angles wrap around to the 0-360 range, i.e., -20^{o} is displayed as 340^{o}). Note that paradoxical motion would appear to have a non-zero amplitude and a phase value opposed to normal areas (i.e., the color of the phase will correspond to a different portion of the parametric color stripe).

Note It is well known that, even in normal patients, the septum typically moves less than the lateral wall (resulting in a “dark” area in the motion map).

2.2.14 Diastolic Function

Clicking the Diastolic toggle replaces the LV and RV volumes curves with LV and RV volume and filling curves as well as computed diastolic parameters. The user may have to scroll down the Info box or maximize the QBS window to see all the computed parameters. (Figure 2.24)

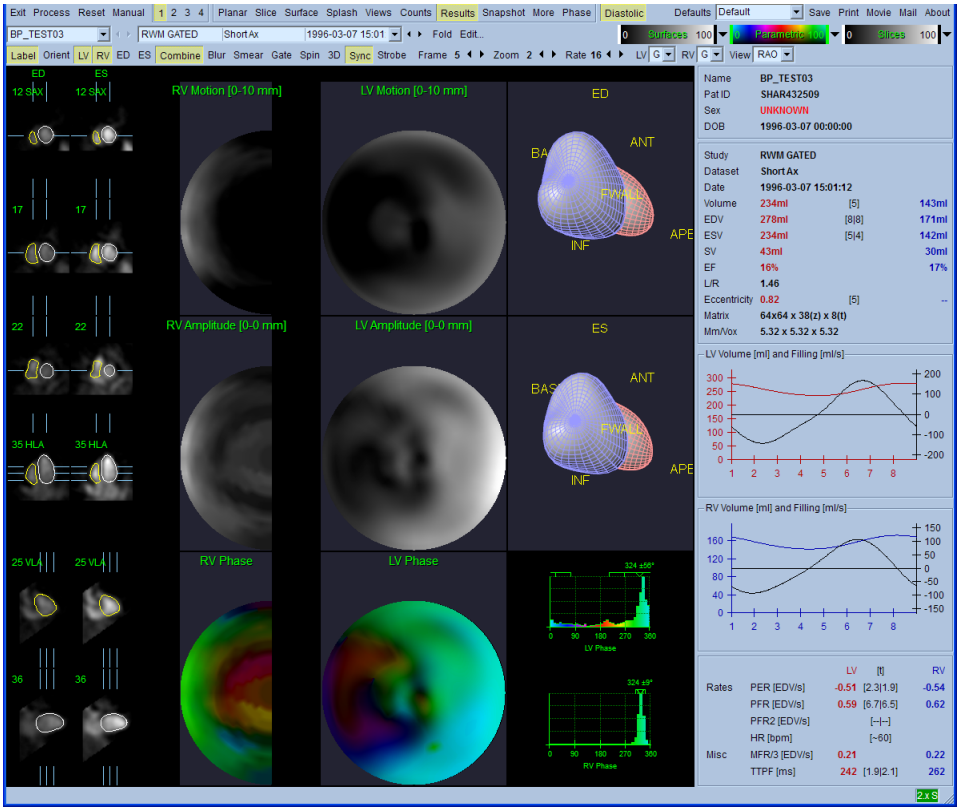


Figure 2.24. Diastolic results

2.2.15 Pixel size

QBS volume measurements can be hampered by incorrect listing of the pixel size in the image header (this is usually not a problem with the ejection fractions, which are derived from a ratio of volumes). Pixel size is usually automatically calculated by modern cameras, based on knowledge of field of view and zoom information. However, older cameras or "hybrid" systems (where one manufacturer's camera is interfaced to another manufacturer's computer) may not be set up to transfer pixel size information from the gantry, or may take a "standard" size (i.e., 1 cm) as default. In these cases, a correction factor should be manually calculated by imaging a known pattern (for example, two line sources separated by an exact distance), and counting the number of pixels between the lines' centroids in the reconstructed transaxial image.

2.2.16 Saving your Results

With completion of the processing and reviewing steps outlined above, the user has the option of saving the results to a results file. From the main tool bar click **Save** to display the **Save Results** dialog window as shown in Figure 2.25**.**

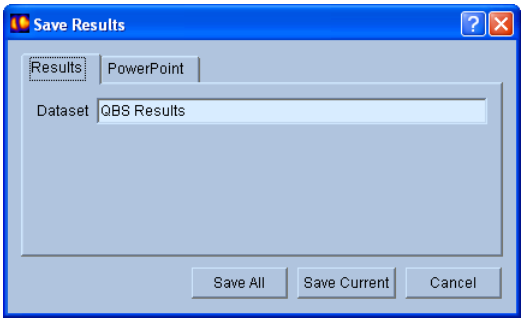


Figure 2.25. Save Results dialog

There are two tab choices for saving, **Results** and **PowerPoint**. Selecting the Results tab (default) allows saving of processed results as a dataset within the patient study. The user gives the results dataset a name that will appear in the patient study dataset list upon exiting QBS.

Selecting the PowerPoint tab allows saving of results and application configuration information in a format that allows for fast and easy launching of case studies directly from a PowerPoint presentation. The PowerPoint saving feature is described in detail in Section 15 of this manual.

The following actions are supported:

Action	Purpose
Save All	Saves results for all selected studies
Save Current	Saves results for the currently displayed study.
Cancel	Exits the dialog without saving results. The user may also exit the dialog by clicking the "X" in the upper right-hand corner of the dialog window.

2.2.17 PowerPoint Save Feature

The PowerPoint save feature is a useful tool that allows saving a set of images and results along with a batch file. The batch file launches the **QPS/QGS/QBS** application and loads the images and results. This is useful for showing case studies within a Microsoft PowerPoint presentation.

To save a study for showing in a PowerPoint presentation follow these steps:

1. Select your study(ies) and start your application.
2. Review the results of the study(ies) on the display page you wish to save (eg. **Slice page**) and make changes as necessary (intensity/color scale, zoom, frame rate settings etc.)
3. Click the **Save** button to open the **Save Results** dialog.
4. Click the **PowerPoint** tab to display save options. See Figure 1 below.
5. Click **Browse** to select a directory to store the images and batch file.
6. Type a name in the **Filename** text area
7. Click **Save Current** to save the currently display study or click **Save All** to save all the selected studies for the current application session.

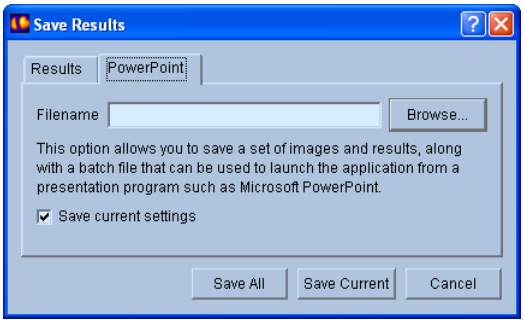


Figure 2.26. Save Results with PowerPoint tab selected

2.2.17.1 Description of Saved Files

Several files will be saved (at least one per dataset), including additional files depending on whether the **Include current defaults** check box has been checked. It is recommended to save each presentation in its own folder to keep all files well organized. The ".vbs" file is a Visual Basic script file that will launch **QBS** and load the corresponding data files. If a corresponding ".def" or ".def.xml" file is found, the defaults for the study will also be loaded.

2.2.17.2 Launching application studies from PowerPoint

Studies must be saved using the procedure in the preceding section in order to use this PowerPoint feature.

To create a slide that will launch an QBS study session follow these steps.

1. Open PowerPoint and insert a new slide.
2. Under the Slide Show menu drop-down, select Action Buttons and choose an action button graphic from the list.
3. Draw the action button on the slide. An Action Settings dialog window should be displayed when finished drawing. Optionally, right-click on the action button and select Properties to bring up the Action Settings dialog.
4. In the Action Settings dialog click the **Run program** toggle.
5. Using the **Browse** command, locate the "vbs" file and select it. The **Files of type** selection in the browse window may have to be changed from Programs (*.exe) to All Files (*.*)**.**
6. Click **OK**.
7. Launch the slide show for the current slide and click the action button to verify correct launching of the study.
8. Adding a text description beside the Action button will aid in reminding what the study was about during a presentation.

3 QBS

QBS provides an intuitive and flexible user interface, including:

- Interactive orthogonal slice displays in standard ACC (American College of Cardiology) format with overlaid LV and RV surface contours and labeling.
- Interactive LV and RV surface rendered images with optional orientation tags and graphics.
- Regional wall motion polar maps and parametric surfaces.
- Chamber volumes versus interval plot.
- Global statistics including ED and ES chamber volumes and ejection fractions.
- Calculation of values using three methods: Surfaces, Count-Based Calculations and Count-Based Volumes. The user can select for which method results are displayed, and can adjust some of the processing parameters.
- On-the-fly computation and display of FFH images (phase and amplitude), computation of phase histograms (whole image, ROIs, surfaces).
- Computation of diastolic function metrics for the left and right ventricles including PER (peak emptying rate), PFR (peak filling rate), PFR2 (secondary peak filling rate), MFR/3 (mean filling rate over the first third of the ES to ED phase), and TTPF (time to peak filling from ES). HR (heart rate in beats per minute) is also displayed if available.
- Manual override of automatic segmentation.
- Multiple input datasets.

The QBS application user interface is designed as a series of modular pages, with each page providing a different perspective on the input data and processed results. These pages are as follows:

Page	Purpose
Main	Contains all other pages and those controls with application wide effects. Note: there is no button or toggle named Main.
Recon	Integrated AutoRECON application. Note: Not available on all platforms.
Planar	Displays cine display of one or more gated or raw projection datasets.
Slice	Displays six interactively selected slices: three short axis slices, two vertical long axis slices, and one horizontal long axis slice. The corresponding surface contours can optionally be displayed.
Splash	Displays 32 interactively selected slices: 16 short axis slices, 8 vertical long axis slices, and 8 horizontal long axis slices. The corresponding surface contours can optionally be displayed.
Surface	Renders a single three-dimensional image of the surfaces. This image can be interactively rotated and zoomed. One isosurface from the dataset can be displayed along with the ventricular surfaces.
Views	Renders six three-dimensional images of the surfaces, three at ED, three

	at ES. These images can be interactively rotated and zoomed.
Snapshot	Displays screen snapshots.
More	Displays dataset header information.
Counts	Displays counts based results including phase histograms and time-activity curves. The display format is suitable for hardcopy.
Results	Displays text, slice, surface, and polar map views of processed results in a format suitable for hardcopy.
Phase	Displays regional phase information for the assessment of wall motion contraction patterns and synchronicity.
Manual	Allows the user, if necessary, to provide hints to the segmentation algorithm by specifying the location of the LV using an ellipsoidal mask. This allows re-processing of the data with subsequent re-calculation of all parameters.

Each page is described in more detail below. Note that the number of images displayed in each page may vary slightly when the program is used to display multiple simultaneous datasets.

4 Main Page

The Main page (Figure 4.1) provides a container for all other pages. It consists of the toolbar, color control(s), dataset selector, page control bar, info box, and work area. The toolbar contains those controls required throughout the application, including selection of application mode and initiation of processing and review. The color control selects the current color scale and color scale mapping. The dataset selector selects the current dataset from the set of input datasets. The page control bar contains page-specific buttons and toggles. The work area is where the other contained pages are placed and where images are displayed. The info box area contains patient information as well as calculated results from the QBS processing algorithms. More detailed descriptions follow.

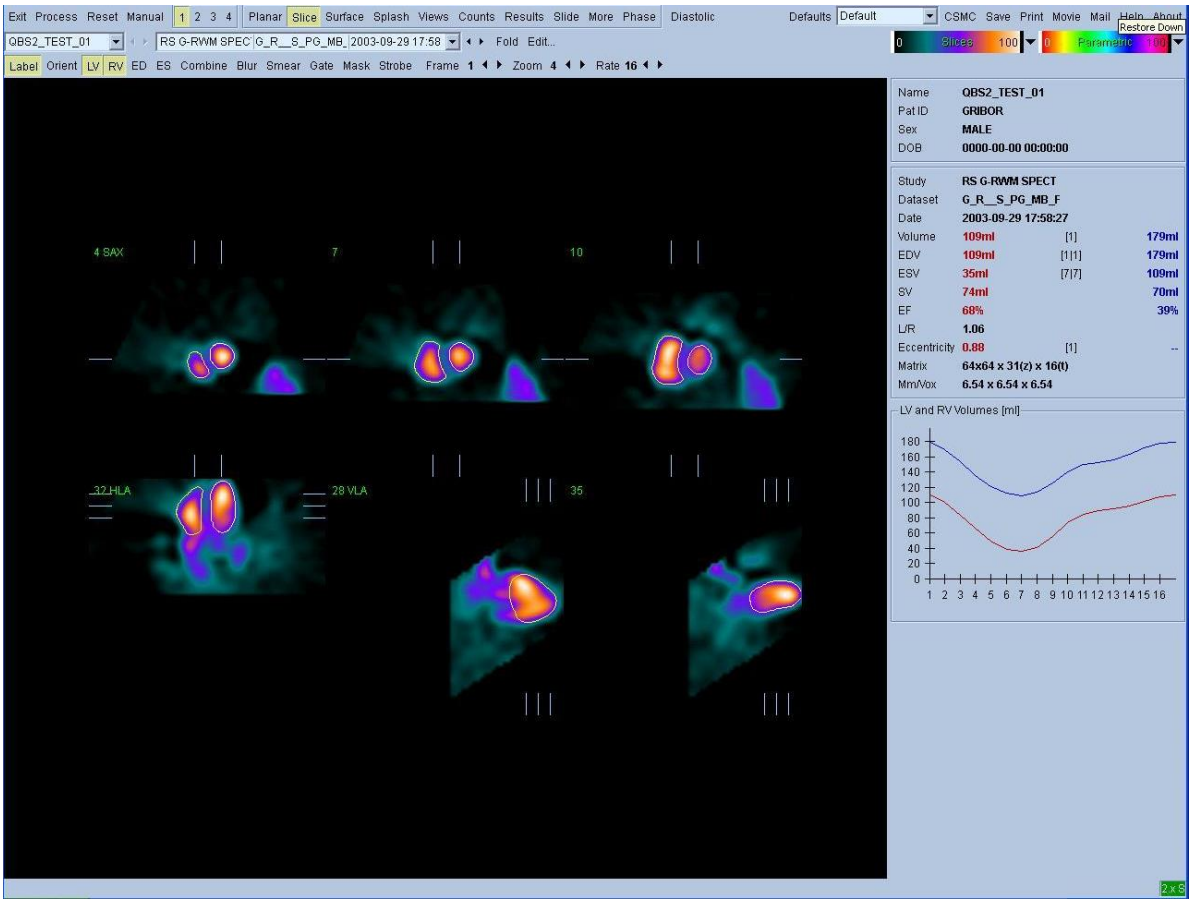


Figure 4.1. Main Screen with Slice page selected (after processing)

4.1 Toolbar

The toolbar (Figure 4.2) provides access to a variety of QBS functions, including:

Exit	Exits the program.
Process	Processes all datasets, automatically segmenting and quantifying.
Reset	Deletes processed results from the current dataset.

Manual	Toggles manual mode.
1 2 3 4	Sets single, dual, triple or quadruple display mode.
Recon	Integrated AutoRECON application for reconstructing raw projection datasets.
Planar	Displays planar studies and raw projections (if loaded) for review.
Slice	Sets Slice page as the current page.
Surface	Sets Surface page as the current page.
Splash	Sets Splash page as the current page.
Views	Sets Views page as the current page.
Snapshot	Sets the Snapshot page as the current page. Displays previously saved screen snapshots.
More	Sets the More page as the current page. Displays dataset header information for one or more datasets.
Counts	Sets the Counts page as the current page. Displays counts based results including phase histograms and time-activity curves. The display format is suitable for hardcopy.
Phase	Sets the Phase page as the current page. Displays regional phase histogram that can be used to assess inter- and intra-ventricular dyskinesia.
Results	Sets Results page as the current page.
Diastolic	A toggle that when enabled displays LV and RV diastolic parameters in the Info box area.
Defaults	Brings up the Defaults editor to set application specific features.
Save	Saves the processed results.
Print	Allows saving of static pages as static "snapshot" database files or as static image files (TIFF, JPEG formats etc.) to a default (or user-specified) location on the local PC.
Window	Launches secondary windows of the same QBS instance.
Movie	Allows saving of cine datasets as "movie" files in "AVI" format to a default (or user-specified) location on the local PC.
About	Brings up version and copyright information.

These functions are for the most part modeless, i.e. they can be called irrespective of the current application state. In particular, Process, Manual, 1, 2, 3, 4, and Reset can be called no matter what the current page.

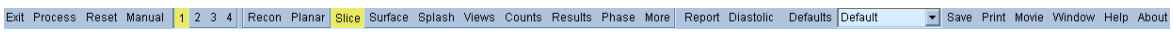


Figure 4.2. Toolbar

4.2 Folder Selector

At start up, QBS is passed as input a list of one or more folders (patients), each containing one or more datasets. The folder selector selects from this list the current folder, i.e. the patient to be viewed. It allows the user to page through the folders by clicking the arrow button (or anywhere in the folder selector box) to display a drop-down list of available folders (Figure 4.3). The user can jump directly to any folder in the list by clicking it.

Figure 4.3. Folder selector with drop-down menu

4.3 Dataset Selector

If the current folder contains one or more datasets the dataset selector selects from this list the current dataset, i.e. the dataset to be viewed. It allows the user to select a dataset by clicking the arrow button (or anywhere in the dataset selector box) to display a drop-down list of available datasets (Figure 4.4). The user can jump directly to any folder in the list by clicking it. In 2, 3 or 4 display mode two, three or four dataset selectors are presented, allowing multiple dataset selection and display (Figure 4.5).

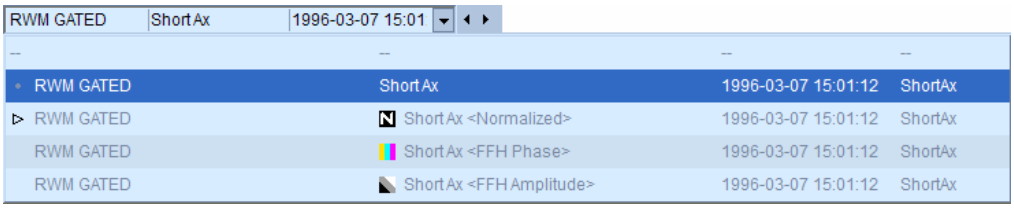


Figure 4.4. Dataset Selector drop-down menu

Figure 4.5. In 2 display mode two dataset selectors are available

4.4 Dataset Editor

Clicking the Edit button to the right of the Dataset Selector (Figure 4.4) opens up the Dataset Editor window (Figure 4.6). It allows the user to select datasets as being active or inactive. Active datasets can be processed and displayed while inactive datasets will be excluded from display or processing.

The following actions are supported:

OK	Exits editor accepting all changes.
Cancel	Exits editor discarding all changes.

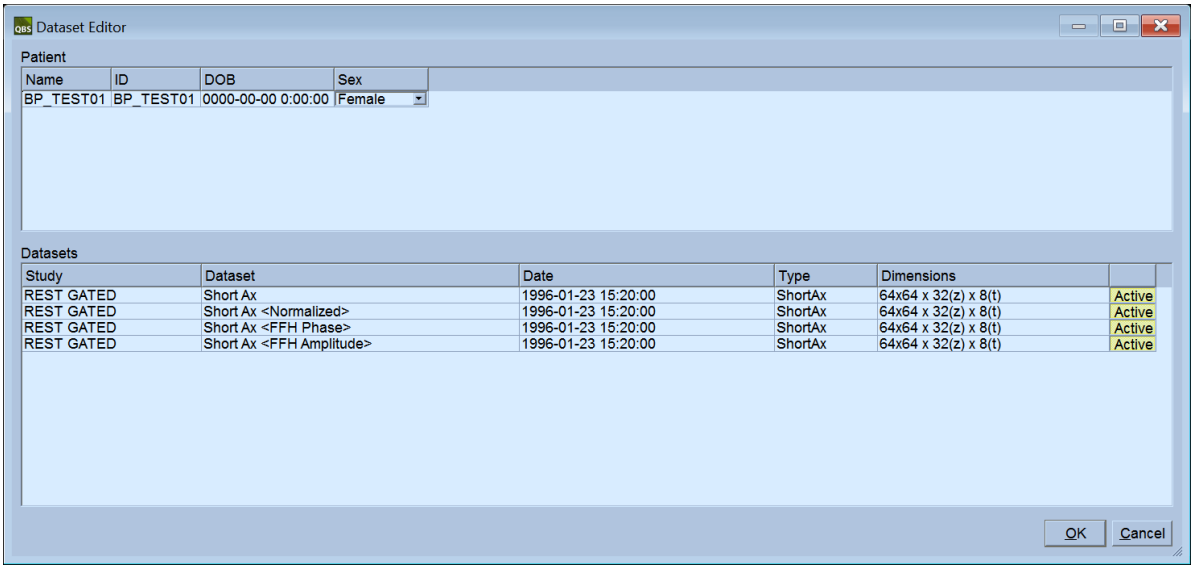


Figure 4.6. Dataset Editor

4.5 Color Control

The Color Control (Figure 4.7) selects the current color scale and color scale mapping. The current color scale is selected by clicking on the drop-down menu arrow to the right of the color scale; this pops up a list of available color scales from which the desired color scale can be selected (Figure 4.8). The color scale mapping is set using two parameters, the lower and upper levels, either of which can range from 0 to 100 percent. Together they specify that portion of a datasets dynamic range that should be mapped onto the full color scale.

Depending on the page displayed, there may be more than one color scale. For example, on the Results page there are three color controls (Figure 2.23). One for surface color scaling, one for parametric color scaling and one for slices color scaling. All three controls function in the same manner as described below.

Figure 4.7. Color Control with drop-down menu selector

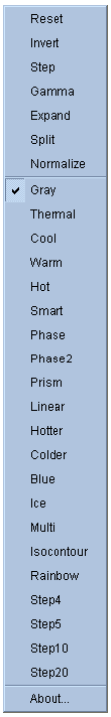


Figure 4.8. Color Control drop-down menu

The lower and upper levels of the color scale mapping, represented with the lower and upper level bars, can be set through the color scale viewport, which supports the following interactions:

- Left-click and drag either level bar to move it.
- Left-click and drag any other point on the viewport to move both level bars simultaneously.
- Middle-click or drag any point on the viewport to move the closest level bar to that point.
- Double left-click anywhere in the viewport to reset the level bars to 0 and 100.

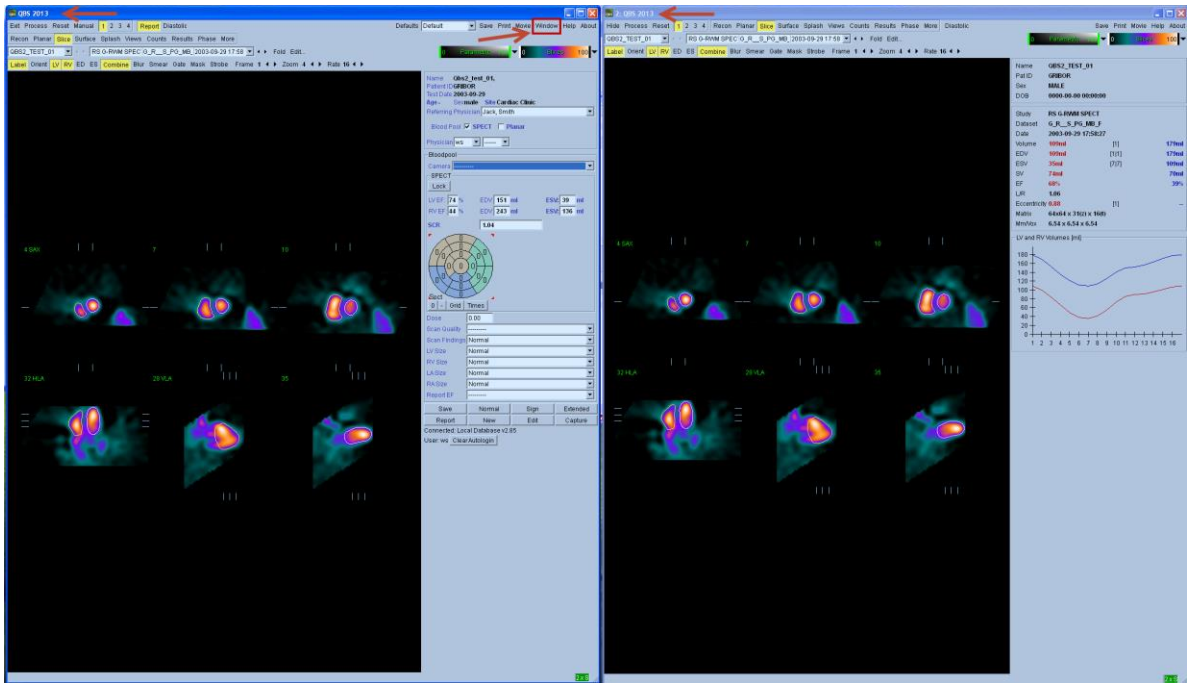
The following features are also provided through the drop-down menu (along with available color scales):

Reset	Resets lower and upper levels.
Invert	Toggles the sense of the lower and upper levels.
Step	Toggles color scale discretization.
Gamma	Toggles display of color scale gamma control (Figure 4.9).
Expand	Toggles dynamic range expansion of lower and upper levels.
Split	Toggles individual dataset controls. Available only on pages with multiple datasets displayed.
Normalize	Toggles automatic dataset normalization based on segmentation results.

