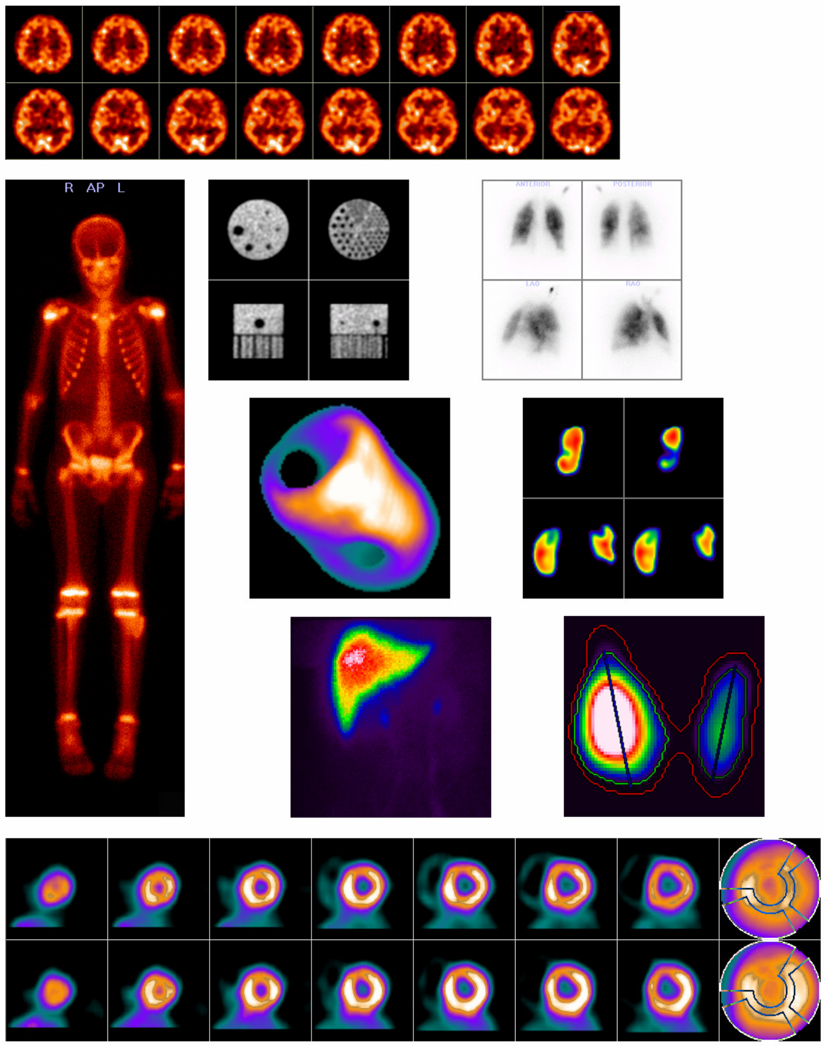
# Handbook of *InterViewXP*

## Clinical guide of SPECT / Whole Body / Planar processing software package

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Medical Imaging Systems

*Note: Original images always lose a certain amount of detail when reproduced.*

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## Glossary of abbreviations

| | |
|---|---|
| BMI | Body mass index |
| BP | Blood pressure |
| BPR | Back projection |
| CAD | Coronary artery disease |
| CCW | Counter clockwise |
| CX | Circumflex |
| DM | Diabetes mellitus |
| ECG | Electrocardiography |
| ED | End diastole |
| EF | Ejection fraction |
| ES | End systole |
| FBP | Filtered back projection |
| HR | Heart rate |
| LAD | Left anterior descending artery |
| LBBB | Left bundle branch block |
| LEAP | Low energy all purpose |
| LEGP | Low energy general purpose |
| LEHR | Low energy high resolution |
| LPO | Left posterior oblique |
| LV | Left ventricle |
| MI | Myocardial infarction |
| OS-EM | Ordered subset expectation maximization |
| PCI | Percutaneous coronary intervention |
| PTCA | Percutaneous transluminal coronary angioplasty |
| RAO | Right anterior oblique |
| RCA | Right coronary artery |
| SPECT | Single photon emission tomography |

# 1. Introduction

***InterViewXP*** ™ is a dedicated Nuclear Medical Image processing Software Package running under Microsoft® Windows® platforms, providing the well-known Windows based user-friendly interface. The high-resolution true-colour display allows multi format image presentation in excellent quality.

The clinical tasks are organized into logical steps and controlled by highly automated processing tools. Each of them corresponds to a page of a workbook and allows the user to return to the previous steps to make modifications, if necessary.

The program leads the user through the steps of processing, requiring minimal interventions.

The high-speed hardware supports the necessary computing power in the case of iterative reconstructions (including Ordered Subsets Expectation Maximization) to make them applicable in the clinical routine. In some cases these methods deliver a higher image quality than filtered back projection (FBP) (also included in the system).

Applying user-definable templates allows arbitrary combinations of pictures and texts in a simple interactive way to create final report formats. The way of documentation is according to the recommendations of the working group standardized Image Documentation of the German Nuclear Medicine Society (DGNM). The software package supports data exchange with any nuclear medical workstation, using the industry standards DICOM and Interfile protocols.

## Processing of Tomographic Studies

**Reconstruction Methods**

| | | |
|---|---|---|
| FBP | Filtered Back Projection | |
| OS-EM | Ordered Subset Expectation Maximization | iteration |
| MOS-EM | Modified Ordered Subset Expectation Maximization | iteration |
| ML | Maximum Likelihood | iteration |

Users can define the parameters for the following filters as well as they can archive catalogues for future use:

- Ramp
- Shepp-Logan
- Modified Shepp-Logan
- Parzen
- Metz
- Wiener
- Butterworth
- Hanning
- Hamming

**Corrections**

| | |
|---|---|
| - Smooth | linear |
| - Background subtraction | automatic |
| - Multiplication | |
| - Activity correction | smoothing extreme pixels |
| - Filters (see above) | |
| - Motion correction | |

## Clinical studies

Evaluation phases
Reconstruction
Attenuation correction by Chang method for brain studies
Reorientation
Different final images

**Cardiac SPECT**

| | |
|---|---|
| $^{201}$Tl perfusion | 5 different reports from analysis of tomographic images. Reports provide long and short axis images and Bull's-eye with quantitative polar map analysis. |
| $^{201}$Tl redistribution | 6 different reports from analysis of $^{201}$Tl stress-redistribution tomographic images. Reports provide long and short axis slices and stress, redistribution Bull's-eye. |
| $^{99m}$Tc Stress-Rest | 6 different reports from analysis of $^{99m}$Tc-Sestamibi tomographic images. Reports provide long axis, short axis and coronal slices, subtraction Bull's-eye. |
| Rest 24 hours | 6 different reports from analysis of $^{201}$Tl rest-late rest tomographic images. Reports provide long and axis, short axis, and coronal slices, stress, rest, late rest and subtractional Bull's-eye. |
| Gated SPECT | 5 different reports from gated SPECT processing with quantitative analysis. |

**Brain SPECT**

| | |
|---|---|
| Brain SPECT | 4 different reports from analysis of $^{99m}$Tc-HMPAO brain tomographic images with attenuation correction and reorientation.<br>Reports provide frontal, sagittal and transversal slices. |
| Brain Stress-Rest SPECT | 5 different reports from analysis of $^{99m}$Tc-HMPAO brain tomographic images.<br>Reports provide frontal, sagittal and transversal slices, and each of S, R, S-R, R-S, S-R+R-S images are viewed on separate pages.<br>Movement of patient's head can be corrected. |
| Quantitative brain region analysis | Automatic contour determination.<br>All slices are divided into 8-segments with quantitative determination right-left hemisphere analysis |

**Whole Body Studies**

| | |
|---|---|
| WB bone | Display and zoom of multiplied AP and PA images and additional static views. Multilevel display:<br>Double intensity whole body presentation |

**3D Presentation**

- 3 D Surface rendering
- 3 D Volume rendering

# 2. PHANTOMS

# Jaszczak Phantom SPECT Imaging

## Application

Jaszczak phantom is one of the best tools to test the performance (both intrinsic and clinical conditions) of the imaging system from both hardware and image processing program aspect. In the case of a particular hardware configuration, it is possible to test the different pre-processing, post-processing and reconstruction algorithms. With the help of the phantom it is possible to determine the attenuation coefficient for water equivalent uniform attenuation media (like the brain) in an experimental way.

## Acquisition protocol

**SPECT STUDY**

Step and shoot mode
Matrix size: 128x128
Number of steps: 128 (360° rotation)
Exposition: 70 sec
Applied activity: 300 MBq $^{99m}$Tc mixed in water
Collimator: LEHR
Phantom position: supine
Direction of rotation: CCW
Start angle: 0°

## Image processing

**SPECT**

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% background subtraction after the reconstruction
- Attenuation correction
- Reorientation of the transaxial slices (Reference: long and short axis of the cylinder)
- Generation of coronal and sagittal slices

## Case study

A high count density (~150M total counts) phantom was evaluated by "optimal" 2D Butterworth pre-filtering and BPR with ramp filter. The reconstructed slices are artifact-free (no aliasing) and the geometrical structure of the phantom was imaged according to the phantom pattern.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

# Jaszczak Phantom Imaging

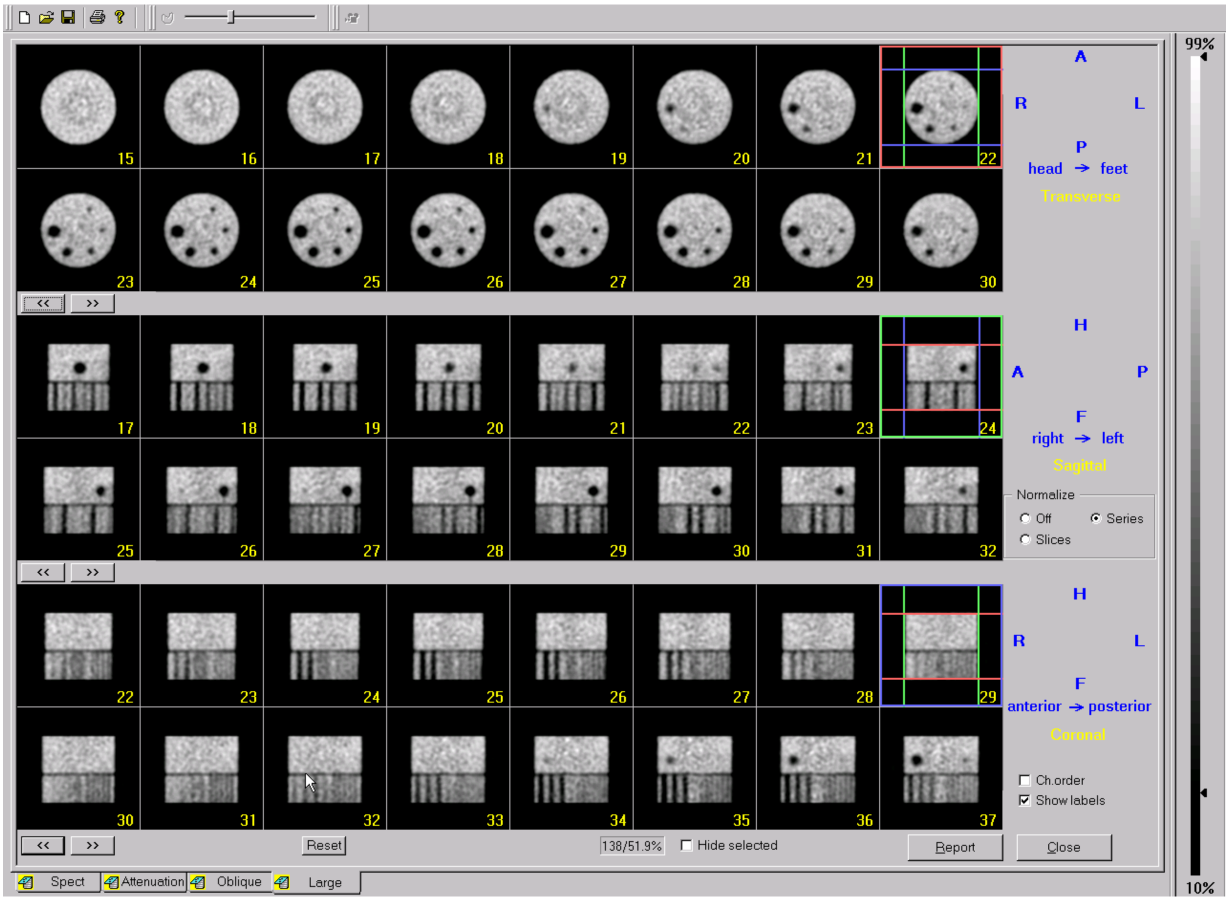



Figure 2-1 Slices

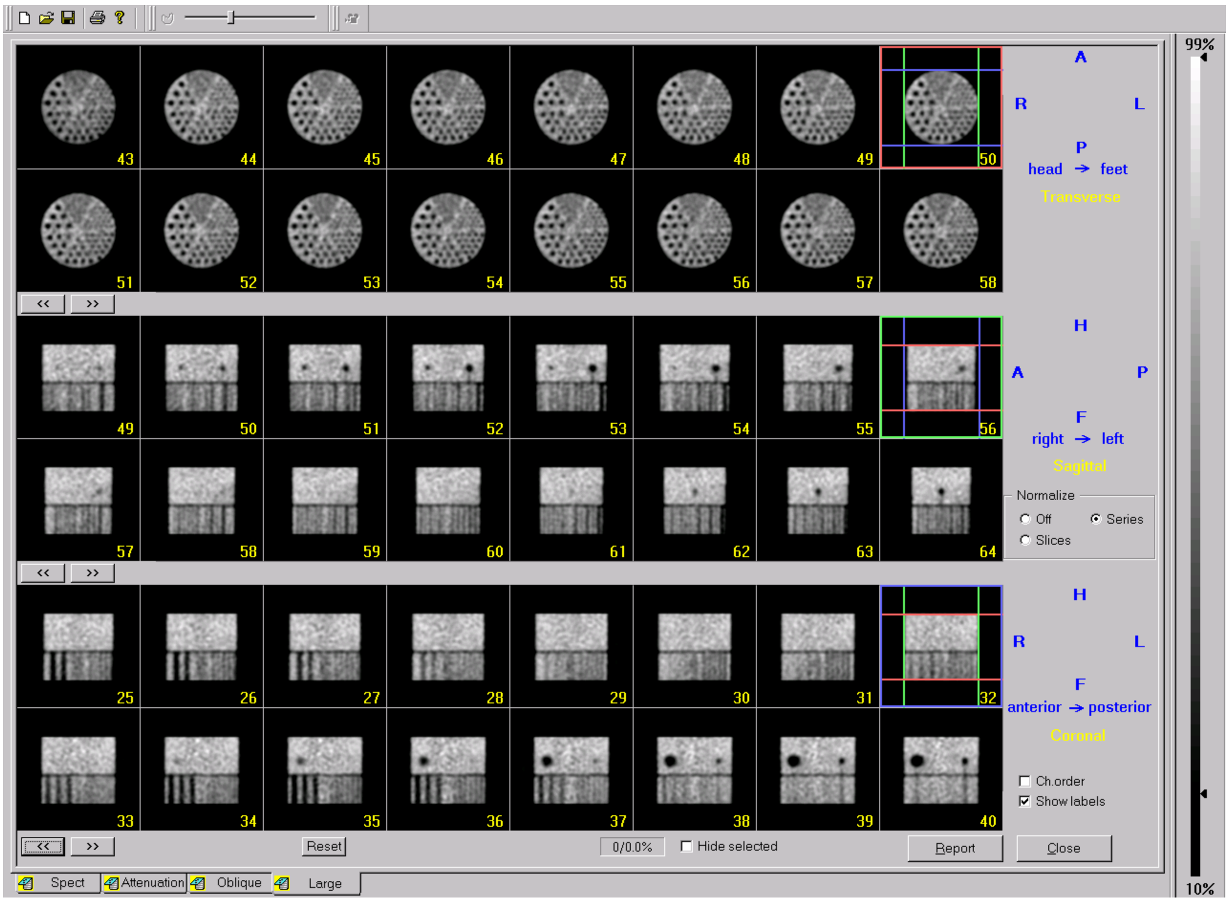



Figure 2-2 Slices

# Capintec Myocardiac Phantom SPECT Imaging

## Application

Capintec myocardiac phantom is a good approximation of the real physical environment for myocardiac functional study. With the help of the phantom it is possible to estimate the minimum detectable defected size and the quality of the imaging depending on the variable defect size under the clinical conditions, as well as including the applied pre-processing, post-processing and reconstruction algorithms.

## Acquisition protocol

**SPECT STUDY**

Step and shoot mode
Matrix size: 64x64
Number of steps: 30 (180° rotation)
Exposition: 20 sec
Applied activity: 74 MBq $^{99m}$Tc mixed in water
Collimator: LEAP
Phantom position: supine
Direction of rotation: CCW
Start angle: LPO-45°

## Image processing

**SPECT**

- Regular smoothing of the projection data
- 2D pre-filtering on the smoothed data set by Butterworth filter
- Reconstruction with OS-EM algorithm
- 15% background subtraction after the reconstruction
- Reorientation of the transaxial slices (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical and longitudinal (apical) slices
- Polar-map generation

## Case study

A normal and an abnormal myocardiac phantom study was imaged (according to the clinical requirements) and evaluated. The simulated defect size corresponded to ~20% on the inferior, inferoseptal location. Separation of the normal and the defected parts of the myocardium can be evaluated qualitatively and quantitatively on the presented slices and polar-map.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## Capintec Phantom Imaging

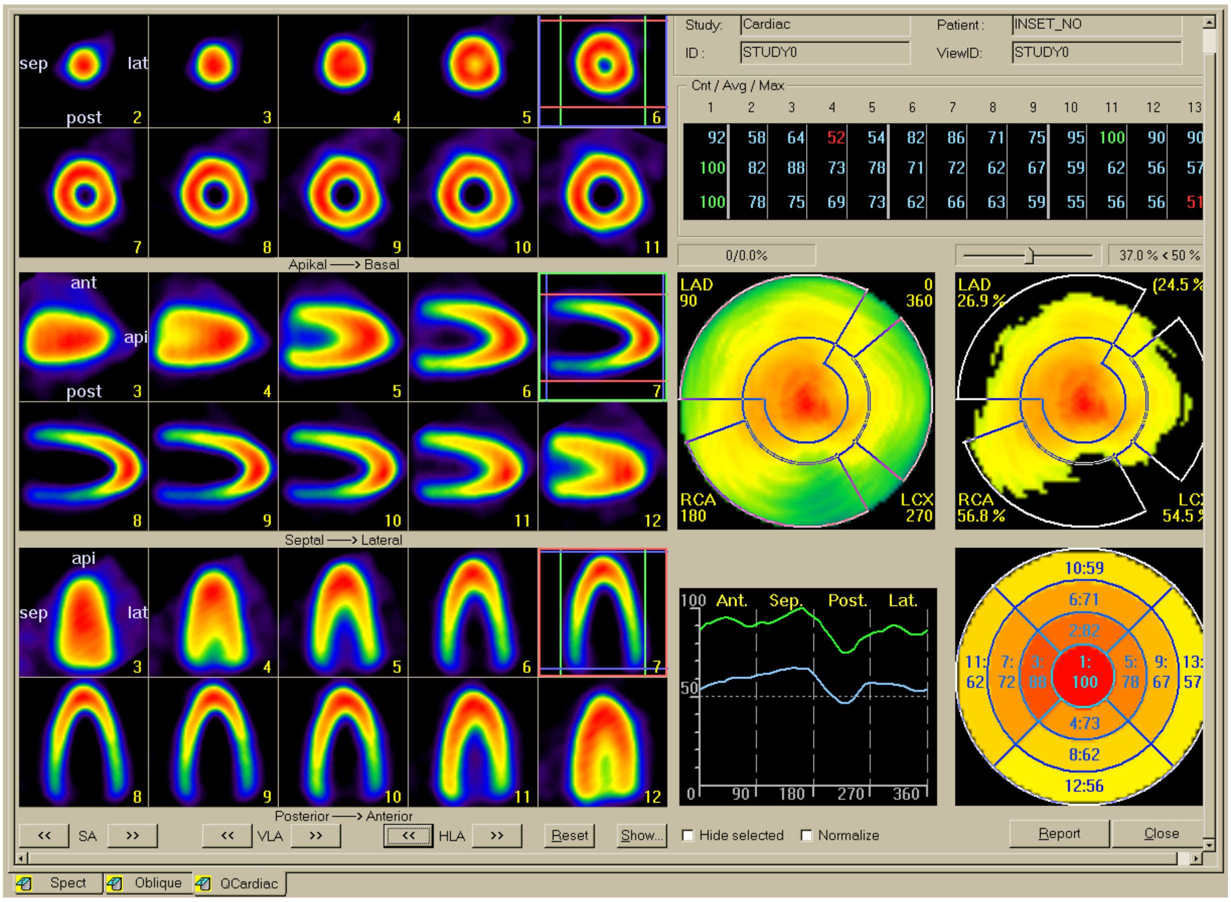



Figure 2-3 Simulation of the normal case

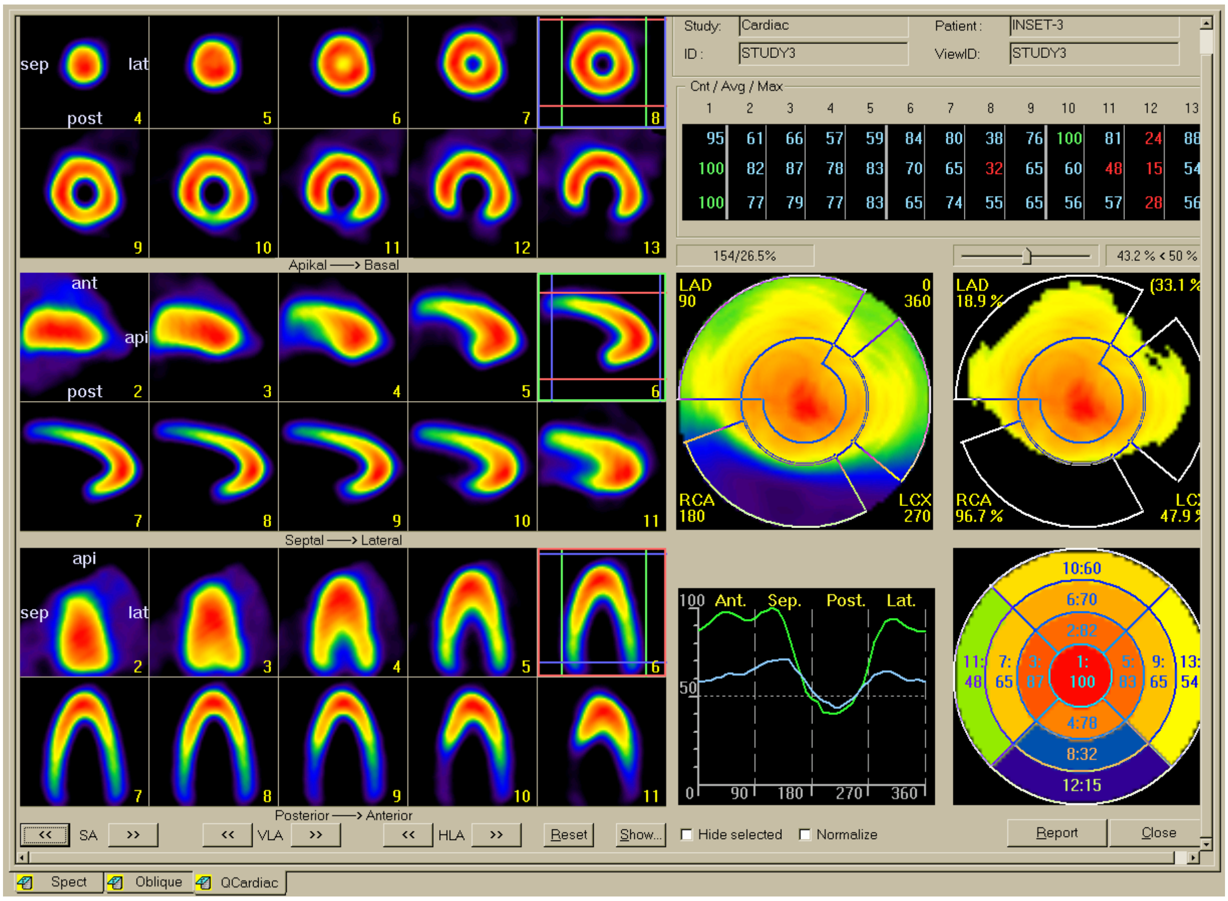



Figure 2-4 Simulation of the defect in the inferior, inferoseptal region

## Capintec Phantom Imaging

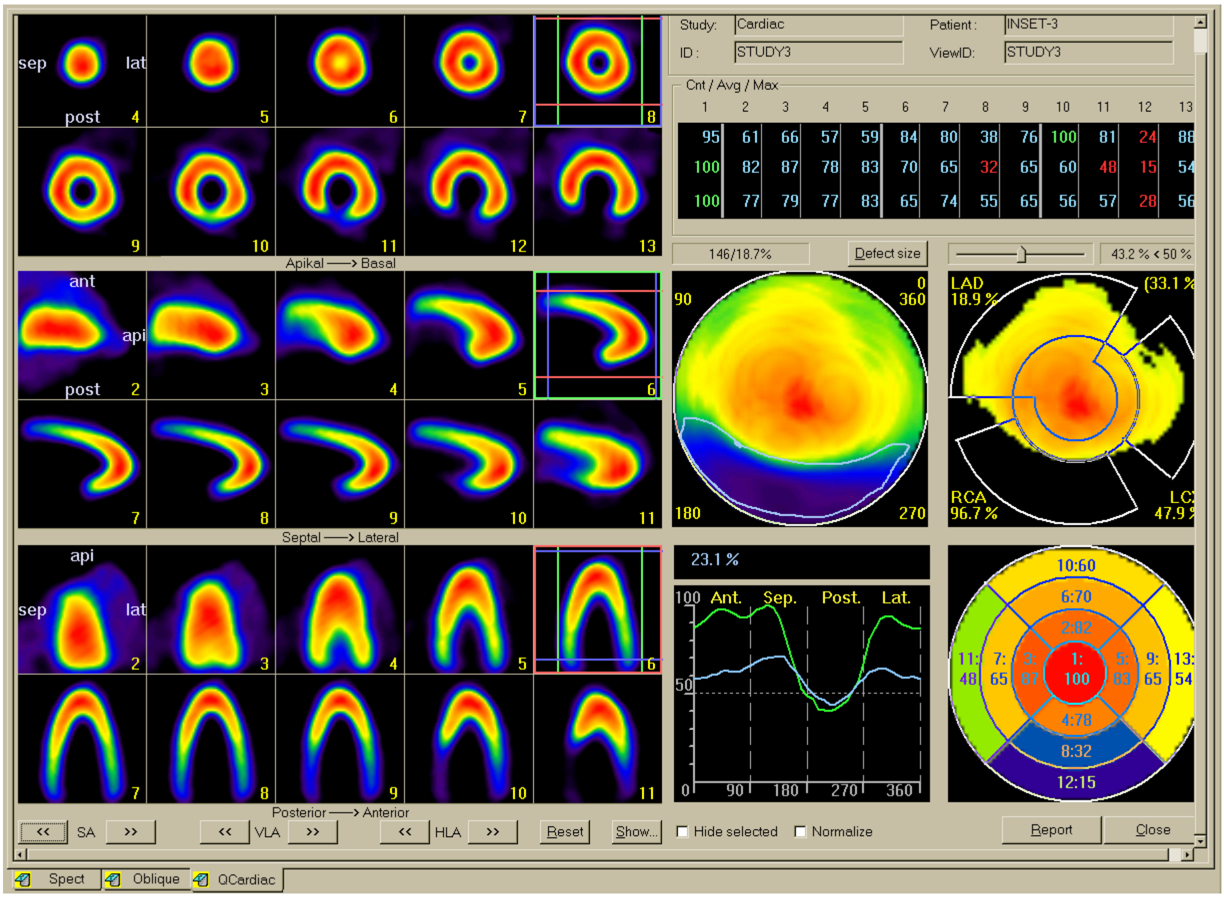


Figure 2-5 Quantitative analysis of the defected area by ROI

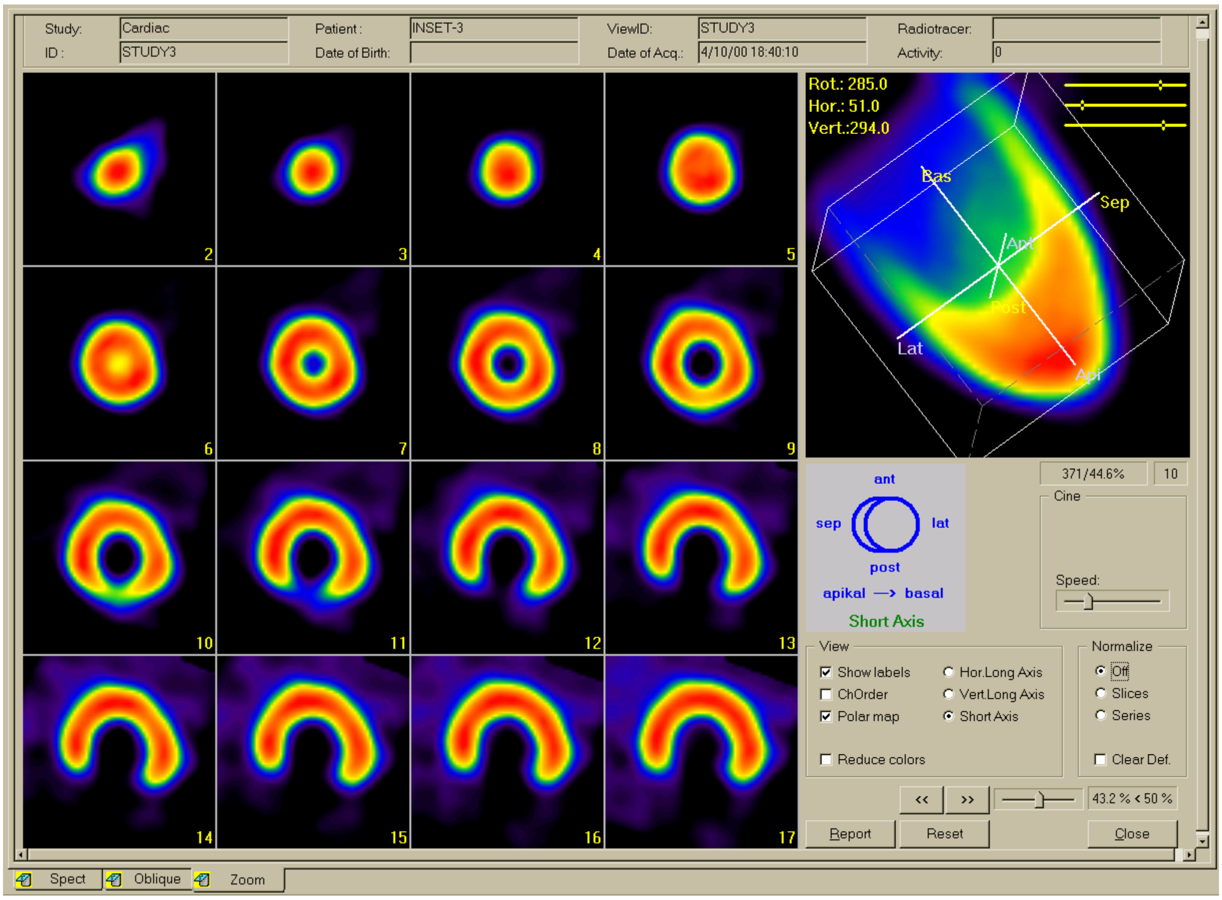


Figure 2-6 3D presentation (deep rendering)

# Biodex Myocardiac Phantom SPECT Imaging

## Application

This other type of myocardial phantom is also a good tool for the approximation of the real physical environment for myocardial functional study for both visual and quantitative application.

Biodex SPECT Anthropomorphic Torso Phantom with Cardiac Insert was used for system performance check.

With the help of this phantom it is possible to estimate the minimal detectable size and the location of defect as well as the quality of the imaging, depending on the variable defect size under different clinical conditions (signal/noise control) with the applied pre-processing, post-processing and reconstruction algorithms.

## Acquisition protocol

**SPECT Study**

Matrix size: 128x128
Number of steps: 32
Collimator: LEHR
Photopeak windows: 140 keV ± 20%
Applied activity: 250 MBq
Orbit: 180° CCW step and shoot (45° RAO → 45° LPO)
Time/view: 50 sec
Patient position: supine

## Image processing

**SPECT**

- Regular smoothing of the projection data
- 2D pre-filtering on the smoothed data set by Butterworth filter
- Reconstruction with OS-EM algorithm
- 15% background subtraction after the reconstruction
- Reorientation of the transaxial slices (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical and longitudinal (apical) slices
- Polar-map generation and 3D presentation
- Evaluation by EMORY CARDIAC TOOLBOX (ECToolbox)

## Case study

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## Biodex Phantom Imaging

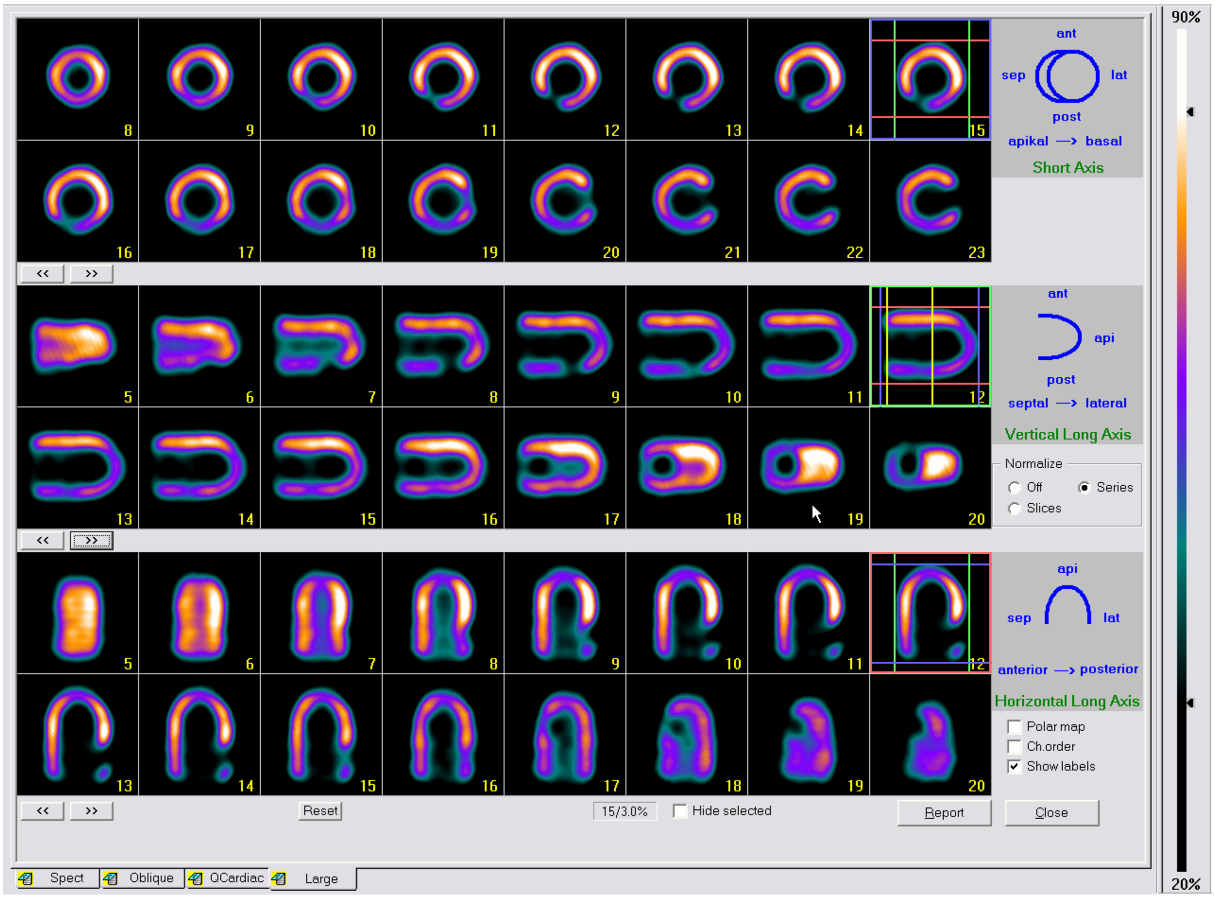



Figure 2-7 Reoriented Slices (***InterViewXP***)

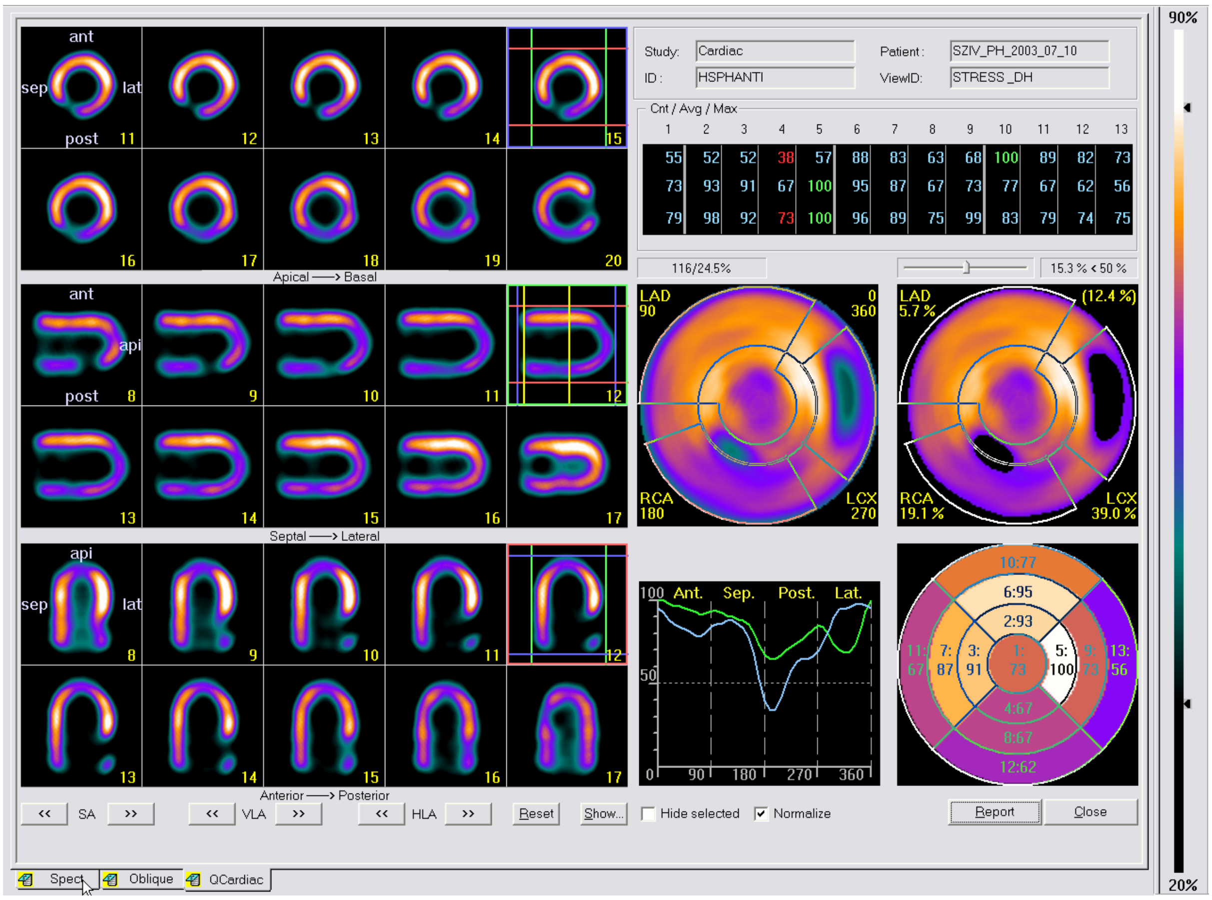



Figure 2-8 Quantitative analysis of the defected area by circumferential profile curves (***InterViewXP***)

## Biodex Phantom Imaging

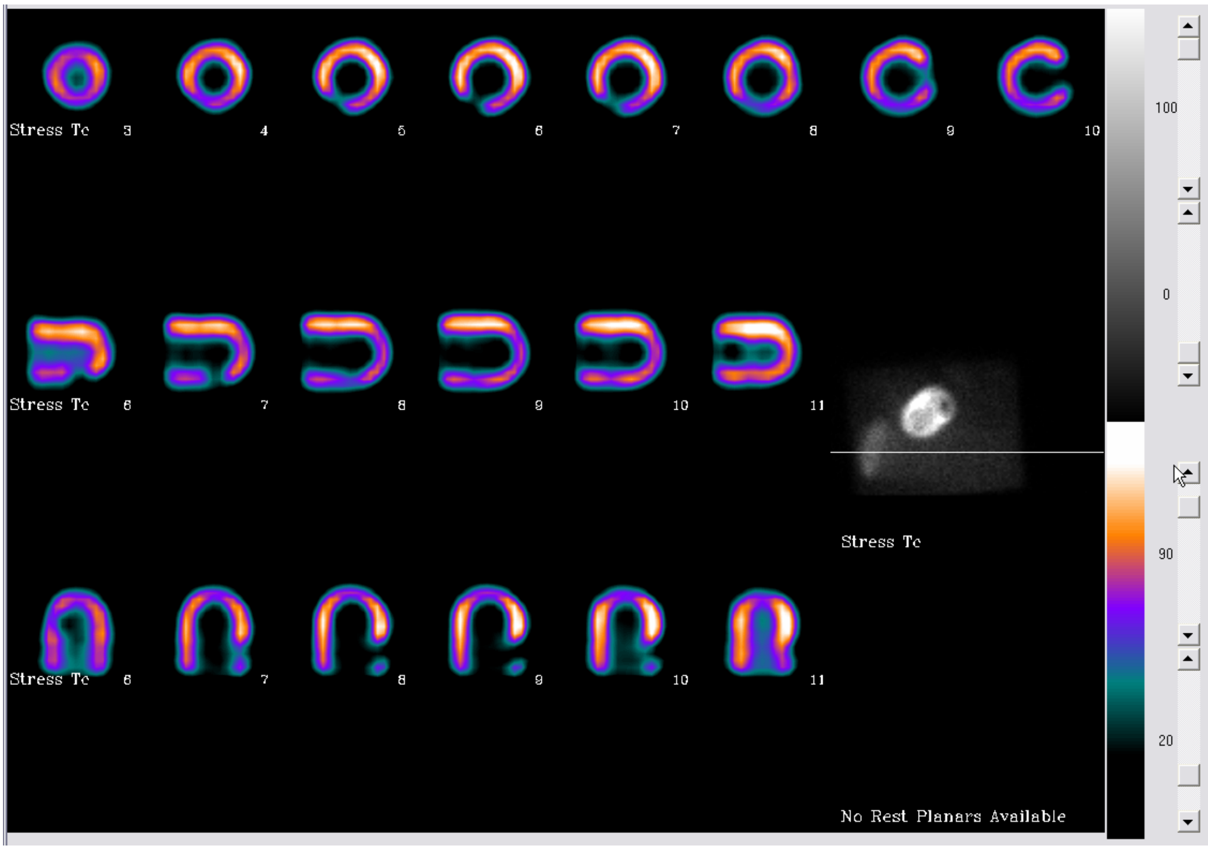



Figure 2-9 ECToolbox Slices

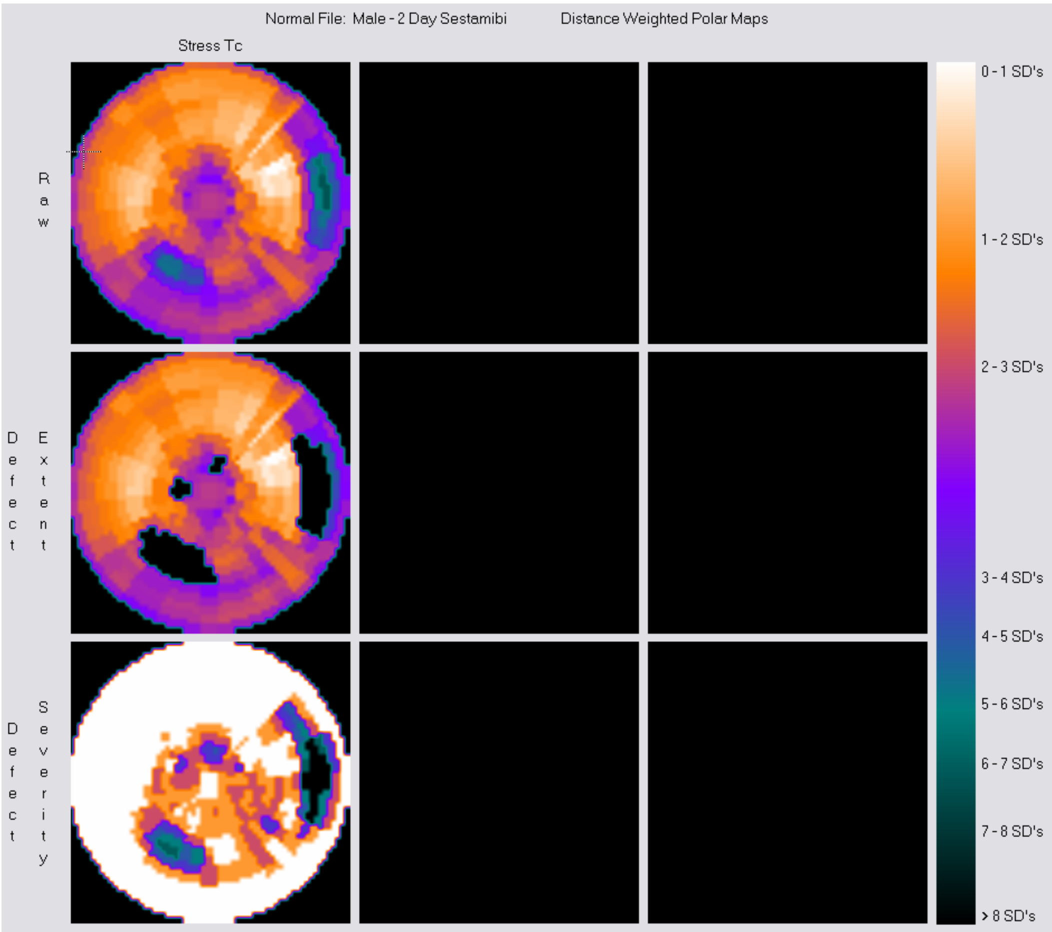



Figure 2-10 ECToolbox Polar Maps

# RSD Striatal Phantom SPECT Imaging

## Application

The phantom test serves dopaminargic receptor studies. The specific striatal uptake and the background cerebral uptake of the diagnostic radiopharmaceutical are represented in the phantom.

## Acquisition protocol

**SPECT STUDY**

Step and shoot mode
Matrix size: 128x128
Number of steps: 128 (360° rotation)
Exposition: 40 sec
Applied activity: 70 MBq $^{123}$I mixed in water
Collimator: LEHR
Phantom position: supine
Direction of rotation: CCW
Start angle: 0°

## Image processing

**SPECT**

- Decay correction
- Half size application (pixel size correction)
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 10% background subtraction after the reconstruction
- Attenuation correction
- Reorientation of the transaxial slices (Reference: long and short axis of the cylinder)
- Generation of coronal and sagittal slices

## Case study

A low count density (~820k total counts) phantom was evaluated by "optimal" 2D Butterworth pre-filtering and BPR with ramp filter. The reconstructed slices are artifact-free (no aliasing) and the geometrical structure of the phantom was imaged according to the phantom pattern.

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*

# RSD Striatal Phantom Imaging

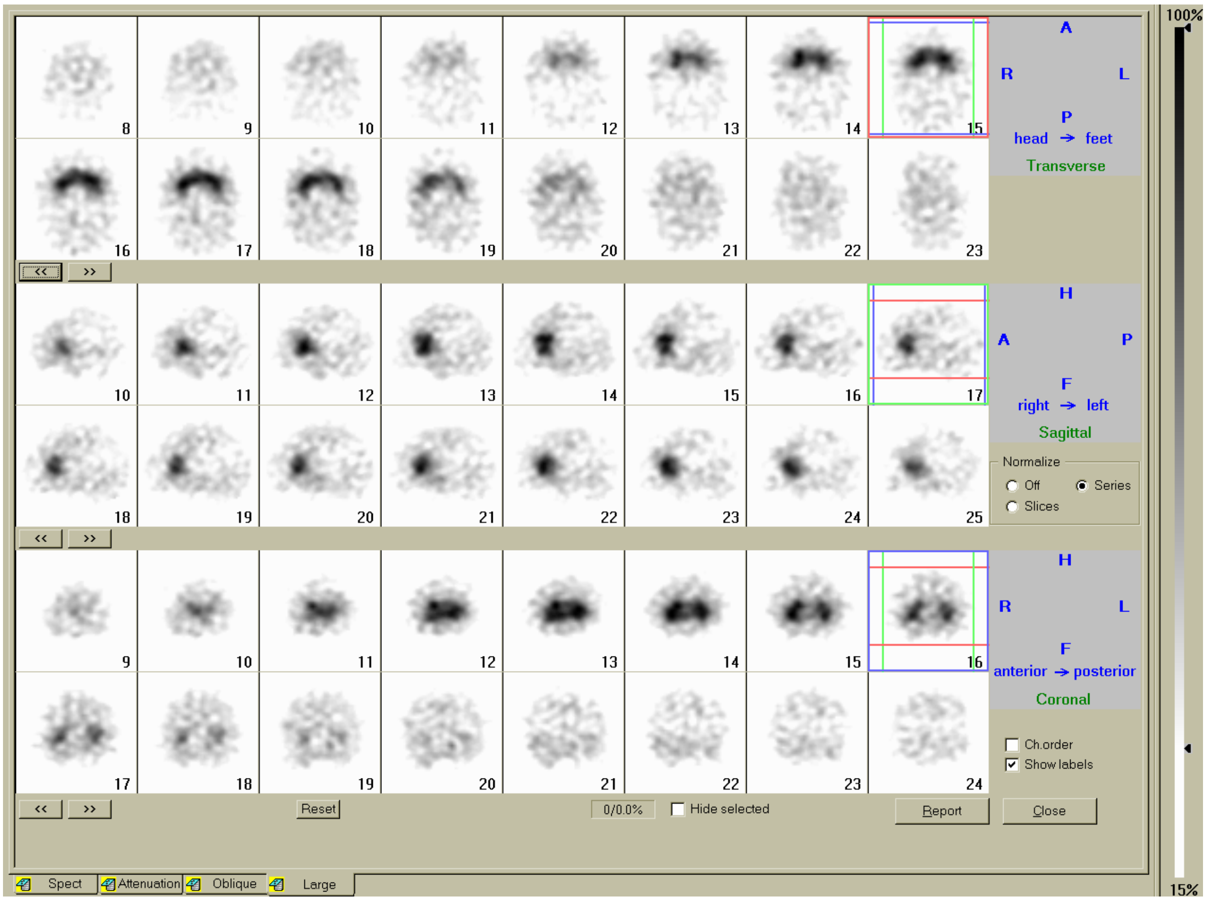



Figure 2-11

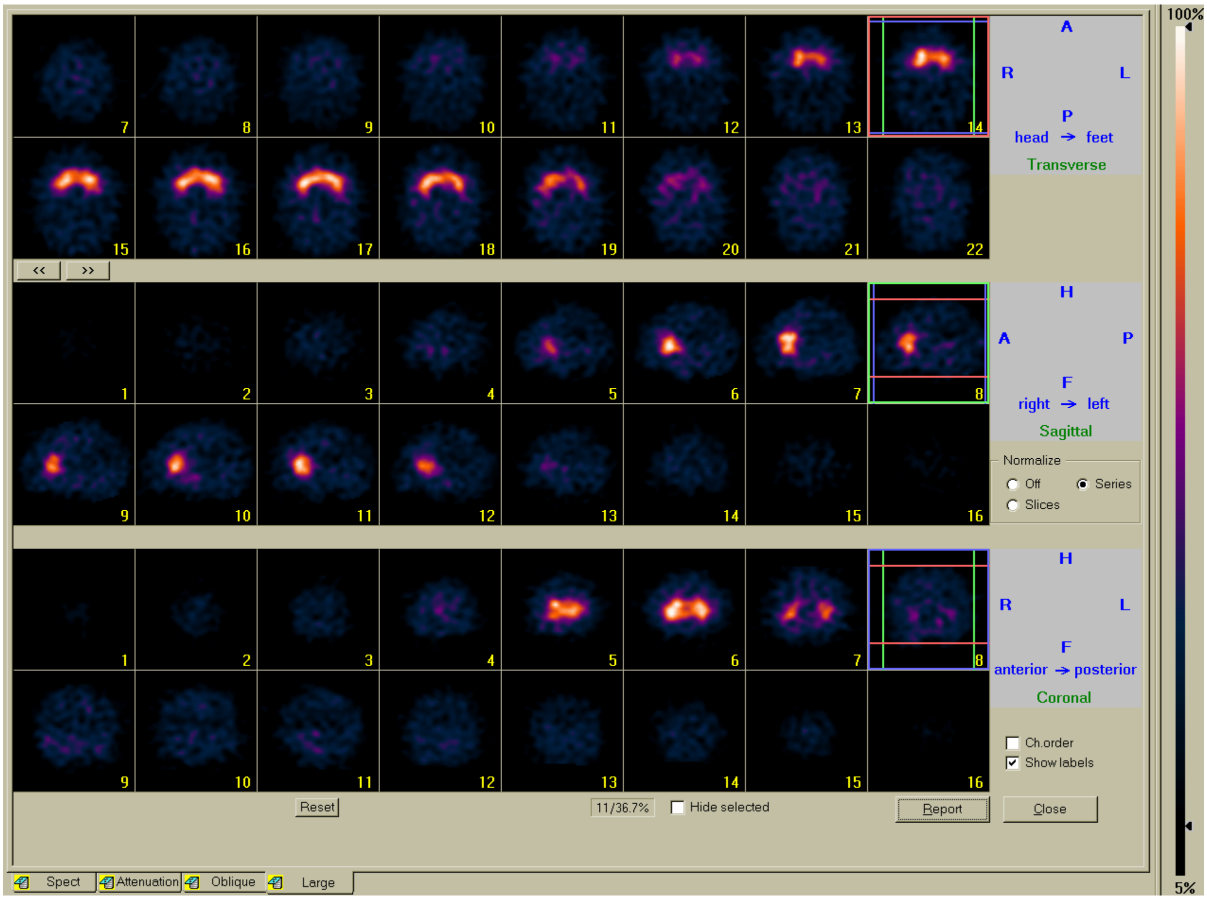



Figure 2-12

# 3. CARDIOLOGY

# Perfusion SPECT imaging with $^{201}$Tl

## Stress-redistribution imaging

### Clinical application

$^{201}$Tl ($^{201}$TlCl) accumulates in the myocardium depending on the regional blood flow. A subsequent SPECT imaging can present the regional perfusion and viability of the myocardium. Most of the cases stress (either by exercise or by pharmaceutical, e.g. Dipyridamol) and appr. 4h later redistribution (in rest phase) imaging are performed. Timing is a very important factor, because the redistribution process becomes more significant half an hour after the injection of stress phase. Quantitative wash-out analysis can be carried out by the polar-map displays.

