

EACVI CORE SYLLABUS

Nuclear Cardiology

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The EACVI Nuclear Cardiology core syllabus will be reviewed and amended on a regular basis. The Nuclear Cardiology core syllabus provides a summary of the core knowledge for cardiac fellows and for continuing medical education of trained cardiologists. The core syllabus aims to be an educational framework in teaching hospitals across Europe. It will also be used to standardize the content on educational activities within the European Association of Cardiovascular Imaging and in its external relations with National Societies and National Working Groups on Nuclear Cardiology.

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1. PHYSICS, INSTRUMENTATION, TRACERS

1.1 Physics

- 1/Atoms and nuclei
- 2/Isotope decay
- 3/Interactions of radiation with matter
- 4/Production of radiopharmaceuticals, generators, red blood cell tagging
- 5/Physics of Single photon emission computed tomography (SPECT)
- 6/Physics of Positron emission tomography (PET)
- 7/Physics of hybrid and fusion imaging

1.2 Instrumentation

- 1/Gamma cameras, collimation, equipment quality control
- 2/Attenuation correction, including transmission and Computed tomography (CT) methods
- 3/Multi pin-hole scintigraphy with CZT technology
- 4/PET cameras
- 5/Hybrid techniques (PET/CT and SPECT/CT) for attenuation corrected imaging and for combined anatomical and functional imaging
- 6/Hybrid PET/Cardiac magnetic resonance (CMR) technique

1.3 Tracers

- 1/Tracers for SPECT:
 - ^{201}Tl , $^{99\text{m}}\text{Tc}$ -sestamibi, or $^{99\text{m}}\text{Tc}$ -tetrofosmin, ^{123}I -MIBG, others
- 2/Tracers for PET:
 - ^{18}F -FDG, ^{13}N - NH_3 , Rubidium-82, ^{15}O - H_2O , ^{11}C -HED, others
- 3/Tracer kinetics and characteristics of SPECT agents
- 4/Tracer kinetics and characteristics of PET agents
- 5/Quality assurance and quality control

2. RADIATION SAFETY

2.1 Radiopharmaceutical receiving, handling, and containment

2.2 Dose dispensing

2.3 Contamination control and waste management

2.4 Monitoring radiation (periodic area surveys, personnel)

2.5 Quality control testing of radiopharmaceutical dose calibrator

2.6 Principles of radiation protection

2.7 Effective doses of radiotracers used in nuclear cardiology tests

2.8 Radiation exposure and ALARA principle

2.9 Principles of legislation and local regulatory authorities rules on radiation use

3. METHODOLOGY

3.1 Indications and appropriate use criteria

3.2 Absolute and relative contraindications to stress testing and imaging exams

3.3 Necessary background in clinical cardiology (i.e. stress test physiology, management of nuclear stress emergencies)

3.4 Patient preparation procedures

- 1/ Patient preparation for stress
- 2/ Exercise stress (practical aspects, performing the test)

3.5 Exercise and pharmacologic stress protocols

- 1/ Exercise stress (treadmill, bicycle)
- 2/ Vasodilator drugs (pharmacology, dipyridamole, adenosine, selective A_{2A} receptor agonists, performing the test, adverse effects)
- 3/ Dobutamine stress (pharmacology, performing the test, adverse effects)

3.6 Imaging protocols

- 1/ Rest/stress
- 2/ Stress/rest
- 3/ Thallium stress/redistribution-reinjection
- 4/ Viability
- 5/ Nitrate-enhanced Tc-99m imaging
- 6/ etc

3.7 Image acquisition

- 1/Equilibrium radionuclide ventriculography (RNV)
- 2/First-pass ventriculography
- 3/Planar
- 4/Gating
- 5/SPECT
- 6/PET
- 7/Attenuation correction
- 8/Hybrid (SPECT/CT, PET/CT, PET/CMR)

3.8 Image processing

- 1/Filtering
- 2/Reorientation
- 3/Reconstruction
- 4/Motion correction
- 5/Attenuation correction
- 6/Image display
- 7/Quality control

3.9 Artifacts

- 1/Attenuation
- 2/Patient-related artifacts (i.e. motion)
- 3/Instrumentation error
- 4/Reconstruction error
- 5/Causes of false-positive and false-negative results

3.10 Image interpretation

- 1/Visual analysis (perfusion, metabolism, innervation)
- 2/Quantitative analysis (perfusion, metabolism, innervation)
- 3/Visual and quantitative analysis of ventricular function
- 4/Coronary territories
- 5/Report of findings
- 6/Quality control

4. CLINICAL IMAGING PROTOCOLS

4.1 Myocardial perfusion imaging

- 1/SPECT perfusion imaging
 - Rest imaging
 - Stress imaging
 - 2-day and 1-day protocols
 - Hybrid imaging (SPECT/CT)

2/PET perfusion imaging

- Rest imaging
- Stress imaging
- Quantitation of myocardial blood flow (MBF)
- Hybrid imaging (PET/CT and SPECT/CT) for attenuation corrected imaging and for combined anatomical and functional imaging

3/Perfusion imaging interpretation

- Relationship of perfusion abnormalities to clinical, hemodynamic, ECG and stress parameters
- Relationship of perfusion abnormalities to coronary anatomy
- Combined function-perfusion imaging

4.2 Ventricular function imaging

1/First pass radionuclide ventriculography (LV and RV function measurements, shunt detection and quantification)

