Obtaining Standard Uptake Values

OVERVIEW

Standardized uptake values (SUVs) are a measure of radiotracer uptake normalized for injected dose and patient weight. SUVs are most commonly used in the assessment of ^{18}F–FDG PET/CT oncology studies for the diagnosis and staging of cancer. More recently, FDG PET/CT studies have been used in cardiac imaging for the diagnosis and follow-up of patients with sarcoidosis and other inflammatory conditions of the heart including endocarditis and pacemaker/ICD infections.

In cancer imaging, FDG uptake is related to the number of viable tumor cells and proliferative activity. In FDG oncology studies, high SUVs reflect tumor burden and decreasing SUVs reflect a response to therapy.

By comparison, SUVs in cardiac nuclear medicine imaging are used almost exclusively for identifying and assessing cardiac and extra-cardiac inflammation. In patients with known or suspected sarcoidosis, SUVs may be of value in assessing mediastinal and hilar lymph nodes as well as pulmonary (lung) infiltrates. There is the potential for identifying an unsuspected neoplasm as well as vascular inflammation related to atherosclerosis or vasculitis.

In inflammatory diseases of the heart, such as sarcoidosis, FDG uptake is related to the metabolic activity of the incited cells and disease activity. Elevated SUVs indicate the extent and intensity of the inflammation. Response to treatment is accompanied by decreasing FDG uptake and the associated decreasing SUVs.

***Note**: Patient Preparation is important for SUV – see Appendix for additional information.*

HOW TO GUIDE

The user must verify that the patient weight and ^{18}F-FDG injected dose and injection time are accurate since these are used in the SUV calculation. If the calibration time and the injection time are not the same they both need to be input. Syringe and IV line residual should be checked, i.e. the long form for dose entry may be required.

- Perform image quality assurance (QA) and verify data needed for SUV calculation on the **MI Processing** screen
- The SUVs for FDG uptake are calculated for extracardiac uptake via manually drawn ROIs on the **Fusion** screen and calculated automatically for regional myocardial uptake via polar maps.

To QA and verify patient information for SUV calculation, perform the following:

1. Launch a patient into 4DM.
2. On the **MI Processing** screen (Figure 1), perform QA of the FDG dataset. Refer to the MI Processing Reference Guide for further assistance with QA and processing.

   ***Note:** In patients with suspected sarcoidosis that have little or no disease, the LV contour generation for FDG uptake may fail. The manual definition of LV contours can be done on the **Fusion** screen using the **Indirect Registration** tool if a PET MPI dataset is available to correlate with the PET FDG. If a PET MPI dataset is not available, then manually drawn ROIs on the **Fusion** screen are the only option for calculating SUVs.*

3. Right-click on the gray margin to the left of the images displayed to see the **Dataset Information** selection (see ❶ Figure 1).

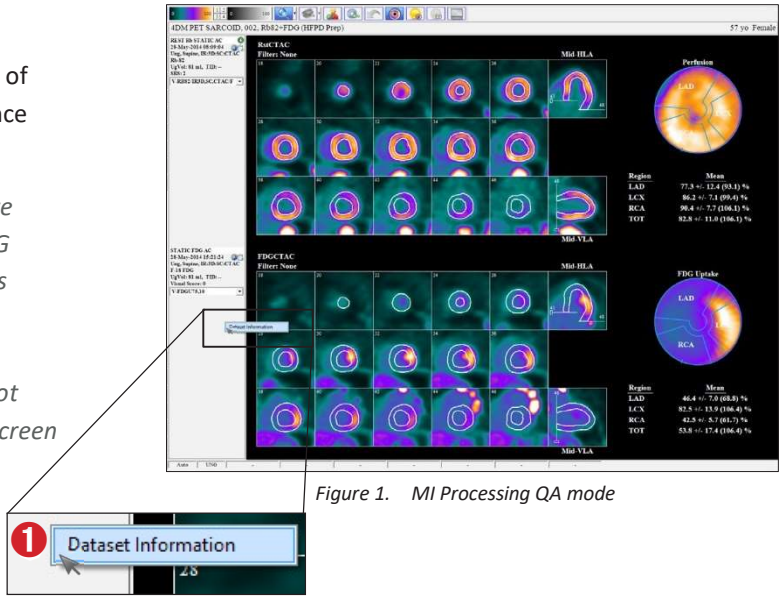

Figure 1. MI Processing QA mode

4. Select **Dataset Information** to view the *Dataset Information* window (Figure 2).

5. Enter and verify the following information necessary to calculate SUV:

   - **Weight** - Enter the weight based upon the **Units** option selected, **SI** units for **kg** or **English** units for **lb** (see ❶ Figure 2).
   - **Injected Activity** - Enter the injected dose in **mCi** (see ❷ Figure 2).
   - **Injection Time** - Enter the dose injection time in **hh:mm:ss** (see ❸ Figure 2).
   - **Radiopharmaceutical** - Verify the correct PET radiopharmaceutical is selected (see ❹ Figure 2).