### Acquisition protocol

**SPECT STUDY**

Step and shoot mode
Matrix size: 64x64
Number of steps: 30 (180° rotation)
Exposition: 40 sec (stress phase), 50 sec (rest phase)
Applied activity: 100 MBq $^{201}$Tl ($^{201}$TlCl)
Collimator: LEAP
Patient position: supine
Direction of rotation: CCW
Start angle: LPO-42°

### Image processing

**SPECT**

- 2D pre-filtering on the projection data by Butterworth filter
- Reconstruction with OS-EM algorithm
- 20% background subtraction after the reconstruction
- Reorientation of the transaxial slices
  (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical, longitudinal (apical) slices
- Polar-map generation

### Case study

Dipyridamol stress and rest studies were performed on a 65-year-old female patient. Diabetes mellitus I, systemic hypertension and carotid artery sclerosis in her history. Preoperative risk stratification for major non-cardial surgery. Transient ischaemia due to stenosis of the diagonal branches (1, 2) of the LAD, and that of the marginal branch of the non-dominant CX artery.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## $^{201}$Tl Stress-redistribution imaging

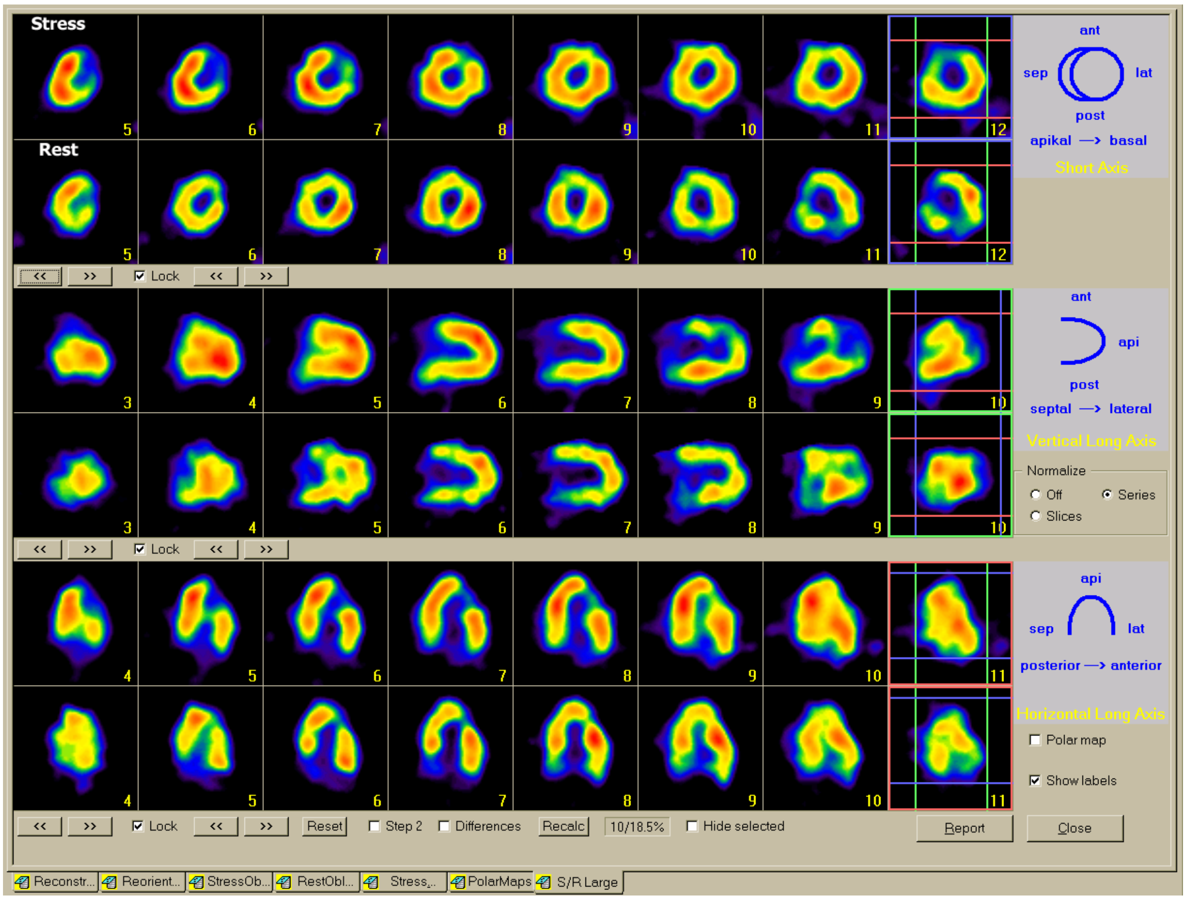


Figure 3-1 Reoriented slices

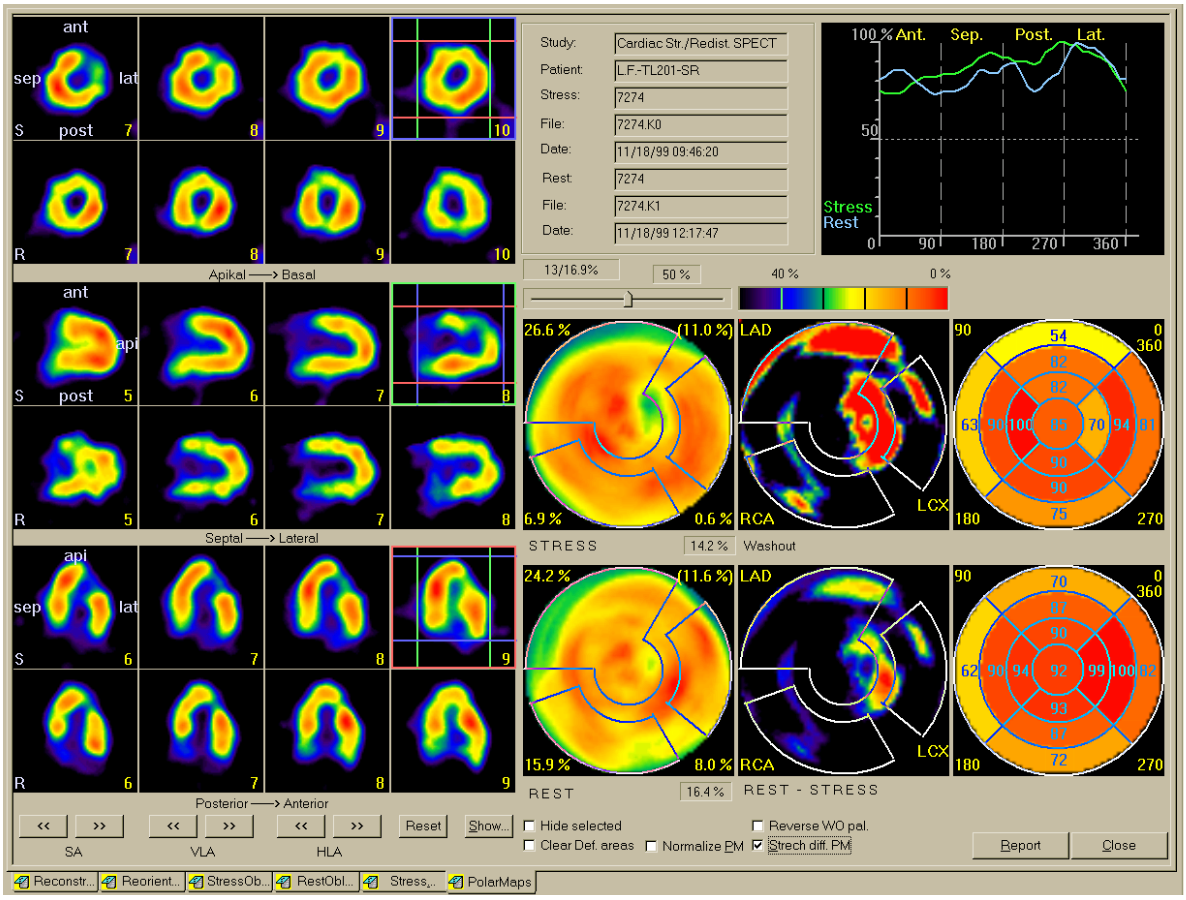


Figure 3-2 Polar maps

# Thallium reinjection

## Clinical application

In selected cases after the $^{201}Tl$ stress + rest study when the evaluation of hibernating myocardial mass is necessary an additional 50MBq $^{201}TlCl$ radiopharmaceutical has to be injected – reinjection – after the redistribution imaging, or a rest-redistribution study should be acquired. SPECT imaging needs to be performed after the reinjection and appr. 24h later, too. The rest phases may be evaluated like individual rest studies and it also is possible to evaluate the dynamic of the rest-redistribution study process.

## Case study

71-year-old male with previous myocardiac infarction and LV dysfunction. Dyspnoea on exercise stress test without significant ischaemic ECG changes. 3 vessel disease with previous antero septal apical myocardiac infarction. Mild transient ischaemia in the anteroseptal and inferior regions and no hibernating myocardial mass at all on $^{201}Tl$ reinjection.

# $^{201}$Tl Stress + Redistribution Imaging with Reinjection Images

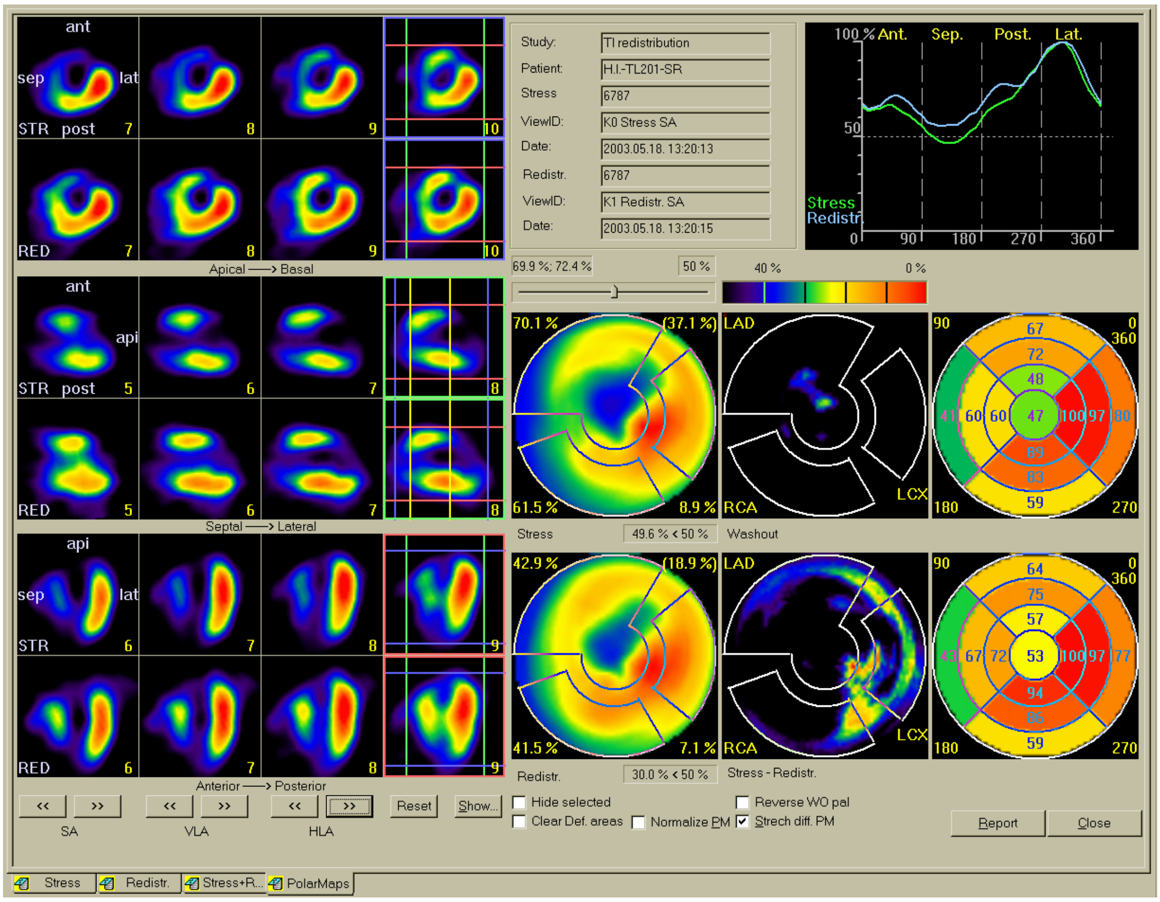



Figure 3-3 $^{201}$Tl Stress + Redistribution Polar Map

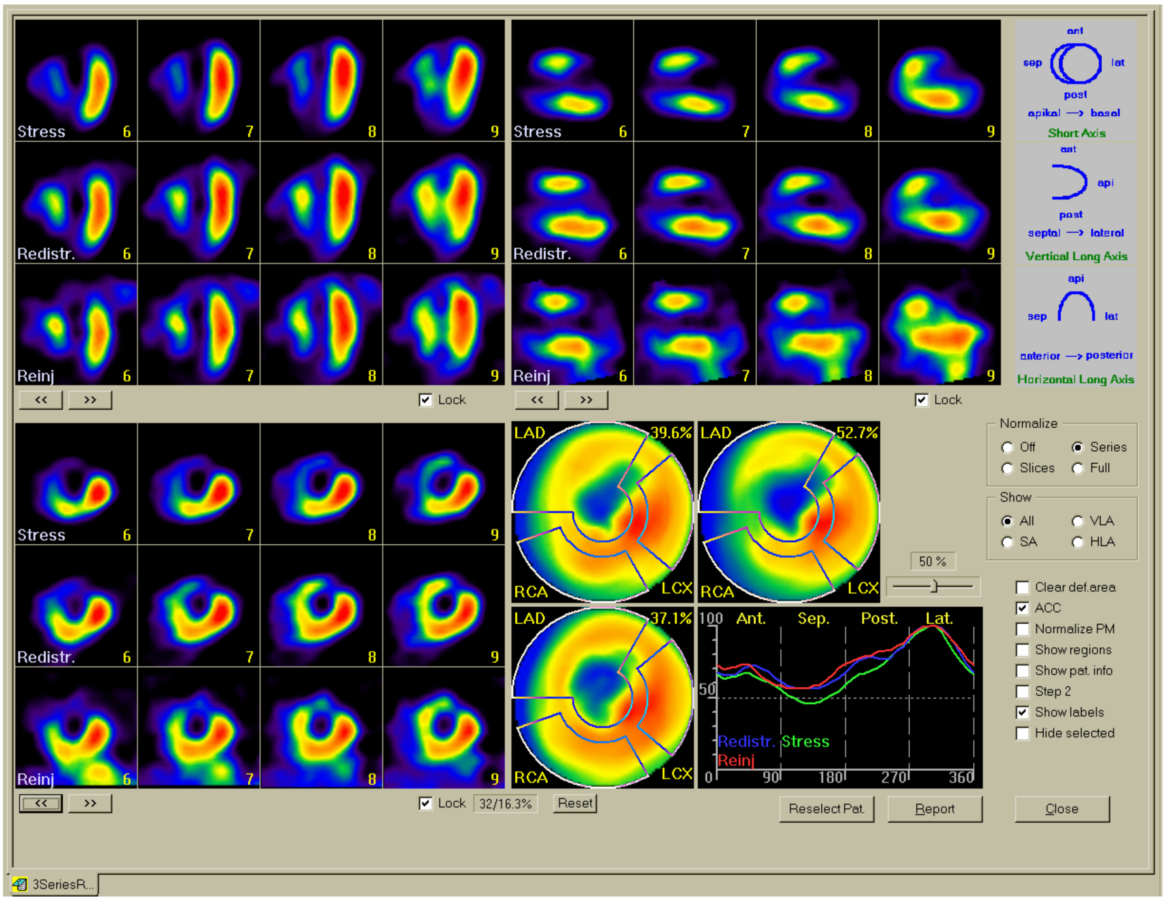



Figure 3-4 $^{201}$Tl Stress-Redistribution and Reinjection (24h)

# Other typical stress-redistribution studies

## Imaging protocol

110MBq (3 mCi) $^{201}$TlCl radiopharmaceutical is injected at peak stress maximum 10 minute before the stress SPECT. Then 3-4 hours later a redistribution rest SPECT is acquired.

## Acquisition protocol

**SPECT Study**

Collimator: LEGP
Photopeak windows: 70 keV ± 25%, 167 keV ± 20%
Acquisition matrix: 64x64
Orbit: 180° CCW step and shoot (45° RAO → 45° LPO)
Number of projections: 32
Time/view: 60 sec
Patient position: supine

## Image processing

**SPECT**

- Regular smoothing of the projection data set
- 2D pre-filtering on the smoothed projection data by Butterworth filter
- Reconstruction with MOSEM algorithm
- 20% background subtraction after the reconstruction
- Reorientation of the transaxial slices
  (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical, longitudinal (apical) slices
- Polar-map generation
- Evaluation by ECToolbox with score analysis

## Case study I: Necrosis with transient ischaemia

### *Patient History*

77-year-old male
Family history: MI, Hypertension
Hypertension for 25 years – medical treatment
Artificial knee prosthesis implantation (1995.)
Uncomplicated inferior (Q wave) MI (2002.)
Angina free period up to March of 2003 with medical treatment
Indication of SPECT study: recurrent chest pain / chest discomfort episodes up to 20 minutes in April responding to sublingual Nitrate application

### *Stress Test*

Pharmacological stress test Dipyridamole (0.56 mg/kg-bodyweight for 4 min): No significant ischemic ECG changes. Did not develop chest discomfort. Frequent monomorphic ventricular extrasystoles and couplets.

| | **Baseline** | **Peak action** | **Recovery** |
|---|---|---|---|
| **BP** [Hgmm] | 180/100 | 170/100 | 140/90 |
| **HR** [BPM] | 97 | 98 | 87 |

### *Interpretation*

Severe, posteroinferior stable perfusion defect. Severe to moderate inferior and apical, partially reversible defect. Mild septal reversible defect. Elevated lung uptake and LV enlargement at stress.

### *Diagnostic Impression*

Posteroinferior, inferior and apical necrosis with transient ischemia in the apex and inferior wall. Additional transient ischemia in the septum. Left ventricular enlargement and elevated lung uptake at stress as signs of high risk multi vessel disease. Coronarography is recommended.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

# $^{201}$Tl Study: Necrosis with Transient Ischaemia

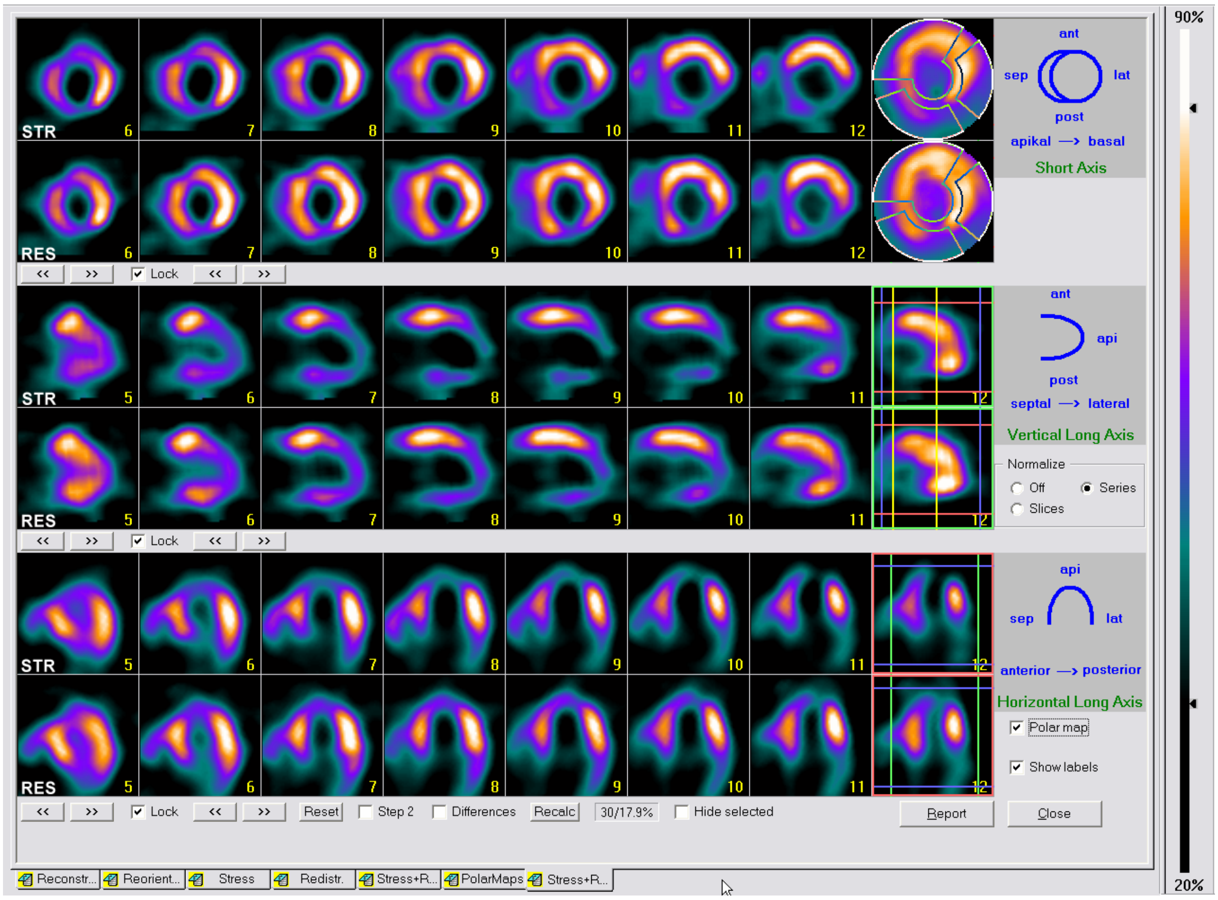



Figure 3-5 Stress + Redistribution Reoriented Slices (***InterViewXP***)

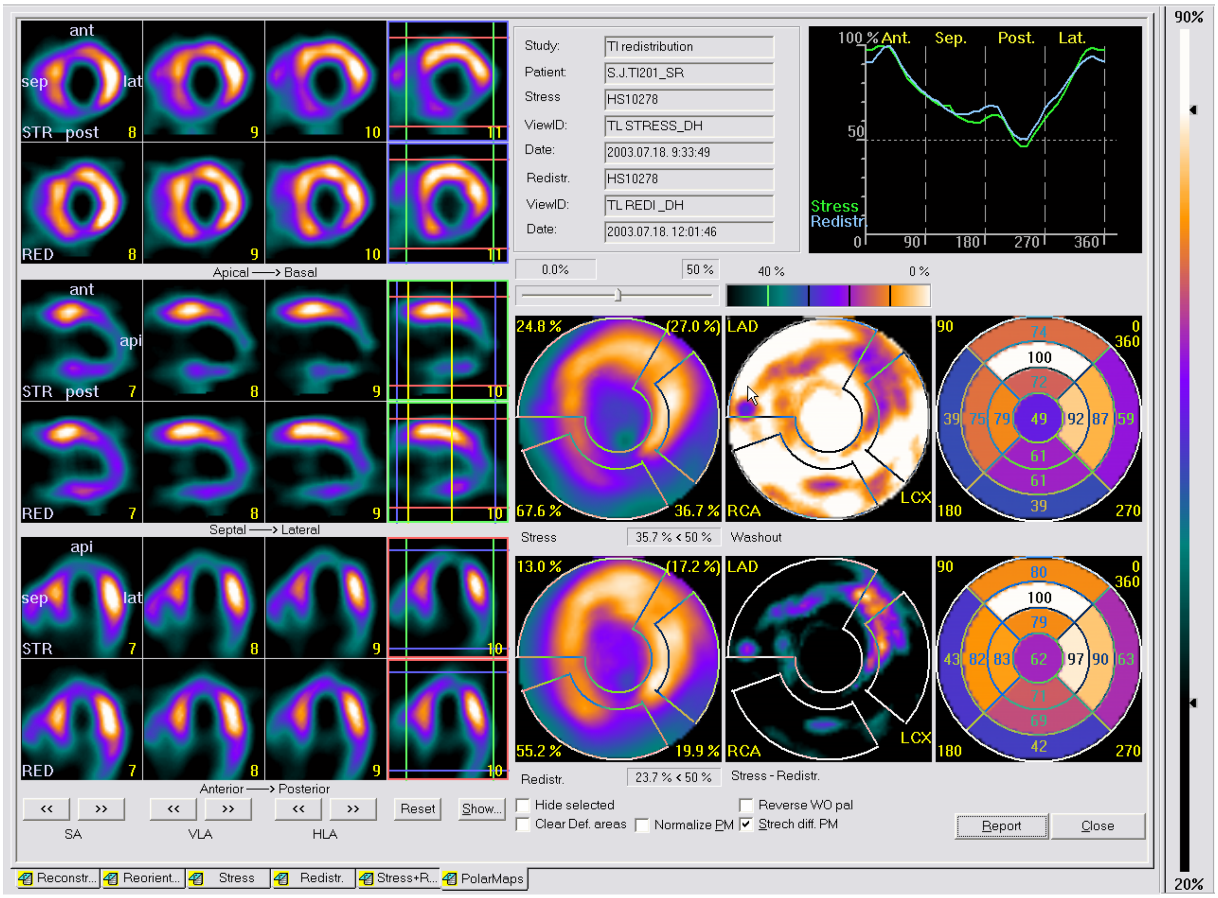



Figure 3-6 Polar Maps (***InterViewXP***)

## $^{201}$Tl Study: Necrosis with Transient Ischaemia

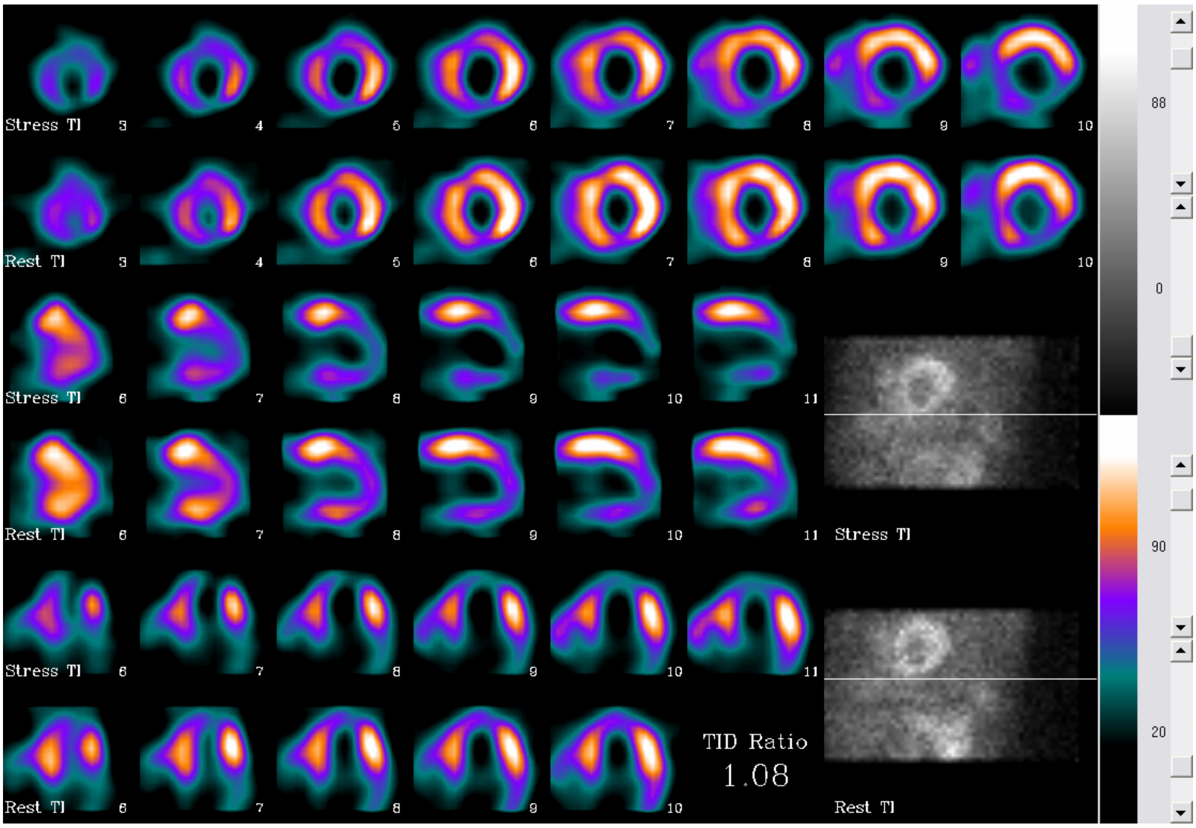


Figure 3-7 ECToolbox Reoriented Slices

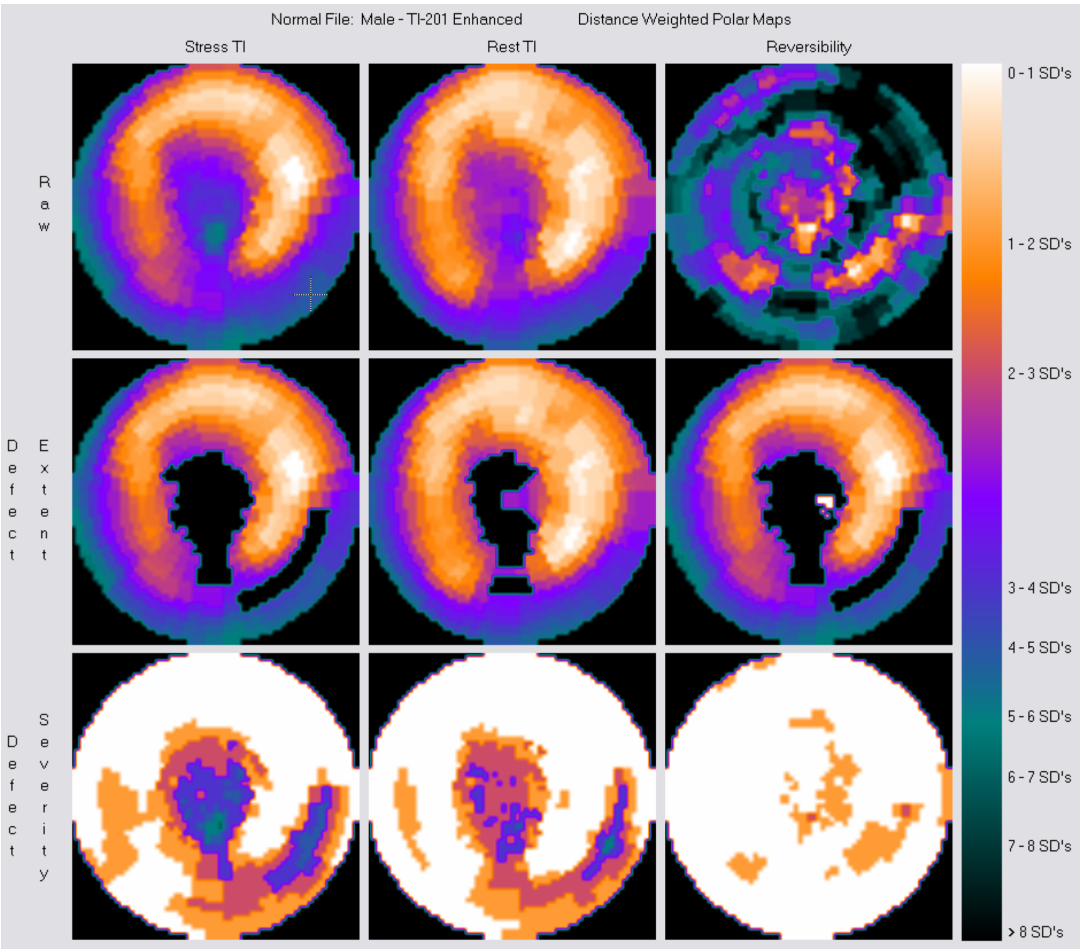


Figure 3-8 ECToolbox Polar Maps

## Case study II: Inferior myocardial infarction

### *Patient History*

75-year-old male
Family history: Hypertension, DM type II
DM type II (orally treated) since 1986
Peripheral arterial obliterative disease, intermittent claudication (1998)
Inferior (Q-wave) MI (1998)
Recurrent inferior MI without complications ten days before the SPECT study
Risk factors: Hypercholesterinemia, obesity (elevated BMI), DM type II, previous MI
Indication of SPECT study: predischarge test, risk stratification

### *Additional Studies*

Moderately reduced LV function. LV EF: 48%. Inferior, posteroinferior hypo-akinesia. No thrombus. No mitral regurgatation.
Chest X-ray: Elongated, sclerotic aorta. Normal heart dimensions. No venous hypertension.

### *Stress Test*

Pharmacological stress test Dipyridamole (0.56 mg/kg-bodyweight for 4 min): No significant ischemic ECG changes to the baseline. Did not develop chest discomfort.

| | **Baseline** | **Peak action** | **Recovery** |
|---|---|---|---|
| **BP** [Hgmm] | 110/80 | 110/80 | 110/85 |
| **HR** [BPM] | 76 | 87 | 86 |

### *Interpretation*

Moderate to severe, extensive inferior, posteroinferior and infero-apical perfusion defect. No significant reversibility. Minimal reversibility in the infero-apical region. The severity of the defect in the inferior, infero-apical wall allows some hibernating myocardium. The LV dimensions are not different from the normal case.

### *Diagnostic Impression*

Extensive inferior, posteroinferior MI without significant transient ischemia. Minimal transient ischemia and hibernating myocardium cannot be excluded in the infero-apical segments. Viability study is recommended.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## $^{201}$Tl Study: Inferior MI

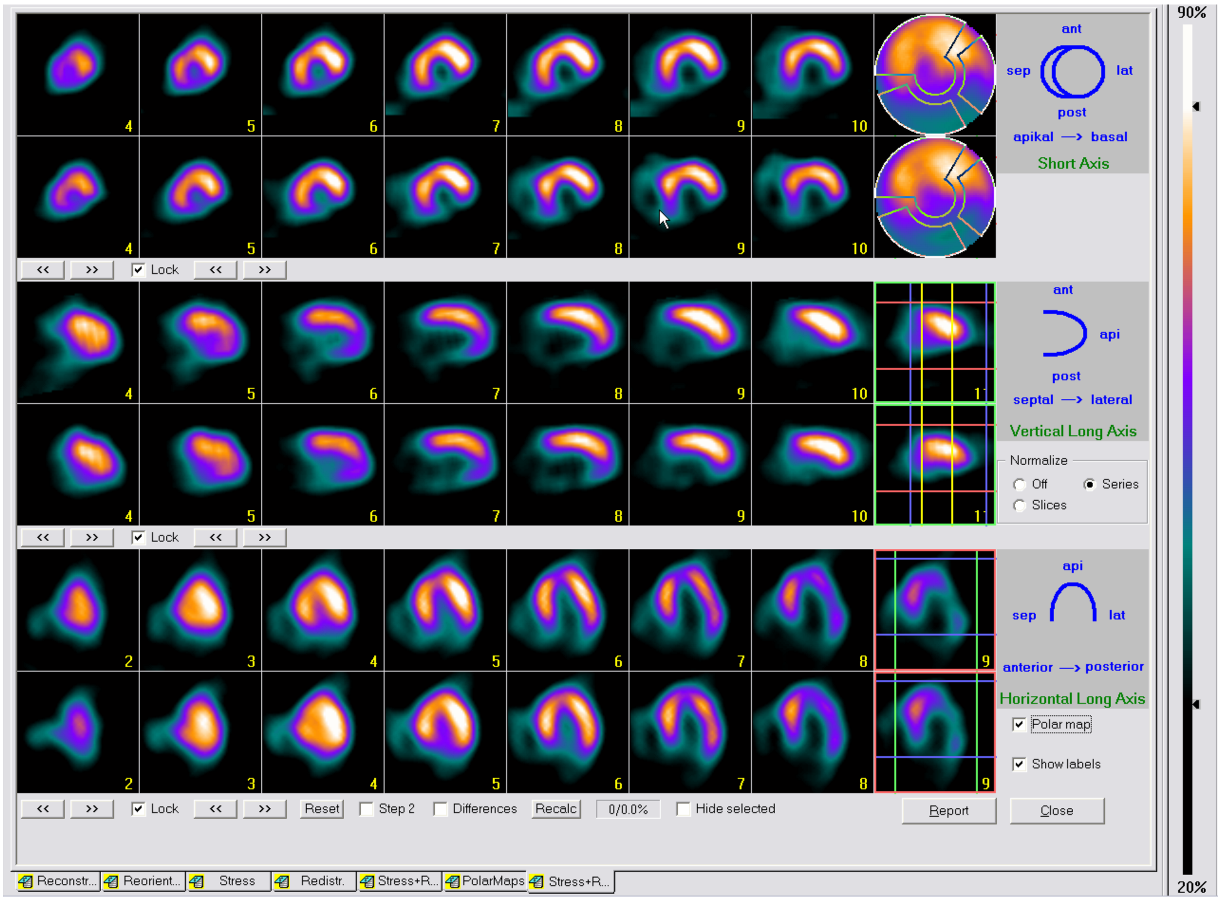



Figure 3-9 Stress + Redistribution Reoriented Slices (*InterViewXP*)

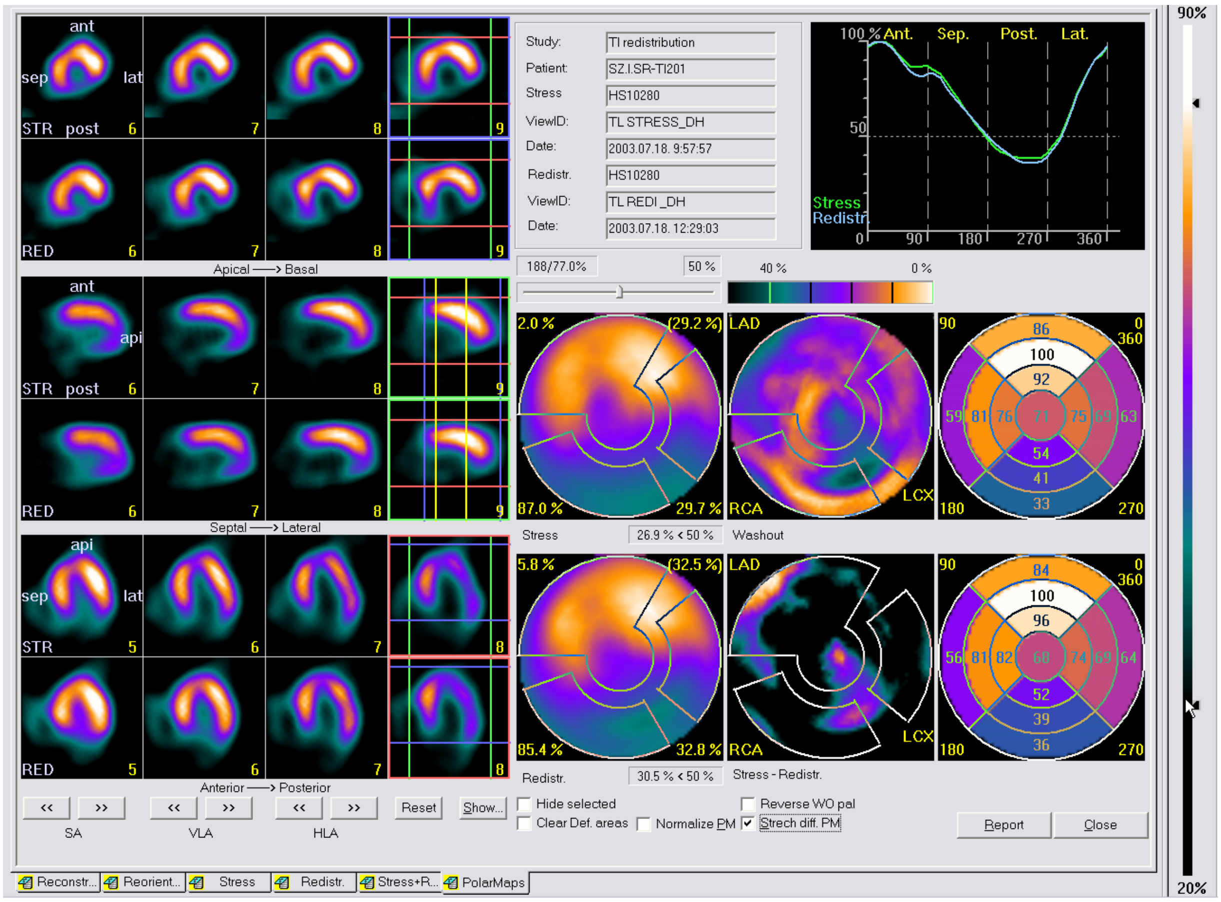



Figure 3-10 Polar Maps (*InterViewXP*)

## $^{201}$Tl Study: Inferior MI

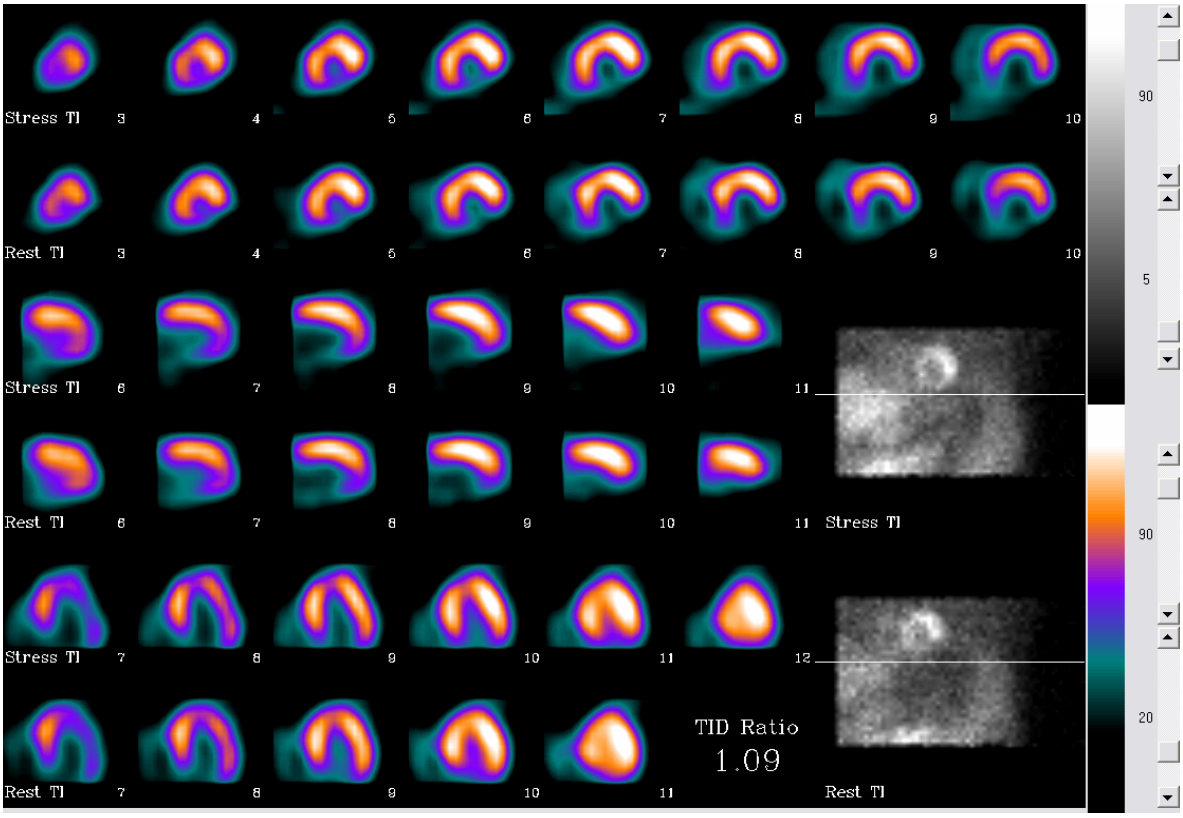



Figure 3-11 ECToolbox Reoriented Slices

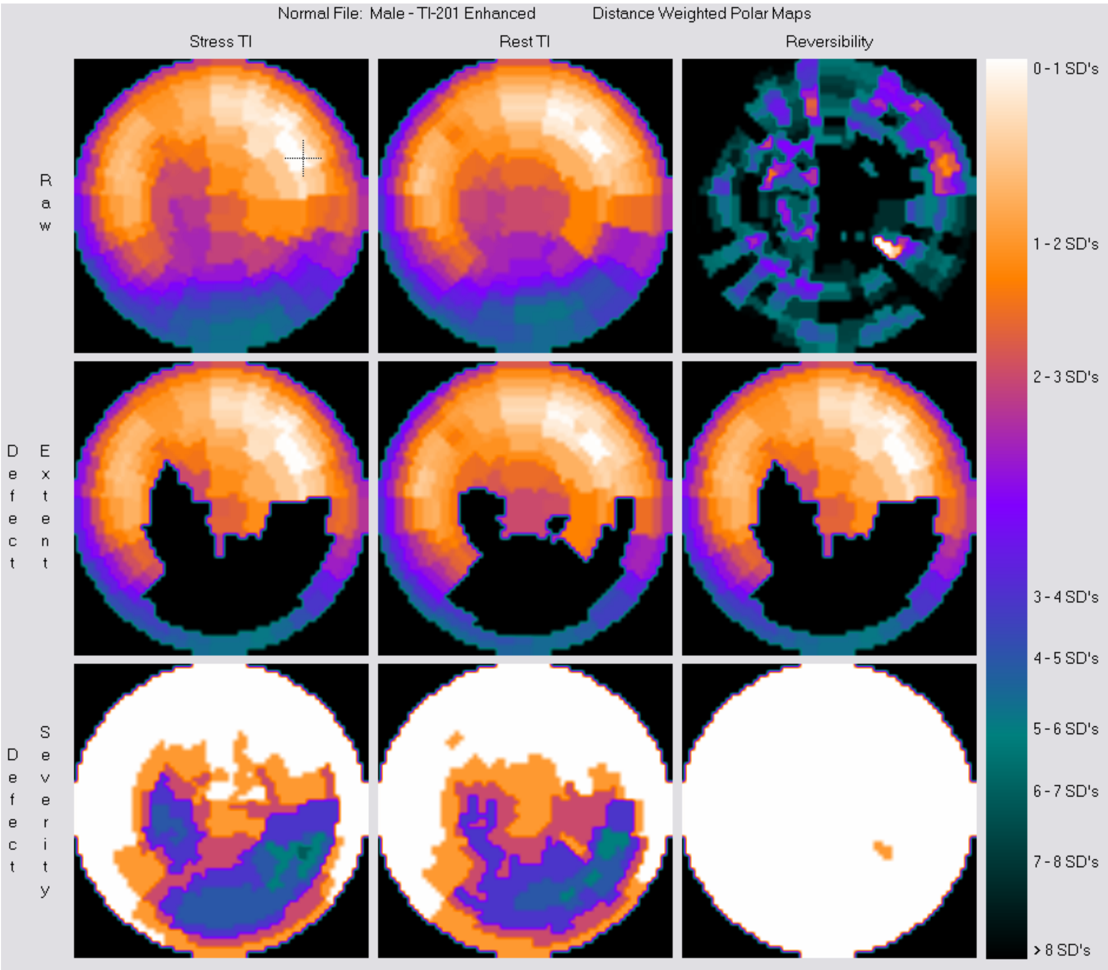



Figure 3-12 ECToolbox Polar Maps

# Perfusion SPECT imaging with $^{99m}$Tc-labelled agents

## $^{99m}$Tc Sestamibi SPECT

### Clinical application

High quality myocardiac SPECT study can be performed by $^{99m}$Tc-MIBI with various imaging protocols like stress + rest, rest + stress with one day or two days protocol. Due to the insignificant redistribution process, the timing between the injection and imaging is not an important factor (could be 30÷300 min.). The studies can be repeated without any problems. Separate injections are necessary for stress and rest cases. Polar-map generation may help for quantitative evaluation and analysis.

### Acquisition protocol

**SPECT STUDY**

Step and shoot mode
Matrix size: 64x64
Number of steps: 30 (180° rotation)
Exposition: 40 sec (both Stress and Rest cases)
First rest and 24h later -two days protocol- stress study is carried out
Applied activity: 300 MBq $^{99m}$Tc-MIBI
Collimator: LEAP
Patient position: supine
Direction of rotation: CCW
Start angle: LPO-42°

### Image processing

**SPECT**

- Regular smoothing of the projection data
- 2D pre-filtering on the smoothed data set by Butterworth filter
- Reconstruction with OS-EM algorithm
- 20% background subtraction after the reconstruction
- Reorientation of the transaxial slices
  (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical, longitudinal (apical) slices.
- Polar-map generation

### Case study

Rest and Dipyridamol stress studies were performed (two days protocol). 60-year-old male with previous anterior-apical and posterolateral myocardiac infarction as well as left ventricular dysfunction and LBBB ( LV EF 0.28 ) post. ACBG and PTCA. Mild transient ischeamia in the revascularised regions. Enlarged LV.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## $^{99m}$Tc MIBI Stress + Rest Study

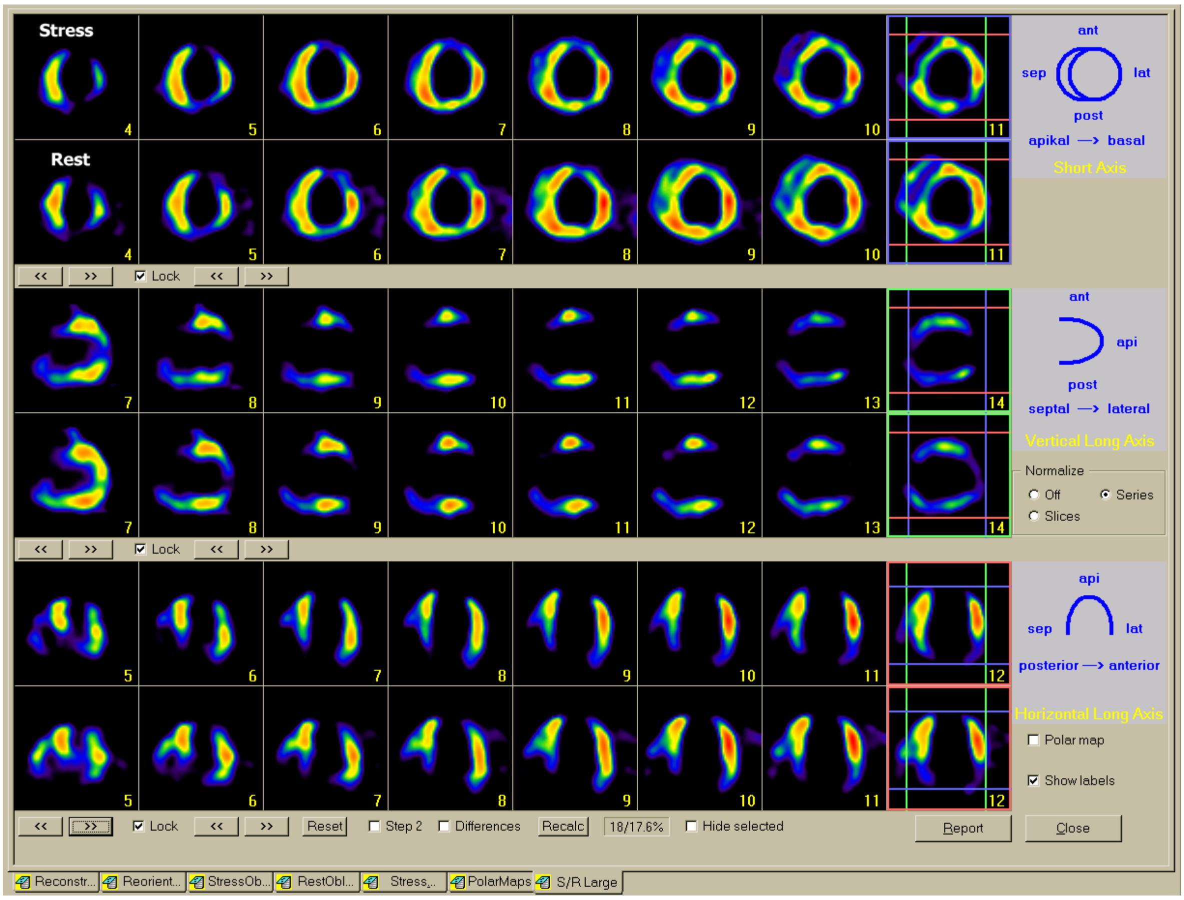



Figure 3-13 Stress + Rest Reoriented Slices

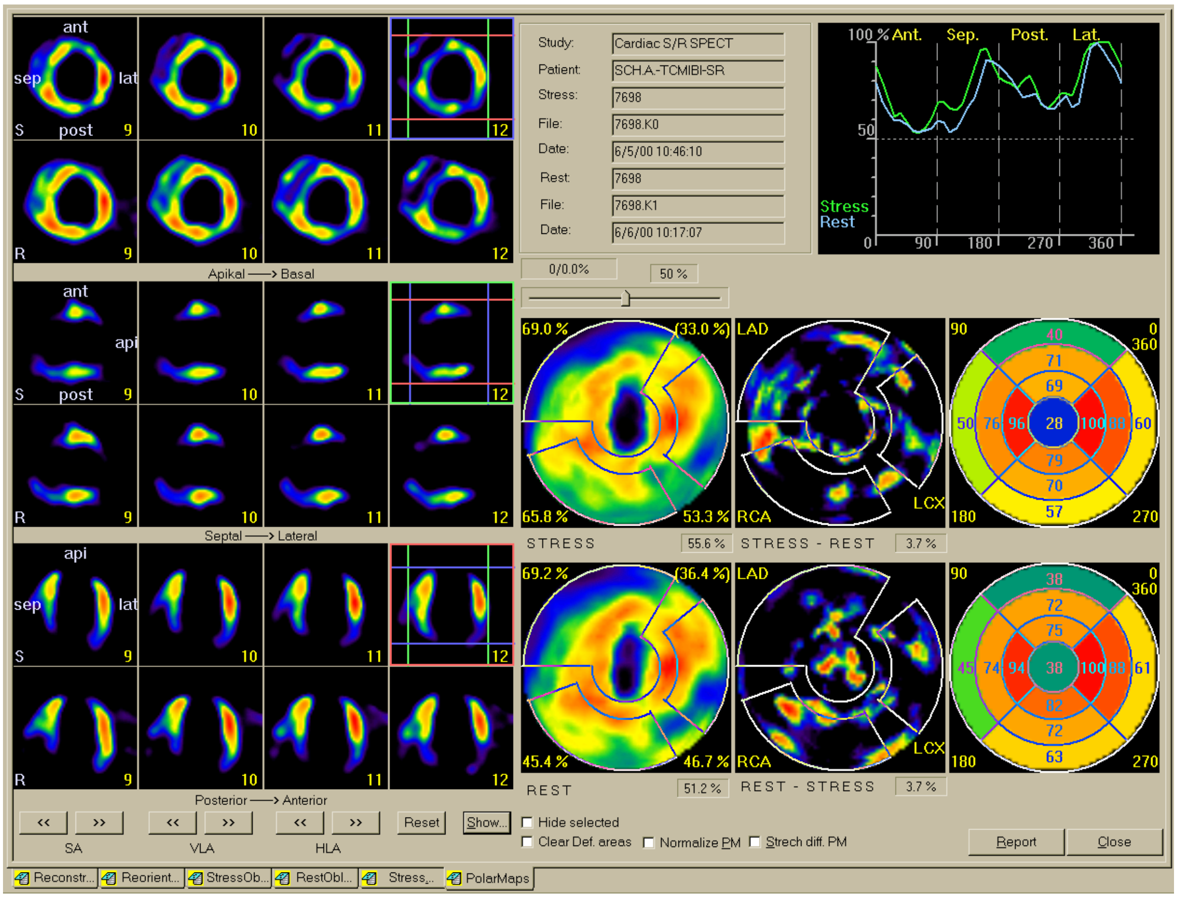



Figure 3-14 Polar Maps

# Typical $^{99m}Tc$ tetrofosmin stress+rest SPECT studies

## Imaging protocol

540-900MBq (15-25 mCi) stress injection then 30-90 minute later stress SPECT study. Next day another 540-900MBq (15-25 mCi) rest injection will be administered and 30-90 minutes later a rest SPECT acquisition is carried out.

