

EUROPEAN ASSOCIATION OF CARDIOVASCULAR IMAGING
A Registered Branch of the ESC



EACVI CORE SYLLABUS

Cardiac Computed Tomography

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1. PRINCIPLES OF COMPUTED TOMOGRAPHY

1.1 Historical development of CT technology

- 1/ Axial CT
- 2/ Electron beam CT
- 3/ Spiral CT
- 4/ Multi-detector CT
- 5/ Multi-source CT

1.2 X-ray generation and X-ray tube characteristics

- 1/ X-ray generation
- 2/ Focal spot and X-ray beam characteristics
- 3/ Rontgen filters and collimation
- 4/ Rontgen profiles
- 5/ Heat dispersion

1.3 X-ray attenuation physics

1.4 Rontgen detector technology

- 1/ Detector physics
- 2/ Detector composition
- 3/ Detector collimation
- 4/ A/D conversion

1.5 Scan modes

- 1/Axial scan mode
- 2/Spiral scan mode
 - Pitch
- 3/Stationary full-coverage mode
- 4/Dynamic acquisition mode

1.6 Image reconstruction techniques

- 1/ Filtered back-projection
- 2/ Longitudinal interpolation in spiral scan protocols
- 3/ Iterative reconstruction techniques
- 4/ Reconstruction parameters: slice thickness, slice increment, convolution kernels

1.7 Spectral CT techniques and applications

- 1/ Acquisition techniques
- 2/ Reconstruction
- 3/ Applications

2. CARDIAC CT EXAMINATIONS

2.1 ECG synchronization for cardiac applications

- 1/ Prospectively ECG-triggered CT protocols
 - Arrhythmia recognition
 - Exposure window width and positioning
- 2/ Retrospectively ECG-gated CT protocols
 - Pitch selection
 - Prospectively ECG-triggered X-ray tube modulation
 - Reconstruction window positioning
 - ECG editing

2.2 Acquisition parameters: effect on image quality, dose

- 1/ Tube voltage (kV)
- 2/ Tube current (mA)
- 3/ Scan range
- 4/ Scan protocol

2.3 Reconstruction parameters

- 1/ Reconstruction field-of-view
- 2/ Slice thickness selection
- 3/ Slice increment
- 4/ Reconstruction filters
- 4/ Multi-cycle reconstruction algorithms (combining data from multiple heart cycles)

2.4 Contrast injection protocols

- 1/ Single and multi-phase injection protocols
- 2/ Saline bolus chasing
- 3/ X-ray attenuation characteristics of iodinated contrast material
- 4/ Effect of injection protocols and iodine concentration on attenuation

3. QUALITY & SAFETY

3.1 Quality parameters and optimization techniques

- 1/ Temporal resolution
- 2/ Spatial resolution
- 3/ Contrast resolution
- 4/ Image noise

3.2 Artifacts recognition and management

- 1/ Fundamental CT artifacts
 - Scanner hardware failure
 - Partial volume artifacts
 - Beam hardening artifacts
 - Metal related artifacts
- 2/ Artifacts specific to cardiac CT
 - Slab misalignment
 - Tube modulation artifacts
 - Cardiac motion
 - Patient motion
- 3/ Image reconstruction and processing artifacts

3.3 Patient selection and contraindications

3.4 Patient instruction prior to a scan

3.5 Situation specific protocol modifications: techniques, effectiveness, consequences

- 1/ Atrial fibrillation and other arrhythmia
- 2/ Obesity
- 3/ Extensive calcifications
- 4/ Low cardiac output

3.6 Radiation

- 1/ Dose estimation principles
- 2/ Determinants of radiation dose in cardiac CT
- 3/ Dose minimization techniques and strategies
 - Longitudinal and radial tube modulation
 - ECG-triggered tube modulation
 - Effect of reducing kV and mA
 - Iterative reconstruction techniques
 - Doses associated with different scan protocols

3.7 Iodine contrast media

- 1/ Contrast media and characteristics
- 2/ Osmolality
- 3/ Adverse reactions, management and prevention
- 4/ Renal interactions, management and prevention

3.8 Peri-procedural medication: indications and contra-indications, doses and administration, effects, side-effects, interactions and complications, etc.