Figure 4.9. Color Control with Gamma

4.6 Multi-Monitor support

QBS supports unlimited number of displays, however, typically 2-4 monitor setups are most commonly used in clinical settings. Multiple windows of the same QBS instance may be launched using the **Window** button. All secondary windows operate in a synchronous manner with the primary window so that changes made to a study on the primary window are reflected on all secondary windows.



The title bar of the secondary windows will contain the instance number of that window. For example, the above image (right side) shows a **2** in its title bar.

Note: Reporting panel is only available from the primary window. Additionally, secondary windows can only be launched from the primary window. Closing the primary window will automatically close all secondary windows automatically.

4.7 Info box

The Info box displays information about the current dataset. The amount of information displayed depends on whether or not the data has been processed. Figure 4.10 shows an info box prior to processing, Figure 4.11 shows the same info box after processing, and Figure 4.12 shows the same info box with diastolic results.

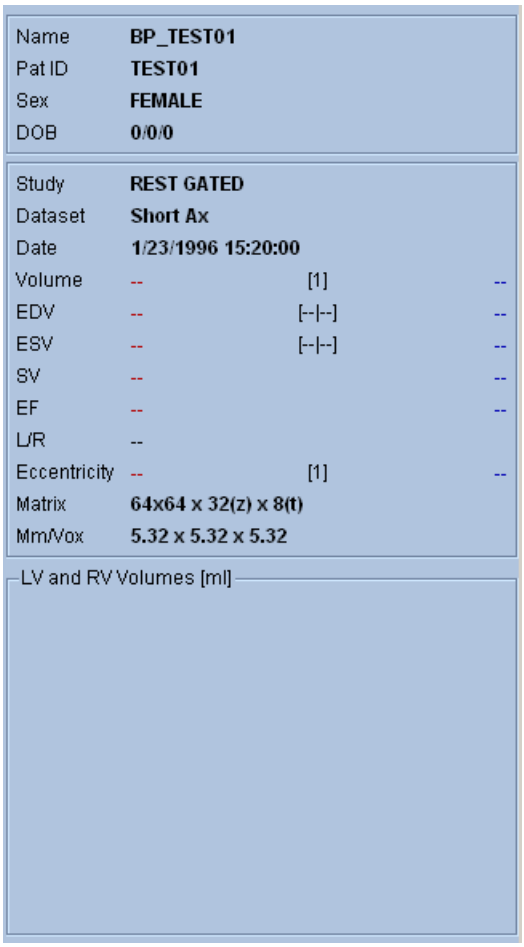


Figure 4.10. Infobox before processing

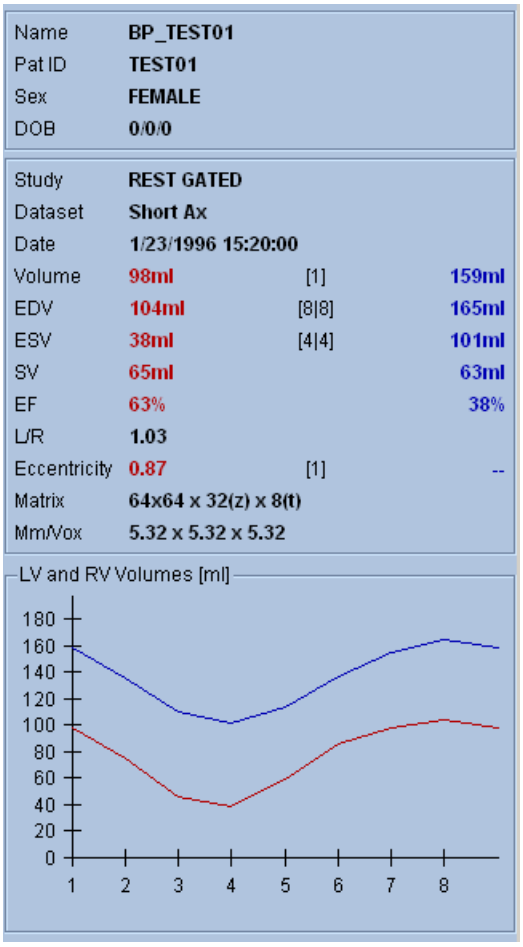


Figure 4.11. Infobox after processing

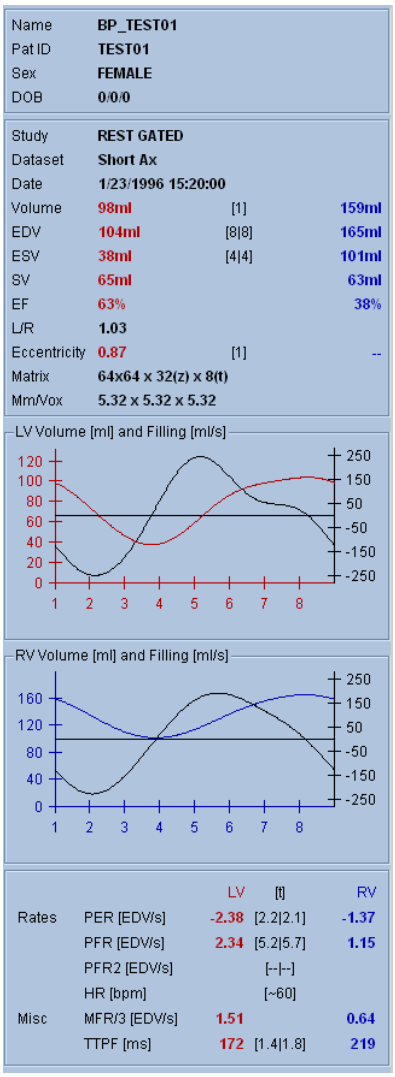


Figure 4.12. Infobox after processing and displaying Diastolic Function parameters

This information displayed in the Info box includes the following:

Name	Patient name.
Pat ID	Patient ID.
Sex	Patient gender.
DOB	Patient date of birth.
Study	Study ID.
Dataset	Dataset ID.
Date	Acquisition data and time (if available).
Volume	LV (red) and RV (blue) volumes in ml. at specified frame number in square braces[]. Manual adjustment of frames is accomplished by clicking the Frame indicators ◄►.
EDV	LV (red) and RV (blue) end-diastolic volumes in ml. with respective frame

	numbers in square braces[].
ESV	LV (red) and RV (blue) end-systolic volumes in ml. with respective frame numbers in square braces[].
SV	Stroke volume (EDV-ESV) in ml.
EF	LV (red) and RV (blue) ejection fractions.
L/R	Ratio of LV end-systolic volume to RV end-systolic volume.
Eccentricity	LV eccentricity index at specified frame number in square braces []. Manual adjustment of frames is accomplished by clicking the Frame indicators ◄►. Eccentricity is not available for the RV.
Matrix	Slice width, height, number of slices, and number of time bins (x, y, z, and t dimensions respectively).
Mm/Vox	Millimeters per voxel (width x height x depth)

Diastolic information displayed in the Info box includes the following:

PER	LV (red) and RV (blue) Peak Emptying Rates (EDV/s).
PFR	LV (red) and RV (blue) Peak Filling Rates (EDV/s).
PFR2	LV (red) and RV 9blue) Secondary Peak Filling Rates (EDV/s), if available.
HR	Heart Rate in beats per minute, if available.
MFR/3	LV (red) and RV (blue) Mean Filling Rates over the first third of the cardiac cycle (from ED to ES).
TTPF	LV (red) and RV (blue) Time To Peak Filling from ES (ms).

5 Application Defaults Editor

The Application Defaults editor (Figure 5.1) is used to display, edit, reset and save the default application launch configuration and is activated by clicking the **Defaults** button on the application toolbar. This editor dialog is composed of five tab pages, **General**, **AutoMatch**, **Themes**, **Graphics,** and **Language**.

QBS supports multiple sets of defaults in order to easily accommodate multiple users using the same system username. The following **Application Defaults** editor commands on the main window are supported:

Top controls	Purpose
Defaults	Select the current defaults
New	Create a new defaults
Reset	Reset the current defaults
Clone	Captures the current settings of all of the controls within the application.
Reload	Reload the current defaults
Save	Save the current defaults
Save As	Save the current defaults under a different name
Delete	Delete the current defaults
Set As Startup	Set the current defaults as the startup defaults
Tools:	**Contains the following 3 options:**
Import	Import a defaults that had previously been exported
Export	Save the current defaults to a file
Reinitialize	Reset the Default defaults to its factory settings and make the startup defaults
Bottom controls	**Purpose**
OK	Applies defaults chosen to the application (one-time).
Cancel	Exits default dialog without making any changes.

5.1 General Settings

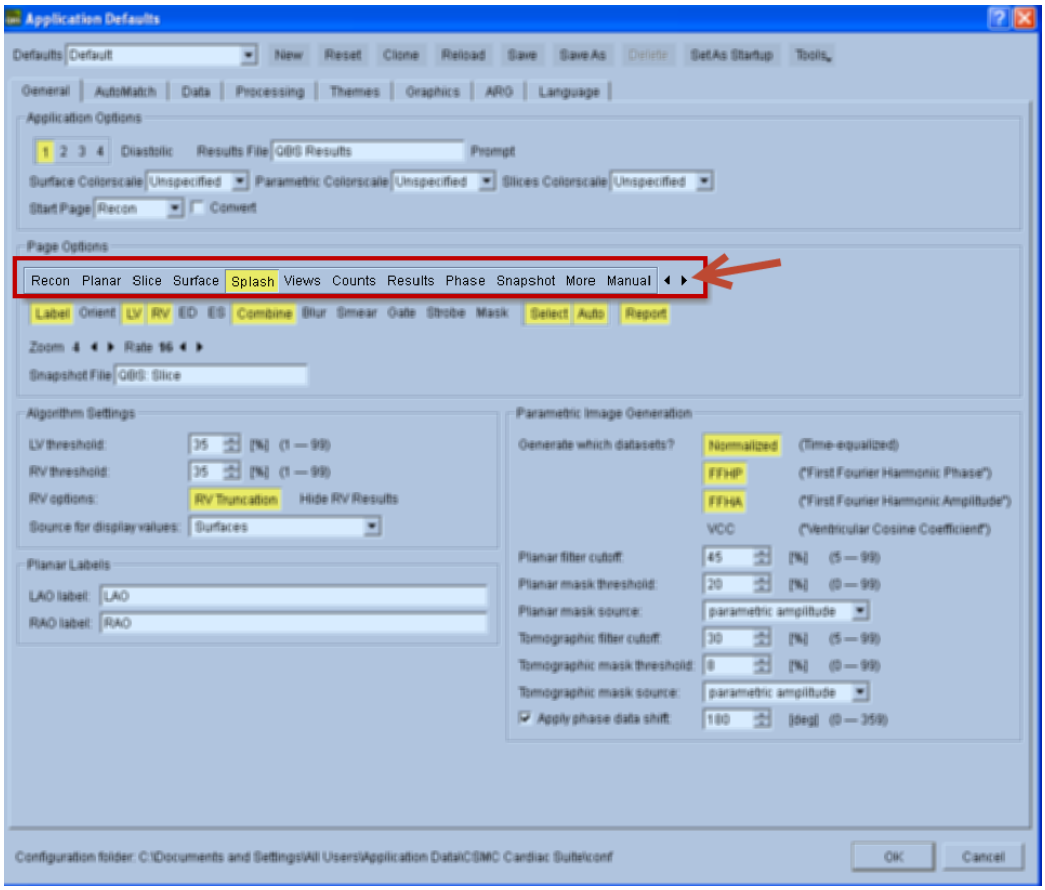
The following settings are available on the General tab page (Figure 5.1) in the Application Options section:

Controls	Purpose
1 2 3 4	Sets default display mode (one, two, three or four datasets).

Diastolic	Toggles display of diastolic calculation results.
Results File	Sets results file dataset ID.
Prompt	Toggles prompting for a file name when saving results.
Surface Color scale	Sets the default surface color scale for all 3D surface images.
Parametric Color scale	Sets the parametric surface color scale on the Views and Surface pages and the FFH Phase polar maps on the Results page.
Slice Color scale	Selects the default color scale for all 2D images.
Start Page	Used to select the page in which QBS opens upon initial launch. If the loaded data cannot be displayed in this window, QBS opens instead on the first applicable window in the sequence.

The following settings are available on the bottom section of the **General** tab page in the **Page Options** section: Availability of any setting is specific to the page selected in this section. Each QBS window can be customized with its own window-specific parameters.

Page Sequence arrows (◄►) Allows the ability to reorder the page sequence as desired. To change the default sequence of QGS + QPS pages listed at the top of the application's main window, click on a window name and use the arrows to move it (left or right) to the desired location in the sequence.



The following settings are available on the General tab page (Figure 5.1) in the Page Options section: Availability of any setting is specific to the page selected in this section.

Controls	Purpose
Label	Toggles image labeling.
Orient	Toggles orientation labels adjacent to each image.
Lines	Toggles motion reference lines.
Spin	Toggles continuous spatial cine.
Gate	Toggles temporal cine.
Rock	Toggles bi-directional angular projection cine (with Spin also enabled).
Box	Toggles LV surface orientation box.
Contours	Toggles LV surface contour display.
LV	Toggles/selects LV contour/surface reference overlay.
RV	Toggles/selects RV contour/surface reference overlay.
ED	Toggles end-diastole contour/surface reference overlay.
ES	Toggles end-systole contour/surface reference overlay.
Blur	Toggles 1-2-1 temporal smooth of displayed gated slices/surfaces.
Smear	Toggles 1-2-1 spatial smooth of displayed 2D slices.
Skip	Toggles display of every other slice.
Surface	Selects surface render mode.
3D	Toggles 3D surface display.
Strobe	Toggles display of contraction patterns in FFH phase images, surfaces, and FFH Phase polar maps. Use with Gate toggle enabled.
Controls	Toggles display of frame and color scale mapping controls on Planar page.
Volumes	Toggles volume based curve display. When disabled, counts based curves are displayed.
Mask	Toggles display of LV (red) and RV (blue) mask ROIs used in count-based calculations.
Sync	Toggles individual or grouped manual reorientation of surface images on the Results page.
View	Selects surface orientation.
Zoom	Selects image zoom.
Scale	Selects surface zoom.

Rate	Selects cine speed.
Snapshot	Sets snapshot file dataset ID.
Select	Selects preferred page display mode (Auto, 1, 2, 3, or 4).
Report	Toggles ARG reporting panel.

The following settings are available on the General tab page (Figure 5.1) in the Algorithm Settings section:

Controls	Purpose
LV Threshold	Sets threshold used for all count-based LV calculations.
RV Threshold	Sets threshold used for all count-based RV calculations.
RV Truncation	Sets truncation of RV at the estimated location of the pulmonary valve.
Hide RV Results	Sets display of RV results, displayed or hidden.
Source for display values	Sets the method the QBS algorithms use to calculate values. Choices are; Surfaces, Count-based calculations, or Count-based volumes. See Chapter 11, Results Page, for descriptions of the calculation methods.

The following settings are available on the General tab page (Figure 5.1) in the Planar Labels section:

Controls	Purpose
LAO Label	Sets the label shown on the Planar page for LAO datasets.
RAO Label	Sets the label shown on the Planar page for RAO datasets.

The following settings are available on the General tab page (Figure 5.1) in the Parametric Image Generation section:

Controls	Purpose
Generate which datasets?	Selects datasets to compute. Choices are; FFHP (First Fourier Harmonic Phase), FFHA (First Fourier Harmonic Amplitude), VCC (Ventricular Cosine Coefficient), and Normalized (Time-equalized).
Planar filter cutoff, Planar mask threshold, Planar mask source	Sets cutoff of the 5th order Butterworth filter applied to the planar images before FFH calculations. User then sets masking mode to parametric amplitude to apply the threshold to the FFH amplitude image, or raw counts to apply the threshold to frame 0 of the original dataset. The threshold is set as the percentage of the maximum value in the image used for masking.
Tomographic filter cutoff, Tomographic mask threshold, Tomographic mask source	Sets cutoff of the 5th order Butterworth filter applied to the tomographic images before FFH calculations. User then sets masking mode to parametric amplitude to apply the threshold to the FFH amplitude image, or raw counts to apply the threshold to frame 0 of the original dataset. The threshold is set as the percentage of the maximum value in the image used for

	masking.
Apply phase data shift	Check the box to turn on shifting of phase values (range: 0 – 359°, values wrap around 360° after shift angle has been added).

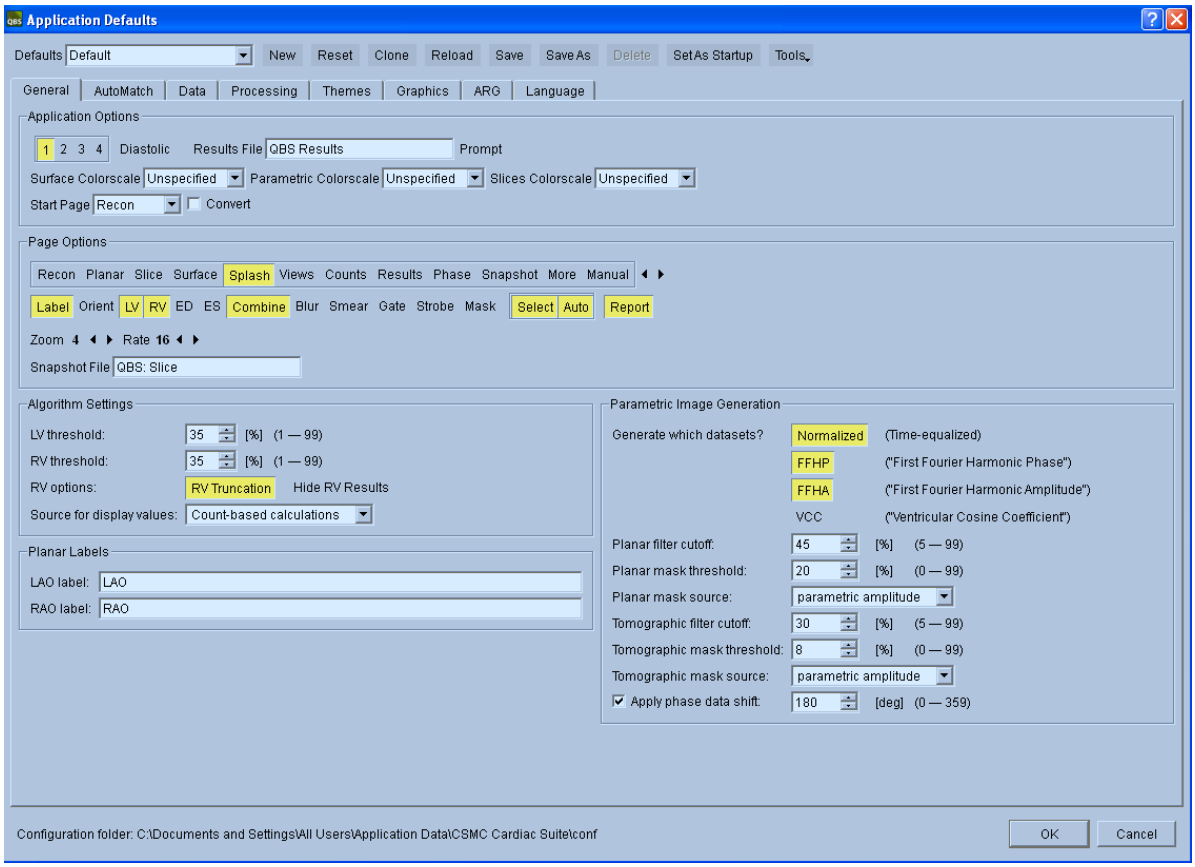


Figure 5.1. Application Defaults Editor with General tab page displayed

5.2 AutoMatch Settings

The following settings are available on the **AutoMatch** tab page (Figure 5.2) of the Application Defaults editor:

Controls	Purpose
AutoMatch Include	Tags a dataset as active based on text strings in study, dataset, isotope or matrix fields. In the Dataset Editor active datasets are highlighted in yellow.
AutoMatch Exclude	Tags a dataset as inactive based on text strings in study, dataset, isotope or matrix fields. In the Dataset Editor inactive datasets are not highlighted.
LAO Planar Filter	Sets LAO planar dataset based on text string matching.
RAO Planar Filter	Sets RAO planar dataset based on text string matching.

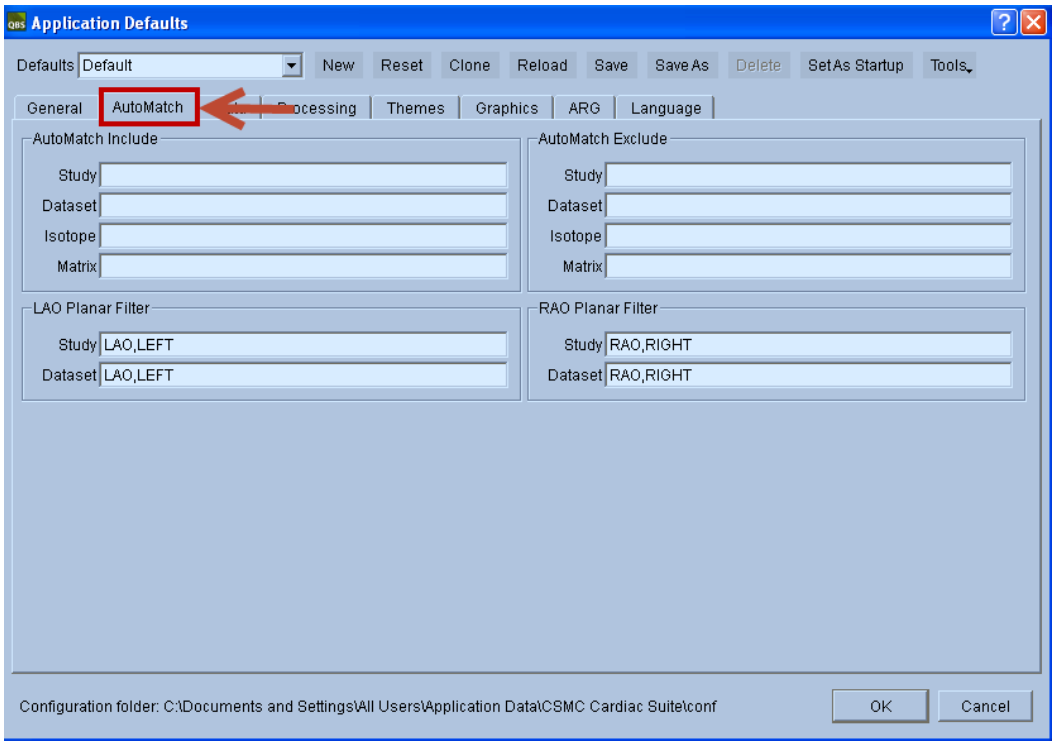
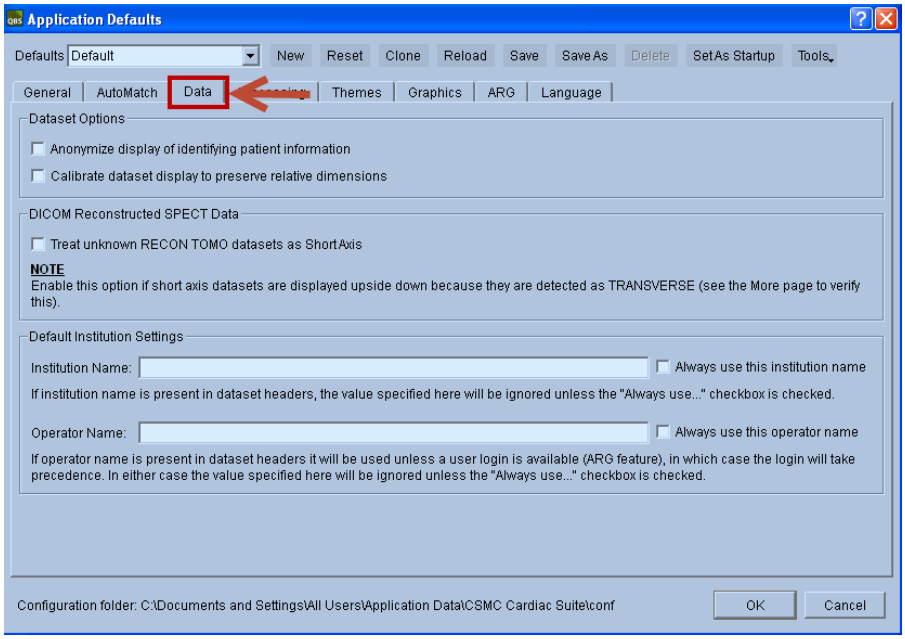


Figure 5.2. Application Defaults editor with AutoMatch tab page displayed

5.3 Data settings

The **Data** tab in the defaults settings can be used to set general default settings dealing with dataset settings.