## Acquisition protocol

**SPECT Study**

Collimator: LEHR
Photopeak window: 140 keV ± 20%
Acquisition matrix: 64x64
Orbit: 180° CCW step and shoot (45° RAO → 45° LPO)
Number of projections: 32
Time/view: 60 sec
Patient position: supine

## Image processing

**SPECT**

- Regular smoothing of the projection data
- 2D pre-filtering on the smoothed data set by Butterworth filter
- Reconstruction with OS-EM algorithm
- 20% background subtraction after the reconstruction
- Reorientation of the transaxial slices
  (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical, longitudinal (apical) slices.
- Polar-map generation
- Evaluation by ECToolbox

## Case study I: Transient ischaemia

### *Patient History*

80-year-old female
Family history: hypertension and DM type II
Orally treated DM type II since 1993
Moderate hypertension treated medically for 30 years
Hyperlipidaemia
Intermittent LBBB known since April of 2003
Indication of SPECT study: progressive effort chest pain recently. Intermittent LBBB on ECG.

### *Stress test*

Pharmacological stress test Dipyridamole (0.56 mg/kg-bodyweight for 4 min): Mild chest discomfort + 1 mm horizontal ST depression in leads I-II, V5-6

| | **Baseline** | **Peak action** | **Recovery** |
|---|---|---|---|
| **BP** [Hgmm] | 140/80 | 160/90 | 130/80 |
| **HR** [BPM] | 75 | 84 | 84 |

Positive test (no LBBB during the test)

### *Interpretation*

Might to moderate reversible inferolateral, posterolateral perfusion defect.

### *Additional studies*

Echocardiography: moderately enlarged LV with diffuse hypokinesis, no regional wall motion difference. LVEF: 44%

### *Diagnostic Impression*

Moderate transient ischemia in the inferolateral, posterolateral region of the LV.
Coronagraphy should be considered due to possible single vessel disease and LV disfunction in the hope of a low risk PCI.

### *Comments*

Reduced uptake in the anteroseptal region is most likely due to breast attenuation.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## $^{99m}$Tc Tetrofosmin Stress + Rest Study: Transient ischaemia

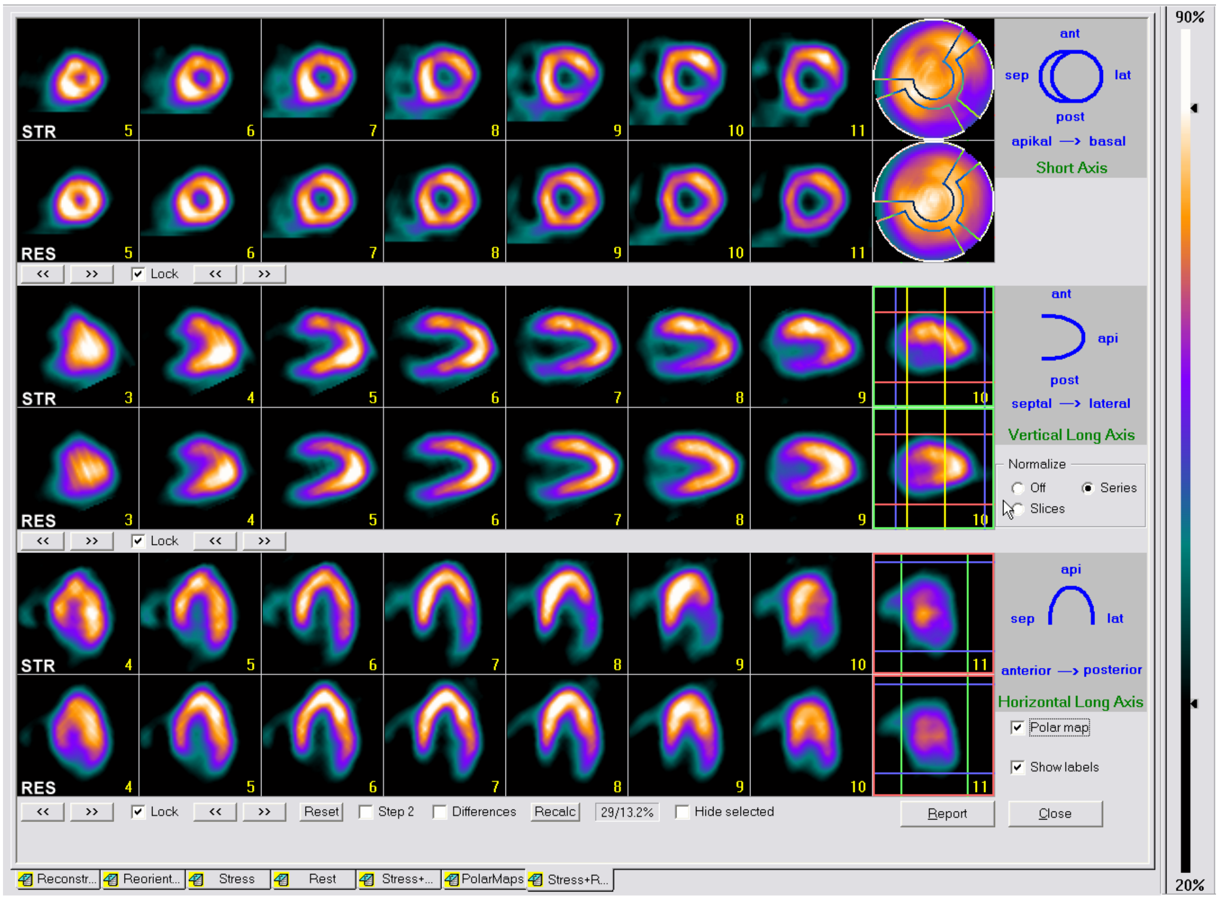



Figure 3-15 Stress + Rest Reoriented Slices (***InterViewXP***)

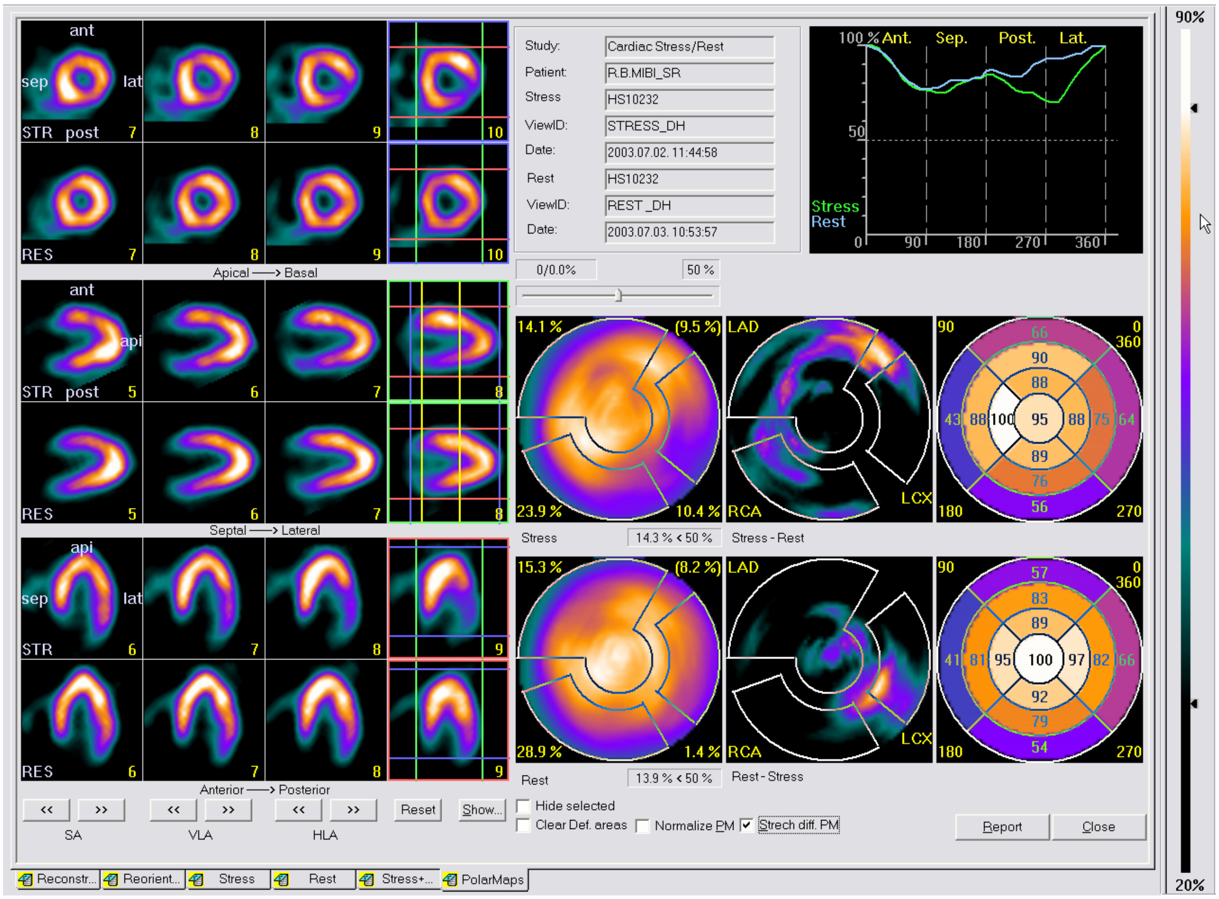



Figure 3-16 Polar Maps (***InterViewXP***)

## $^{99m}$Tc Tetrofosmin Stress + Rest Study: Transient ischaemia

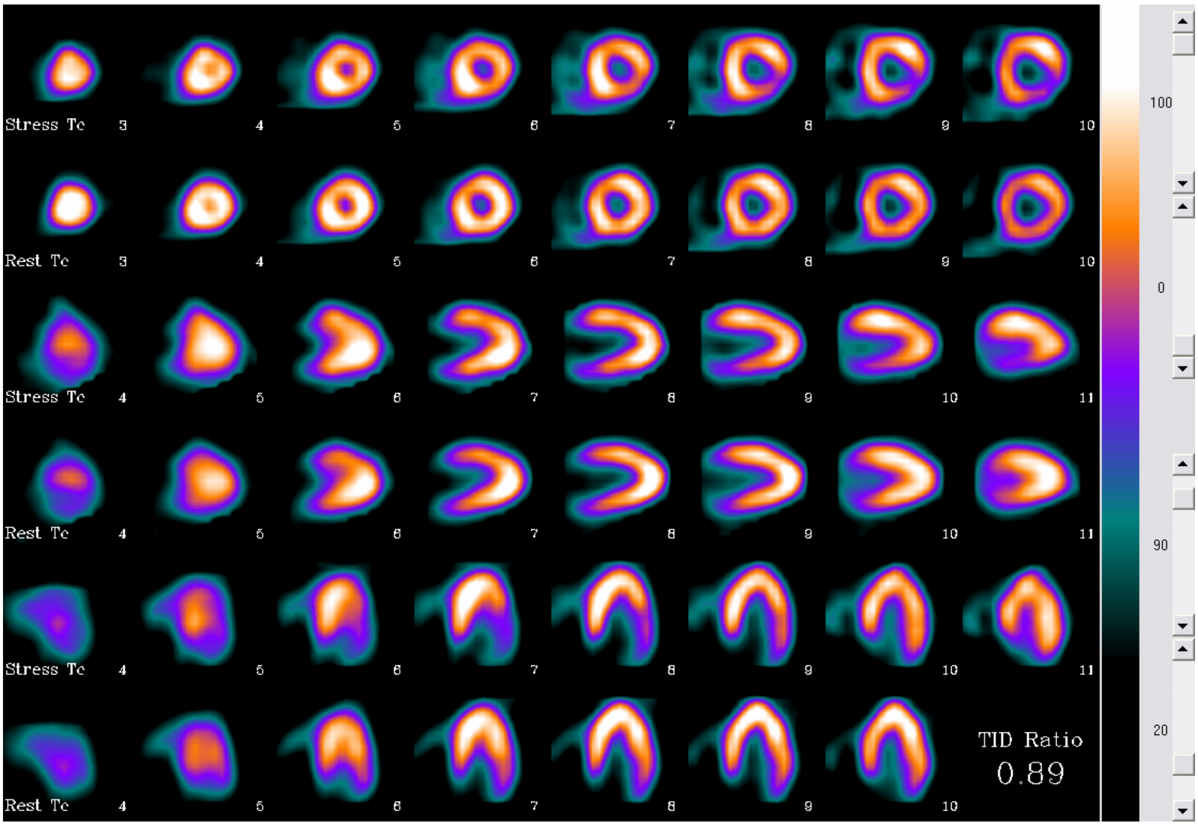



Figure 3-17 ECToolbox Reoriented Slices

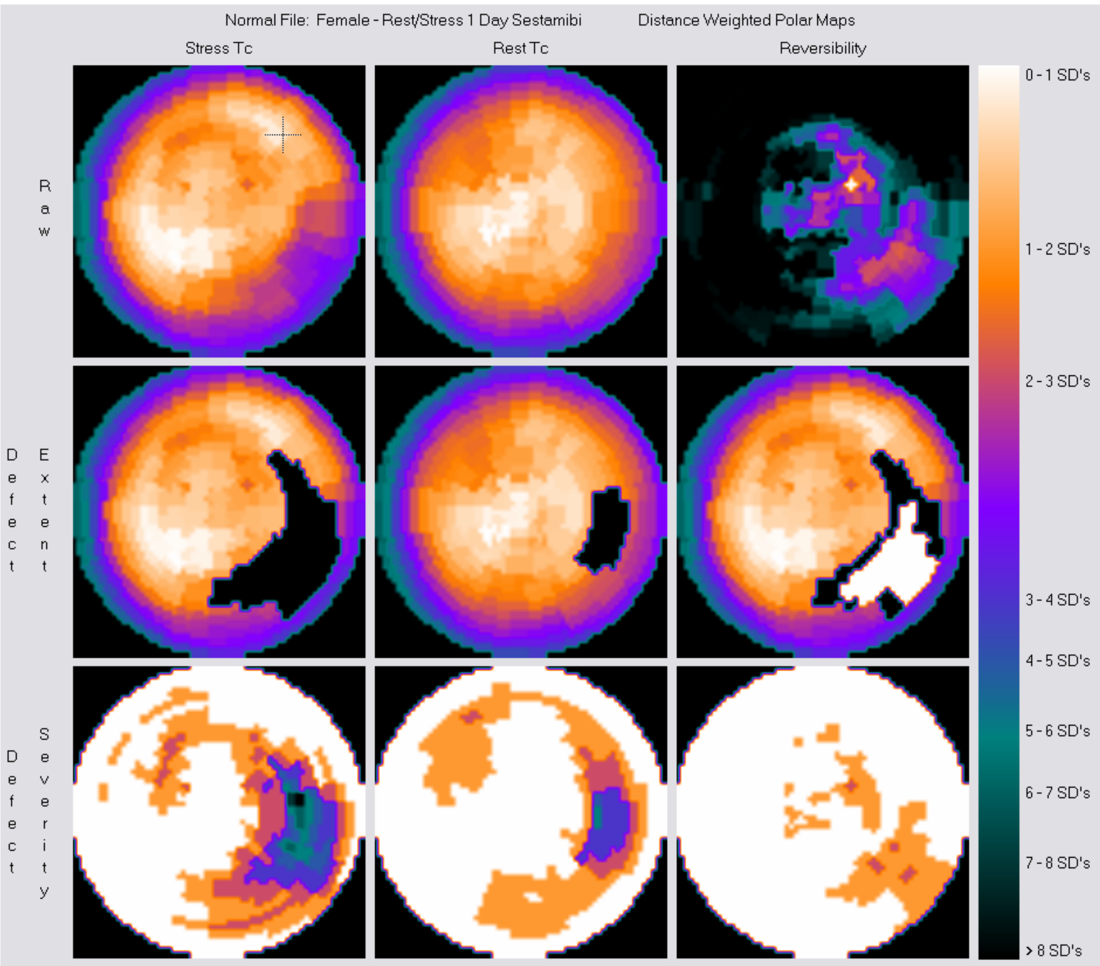



Figure 3-18 ECToolbox Polar Maps

## Case study II: Extensive apical-anterior MI

### *Patient History*

48-year-old female
Family history: MI
Risk factors: nicotine abuse, elevated cholesterol, triglyceride and slightly elevated BMI
Extensive anterior MI (2002.)
Medical evaluation for progressive effort dyspnea and chest discomfort
Indication for SPECT: detection of transient ischemia or myocardial viability

### *Additional studies*

Coronarography: LAD proximal occlusion and two non-significant stenoses in the mid part of the dominant RCA.
Echocardiography: extensive apical, anterior akinesia. Reduced LV function. EF: 45%. No thrombus.

### *Stress Test*

Exercise bicycle test 3.6 MET

| | **Baseline** | **Peak action** |
|---|---|---|
| **BP** [Hgmm] | 140/90 | 160/80 |
| **HR** [BPM] | 82 | 118 |

Test was terminated due to fatigue and shortness of breath at somewhat below submaximal age related heart rate (80%).
No significant ECG changes to baseline.
Rest study was performed after sublingual Nitrate administration.

### *Interpretation*

Severe extended apical, septal and anterior stable perfusion defect. Slightly reversible perfusion defect in the infero-apical, inferior segments.

### *Diagnostic Impression*

Extensive apical, anteroseptal infarction. Transient ischemia or viable myocardium could not be detected in the region of the necrosis (LAD occlusion). Some degree of transient ischemia was detected in the region of RCA.
PCI should be considered.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

## $^{99m}$Tc Tetrofosmin Stress + Rest Study: Extensive apical-anterior MI

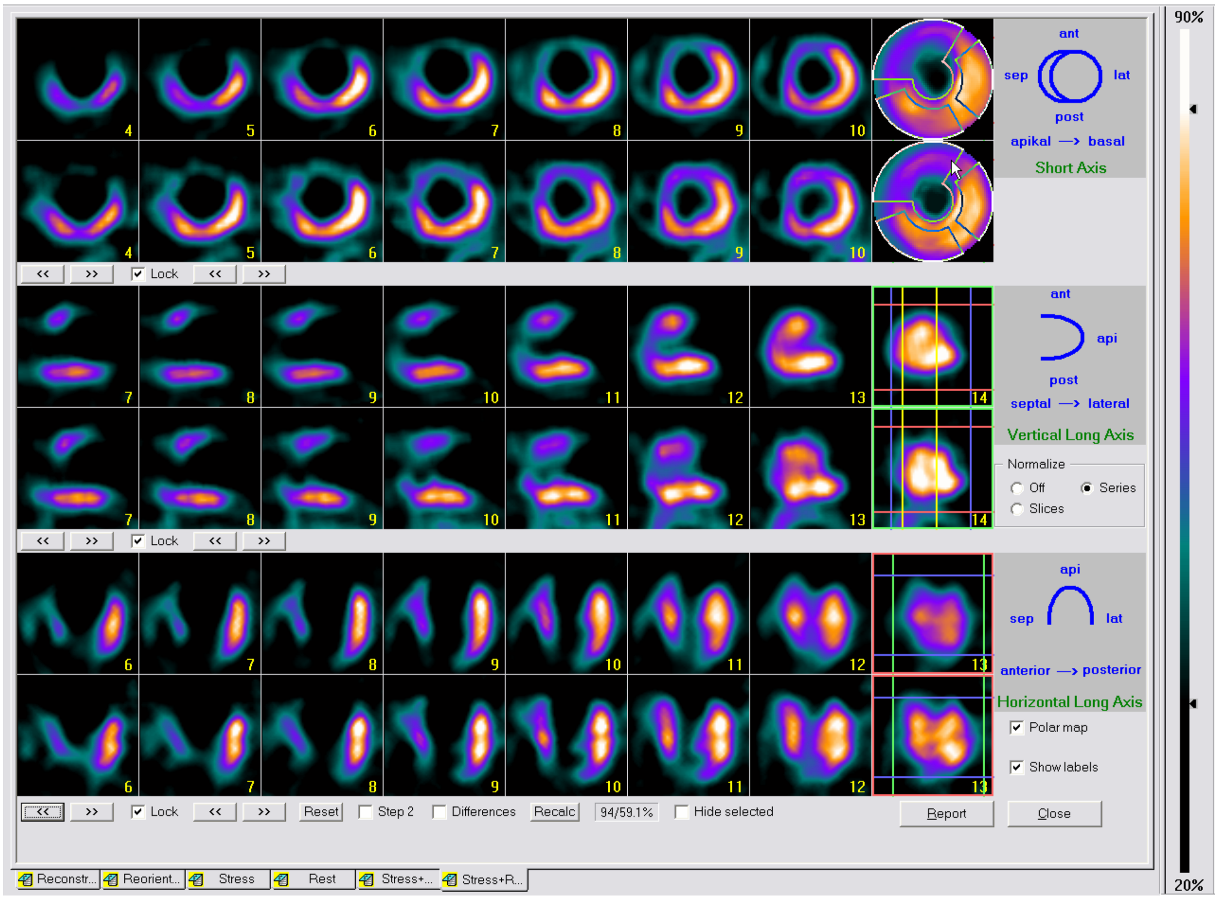



Figure 3-19 Stress + Rest Reoriented Slices (*InterViewXP*)

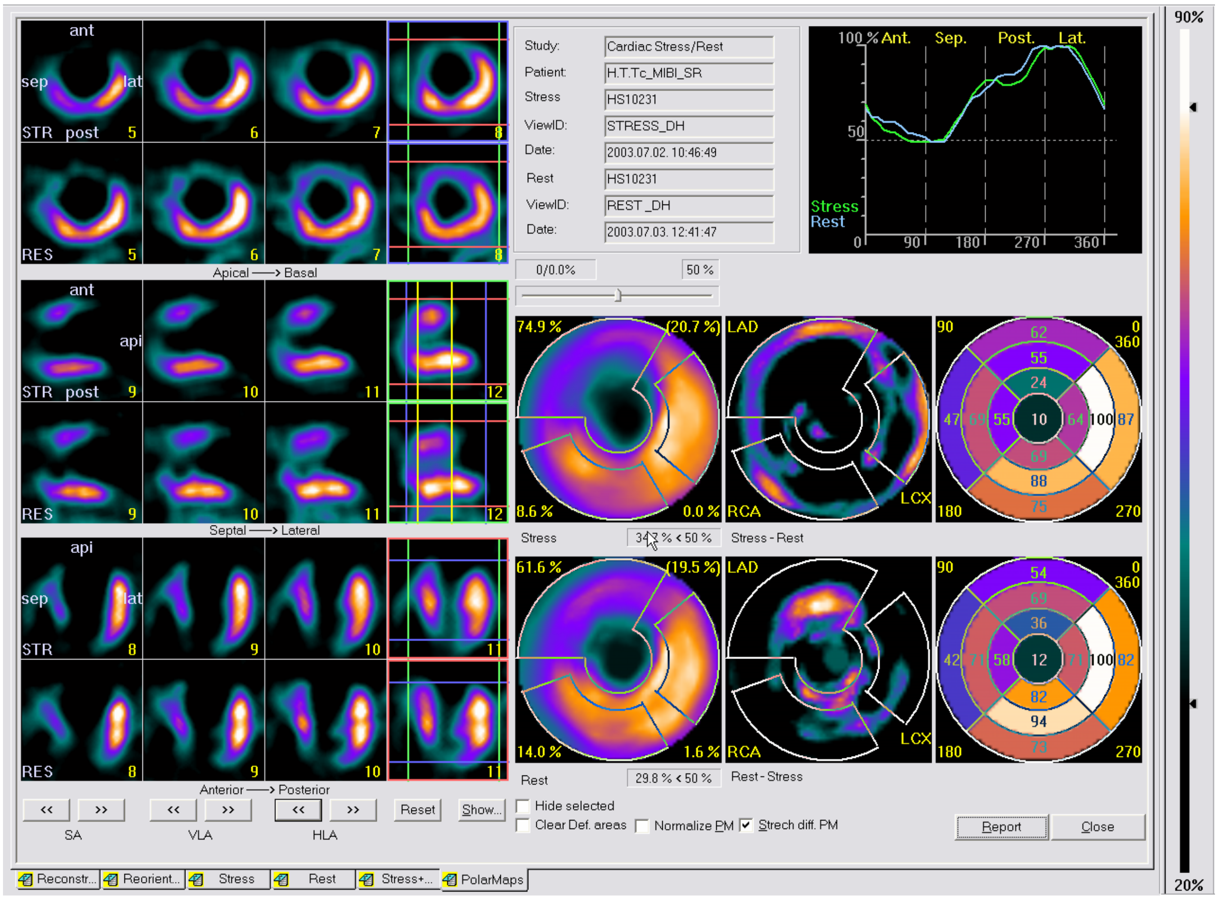



Figure 3-20 Polar Maps (*InterViewXP*)

## $^{99m}$Tc Tetrofosmin Stress + Rest Study: Extensive apical-anterior MI

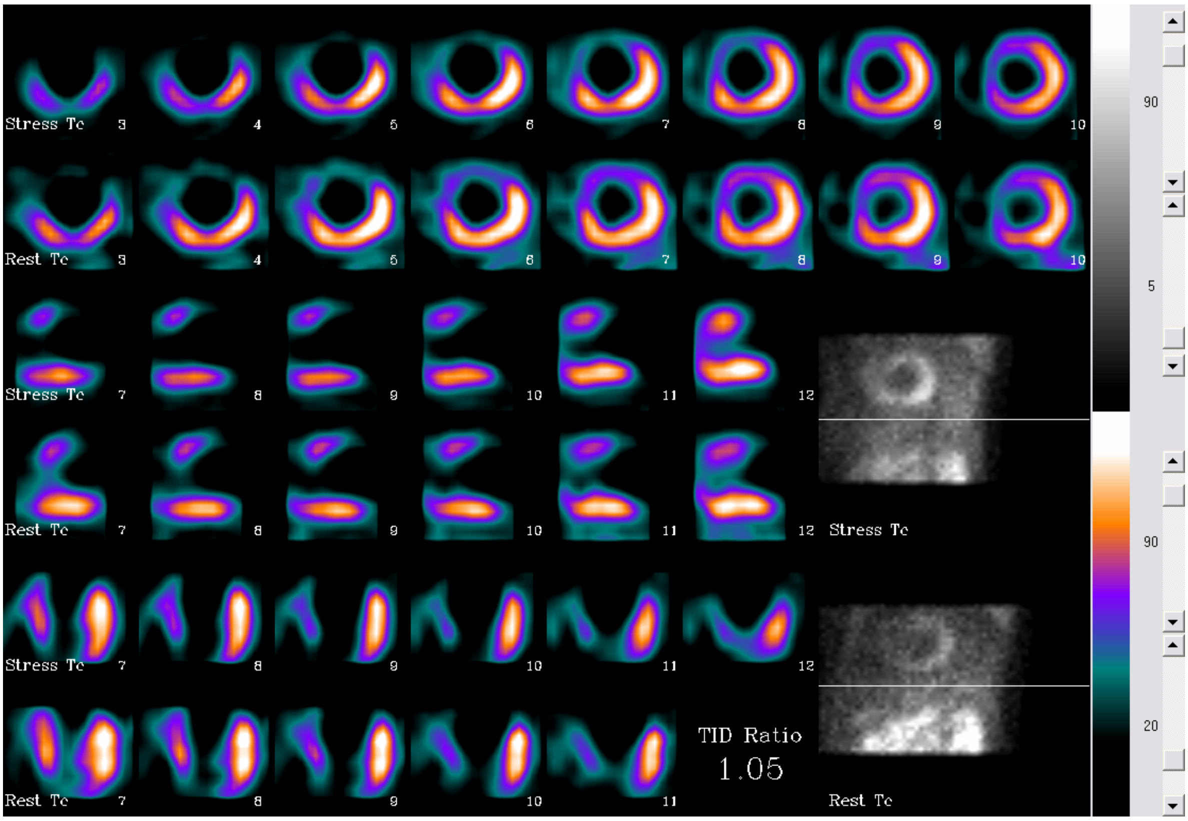



Figure 3-21 ECToolbox Reoriented Slices

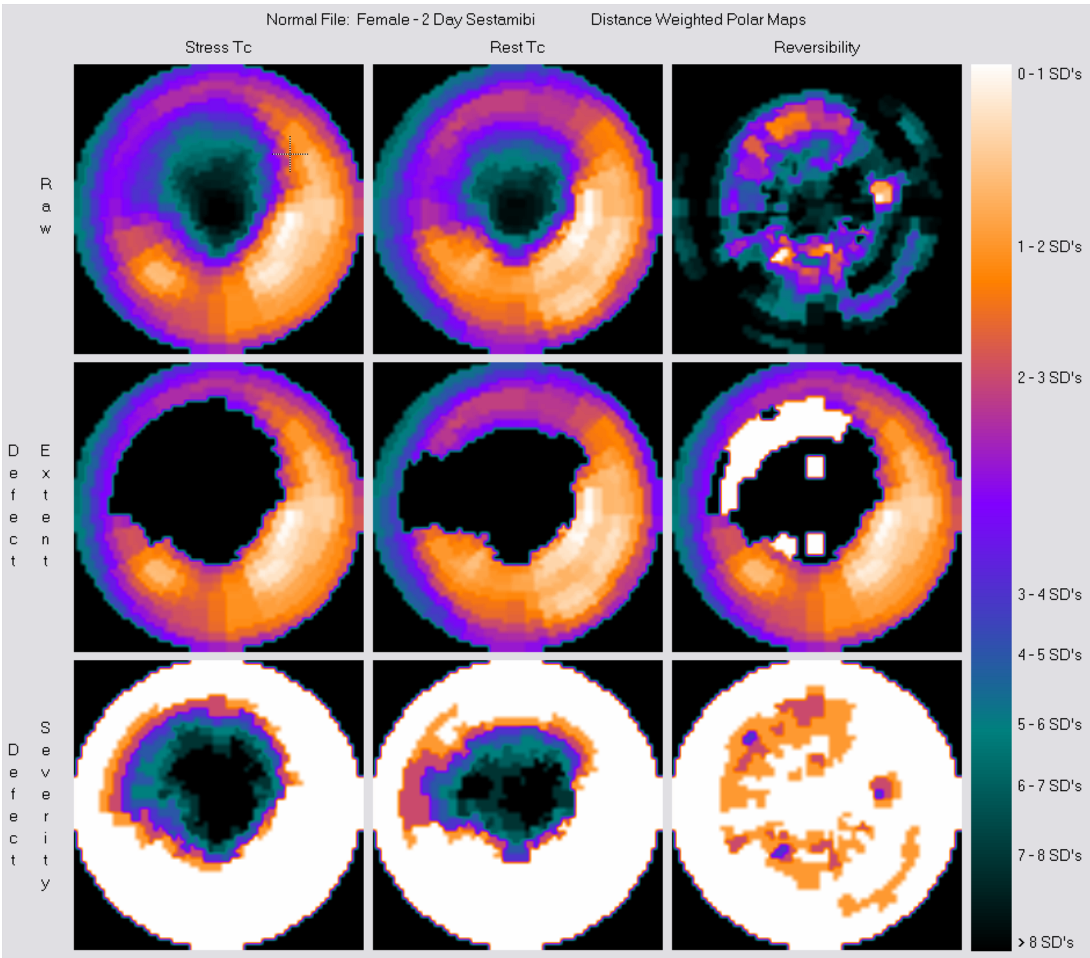



Figure 3-22 ECToolbox Polar Maps

# Case study III: Multivessel disease

### *Acquisition protocol*

In this particular case the Acquisition matrix was 128x128, the other acquisition parameters were the same.

### *Patient History*

62-year-old male
Family history: hypertension and cerebrovascular disease
Mild hypertension since 1996
Non Q-wave posteroinferior MI (1997) 8.1 MET negativ predischarge stress test
Indication of SPECT study: Atypical chest pain and progressive effort dyspnea
Risk factors: hypertension, mild hypercholesterinemia, slightly elevated BMI

### *Stress Test*

Exercise bicycle test 5.1 MET.
No significant ECG changes.
Did not develop chest discomfort, but was terminated due to fatigue and shortness of breath at submaximal age related heart rate.

### *Interpretation*

Moderate to severe reduction of perfusion in the posterolateral and apical region. Moderate reduction in the anterior, anterolateral segments and mild reduction in the lateral wall. Reversibility in the anterior wall and partial reversibility in the lateral, anterolateral and apical region. No significant change in the size of the left ventricular cavity and wall thickness to the normal case.

### *Diagnostic Impression*

Posterolateral infarction with moderate to severe perfusion defect. Severe and extended transient ischemia in the anterior and lateral wall and in the apex. Mild necrosis could not be excluded in the apex.
High risk multivessel disease.
Coronagraphy and possible revascularization is recommended.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology Department of Nuclear Cardiology*

# $^{99m}$Tc Tetrofosmin Stress + Rest Study: Multivessel disease

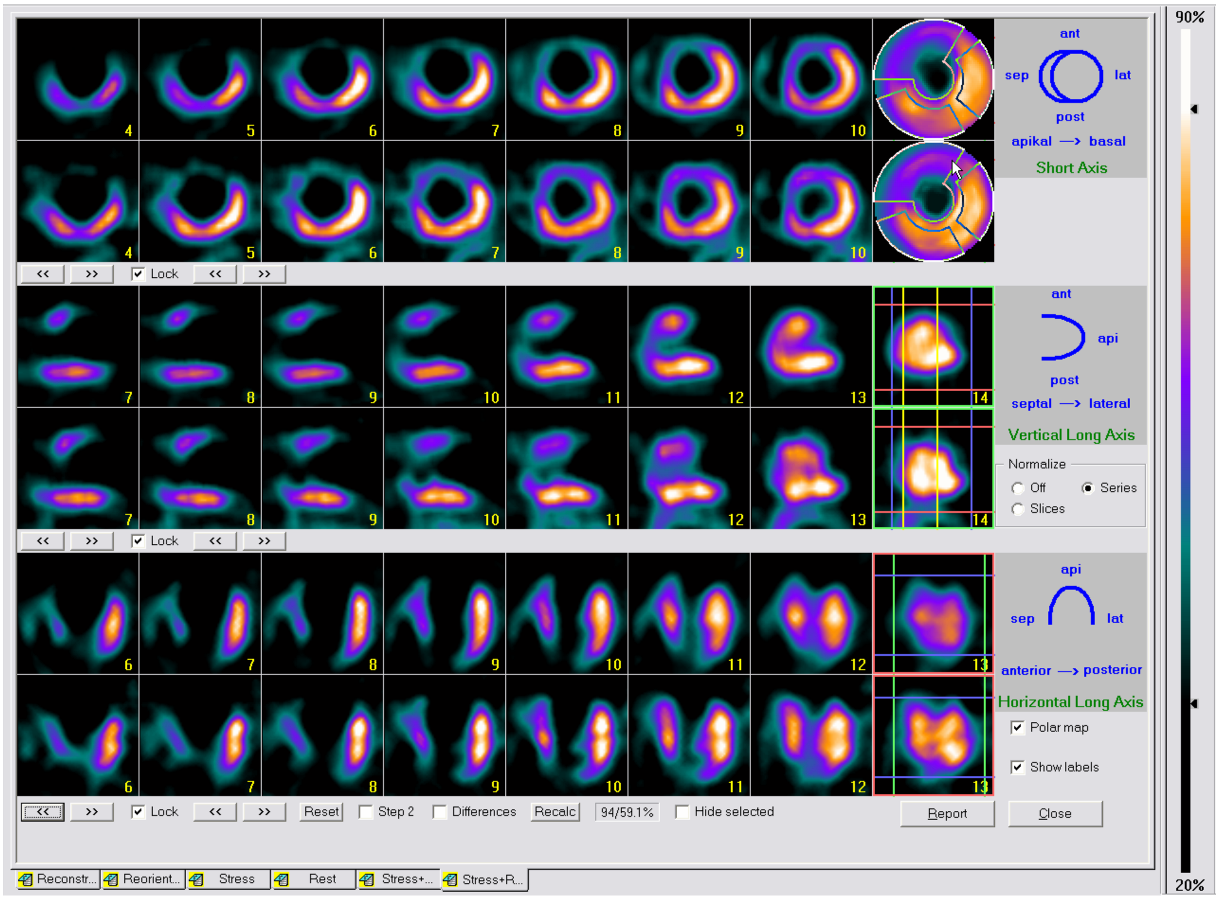



Figure 3-23 Stress + Rest Reoriented Slices (*InterViewXP*)

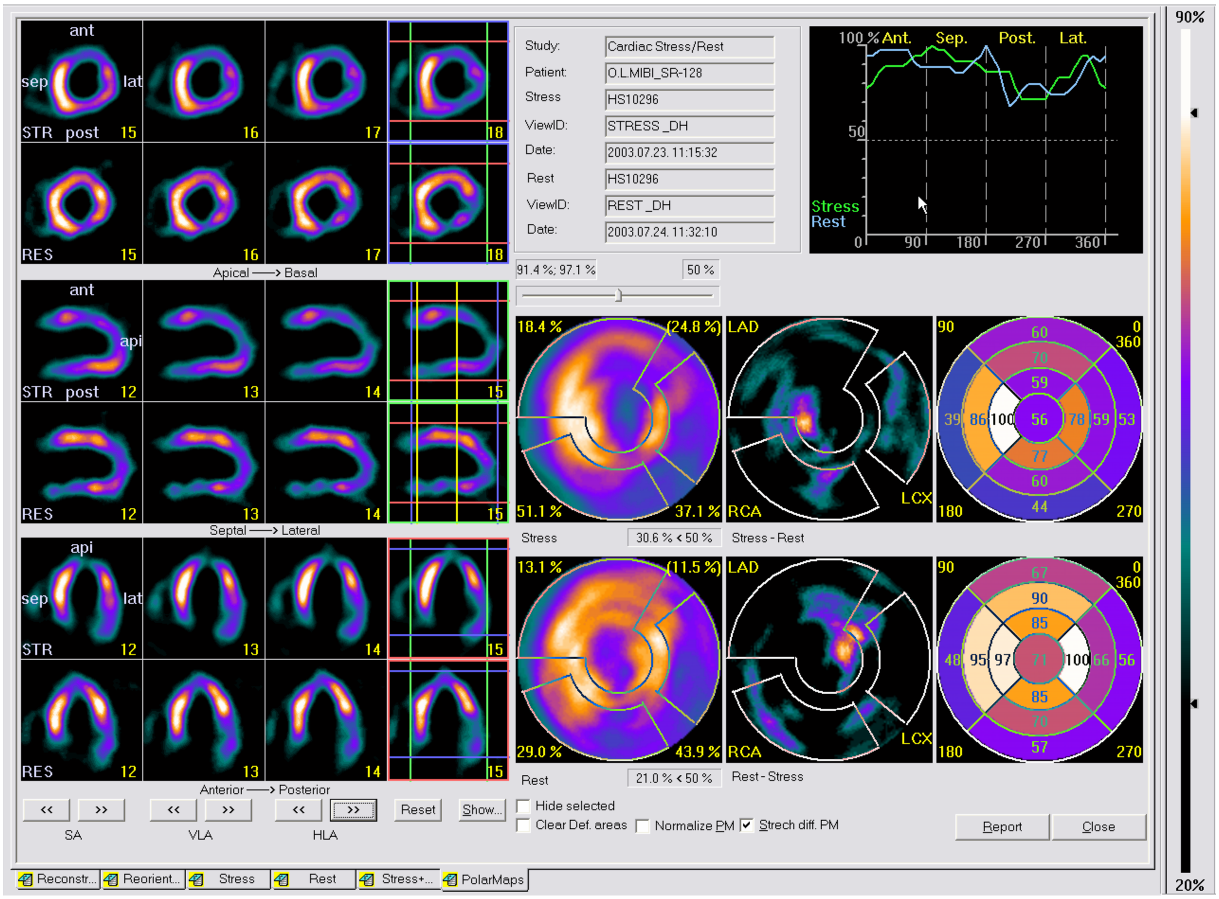



Figure 3-24 Polar Maps (*InterViewXP*)

## $^{99m}$Tc Tetrofosmin Stress + Rest Study: Multivessel disease

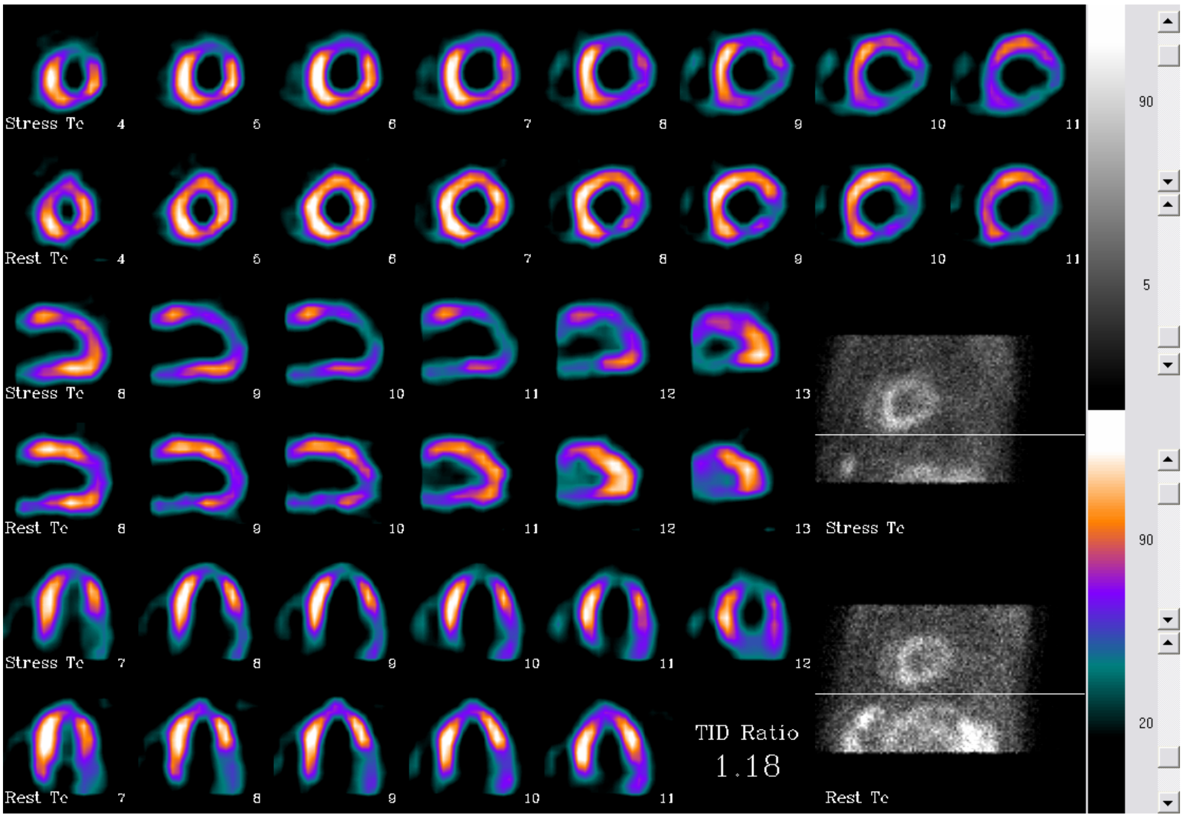



Figure 3-25 ECToolbox Reoriented Slices

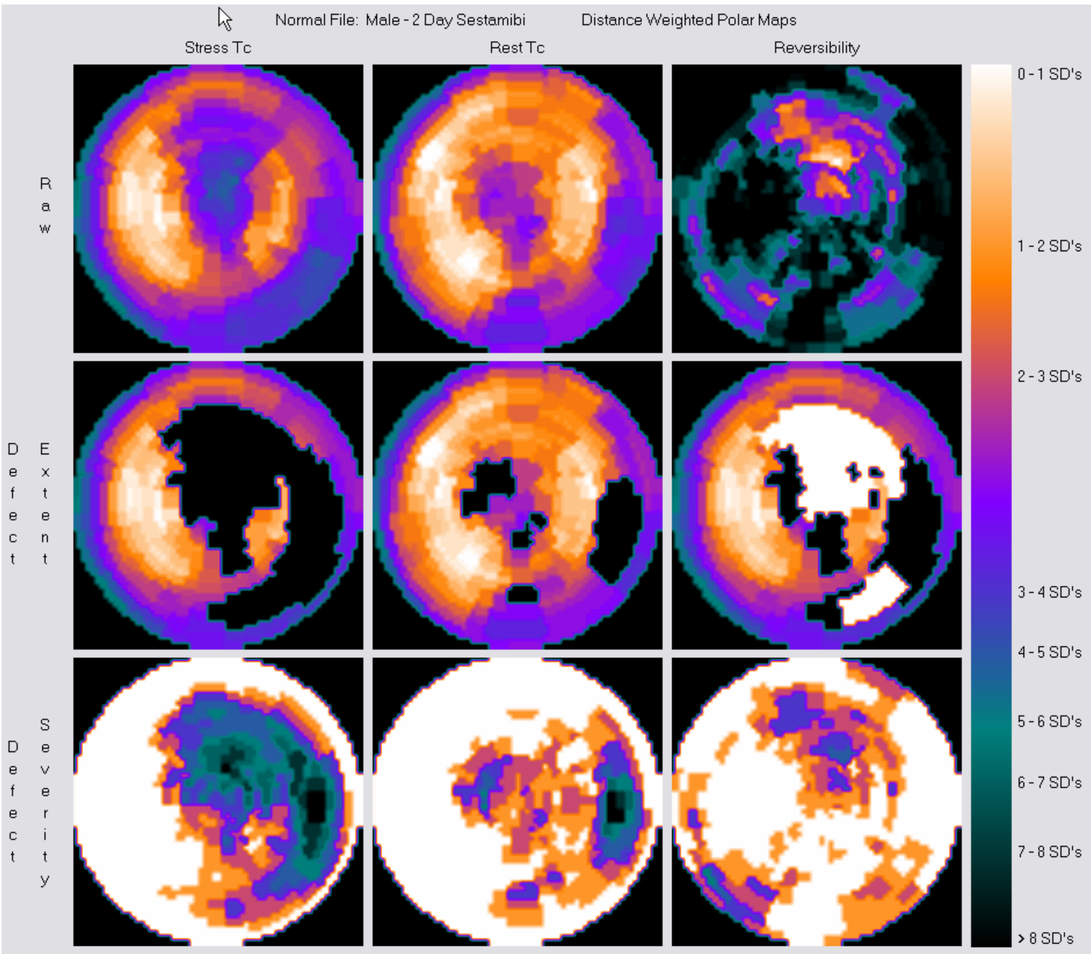



Figure 3-26 ECToolbox Polar Maps

## Case study IV: Homogeneous myocardial perfusion

### *Patient History*

67-year-old female
Family history: hypertension, DM type II, malignant disease
Hypertension for 16 years – medical treatment
Hypothyreoidism – hormone substitution (observation + medical treatment for 20 years)
GERD (Gastro esophageal reflux disease)
Hypercholesterinemia known for 10 years
Bronchial asthma episodes for 30 years
Exercise bicycle test was performed for atypical chest pain and effort dyspnea with significant ST depression two months ago. Coronarography verified significant proximal dominant RCA stenosis. PCI was performed (PTCA and stent implantation).
Indication of SPECT study: Two short episodes of chest discomfort on mental stress two months after PCI

### *Stress Test*

Exercise bicycle test 5.2 MET
Test was terminated due to shortness of breath at submaximal age related heart rate (85%)
No significant ECG changes.

### *Interpretation*

No significant perfusion defect in the region of the RCA and at all.