6. Click **Save** once the information has been verified (see ❺ Figure 2).

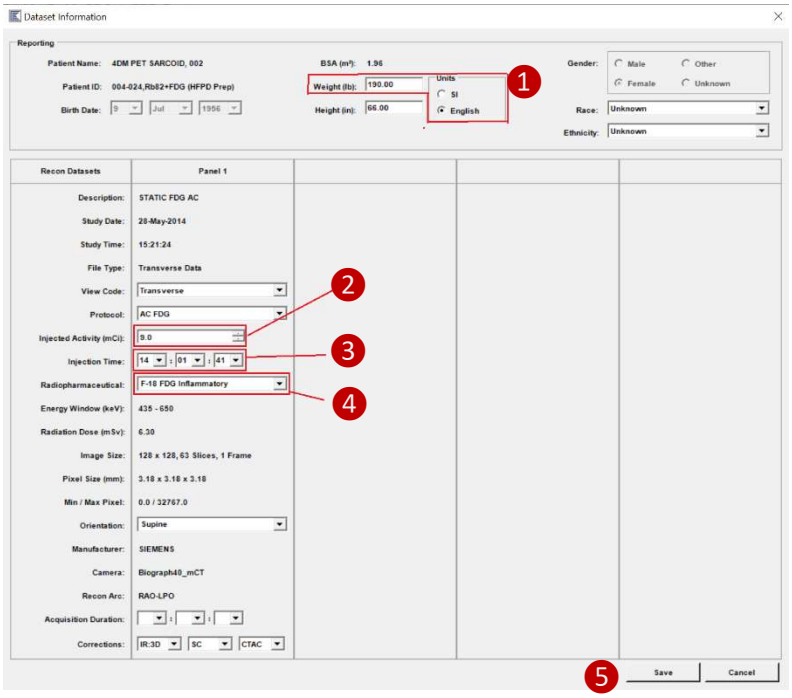

Figure 4. Slice Plane Indicator Tools

To calculate SUV on the Fusion screen, perform the following:

1. Select the **Fusion** screen (see ❶ Figure 3).
2. Using the **Object Dataset Selector** (see ❷ Figure 3), select the PET dataset for SUV calculation.
3. The transverse slice displays by default in the large viewport (see ❸ Figure 3). To display coronal or sagittal views in the large viewport, double left-click on either view.

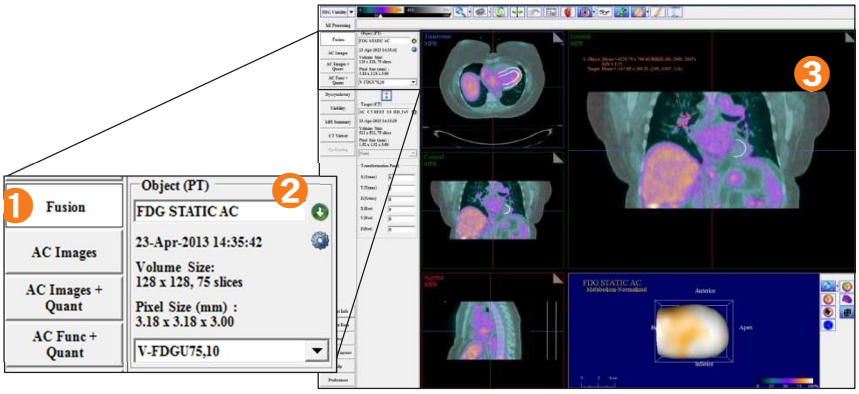

Figure 3. Fusion screen

4. SUVs can be calculated anywhere in the image. Scroll through the images to identify areas of interest for 18F-FDG tracer uptake where SUV calculations may be desired. Use the scroll wheel on the mouse, the **Slice Plane Indicators** (see ❶ Figure 4), or use the **Dog-ear** tool (see ❷ Figure 4). The **Slice Plane Indicators** colors signify which plane they correspond to by the view outline color:

   - Blue = **Transverse** or short axis (**SA**)
   - Green = **Coronal** or horizontal long axis (**HLA**)
   - Red = **Sagittal** or vertical long axis (**VLA**)