The following settings are available on the **Data** tab:

Dataset Options

1. Check this option to toggle off display of patient identifiers.
2. When this option is checked, all displayed slices from short axis and transverse datasets (gated and ungated) for the patient are scaled so that they share the same number of millimeters per screen pixel, assuming that they share equal screen zooms (as is the case for all side by side displays).

DICOM Reconstruction SPECT Data

3. When this option is checked, the application will assume that DICOM datasets that are of RECON TOMO or GATED RECON TOMO image type but contain no view type are short axis datasets.

Default Institution Settings

4. Use this field to enter a default institution name. This will be used for the institution field for the dataset legend within secondary screen captures.

   Note: If institution name is present in dataset headers, the value specified here will be ignored unless the "Always Use this institution name" checkbox is also selected.

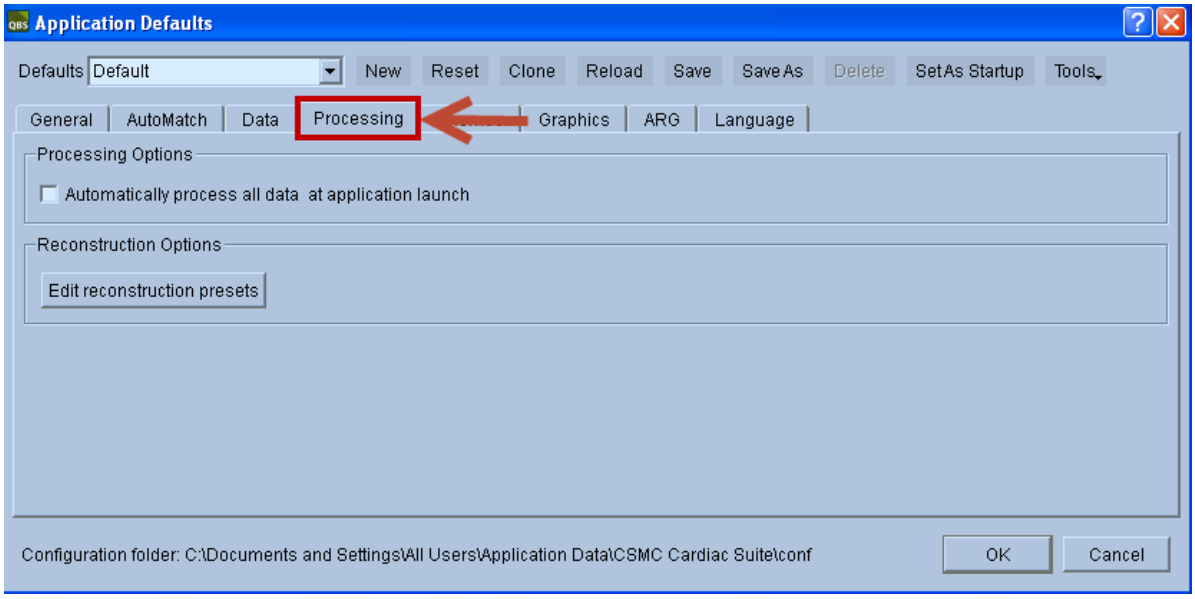
5. Use this field to enter a default operator name. This will be used for the operator name field for the dataset legend within secondary screen captures.

   Note: If operator name is present in dataset headers it will be used unless a user login is available (ARG feature), in which case the login will take precedence. In either case the value specified here will be ignored unless the "Always Use this institution name" checkbox is also selected.

   Note: Operator name is specific to a user at the Windows Operating System level (one logged into Windows) and not at the application level. If all QBS defaults are created using the same Windows user, the operator name cannot be different as this field is user specific to the Windows Operating System user.

5.4 Processing settings

The **processing** tab can be used to specify dataset processing related settings.



The following settings are available on the **Processing** tab:

1. When this option is checked, QGS + QPS automatically processes all loaded studies when it is launched.
2. This option specifically controls settings for the reconstruction and motion correction programs (AutoRECON and MoCo). These options may not available on all platforms. Please refer to the AutoRECON reference manual for more details.

5.5 Themes Settings

The **Themes** tab page (Figure 5.3) allows the user to set default colors and fonts for QBS's user interface (buttons, labels, background etc). The user can view changes in the **Preview** area prior to saving them permanently. The user creates a new theme by clicking the **New…** button or the edit the currently displayed theme (in the **Theme Name** box) by clicking the **Edit…** button.

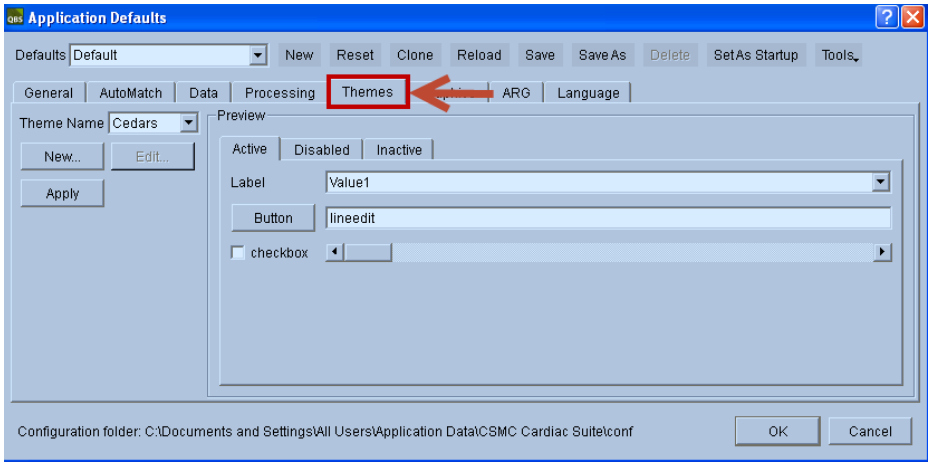


Figure 5.3. Themes tab page

To change colors and fonts for the currently selected theme click the **Edit** button to display the Theme Editor window (Figure 5.4).

To change the font, click the **Change Font** button to display the **Select Font** window. The **Select Font** window is similar to the regular Windows 2000 and Windows XP dialog for font selection. Select font, font style and font size from this window and then click **OK** to accept the choices or **Cancel** to abort.

There are also other choices for the user interface such as Foreground/Background color etc. for the **Active**, **Disabled**, and **Inactive** regions of the display. The user is allowed a great variety in tailoring the user interface to his/her liking.

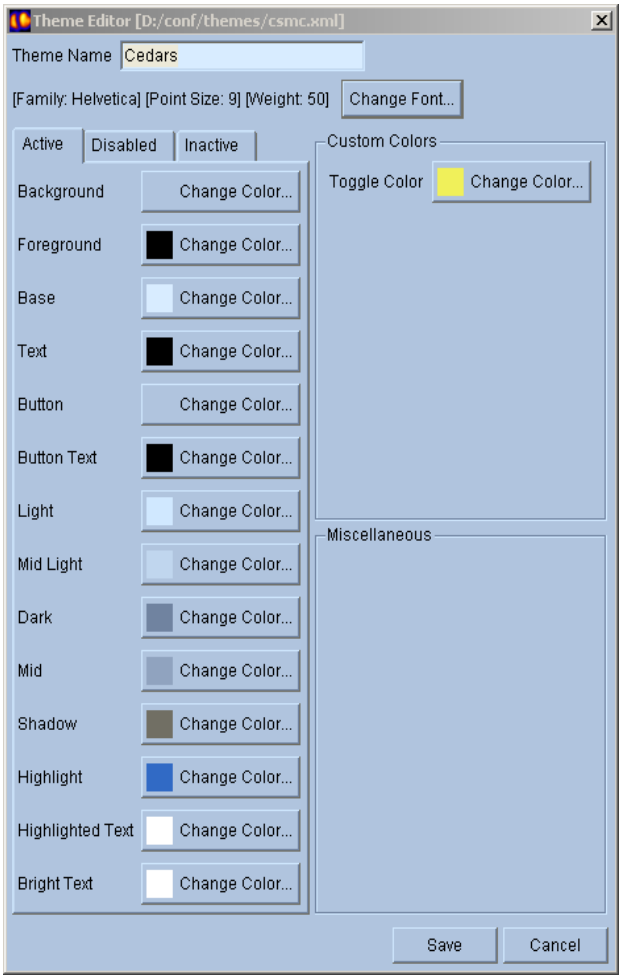


Figure 5.4. Theme Editor window

5.6 Graphics Settings

The **Graphics** tab page (Figure 5.5) allows the user to set certain parameters that affect the rendering of 3D surfaces. In general, using hardware acceleration is beneficial as the program is more responsive when surfaces are interactively rotated. In some instance, however, there may be a degradation in image quality that may justify disabling hardware acceleration. QBS uses OpenGL hardware acceleration, which is available on most systems. The following options are available in the graphics tab:

Controls	Purpose
Enable 3D hardware rendering (OpenGL)	If hardware rendering causes problems, it may be necessary to disable OpenGL by unchecking this checkbox. Turning off this option may adversely affect performance for some advanced visualization tasks such as viewing coronary trees. In case of issues with rendering, try turning off hardware acceleration first (see below). *Note: changing this setting will only affect viewports that have not been created yet, i.e., to pages that have not been visited. To apply this setting fully, save the defaults and restart the application.*
Enable OpenGL hardware acceleration	If hardware acceleration causes problems, it is recommended to disable OpenGL hardware acceleration by setting this option to No. A typical issue involves dual monitor setups where on the secondary display the 3D viewports appear "frozen." If this is the case, set acceleration to **No**, save the defaults and restart the application. *Note: changing this setting will only affect viewports that have not been created yet, i.e., to pages that have not been visited. To apply this setting fully, save the defaults and restart the application.*
Enable specular highlights	If OpenGL is enabled, surfaces can be rendered with added specular reflections. This adds a "shiny" appearance to the surfaces, potentially making it easier to visually assess the shape of the surface. This can be useful for isosurfaces, but may also be distracting. If checked, the amount of specular reflection can be controlled using the Surface shininess slider.
Surface shininess	Controls the amount of specular reflection (or "shine"), from 0 (none) to 100 (maximum reflection).
Enable parametric image shading	If enabled, parametrically-mapped surfaces (such as perfusion-mapped, Fourier phase- and amplitude-mapped surfaces) are also shaded. In some cases, the shading may interfere with the interpretation of the parametric mapping, hence the ability to disable this option. *Note: Currently this option is always enabled if OpenGL is enabled. This behavior may change in future releases.*

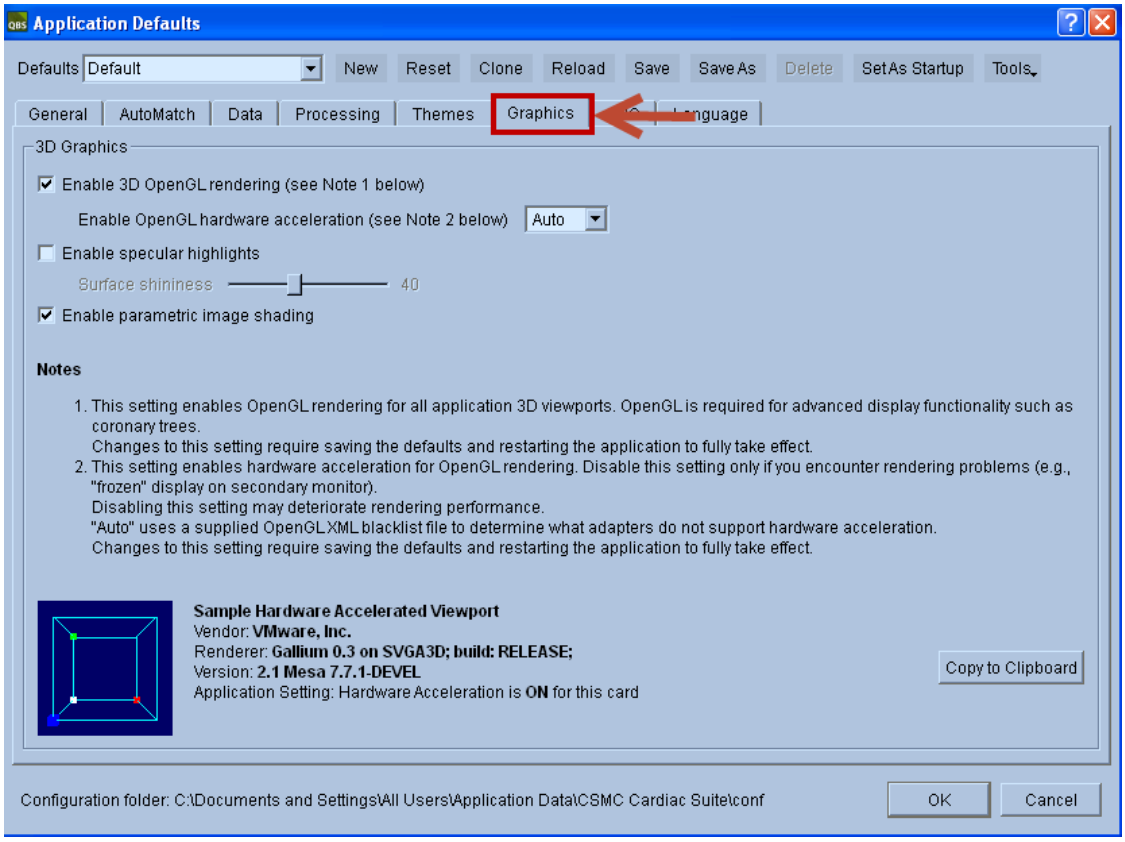


Figure 5.5. Graphics tab

5.6.1 Hardware rendering and acceleration

The Notes in the graphics tab help describe the OpenGL hardware rendering options. The viewport with the cube at the bottom left of the tab is active and can be used to determine what functionality is available on multiple monitors by dragging the **Defaults** dialog to another screen, then attempting to rotate the cube by left-dragging with the mouse. If the rotation succeeds, hardware acceleration is supported on that monitor. If the viewport appears frozen, hardware acceleration is not supported and should be disabled for this system, which will allow OpenGL viewport to function correctly on all monitors, trading rendering performance for compatibility.

It is also possible to use a configuration file to let the system decide whether to enable hardware acceleration or not "automatically." Acceleration will be enabled by default if the setting is set to **Auto**, unless the identifier of the graphics card is found in a "blacklist" file named **opengl.xml** and located in the system's configuration folder for CSMC software (listed at the bottom of the **Defaults** dialog after **Configuration folder**). The contents of this XML file look as follows:

```
<!DOCTYPE OpenGLRendererBlackList>
<OpenGLRendererBlackList>
 <Renderer Id="Implementation_String_1" />
 <Renderer Id="Implementation_String_2" />
 ...
 <Renderer Id="Implementation_String_n" />
</OpenGLRendererBlackList>
```

Where the line containing "Implementation_String_*x*" may be repeated for a variety of graphics adapters. A complete line can be obtained by clicking **Copy to Clipboard** in the **Graphics** tab. For the adapter in the graphics tab example above, the line with the implementation string should read

```
<Renderer Id="NVIDIA Corporation: GeForce 8800 GTS/PCI/SSE2" />
```

If the setting is **Yes**, hardware acceleration will be enabled whether the adapter's identification string is found in the blacklist file or not. This can be used for testing without requiring changes to the blacklist file.

5.6.2 Highlights and shading

The following figures show examples of parametrically-mapped perfusion surfaces with various settings for the graphics options.

NOTE: specular reflection and shading should be taken into account if parametric surfaces are evaluated. If such surfaces are used to assess the patient's condition, it is recommended to turn off parametric shading and specular reflections.

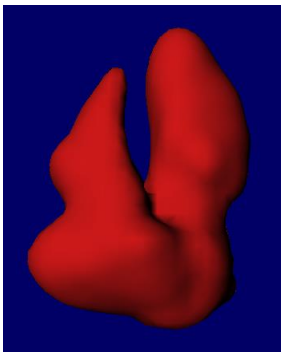


Figure 5.6. No specular reflection

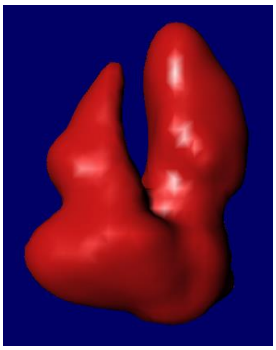


Figure 5.7. Specular reflection set to 100

Figure 5.6 and Figure 5.7 show blood pool isosurfaces rendered with and without specular reflection.

Figure 5.8, Figure 5.9, and Figure 5.10 show parametric surfaces rendered with and without hardware acceleration, and with and without parametric shading (when OpenGL is disabled).

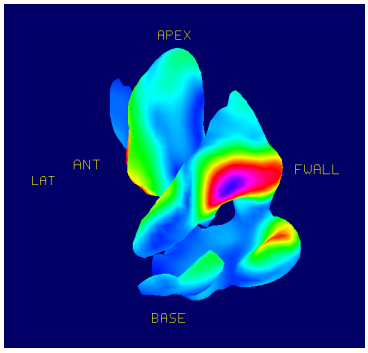


Figure 5.8. No hardware acceleration and no parametric shading

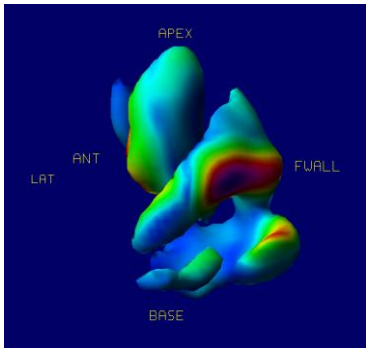


Figure 5.9. No hardware acceleration, parametric shading enabled

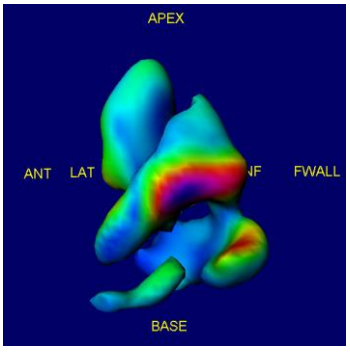
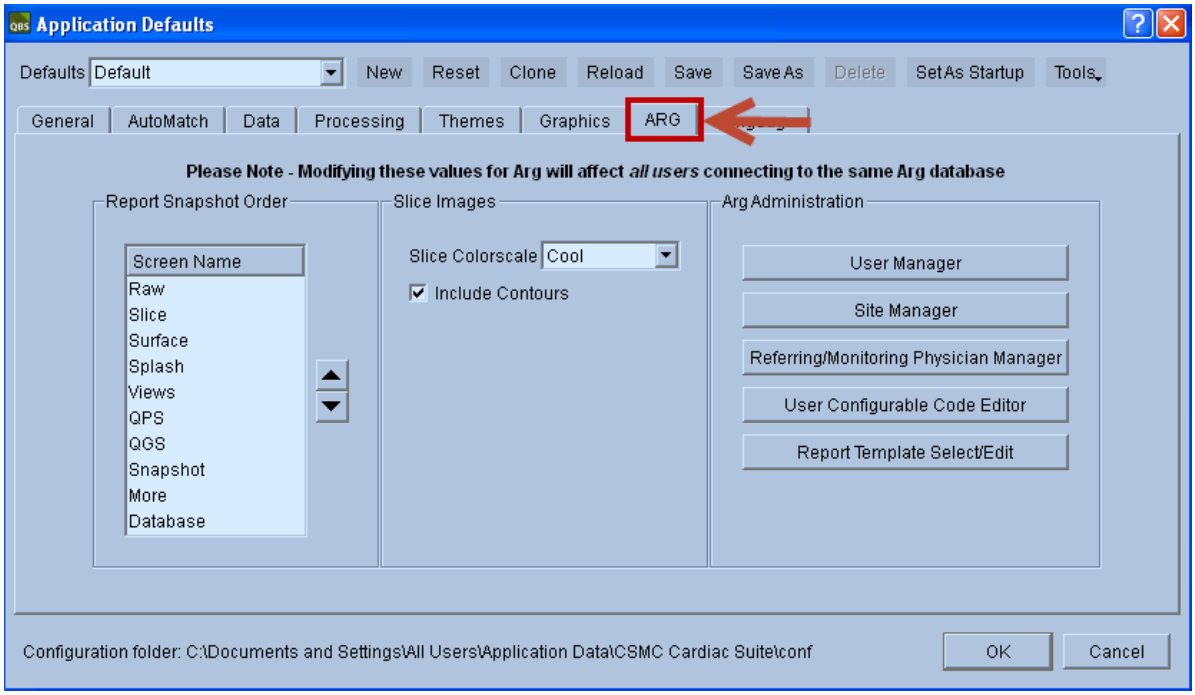


Figure 5.10. Hardware acceleration and parametric shading enabled

5.7 ARG settings

The **ARG** tab within the defaults editor contains options specifically pertaining to Cedars-Sinai's Automated Report Generator (ARG). This option may not be available on all platforms.



1. **Report Snapshot order** is the order in which captured snapshots should appear in the report. If multiple snapshots of the same page are included, they will be appended in the order they were created.
2. **Slice images** are automatically captured for all studies at the time of saving. These are included in the report by default, but can be removed, by creating a manual report and removing the slices from the perfusion page.
3. The **ARG Administration** section provides a method within QBS to access the QARG administrative features. For descriptions on the dialogs here, please refer to the administration section of the ARG reference manual.

5.8 Language Settings

The **Language** tab within the defaults editor can be used to localize the user interface to a non-english language. QBS supports a wide range of languages, including but not limited to: Chinese (Simplified), Czech, Danish, Dutch, English, Finnish, French, German, Hungarian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish, Turkish.

Note: Application must be restarted for the new language to take effect.

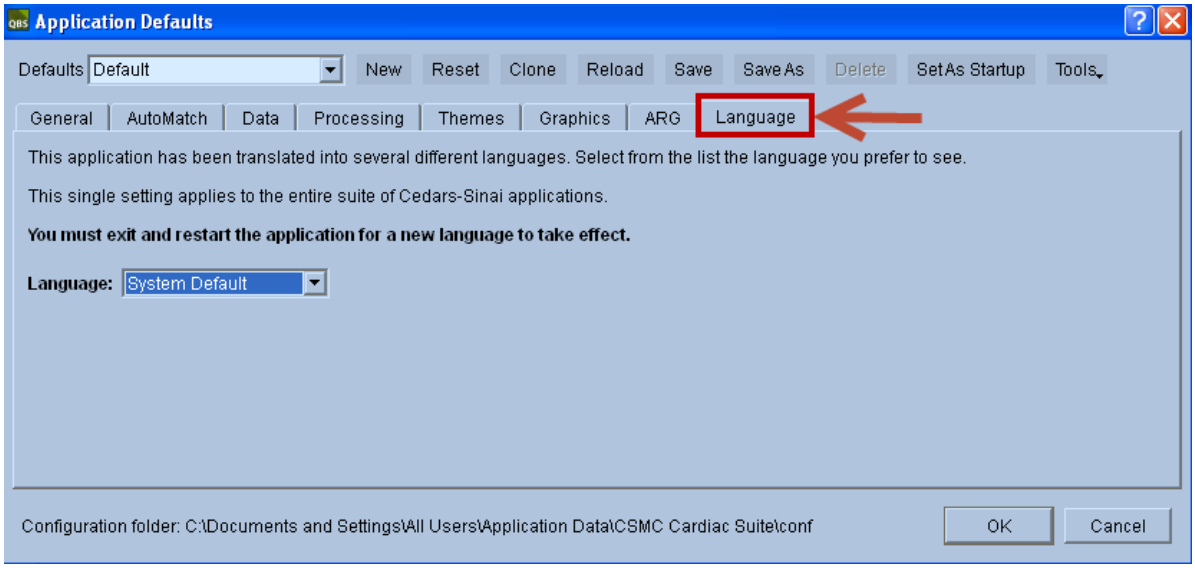


Figure 5.11. Language tab

To select the current language for the suite, follow these steps:

- choose the desired language from the Language drop-down selector;
- click OK;
- restart the application.

The new language setting will take effect when the application is restarted.

6 Planar Page

The **Planar** Page (Figure 6.1 and Figure 6.2) provides a cine display for one or more gated or summed projection datasets. It is the default QBS page when the application is started. One counts projection dataset is displayed. If there is more than one projection dataset in the patient folder, toggling the 1, 2, 3, 4 display setting toggles will display them. Also displayed with the projection data are the FFH Amplitude slice, the FFH Phase slice, and the FFH Phase histogram.