2/Rest and stress equilibrium radionuclide ventriculography, including volume measurements and systolic and diastolic function

3/ECG-gated SPECT/PET myocardial imaging

4/Effect of arrhythmia on ECG gating

5/Evaluation of systolic and diastolic function by gated SPECT/PET

4.3 Myocardial viability

1/Thallium-201 imaging

2/Technetium-99m imaging

3/FDG imaging

4.4 Innervation

1/MIBG imaging

2/Regional and standard quantification

4.5 Imaging of myocardial sarcoidosis

4.6 Molecular imaging (atherosclerosis, vulnerable plaque, inflammation, apoptosis)

4.7 Labelled leucocyte imaging for myocardial abscesses and infection

4.8 Comparing nuclear cardiology data with other imaging modalities (i.e. echocardiography, cardiac computed tomography, magnetic resonance imaging)

5. ISCHAEMIC HEART DISEASE

5.1. Chronic ischaemic heart disease

1/ Ischaemia testing for detection of ischaemia in known or suspected CAD

- Pre-test likelihood of CAD (risk scores, Bayes' theorem)
- Sensitivity and specificity for CAD detection
- Stress methods
 - Exercise stress test
 - Dobutamine
 - Adenosine
 - Selective A_{2A} receptor agonists
 - Dipyridamole
- Perfusion imaging during stress & rest
 - Sequences & scanning technique
 - Indications, guidelines and appropriate use criteria
 - Contraindications
 - Clinical validation and application
 - Artefacts and pitfalls
 - Analysis of perfusion
 - Prognostic information
- Evaluation of absolute MBF and MBF reserve by PET
 - Quantitative analysis
 - Different tracers
 - Indications and guidelines
 - Clinical validation and application
 - Artefacts and pitfalls
 - Evaluation of microvascular dysfunction
 - Prognostic information
- Evaluation of regional & global function at rest and after stress
 - Indications & guidelines
 - Contraindications
 - Clinical validation & application
 - Comparison with other techniques
 - Prognostic information

2/ Viability assessment

- SPECT assessment
 - ²⁰¹Tl reinjection and redistribution
 - ²⁰¹Tl Rest-redistribution
 - Standard ^{99m}Tc protocols plus nitrates
 - Clinical validation
 - Quantification of viable and scarred myocardium

- Clinical application (prediction of regional or global functional recovery)
- Prognostic information
- PET assessment
 - FDG protocol
 - Combined FDG and myocardial perfusion protocol (mismatch pattern)
 - Clinical validation and application
 - Prognostic information
- 3/Chronic myocardial infarction
 - Imaging with SPECT and PET
 - Quantification of infarct area
 - Prognostic information
- 4/Assessment of results of therapy
 - After medical therapy
 - After revascularization
 - Prognostic information
- 5/Evaluation before non-cardiac surgery
 - Indications and guidelines
 - Prognostic information
- 6/Nuclear cardiology techniques in resynchronisation therapy (see also in cardiomyopathy section)
 - Nuclear cardiology methods to assess dyssynchrony
 - Clinical validation and application
 - Prognostic information

5.2. Acute ischaemic heart disease (IHD)

- 1/Acute coronary syndromes (ACS)
 - Clinical application of myocardial scintigraphy in the emergency department
 - Indications and guidelines
 - Scanning protocol (tracers, rest versus stress imaging)
 - Detection of ACS
 - Differential diagnosis (chest pain, troponin rise & normal coronary arteries)
 - Myocardial infarction quantitative assessment
 - Peri-procedural injury
 - Clinical and prognostic significance
- 2/Evaluation of innervation in the acute IHD
 - Clinical application and prognostic significance

6. CARDIOMYOPATHIES, OTHER

6.1. Dilated cardiomyopathy

- 1/Evaluation of perfusion by SPECT
- 2/Measurement of absolute MBF and MBF reserve by PET
- 3/Patterns of perfusion defects in comparison with CAD
- 4/Evaluation of myocardial innervation
- 5/LV function using gated SPECT
- 6/Prognostic information

6.2. Takotsubo-cardiomyopathy

- 1/Evaluation of perfusion by SPECT
- 2/Measurement of absolute MBF and MBF reserve by PET
- 3/Evaluation of myocardial innervation

6.3. Transplant cardiomyopathy

- 1/Evaluation of perfusion by SPECT
- 2/Measurement of absolute MBF and MBF reserve by PET
- 3/Evaluation of myocardial innervation

6.4. Myocarditis

- 1/PET, PET/CT in myocarditis (inflammation imaging)

6.5. Sarcoidosis

- 1/Evaluation of inflammation with ¹⁸F-FDG PET
- 2/Prognostic importance

6.6. Amyloidosis

- 1/Nuclear imaging in cardiac amyloidosis

6.7. Nuclear cardiology in resynchronisation therapy (see also in ischaemic heart disease section)

- 1/Nuclear cardiology methods to assess dyssynchrony and myocardial damage
 - Detection of scar
 - Assessment of dyssynchrony with gated SPECT/PET
- 2/Clinical validation and application
- 3/Prognostic information

6.8. Nuclear cardiology in oncology

- 1/Monitoring of LV function before, during and after cardiotoxic chemotherapy

6.9. Nuclear cardiology in vasculitis

- 1/Aortitis, infectious and non-infectious: PET inflammatory imaging