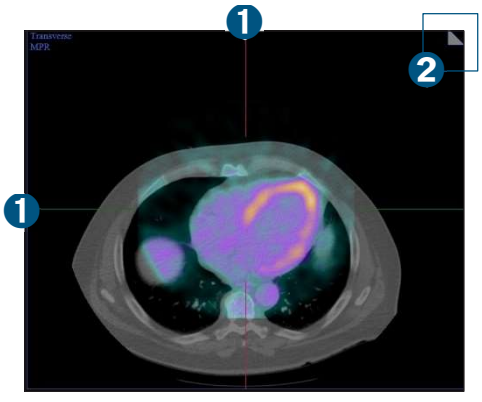

Figure 4. Slice Plane Indicator Tools

5. Select the **Region of Interest** menu from the toolbar to activate and choose a ROI drawing tool (Figure 5).

Figure 5. Region of Interest menu

6. With the ROI drawing tool active, draw the ROI around the area of tracer uptake (Figure 6).
7. The SUV calculation displays under the **Object** ROI calculations (see ❶ Figure 6).
8. If generating multiple ROIs through the volume, generate a DICOM Secondary Screen Capture (SSC) of each ROI by clicking the **Screen Capture** button (see ❶ Figure 7) in the **Application Control Panel**.

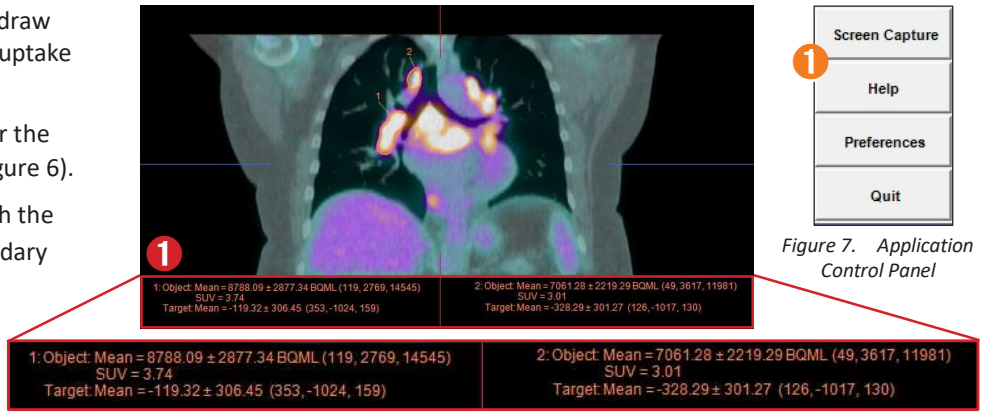

Figure 7. Application Control Panel

Figure 6. Region of Interest and SUV Calculation

To calculate myocardial SUV using Polar Maps, indirect registration should first be performed, then the following:

1. On the **MI Processing** screen in **QA Mode**, verify that the HLA valve plane limit is placed correctly for the FDG dataset (see ❶ Figure 8). This ensures that polar map screen objects display the correct extent of the myocardium for SUV quantification. Refer to the **MI Processing** Reference Guide for further assistance with QA and processing.

   Note: *It may be necessary to verify the HLA valve plane placement using the PET MPI dataset (see ❷ Figure 8) if there is little to no disease in a patient with suspected sarcoidosis.*

2. On the **AC Images + Quant** screen (Figure 9), choose the **SUV** selection in the **Quant Map Menu** (see ❶ Figure 9) for polar maps to display SUV quantification. The FDG dataset displays SUV calculations (see ❷ Figure 9) that can be used for sarcoidosis assessment. For more detailed 17-segment SUV calculations, change the **Segmental Overlay Menu** selection to **17 Seg**.