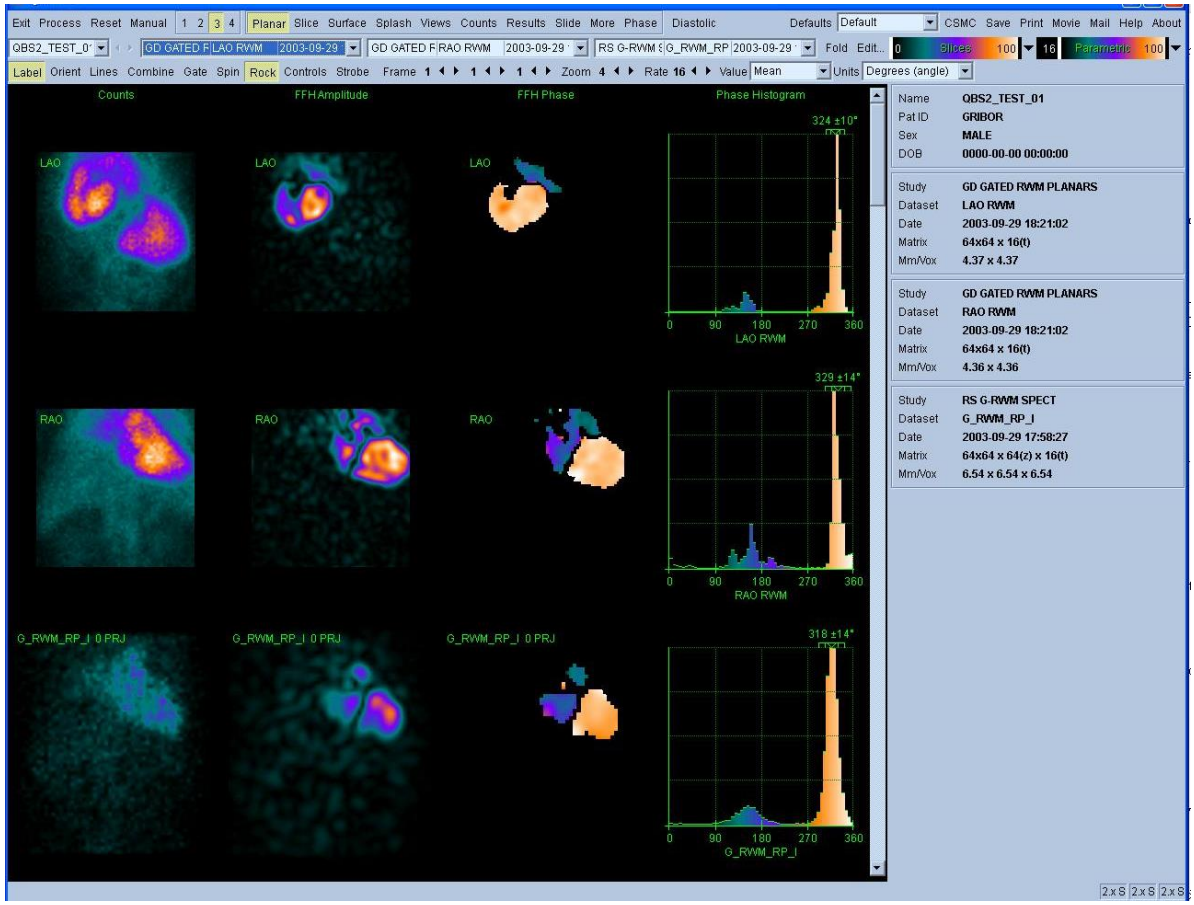


Figure 6.1. Planar Page

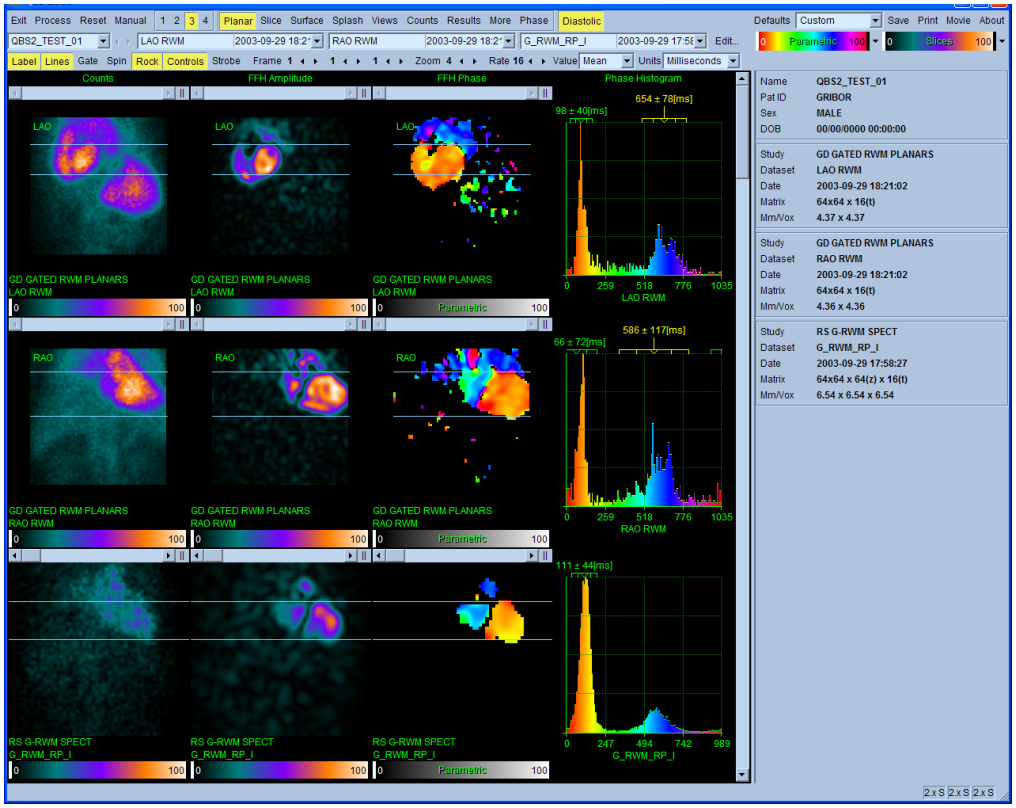


Figure 6.2. Planar Page with Lines and Controls enabled

6.1 Controls

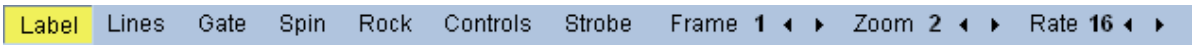


Figure 6.3. Page Control Bar – Planar Page

Label	Toggles slice labeling on and off. Slices labeling includes slice numbers and phase histogram grid and peak information.
Lines	Toggles motion reference lines.
Combine	Toggles combined display of FFH phase and amplitude.
Gate	Toggles temporal cine on and off.
Spin	Toggles cine on and off for the projection, FFH Amplitude, and the FFH Phase images.
Rock	Toggles bi-directional cine for sub 360° acquisitions (with Spin also enabled).
Controls	Toggles display of individual frame and color scale mapping controls.
Strobe	Toggles display of contraction patterns in FFH phase images and phase histograms. Use with Gate toggle enabled.
Frame	Selects current image gating frame or, when Gate enabled, shows a running display of frames.

Zoom	Selects the projection zoom.
Rate	Selects the cine speed.

7 Slice Page

In **1** (single) display mode, the **Slice** Page (Figure 7.1) displays six slices from the current dataset, three short axes, two vertical long axes, and one horizontal long axis. These slices can be interactively selected through the movement of their corresponding slice reference lines in orthogonal views. In particular, the three short axis slices can be selected by dragging their corresponding slice reference lines in the horizontal and vertical long axis viewports and the vertical and horizontal long axis slices can be selected by dragging their corresponding slice reference lines in the short axis viewports. The short axis views are always sorted so that the sequence from left to right is apical to basal. Whenever additional information is available about ventricular geometry, i.e. when processed results are available (Figure 7.2), slices are automatically evenly distributed across the LV and RV.

In **1** (single) display mode (Figure 7.2), six slices per dataset will be displayed with the short axis sequence (3 images) from left to right being apical to basal (top row), the bottom row consisting of a horizontal and two vertical long axis images.

In **2** (dual) display mode (Figure 7.3), the display is divided in two with one dataset on the left side and another on the right side. The six slices per dataset are displayed with the short axis sequence from top to bottom being apical to basal.

In **3** or **4** display mode the five slices per dataset are displayed horizontally (1 dataset per row) with the three short axis datasets from left to right being apical to basal. Figure 7.4 shows an example of 3 display mode.

Note that the volume curves are not displayed when 2, 3, or 4 display mode is selected. (see Figure 7.3 and Figure 7.4)

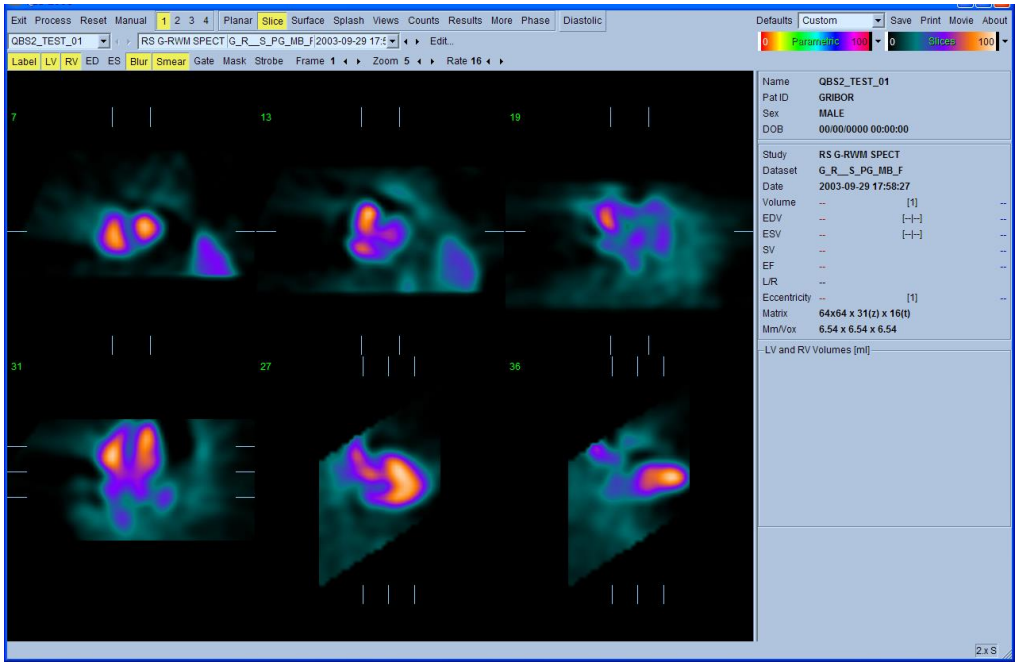


Figure 7.1. Slice page before processing

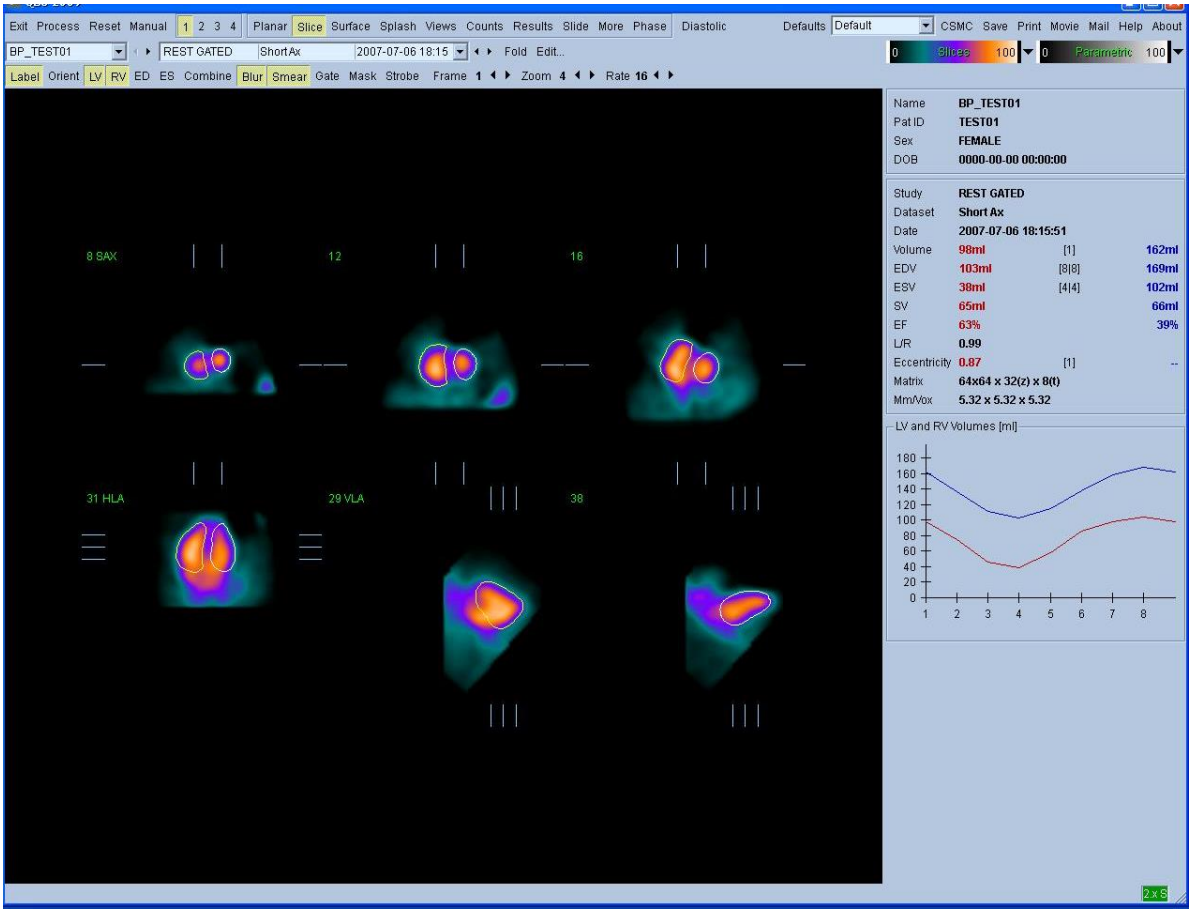


Figure 7.2. Slice page after processing with LV and RV contours enabled (1 display mode)

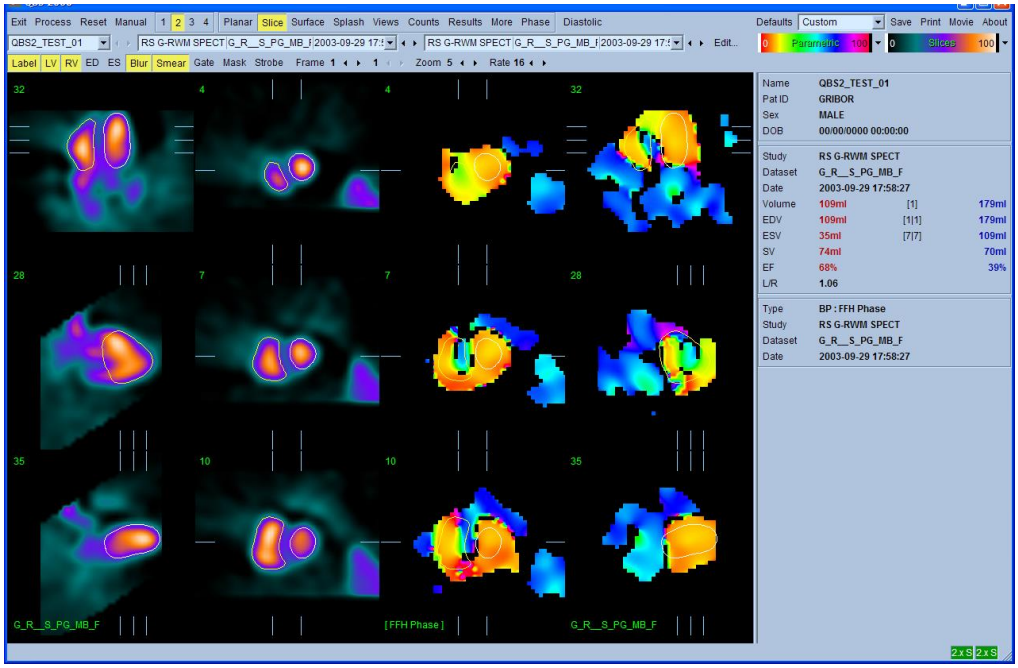


Figure 7.3. Slice page with 2 display mode

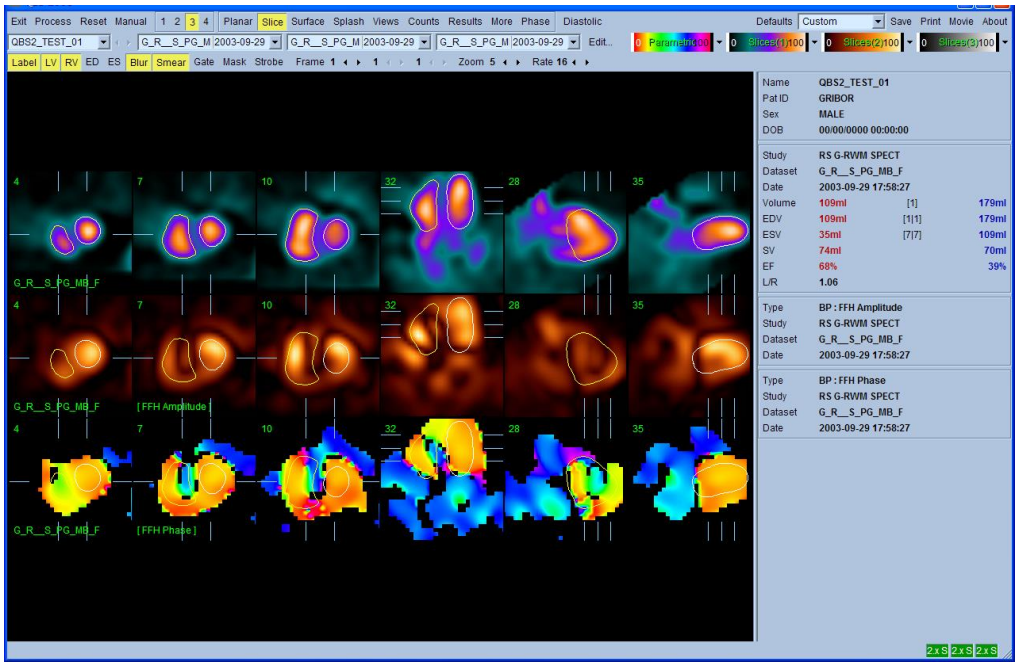


Figure 7.4. Slice page with 3 display mode and split color scales

Figure 7.5. Page Control Bar – Slice Page

7.1 Controls

Label	Turns slice labeling on and off. Slices labeling includes slice numbers and slice reference lines.
LV	Turns LV contour display on and off, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
RV	Turns RV contour display on and off, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
ED	Toggles ED contour lock. When on, ED contour overlays are displayed for every gate interval.
ES	Toggles ES contour lock. When on, ES contour overlays are displayed for every gate interval.
Combine	Toggles combined display of FFH phase and amplitude.
Blur	Turns temporal smoothing on and off. Blur, if enabled, is a 1-2-1 smoothing kernel that wraps around the last interval.
Smear	Turns spatial smoothing on and off. Smear, if enabled, applies a spatial smoothing algorithm (1-2-1 spatial z-axis filter) to all images on the screen.
Gate	Turns temporal cine on and off.
Mask	Turns masking of ventricular voxels used in counts calculations on and off.

Strobe	Toggles display of contraction patterns in FFH phase images. Use with Gate toggle enabled. It is functional only if a short axis FFH Phase dataset is displayed along with the gated short axis dataset.
Frame	Selects current image gating frame or, when Gate enabled, shows a running display of frames. If there is more than one dataset displayed, the number of Frame selectors present on the page control bar is adjusted to one per displayed dataset.
Zoom	Selects the slice zoom.
Rate	Selects the cine speed.

8 Splash Page

The **Splash** Page (Figure 8.1) displays 32 slices from the current dataset, 16 short axes, 8 vertical long axes, and 8 horizontal long axes. These slices are always uniformly spaced and maintained in the following sequences:

Short axis	Apical to basal.
Horizontal long axis	Inferior to superior.
Vertical long axis	Septal to lateral.

These slices can be interactively selected through either the movement of their corresponding scrollbars or by dragging of slice reference crosshairs in orthogonal views. These crosshairs are only visible while the left mouse button is depressed in a viewport. The central slice of orthogonal slice sequences is set according to the position of these crosshairs, with the rest of the slices in the sequences adjusted to maintain uniform slice spacing. Section 3.2.6 of the Tutorial describes the use of the Popout feature to zoom in on selected slices for closer inspection.

In **2** (dual) display mode, images will be displayed in interleaved fashion for the two datasets (Figure 8.2). In essence, the first dataset to appear in the Info box will correspond to rows 1, 3, 5 and 7 of the display, the second dataset to rows 2, 4, 6 and 8. Both datasets ought to be well aligned; in case it were desired to shift a dataset by one or more slices, however, this can be achieved by clicking and dragging the appropriate scrollbars to the right of the images.

In **3** or **4** display mode, images are displayed in row format (interleaved) with 12 slices per dataset being displayed in any particular row. Figure 8.3 shows an example of 3 display mode

Note that the volume curves are not displayed when 2, 3, or 4 display mode is selected.

