

## Cardiac Functional Images

PET is routinely applied in the study of perfusion, metabolism, viability and function of the myocardium. It is considered the gold standard for quantitative assessment of cardiac perfusion for research purposes. Over the past decade, cardiac MR has been developed to a degree that absolute quantification of perfusion is within reach.

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

## Quantification of Dynamic Cardiac PET and MR

PMOD offers two companion cardiac tools for PET and MR. They provide state-of-the-art methods for the model-based analysis of cardiac data, allowing researchers to directly compare the results of the two modalities. Both tools essentially use the same workflow, with some sub-steps pertinent to the two modalities. The images are processed in 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 averaged, resulting in representative tissue signals. An input curve representing the available tracer or contrast agent is derived from the signal in the left ventricular cavity. It is used for the analysis of the segmental signals with an appropriate kinetic model, resulting in the tissue property of interest.

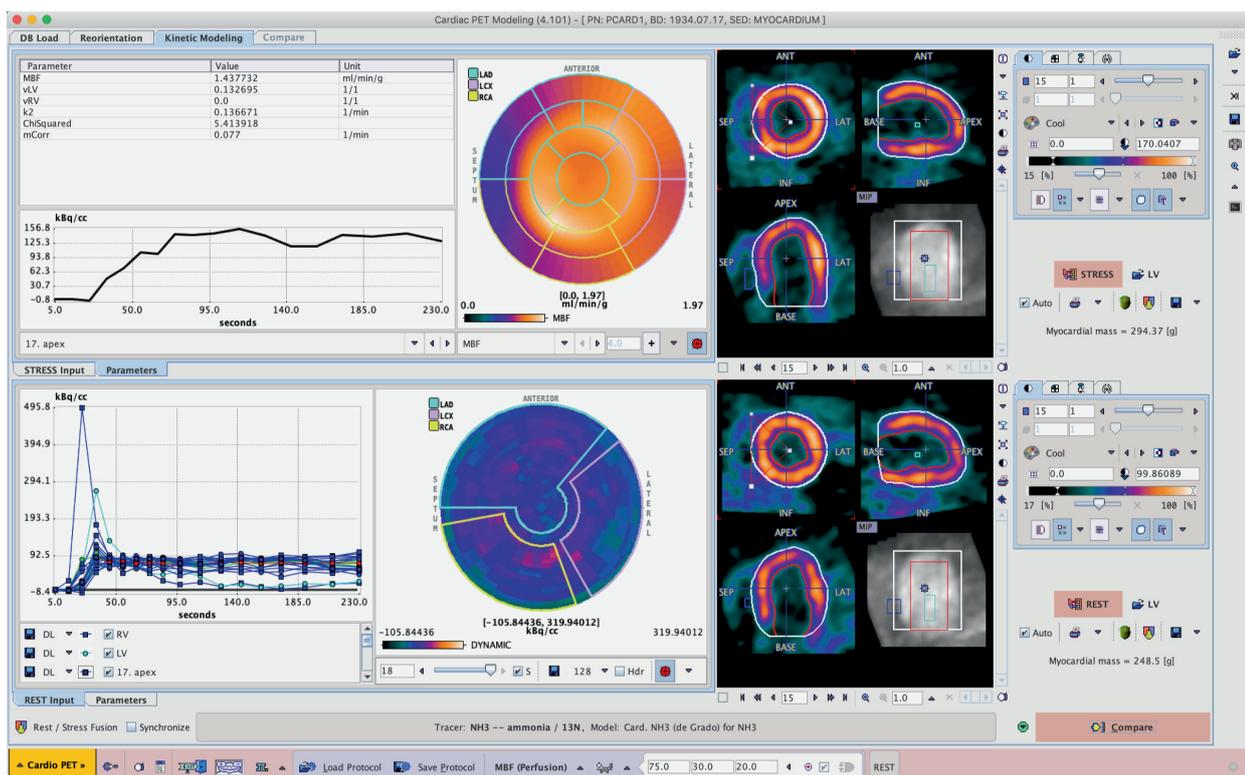
## Analysis of Gated Cardiac PET and MR Images

The analysis of ECG-gated PET and MR series is based on the contouring of the myocardium in each phase of contraction. The two tools derive cardiac function parameters such as ejection fraction and stroke volume from the beating endo- and epicardial contours and document them in comprehensive reports.

*Using PCARD, researchers may apply state-of-the-art perfusion quantification to their data and compare their results across modalities.*

## 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.



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

## Image Data

The cardiac PET tool has been optimized for the analysis of dynamic PET acquisitions started at the time of tracer injection. The cardiac MR tool requires gadolinium first-pass MR images in short-axis orientation, preferably measured with accelerated sequences within a breath hold. For full quantification a B1 and a T1 scan are additionally required to correct field inhomogeneity and convert the MR signal to contrast agent concentration. Both tools also read and analyze ECG-gated images. The gates of such series are handled similarly to the frames of a dynamic series. Note that the cardiac tools may be applied to data from humans, rats or mice.

## Heart Segmentation and Signal Calculation

The myocardium is segmented according to the AHA definitions. Depending on the data, different segmentation strategies are supported, including automatic procedures as well as interactive outlining for difficult cases. In each segment, an average signal is calculated, representing its function.

## 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.

<sup>18</sup>FDG: Glucose consumption for viability assessment (Patlak plot, 2-tissue compartment model)

<sup>13</sup>NH<sub>3</sub>: Perfusion (3 different compartment models)

<sup>82</sup>Rb: Perfusion (1- and 2-compartment models)

<sup>11</sup>C-Acetate: Perfusion (1-compartment model)

<sup>15</sup>O-Water: Perfusion (1-compartment model)

General: Tracer retention

## MR Perfusion Models

The following models are available for the quantification of first-pass cardiac MR (CMR) data.

- Fermi function
- Basis function method
- Model-independent approach

Analysis of conventional first-pass CMR images is reduced in comparison to the full quantification, in that no B1 and T1 correction is performed. However, assuming similar signal distortions in stress/rest studies, the ratio of the outcome can be considered as a measure of the coronary flow reserve.

## Interactive Modeling Environment

Both cardiac tools rely on the PKIN tool for the modeling. By default, the signals are processed in the background. However, they can also be explored in the interactive PKIN environment. This allows thorough investigation of the quantification results and gives access to all methods implemented in PKIN for improvement of fitting robustness.

## Qualitative MR Perfusion Analysis

Conventional perfusion scoring can also be performed in the cardiac MR tool. A separate panel allows interactive review of the rest and stress images, side by side, with the sectors in overlay, using cine mode. Three different grading schemes can be employed to assign defect scores to the sectors.

## Gated Analysis for PET and MR

The analysis of gated images requires contouring of the myocardium. This can be achieved by fitting of an active contour model to the data. If the result is not satisfactory, manual methods allow improvement of the contour definition. 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  $\frac{1}{3}$  filling rate and fraction.

## Documentation of Results

The PCARD 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