### *Diagnostic Impression*

Myocardial transient ischemia can be excluded. No further invasive evaluation is necessary.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

# $^{99m}$Tc Tetrofosmin Stress + Rest Study: Homogeneous myocardial perfusion

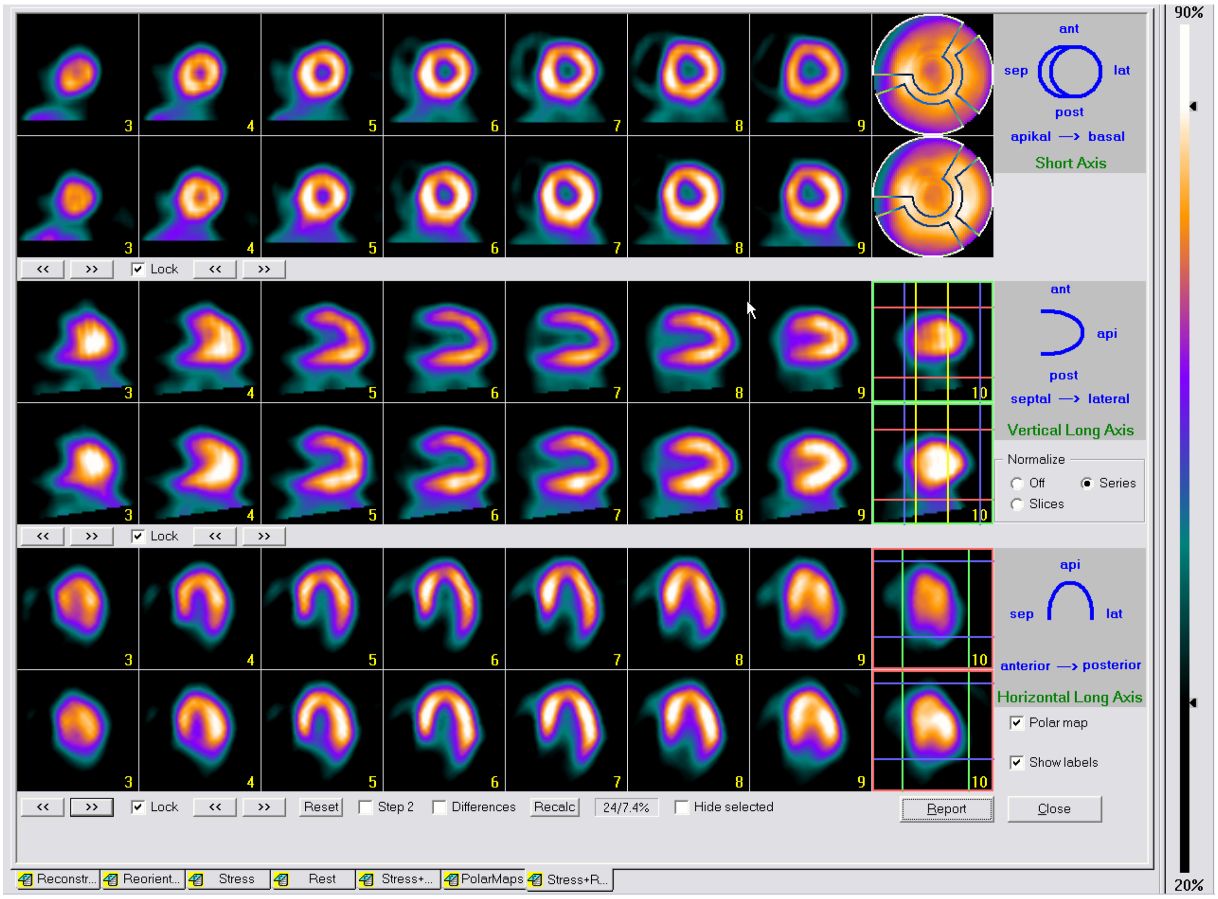



Figure 3-27 Stress + Rest Reoriented Slices (*InterViewXP*)

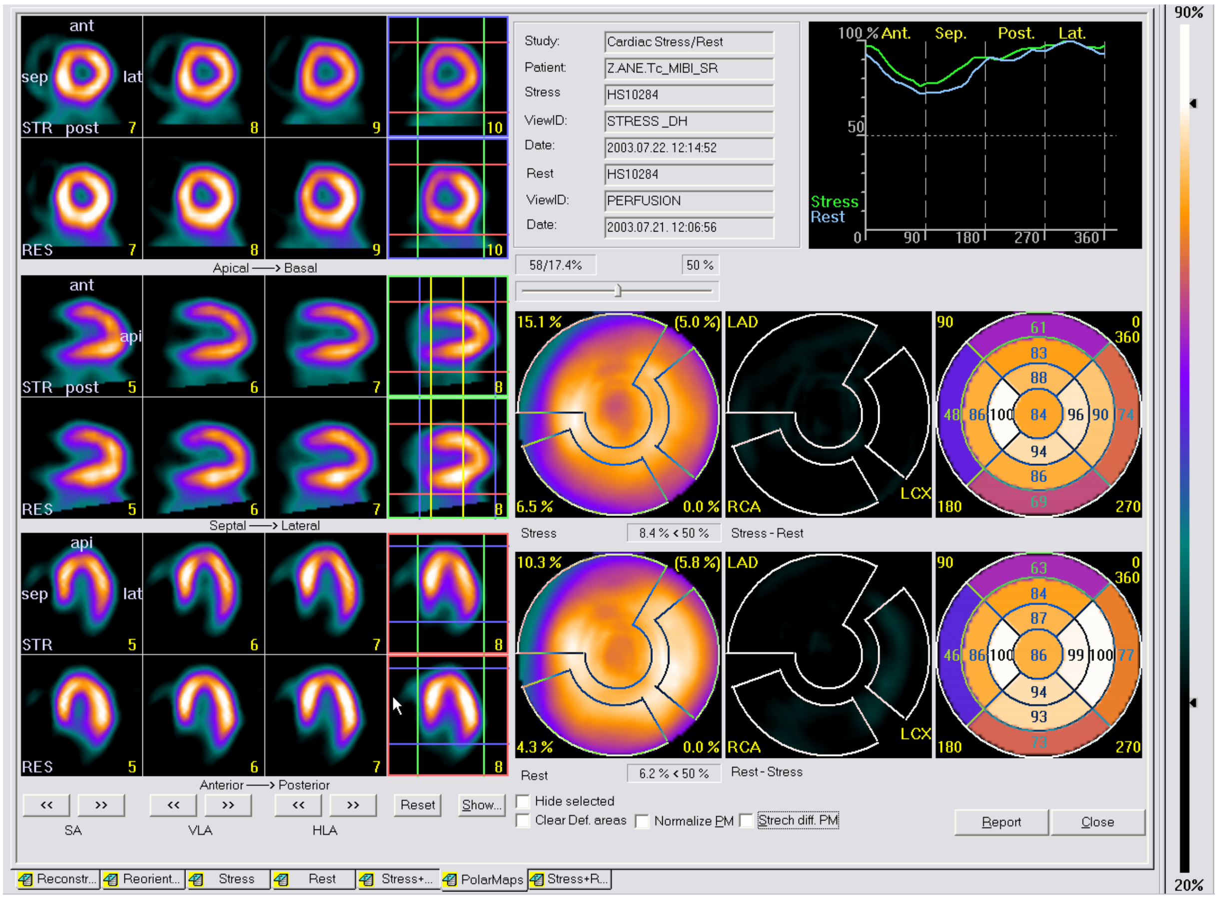



Figure 3-28 Polar Maps (*InterViewXP*)

## $^{99m}$Tc Tetrofosmin Stress + Rest Study: Homogeneous myocardial perfusion

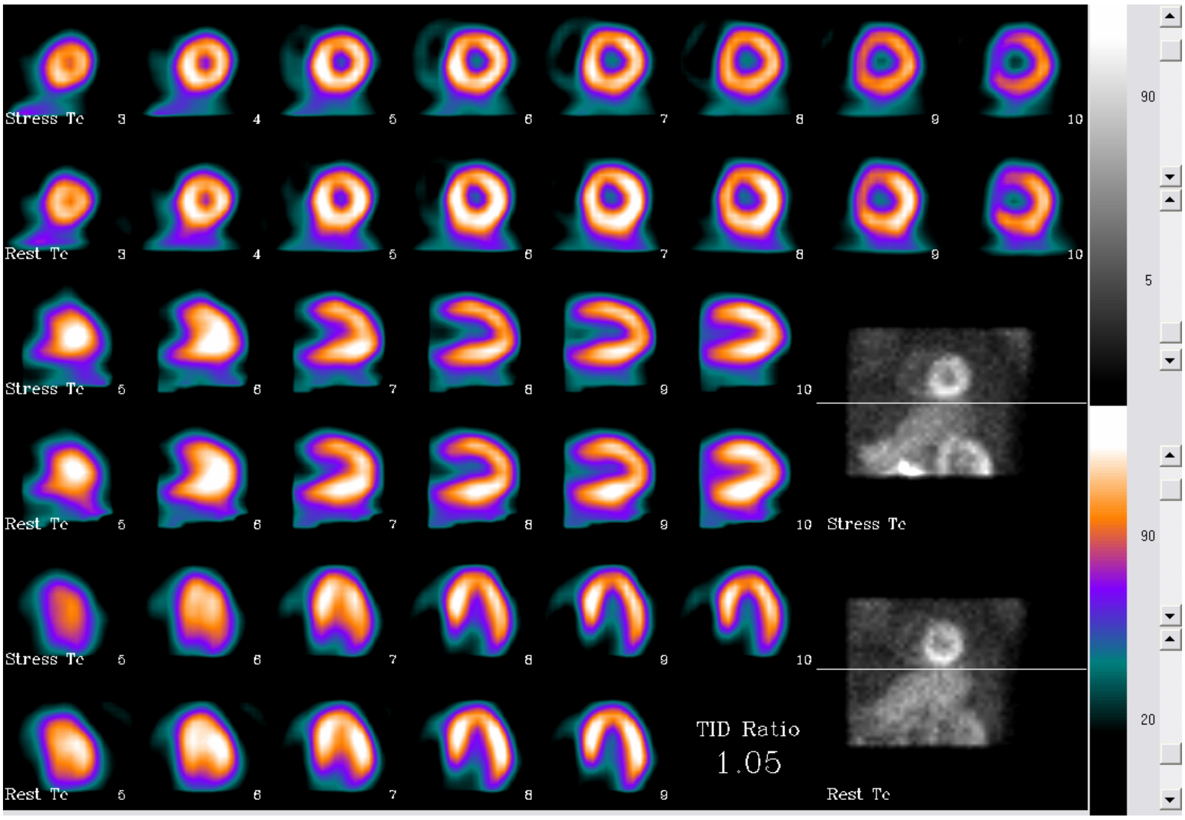



Figure 3-29 ECToolbox Reoriented Slices

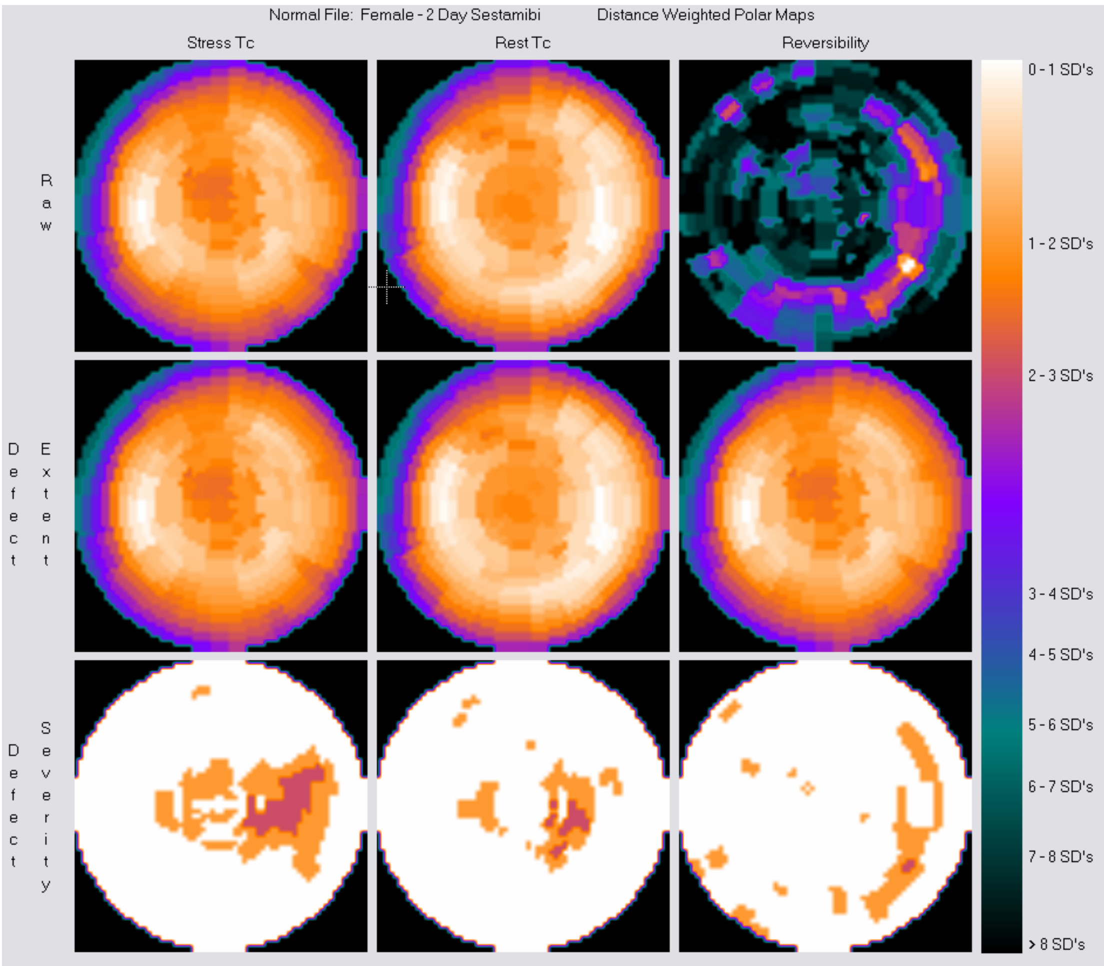



Figure 3-30 ECToolbox Polar Maps

# Gated SPECT Imaging

## Clinical application

ECG gated myocardial perfusion SPECT study with $^{99m}$Tc or $^{201}$Tl labelled perfusion tracers give the possibility to obtain high quality perfusion data and functional parameters of the left ventricle simultaneously. Both provide independent important diagnostic and prognostic information about the ischemic heart disease. Parallel evaluations of the perfusion and function help to recognize the false positive (diaphragmatic and/or mamma) defects and decrease the cardiac motion artifacts. The detection of the real hypoperfusion will be improved (higher specificity). The determination of the following LV parameters as regional perfusion, wall motion, EF and regional EF calculation, wall thickening, phase and amplitude analysis support the accuracy of the diagnosis.

# Case study I

## Acquisition protocol

**SPECT Study**

Step and shoot mode
Matrix size: 64x64
Number of steps: 30 (180° rotation)
Gated mode: forward gating, 20% window and B1 (Buffered)
Number of accepted heart cycles in each view: 100
R-R distance is divided: 8 or 16 pcs images
Applied activity: 740 ÷ 900MBq $^{99m}$Tc-MIBI
Collimator: LEAP
Patient position: supine
Direction of rotation: CCW
Start angle: LPO-42°

## Image processing

**SPECT**

- 2D pre-filtering on the projection data set by Butterworth filter
- Reconstruction with MOS-EM algorithm
- 20% background subtraction after the reconstruction
- Reorientation of the transaxial slices
  (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical and longitudinal (apical) slices in each sampled phase (in R-R interval)
- ED + ES, phase amplitude, wall motion, regional perfusion analysis, EF and wall thickening calculation
- Polar-map generation for perfusion and functional parameters

## Case study

A 43-year-old female patient with exertional dyspnea and atypical ECG changes recently. Systemic hypertension, smoking, impaired. Glucose tolerance in her history. Mild diffuse LV dysfunction on ECHO, more pronounced in septum. Non-diagnostic bicycle stress due to hypertensive answer. Stress-rest $^{99m}$Tc-MIBI SPECT showed two fix defects. ECG gated rest MIBI SPECT (G-SPECT) functional evaluation helps to identify the real septal perfusion defect with impaired functional parameters due to resent myocardial infarction and false positive anterior defect due to small dense breast with maintained function (LV functional parameters are consistent with echo data).

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

# $^{99m}$Tc MIBI Gated SPECT Imaging

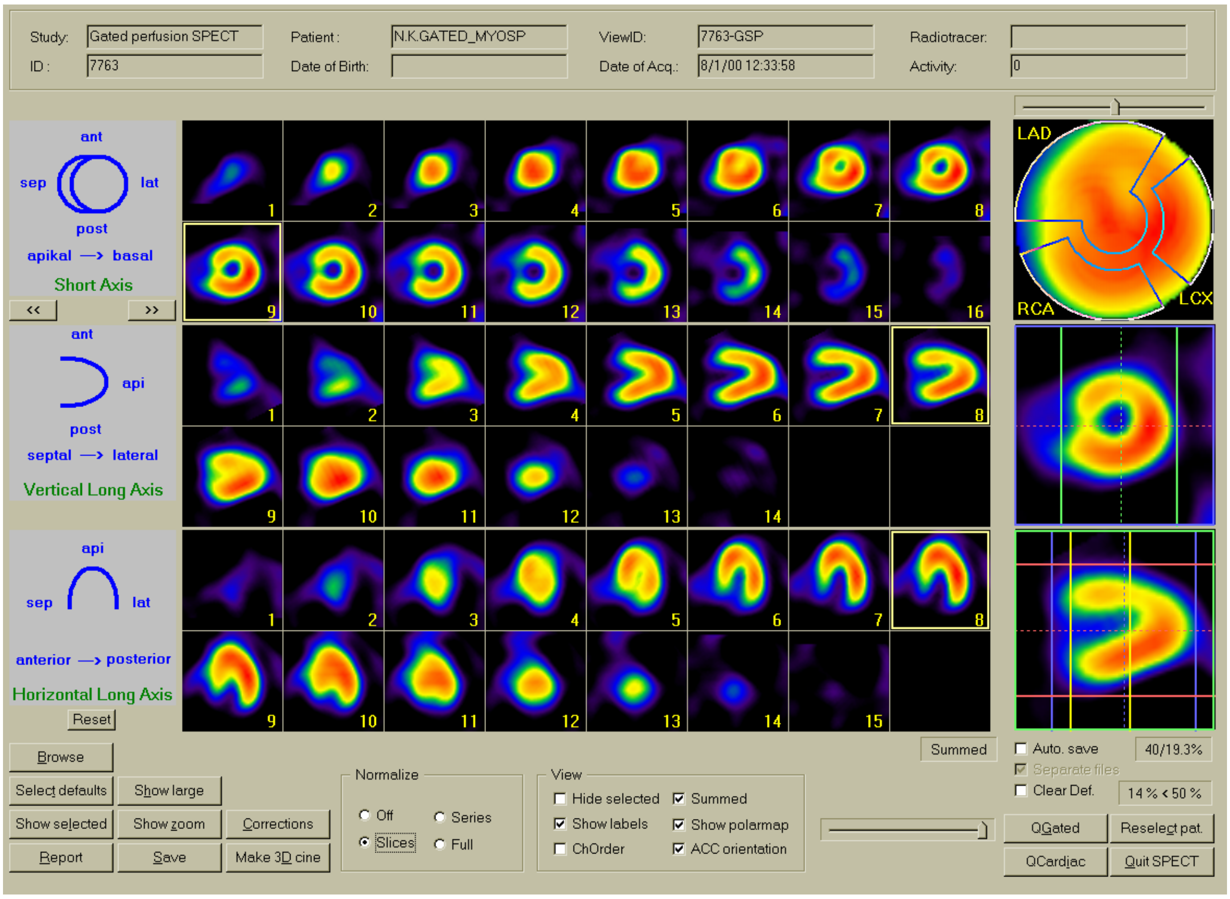



Figure 3-31 Summary image processing

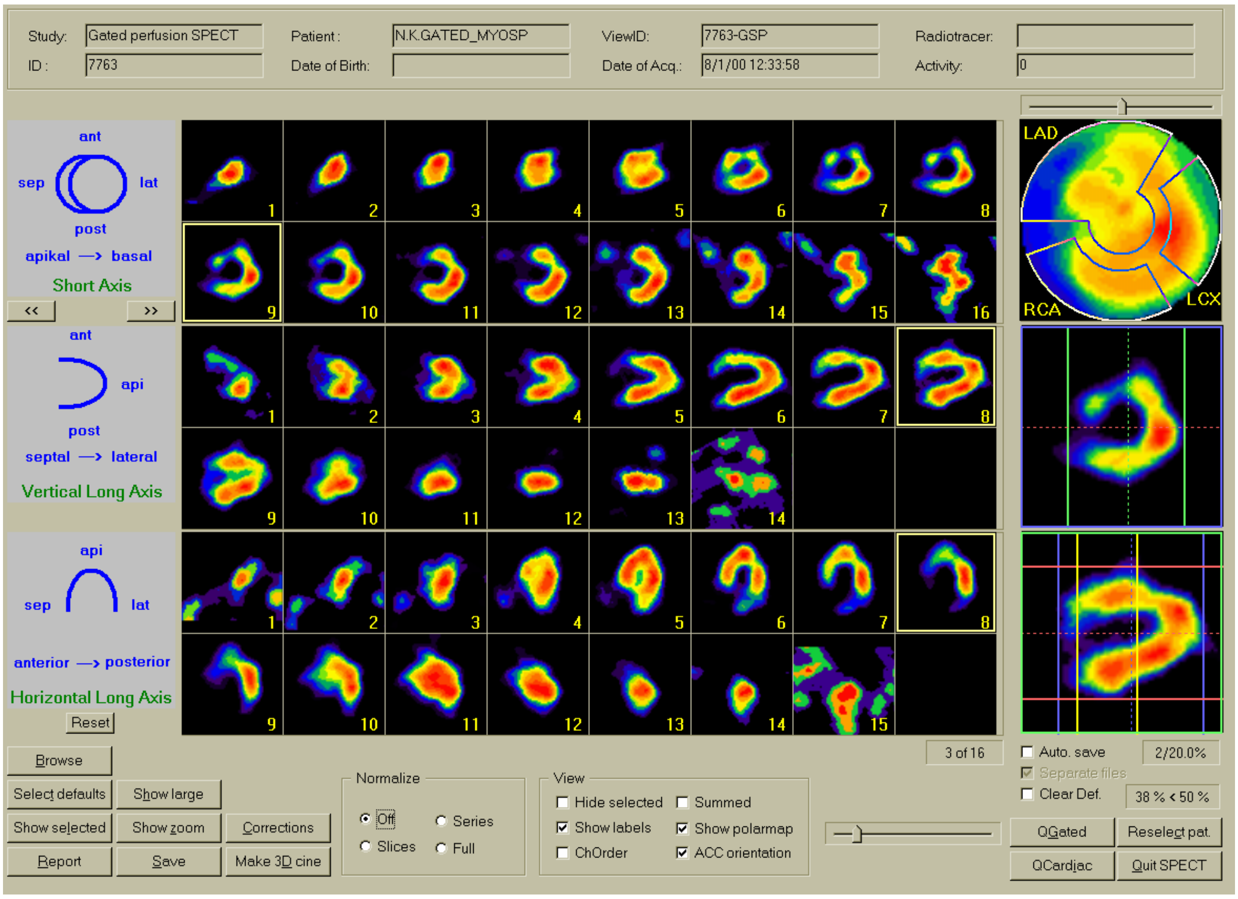



Figure 3-32 Processing like a myocardiac study (e.g. 3rd frame of 16)

# $^{99m}$Tc MIBI Gated SPECT Imaging

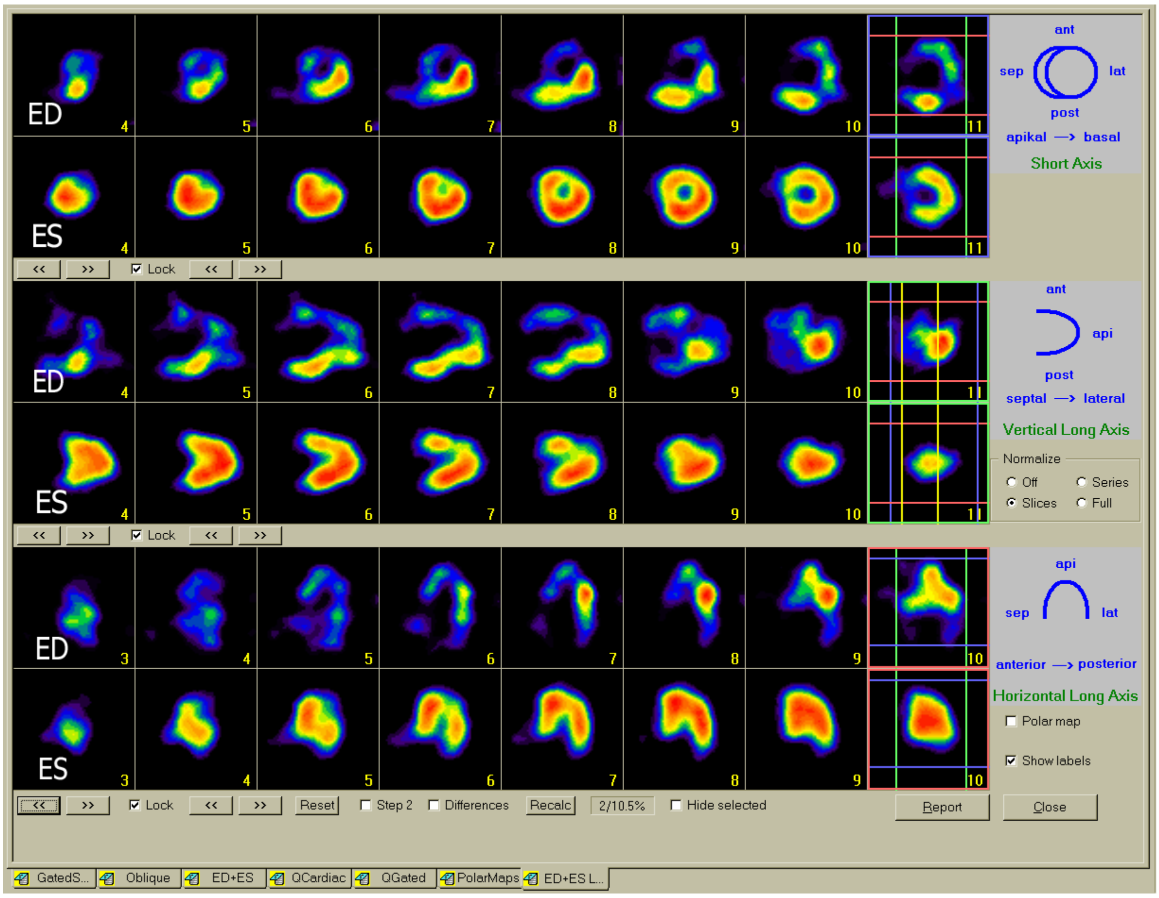



Figure 3-33 ED + ES Analysis

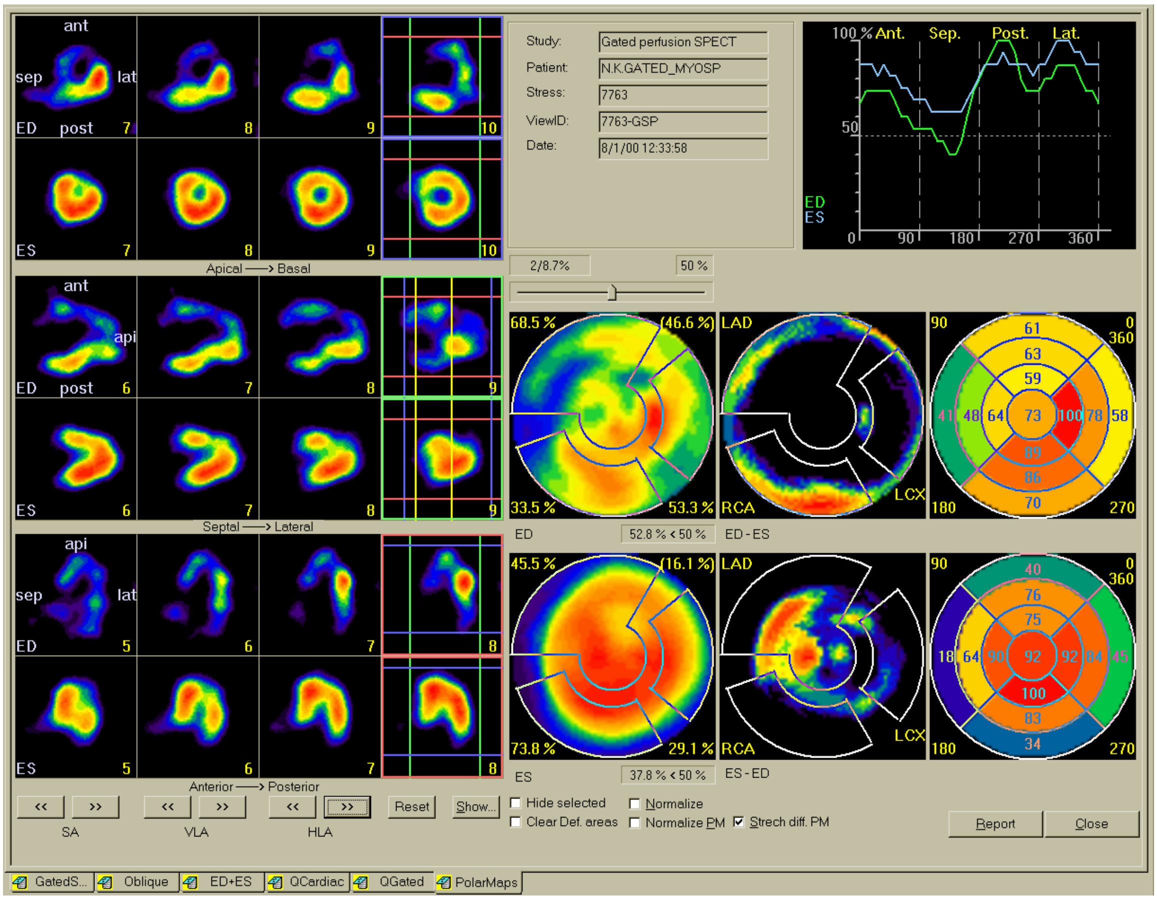



Figure 3-34 ED + ES Analysis – Polar Maps

## $^{99m}$Tc MIBI Gated SPECT Imaging

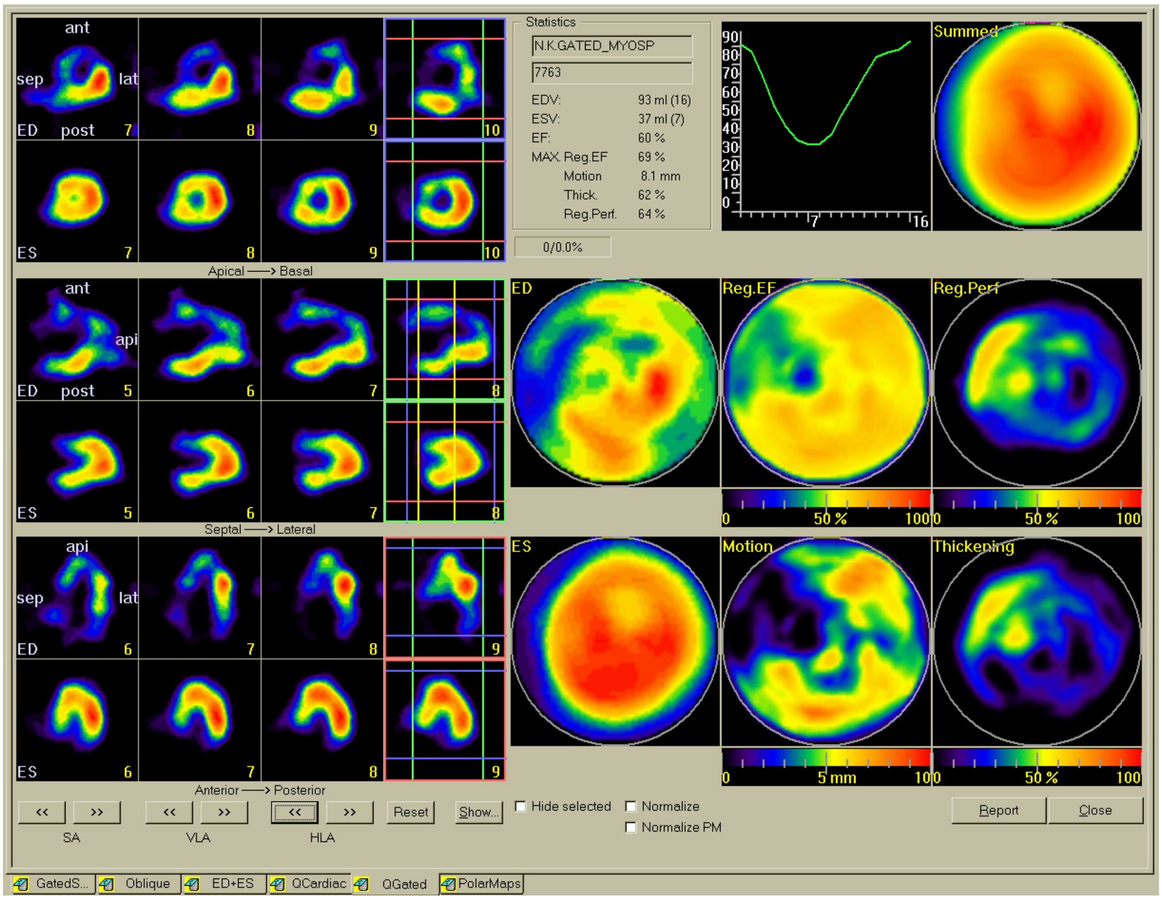



Figure 3-35 Complete polar map analysis

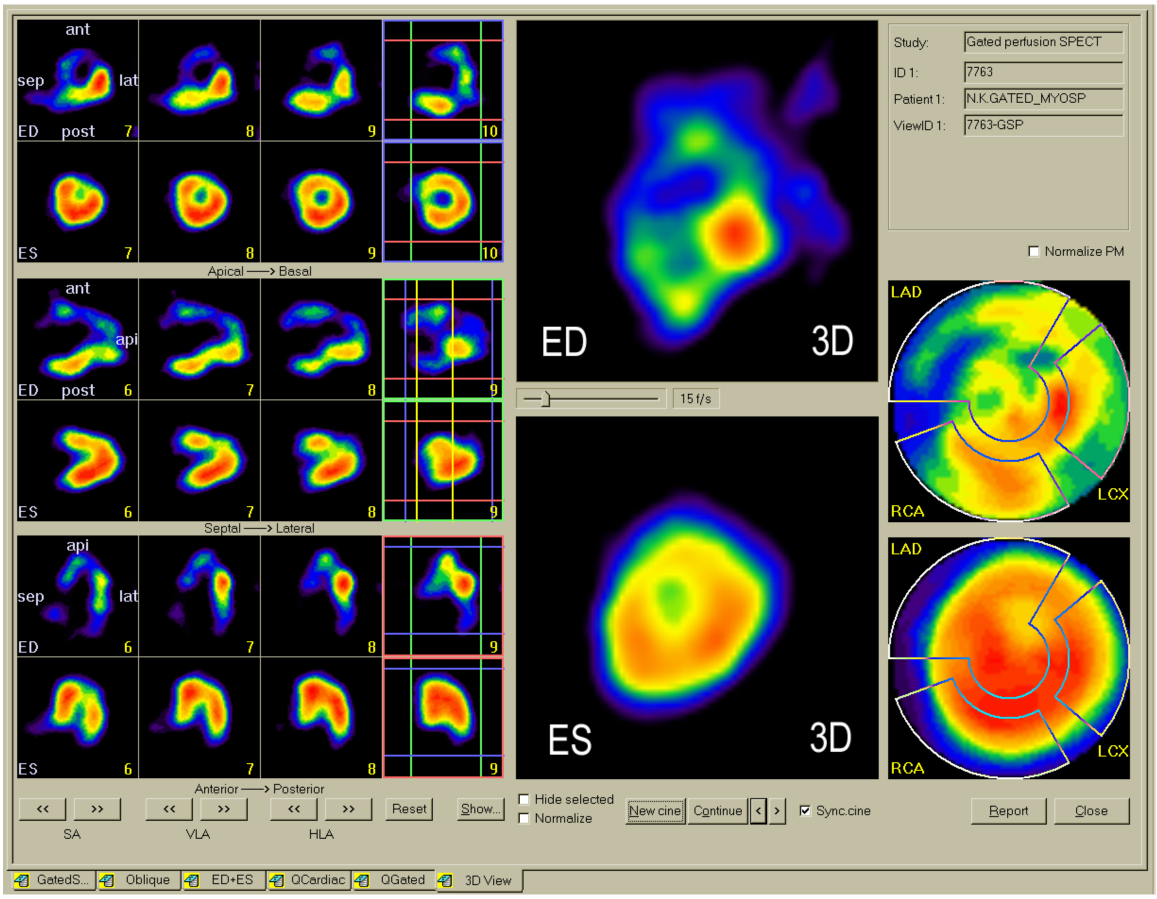



Figure 3-36 3D presentation of ED & ES phases

# Case study II

## Imaging protocol

540-900MBq (15-25 mCi) $^{99m}$Tc-MIBI stress injection then 30-90 minute later stress SPECT study is performed. Next day another 540-900MBq (15-25 mCi) rest injection will be administered and 30-90 minutes later a rest gated SPECT acquisition is carried out.

## Acquisition protocol

**SPECT Study**

Collimator: LEHR
Photopeak window: 140 keV ± 20%
Acquisition matrix: 64x64
Orbit: 180° CCW step and shoot (45° RAO → 45° LPO)
Number of projections: 32
Time/view: 60 sec
Gated SPECT: 16 frames/cycle, allowable change: ± 15%, beat rejection: Buffered 2
Patient position: supine

## Image processing

**SPECT**

- Regular smoothing of the each phase of the projection data set
- 2D pre-filtering on the smoothed projection data set by Butterworth filter
- Reconstruction with MOS-EM algorithm
- 20% background subtraction after the reconstruction
- Reorientation of the transaxial slices
  (Reference: long and short axis of the heart)
- Generation of reoriented horizontal, vertical and longitudinal (apical) slices in each sampled phase (in R-R interval)
- ED + ES, phase amplitude, wall motion, regional perfusion analysis, EF and wall thickening calculation
- Polar-map generation for perfusion and functional parameters
- Evaluation by ECToolbox
- The complete study is evaluated like a $^{99m}$Tc-MIBI Stress+Rest study too

## Case study

### *Patient History*

- 49-year-old female
- Family history: hypertension, cerebrovascular disease, sudden cardiac death, peripheral arterial obliterative disease
- Risk factors: nicotine abuse, high cholesterol level
- Duodenal ulcer (1983.)
- Surgical intervention on ovarial cyst rupture (1988.)
- Intermittent claudication since 1990
- Inferior MI (1992.)
- Negative post discharge stress test 8.1 MET
- Indication of SPECT study: progressive effort dyspnea in the last six months
- Exercise cannot be performed because of physical limitation (intermittent claudication)

### *Stress test*

Pharmacological stress test Dipyridamole (0.56 mg/kg-bodyweight for 4 min): No significant ischemic ECG changes occurred. Did not develop chest discomfort.

| | **Baseline** | **Peak action** | **Recovery** |
|---|---|---|---|
| **BP** [Hgmm] | 110/80 | 110/80 | 105/75 |
| **HR** [BPM] | 74 | 85 | 81 |

Rest study was performed after sublingual Nitrate application.

### *Interpretation*

Perfusion: Severe stable apical, infero-apical perfusion defect. Extensive, severe to moderate inferior, posteroinferior perfusion defect. Minimal reversible lateral, posterolateral perfusion defect.

Function: Moderate reduction of LV function. EF: 38%. Akinesis in the apical and infero-apical segments. Wall motion and thickening can be detected in some extent in the distal-inferior and posteroinferior segments.

### *Diagnostic Impression*

Extensive apical, inferior and posteroinferior infarction. Minimal transient ischemia in the posterolateral segments.

Moderate reduction of LV function. Viable myocardium can be supposed based on functional data in the distal-inferior and posteroinferior segments.

Invasive evaluation recommended.

*Case contributed by Gottsegen György Hungarian Institute of Cardiology*
*Department of Nuclear Cardiology*

# $^{99m}$Tc Sestamibi Gated SPECT Study: Inferior MI with viable myocardium

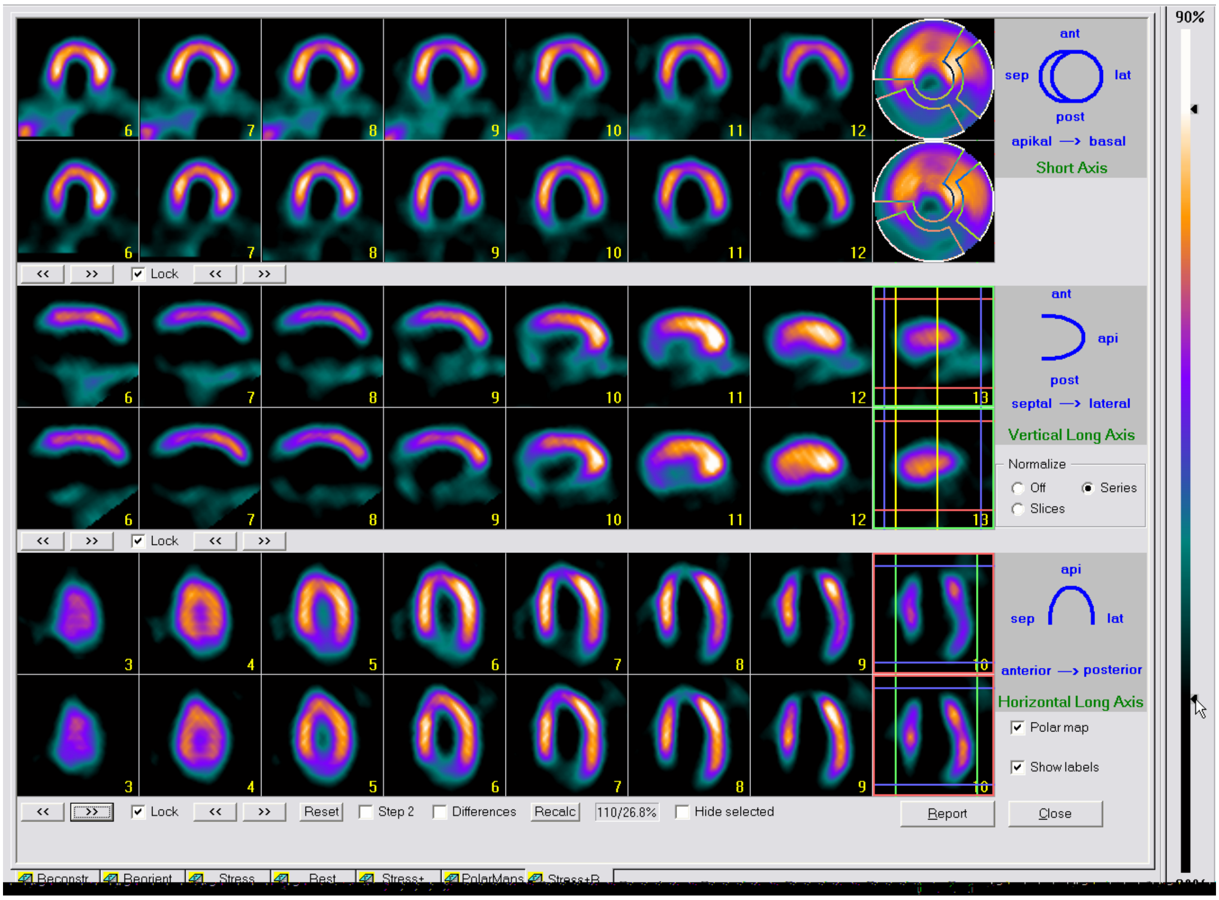



Figure 3-37 Stress + Rest Reoriented Slices (*InterViewXP*)

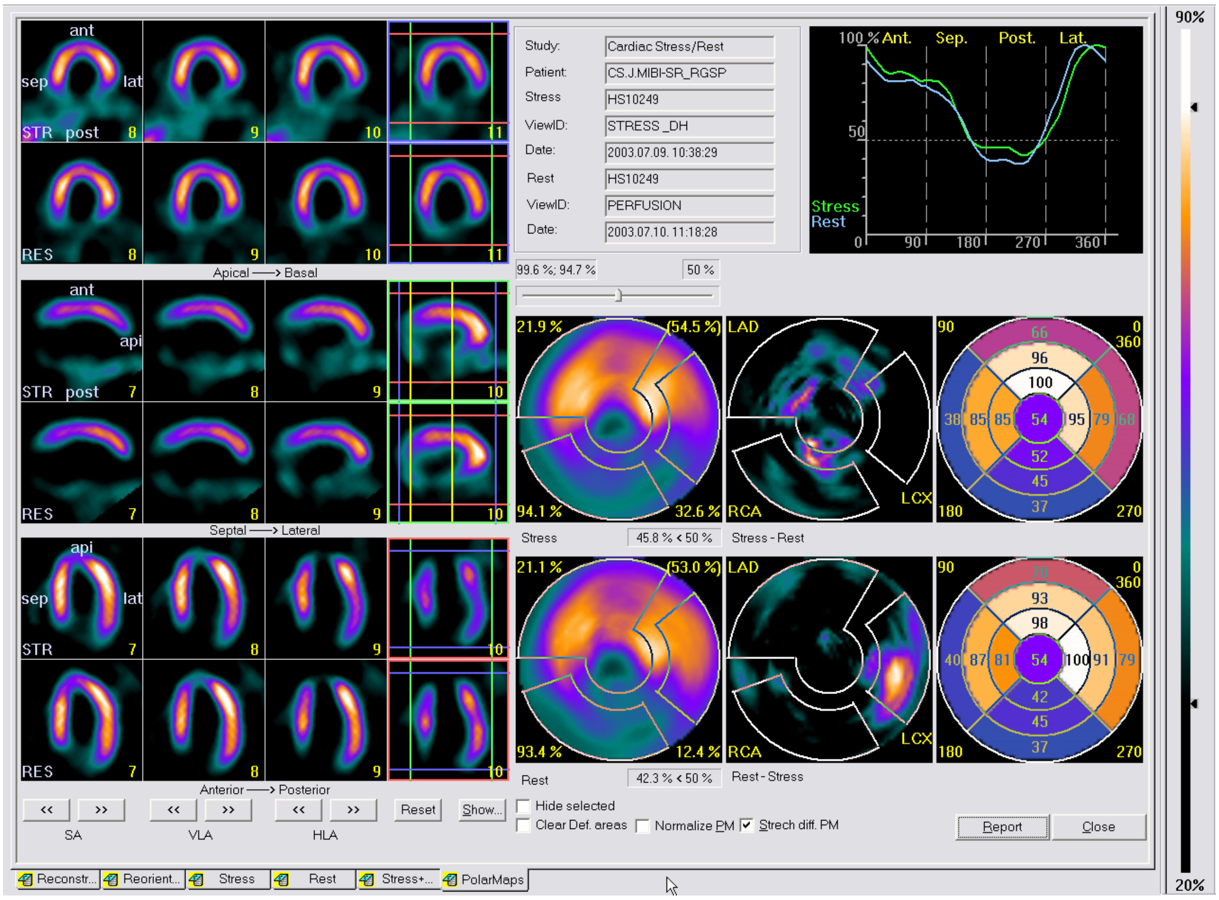



Figure 3-38 Polar Maps (*InterViewXP*)

## $^{99m}$Tc Sestamibi Gated SPECT Study: Inferior MI with viable myocardium

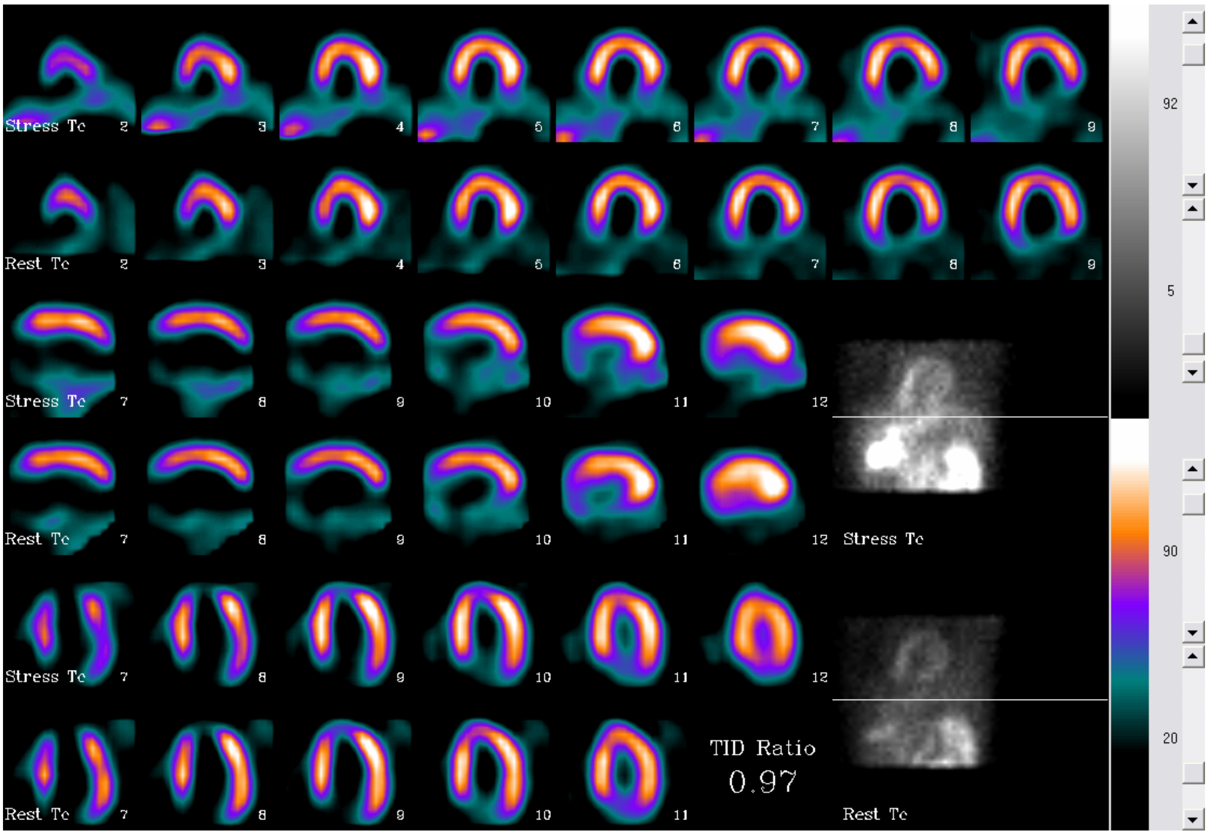



Figure 3-39 ECToolbox Slices

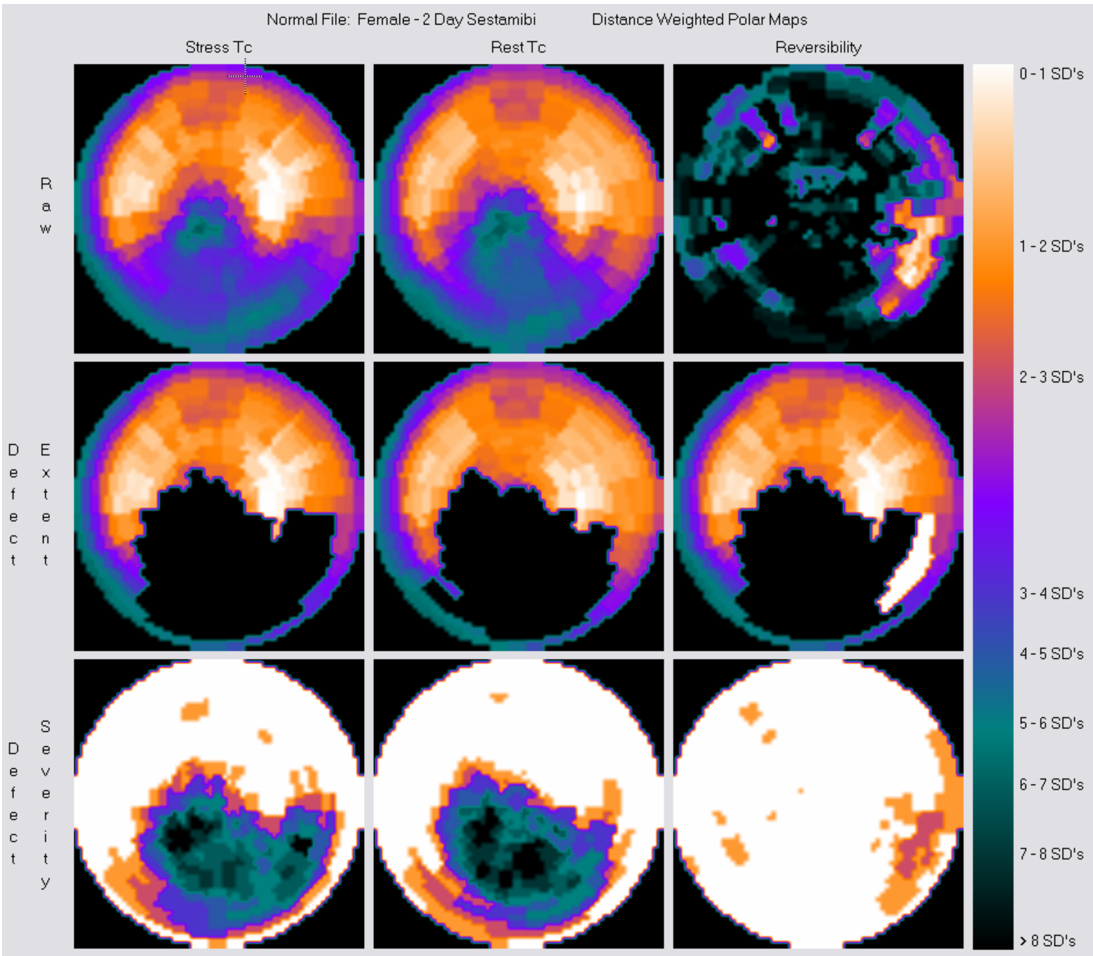



Figure 3-40 ECToolbox Polar Maps

## ${}^{99m}$Tc Sestamibi Gated SPECT Study: Inferior MI with viable myocardium

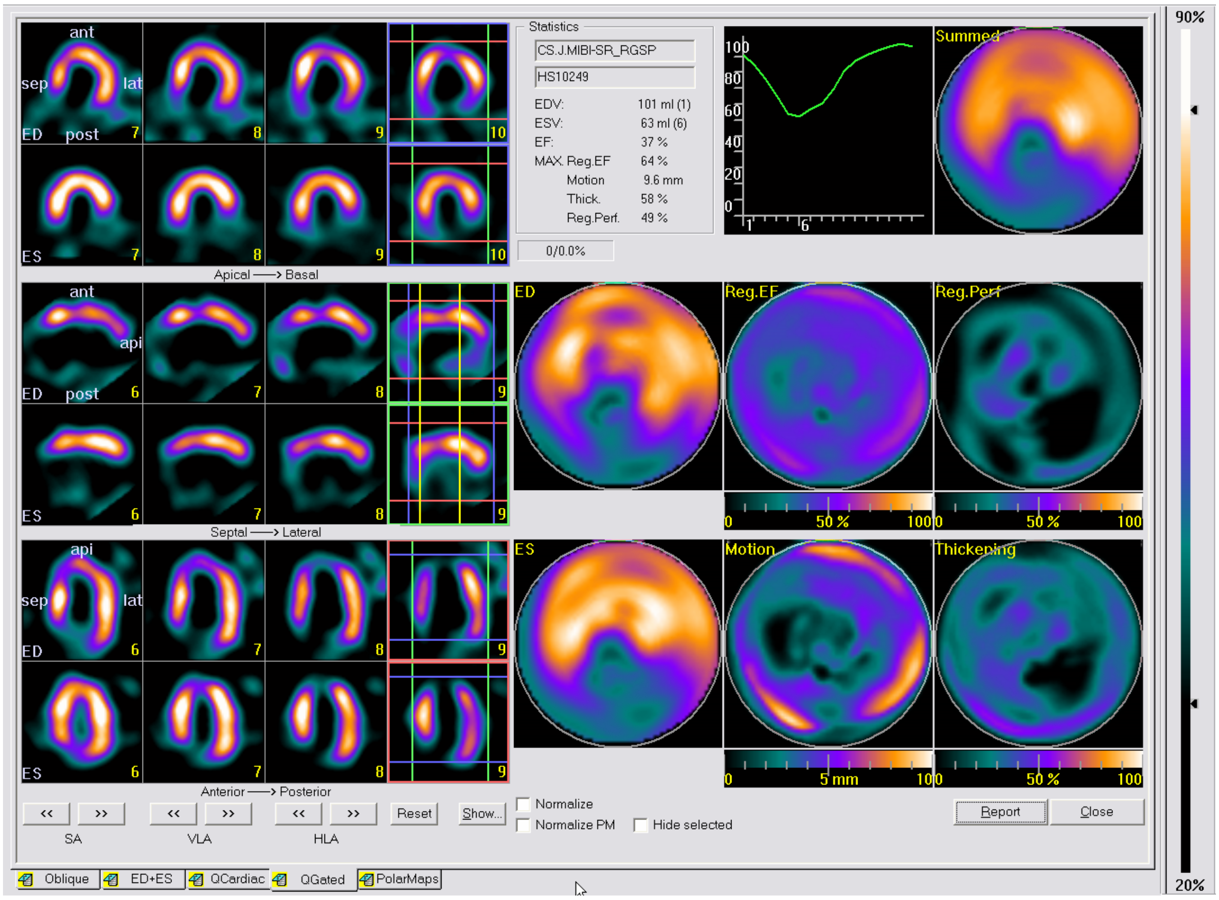



Figure 3-41 Gated Polar Maps (*InterViewXP*)

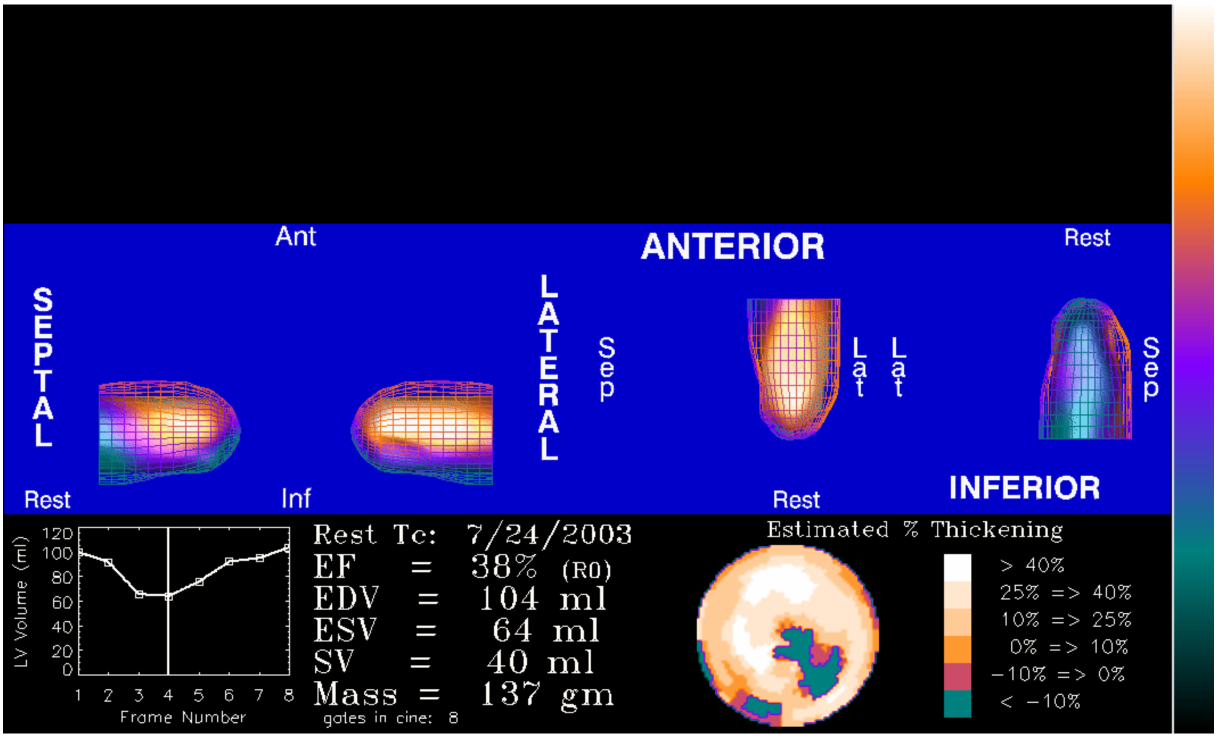



Figure 3-42 ECToolbox Functional Analysis

**$^{99m}$Tc Sestamibi Gated SPECT Study: Inferior MI with viable myocardium**

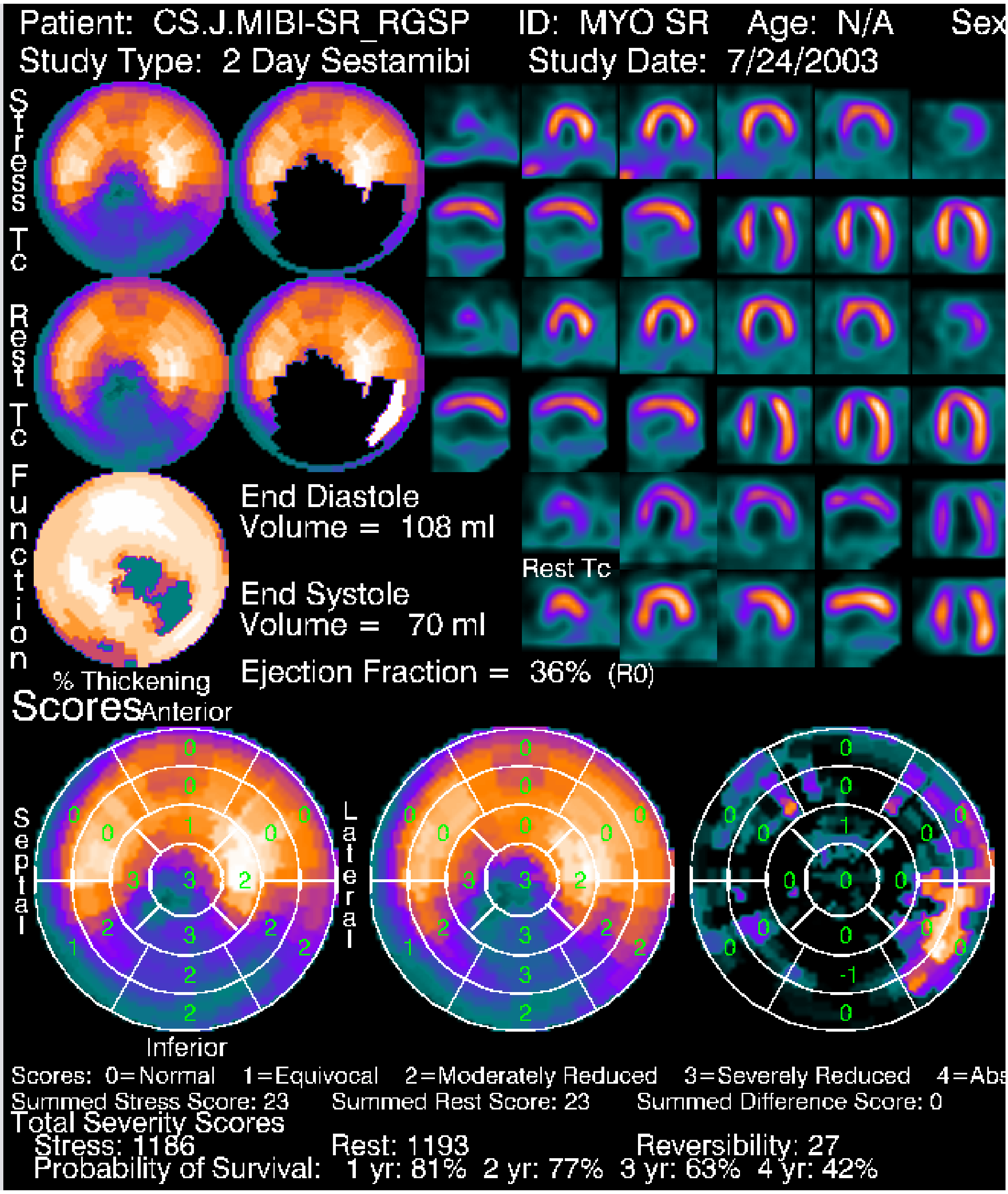



Figure 3-43 ECToolbox Summary

# 4. Neurology

# Brain perfusion SPECT imaging

## Clinical application

The accumulation of $^{99m}$Tc-ECD and $^{99m}$Tc-HMPAO radiopharmaceuticals is proportional to the regional cerebral blood flow, and localized mainly in the grey matter. Since the disappearance of this cerebral activity is very slow, a subsequent SPECT imaging can display the spatial distribution of the cerebral blood flow. The pathological distribution of the brain perfusion can be characteristic in cerebrovascular disease, several types of dementias, and in the case of focal seizures, constituting the main indications for brain perfusion is the SPECT investigation.