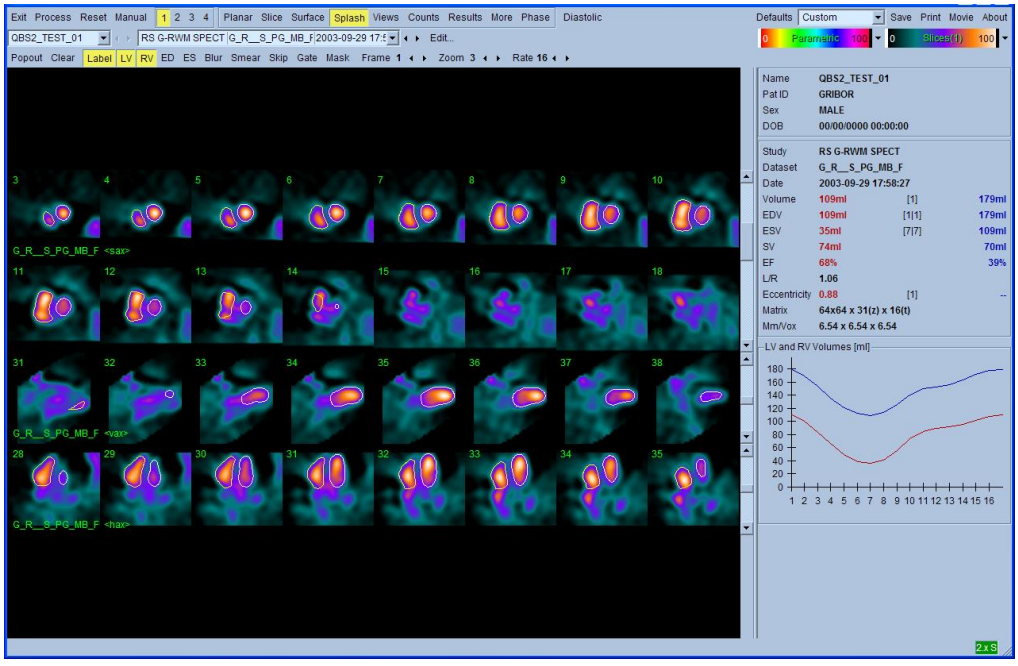


Figure 8.1. Splash Page (1 display mode)

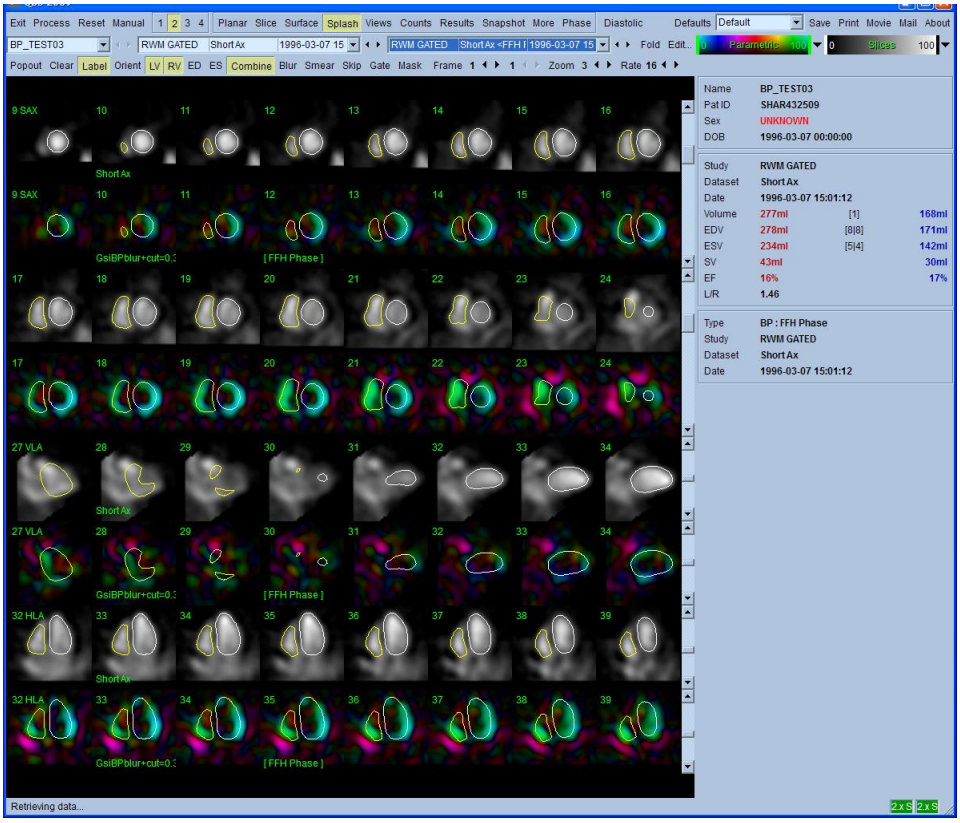


Figure 8.2. Splash page in 2 display mode (Combine on)

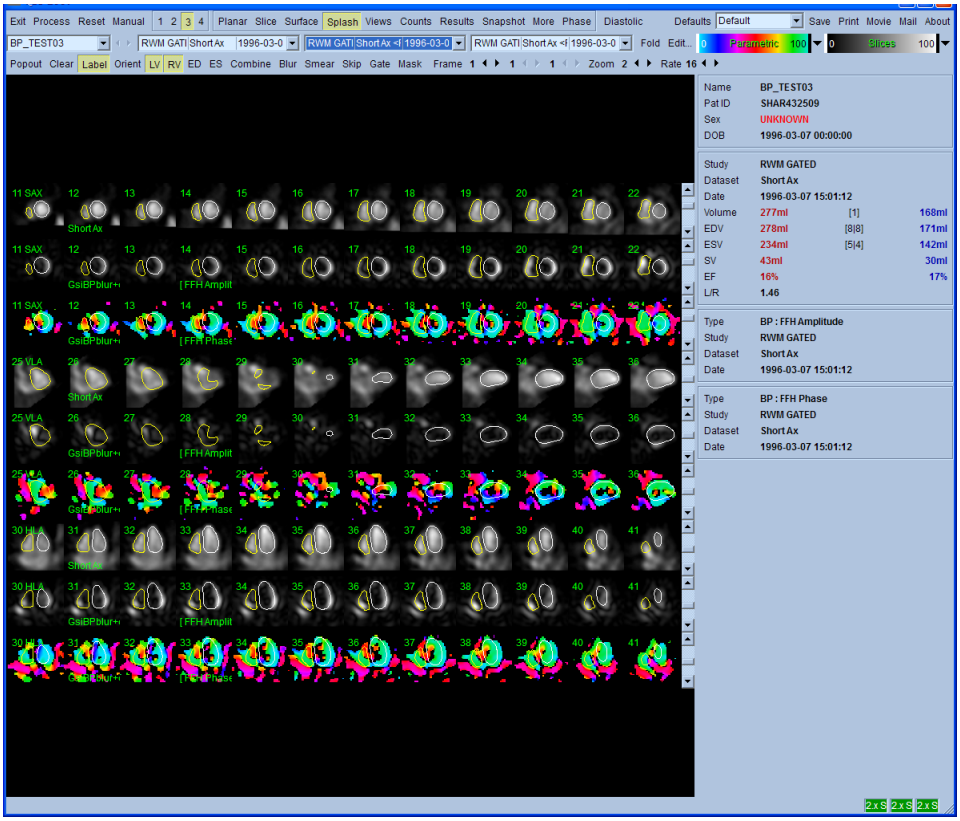


Figure 8.3. Splash Page in 3 display mode (Combine off)

Figure 8.4. Page Control Bar – Splash Page

8.1 Controls

Popout	Allows the selection of fewer than 32 slices (by right-clicking to select slices), and displays them with increased zoom.
Clear	Clears (de-selects) all slices that were selected for the Popout feature.
Label	Turns slice labeling on and off. Slices labeling includes slice numbers.
LV	Turns LV contour display on and off, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
RV	Turns RV contour display on and off, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
ED	Toggles ED contour lock. When on, ED contour overlays are displayed for every gate interval.
ES	Toggles ES contour lock. When on, ES contour overlays are displayed for every gate interval.
Combine	Toggles combined display of FFH phase and amplitude.

Blur	Turns temporal smoothing on and off. Blur, if enabled, is a 1-2-1 smoothing kernel that wraps around the last interval.
Smear	Turns spatial smoothing on and off. Smear, if enabled, applies a spatial smoothing algorithm (1-2-1 spatial z-axis filter) to all images on the screen.
Skip	Toggles display of every other slice.
Gate	Turns temporal cine on and off.
Mask	Turns masking of ventricular voxels used in counts calculations on and off.
Frame	Selects current image gating frame or, when Gate enabled, shows a running display of frames. If there is more than one dataset displayed, the number of Frame selectors present on the page control bar is adjusted to one per displayed dataset.
Zoom	Selects the slice zoom.
Rate	Selects the cine speed.

9 Surface Page

The **Surface** Page (Figure 9.1) displays a single surface-rendered image of the LV and RV endocardial walls, if processed results are available. This surface image can be reoriented either by left-dragging the image or by selecting one of the preset orientations. When left-dragging the image it behaves as if contained within a sphere that can be rotated in any plane as the pointer traverses its surface. In **2**, **3** or **4** display mode, 2, 3 or 4 surfaces are displayed to the same physical scale. Selecting one of the preset views will re-center the surfaces.

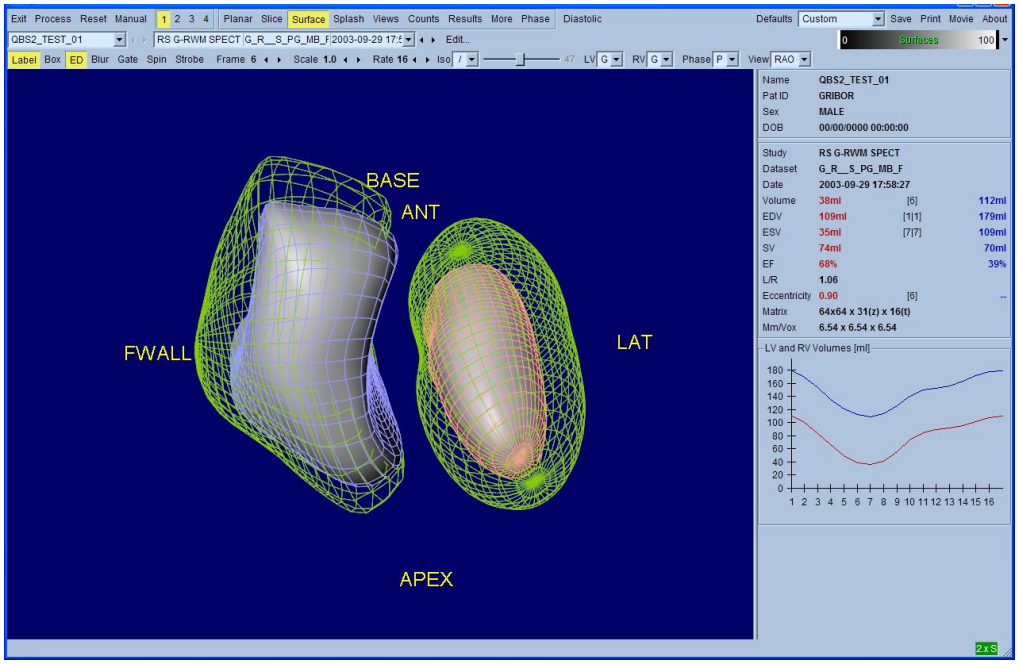


Figure 9.1. Surface Page

Figure 9.2. Page Control Bar – Surface Page

9.1 Controls

Label	Toggles surface image labeling on and off. This labeling consists of the following orientation tags: ANT (anterior), LAT (lateral), INF (inferior), FWALL (septal), APEX (apical), and BASE (basal), and the orientation box whose faces correspond to these tags.
Box	Toggles the orientation box, each face of which corresponds to one of the orientation tags.
ED	Toggles ED lock on and off. When on, the ED surface is displayed as a superimposed wire frame irrespective of the current interval.
Combine	Toggles combined display of FFH phase and amplitude.

Blur	Toggles temporal 1-2-1 smoothing of the data on and off. Used to provide nicer isosurfaces when Iso is set to Shaded or Parametric.
Gate	Turns temporal cine on and off.
Spin	Turns spatial cine on and off. When on, the surface image rotates about the vertical axis.
Strobe	Toggles display of contraction patterns on parametric surfaces. Use with Gate toggle enabled. Parametric surface for LV or RV or both must be selected.
Frame	Sets current image gating frame or, when Gate enabled, shows a running display of frames. If there is more than one dataset displayed, the number of Frame selectors present on the page control bar is adjusted to one per displayed dataset.
Scale	Selects the surface image scale, normalized so that a scale of 1.0 fills most of the viewport.
Rate	Selects the cine (temporal and spatial) speed.
Iso	Selects isosurface to display. Choices are Off, Shaded, or Parametric. The isosurface level can be adjusted using the "slider". The slider sets the isosurface level as a percentage of the maximum voxel count of the current time interval.
LV	Provides different viewing modes for the LV surface: Off (do not display that surface), Mesh (wire frame surface), Shaded (solid surface), Grid (solid surface with overlaid wire frame), Parametric (see Fourier selector).
RV	Provides different viewing modes for the LV surface: Off (do not display that surface), Mesh (wire frame surface), Shaded (solid surface), Grid (solid surface with overlaid wire frame), Parametric (see Fourier selector).
Fourier	When using the parametric mode (from Iso, LV, or RV controls above), the user can select between FFH amplitude, FFH phase, and VCC as the parameter.
View	Sets the display orientation. Choices (described below) are; ANT, LAT, INF, FWL, APX, BAS, LAO, RAO, and ECH.
ANT	Sets the orientation so that the anterior wall is facing forward.
LAT	Sets the orientation so that the lateral wall is facing forward.
INF	Sets the orientation so that the inferior wall is facing forward.
FWL	Sets the orientation so that the RV free wall is facing forward.
APX	Sets the orientation so that the apex is facing forward.
BAS	Sets the orientation so that the base is facing forward.
LAO	Sets the orientation to approximate a left anterior oblique view. The specific orientation angles are generic (i.e. independent of dataset).
RAO	Sets the orientation to approximate a right anterior oblique view. The specific orientation angles are generic (i.e. independent of dataset).

ECH	Sets the orientation to approximate one typically seen in ultrasound. The specific orientation angles are generic (i.e. independent of dataset).

10Views Page

In **1** (single) display mode, the Views Page (Figure 10.1) displays six surface-rendered images of the LV and RV endocardial walls, if processed results are available. These surface images can be reoriented by left-dragging the image. When left-dragging an image it behaves as if contained within a sphere that can be rotated in any plane as the pointer traverses its surface. The images are displayed in a two row by three column grid. Each column forms a pair of images, the top being at end-diastole and the bottom at the current interval that share the same orientation. Clicking the Gate toggle will cine the bottom set of images. Whenever the orientation of one image in such a pair is modified, the orientation of its corresponding image is updated so that they remain the same, allowing for side by side comparison. In **2**, **3**, or **4** display mode, three viewports are used for each dataset. Whenever the orientation of one image in a column of viewports is modified, the orientation of its corresponding images is updated so that they remain the same, allowing for side-by-side (top-bottom) comparison. If some of the datasets are gated, clicking the **Gate** toggle will cine all gated sets of images.

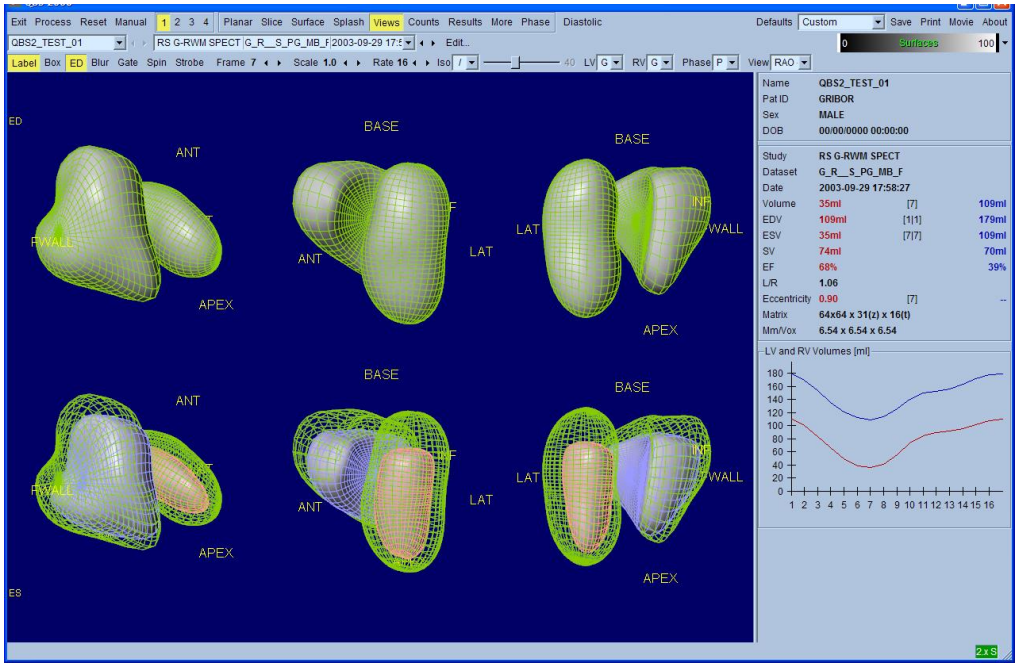


Figure 10.1. Views Page

Figure 10.2. Page Control Bar – Views Page

10.1 Controls

Label	Toggles surface image labeling on and off. This labeling consists of the following orientation tags: ANT (anterior), LAT (lateral), INF (inferior),

	FWALL (septal), APEX (apical), and BASE (basal), and the orientation box whose faces correspond to these tags.
Box	Toggles the orientation box, each face of which corresponds to one of the orientation tags.
ED	Toggles ED lock on and off. When on, the ED surface is displayed as a superimposed wire frame irrespective of the current interval.
Combine	Toggles combined display of FFH phase and amplitude.
Blur	Toggles temporal 1-2-1 smoothing of the data on and off. Used to provide nicer isosurfaces when Iso is set to Shaded or Parametric.
Gate	Turns temporal cine on and off.
Spin	Turns spatial cine on and off. When on, the surface image rotates about the vertical axis.
Strobe	Toggles display of contraction patterns on parametric surfaces. Use with Gate toggle enabled. Parametric surface for LV or RV or both must be selected.
Frame	Sets current image gating frame or, when Gate enabled, shows a running display of frames. If there is more than one dataset displayed, the number of Frame selectors present on the page control bar is adjusted to one per displayed dataset.
Scale	Selects the surface image scale, normalized so that a scale of 1.0 fills most of the viewport.
Rate	Selects the cine (temporal and spatial) speed.
Iso	Selects isosurface to display. Choices are Off, Shaded, or Parametric. The isosurface level can be adjusted using the "slider". The slider sets the isosurface level as a percentage of the maximum voxel count of the current time interval.
LV	Provides different viewing modes for the LV surface: Off (do not display that surface), Mesh (wire frame surface), Shaded (solid surface), Grid (solid surface with overlaid wire frame), Parametric (see Fourier selector).
RV	Provides different viewing modes for the LV surface: Off (do not display that surface), Mesh (wire frame surface), Shaded (solid surface), Grid (solid surface with overlaid wire frame), Parametric (see Fourier selector).
Fourier	When using the parametric mode (from Iso, LV, or RV controls above), the user can select between FFH amplitude, FFH phase, and VCC as the parameter.
View	Sets the display orientation. Choices (described below) are; ANT, LAT, INF, FWL, APX, BAS, LAO, RAO, and ECH.
ANT	Sets the orientation so that the anterior wall is facing forward.
LAT	Sets the orientation so that the lateral wall is facing forward.
INF	Sets the orientation so that the inferior wall is facing forward.
FWL	Sets the orientation so that the RV free wall is facing forward.

APX	Sets the orientation so that the apex is facing forward.
BAS	Sets the orientation so that the base is facing forward.
LAO	Sets the orientation to approximate a left anterior oblique view. The specific orientation angles are generic (i.e. independent of dataset).
RAO	Sets the orientation to approximate a right anterior oblique view. The specific orientation angles are generic (i.e. independent of dataset).
ECH	Sets the orientation to approximate one seen in ultrasound. The specific orientation angles are generic (i.e. independent of dataset).

11 Results Page

The **Results** Page (Figure 11.1) contains a summary of information with an emphasis on functional data and processed results for a single short axis dataset (**2**, **3** or **4** display mode is not supported). This information is divided into the following sections: slices, surfaces, polar maps, and statistics (descriptions start at Section 0).

11.1 Calculation Methods

QBS provides three methods of calculating values:

1. Surfaces (**S**): volumes are computed from the 3D surfaces and ejection fraction (EF) is calculated from the volumes.
2. Count-Based Calculations (**C**): EF is calculated from the counts ratio and the end-diastolic volume (EDV) is calculated using the number of voxels in the LV and RV regions of interest (ROIs). All other volumes are derived by scaling the EDV using count ratios.
3. Count-Based Volumes (**V**): all volumes are calculated using the number of voxels in the LV and RV ROIs, and the EF is derived from the volumes.

The default calculation method used is set in the Application Defaults editor discussed in Section 6 of this manual. After processing, all QBS pages except Snapshot and More will show the results in the Info box area. The bottom right corner of the Main page contains an indicator showing the version of the QBS program used and the calculation method (Figure 11.2). For example, "**2.x S**" displayed in the indicator, informs the user that QBS version 2.0 or later (the "**2.x**") was used and the Surfaces (the "**S**") method was used to compute the results.

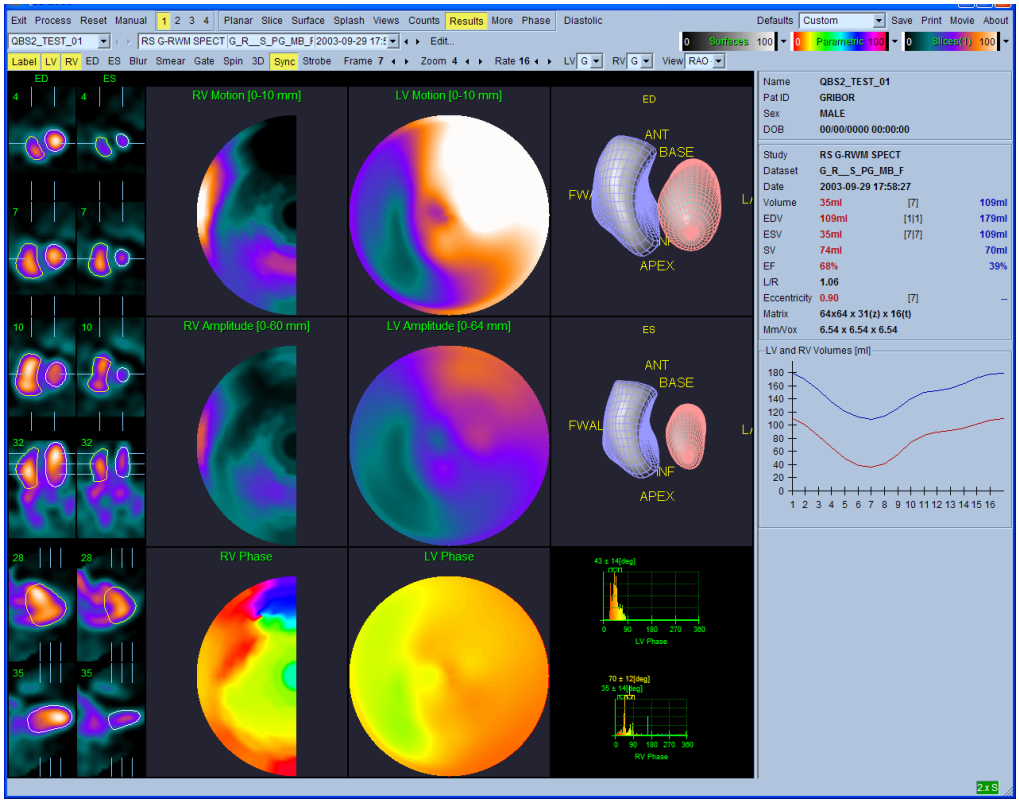


Figure 11.1. Results Page

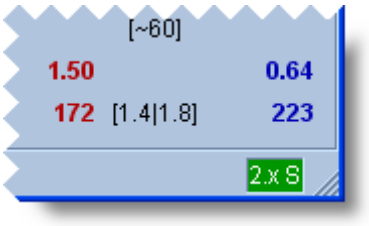


Figure 11.2. Version/algorithm indicator

11.2 Slices Section

The Slices Section presents information in the same manner as the Slice Page. Two sets of six slices, (typically, one at ED and the other at ES, each containing three short axes, one horizontal long axis, and two vertical long axis) are displayed side by side in a two column by six row grid. Each slice can be interactively selected by left-dragging its corresponding slice reference lines in orthogonal views. Selecting one slice automatically selects the same slice in its corresponding view, allowing for side by side comparison. Clicking the **Gate** toggle starts and stops a cine of the five right hand side slices.

11.3 Polar Maps Section

The Polar Maps Section contains two motion polar maps (LV and RV), two FFH Amplitude polar maps (LV and RV), and two FFH Phase polar maps (LV and RV). The LV polar maps are mapped in standard fashion, with the center corresponding to the LV apex and left, right, top, and bottom corresponding respectively to the septal, lateral, anterior, and inferior walls. The RV free wall maps

are mapped in a similar fashion, but since only the free wall is represented, only half a disc is displayed. The mapping is as follows: apex at the center of the disc, free wall to the left, anterior and inferior walls at the top and bottom respectively. Motion is displayed in the polar maps in a range from 0 to 10 millimeters (corresponding to the bottom and top of the color scale), while FFH Amplitude is scaled to the maximum amount of motion. Paradoxical motion is counted as zero (black in most color maps) in the motion maps, but may have a non-zero amplitude in the FFH Amplitude map, along with an out-of-phase FFH Phase.

11.4 Surfaces Section

The Surfaces Section shows two views of the LV and RV surfaces similar to the Surface and Views pages. The top view displays surface-rendered images for the LV and RV at end-diastole. The bottom view displays surface-rendered images for the LV and RV at end-systole. If the **Gate** toggle is enabled the bottom surface view will show a cine of the cardiac cycle. The surface displayed can be independently set for the LV and RV by choosing a surface from the LV and RV selection drop-down menus. Left-dragging in a surface will cause that view to be rotated, or both views to be rotated if the Sync toggle is enabled (default behavior). The polar maps can also be displayed as parametrically mapped surfaces by using the **3D** toggle.

11.5 Statistics Section

The Statistics Section contains generated results from the QBS algorithms. In particular, the following global LV and RV ventricular function parameters are displayed as well as the LV and RV volume curves (Figure 11.3). When the **Diastolic** toggle is enabled, the volume curves are replaced by LV and RV volume and filling curves. LV and RV diastolic results are displayed below these curves (the user may have to scroll down the Info box to see all the diastolic numbers). Figure 11.4 shows the statistics section when the **Diastolic** toggle is enabled.

Global Results	
Volume	LV chamber volume (in ml.) of the current gating interval.
EDV	LV chamber volume (in ml.) at end-diastole.
ESV	LV chamber volume (in ml.) at end-systole.
SV	Stroke volume (in ml.). (SV = EDV-ESV)
EF	Ejection fraction.
L/R	LV/RV stroke volume ratio.
Eccentricity*	LV eccentricity index.
Matrix	Slice width, height, depth (z) in voxels, and time bins (t) (ie. gating intervals).
Mm/Vox	Millimeters per voxel.