- 1/ Betablockers and other heart rate modulation
- 2/ Adenosine and other vasodilators for stress testing
- 3/ Anti-arrhythmic drugs (optional)
- 4/ Nitroglycerine

4. INTERPRETATION OF CT IMAGES

4.1 Appearance of cardiovascular structures on non-enhanced and enhanced CT images

4.2 Basic image display settings

- 1/ Window width
- 2/ Window level

4.3 Secondary image processing techniques (post-processing): methodology, advantages and pitfalls

- 1/ Double-oblique cross-sections
- 2/ Maximum intensity projections
- 3/ Vessel segmentation tools and curved reconstructions
- 4/ 3D rendering and display modes

4.4 Cardiac CT reporting

4.5 Coronary segmentation models

4.6 Myocardial segmentation models

5. CARDIAC ANATOMY ON CT

5.1 Shape and dimensions of the normal heart and surrounding structures

6. CORONARY CT ANGIOGRAPHY (CTA)

6.1 Coronary anatomy

- 1/ Normal anatomy
- 2/ Variant anatomy

3/ Aberrant anatomy

- Abnormal coronary origin
- Abnormal coronary courses
- Abnormal coronary termination (fistula)

6.2 Non-atherosclerotic coronary abnormalities

- 1/ M. Kawasaki
- 2/ Myocardial bridging
- 3/ External compression
- 4/ Coronary dissection

6.3 Coronary CTA for the diagnosis of angiographic CAD

- 1/ Detection of stenotic coronary artery disease
 - Diagnostic performance compared to invasive angiography
 - Diagnostic performance compared to functional tests
 - Advantages and limitations of coronary CTA
 - Factors affecting the accuracy of coronary CTA
- 2/ Bayesian principles and the interpretation of coronary CTA in clinical practice

6.4 Indications for and utility of coronary CTA in coronary artery disease

- 1/ Stable coronary artery disease (suspicion of)
- 2/ Acute chest pain
 - Practical issues of cardiac CT in the ED
 - Triple rule out technique
 - Patient selection
- 3/ Detection of occult coronary artery disease (prior to surgery)

6.5 Coronary CTA after coronary stenting

- 1/ Performance
- 2/ Limitations and challenges
- 3/ Clinical value and indications

6.6 Coronary CTA after bypass graft surgery

- 1/ Performance
- 2/ Limitations and challenges
- 3/ Clinical value and indications

6.7 Coronary CTA based interpretation of hemodynamic significance of CAD: methodology, accuracy, advantages and limitations

- 1/ Longitudinal coronary attenuation patterns
- 2/ CTA derived fractional flow reserve simulations

7. CORONARY CALCIUM IMAGING

7.1 Scan techniques and parameters

7.2 Calcium quantification methods

7.3 Prognostic value of calcium imaging

7.4 Role of calcium imaging in CAD screening

7.5 Diagnostic value of calcium imaging in symptomatic patients

7.6 Interpretation of non-coronary disease on non-enhanced CT images

- 1/ Pericardial disease
- 2/ Valvular disease
- 3/ Myocardial scar tissue

8. ATHEROSCLEROTIC PLAQUE IMAGING

8.1 Appearance of atherosclerotic plaque on contrast-enhanced cardiac CT

8.2 Ability and limitations of coronary CTA to differentiate plaque characteristics

8.3 Recognition and clinical value of characteristics associated with rupture-prone plaques

8.4 Prognostic value of coronary CTA plaque quantification

8.5 Features of plaque vulnerability on cardiac CT

9. CONGENITAL STRUCTURAL HEART DISEASE (IN ADULT PATIENTS)

9.1 Segmental sequential analysis

9.2 Atrial septum defect

9.3 Patent foramen ovale

9.4 Ventricular septum defect

9.5 Patent ductus arteriosus

9.6 Aberrant systemic or pulmonary venous return

9.7 Tetralogy of Fallot

1/ Long-term follow-up of surgery and cardiac function

9.8 Fontan circulation

1/ Venous opacification techniques

9.9 Transposition great arteries

1/ Following atrial redirection

2/ Following arterial switch

3/ Congenitally corrected

10. MYOCARDIAL IMAGING

10.1 Myocardial anatomy and dimensions

1/ Atria

2/ Ventricles

3/ Venous inflow

10.2 Morphological characteristics of cardiomyopathies on CT

1/ Hypertrophic cardiomyopathy

2/ Arrhythmogenic (right) ventricular cardiomyopathy

3/ Non-compaction cardiomyopathy

4/ Dilated cardiomyopathy

10.3 Myocardial tissue differentiation

- 1/ Adipose tissue (chronic infarction)
- 2/ Calcification (chronic infarction)
- 3/ Iron deposition (thalassemia)

