

**Cardiac PET**

PET is routinely applied in the study of perfusion, metabolism, viability and function of the myocardium. A comprehensive range of information can be gathered, depending on the applied tracer and the study protocol. Whereas ECG-gated images allow assessment of the heart contraction pattern, dynamic PET series measuring tracer uptake and washout have the potential to absolutely quantify tissue perfusion and glucose consumption.

*Modeling is performed on the basis of PKIN, leveraging the best-in-class quantification solution for the cardiac environment.*

**Quantification of Dynamic Cardiac PET**

Cardiac PET quantification requires dynamic data acquisition and sophisticated data analysis techniques. First, the images are brought into standard orientation showing the myocardium as short-axis cuts. This facilitates segmentation of the myocardial tissue into well-defined anatomical areas. All signals within each segment are then averaged, resulting in representative time-activity curves (TAC). Next, an input curve is derived from the activity in the left ventricular cavity. Finally, an appropriate kinetic model is applied to the TACs in order to quantify the tissue property of interest.

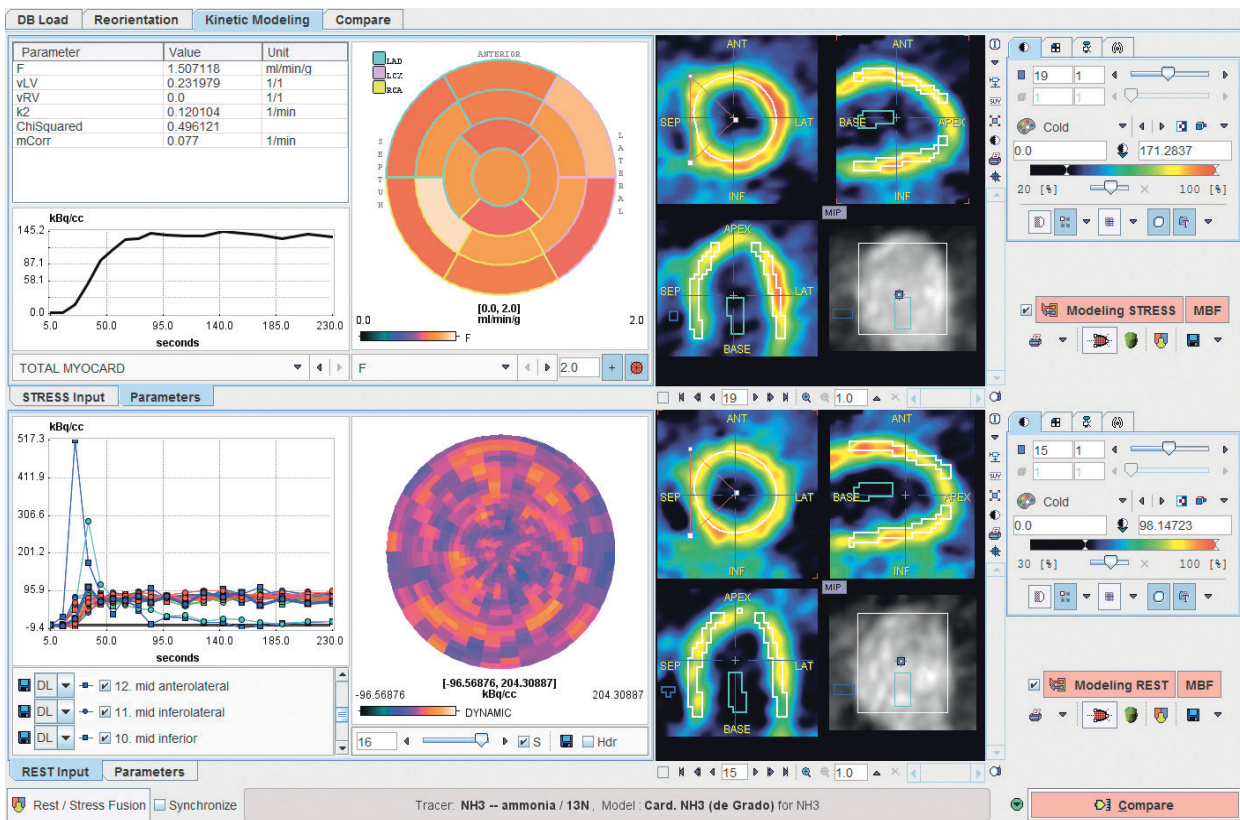
**Analysis of Gated Cardiac PET Images**

The analysis of ECG-gated PET or SPECT series is based on the contouring of the myocardium in each phase of contraction. From the changes in endo- and epicardial contours, cardiac function parameters such as ejection fraction and stroke volume are evaluated and documented