* Eccentricity is a measure of the elongation of the LV, and varies from 0 (sphere) to 1 (line); it is calculated from the major axis *Rz* and the minor axes *Rx* and *Ry* of the ellipsoid that best fits the endocardial surface, according to the formula:

$$Ecc = \sqrt{1 - \frac{Rx \cdot Ry}{Rz^2}}$$

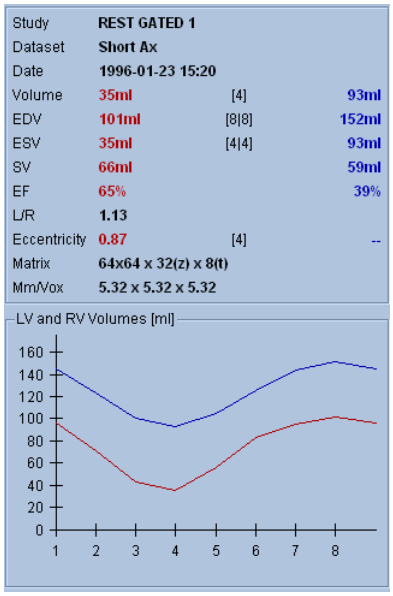


Figure 11.3. Global statistics

Diastolic Results	
PER	Peak emptying rate.
PFR	Peak filling rate.
PFR2	Secondary peak filling rate (empty if the 1st derivative of the time-volume curve only has one maximum).
HR	Heart rate in beats per minute (if available).
MFR/3	Mean filling rate over the first third of the end-systolic to end-diastolic phase.
TTPF	Time to peak filling from end-systole.

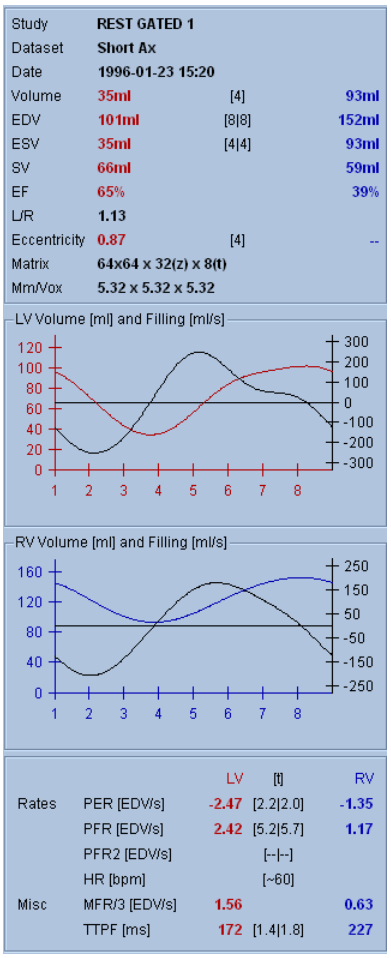


Figure 11.4. Diastolic function statistics

In Figure 11.3 and Figure 11.4 the LV volume curve is displayed in red and the RV volume curve in blue. The filling curves are displayed in black. The numeric results for the LV and RV are also in red and blue, respectively.

Figure 11.5. Page Control Bar – Results Page

11.6 Controls

Label	Turns slice labeling on and off. Slices labeling includes slice numbers and slice reference lines.
LV (toggle)	Turns LV contour display on and off in the slices section, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
RV (toggle)	Turns RV contour display on and off in the slices section, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.

ED	Toggles ED contour lock. When on, ED contour overlays are displayed for every gate interval in the slices section. In the surfaces section, the ED surface is displayed as a superimposed wire frame irrespective of the current interval.
ES	Toggles ES contour lock. When on, ES contour overlays are displayed for every gate interval in the slices section.
Blur	Turns temporal smoothing on and off. Temporal smoothing, if enabled, is a 1-2-1 smoothing kernel that wraps around the last interval.
Smear	Turns spatial smoothing on and off. Spatial smoothing, if enabled, is a 1-2-1 smoothing kernel.
Gate	Turns temporal cine on and off.
Spin	Turns spatial cine on and off. When on, all displayed surface images rotate about the vertical axis.
3D	Toggles display of Polar maps or parametrically mapped surfaces of the corresponding ventricles. See Figure 25c.
Sync	Turns synchronization of surface views on and off. When on, surfaces in the results page are rotated simultaneously when the user clicks and drags on one of them. When off, each surface can be rotated independently, except for the LV and RV parametrically mapped surfaces (displayed when 3D is on) which are rotated as groups (one per ventricle).
Strobe	Toggles display of contraction patterns on the RV and LV FFH Phase polar maps and parametric surfaces when 3D enabled. Use with Gate toggle enabled.
Frame	Selects the currently displayed gating interval in the slices and surfaces sections.
Zoom	Selects the slice zoom in the slices section.
Rate	Selects the cine (temporal and spatial) speed.
LV (drop-down)	Selects the surface display for the LV in the surfaces section. Choices are; Off (do not display that surface), Mesh (wire frame surface), Shaded (solid surface), Grid (solid surface with overlaid wire frame).
RV (drop-down)	Selects the surface display for the RV in the surfaces section. Choices are; Off (do not display that surface), Mesh (wire frame surface), Shaded (solid surface), Grid (solid surface with overlaid wire frame).
View	Sets the display orientation for all surface images. Choices are; ANT, LAT, INF, FWL, APX, BAS, LAO, RAO, and ECH.

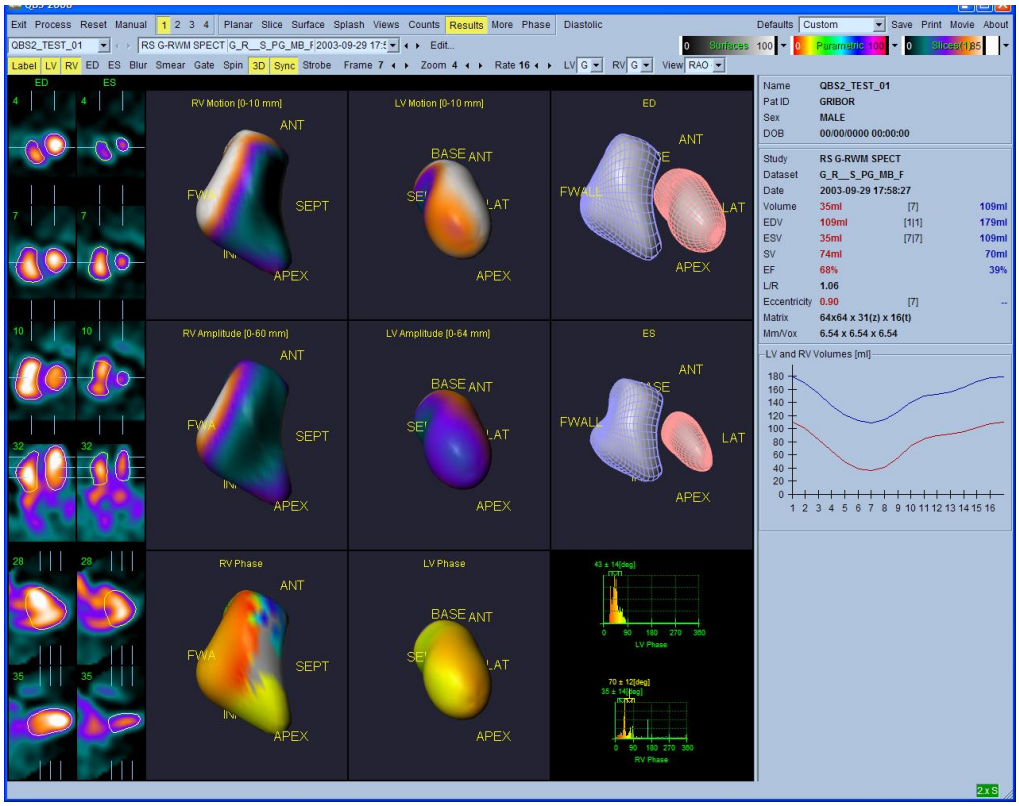


Figure 11.6. Results Page with 3D enabled

12Counts Page

The Counts Page displays the results of the two Count-based methods discussed in Section 12. Descriptions of the page areas follow.

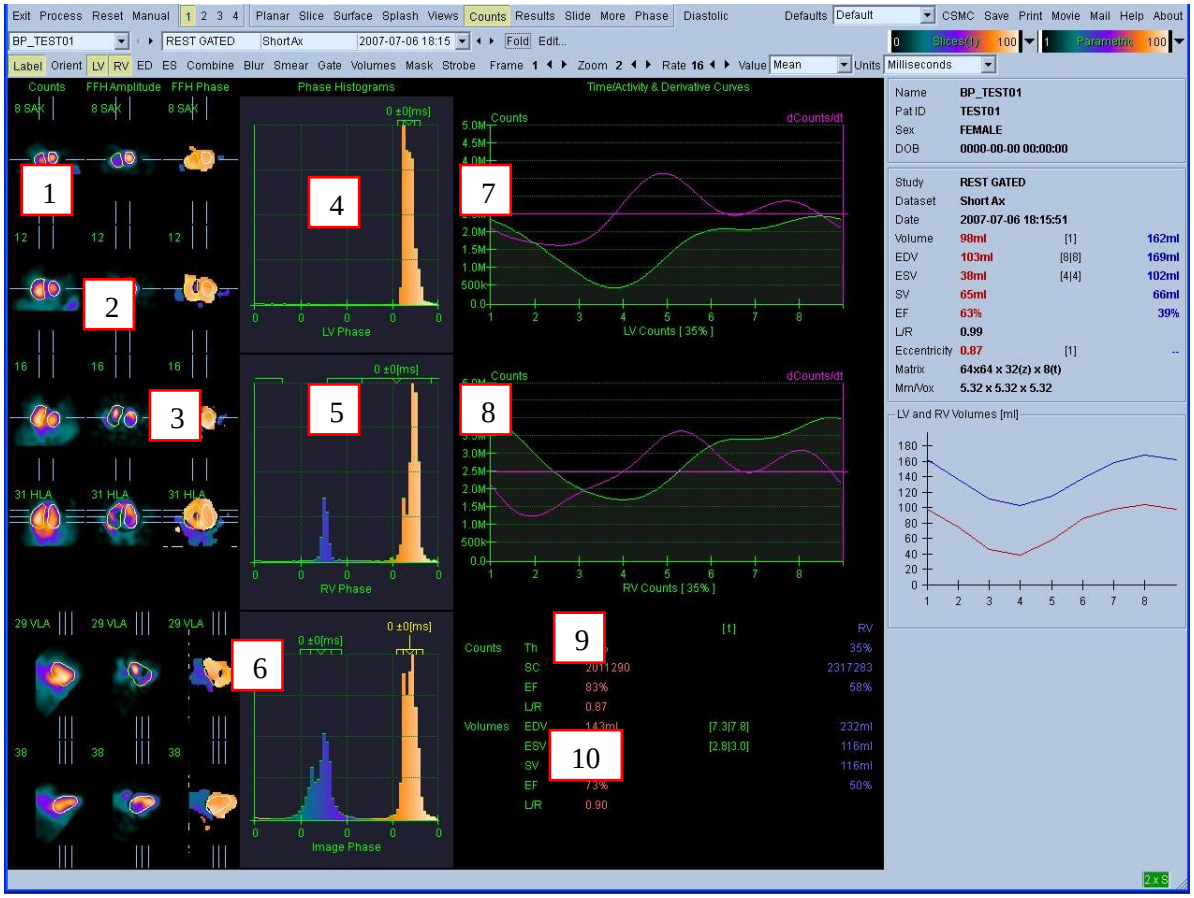


Figure 12.1. Counts Page

1	Original data	Slices section
2	FFH amplitude data	
3	FFH phase data	
4	LV Phase histogram	
5	RV Phase histogram	
6	Short Axis volume Phase histogram	
7	LV Time/Activity (green) and first derivative (purple) curves	
8	RV Time/Activity (green) and first derivative (purple) curves	
9	Count-based calculation (C) results (may be different than Count-based volume results (10)	
10	Count-based volume (V) results (may be different than Count-based calculation results (9)	

Default calculation results (S, C, or V) as displayed in the Version and Calculation method indicator (see Figure 11.2 for its location).

Toggling the **Volumes** button on the page control bar will display the LV and RV time-volume curves (derived from the count-based ROIs) instead of the LV and RV time-activity curves. Count-based volumes are determined by multiplying the number of voxels above the specified threshold by the voxel volume. Count-based values are obtained by summing voxel values directly, if the voxel value is above the specified threshold. The threshold is set in the Application Defaults editor as described in Section 5.1 of this manual.

A summary of the results displayed are listed in the following table.

Count-based values	
Th	Threshold used for the calculations.
SC	LV and RV stroke count.
EF	LV and RV diastolic volumes.
L/R	LV/RV stroke count ratio.
Count-based volume-derived values	
EDV	LV and RV diastolic volumes.
ESV	LV and RV systolic volumes.
SV	LV and RV stroke volumes.
EF	LV and RV diastolic volumes.
L/R	LV/RV stroke volume ratio.

Figure 12.2. Page Control Bar – Counts Page

12.1 Controls

Label	Turns slice labeling on and off. Slice labeling includes slice numbers and slice reference lines.
LV	Turns LV contour display on and off in the slices section, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
RV	Turns RV contour display on and off in the slices section, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
ED	Toggles ED contour lock. When on, ED contour overlays are displayed for every gate interval in the slices section.
ES	Toggles ES contour lock. When on, ES contour overlays are displayed for every gate interval in the slices section.
Combine	Toggles combined display of FFH phase and amplitude.

Blur	Turns temporal smoothing on and off. Temporal smoothing, if enabled, is a 1-2-1 smoothing kernel that wraps around the last interval.
Smear	Turns spatial smoothing on and off. Spatial smoothing, if enabled, is a 1-2-1 smoothing kernel.
Gate	Turns temporal cine on and off.
Volumes	Toggles display of LV and RV time-volume curves versus LV and RV time-activity curves.
Mask	Turns masking of ventricular voxels (in the Slices section) used in counts calculations on and off.
Strobe	Toggles display of contraction patterns on the RV and LV FFH Phase data (in the Slices section) and in the Phase histograms section. Use with Gate toggle enabled.
Frame	Selects the currently displayed interval in the slices and surfaces sections.
Zoom	Selects the slice zoom in the slices section.
Rate	Selects the cine (temporal and spatial) speed.

13Phase page

In **1** (single) display mode, the **Phase** Page (Figure 13.1) displays two 3D viewports for the current dataset (one for the LV and one for the RV), two global phase histograms (LV, RV), and five regional phase histograms (LV: septum, anterior wall, lateral wall, inferior wall; RV: free wall). A label is displayed below each histogram to help the user identify them.

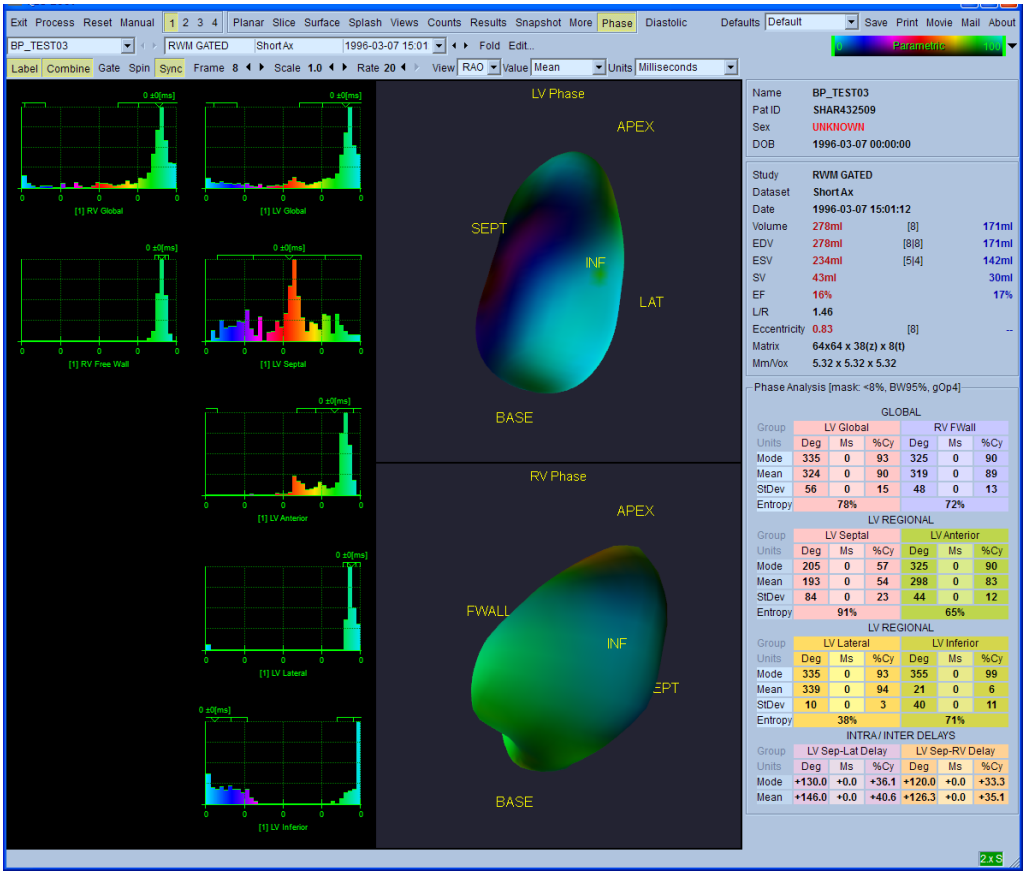


Figure 13.1. Phase page in single mode

In **2** (dual) display mode (Figure 13.2), the display is mirrored to allow the comparison of phase histograms for the two selected datasets.

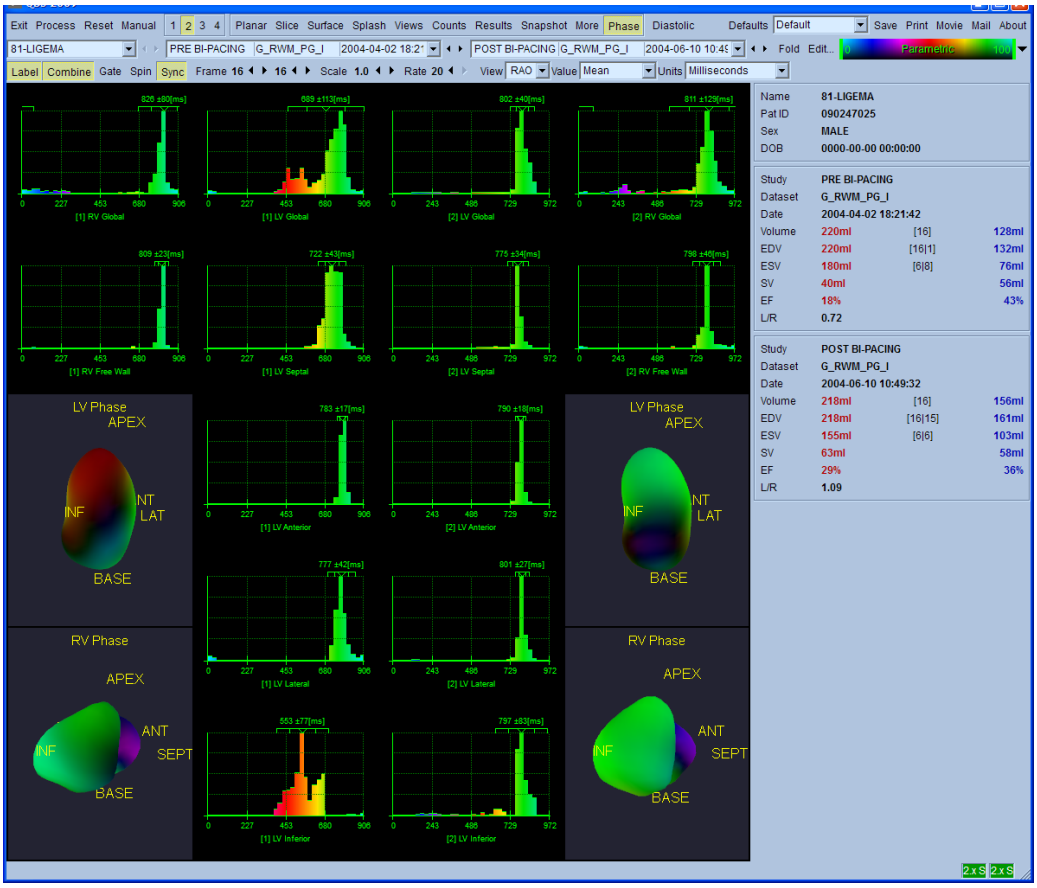


Figure 13.2. Phase page in dual mode

In either configuration, the surfaces in the 3D viewports can be interactively rotated (as in all other pages). Phase information is parametrically mapped on each surface, and the **Phase** color control can be used to select a color lookup table and change the upper and lower limits). To prevent the display of irrelevant information, phase values in areas of the surface where motion is below 10% of the maximum amount of motion for the surface are grayed out.

Each phase histogram is divided in 10^{o} bins and graphically depicts the distribution of phase values in the corresponding region or ventricle. Peak location and width measures and units can be selected using the **Value** and **Units** controls (see below).

In single mode, the right-side information panel displays a summary table of all values using both unit systems (see Figure 13.3).

Phase Analysis

	GLOBAL			
Group	LV Global		RV FWall	
Units	Deg	Ms	Deg	Ms
Mode	55	138	35	88
Mean	87	219	69	174
SDev	54	137	82	206
FW10M	170	428	40	101
Entropy	75%	--	56%	--
	LV REGIONAL			
Group	LV Septal		LV Anterior	
Units	Deg	Ms	Deg	Ms
Mode	55	138	45	113
Mean	67	169	43	108
SDev	19	47	6	16
FW10M	90	226	40	101
Entropy	56%	--	27%	--
	LV REGIONAL			
Group	LV Lateral		LV Inferior	
Units	Deg	Ms	Deg	Ms
Mode	55	138	155	390
Mean	68	171	146	367
SDev	69	173	42	104
FW10M	50	126	150	378
Entropy	55%	--	74%	--
	INTRA / INTER DELAYS			
Group	LV Sep-Lat Delay		LV Sep-RV Delay	
Units	Deg	Ms	Deg	Ms
Mode	+0.0	+0.0	-20.0	-50.3
Mean	+0.5	+1.2	+2.0	+4.9
SDev	+49.8	+125.3	+62.9	+158.3
FW10M	-40.0	-100.7	-50.0	-125.8
Entropy	-0%	--	+0%	--

Figure 13.3. Phase information panel

13.1 Entropy calculation

The entropy *H(X)* is calculated for the distribution of values as follows:

$$H(X) = -\sum_{x} P(x)\log_2[P(x)]$$

where *P(x)* is the probability that variable *X* is in state *x* and $P\log_2 P$ is defined as 0 if *P*==0. *H(X)* is expressed in percent where 0% (minimum) means all values are identical in the region and 100% (maximum) indicates uniform distribution of all values across the region. Entropy values are rounded to the nearest percent.

13.2 Controls

Label	Turns surface labeling on and off. Surface labeling consists of 3D wall labels.
Combine	Toggles combined display of FFH phase and amplitude.
Gate	Turns temporal cine on and off.
Sync	Toggles individual or grouped manual reorientation of surface images.
Frame	Sets current image gating frame or, when Gate enabled, shows a running display of frames. If there is more than one dataset displayed, the number of Frame selectors present on the page control bar is adjusted to one per displayed dataset.
Rate	Selects the temporal cine speed.
View	Sets the display orientation. Choices are; ANT, LAT, INF, FWL, APX, BAS, LAO, RAO, and ECH (see Surface page for details).

Value	Selects the phase value to be displayed for histogram peaks. Two values are always displayed: a measure of peak location and a measure of peak width. Options are: Mean (average), SDev (standard deviation), Mode, FW10M (full width at 10th of maximum), Entropy (see above).
Units	Selects the units to be used to display values. Choices are Degrees or Milliseconds. If heart rate information is not available in the dataset header, 60bpm is assumed.

14Snapshot Page

The **Snapshot** Page will display selected "snapshot" files that have been previously saved with the Print toolbar control. Only **1** (single) display mode is allowed. The user can view only one snapshot at a time by selecting from the dataset selector drop-down menu. Figure 14.1 shows a Snapshot page with a snapshot dataset of the Views page that was previously saved to the database with the **Print** control on the toolbar.