10.4 Ventricular function by cardiac CT

- 1/ Global left ventricular function assessment
- 2/ Global right ventricular function assessment
- 3/ Regional wall motion abnormalities

10.5 Resting myocardial enhancement

- 1/ First-pass myocardial enhancement in relation to myocardial perfusion
 - Interpretation
 - Accuracy
 - Limitations
- 2/ Late myocardial enhancement in relation to myocardial scarring
 - Acquisition techniques
 - Interpretation
 - Accuracy
 - Limitations

10.6 Stress myocardial perfusion imaging

- 1/ Single-shot myocardial perfusion imaging to assess myocardial ischemia
 - Acquisition techniques
 - Interpretation
 - Accuracy
 - Limitations
- 2/ Time-resolved (dynamic) myocardial perfusion imaging to assess myocardial ischemia
 - Acquisition techniques
 - Interpretation
 - Accuracy
 - Limitations

11. VALVULAR HEART DISEASE

11.1 Heart valve morphology

- 1/ Bicuspid aortic valve morphology
- 2/ Valvular calcification

11.2 Possibilities and limitations of functional valve assessments by cardiac CT

- 1/ Valvular stenosis
- 2/ Valvular insufficiency

11.3 Infective endocarditis

- 1/ Ability and limitations to recognize vegetations
- 2/ Involvement of surrounding structures

11.4 Prosthetic valves

- 1/ Endocarditis
- 2/ Functional obstruction of prosthetic valves

11.5 Role of cardiac CT in percutaneous valve procedures

- 1/ Selection of candidates, devices and sizes
- 2/ Procedural guidance
- 3/ Access site assessment
- 4/ TAVI procedures
- 5/ Mitral valve interventions
- 6/ Pulmonary valve prostheses

12. MISCELLANEOUS ACQUIRED STRUCTURAL HEART DISEASE

12.1 Cardiac masses

- 1/ Identification of left atrial and left atrial appendage thrombus
- 2/ Cardiac tumors

12.2 Cardiac venous anatomy, in relation to EP procedures

12.3 Trauma

- 1/ Cardiac trauma
- 2/ Aortic trauma

12.4 Post-transplant cardiac morphology

12.5 Pericardial disease

- 1/ Effusion, characterization and quantification
- 2/ Characteristics of tamponade
- 3/ Pericarditis
- 4/ Constrictive pericarditis

12.6 Cardiac devices

- 1/ Pacemakers
- 2/ ICDs
- 3/ Atrial appendage occlusion devices
- 4/ Mechanical circulatory support devices

13. GREAT VESSELS

13.1 Thoracic aorta

- 1/ Aortic aneurysm
- 2/ Acute aortic syndrome: dissection, hematoma, penetrating ulcer
- 3/ Chronic aortic dissection, follow-up
- 4/ Aortic trauma
- 5/ Congenital aortic abnormalities (aortic coarctation, arch vessel anomalies)
- 6/ Post-surgical assessment of grafts, stents, and other interventions

13.2 Pulmonary arteries

- 1/ Pulmonary embolism
- 2/ Features of pulmonary hypertension and right ventricular pressure/volume overload

13.3 Pulmonary veins

- 1/ Aberrant pulmonary venous return
- 2/ Assessment prior to PV isolation procedures

13.4 Systemic venous return

14. CARDIAC CT IN PERSPECTIVE

14.1 Strengths and weaknesses of cardiac CT in comparison to other diagnostic techniques

- 1/ Echocardiography
- 2/ Magnetic resonance imaging
- 3/ Nuclear imaging techniques
- 4/ Invasive angiography and cross-sectional imaging techniques
- 5/ Exercise testing

14.2 Integration of cardiac CT findings, medical history and conditions and other diagnostic findings

14.3 Incremental value versus potentially inappropriate use of cardiac diagnostics

14.4 Evidence based cardiac imaging

14.4 Cardiac CT recommendations according to (multi-modality) clinical guidelines