**Cardiac Quantification with PCARDP**

PMOD's PCARDP PET tool offers a comprehensive environment for the quantitative analysis of cardiac PET or SPECT images. The user is guided through the processing steps in a streamlined workflow. Automatic procedures are available for crucial steps such as short-axis reorientation of the images and myocardial segmentation, but the user can interactively correct all outcomes if required. Modeling is performed on the basis of PKIN, leveraging the best-in-class PET quantification solution for the cardiac environment. In the case of rest/stress studies, both series are processed in parallel. For perfusion studies, coronary flow reserve is readily calculated. The results are summarized in comprehensive reports, and can be saved numerically or in standard report formats for research purposes.

*Automatic procedures are available for crucial preprocessing steps such as short-axis reorientation of the images and myocardial segmentation.*



PCARDP user interface illustrating the input of the analysis in the lower part (rest) and the outcome in the upper part (stress).

**Image Data**

The PCARDP tool has been optimized for the analysis of dynamic cardiac PET acquisitions started at the time of tracer injection. For modeling, it is important that the acquisition times are correctly encoded, and that the image units are calibrated in kBq/cc. More recently, the analysis of ECG-gated PET or SPECT series has been added. The gates of such series are handled similarly to the frames of a dynamic series. With static series, only a relative analysis can be performed. In that case, the results are given in % uptake relative to the maximum. Note that the PCARDP tool may be applied to data from humans, rats or mice.

**Heart Segmentation and TAC Calculation**

Segmentation according to the AHA definition and calculation of the TACs in the 17 segments uses the following procedure: A model of the left ventricle (LV) is obtained by contouring the myocardial centerlines within 22 interpolated slice images. The slices are assigned to basal (8), mid-cavity (7), apical (4) and apex parts (3). The basal and mid-cavity parts are divided into 6 sectors with 60° angles, whereas the apical part is divided into 4 sectors with 90° angles. For TAC calculation, a polar sampling strategy is used in the basal and mid parts, and conical sampling elsewhere. Two sampling variants are supported. The first uses the location of the radial maximum in a time-averaged image as the sampling position, the second the location where the radial ray intersects the heart mesh model.

**PET Tracers and Corresponding Models**

Cardiac PET is particular in that the myocardial signal may include spillover components from blood in the left and right ventricular cavity. This is taken care of in the kinetic models applied. PCARDP accounts for this situation with left and right ventricular spillover factors in the compartment models.

<sup>18</sup>FDG: Glucose consumption for viability assessment

- Patlak plot
- 2-tissue compartment model

<sup>13</sup>NH<sub>3</sub>: Perfusion

- 1-tissue compartment model, linear metabolite correction (de Grado 1996)
- 2-tissue compartment model, exponential metabolite correction (Hutchins 1993, van den Hoff 2001)
- 2-tissue compartment model, modified two-parameter model (Choi 1999)

<sup>82</sup>Rb: Perfusion

- 1-tissue compartment model, correction for flow-dependent extraction fraction (Lortie 2007)
- 2-compartment model (Herrero 1992)

<sup>11</sup>C-Acetate: Perfusion

- 1-tissue compartment model, correction for flow-dependent extraction fraction (van den Hoff 2001)

<sup>15</sup>O-Water: Perfusion

- Pre-processing by factor analysis
- 1-tissue compartment model (Hermansen 1998)

**Inspection of Modeling Results**

As dynamic heart data may suffer from excessive motion and the data analysis sequence is inherently complex, a critical assessment of the results is highly recommended. In PCARDP, all intermediate results can be thoroughly inspected and manual corrections applied if necessary:

- Inspection of heart motion using cines and myocardial contour overlays
- Examination of sampling positions by interactive use of polar plots and triangulation of the corresponding location in the images
- Use of the interactive PKIN environment for model fitting of the myocardial TACs

**Gated Analysis**

Contouring of the myocardium is achieved by fitting an active contour model to the data. Analysis of the endo- and epicardial volume over the heart beat results in the classic function parameters ejection fraction (EF), end-systolic and end-diastolic volume, stroke volume, stroke index, myocardial mass (index), peak filling rate, time to peak filling rate, and 1/3 filling rate and fraction.

**Documentation of Results**

The PCARDP results can be documented and exported in many ways for research purposes:

- Report pages with TACs, parameters, polar plots and a bar plot overview can be generated to quickly localize compromised segments. The report pages can be saved as graphic or DICOM objects
- The numerical results can be exported to standard statistical programs for further analysis
- The entire configuration can be recorded in a protocol file, so that processing can be exactly repeated at any later time