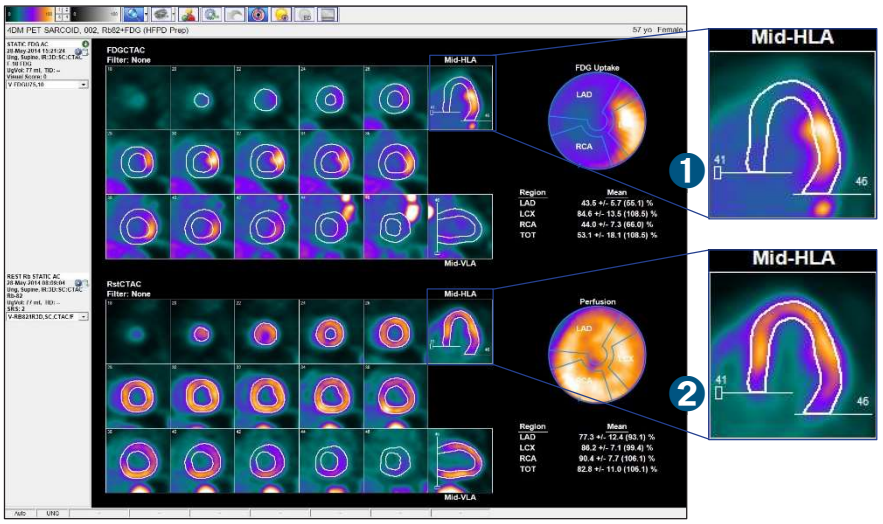

Figure 8. MI Processing screen with F-18 FDG on top and Rb-82 on bottom

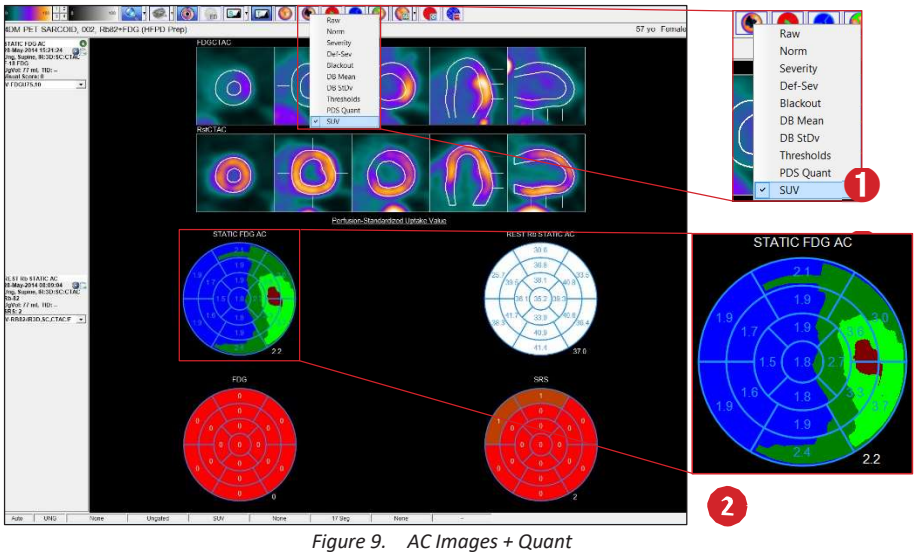

Figure 9. AC Images + Quant

INTERPRETING THE RESULTS

In patients prepared correctly for sarcoidosis/inflammatory imaging to cause adequate suppression of myocardial glucose uptake, recent work has shown that normal myocardial FDG uptake is consistently less than background FDG uptake in the aortic blood pool. Therefore, the ratio of the maximum SUV in normal myocardium to the SUV mean (SUV_{mean}) in the blood pool can be useful for the assessment of the adequacy of metabolic preparation (Larson S, et al. JNC 2019; 27:849-861).

$$\text{Adequate metabolic preparation: } \frac{SUV_{max} \text{ in normal myocardium} < 1.0}{SUV_{mean} \text{ in blood pool}}$$

Areas with ratios of FDG uptake exceeding this value may be considered positive for an inflammatory condition, such as cardiac sarcoidosis.

APPENDIX

IMPORTANCE OF PATIENT PREPARATION

The metabolic preparation of patients for imaging sarcoidosis and other inflammatory conditions is virtually opposite that for viability imaging with FDG. With FDG viability imaging, patients typically fast overnight and are then glucose loaded so that they shift metabolism to glucose. For imaging sarcoidosis or other inflammatory or infectious conditions, it is desired to switch metabolism from glucose to fatty acids. The switch from glucose to fatty acids entails a very low to no carbohydrate diet for at least 12 to 15 hours, preferably greater than 24 hours, prior to FDG injection and imaging. The purpose here is to minimize insulin secretion so that there will be no FDG uptake by normal or ischemic myocardium. With FDG uptake suppressed in normal or ischemic myocardium, FDG uptake in the heart is reflective of myocardial inflammation and or infection. If such preparation is not followed, cardiac regions affected by an inflammatory condition typically cannot be separated from normal myocardium as both normal and inflamed tissue are taking up FDG and may appear exactly the same.

In general two FDG metabolic preparations are utilized for imaging sarcoidosis. Prolonged fasts of 2 to 3 days are commonly used in Japan. More recently, a high fat preparatory diet (HFPD) with as little carbohydrate as possible has been utilized beginning the day prior to imaging. Both of these approaches are often supplemented with heparin injections (10 to 50 units per kilogram). The purpose of heparin is to activate plasma and hepatic lipoprotein lipase in order to break down triglycerides into free fatty acids, which amplifies the effect of the prolonged fast or high-fat diet and minimizes FDG uptake by normal myocardium so that inflammatory uptake of FDG is more readily apparent.

IMAGING PROTOCOL

The imaging acquisition protocol used for sarcoidosis/inflammation imaging can be identical to that used for viability imaging.