## Acquisition protocol

**SPECT Study**

Step and shoot mode
Matrix size: 128x128
Number of steps: 64 (360° rotation)
Exposition: 40 sec
Applied activity: 700÷900 MBq $^{99m}$Tc-ECD
Collimator: LEHR
Patient position: supine
Direction of rotation: CCW
Start angle: 0°

## Image processing

**SPECT**

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% background subtraction after the reconstruction
- Attenuation correction
- Regular smoothing of the transversal slices
- Smoothing among the azimuthally (Z) axis
- Reorientation of the transaxial slices (Reference: OM line)
- Generation of coronal and sagittal slices

## Case study

A 73-year-old female patient. Doppler ultrasonography detected 90% left sided internal carotid artery stenosis. Brain perfusion imaging with $^{99m}$Tc-ECD revealed no relevant perfusion defect.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

# Brain Perfusion SPECT Imaging

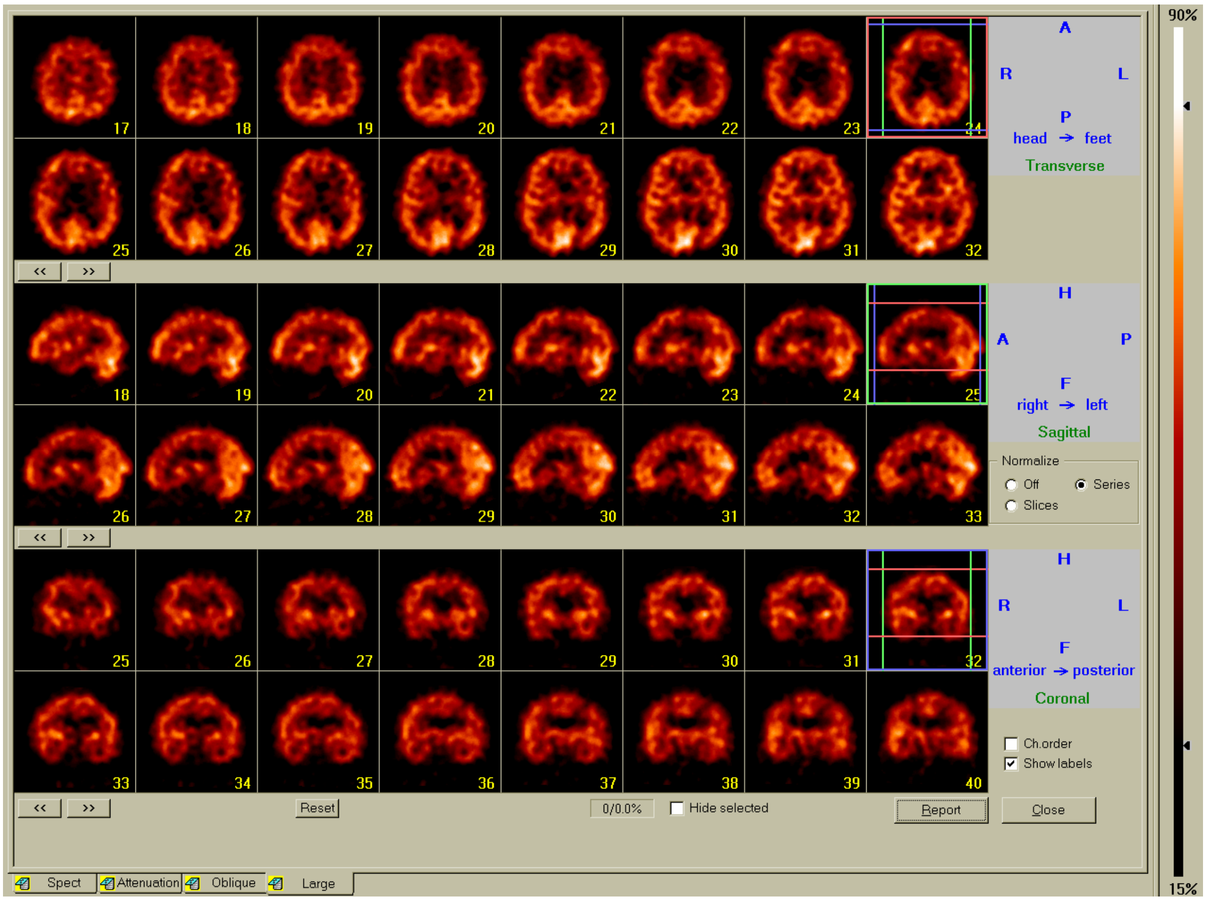



Figure 4-1 Slices

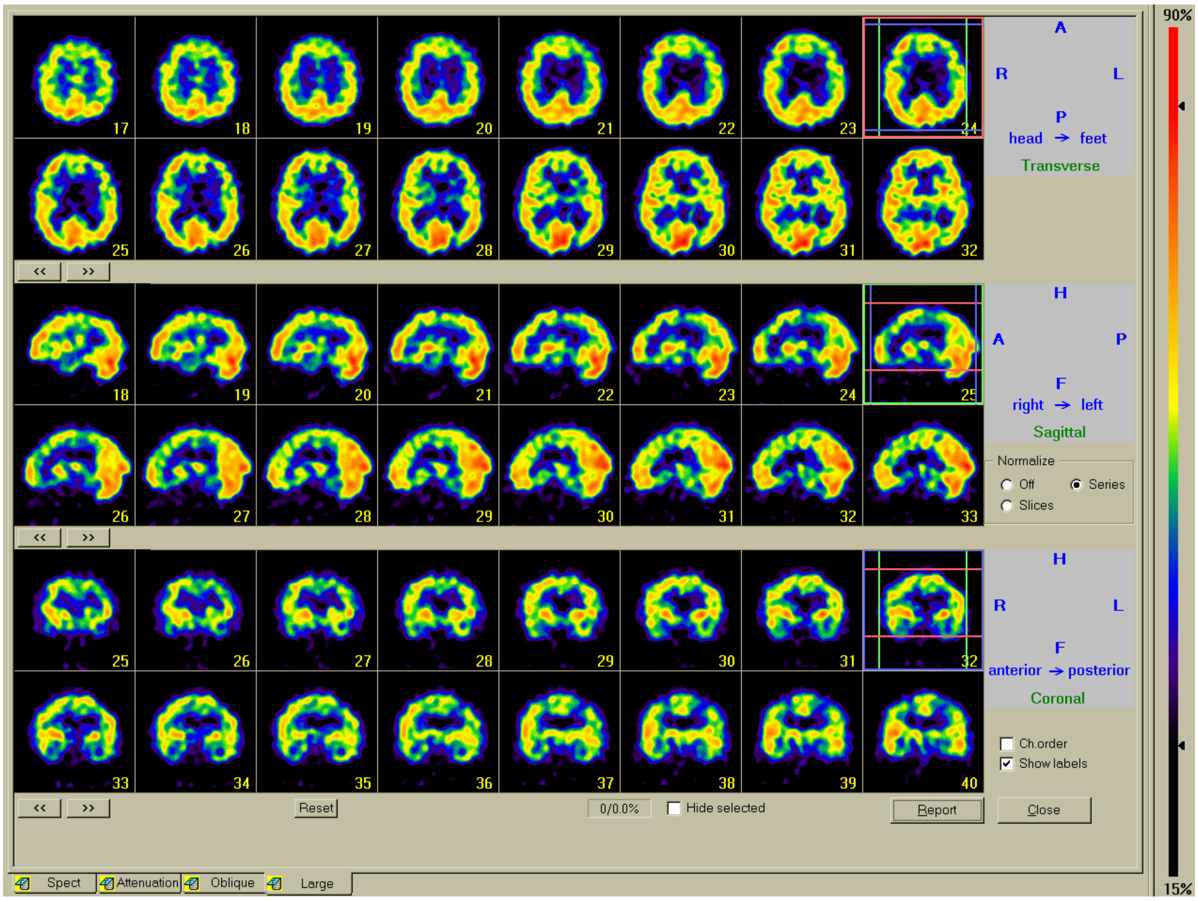



Figure 4-2 Slices

## Brain Perfusion SPECT Imaging

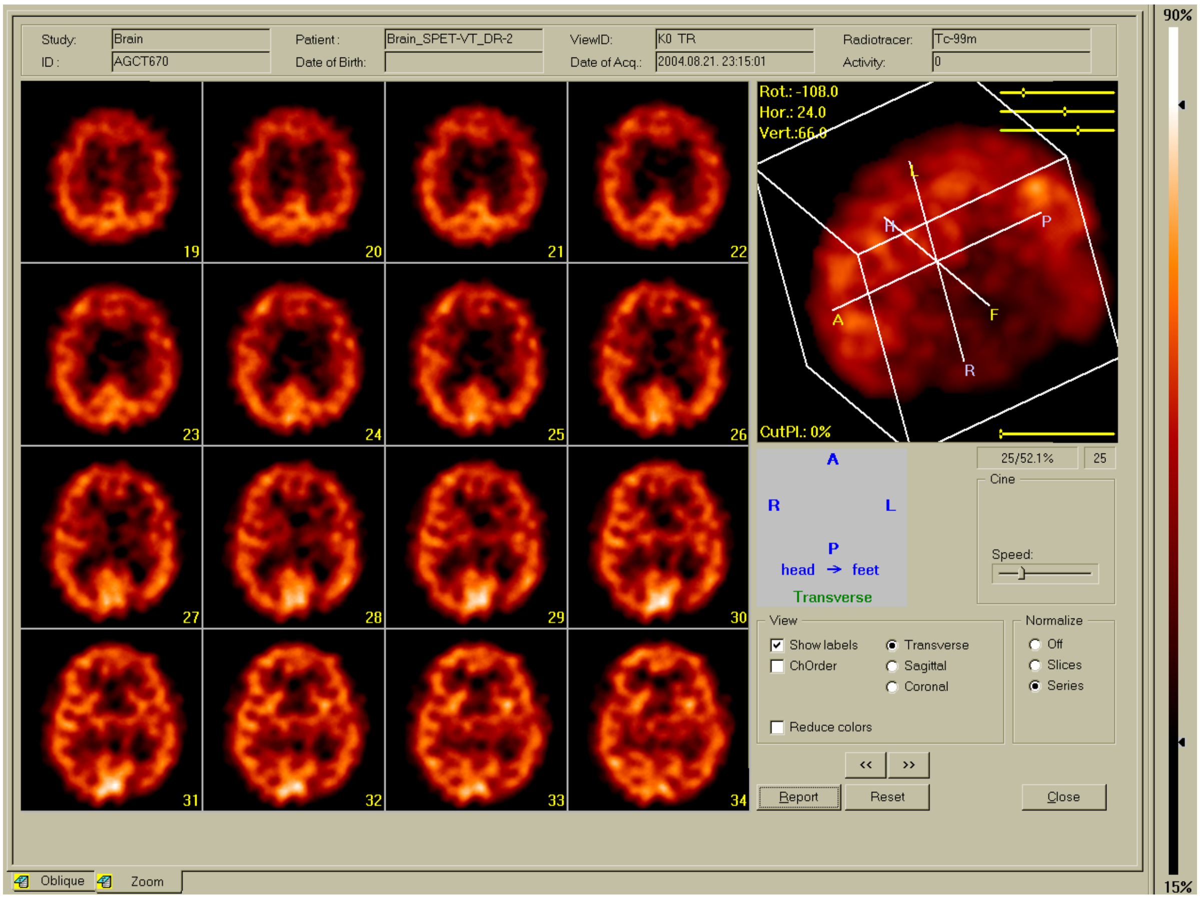



Figure 4-3 Quantitative analysis of the transversal slices

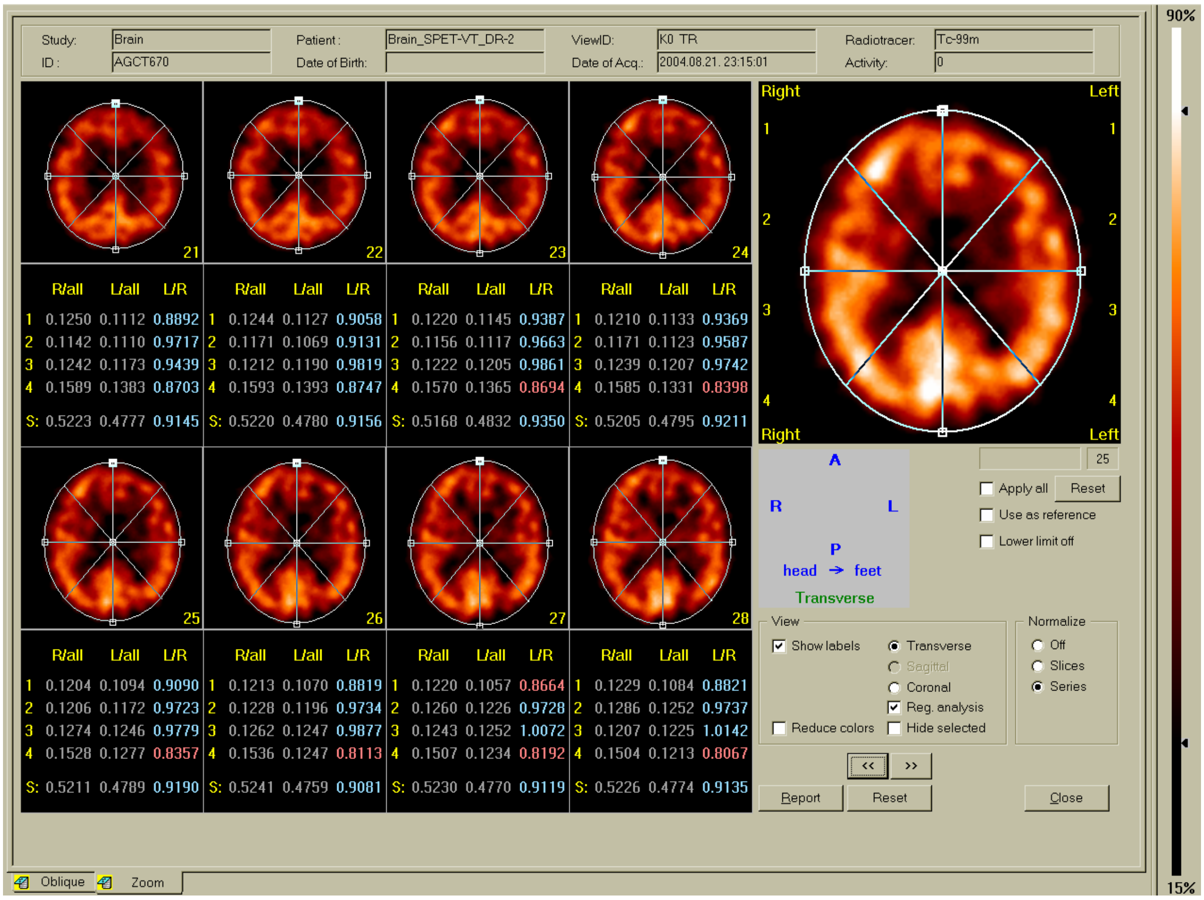



Figure 4-4 3D presentation (Volume Rendering)

# CT and Functional Brain SPECT Imaging

## Imaging protocol

Just before the functional brain SPECT study a morphological single series CT scan is performed by 3mm slice thickness.

## Acquisition protocol

**SPECT Study**

Step and shoot mode
Matrix size: 128x128
Number of steps: 120 (360° rotation)
Exposition: 40 sec
Applied activity: 700÷900 MBq $^{99m}$Tc-ECD
Collimator: LEHR
Patient position: supine
Direction of rotation: CCW
Start angle: 0°

## Image processing

**SPECT**

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% background subtraction after the reconstruction
- Attenuation correction
- Regular smoothing of the transversal slices
- Smoothing among the azimuthally (Z) axis
- Reorientation of the transaxial slices (Reference: OM line)
- Generation of coronal and sagittal slices

## Case study

An 83-year-old male patient suffering from cognitive deficit.
Both cortical and subcortical disturbances are present clinically.

**CT:** signs of cortical atrophy, represented by enlarged ventricles with slight left dominance and by enlarged subarachnoid space. Almost symmetrically decreased white matter density due to leucoaraiosis.

**SPECT:** Severe subcortical cortical perfusion deficit with left dominance in the fronto-temporo-parietal regions. Preserved cerebellar blood flow.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## CT and Functional Brain SPECT Imaging

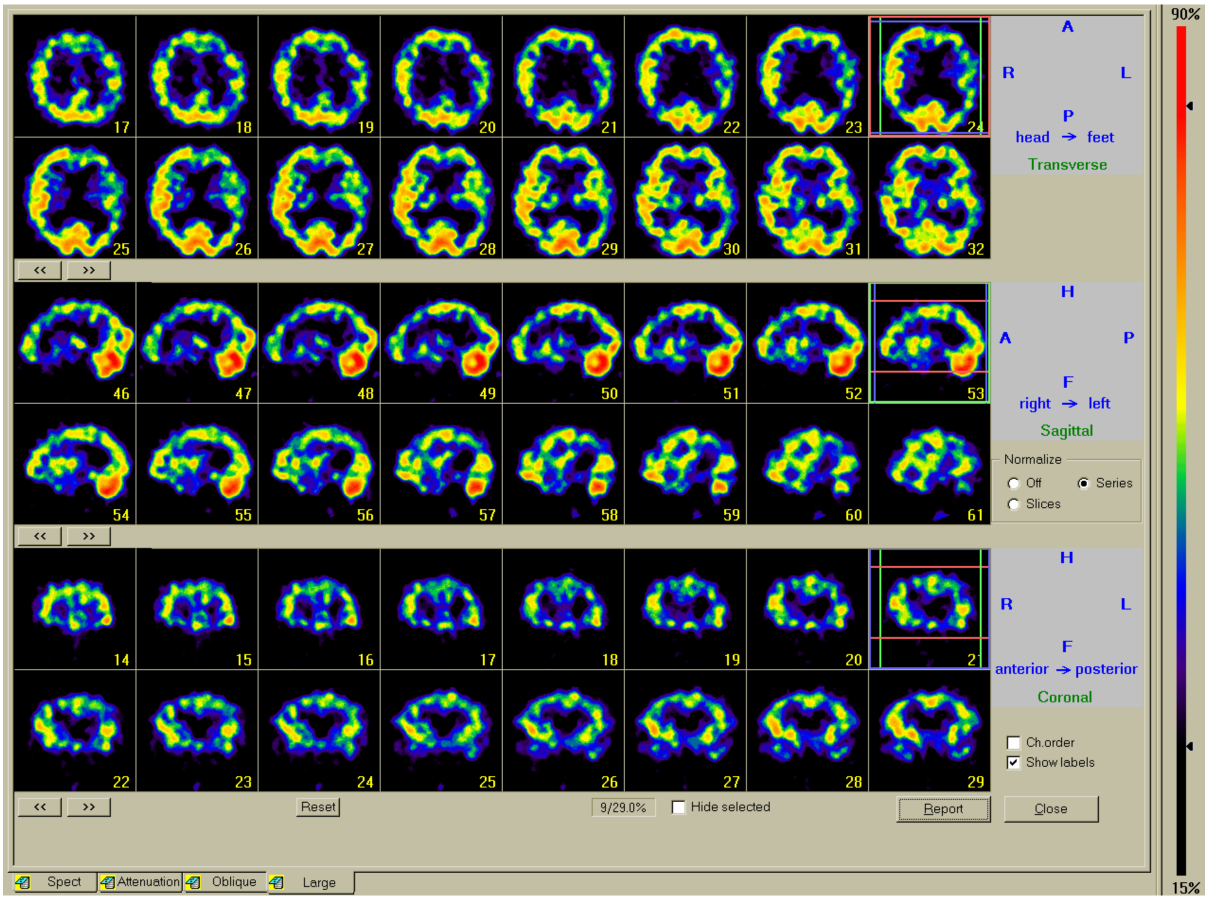



Figure 4-5 SPECT slices

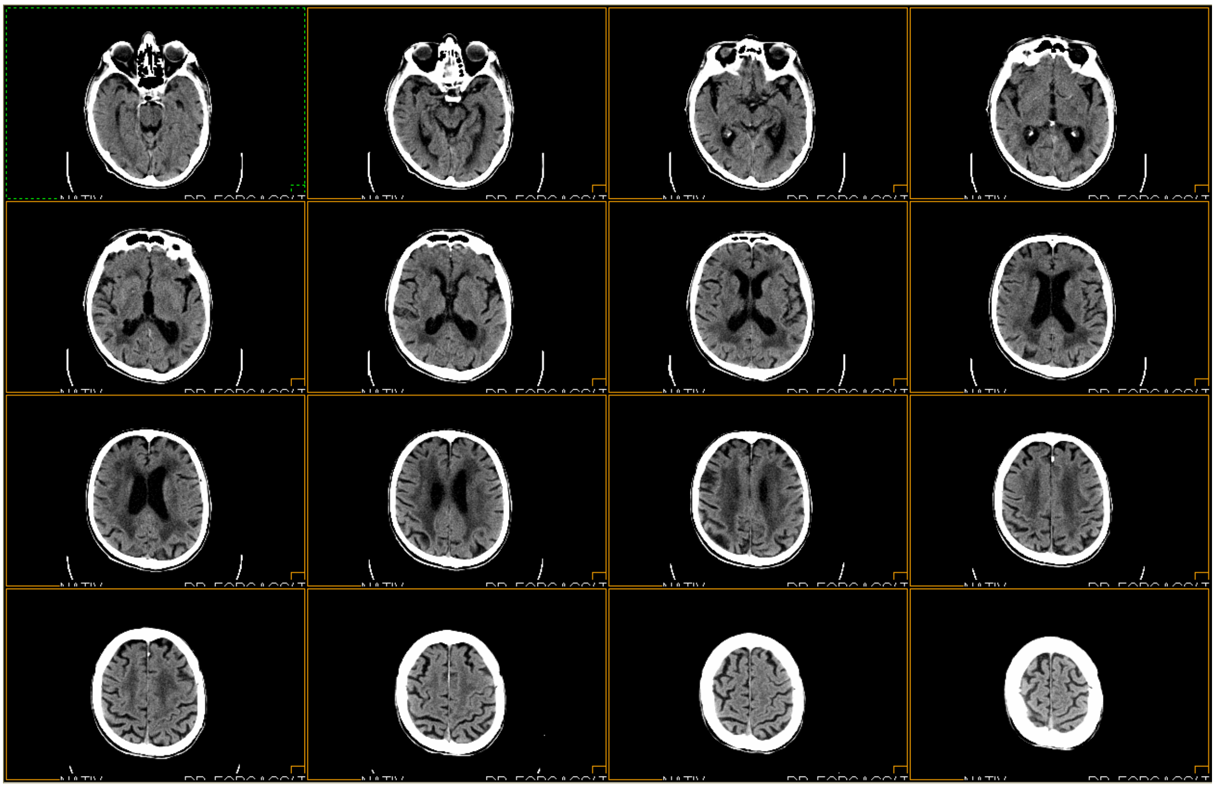


Figure 4-6 CT slices

# Simultaneous CT and Functional Brain SPECT Imaging

## Imaging protocol

Functional brain SPECT imaging is combined by a morphological single series CT scan with 3mm slice thickness. CT study is performed just before the SPECT acquisition.

## Acquisition protocol

### SPECT Study

Step and shoot mode
Matrix size: 128x128
Number of steps: 120 (360° rotation)
Exposition: 40 sec
Applied activity: 700÷900 MBq $^{99m}$Tc-ECD
Collimator: LEHR
Patient position: supine
Direction of rotation: CCW
Start angle: 0°

## Image processing

### SPECT

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% background subtraction after the reconstruction
- Attenuation correction
- Regular smoothing of the transversal slices
- Smoothing among the azimuthally (Z) axis
- Reorientation of the transaxial slices (Reference: OM line)
- Generation of coronal and sagittal slices
- Image fusion between CT and SPECT images

## Case study

28-year-old male patient who suffered from suspicious Parkinsonian symptoms. The regional cerebral blood flow SPECT study obtained after the intravenous injection of 740 MBq $^{99m}$Tc-ECD detected a slightly decreased uptake in both thalamic and left striatal regions. No signs of relevant perfusion abnormality in further regions. The CT images are unremarkable.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Simultaneous CT and Functional Brain SPECT Imaging

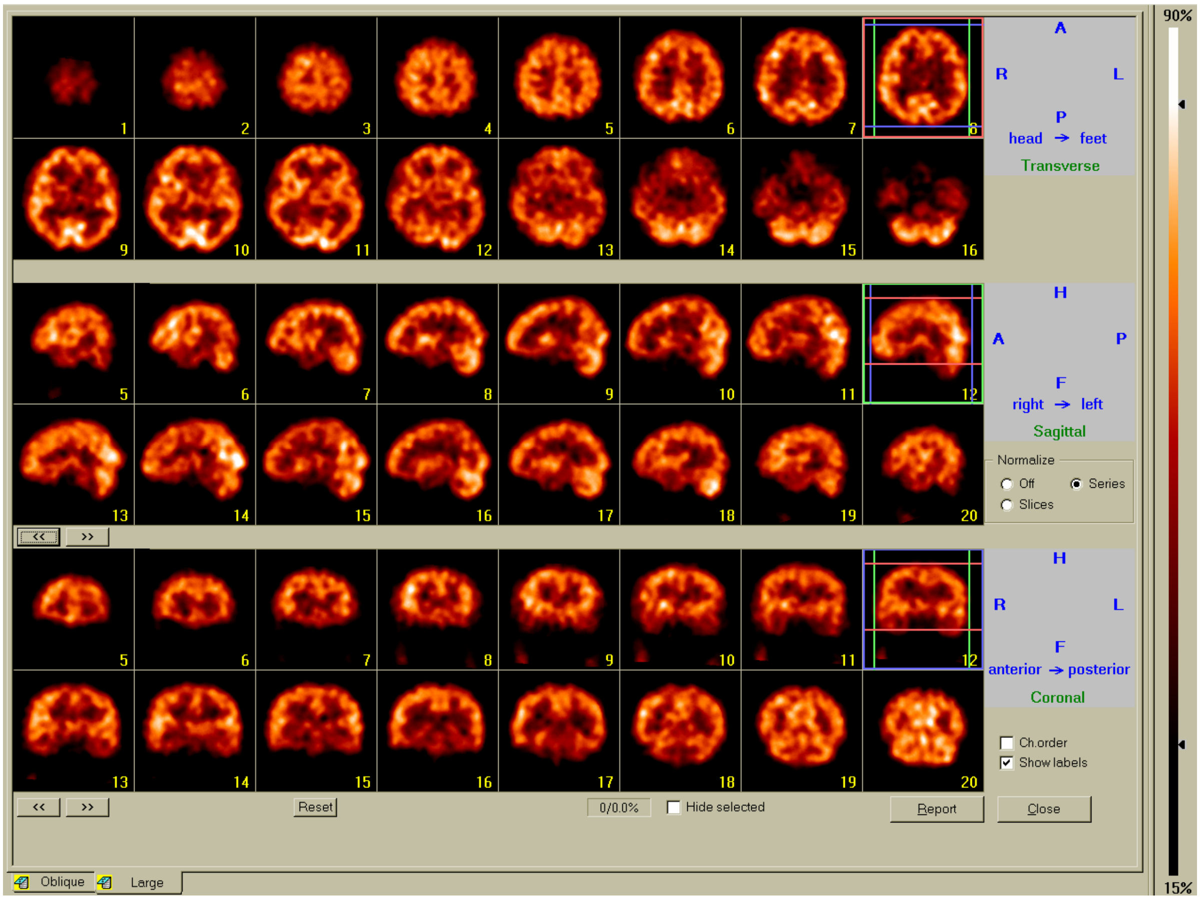



Figure 4-7 SPECT study result with 6.3mm slices thickness

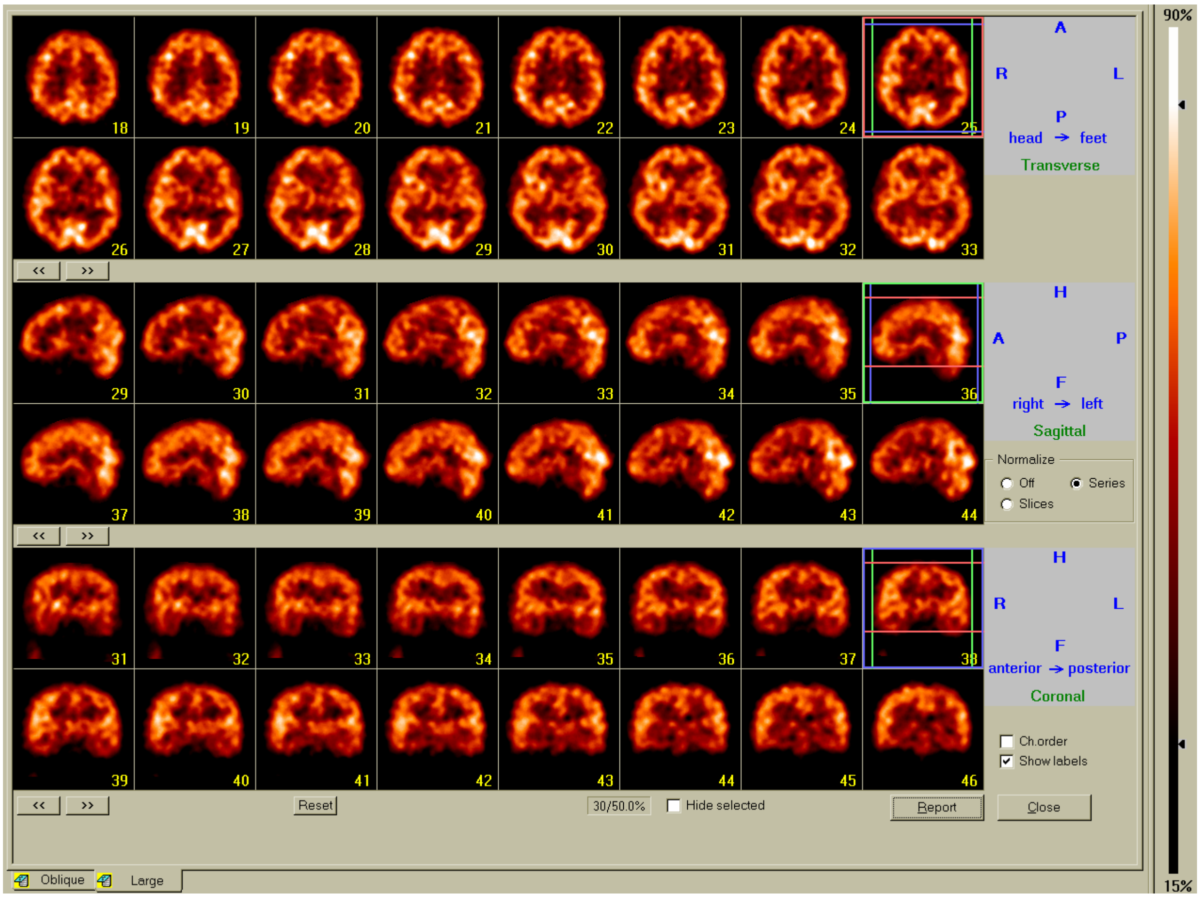



Figure 4-8 SPECT study result with 2.1mm slices thickness

## Simultaneous CT and Functional Brain SPECT Imaging

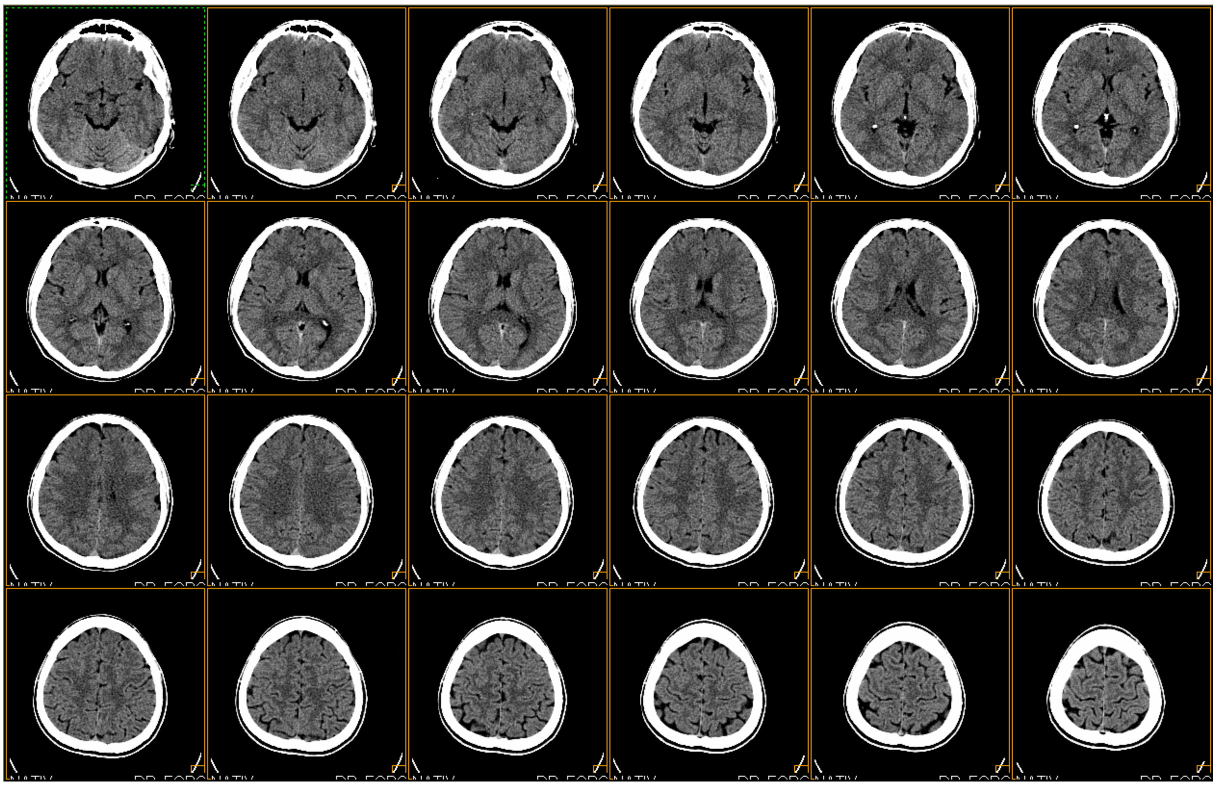


Figure 4-9 CT Transversal slices with 3mm slices thickness

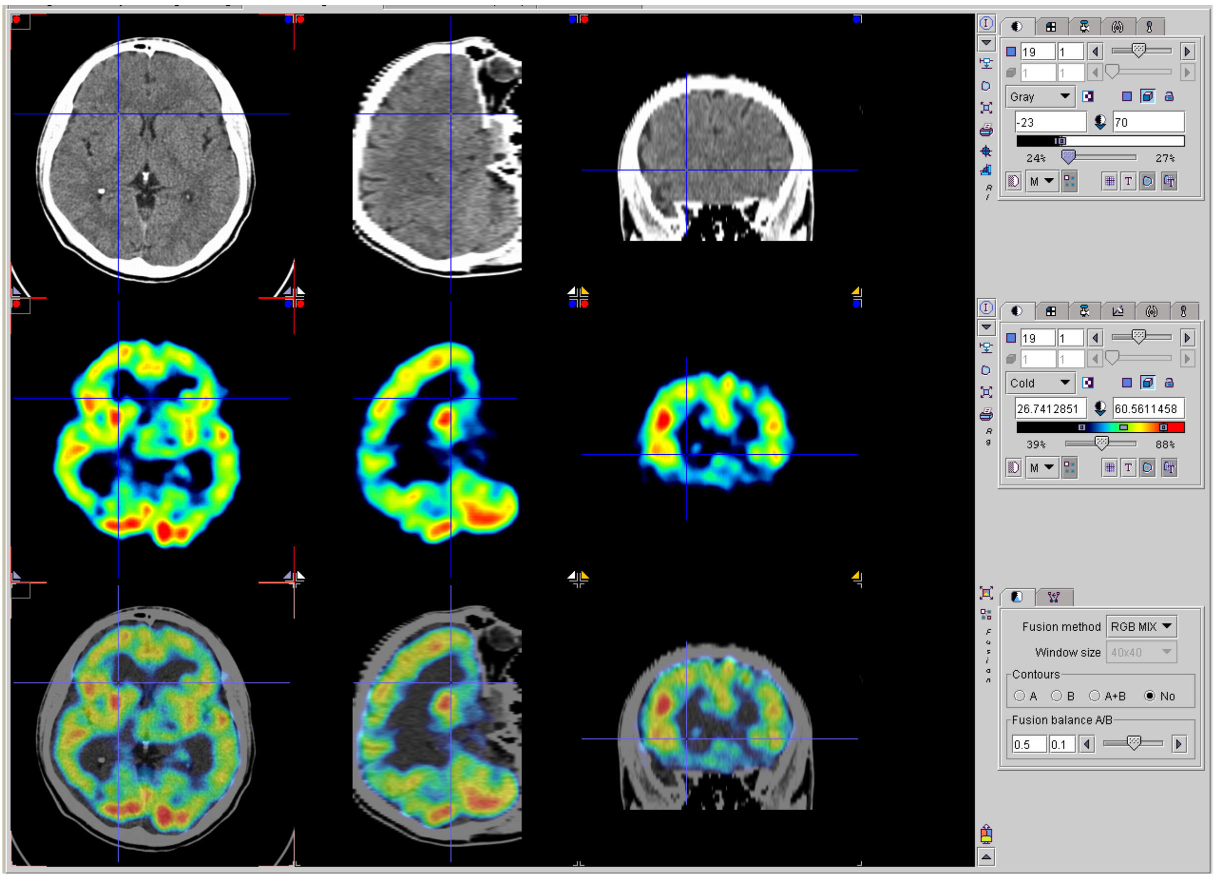



Figure 4-10 CT and SPECT (2.1mm slice thickness) image fusion by PMOD

# 5. Oncology

# Bone imaging

## Whole body (bone) imaging

### Clinical application

Bone scintigraphy with the radiopharmaceutical of $^{99m}$Tc-MDP is a very sensitive and one of the most widely used methods to detect bone lesion due to any kind of bone pathology. Whole body bone imaging is extremely helpful to search bone metastases, benign, malignant bone lesion, musculo-skeletal trauma, osteomyelitis.

### Acquisition protocol

**2 Directions Whole Body Study**

Directions: anterior-posterior
Matrix Size: 512x1024
Continuously scanning with 18 cm/min. speed
Collimator: LEHR
Applied activity: 700 ÷ 1200 MBq $^{99m}$Tc-MDP
Patient position: supine

### Image processing

**Whole Body Study**

Double intensity displaying with identifications and optimal contrast as well as colour scale adjustment. Occasionally special quantitative and qualitative analysis of whole body segments.

### Case study

A 60-year-old female patient with a history of breast cancer (11 years ago). Multiple increased activities throughout the axial skeleton. Multiple osseous metastases.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Whole body (bone) imaging

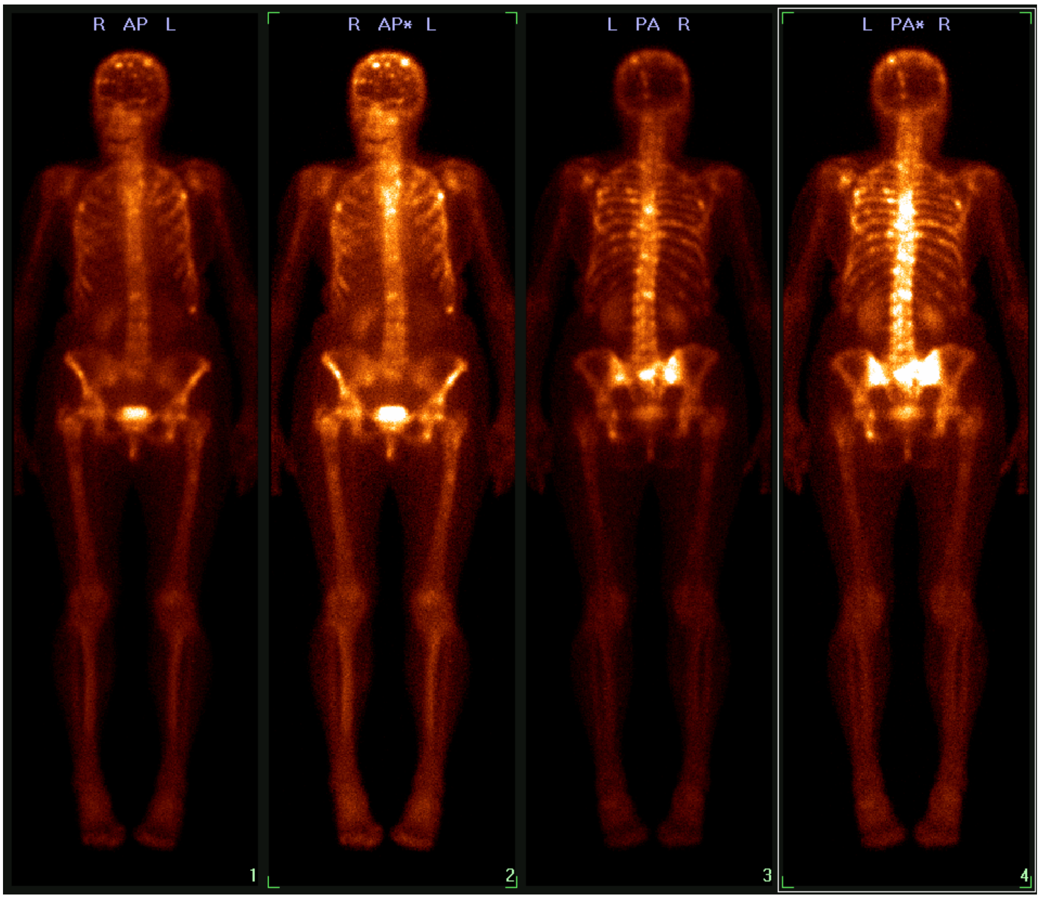



Figure 5-1 Whole body images are displayed by thermal colour scale

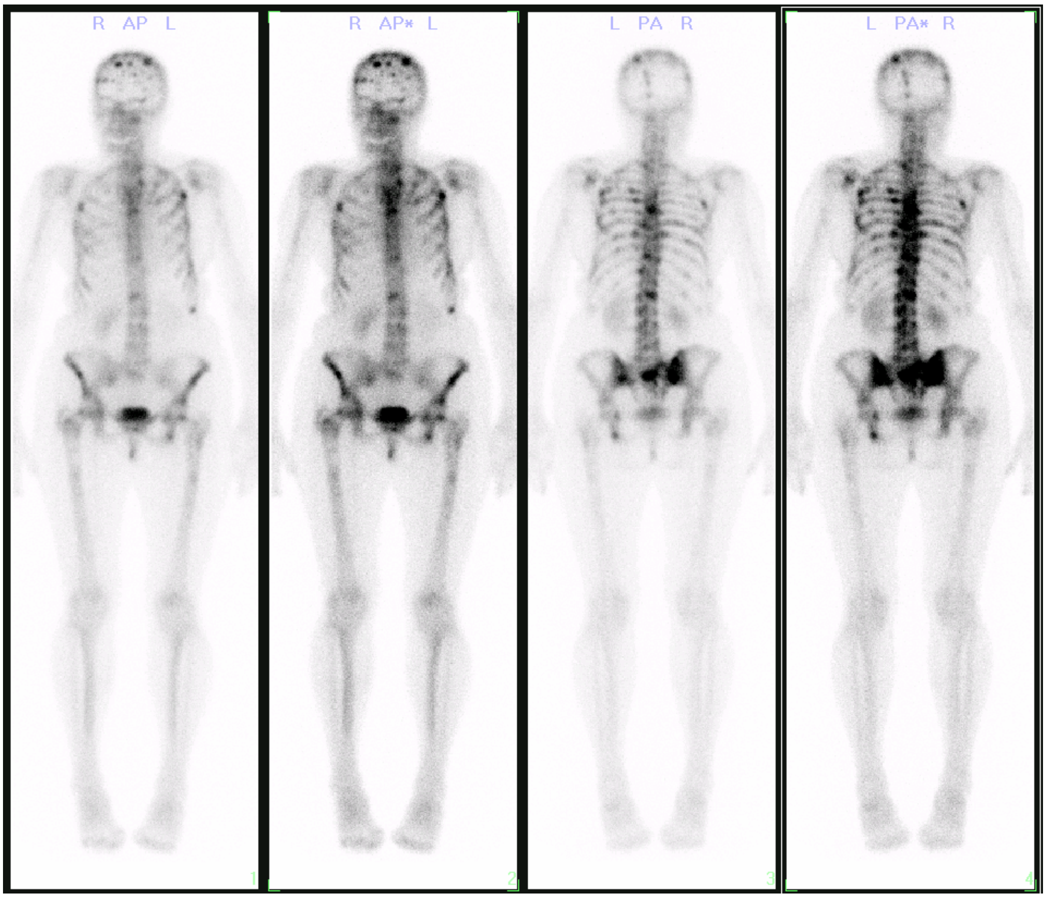



Figure 5-2 Whole body images are displayed by invert grey colour scale

# Whole body (bone) imaging: Follow-up studies

## Clinical application

Follow-up study for controlling the applied therapy.

## Acquisition protocol

**2 Directions Whole Body Study**

Directions: anterior-posterior
Matrix Size: 512x1024
Continuously scanning with 15 cm/min. speed
Collimator: LEHR
Applied activity: 700 ÷ 1200 MBq $^{99m}$Tc-MDP
Patient position: supine

## Image processing

**Whole Body Study**

Double intensity displaying with identifications and optimal contrast as well as colour scale adjustment. Occasionally special quantitative and qualitative analysis of whole body segments – cut zoom of the interested segments.

## Case study I

A 40-year-old female patient with breast cancer after surgery a staging whole body scintigraphy were performed. Inconclusive focal uptake in the right frontal region of skull.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Whole body (bone) imaging: Follow-up study I.


Figure 5-3 Whole body images are displayed by invert grey colour scale


Figure 5-4 Whole body images with cut and enlarged spots

## Case study II

An 11-year-old male patient with a history of osteosarcoma in left fibula. Follow up whole body bone scintigraphy after multiple chemotherapies and fibular resection. No sign recurrance or bone metastases.