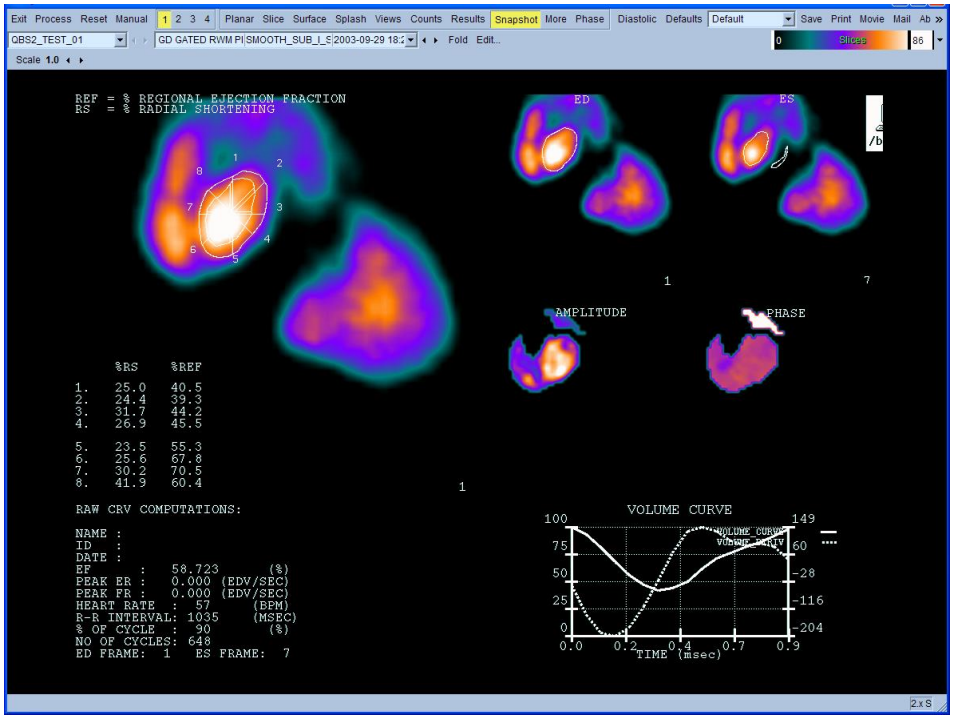


Figure 14.1. Snapshot Page with a snapshot of a planar MUGA processing page.

QBS also supports DICOM multi-frame secondary captures as input files on all platforms on which the **Snapshot** page is available. These files can be displayed in cine fashion in the snapshot page, which then shows controls for playback, frame and frame rate selection.

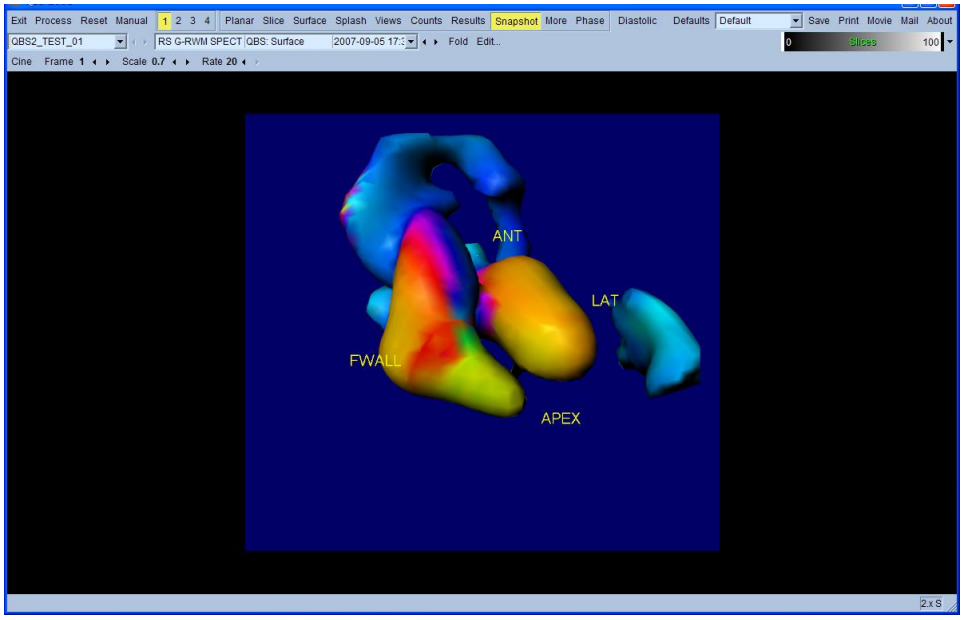


Figure 14.2. Snapshot Page with a scaled-down movie of the Surface page.

14.1 Controls

Cine	Turns cine on and off.
Frame	Selects the currently displayed frame.
Scale	Selects the display scaling factor.
Rate	Selects the cine speed.

15More Page

The More Page (Figure 15.1) displays data from the dataset header.

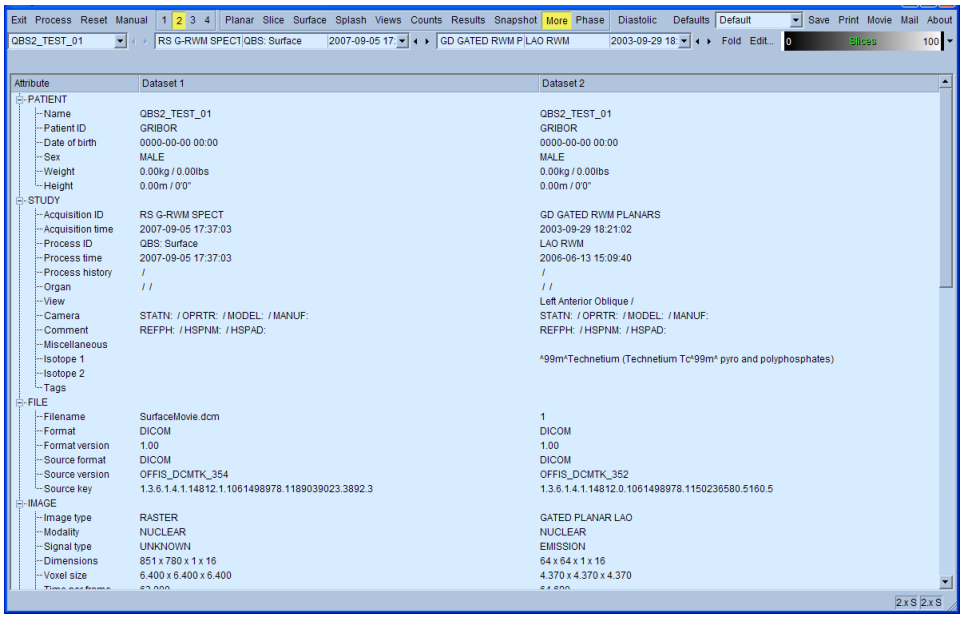


Figure 15.1. More Page

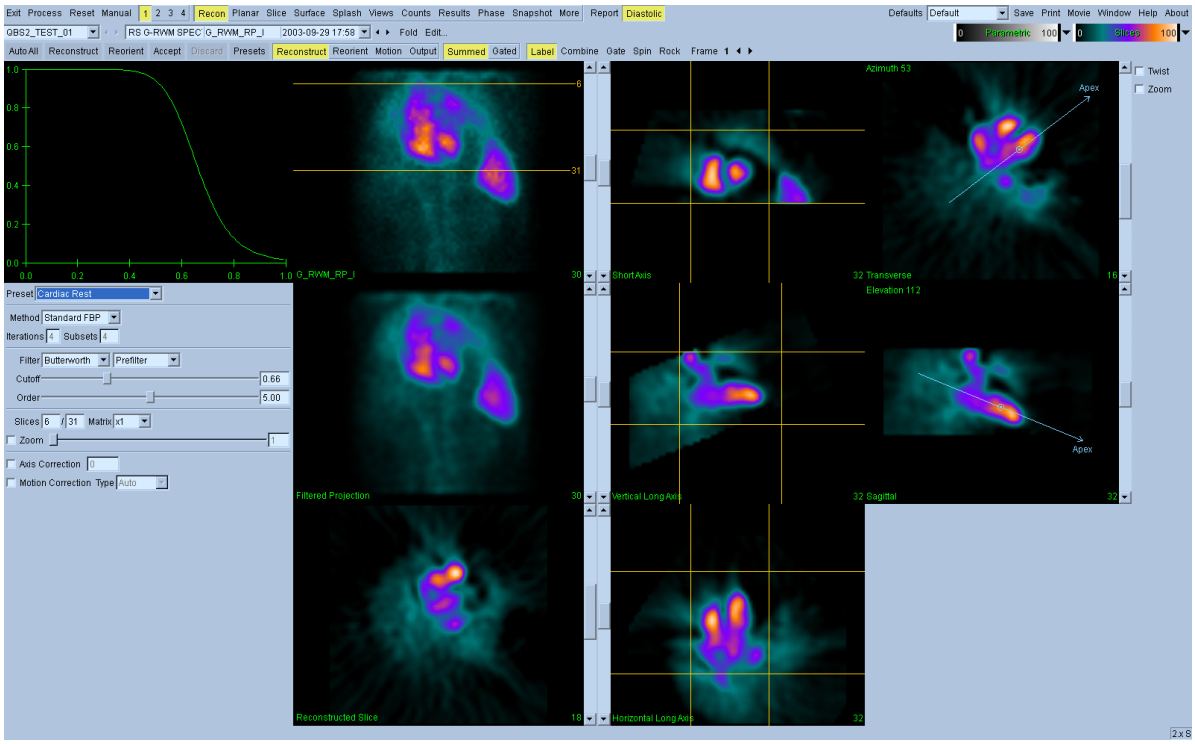
15.1 Controls

There is no page control bar for this page.

15.2 Data availability

Note that for some input data formats not all fields displayed in the **More** page are available, therefore some of these fields may remain blank.

16Recon Page



AutoRecon is an interactive application for the automatic or manual processing (motion correction, reconstruction, reorientation, filtering, etc…) of one of more raw datasets. AutoRecon applies validated rules to processing and reorienting the ventricle while reducing the number of decisions required when processing datasets, which allows for consistent and reproducible results. The amount of automation and processing options provided by AutoRecon depends upon the dataset selected. Refer to the AutoRecon reference manual for more details.

Note: AutoRECON may only be available on select platforms.

17Manual Page

The **Manual** Page (Figure 17.1) is used to supply hints to the segmentation algorithm in cases where the fully automatic segmentation fails or returns unsatisfactory results. These hints are provided using an interface similar to that of the **Slices** Page, using masking graphics that are superimposed upon the slices. The shape and position of the masking graphics can be modified by left dragging the masking graphic handles, small blue circles and squares placed at various points on the yellow masking graphics. The mask is designed to assist in the specification of the delineation between the atria and ventricles, between the left and right ventricle, as well as the location of the pulmonary valve. The user sets the mask for two time intervals, the first frame and an estimate of the end-systolic interval (see Section 2.2.12 for guidelines). Figure 17.1 shows an example of a correctly placed mask (note that the lines correctly separate all important structures).

Section 2.2.6 of the tutorial also describes the **Manual** page.

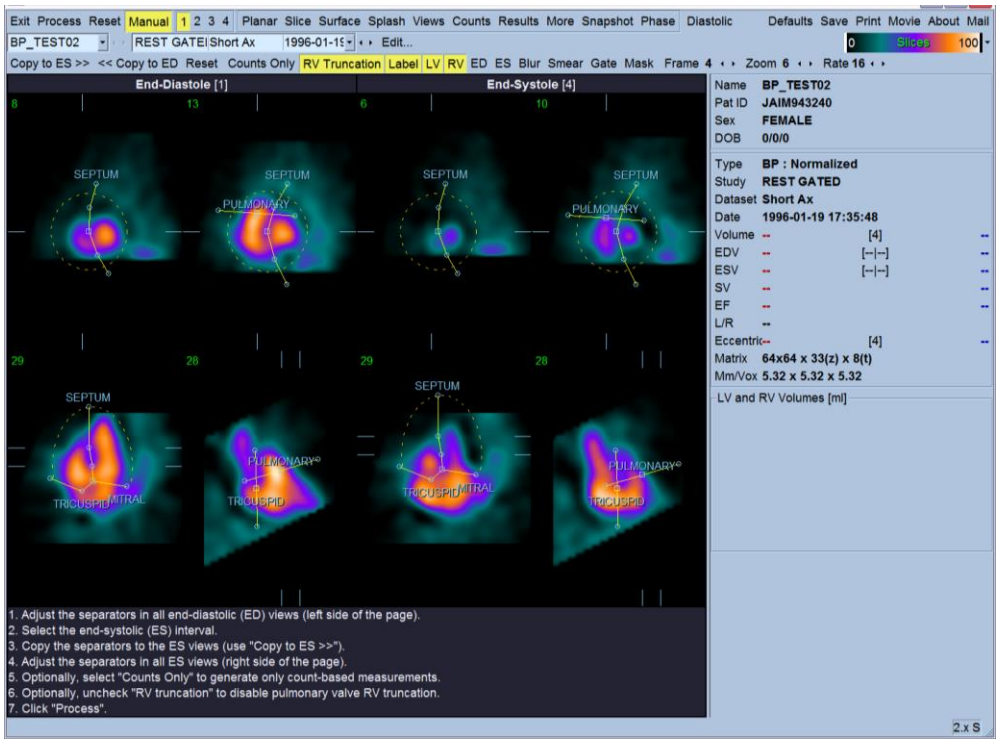


Figure 17.1. Manual Page

Note the dashed ellipsoidal part of the mask, which determines the portion of the dataset that will be used during calculations, i.e., this line determines what extra-cardiac activity is eliminated from the calculations. Its position is a function of the position of the basal and apical septal handles as well as the mitral handle (in the HLA view). In fact, the masking ellipsoid is centered on the most basal septal handle and its dimensions are computed by fitting the positions of the apical septal handle and the mitral handle. These details are not strictly necessary to correctly position the mask, but may help in understanding how to best position the handles to achieve the desired masking. Figure 17.2 shows a few examples of masking using different handle positions. Note the effect on the ellipsoidal extra-cardiac activity mask.

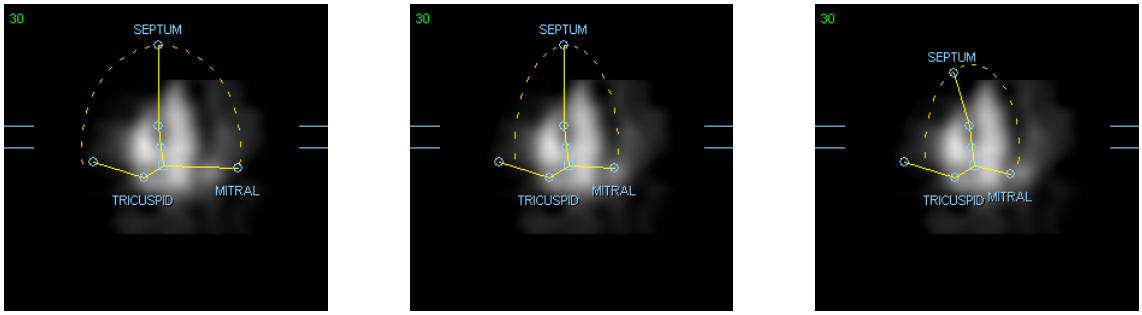


Figure 17.2. Sample mask positions and effect on extra-cardiac masking

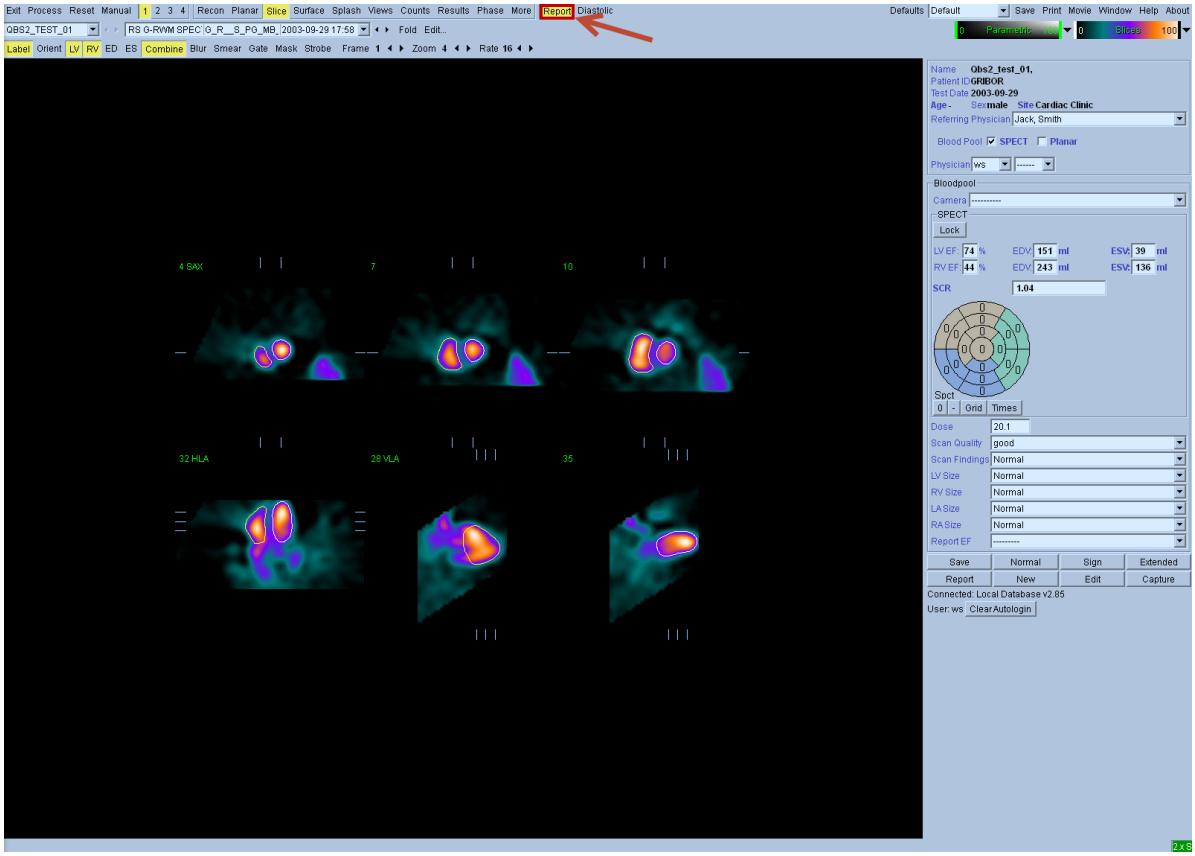
17.1 Controls

Copy to ES >>	Copies the ED mask to the ES frame.
<< Copy to ED	Copies the ES mask to the ED frame.
Reset	Resets the mask to a default configuration.
Counts Only	Use a simplified calculation method that only provides count-based estimates.
RV Truncation	Toggles pulmonary conus truncation at the valve on and off.
Label	Turns slice labeling on and off. Slices labeling includes slice numbers and slice reference lines.
LV	Turns LV contour display on and off in the slices section, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
RV	Turns RV contour display on and off in the slices section, if processed results are available. Contours are the intersection of a given slice and the inner wall of the ventricle.
ED	Toggles ED contour lock, if processed results are available. When on, ED contour overlays are displayed for every gate interval.
ES	Toggles ES contour lock, if processed results are available. When on, ES contour overlays are displayed for every gate interval.
Blur	Turns temporal smoothing on and off. Temporal smoothing, if enabled, is a 1-2-1 smoothing kernel that wraps around the last interval.
Smear	Turns spatial smoothing on and off. Spatial smoothing, if enabled, is a 1-2-1 smoothing kernel.
Gate	Turns temporal cine on and off.
Mask	Turns masking of ventricular voxels used in counts calculations on and off.
Frame	Selects the desired (user-estimated) ES interval.

Zoom	Selects the slice zoom.
Rate	Selects the cine speed.

18ARG (Automated Report Generator)

Integration of ARG (Automatic Report Generator) provides the ability within QBS to create, edit, sign, review, archive, and share customizable, consistency-checked, reports. A reporting pane and a few extra dialogs have been added to QBS for this purpose. ARG is enabled by the **Report** button on the right hand side of the top row of buttons. When toggled ON, the info panel is replaced by the ARG panel.

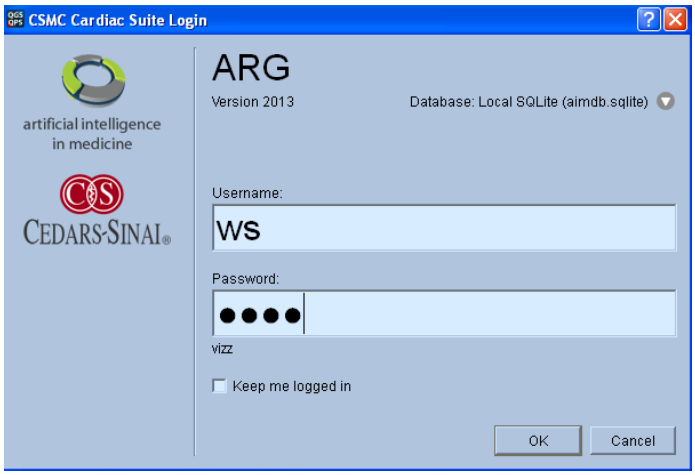


18.1 Starting QBS with ARG

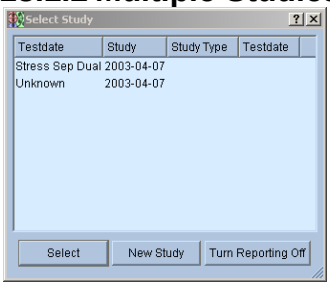
ARG will automatically match the identifying information contained in the image headers with existing (previously saved) studies. If an existing study is found, then it is possible to modify the data or view the report associated with that study. If no study is matched, then ARG will automatically create a new study. This new study will not get permanently saved to the database until the Save button is clicked.

18.1.1 User Login

When QBS is launched with ARG integration, users must login with their username and password credentials. The program will remember the Username and Password for up to 2 hours of inactivity if "Keep me logged in" is selected. Refer to the ARG reference manual for more details.

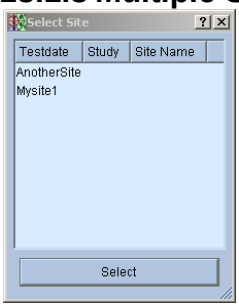


18.1.2 Multiple Studies



If a patient has more than one study within two days of one another, then a dialog is displayed prompting the user to choose the relevant study. Multiple studies are a unique occurrence, and should only be used when the user wishes to bill for multiple studies. To create multiple studies, click the **New** button located in the Reporting Panel of QBS, or the **New** button on the multiple study dialog.

18.1.3 Multiple Sites

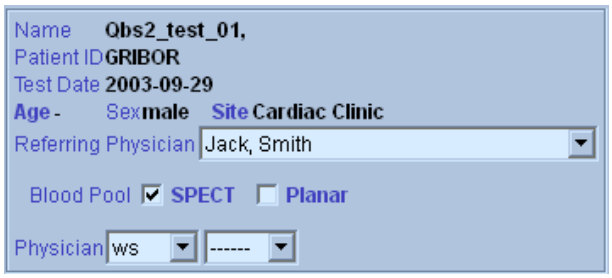


Many physician groups read studies for more than one hospital or location (site). ARG is designed to support multiple sites. When more than one site has been configured, a dialog will be displayed each time a new study is created. The user must choose the site to which the patient belongs. If the intended use of ARG is to support only one site, then this dialog will not be displayed.

18.2 **Reporting Panel**

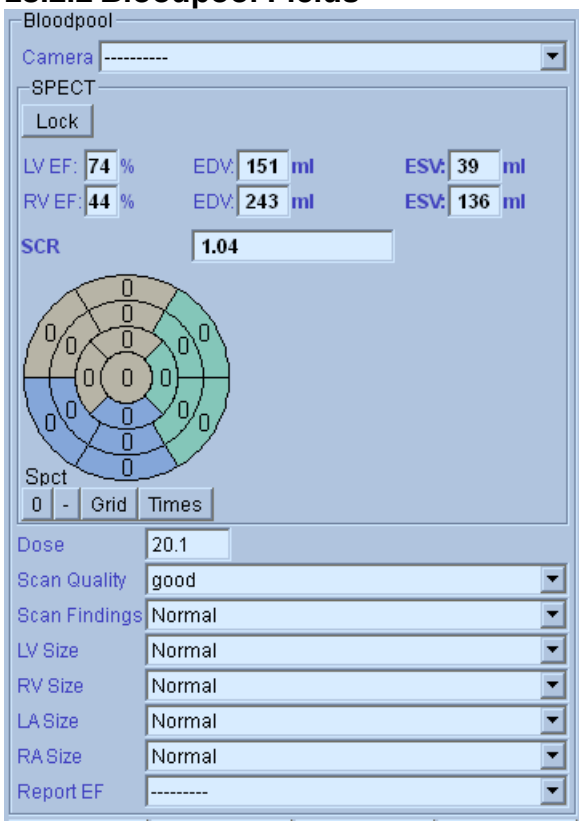
The ARG fields are displayed on the right hand portion of the screen. These fields can be toggled on or off at any time by using the **Report** button located on the toolbar.

18.2.1 Patient Information



The items listed in the patient information portion contain the values as contained in the database. These values can be easily edited by double clicking on any of the fields or by using the **Edit** button in the reporting panel. Three fields that must be filled in by the user are the Referring Physician, Test Type and (Reading) Physician fields.

18.2.2 Bloodpool Fields

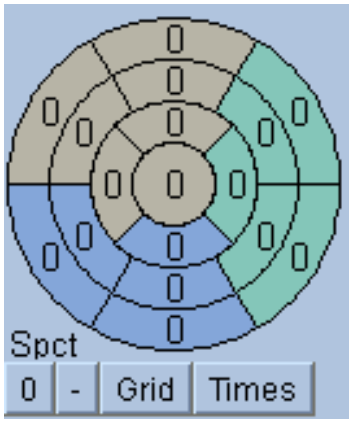


Many Bloodpool fields such as volumes are automatically populated by ARG while other subjective fields can be filled in by the reporting physician. Descriptions of the field entries are listed in the table below.

Camera	The imaging camera used to acquire the images.
LV EF	Left Ventricle Ejection Fraction is auto populated.
LV EDV	Left Ventricle End Diastolic Volume is auto populated.
LV ESV	Left Ventricle End Systolic Volume is auto populated.
RV EF	Right Ventricle Ejection Fraction is auto populated.
RV EDV	Right Ventricle End Diastolic Volume is auto populated.
RV ESV	Right Ventricle End Systolic Volume is auto populated.
SCR	Stroke Volume Ratio is auto populated.
Visual Score Polar Map	Allows the physician to manually assign scores to each segment. Values can range from 0 (for normal) to 5 (maximum abnormal).

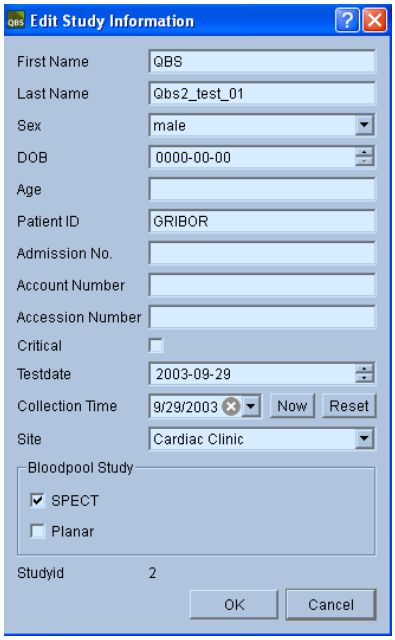
Dose	Injected dose in mCi.
Scan Quality	The technical quality of the scan.
Scan Findings	The overall perfusion scan findings.
LV Size	LV size.
RV Size	RV size.
LA Size	LA size.
RA Size	RA size.
Report EF	Options to report EF from either SPECT or Planar dataset.

18.2.3 Visual Scores



ARG extends scoring by assigning a coronary vessel to each segment. By default ARG will attempt to choose the vessel based on the visual scores. This can be overwritten by right clicking on a segment and selecting the appropriate vessel. In some cases it is unclear to which vessel the defect belongs. When this occurs, select the abnormal segment in question and choose a combination of vessels.

18.2.4 Edit Panel

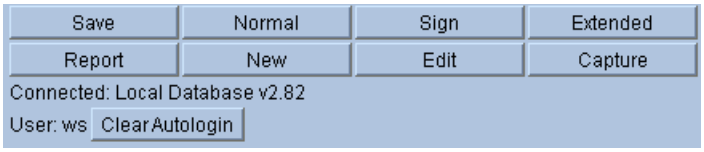


The Edit Panel allows editing of patient demographic data for reporting purposes only. This will not change the data in the image header.

Note that either DOB (date of birth) or Age can be filled in at any given time. DOB will always take precedence over age, if age was originally entered.

18.2.5 Reporting Panel

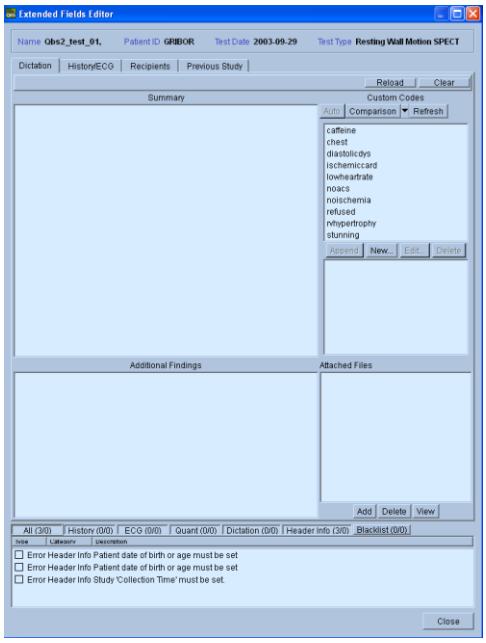
Up to two physician signatures can be placed on the report. The physician drop down displays all Signing Physicians as defined in the QARG database (See ARG Reference Manual).
The primary physician is displayed topmost.



The ARG action buttons shown on the left are described in the table below.

Save	Saves all ARG information to the database.
Normal	Sets all blank fields to values consistent with a normal study.
Sign/ Unsign	Reports must be signed (by the physician entering their password) prior to the signature appearing. Once the study has been signed, it is locked from future modifications. If it is necessary to modify the study, physicians may un-sign the study by entering their password, thus releasing the study lock. However, once the data is un-signed and re-saved, the old data (and corresponding report) will be overwritten.
Extended	Opens the extended editor, which permits editing of the dictation, history and ECG sections.
Report	Displays the PDF report.
New	Creates a New (multiple) study for this patient.
Edit	Displays the study editor dialog.
Capture	Captures the current screen to save in report. (Ctrl+Shift+P will also capture the current screen. The key combination is useful if the ARG Panel is not desired in the screen capture).
Clear Autologin	If “Keep me logged in” was checked when QGS + QPS was launched, this option clears it out so that the user is required to login when QGS + QPS is re-launched.

18.2.6 Extended Editor



The Extended editor contains areas for dictation, History/ECG, Recipients and Previous Studies. Each study may have a main dictation associated with it, in addition to a history dictation. The dictation is free text that is included on the report cover letter. The dictation editor is designed to make this process as efficient as possible. ARG includes powerful built-in macros and a very flexible custom code editor.

For more details, reference the ARG manual.

18.2.6.1 Dictation

Two powerful macros are included on the dictation editor. The buttons for these macros are located directly underneath the Custom Codes title in the Dictation Editor window beside the Refresh button.

Auto	An automatic dictation is used by default. This dictation updates real-time as fields are modified. The automatic dictation is shown in blue. Note that text can be added before or after the automatic dictation without affecting the behavior of the auto dictation. You may alter or remove the automatic dictation at any time simply by editing it. Note that once the automatic sentence(s) have been modified then the dictation will no longer be updated automatically. To re-enable the automatic dictation, click the Auto button.
Comparison	If the patient is returning for a follow-up visit, the Comparison button is enabled. If this is the case then the signing physician should mention any changes (or no change) since the patient's last visit. ARG will provide a warning if no mention is made. Clicking the comparison button will initialize the comparison sentence. ARG matches the previous study based on patient ID. If the patient ID was mistyped in the original study, it must be changed before ARG can auto match. Of course you may also manually enter the old study date and ARG will be able to auto-match any future studies. For more information on editing the comparison sentence or viewing raw changes, refer to the dictation section in the QARG manual.
Refresh	Refreshes the list of codes in the database.

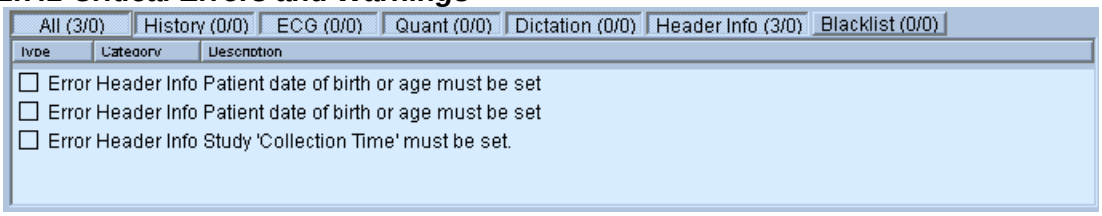
Custom Codes	Custom codes are simple macros that provide a mechanism to store frequently typed sentences. Codes are made up of a code-key (small word describing the code) and code-value (text which is appended to the dictation). Codes are accessed by highlighting the code-key and clicking the Append/Add button, double clicking a code-key or typing *@code-key* in the dictation editor. Please see the Custom Code Manager section in the QARG User Manager for details regarding customization of these codes.

18.2.7 Consistency Checks

ARG contains a collection of checks resulting in various notifications of errors and warnings. These checks ensure that the report data is consistent.

For Example: If 'Normal' was entered for overall perfusion scan findings and a large defect exists in the visual scores, then an error will occur. Most checks can be viewed directly from the ARG interface by looking at the color of the field name (field inconsistencies resulting in errors are labeled in red, warnings in yellow). Descriptions of errors and warning are displayed in the Errors and Warnings window (shown below) after clicking the **Save** button.

18.2.7.1 Critical Errors and Warnings



Critical errors prevent the report from being saved. These fields show up red in the ARG panel and are listed next to a check box in the errors and warning dialog. Most critical errors deal with the absence of required data; however some are due to major inconsistencies with the data. If errors exist in the report it is possible to continue, however the errors must be acknowledged by clicking the checkbox next to the error. Clicking the checkbox will accept the error for the current study only. To permanently disable (hide) and error right click the error and select 'Add consistency check to blacklist.

Warnings do not prevent the report from being saved. However the physician must review them and explicitly choose to ignore them prior to saving. Theoretically, warnings should not be allowed. However, in some circumstances the inconsistency should be allowed (i.e.: the patient had a bypass surgery). Ignoring warnings should be done scarcely and only after careful consideration.

18.2.7.2 Hiding unwanted consistency checks

Users may disable errors and warnings that are irrelevant to their site by right clicking the consistency check once the dialog is opened. This moves the consistency check to a "hidden" group. The consistency check can be re-enabled by right clicking on the error inside the black listed group.

19Progress Notification

Since processing can be a time-consuming operation, the user is notified of the progress of the algorithm and has the capability to interrupt computations at various points. Interrupting calculations at any time will cause all previously computed results to be lost, without the option to resume calculations where interrupted. Figure 19.1 and Figure 19.2 show two states of the progress bar.

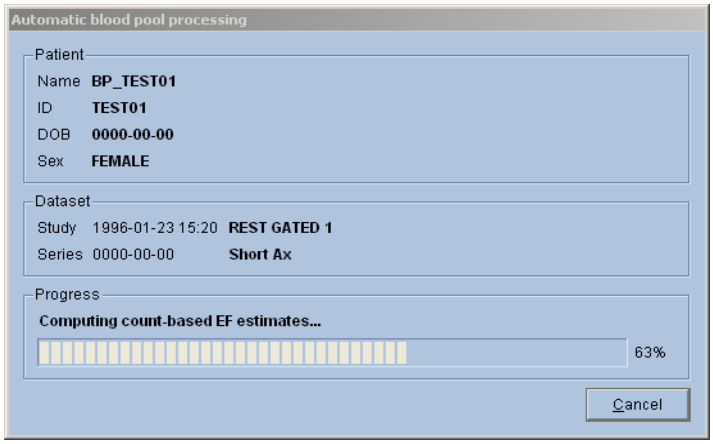


Figure 19.1. Progress bar (1)

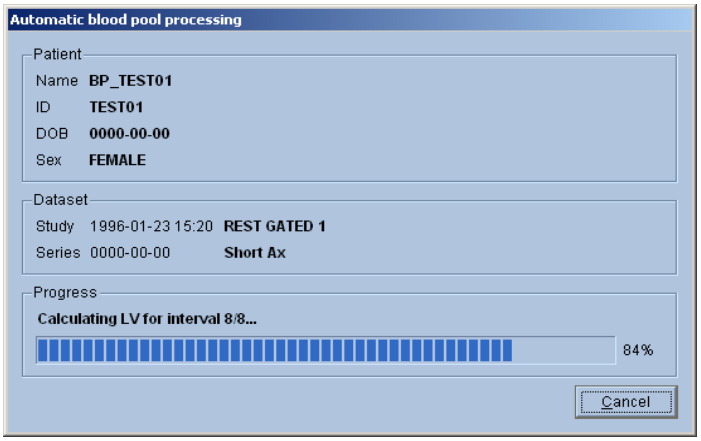


Figure 19.2. Progress bar (2)

20Error Messages

Application errors and warnings are communicated to the user through the error dialog box. This is followed by graceful application exit in the case of fatal errors. The possible errors are listed below; the application adds qualifying details when available. The error dialog box is shown in Figure 20.1.

Code	Message	Description
100	No help available.	Warning. The vendor did not provide a help system and the Help button was pressed.
101	Invalid checksum in results file, ignoring results!	Warning. An invalid results file was read in "review" mode. The results are ignored.
102	No results were returned by processing algorithm.	Warning. An error occurred while processing the data; no results were returned by the algorithm.
103	Voxel should have equal X and Y dimensions	Warning. May indicate that the data header information is incorrect. Normally X and Y voxel dimensions are identical for short axis images.
800	Generic Error <details>	Error that does not belong to a specific category.
801	File Open Error <details>	Error opening a file.
802	File Write Error <details>	Error writing to a file.
803	File Read Error <details>	Error reading from a file.
804	Memory Allocation Error <details>	Error attempting to allocate memory.
805	Input Error <details>	Error caused by invalid object input.
806	State Error <details>	Error caused by invalid object state.
900	Could not connect to X server <details>	Error while connecting to the specified X server.
901	Could not reserve image display resources <details>	Error while reserving display resources required for image display.
902	Could not retrieve input dataset list <details>	Error while retrieving the specified input dataset list.
904	Dataset Read Error <details>	Error reading the specified dataset.
905	Dataset Write Error <details>	Error writing the specified dataset.

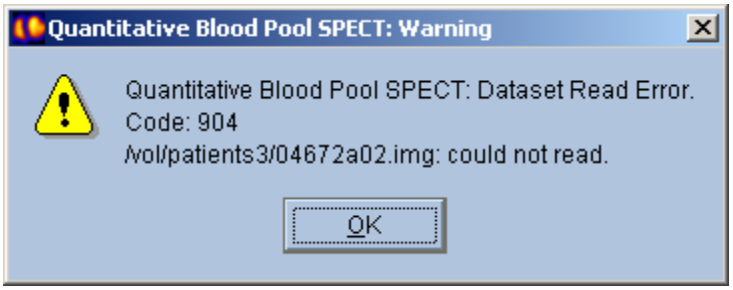


Figure 20.1. Error dialog box

21 FAQs

1. Why am I not getting an Ejection Fraction after manually processing a dataset?

There can be scenarios where an Ejection Fraction is not reported in the right hand panel with the other results after manually processing a dataset. This can be a result of using the Counts Only method from the manual page itself.

2. What is the difference between the Ejection Fraction in the Demographics panel and the Ejection Fractions reported on the Counts page?

When looking at the Counts page in QBS, the user will see up to three different Ejection Fractions for each ventricle. This is because of the method that was used to calculate them. The three different methods can be chosen from the Defaults page and are Surface (most similar to 1.x QBS), Count based calculations (recommended) and Count based volumes.

Note: Even when using one of the Count based methods, the EF's may differ slightly between the 2 areas of the screen because the volumes used in the calculations come from different intervals. The volumes and counts are calculated for each interval based on the method considered. The ED and ES intervals are then computed by selecting the intervals corresponding to the highest and lowest volume or count value. Depending on the calculation method these maxima may fall in different intervals, this is not a rare occurrence. The effect is clearly decreased as the number of gating frames increases. The count-based volume calculations are especially susceptible to this as the threshold-based selection forces the addition of entire voxels to the volume (i.e., each volume is an exact multiple of the volume of one voxel, meaning that effectively the granularity of this measurement is coarser than that of the counts and surface calculations).

3. What is the function of Strobe?

Strobe, which is only seen when Gate is also on, shows the propagation of the contraction patterns. This can be seen on the First Fourier Harmonic phase images and histograms and the surface maps of parametric type.

4. How can I see the effects of Strobe on the Slice page?

A parametric image must be loaded on to the Slice page. Selecting the FFH Phase image from the dataset selector pull down in conjunction with the original short axis gated data does this. In order to do this, the display mode must be 2 or higher. Strobe can then be used with Gate.
Note: This assumes that the default is configured to generate this image upon processing.

5. Which datasets can be displayed on the Planar page?

The designed purpose of the Planar page is to review planar gated datasets such as LAO and RAO as well as raw projection datasets to assess patient motion. However, other types of non-cardiac SPECT can also be loaded on to this page.

6. What is the difference between Planar Label and Planar Filter on the Defaults page?

The Planar label, which is under the General tab, will actually attach a label or extension to the image itself as it is displayed on the Planar page. The Planar filter, which is under the Automatch tab, will determine which dataset are classified as LAO or RAO. The classification of the image can be seen under the dataset editor pull down list (Edit button).

7. Why are there additional datasets in the dataset editor pull down list?

For every gated dataset loaded into QBS, additional datasets may be generated as per the default settings. These are Parametric Images and include
First Fourier Harmonic Phase (FFHP)
First Fourier Harmonic Amplitude (FFHA)
Normalized (Time-equalized)
Ventricular Cosine Coefficient (VCC)

Only the VCC type is optional as disabling the others will disable certain functions of QBS.

8. What is stroke volume? L/R ratio?

Stroke volume is the chamber volume at end-diastole minus the chamber volume at end-systole: EDV-ESV. L/R ratio is LV stroke volume divided by the RV stroke volume.

9. What is the difference between stroke counts and stroke volume?

Stroke volume and stroke counts are basically the same thing. The amount of blood pumped out of the heart in a single heartbeat. The only difference is stroke counts is expressed in counts (diastolic counts within the ventricular ROI minus systolic counts within the ventricular ROI).

10. What do the number and letter in the bottom right corner of the screen mean?

The number and letter in the bottom right corner of the QBS screen is referring to two things:
The number references the version of QBS used in the calculation of the data. In other words, if a results file is loaded and the data is from 1.x QBS, it will say 1.x in the corner.
The letter following the number refers to the method of process (surface, count based calculations or count based volumes [S, C or V respectively]) in generation of results like EF.

11. How can I see the entire image on the Snapshot page in case the image is clipped?

The images on the Snapshot can be panned in the event the image is greater than the display. In order to do this, click with the mouse pointer on the image and drag to the desired position.

12. What is the function of the mask button?

The mask button shows the LV and RV ROI's that are used in count-based calculations. Only the voxels shown with mask are used in the calculations. This option is only available on Slice, Splash and Counts page.

22Algorithms

This is a brief overview of the processing algorithms used in QBS. A detailed description, including validation against planar and first pass data, has been presented (see Chapter 23, Bibliography, for references). The major algorithm is the ventricular segmentation, in which ventricular surfaces (endocardium for each ventricle) are computed for each interval. These surfaces are then used to compute a variety of global and regional functions. Note that this algorithm is different from the one used in QBS 1.x, and will likely provide different values from the previous versions of this application. Refer to the bibliography for comparison data. The new algorithm was designed to improve both accuracy and reproducibility of the measurements.

22.1 Ventricular Segmentation

Ventricular segmentation is a multi-step process. The first step is the generation of a ventricular mask that excludes activity from the atria and extra-cardiac structures. The second step is the calculation of a biventricular surface which surrounds both ventricles. The third step is the generation of a septal surface that separates the ventricles. The surfaces are then resampled into separate LV and RV surfaces. For the right ventricle, an optional additional processing step is used to determine the location of the pulmonary artery and truncate the portion of the conus that lies beyond the valve. All surface generation operations are accomplished at sub-voxel resolution, and the resulting data is stored in a physical coordinate system (units are millimeters and not voxels). Both ventricular surfaces are filtered spatially and temporally to enforce continuity constraints. These endocardial surfaces are then used to compute ventricular volumes at each interval, which in turn allows the calculation of the ED and ES intervals. The stroke volumes and ejection fractions are calculated using these intervals.

Count-based calculations are performed using user-definable thresholds. For each frame of the gated dataset the LV and RV surfaces are used to define ROIs that comprise all voxels with a count value greater than the threshold (expressed as a percentage of the maximum count value within the LV or RV surface). For count-based statistics the voxel values within each ROI are summed and used to generate stroke counts and EFs much as is done for planar data. For count-based volume calculations the number of voxels with a count value above the specified value is multiplied by the individual voxel volume.

22.2 Global Function

The following standard global functions are computed:

ED	End-diastole, the interval in which the LV chamber volume is at a maximum (not necessarily the first interval).
ES	End-systole, the interval in which the LV chamber volume is at a minimum.
LV & RV EDV	End-diastolic volume, the chamber volumes at end-diastole.
LV & RV ESV	End-systolic volume, the chamber volumes at end-systole.
LV & RV SV	Stroke volume, the chamber volume at end-diastole minus the chamber volume at end-systole: EDV-ESV.

LV & RV EF	Ejection fraction, the chamber volume at end-diastole minus the chamber volume at end-systole, all divided by the chamber volume at end-diastole, in percent: 100×(EDV-ESV)/EDV.
L/R ratio	LV stroke volume divided by the RV stroke volume.
LV Eccentricity	SQRT(1–(Rx Ry/Rz2)) where Rz is the length of the long axis and Rx, Ry are the lengths of the minor axes. The eccentricity value is a measure of the elongation of the LV bounded by 0 (sphere) and 1 (line segment).

22.3 Regional Function

The only regional function that is calculated is wall motion. The amount of motion is determined at each point by resampling the ventricular surface normally, then calculating the distance between the end-diastolic and end-systolic points of intersection between the surface and the normal. The normals are generated at points located on the average surface between ED and ES, and evenly spaced in a spherical coordinate system. This coordinate system is defined such that the polar (Z) axis corresponds to the long axis of the heart, with the reference longitude at the lateral wall. For the right ventricle, matters are complicated by the irregular shape. The sampling coordinates are not spherical anymore, although they are similar. The sampling system has been modified from that used in QBS 1.x to better represent the shape of the RV. The poles of the spherical coordinate system are now oriented towards the septum and free wall of the heart, as seen from the center of the LV. Figure 22.1shows the RV as seen from the free wall.

Because of the unusual nature of this sampling, the RV map in particular is only made available as a visual aid, not as a quantitative tool. Its clinical application should be considered in view of the clinical status of the patient being evaluated. The assumption in Figure 32 is that the number of sampled longitudes and latitudes are 36 and 24 respectively. For the LV the distribution is equally spaced by angle, while for the RV the sampling is dependent on the geometry of the ventricle. All polar maps show the apical ¾ of the surface (i.e., the basal quarter of the surface, measured in spherical coordinates, is not shown). In Figure 22.2, the red outline on the LV shows the portion of the surface (as viewed from each angle) that is included in the polar map. The blue outline shows the portion of the RV used for the polar map. Note that the septal wall of the RV is not included in the polar map.

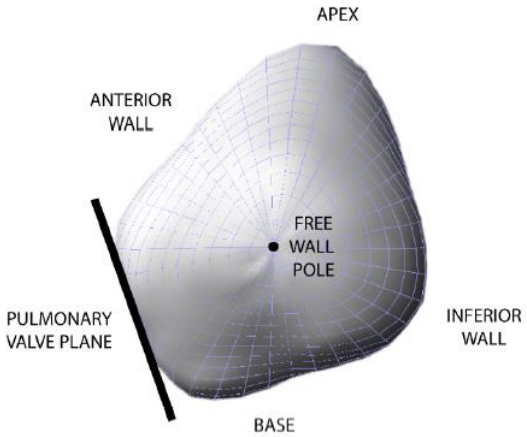


Figure 22.1. New (2.x) RV sampling

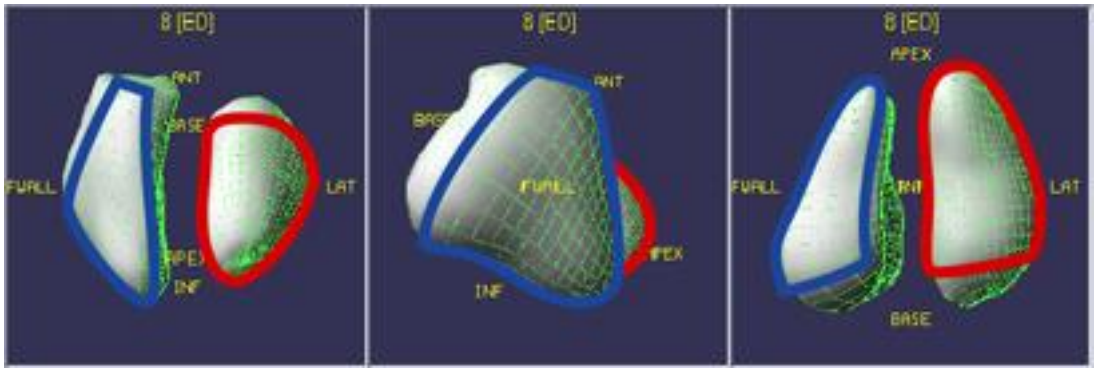


Figure 22.2. Polar map coverage

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