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*


Figure 5-5 Whole body images are displayed by thermal colour scale

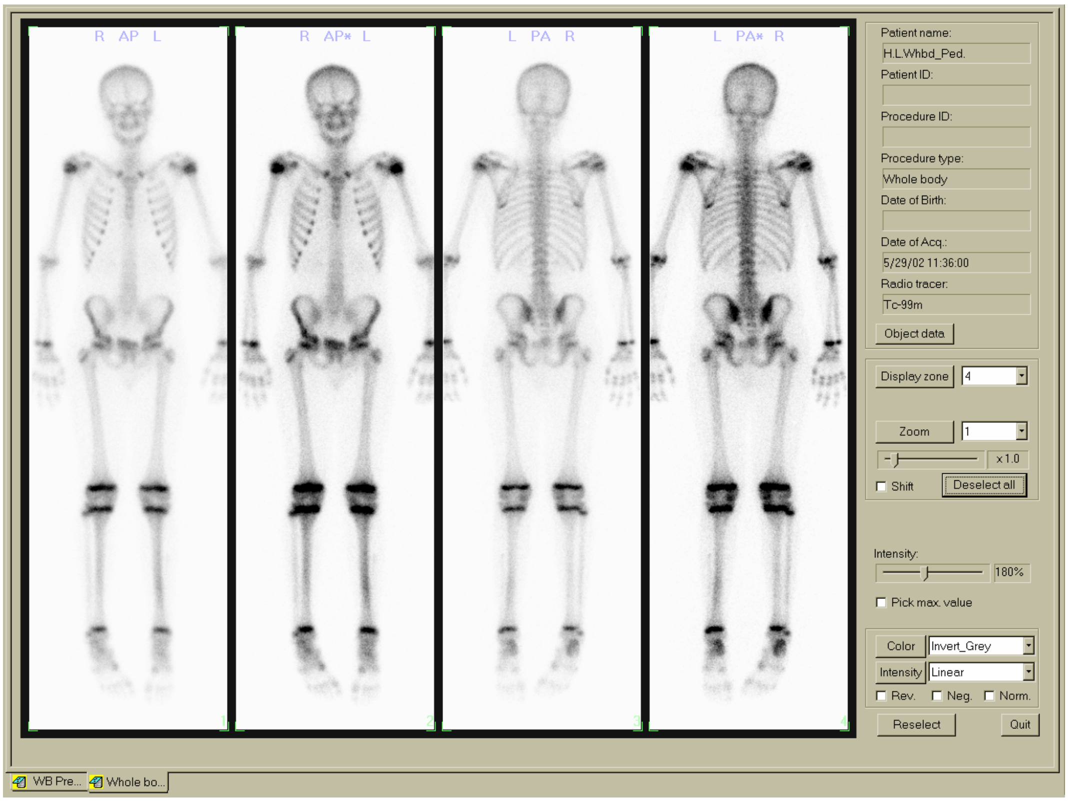



Figure 5-6 Whole body images are displayed by invert grey colour scale

# Whole body and bone SPECT imaging

## Clinical application

High resolution subsequent bone SPECT images may be necessary for optimal detectability and three dimensional localization after the whole body scan. SPECT imaging may detect more lesions than planar imaging. It is also very useful for disease localization in the case of complex anatomic structures (e.g. spine, skull).

## Acquisition protocols

### 2 Directions Whole Body Study

Directions: anterior-posterior
Matrix Size: 512x1024
Continuously scanning with 18 cm/min. speed
Collimator: LEHR
Applied activity: 700 ÷ 1200 MBq $^{99m}$Tc-MDP
Patient position: supine

### SPECT Study

Step and shoot mode
Matrix size: 128x128
Number of steps: 64 (360° rotation)
Exposition: 50 sec
Patient position: supine
Direction of rotation: CCW; Start angle: 0°

## Image processing

### Whole Body Study

Double intensity displaying with identifications and optimal contrast as well as colour scale adjustment. Occasionally special quantitative and qualitative analysis of whole body segments.

### SPECT

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% Background subtraction after the reconstruction
- Reorientation of the transaxial slices (Ref.: spine)
- Generation of coronal and sagittal slices

## Case study

A 58-year-old male patient underwent right sided nephrectomy because of renal cell cancer two years ago. Focal increased activity projecting on 11th thoracal vertebra on whole body bone scintigraphy.
SPECT imaging of the spine localized the lesion beyond the antero-lateral vertebral body surface, representing osteophyte. No metastasis disease.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Whole body and bone SPECT imaging

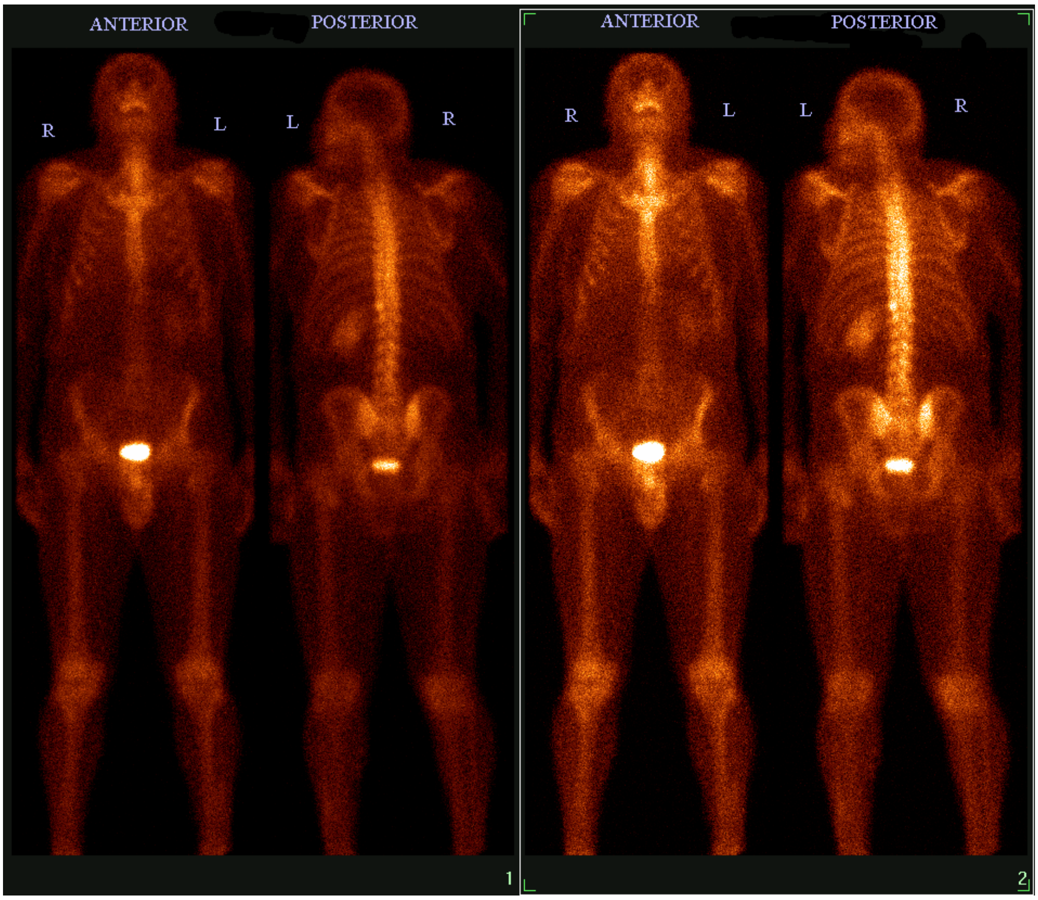



Figure 5-7 Whole body images

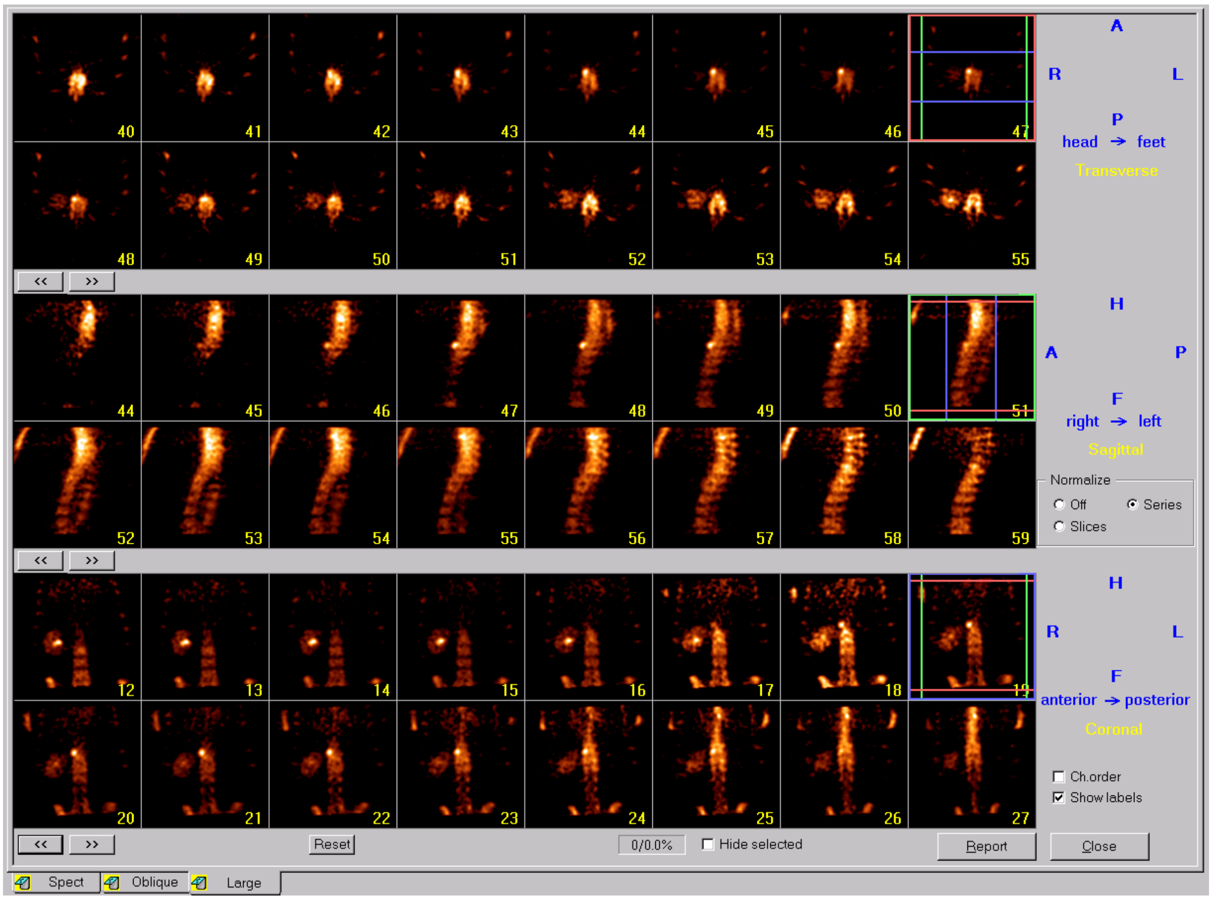



Figure 5-8 Bone SPECT slices

# Whole body and bone SPECT imaging extended by static studies

## Clinical application

In selected cases further high resolution static images have to be made from special orientations (spots), based on the result of a whole body scan to help in the spatial localization of the lesions. The optimum view angle, distance, zoom and number of counts should be predefined in order to get as high a quality image as possible from particular orientations.

## Acquisition protocols

Patient position: supine

### 2 Directions Whole Body Study

Directions: anterior-posterior
Matrix Size: 512x1024
Continuously scanning with 18 cm/min. speed
Collimator: LEHR
Applied activity: 700 ÷ 1200 MBq $^{99m}$Tc-MDP

### SPECT Study

Step and shoot mode
Matrix size: 128x128
Number of steps: 64 (360° rotation)
Exposition: 50 sec
Patient position: supine
Direction of rotation: CCW; Start angle: 0°

### Multi-Directions Static Studies (SPOTS)

Directions: Predefined orientation
Matrix Size: 256x256
750÷1000 kcounts from each direction
Collimator: LEHR
Patient position: supine

## Image processing

### Whole Body Study and Static Images

Presentation of the whole body images together with the static studies and identifications by a predefined special display arrangement. Optimal contrast and colour scale adjustment. Occasionally, special quantitative and qualitative analysis of whole body segments and static images.

### SPECT

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% Background subtraction after the reconstruction
- Reorientation of the transaxial slices (Ref.: spine)
- Generation of coronal and sagittal slices

## Case study

A 87-year-old female patient with a history of breast cancer. Multiple increased activities throughout the axial skeleton. Multiple osseous metastases.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

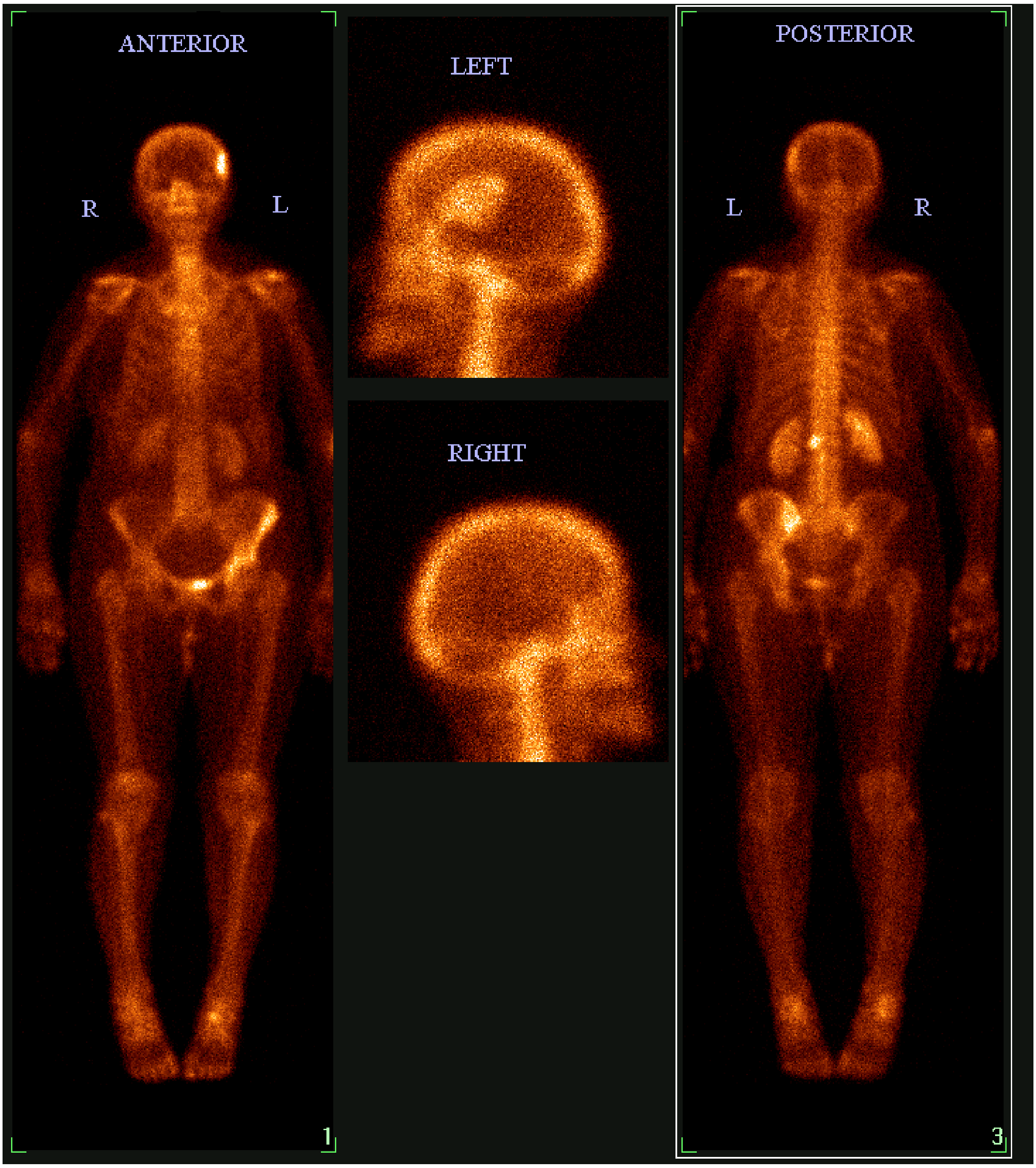



Figure 5-9 Whole body study

# Whole body and bone SPECT imaging extended by static studies

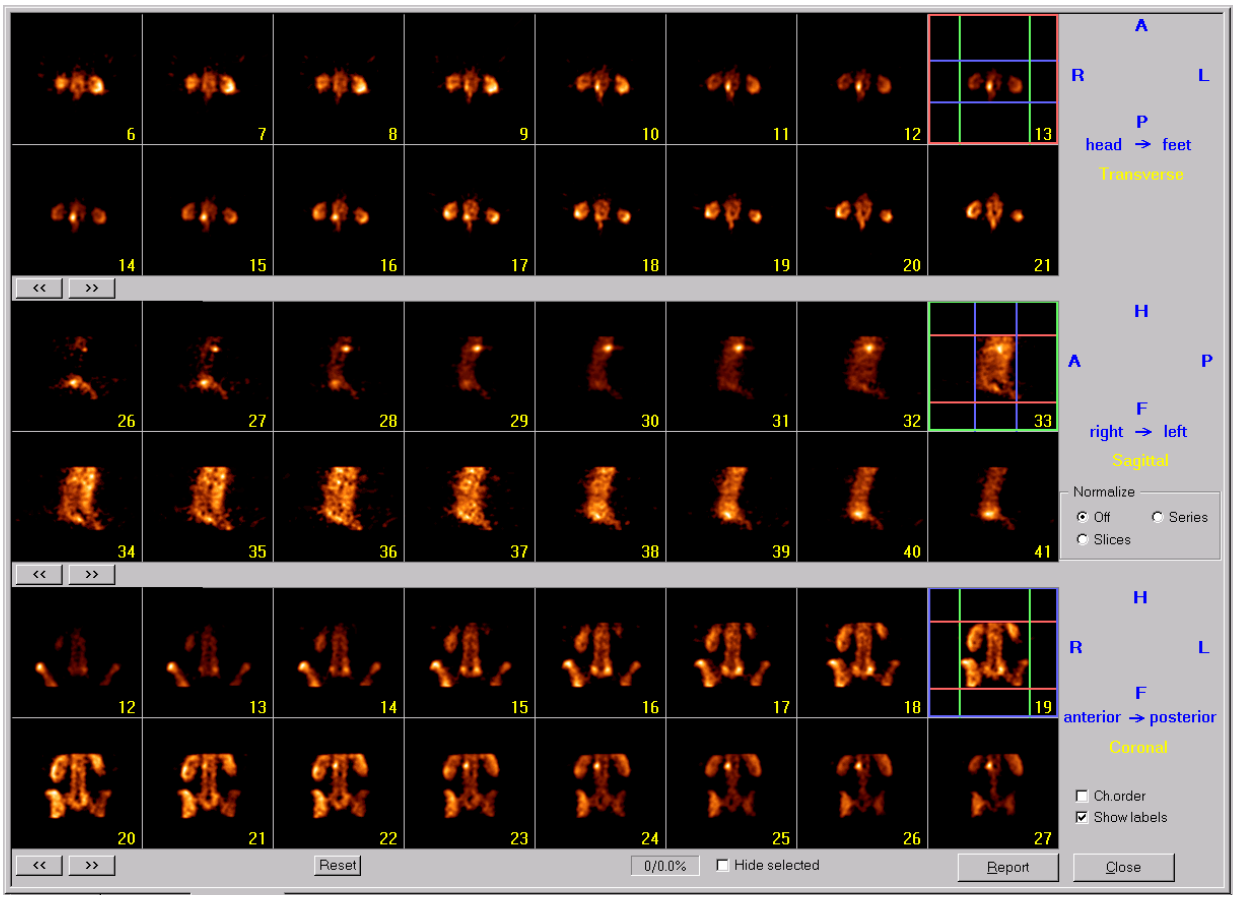



Figure 5-10 SPECT slices

# Whole body imaging extended by three-phase bone scan

## Clinical application

Under certain circumstances, a three-phase bone scan will provide valuable additional information regarding the vascularity of a lesion. This involves the dynamic flow study of the interest area with rapid sequential images taking 2 seconds for 30 frames. This is followed by a blood pool image at 5 minutes. Delayed static and whole body images are obtained in 2 hours.

## Acquisition protocols

**2 Directions Dynamic Flow Phase**

Directions: anterior-posterior
Matrix Size: 64x64
Applied activity: 700 ÷ 1200 MBq $^{99m}$Tc-MDP
Number of frames: 30
Exposition time: 2 seconds
Collimator: LEHR
Patient position: supine

**2 Directions Static Studies – SPOTS - (at 5minutes and 2hours)**

Directions: anterior-posterior
Matrix Size: 256x256
750kcounts from each direction
Collimator: LEHR
Patient position: supine

**2 Directions Whole Body STUDY (at 2hours)**

Directions: anterior-posterior
Matrix Size: 512x1024
Continuous scan with 18 cm/sec. speed
Collimator: LEHR
Patient position: supine

## Image processing

**Dynamic and Static Images**

Presentation of the sum of the dynamic images together with the static studies and identifications by a predefined special display arrangement. Optimal contrast and colour scale adjustment.

**Whole Body**

Anterior and Posterior directions are displayed with double intensity with identifications and optimal contrast as well as colour adjustment. Occasionally with special quantitative and qualitative analysis of whole body segments.

## Case study

An 18-year-old boy continuously complained about sever pain in his left knee. There is a massively increased blood-flow to the metaphyseal region of the left fibula and associated soft tissue. Delayed images show intense metabolic activity, an increased tracer uptake is seen in the metaphysis of the left fibula and associated soft tissue. There is no evidence of metastatic disease elsewhere in the skeleton.

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*

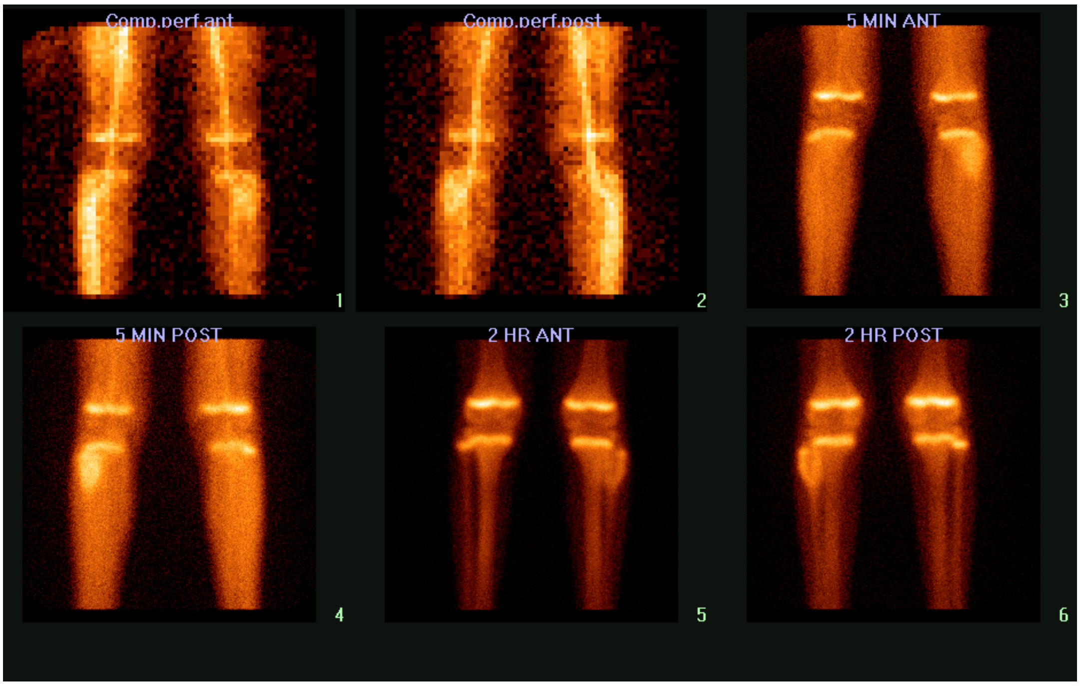



Figure 5-11 Presentation of the planar images (3 phases)

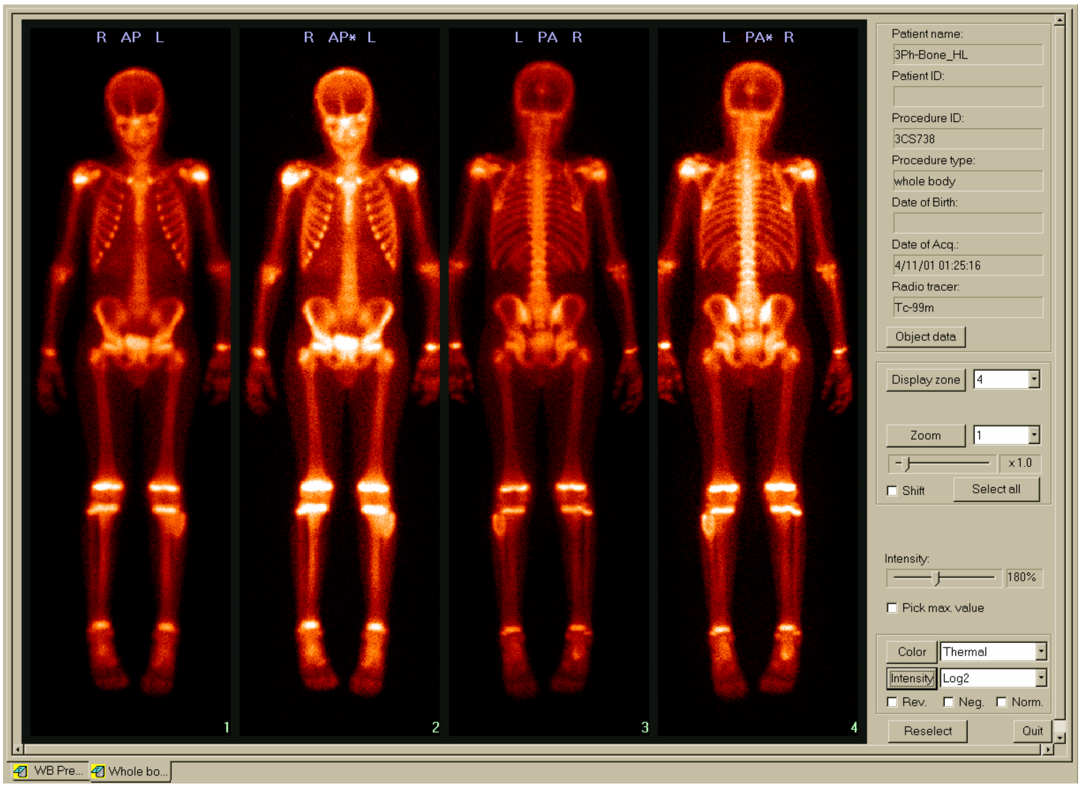



Figure 5-12 Whole body imaging (at 2h)

# Bone SPECT – skull – imaging

## Clinical application

SPECT imaging of the skull can help to detect lesion of calvaria. Osteomas are benign tumors that are usually found in the calvaria, paranasal sinuses and mandible. They are usually asymptomatic and do not undergo malignant degeneration.

## Acquisition protocol

### SPECT Study

Step and shoot mode
Matrix size: 128x128
Number of steps: 64 (360° rotation)
Exposition: 50 sec
Patient position: supine
Collimator: LEHR
Patient position: supine
Direction of rotation: CCW
Start angle: 0°

## Image processing

### SPECT

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% Background subtraction after the reconstruction
- Reorientation of the transaxial slices (Ref.: OM line)
- Generation of coronal and sagittal slices

## Case study

An 18-year-old girl continuously complained of sever pain in the left frontal region of skull and has one year history of headache. CT scan shows homogen, calcified bone density mass, filling the left frontal sinus. This morphological appearance is typical of osteoma. SPECT imaging confirmed increased tracer uptake in the left supraorbital region involving the left frontal sinus.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Bone SPECT – skull – imaging

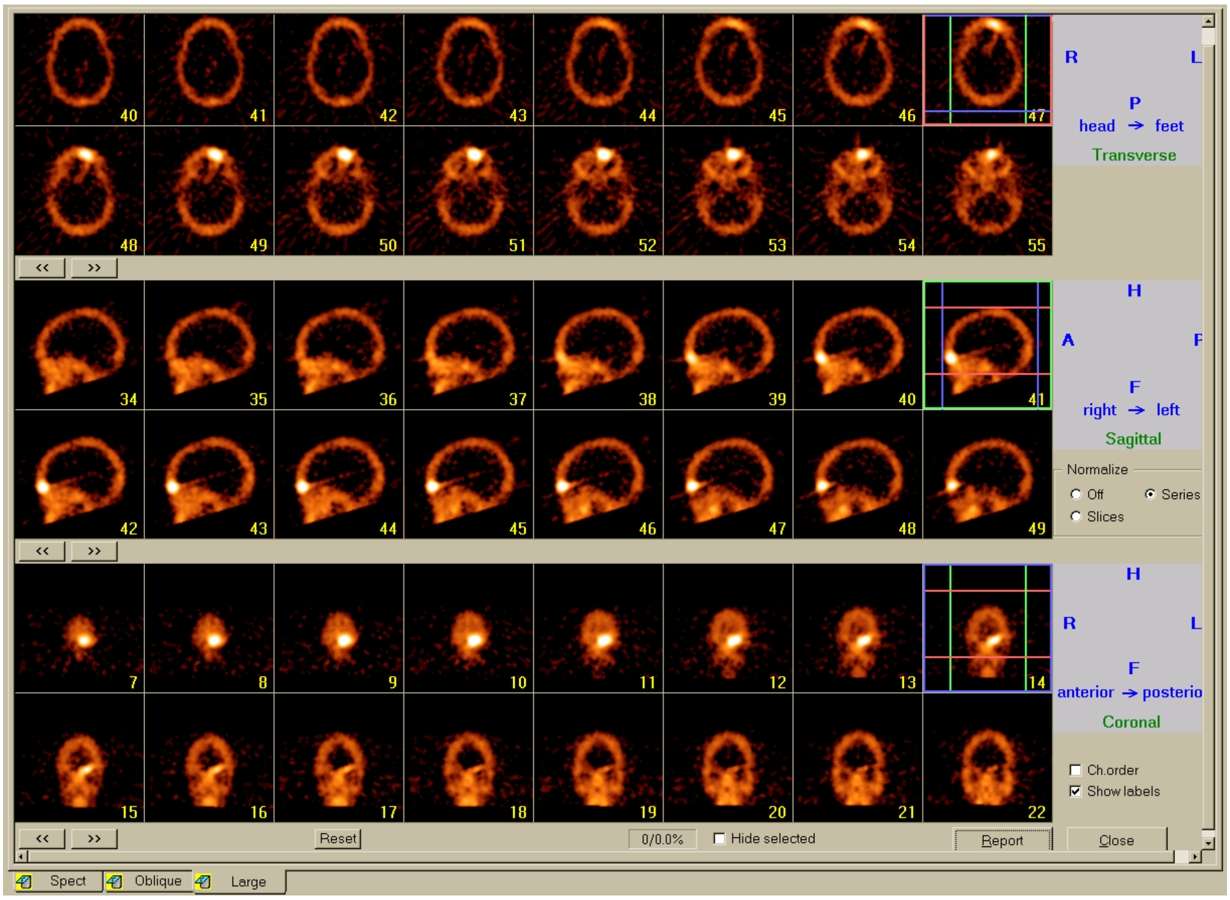



Figure 5-13 Result of the SPECT evaluation

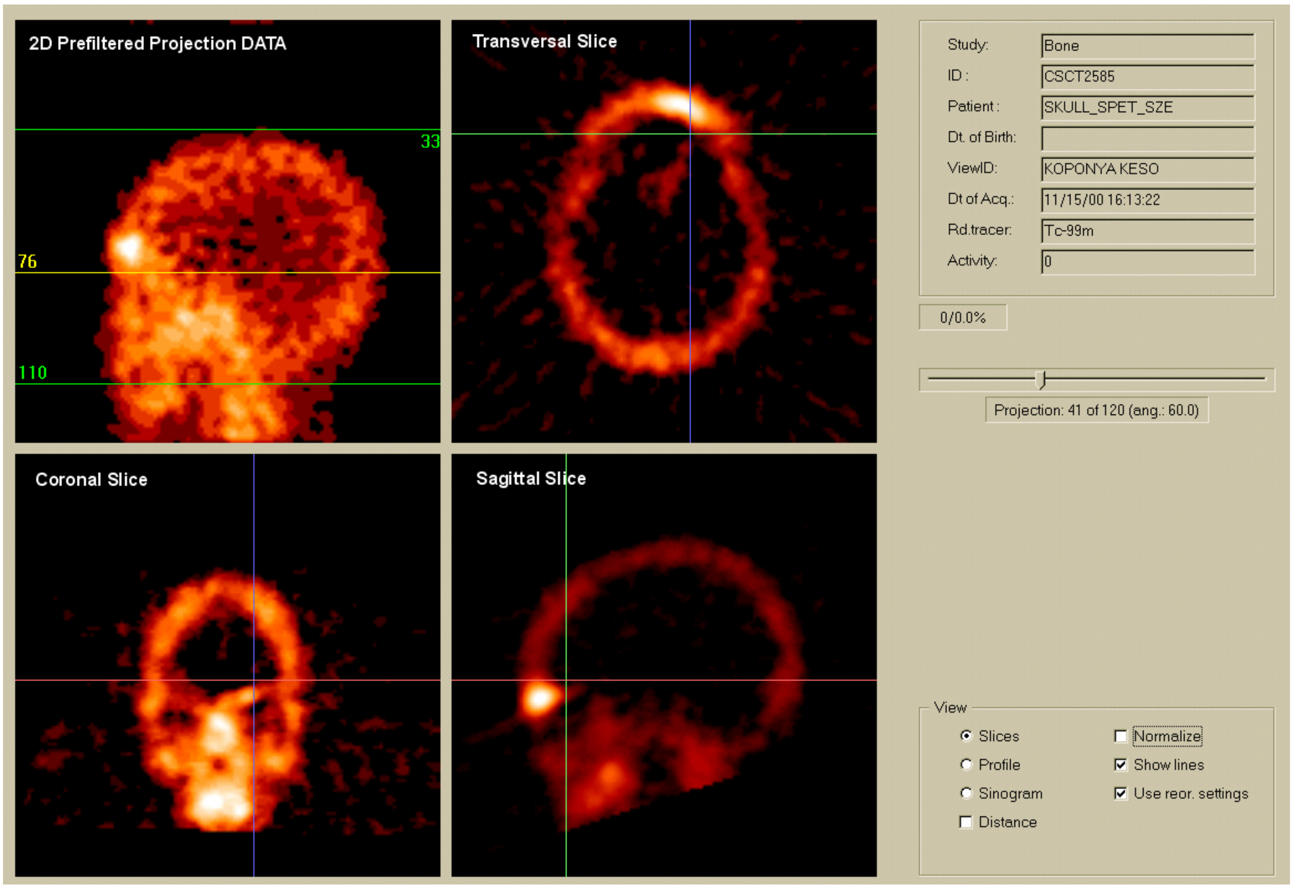



Figure 5-14 Determination of the corresponded slices

## Bone SPECT – skull – imaging:
## Semi-quantitative analysis of the selected slices

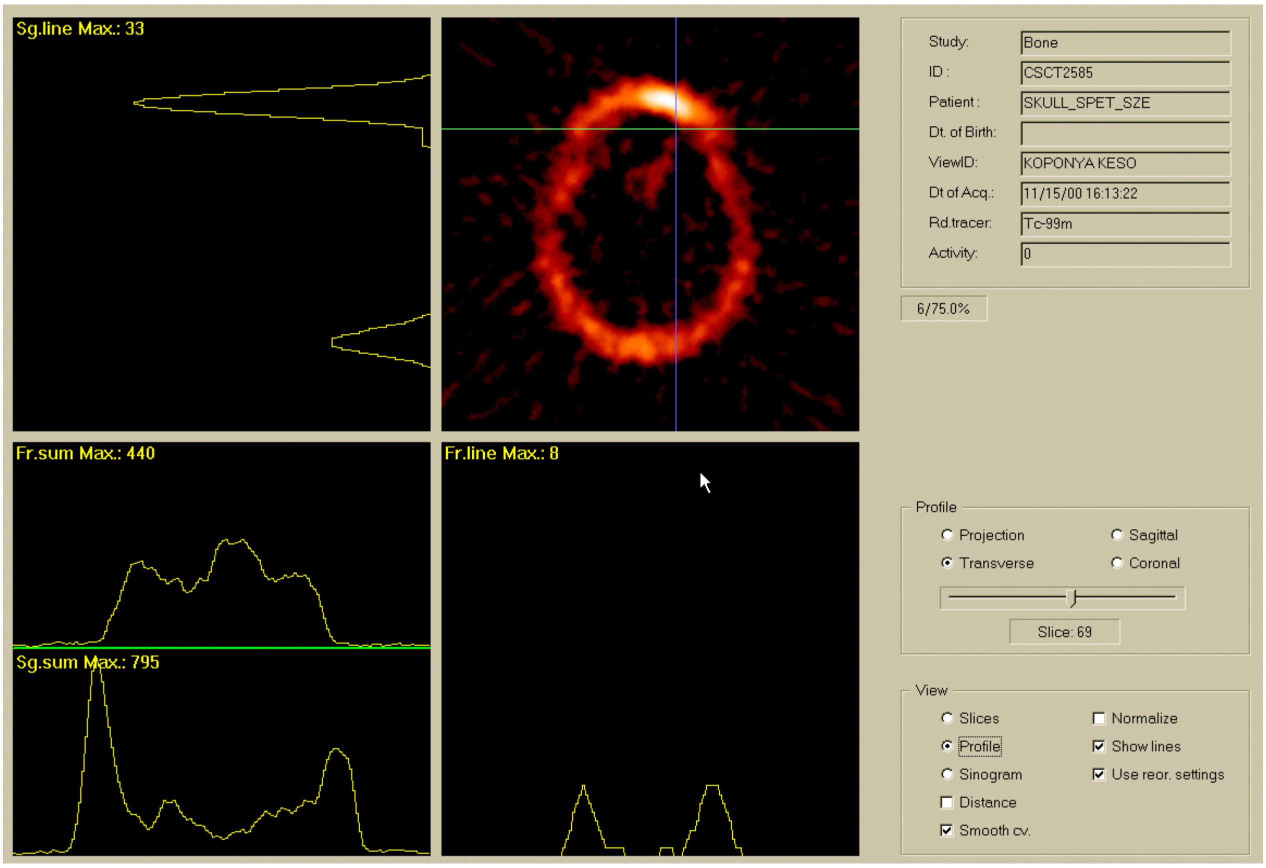



Figure 5-15 Profile curves for Transversal slice

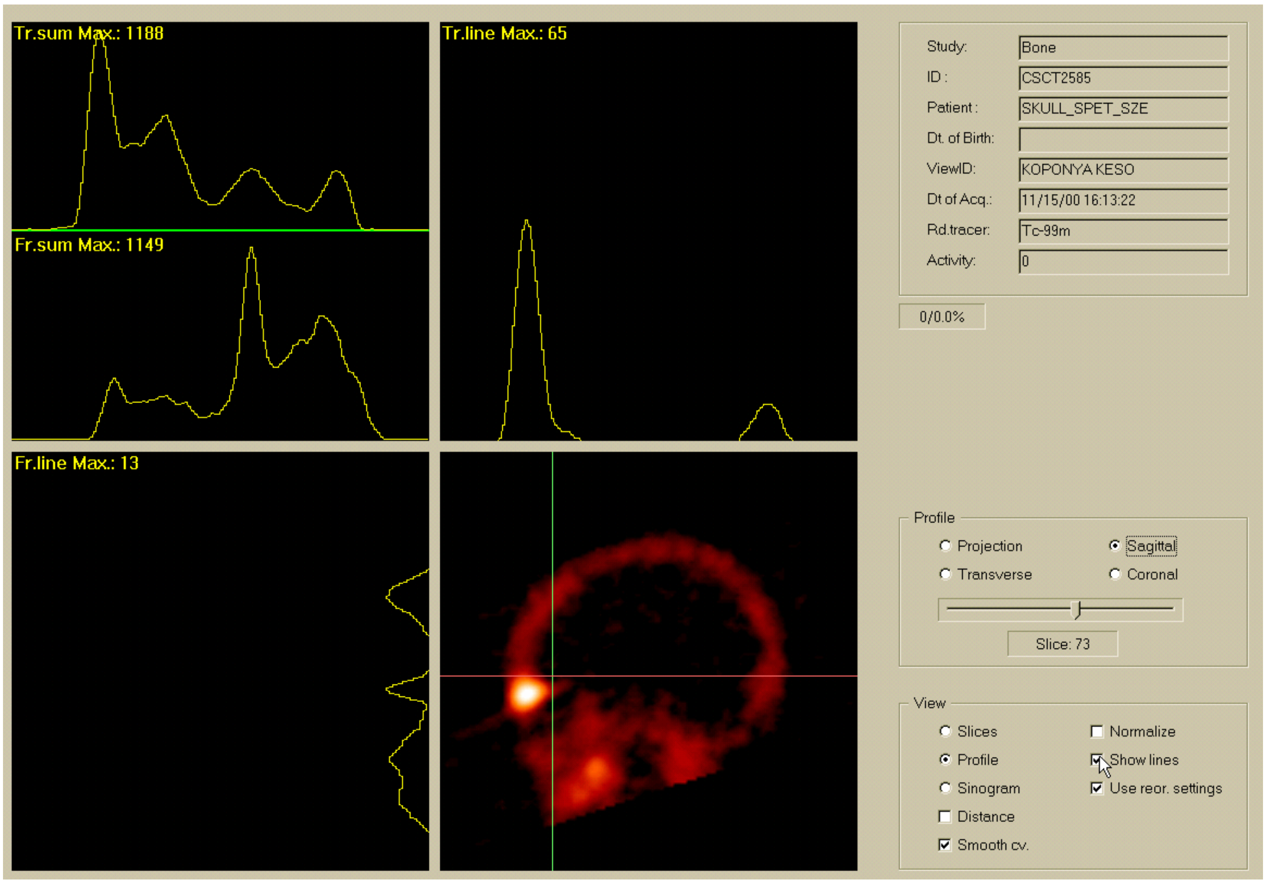



Figure 5-16 Profile curves for Sagittal slice

# Pulmonary scintigraphy

## NeoSPECT: Receptor imaging

### Clinical application

$^{99m}$Tc-depreotide (NeoSpect®) is a radiopharmaceutical that binds to Somatostatin receptors which are over-expressed in lung cancer (both small cell and non-small cell lung cancer). NeoSpect® is effective in ruling out non-invasively malignancy of the lung in patients with solitary pulmonary nodule and has a negative predictive value of up to 98% in combination with CT or chest X-ray. NeoSpect® scan is helping to spare patients - especially risk patients – from unnecessary biopsies with associated significant risk of pneumothorax, pain and subsequent hospitalization.

### Acquisition protocols

**2 Directions Whole Body Phase**

Directions: anterior-posterior; Matrix Size: 512x1024
Continuously scanning with 15 cm/min. speed
Collimator: LEHR
Applied activity: 700 MBq $^{99m}$Tc-depreotide
Patient position: supine

**SPECT Phase**

Step and shoot mode; Matrix size: 128x128
Number of steps: 120 (360° rotation)
Exposition: 30 sec
Direction of rotation: CCW; Start angle: 180°
Patient position: supine

### Image processing

**Whole Body Phase**

Double intensity displaying with identifications and optimal contrast as well as colour scale adjustment.

**SPECT**

- 2D pre-filtering on the projection data set by Butterworth filter
- Reconstruction with MOS-EM algorithm
- 5% Background subtraction after the reconstruction
- Reorientation of the transaxial slices
- Generating of coronal and sagittal slices

### Case study

A 72-year-old male smoker with a history of chronic dry cough. CT investigation revealed an indeterminate solitary pulmonary nodule in right middle lobe. NeoSpect® scan shows an increased focal uptake according to the mass. Subsequent histology of the specimen obtained from fine needle aspiration biopsy (FNAB) revealed NSCLC (squamos cell carcinoma).

## NEOSPECT® Imaging

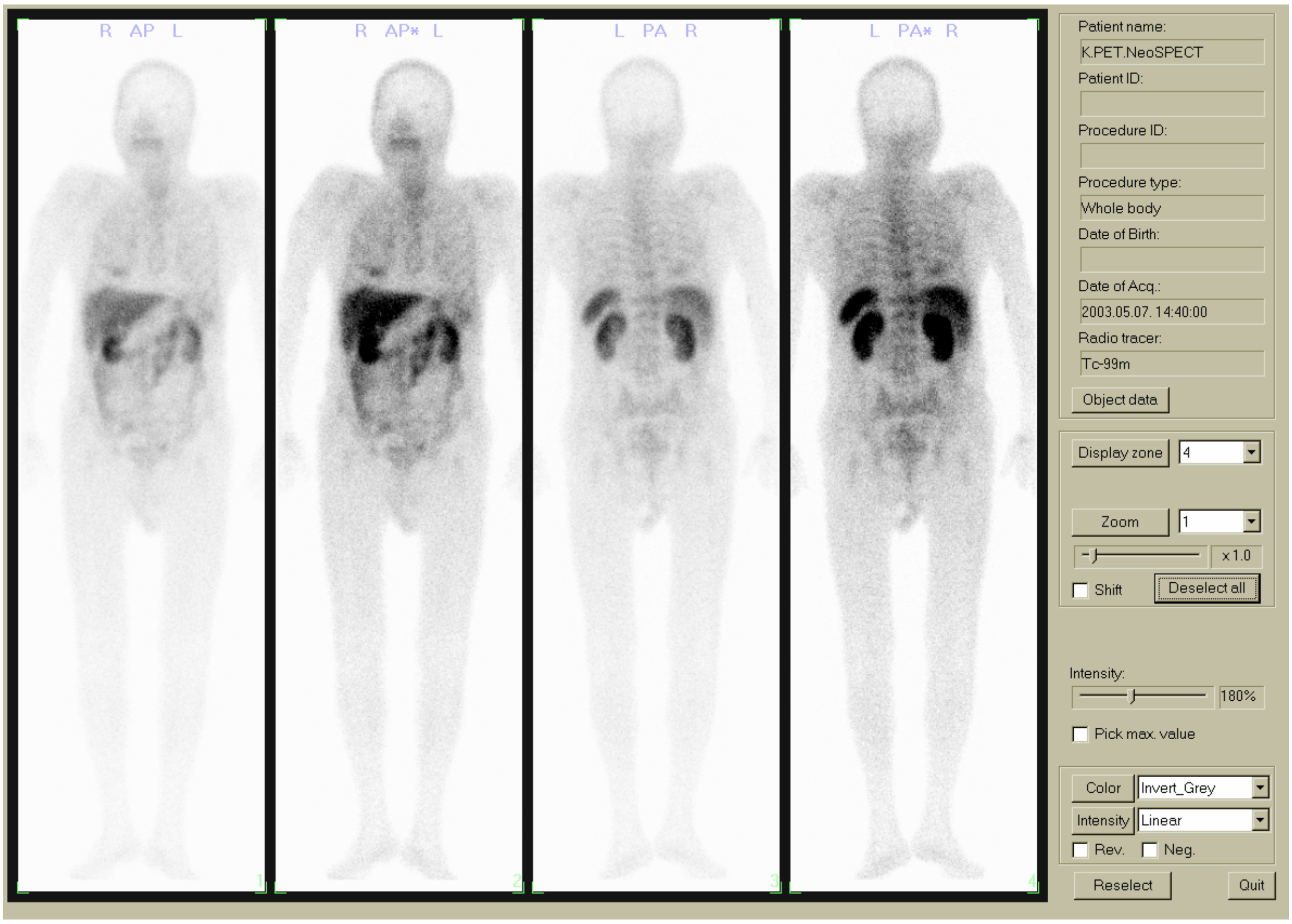



Figure 5-17 Whole body presentation

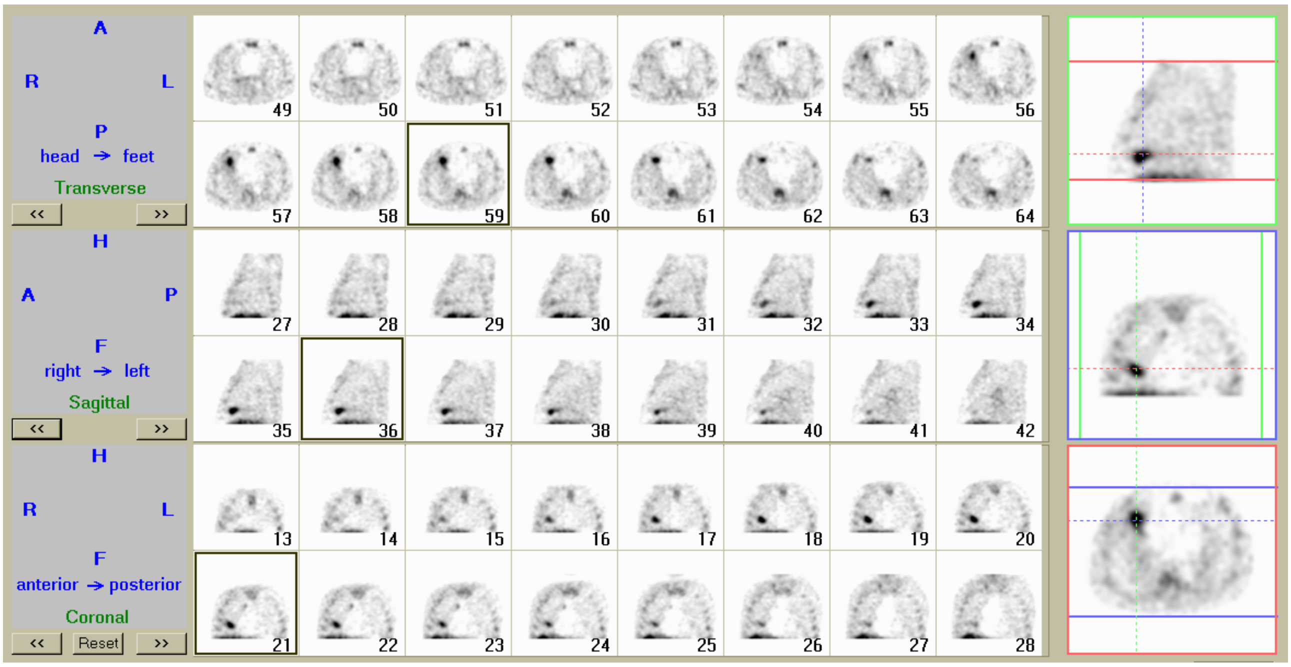



Figure 5-18 SPECT evaluation

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*

# 6. KIDNEY

# Renal study: renography and static renal scan

## Clinical application

Functional renal scintigraphy (renography) is performed to determine regional excretory function (either by glomerular filtration or by tubular secretion) of the kidneys. Based on the dynamic images and several semi-quantitative or even quantitative data the renal perfusion, the renal parenchymal activity and also the urinary flow in the entire urinary tract can be evaluated.

The investigation is very useful in several clinical settings, e.g. in acute anuria, in the case of one sided renal disease preoperatively, in hypertension, systemic diseases and in transplanted kidneys. In the case of obstructive uropathies diuretic renography can help in differentiating organic obstruction from nonobstructive dilatation of the collecting system.

## Acquisition protocol

### Dynamic First Pass Phase

Directions: posterior
Matrix Size: 128x128
Applied activity: 200 MBq $^{99m}$Tc-MAG3
Number of frames: 60
Exposition time: 1 sec
Collimator: LEHR
Patient position: supine

### Dynamic Functional Phase

Directions: Posterior
Matrix Size: 128x128
Applied activity: 200 MBq $^{99m}$Tc-MAG3
Number of frames: 90
Exposition time: 20 sec
Collimator: LEHR
Patient position: supine

## Case study

A 24-year-old female patient with a history of urolithiasis. She suffered from urinary tract infection with bacteriuria and high fever (40 grad Celsius) and also right flank pain. Ultrasonography depicted a moderate dilatation of the left renal collecting system.

**Dynamic renal scan** (with $^{99m}$Tc-MAG3) shows preserved parenchymal uptake and normal intrarenal transport of the radiopharmaceutical. The emptying of the right renal pelvis is slightly slower compared to the right side by visual evaluation but without any sign of a significant obstruction.

# Renal scan

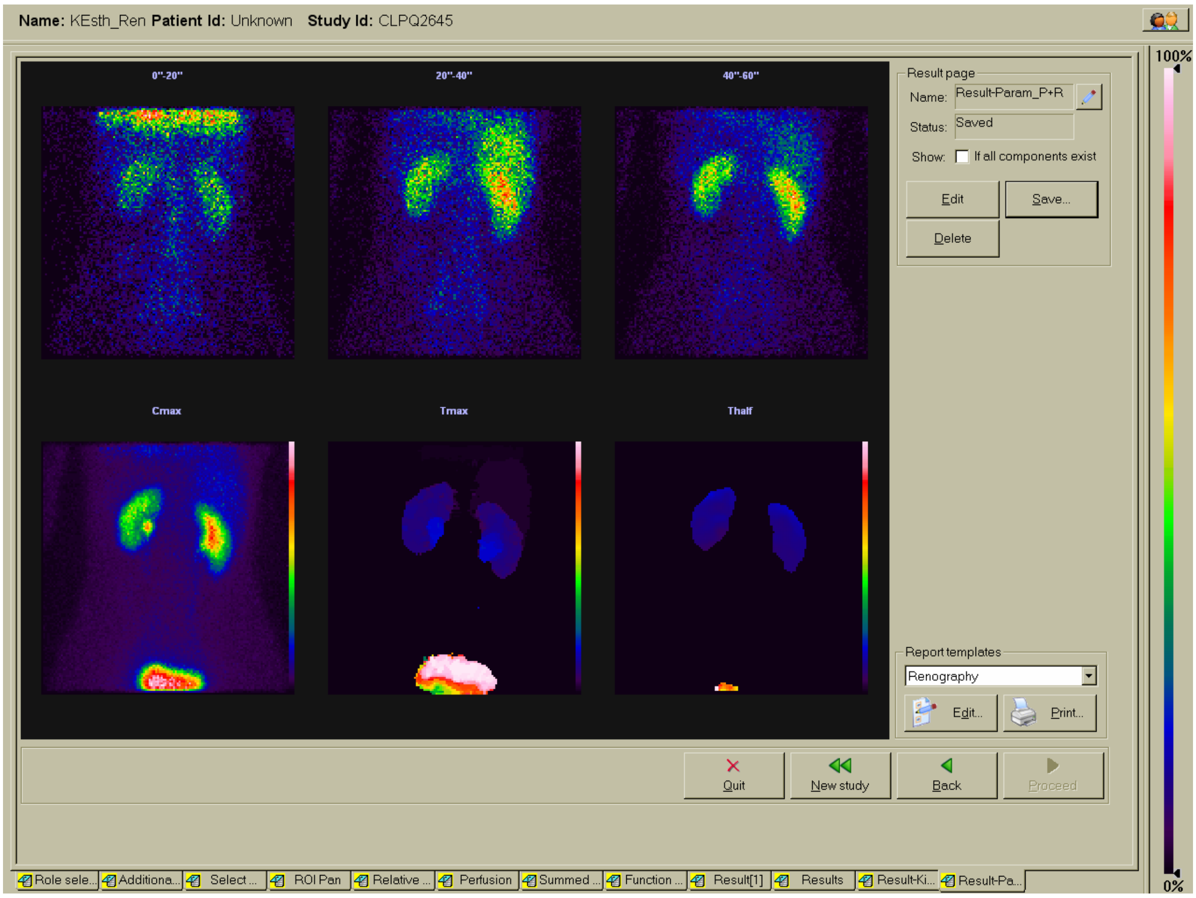



Figure 6-1 First pass images and parametric image presentation of the renography phase

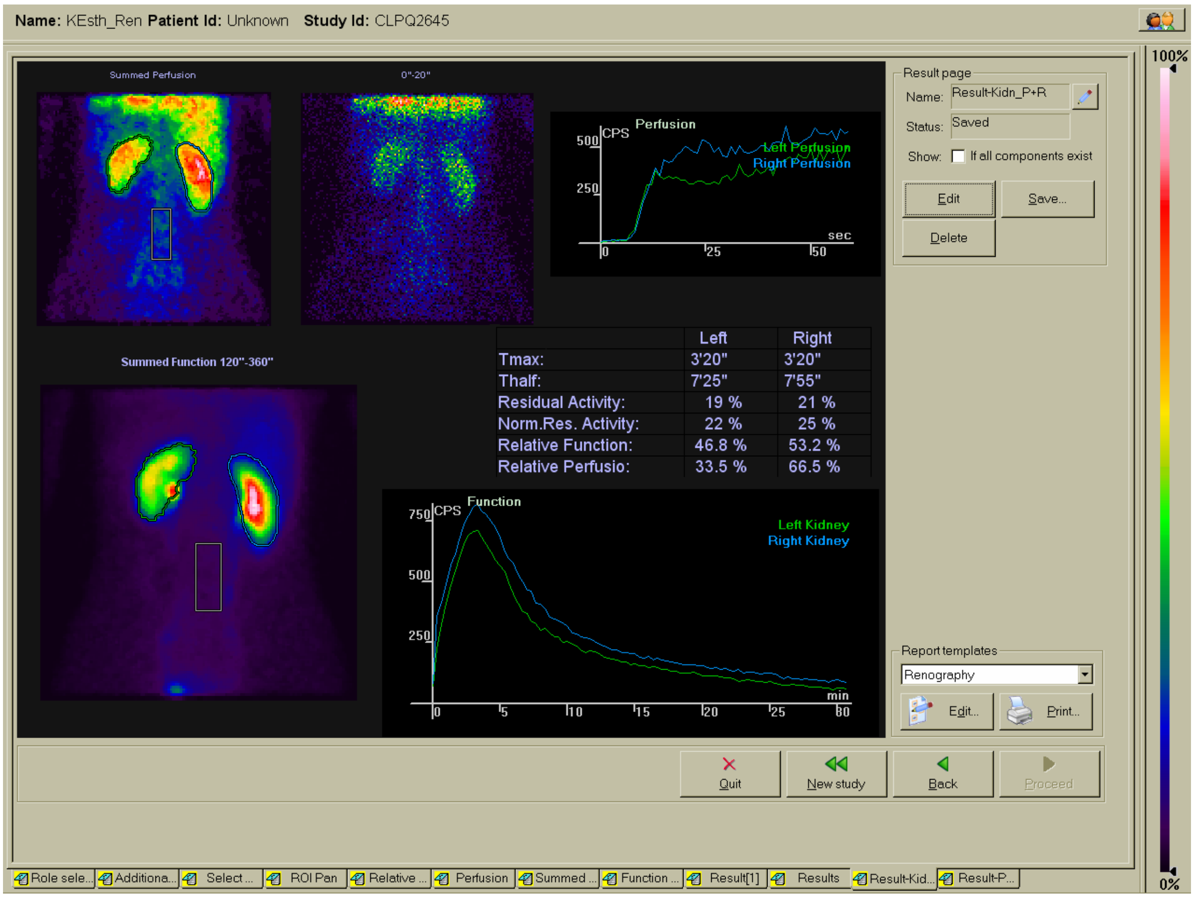



Figure 6-2 Final result page of the first pass kidney and renography evaluation procedures

**STATIC RENAL SCAN ($^{99m}$Tc-DMSA)**

## Clinical application

Static renal scintigraphy is performed by $^{99m}$Tc-DMSA which indicates the functioning renal mass. Renal parenchymal damage and focal scarring can be detected with high sensitivity as cold defects in case of pyelonephritis.

## Acquisition protocol

**Multi-Directions Static Studies**

Directions: anterior, posterior, LPO, RPO
Matrix Size: 256x256
Applied activity: 200 MBq $^{99m}$Tc-DMSA
Collimator: LEHR
Patient position: supine

## Case study

Static renal scan was made few days after the renography on the same female patient. It shows normal appearance of both kidneys and no sign of focal cortical defect ruling out an apparent acute pyelonephritis. Patient recovered following discharging a small stone and appropriate medical treatment.

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*

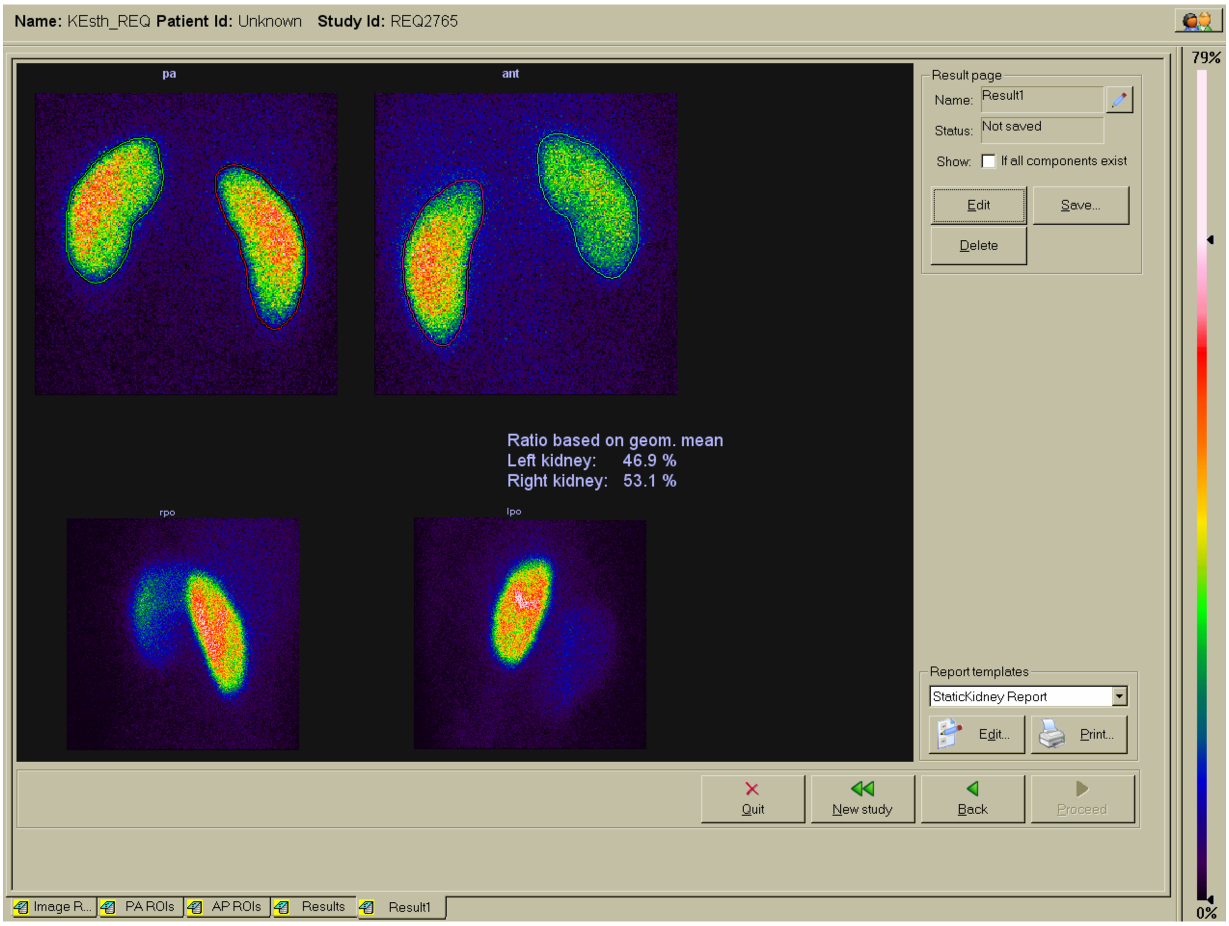



Figure 6-3 Displaying of static DMSA kidney result

# Typical renography case studies in pediatric applications

## Imaging protocol

50-100MBq $^{99m}$Tc-MAG3 radiopharmaceutical is injected when the patient is positioned for the dynamic kidney study. 15min after the $^{99m}$Tc-MAG3 administration an intraveneus Furosemid provocation is applied.

## Acquisition protocol

**Dynamic First Pass Phase**

Directions: Posterior
Matrix Size: 128x128
Number of frames: 60
Exposition time: 1 sec
Collimator: LEHR
Patient position: supine

**Dynamic Functional Phase**

Directions: Posterior
Matrix Size: 128x128
Number of frames: 90
Exposition time: 20 sec
Collimator: LEHR
Patient position: supine

## Case study: Left sided hydronephrosis

A 7-year-old girl with left sided hydronephrosis, detected by ultrasonography during an episode of abdominal pain.

**Functional renal scintigraphy**

The left kidney is enlarged and its secretory capacity seems a bit decreased. An accumulation of the radiotracer is detectable in the left renal pelvis. Following intravenous Furosemide administration in the 15. min. of the investigation only a minimal decrease of pelvic retention, suggesting an organic obstruction at the pyelo-ureteric junction. Slightly slowered, gradual emptying of the right renal pelvis.

**Follow-up investigation six months after left pyeloplasty:**

Tubular secretory capacity of the left kidney is recovering. Intense decrease of left renal pelvic activity retention after the administration of diuretic agent (at 15 min. p.i.), suggesting a residual dilatation of the left renal collecting system without obstruction. Similarly, pelvic retention on the right side with a good diuretic answer too.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Left sided hydronephrosis

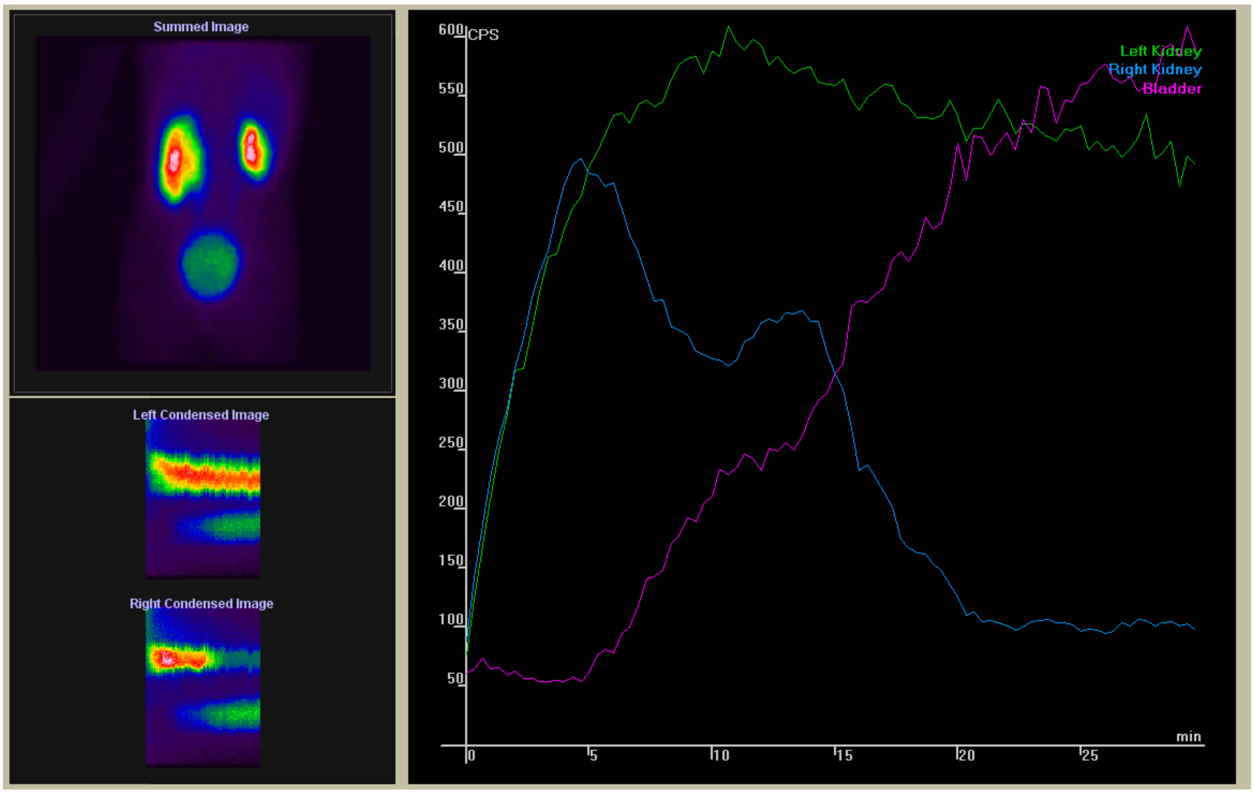
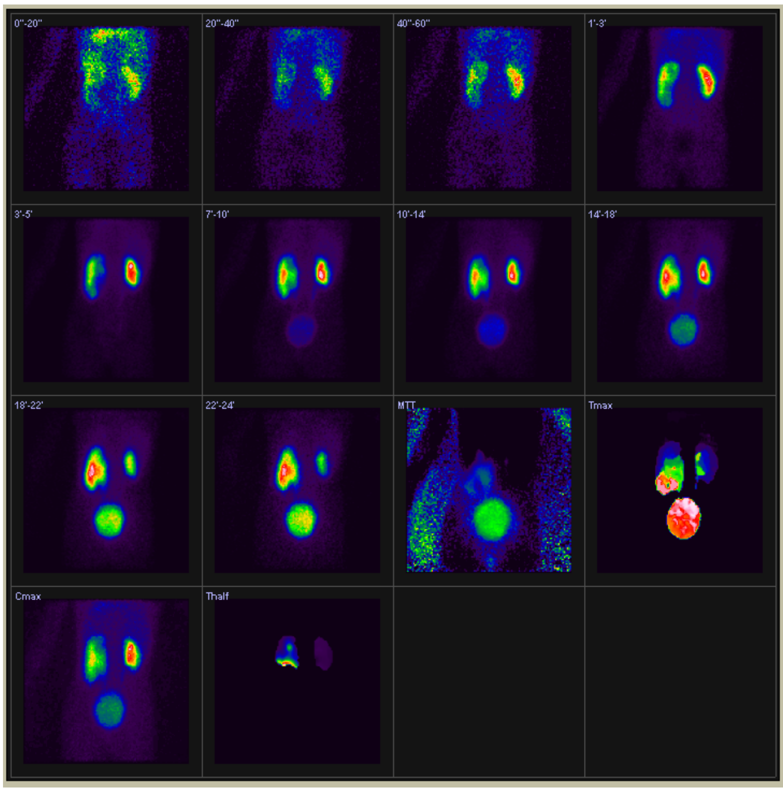



Figure 6-4 Time activity curves of kidney functions




| | Left | Right |
|---|---|---|
| T0 (sec) | 10 | 10 |
| Tmax | 10'30" | 4'30" |
| Thalf | 75'52" | 8'45" |
| Residual Activity % | 91 | 32 |
| Norm.Res.Activity % | 169 | 53 |
| Relative Function % | 48.7 | 51.3 |

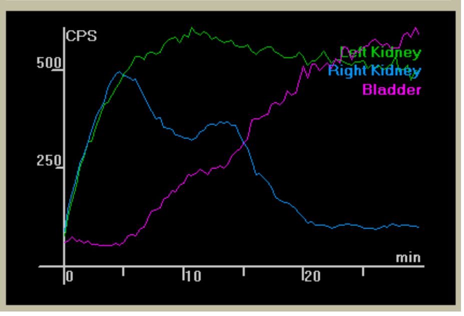



Figure 6-5 Summarized result of functional phase

## Left sided hydronephrosis: Follow-up study

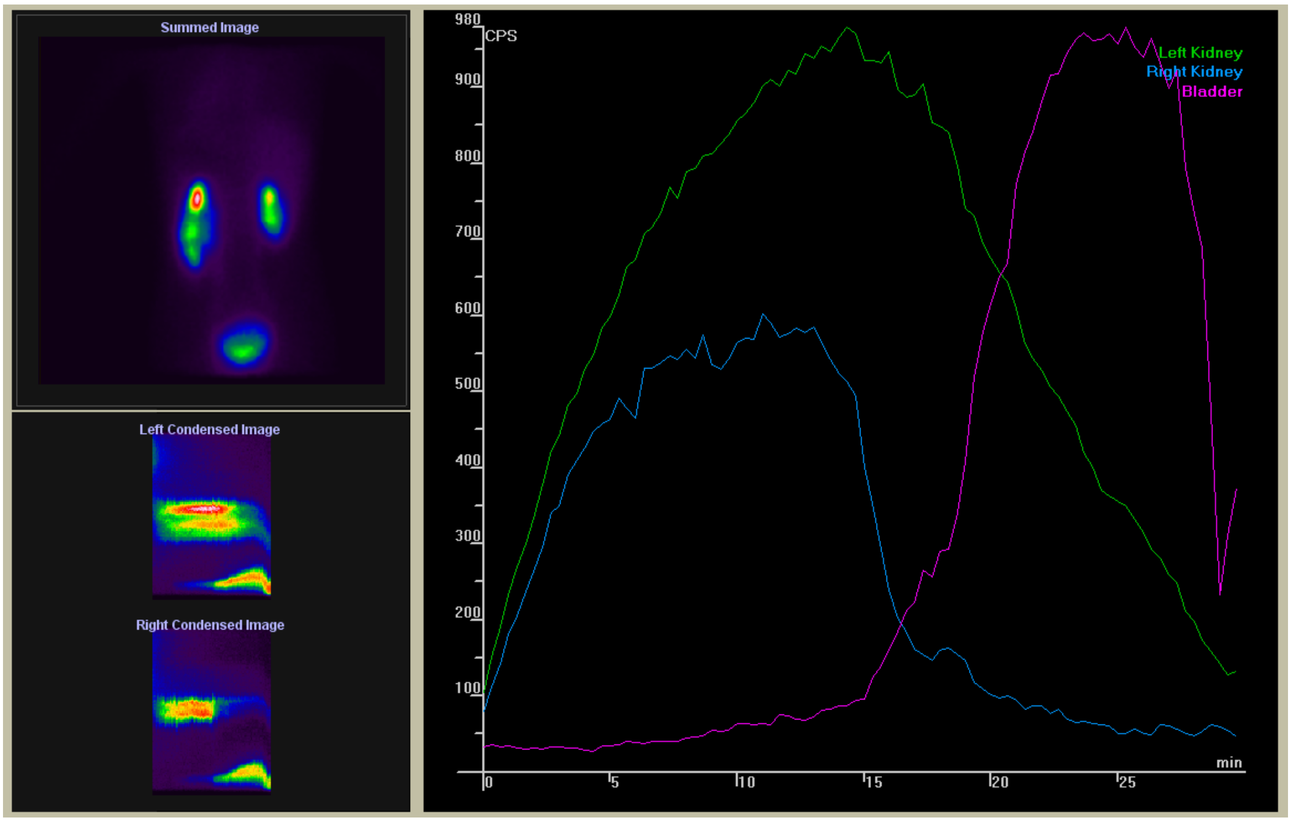
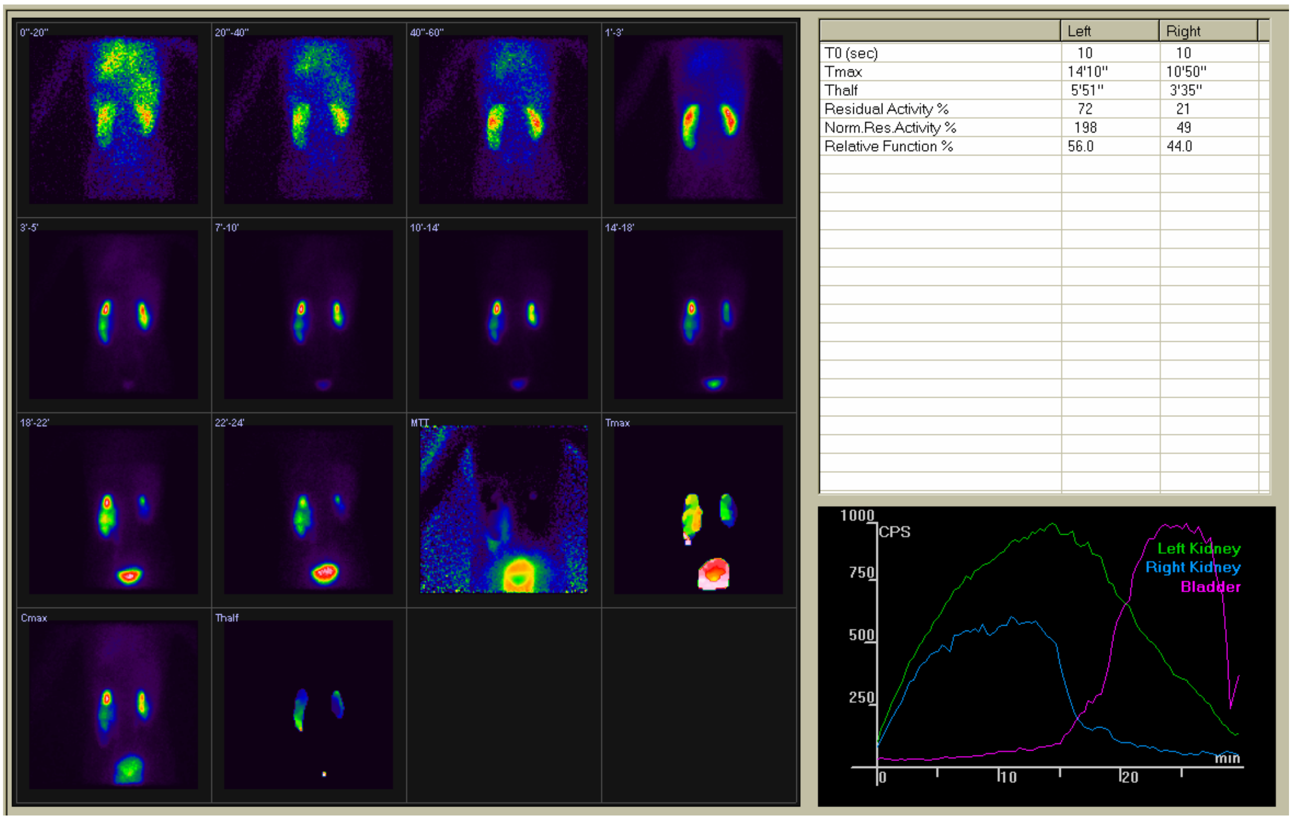



Figure 6-6 Time activity curves of kidney functions




| | Left | Right |
|---|---|---|
| T0 (sec) | 10 | 10 |
| Tmax | 14'10'' | 10'50'' |
| Thalf | 5'51'' | 3'35'' |
| Residual Activity % | 72 | 21 |
| Norm.Res.Activity % | 198 | 49 |
| Relative Function % | 56.0 | 44.0 |

Figure 6-7 Summarized result of functional phase

## Case study: Acute Pyelonephritis

A 1-year-old girl investigated following an episode of acute pyelonephritis. Minimal dilatation of the right collecting system by ultrasonography. Functional renal scan detected normal renal function and voluminous vesico-ureteric reflux on both sides during and pre-micturation.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Acute Pyelonephritis

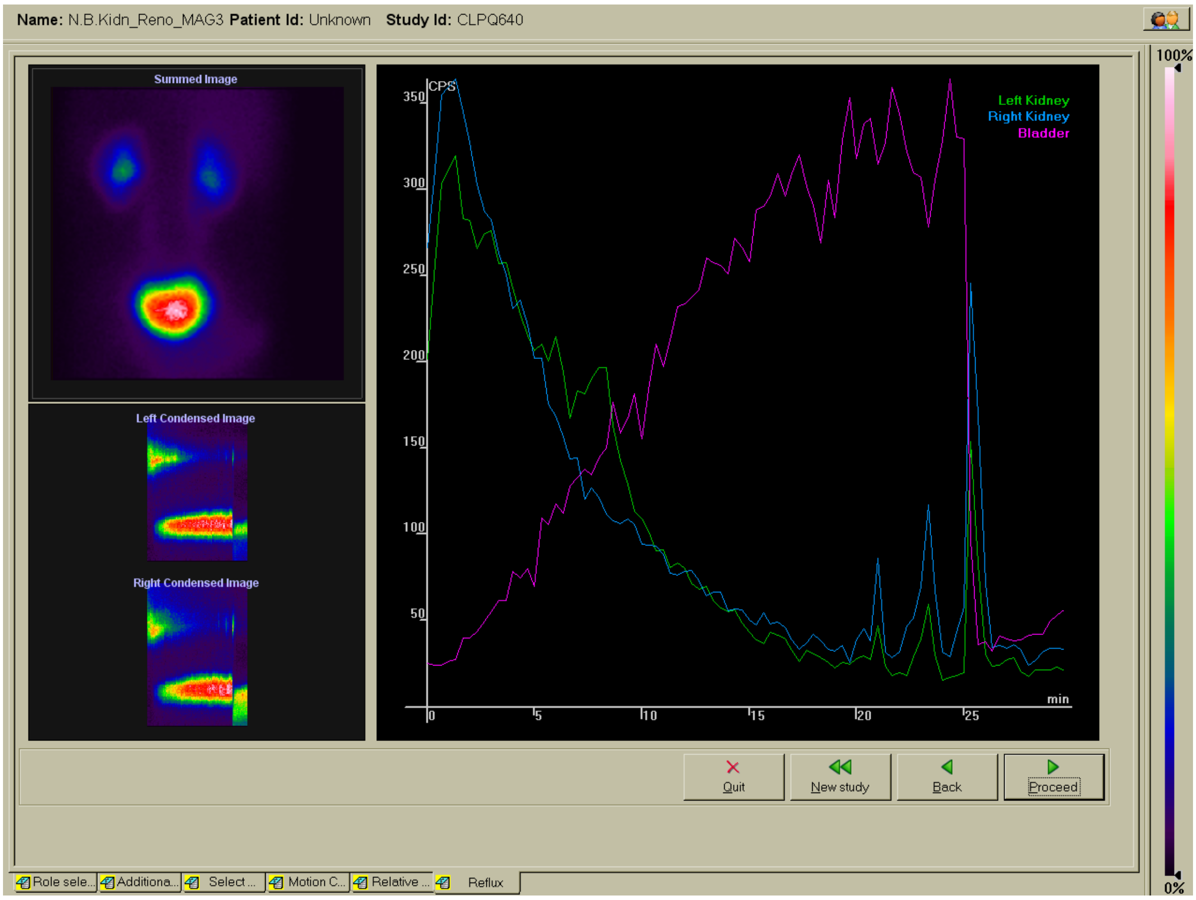



Figure 6-8 Time activity curves of kidney functions

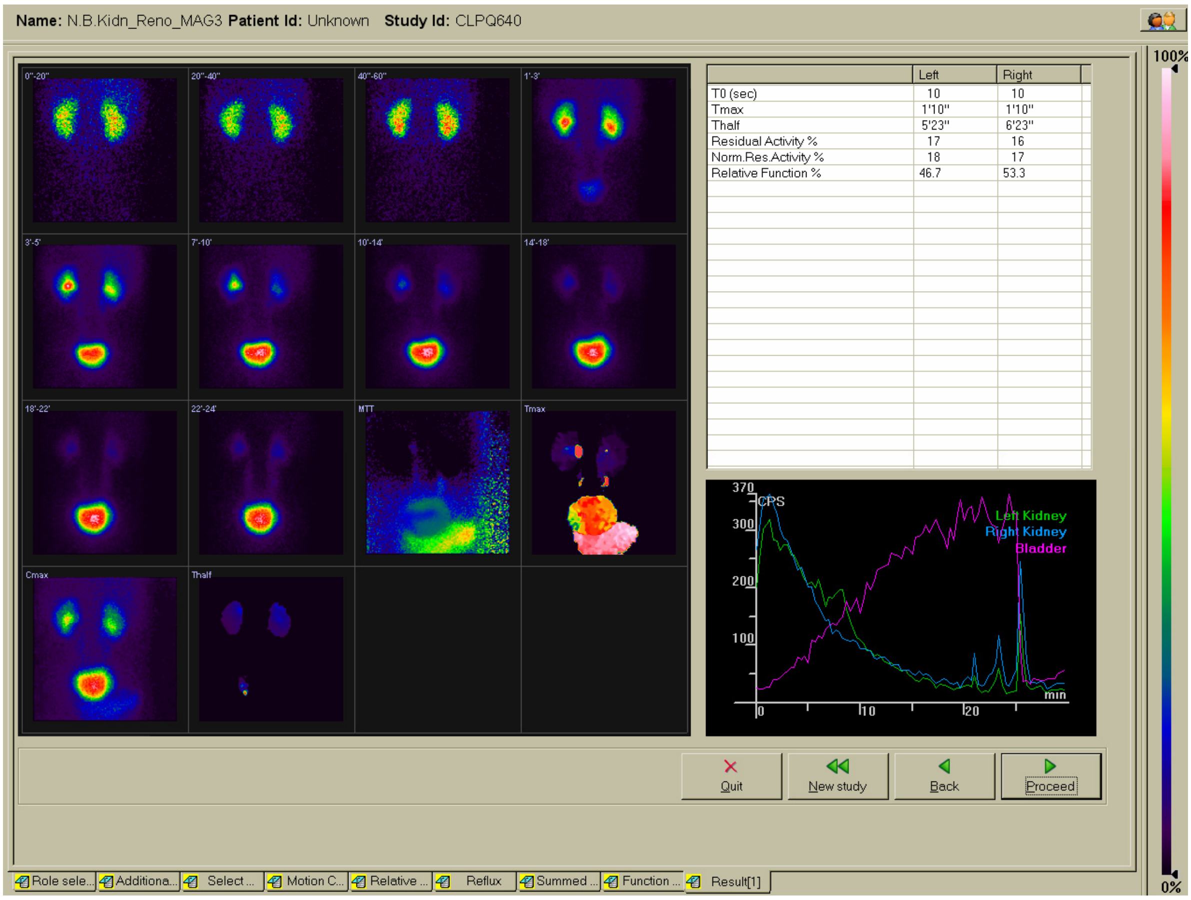



Figure 6-9 Summarized result of functional phase

# Static renal study with $^{99m}$Tc –DMSA

## Clinical application

Static renal scintigraphy is performed by $^{99m}$Tc-DMSA which indicates the functioning renal mass. Renal parenchymal damage and focal scarring can be detected with high sensitivity as cold defects in case of pyelonephritis.

## Acquisition protocol

**Multi-Directions Static Studies**

Directions: posterior, LPO, RPO
Matrix Size: 128x128
Applied activity: 100 MBq $^{99m}$Tc-MAG3
Collimator: LEHR
Patient position: supine

## Image processing

**Multi-Directions Static Studies**

Optimal contrast adjustment, background subtraction and ROI based quantitative analysis of the imaged kidneys.

## Case study: Urinary tract infection

A 1.5-year-old boy with urinary tract infection. There was a clinical suspicion of acute pyelonepritis. Static renal scan (with 50 MBq $^{99m}$Tc-DMSA) detected multiple areas of decreased uptake in the left kidney confirming the diagnosis of acute pyelonephritis.

**Follow up study after 6 months later**

Follow up investigation after 6 months verified a significant regression particularly in the left upper pole ruling out a relevant persistent parenchymal scarring in this location.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

# Static renal study with $^{99m}$Tc –DMSA: Urinary tract infection

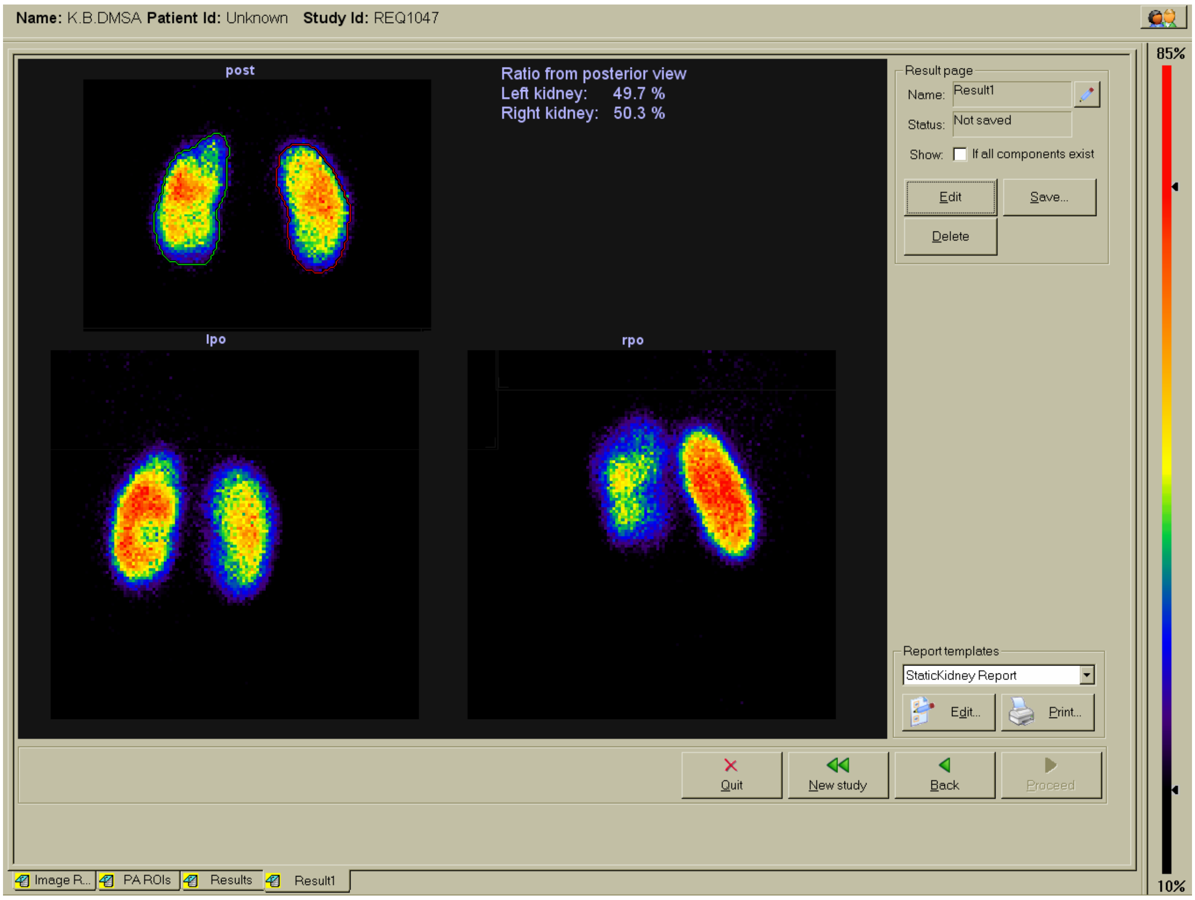



Figure 6-10 Urinary tract infection tested by $^{99m}$Tc-DMSA static study

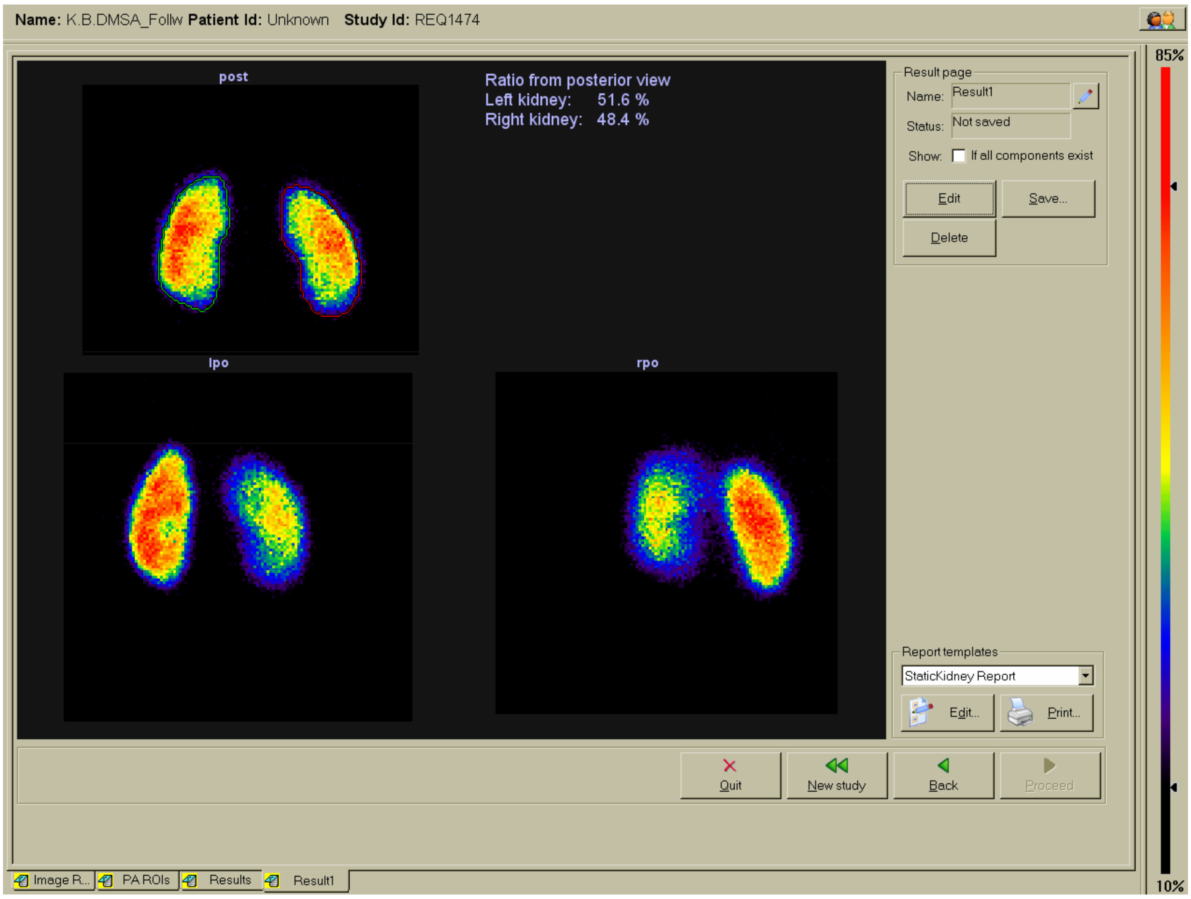



Figure 6-11 Result of the follow-up study 6 months later

# Static renal scan ($^{99m}$Tc –DMSA) extended by SPECT study

## Clinical application

Static renal scintigraphy is performed by $^{99m}$Tc-DMSA which indicates the functioning renal mass. Renal parenchymal damage and focal scarring can be detected with high sensitivity as cold defects in case of pyelonephritis. It is very useful in the evaluation of congenital and localization abnormalities of the kidneys. SPECT imaging will help in the spatial localization of the kidneys as well as different cold defects in the kidneys.

## Acquisition protocol

**Multi-Directions Static Studies**

Directions: anterior, posterior
Matrix Size: 256x256
Applied activity: 200 MBq $^{99m}$Tc-MAG3
Collimator: LEHR
Patient position: supine

**SPECT Study**

Step and shoot mode; Matrix size: 64x64
Number of steps: 64 (360° rotation)
Exposition: 40 sec
Applied activity: 200÷300 MBq $^{99m}$Tc-DMSA
Collimator: LEHR
Patient position: supine
Direction of rotation: CCW; Start angle: 0°

## Image processing

**Multi-Directions Static Studies**

Optimal contrast adjustment, background subtraction and ROI based quantitative analysis of the imaged kidneys.

**SPECT**

- Decay correction
- Regular smoothing
- 2D pre-filtering of the projection data by Butterworth filter
- Reconstruction by MOS-EM algorithm
- 10% background subtraction after the reconstruction
- Reorientation of the transaxial slices (Ref.: spine)
- Generation of coronal and sagittal slices

## Case study

An 8-year-old male patient with the history of chronic pyelonephritis. Multiple focal scaring in the left kidney and focal scare in the right upper pole.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Static renal scan ($^{99m}$Tc –DMSA) extended by SPECT study

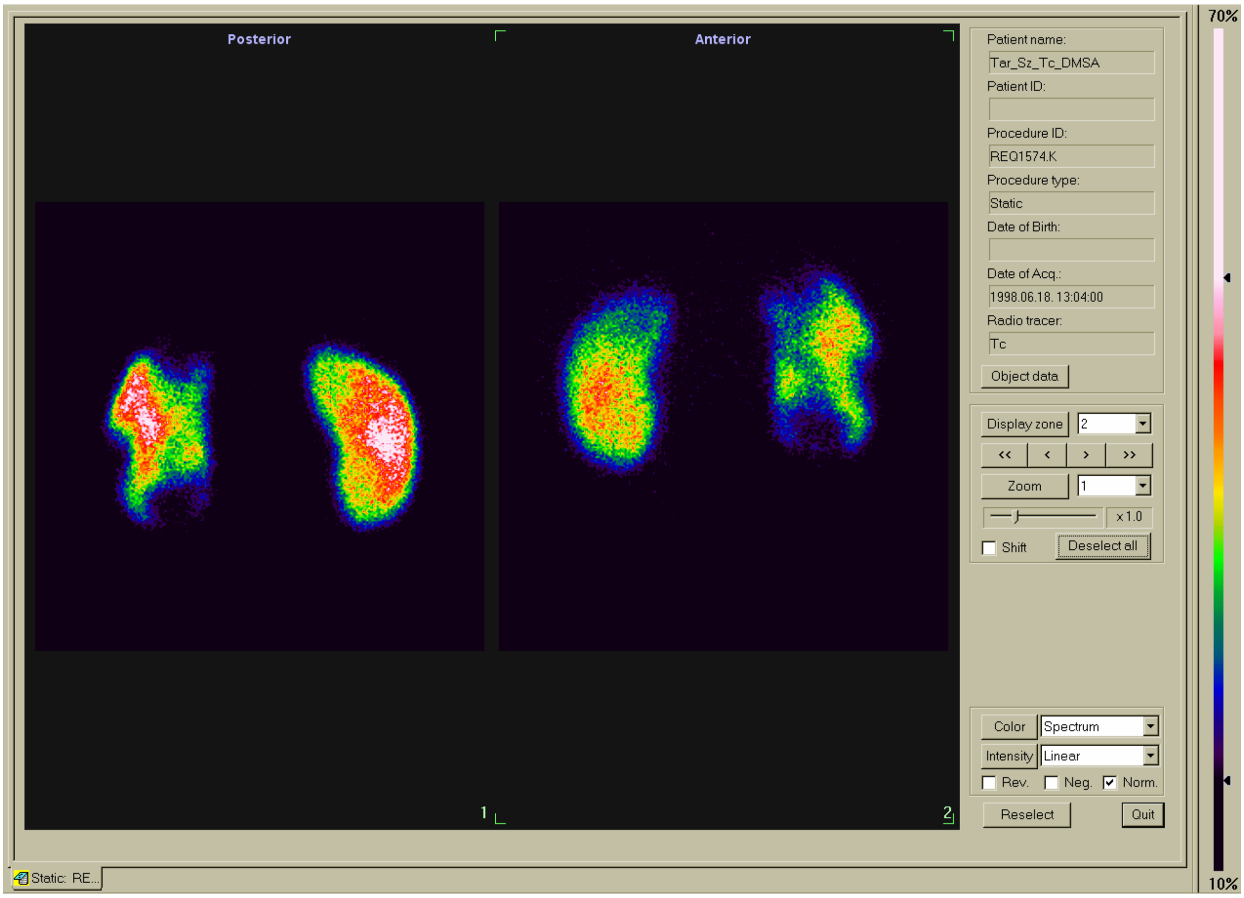



Figure 6-12 Static phase presentation

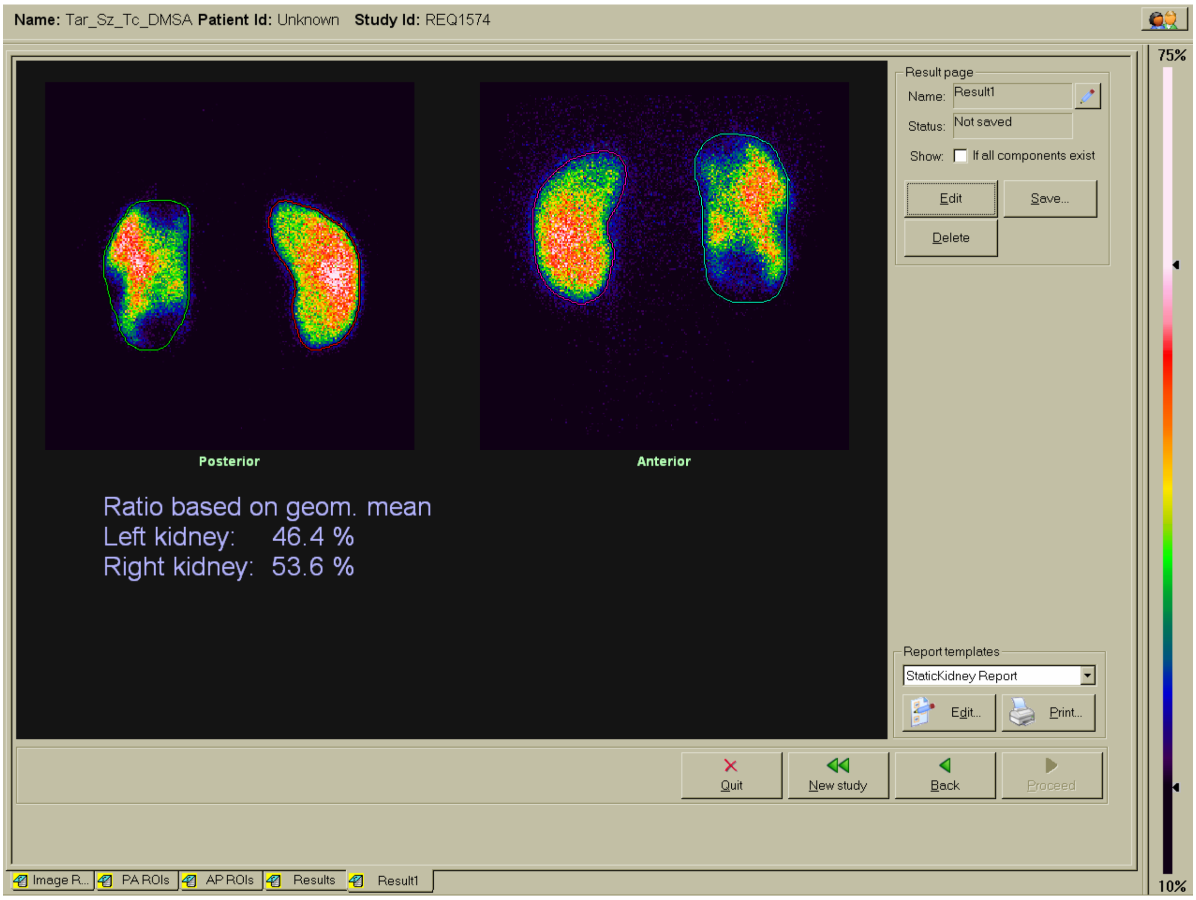



Figure 6-13 Static phase presentation with calculated results

# Static renal scan ($^{99m}$Tc –DMSA) extended by SPECT study

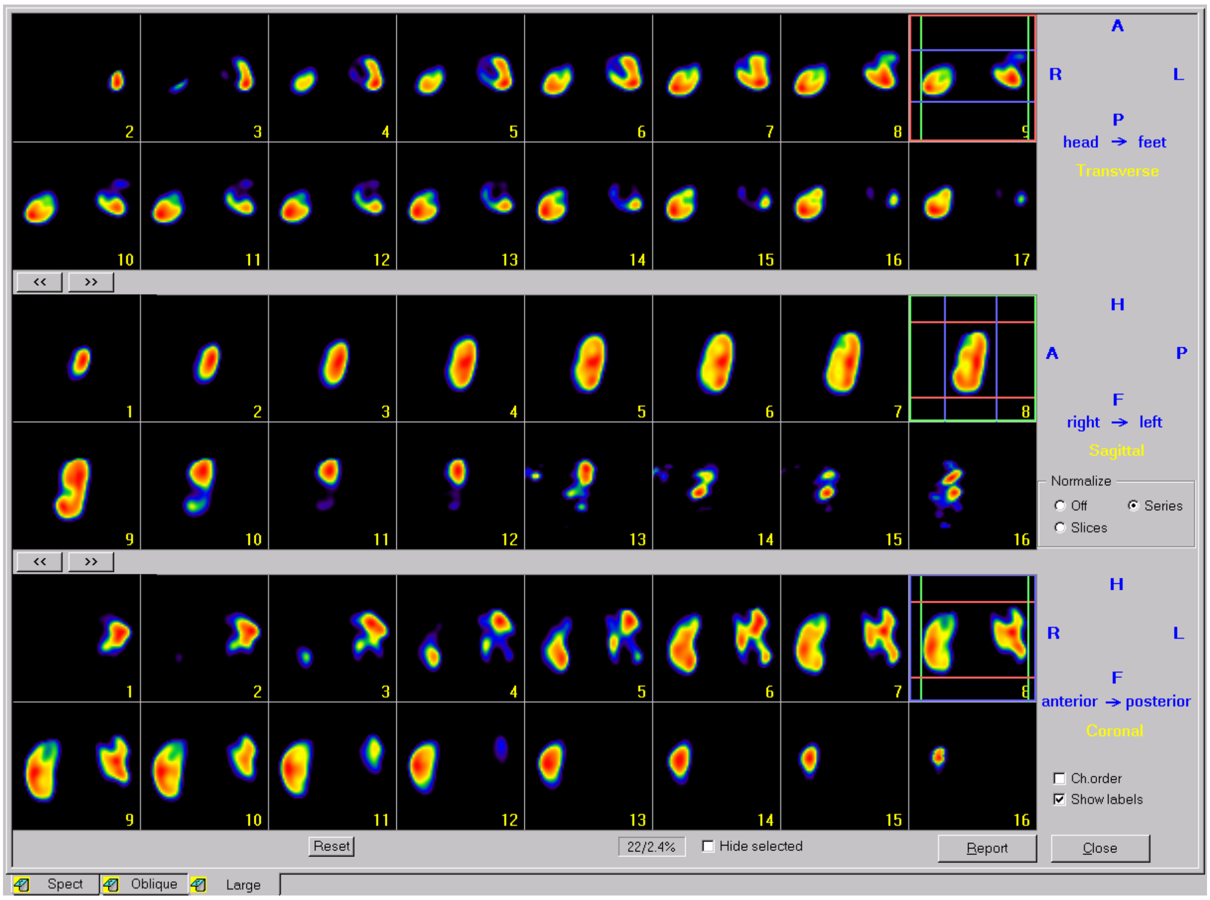



Figure 6-14 DMSA SPECT slices: right kidney

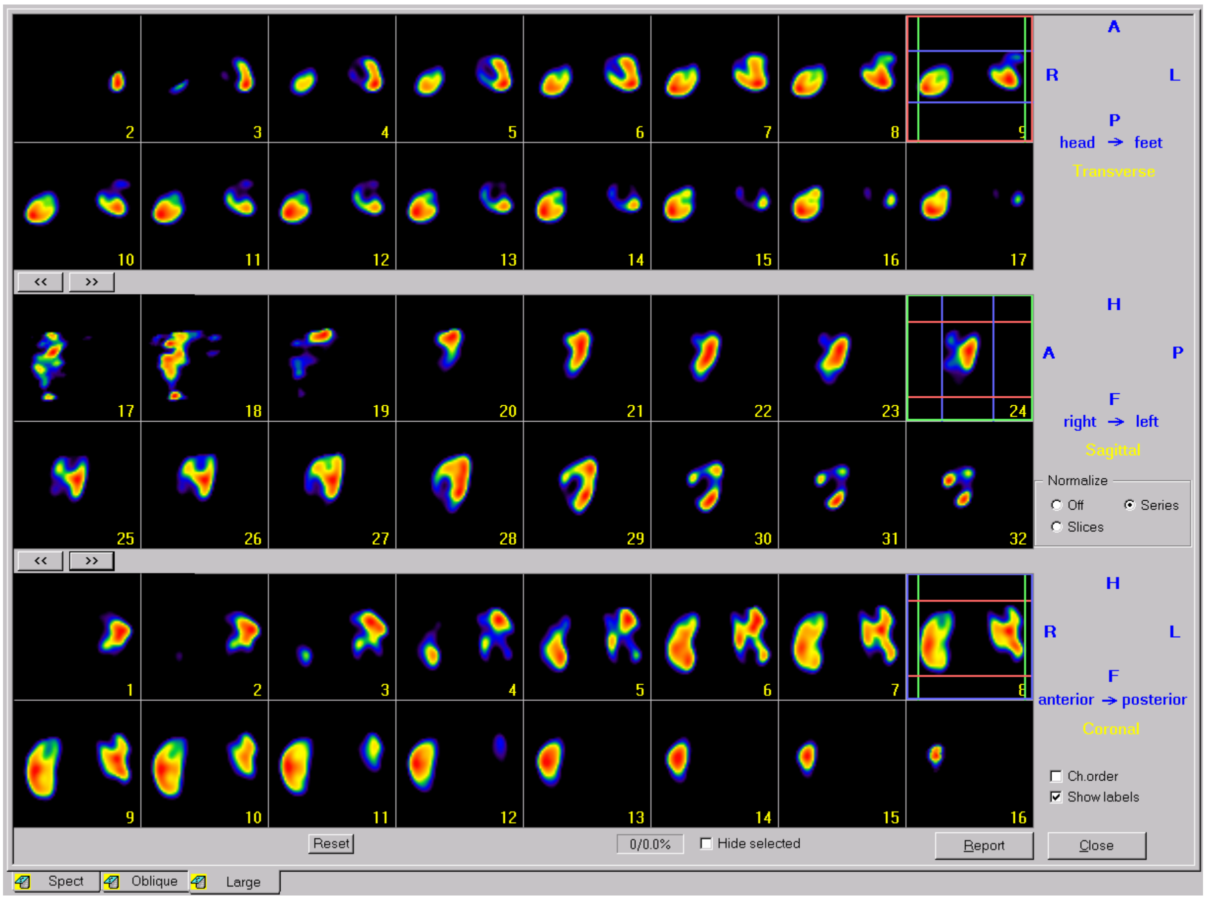



Figure 6-15 DMSA SPECT slices: left kidney

# 7. GASTROENTEROLOGY

# Functional cholescintigraphy / Hepatobiliary scintigraphy

## Clinical application

Hepatobiliary scintigraphy is performed with $^{99m}$Tc-labelled Hepatobiliary-IDA agents excreted through the liver into the bile. In gastroenterology hepatobiliary scintigraphy is a very sensitive investigative method of several functional diseases of the biliary tract even in the absence of morphological changes. Using pharmacologic or physiologic (fatty meal) stress studies functional dyskinesias of the gallbladder or the sphincter of Oddi can be clarified.

## Acquisition protocol

**Dynamic Functional Phase with provocation**

Directions: Anterior
Matrix Size: 128x128
Applied activity: 150 MBq $^{99m}$Tc-HIDA
Number of frames: 90
Exposition time: 60 sec
Collimator: LEHR
Patient position: supine

## Case study

A 58-year-old female patient suffering from dyspeptic complaints. Hepatobiliary $^{99m}$Tc-HIDA study depicts normal liver image and preserved liver uptake. No sign of biliary obstruction. The gallbladder filling was intense. Following fatty meal (300 ml milk) provocation the gallbladder activity washout was normal. Multiple episodes of activity appearence in the region of the stomach representing duodeno-gastric reflux (purple ROI and curve). Following appropriate medical treatment the patient recovered.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

# Hepatobiliary scintigraphy study

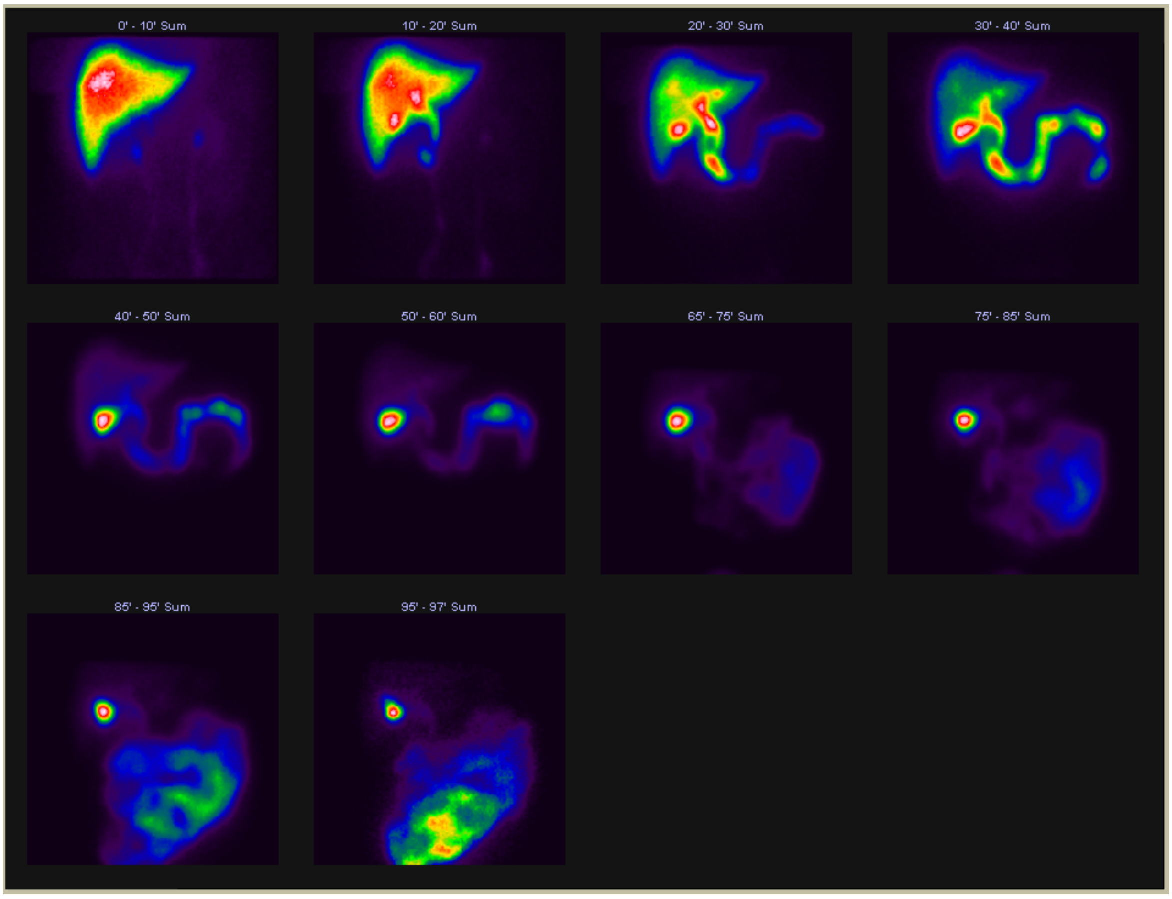



Figure 7-1 Presentation of the dynamic process by image series sampling

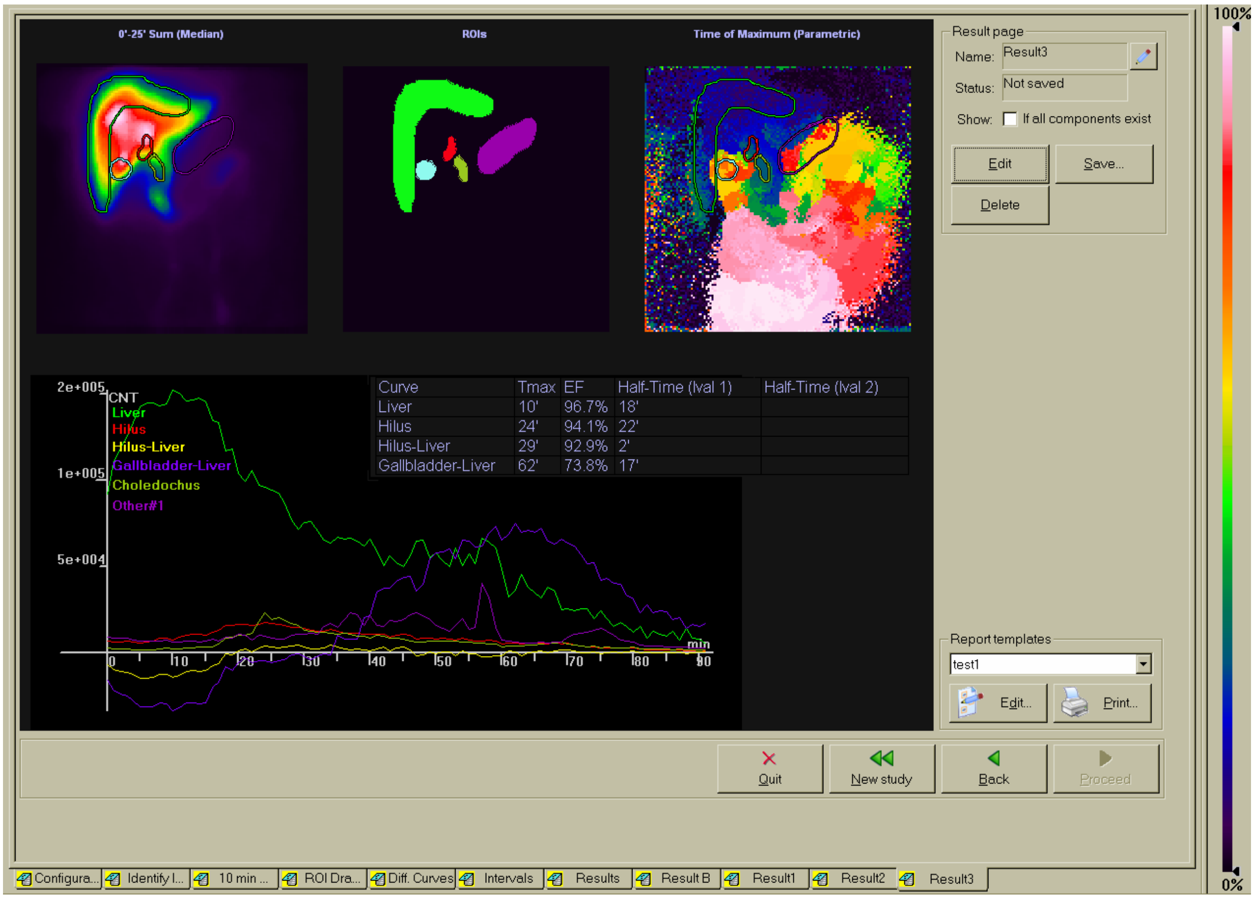



Figure 7-2 Quantitative evaluation of heapatobiliary scintigraphy

# Liver SPECT imaging (haemangioma)

*($^{99m}$Tc labelled by red blood cells)*

## Clinical application

One of the focal space occupying liver lesions is cavernous haemangioma which is incidental detected during the abdominal ultrasonography. Three phase blood pool imaging with in-vitro or in-vivo labelled red blood cells can characterize functionally these focal liver lesions as haemangiomas due to the gradually increasing activity in the lesions representing large blood volume in haemangiomas. SPECT imaging can help to detect small haemangiomas even in deep located in liver parenchyma.

## Acquisition protocol

**SPECT Study**

Step and shoot mode
Matrix size: 128x128
Number of steps: 64 (360° rotation)
Exposition: 40 sec
Applied activity: 700 ÷ 900 MBq $^{99m}$Tc labelled by red blood cells
Collimator: LEHR
Patient position: supine
Direction of rotation: CW
Start angle: 180°

## Image processing

**SPECT**

- Decay correction
- 2D pre-filtering of the projection data by Butterworth filter
- Back-projection with Ramp filter
- 5% background subtraction after the reconstruction
- Attenuation correction
- Reorientation of the transaxial slices
- Generation of coronal and sagittal slices
- 3D Volume rendered presentation

## Case study

A 51-year-old female patient with recently diagnosed colonic cancer. Abdominal ultrasonography detected two focal liver lesions representing either metastases or cavernous haemangiomas. Blood pool scintigraphy with SPECT imaging proved the haemangiomatous nature of lesions.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

## Liver SPECT imaging (haemangioma)

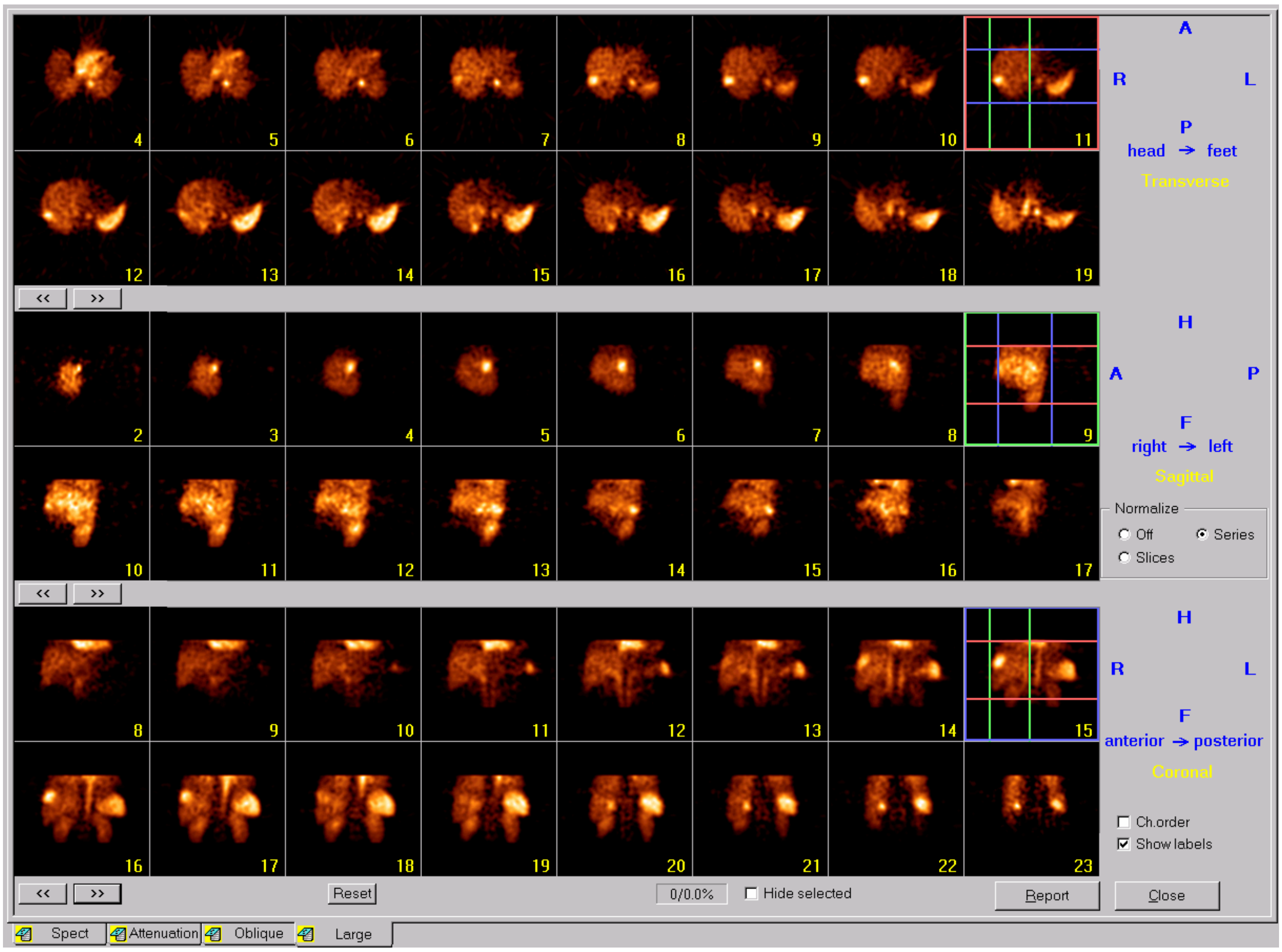



Figure 7-3

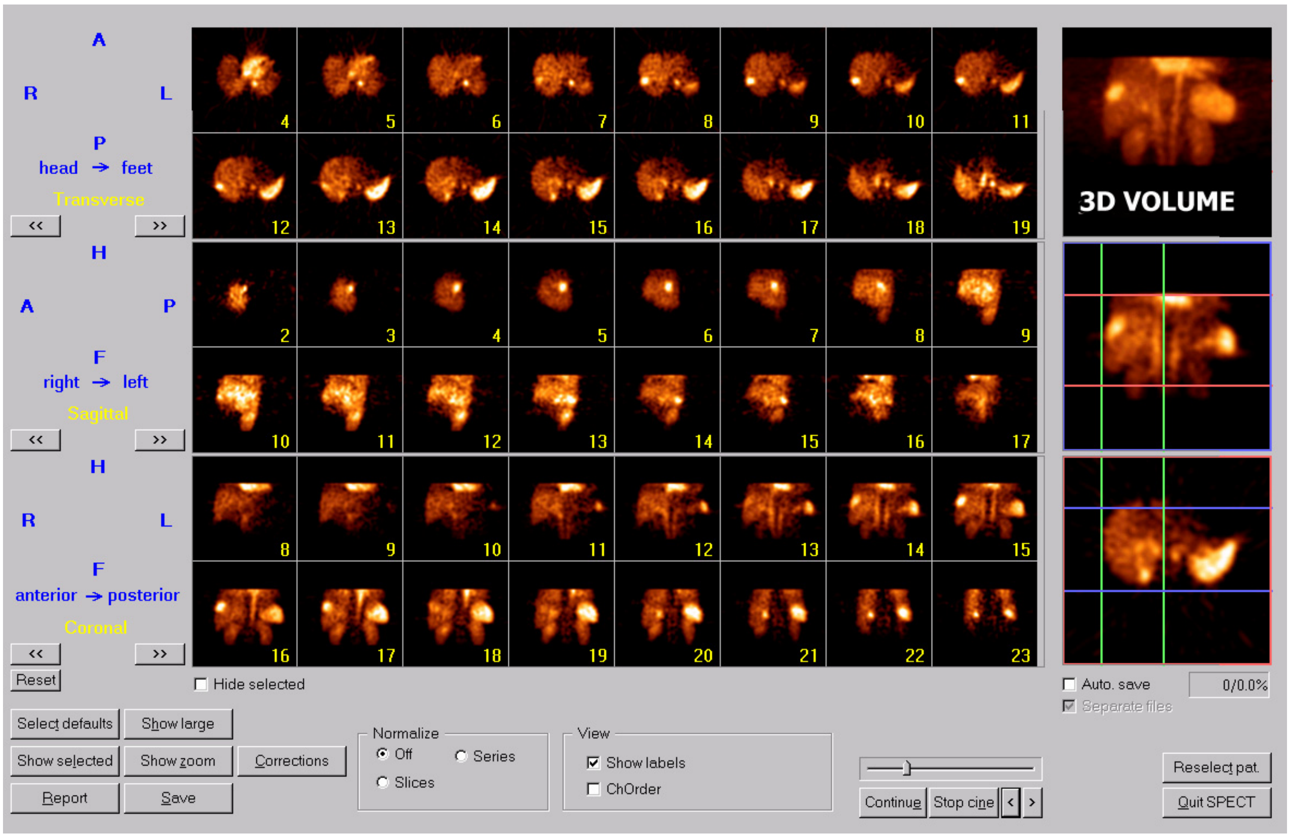



Figure 7-4

# 8. ENDOCRINOLOGY

# $^{99m}$Tc thyroid uptake

## Clinical application

The uptake of $^{99m}$Tc-pertechnetate in the thyroid gland is proportional to the regional endocrine functional activity of the gland. Thyroid scan is very useful for the determination of the functional activity of nodules detected by palpation or ultrasonography. Malignant thyroid lesions show routinely decreased uptake („cold nodules”). The origin of hyperthyreosis can be either diffuse or focal in origin and this is also easily distinguished by a thyroid scan.

## Acquisition protocol

**Multi-Directions Static Studies with location markers**

Directions: Anterior
Matrix Size: 128x128
Applied activity: 250 MBq $^{99m}$Tc-MAG3
Preset Time: 300sec
Collimator: Parallel “Butterfly shape” Tc Thyroid
Patient position: sitting

## Case study

A 32-year-old female patient had an ultrasound finding of a mass lesion with decreased echogenity and increased vascularisation in the right thyroid lobe which proved to be a papillary thyroid cancer based on cytology. The thyroid scan depicted an atypical finding of a nodulary increased uptake in the right thyroid lobe.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

# $^{99m}$Tc thyroid uptake

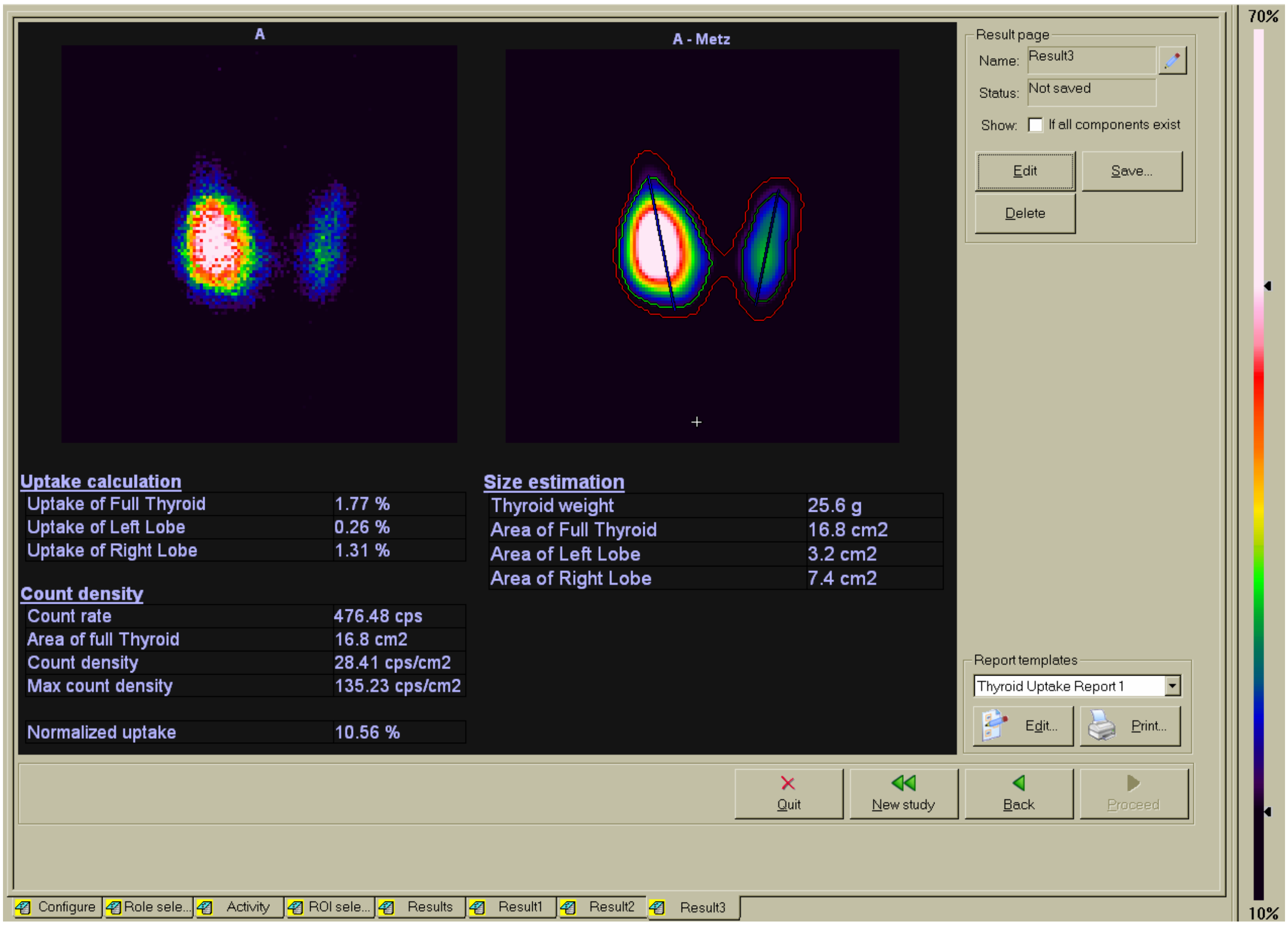



Figure 8-1 Final result page of $^{99m}$Tc thyroid uptake evaluation

# Parathyroid scintigraphy

## Clinical application

Hyperparathyreosis is most frequently caused by parathyroid adenomas. Parathyroid adenomas take up Thallium isotope or $^{99m}Tc$ labelled isonitrile radiopharmaceuticals. $^{99m}Tc$ labelled isonitriles have a slower washout from parathyroid adenomas compared to thyroid tissue, consequently they are detectable either on sequential images with washout differences or by the comparison to thyroid scans preferably based on a subtracted images. SPECT imaging further enhances the reliable localization. The localization of parathyroid adenomas is extremely important in postoperative cases with persistent hyperparathyreosis. Nowadays the primary localization has become also required in order to perform minimally invasive surgery.

## Acquisition protocol

**Multi-Directions Multi-Phases Static Studies**

Directions: anterior, posterior
Matrix Size: 256x256
Applied activity: 700 MBq $^{99m}Tc$-MIBI
Prest Time: 600sec
Collimator: LEHR
Patient position: supine
Different Time Phases: 5min., 50min., 120min.

**SPECT STUDY (at 60min.time phase)**

Step and shoot mode
Matrix size: 64x64
Number of steps: 120 (360° rotation)
Exposition: 20 sec
Applied activity: 700 MBq $^{99m}Tc$-MIBI
Collimator: LEHR
Patient position: supine
Direction of rotation: CW
Start angle: 180°

## Image processing

**Multi-Directions Multi-Phases Static Studies**

Simultaneous presentation of different phases with optimal contrast adjustment, background subtraction as well as special image subtraction based semi-quantitative technique and ROI based quantitative analysis of the image.

**SPECT**

- Decay correction
- Regular smoothing
- 2D pre-filtering of the projection data by Butterworth filter
- Reconstruction by MOS-EM algorithm
- 5% background subtraction after the reconstruction

- Reorientation of the transaxial slices (Ref.: spine)
- Generation of coronal and sagittal slices

## Case study

A 63-year-old female patient with an accidental finding of hypercalcemia and hyperparethyreosis during osteoporosis screening. Parathyroid scintigraphy ($^{99m}$Tc-MIBI washout study) was performed for the primary localization of a parathyroid adenoma in order to perform minimal invasive surgery. On sequential planar images an increased focal uptake and delayed washout of the radiopharmaceutical could be depicted in the right lower pole region medially. This lesion is reliably localized on SPECT images. The patient was operated with the help of radio-guidance by a gamma probe and a parathyroid adenoma could be find in the above location confirmed by histology.

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*

## Parathyroid study

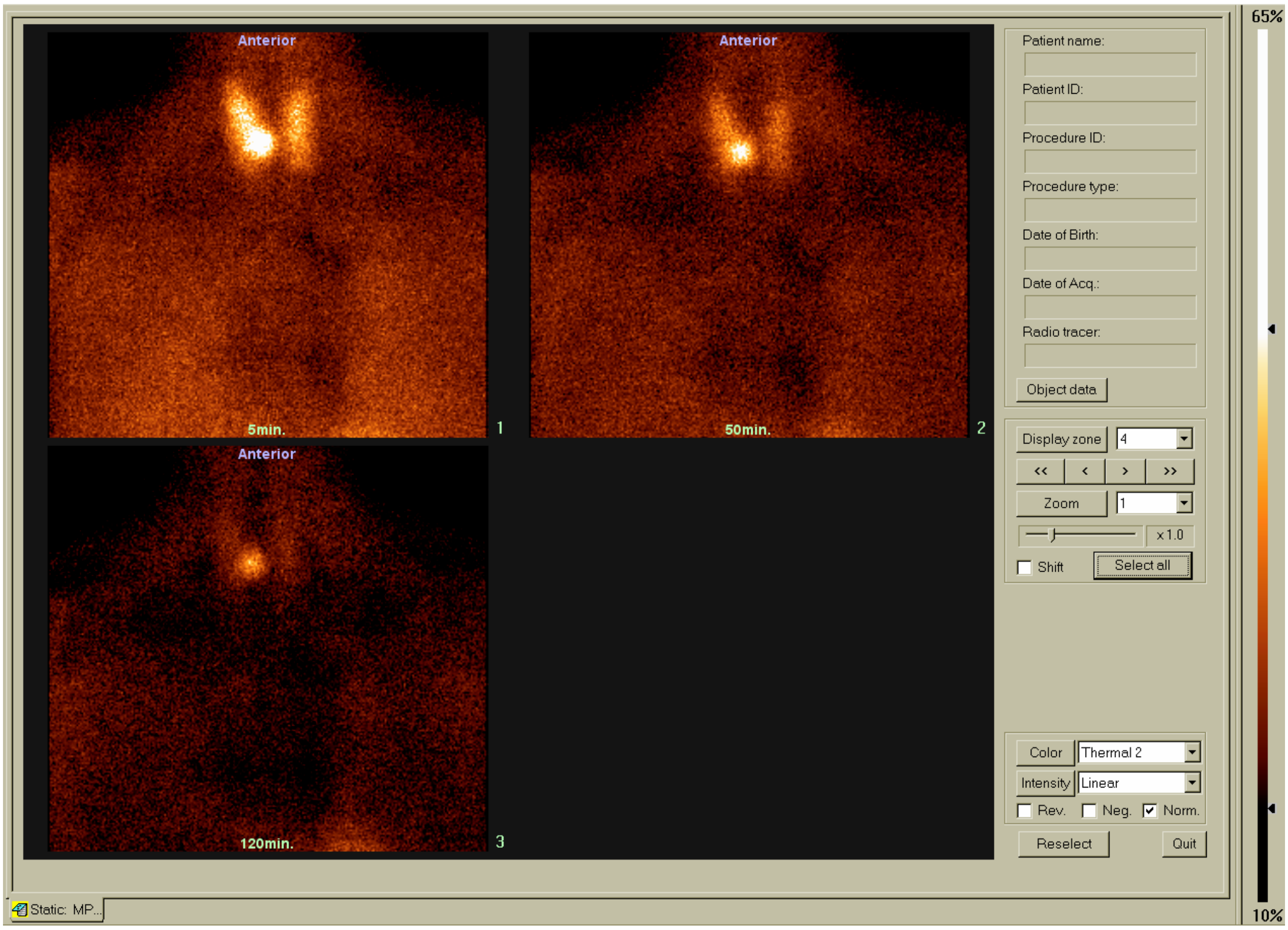



Figure 8-2 Presentation of multi-phases anterior direction images

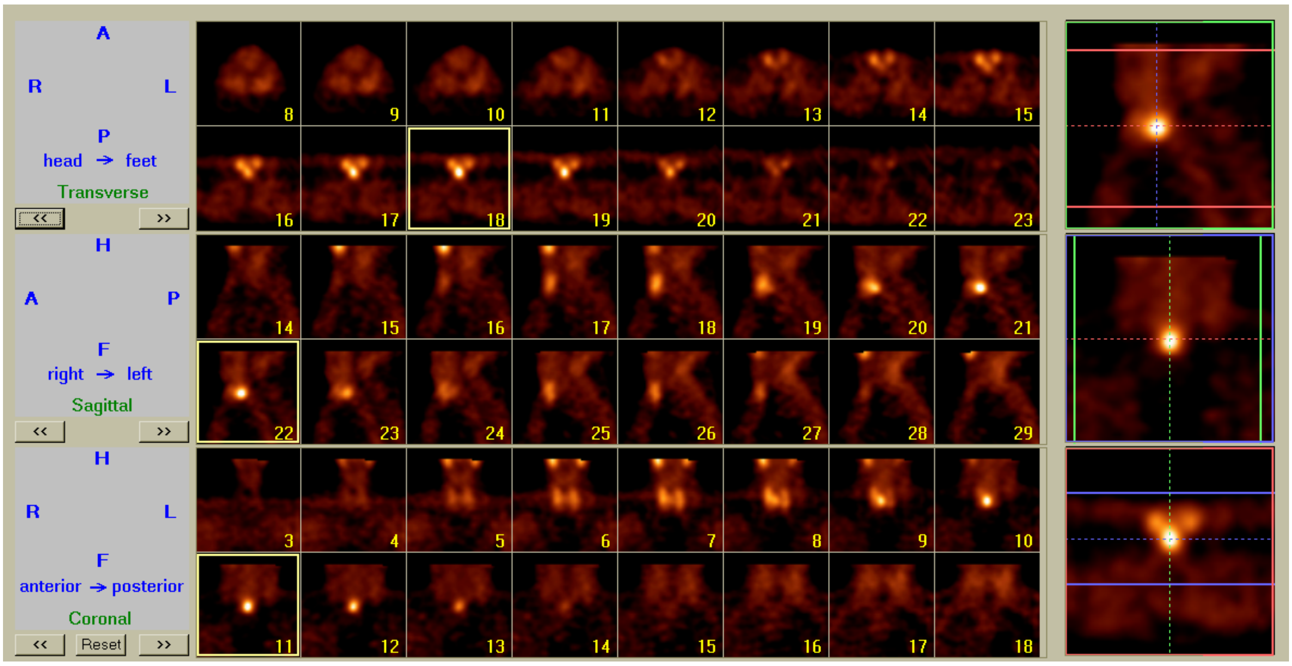



Figure 8-3 Parathyroid slices (SPECT result)

# 9. PULMONOLOGY

# Lung perfusion imaging by $^{99m}$Tc-MAA

## Clinical application

Following intravenous injection $^{99m}$Tc MAA albumin particles are trapped in pulmonary capillary bed according to the regional arterial perfusion in the lungs. The nuclear medical imaging will display the activity distribution in the different segments of the lung and embolised areas are depicted as filling defects distal to the embolous.

The perfusion image should compare with a current chest X-ray of the patient. Segmental localization of the hypo-perfusion can be imaged by SPECT study more expressed just after the most important multi-direction planar imaging.

## Acquisition protocols

### 6 Directions Static Studies

Directions: LPO-RAO, anterior-posterior, LAO-RPO
Matrix Size: 256x256
750 kcounts from each direction
Collimator: LEHR
Applied activity: 200MBq $^{99m}$Tc-MAA
Patient position: supine

### SPECT Study

Step and shoot mode
Matrix size: 128x128
Number of steps: 120 (360° rotation)
Exposition: 8 sec
Patient position: supine
Direction of rotation: CCW; Start angle: 0°

## Image processing

### Planar DATA

Display all static images with identifications and optimal contrast setting.

### SPECT

- 2D pre-filtering of the projection data by Butterworth filter
- Back projection with Ramp filter
- 5% Background subtraction after the reconstruction
- Reorientation of the transaxial slices
- Generating of coronal and sagittal slices

## Case study

A 76-year-old female had typical symptoms of pulmonary emboli, and also left side deep venous thrombosis was revealed.

The patient had normal chest X-ray while the perfusion imaging detected multiplex segmental, and sub-segmental lesions. SPECT study shows expressed hypo-perfusion on S2 and other sub-segmental areas comparing to the planar imaging.

*Case contributed by Semmelweis University Budapest Faculty of Medicine*
*Department of Diagnostic Radiology and Oncotherapy*

# Lung perfusion imaging by 99mTc-MAA

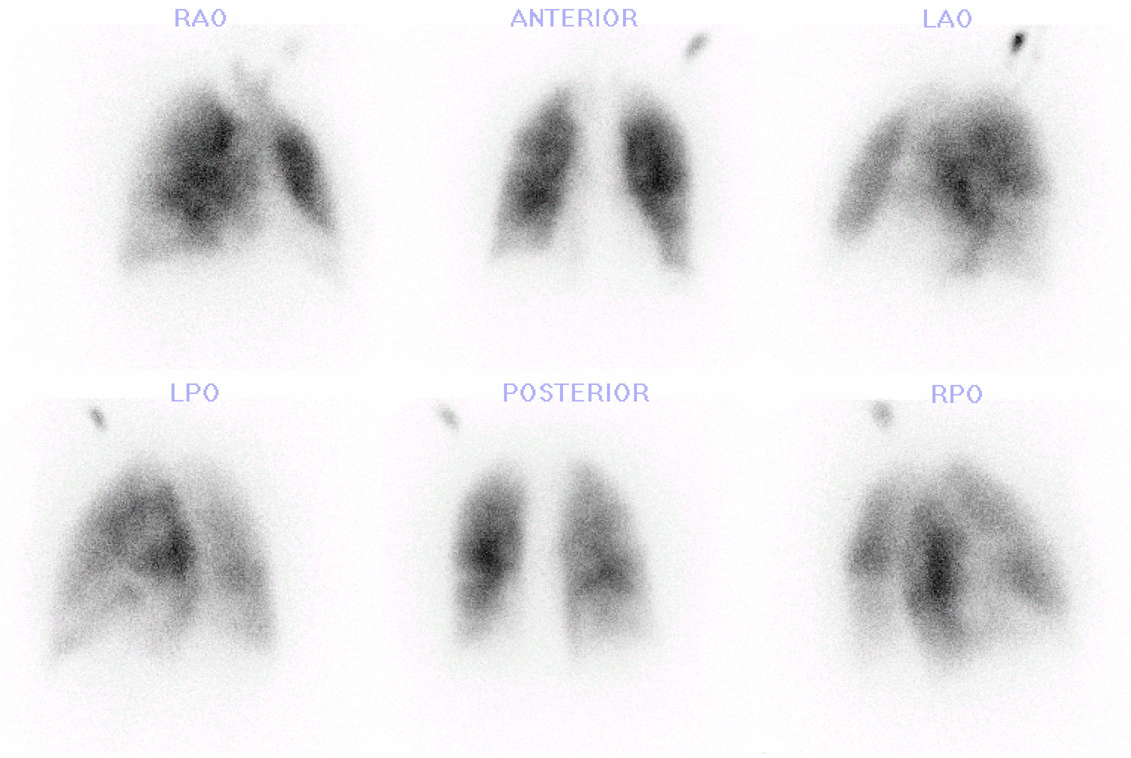



Figure 9-1 Static perfusion images

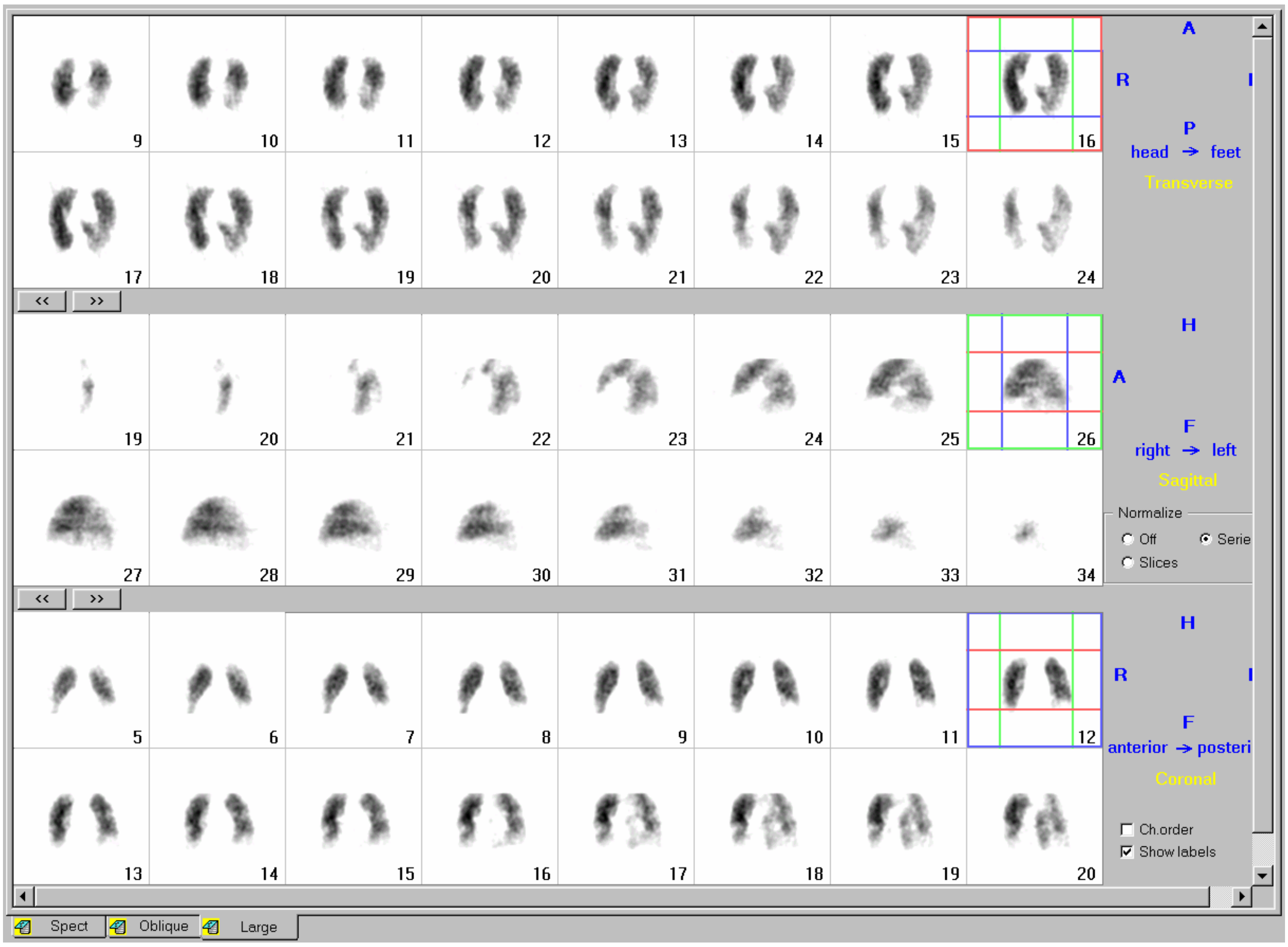



Figure 9-2 SPECT slices

# 10. MAMMO SCINTIGRAPHY

# Mammo scintigraphy

## Clinical application

An increased uptake of $^{99m}$Tc labelled isonitrile radiopharmaceuticals is characteristic for malignant breast lesions, which are detectable by scintigraphy most preferably imaged the female breasts in a hanging position. Scintimammography is a useful non-invasive method for characterizing mass lesions in the breast with an equivocal X-ray mammographic appearance or for detecting malignant masses in breasts when X-ray mammography has a low sensitivity (i.e. dense breast tissue).

## Acquisition protocols

**4 Directions Static Study (10 minutes later after injection)**

Directions: LLAT, RLAT, anterior, posterior
Matrix Size: 256x256
Preset Time: 600sec
Collimator: LEHR
Applied activity: 700 ÷ 750 MBq $^{99m}$Tc-MDP
Patient position: prone (LLAT, RLAT), supine (anterior, posterior)

**2 Directions Static Study (90 minutes after injection)**

Directions: LLAT, RLAT
Matrix Size: 256x256
Preset Time: 600sec
Collimator: LEHR
Patient position: prone

**SPECT STUDY (appr. 35 minutes after the injection)**

Step and shoot mode
Matrix size: 128x128
Number of steps: 120 (360° rotation)
Exposition: 30 sec
Direction of rotation: CCW
Start angle: 0°
Patient position: prone

## Image processing

**Static Images**

Presentation of the static studies with their identifications by a predefined special display arrangement. Optimal contrast and colour scale adjustment. Occasionally special quantitative and qualitative analysis of the acquired spots.

**SPECT**

- Decay correction
- Regular smoothing of the projection data
- 2D pre-filtering on the smoothed projection data set by Butterworth filter
- Reconstruction by MOSEM algorithm
- 5% background subtraction after the reconstruction

- Reorientation of the transaxial slices
- Generation of coronal and sagittal slices

## Case study

A 40-year-old female patient with a history of cancer in her left breast 1.5 years ago. Currently an enlarged lymph node appeared in her opposite axilla which was metastatic in origin according to cytology finding. X-ray mammography and ultrasonography were negative for both breasts. MR imaging depicted a suspicious lesion in the right breast but blind biopsy was also inconclusive. Scintimammography with $^{99m}$Tc-MIBI was performed and an increased uptake is detectable on the border of the lateral quadrants of the right breast and according to the finding of MR imaging. (Note also the increased uptakes of metastatic lymph nodes in right axilla.) Based on the scintigraphic finding the right breast lesion could be resected by radio-guided surgery and subsequent histology reported a ductal invasive cancer.

*Case contributed by Semmelweis University Budapest Faculty of Medicine Department of Diagnostic Radiology and Oncotherapy*


Figure 10-1 Static images: Early phase of anterior direction

## Mammo scintigraphy

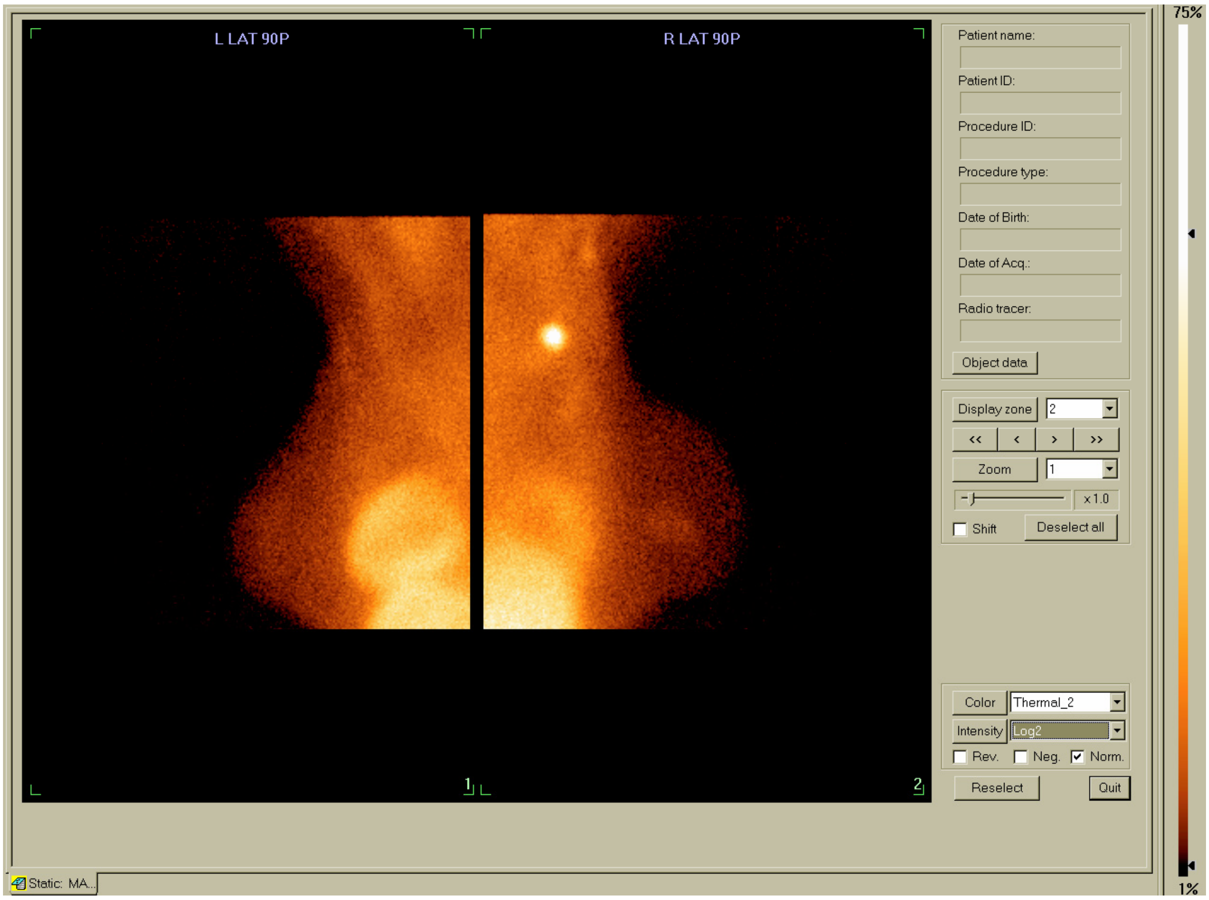



Figure 10-2 Static images: Presentation of lateral views in delayed phase

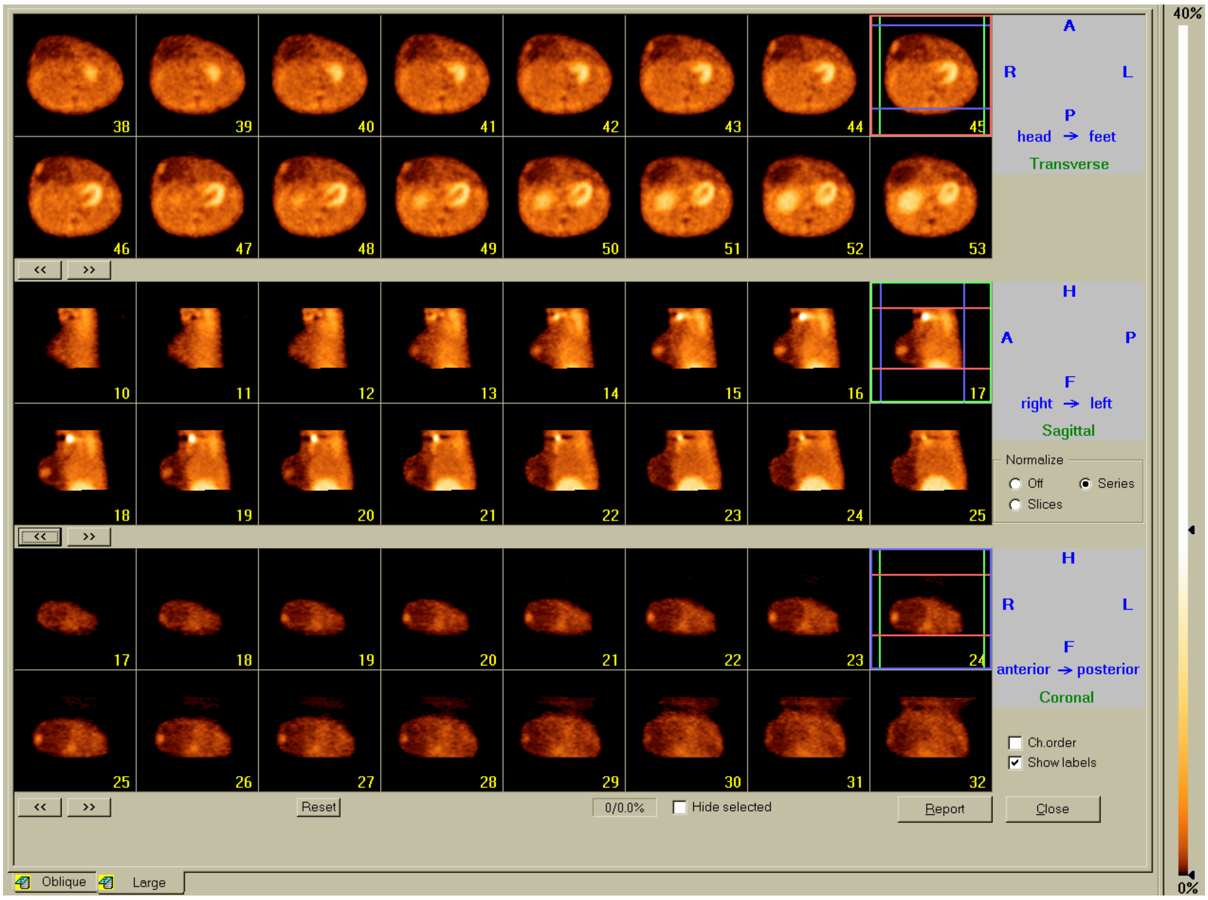



Figure 10-3 Presentation of SPECT evaluation

# Mammo scintigraphy

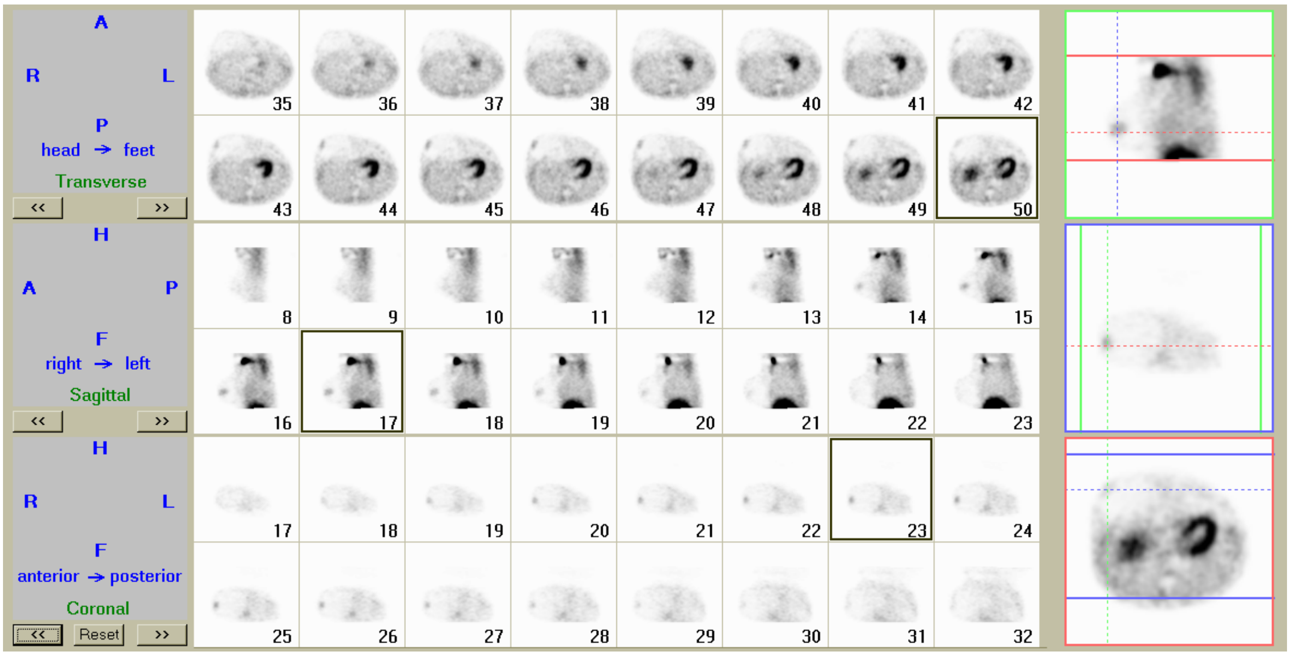



Figure 10-4 Presentation of SPECT evalutation