Modern imaging techniques (3D echo, CT, MR) in the medical curriculum II.

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Teaching cardiology

- General skills
  - history taking, physical examination

- Cardiology methods
  - Routine techniques
  - Advanced imaging methods

- Decision making plans
Cardiology diagnostics

1970
Cardiology diagnostics

1970

History
Physical diagnostics
Cardiology diagnostics

1970

History
Physical diagnostics
ECG
Cardiology diagnostics

1970

History
Physical diagnostics

ECG

Chest X-ray
Cardiology diagnostics

1970

History
Physical diagnostics
ECG

Chest X-ray

Heart catheterization
Cardiology diagnostics

1970

History
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History
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ECG
Chest X-ray
Heart catheterization

XXI.

History
Physical diagnostics

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Cardiology diagnostics

1970

History
Physical diagnostics
ECG
Chest X-ray
Heart catheterization

XXI.

History
Physical diagnostics
ECG, Holter
Cardiology diagnostics

1970

History
Physical diagnostics
ECG
Chest X-ray
Heart catheterization

XXI.

History
Physical diagnostics
ECG, Holter
Imaging
(Echo, CT, MR)

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Cardiology diagnostics

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<td>Heart catheterization</td>
<td>Coronarography, (PCI)</td>
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Imaging techniques

◆ A diagnostic test
  ▪ answer clinical questions
  ▪ guide treatments
  ▪ help in decision making
Choosing a diagnostic test

- **Invasive - non-invasive**
  - No radiation exposure
    - ECG, echocardiography, MR
  - Radiation exposure
    - X-ray, coronaryography, CT, nuclear imaging, PET
- **Imaging - non-imaging**
Echocardiography

◆ One of the most frequently used imaging method

◆ Able to detect all cardiology malformations
  ■ Valvular heart disease
  ■ Myocardial disease
  ■ except for coronary disease

◆ For teaching purposes multiple examples needed
Echocardiography

- Noninvasive
- Repeatable unlimitedly
- Bedside
- Complete evaluation of the heart and the great vessels
Echocardiography

- M-mode
- 2-dimensional
- Doppler
  - Pulsed-wave
  - Continuous-wave
  - Colour-coded
2-dimensional echocardiography

- Morphology
- Heart chamber size
- Valves
- Myocardial function
  - global
  - regional
- Pericardial fluid
- Guiding procedures
2D-echocardiography
2D-echocardiography
Doppler echocardiography

- **Pulsed-wave Doppler**
  - Diastolic function
  - Cardiac output

- **Continuous-wave Doppler**
  - Valvular gradients, valve area
  - Pulmonary systolic pressure
  - Contractility

- **Colour Doppler**
  - Differentiation of normal and abnormal flows
  - Assessing valvular regurgitations
  - Unexpected flows
Doppler echocardiography
Doppler echocardiography

5.5 m/s  121 Hgmm
Colour Doppler
Colour Doppler
Transoesophageal echocardiography

- "New window" to the heart
- Higher transducer frequency
- Better resolution
- Mitral valve, prosthetic valve in the near-field
- Atrial septum, atrial thrombi
- Proximal coronary branches
- Aortic pathology
Transoesophageal echocardiography

**Indications**

- Detection of the source of emboli
- Infective endocarditis
- Aortic pathology
- Prosthetic valve function and dysfunction
- Anomalies of the atrial septum, complex cong. heart diseases
- Atrial tumors and masses
- Proximal coronary arteries
- Mitral insufficiency
- Suboptimal TTE echo quality
Transoesophageal echocardiography
Transoesophageal echocardiography
Stress echocardiography

◆ New, alternative stress type
◆ More precise
  ▪ sensitivity - 80-85 %
  ▪ specificity - 90 %
◆ Dipyridamole, dobutamine, (exercise)
◆ Complementary
Stress echocardiography

**Indications**

- Non-diagnostic stress ECG
- Detection of ischaemia
- Significance of coronary heart disease
- Effect of therapy (PTCA, CABG)
- Risk stratification (postmyocardial infarction, vascular surgery)
- Myocardial viability
Imaging approaching clinical practice

- New imaging techniques
- Improve diagnostic accuracy
- Availability is restricted
  - shortage of systems
  - shortage of operators
  - research tools
- Implementation into clinical practice
Newer imaging techniques

◆ Ultrasound technology
  ▪ Contrast echocardiography
  ▪ Tissue Doppler imaging
  ▪ Real-time 3D-echocardiography
  ▪ Intracardiac echocardiography (ICE)
  ▪ IVUS, virtual histology, OCT

◆ MDCT
◆ Cardiac MR
Contrast echocardiography

- New „contrast agents” - passing the lung
- Application
  - improved endocardial definition
  - enhanced colour sensitivity
  - myocardial perfusion
- New techniques
  - „second harmonic”
  - intermittent imaging
  - „pulse inversion imaging”
  - power Doppler imaging
Myocardial contrast echo
Possible clinical applications

- Diagnosis of myocardial infarction
- Estimation of “area at risk”, success of reperfusion
- “no-reflow” phenomenon

Advantage
- No radiation exposure

Disadvantage
- special equipment
- price of contrast agents
Segmental analysis of myocardial function

Resynchronization therapy

E/E′ - diastolic function

- < 8 – normal LVEDP
- >12 – elevated LVEDP

Angle dependant
Intracardiac echocardiography (ICE)

- Catheter based technique - invasive
- Mainly during electrophysiology studies
- Intracardiac manipulations - e.g. transseptal puncture
3D-echotomography

3D data acquisition
3D-echotomography

3D data acquisition
3D-echotomography

3D data acquisition
3D-echotomography

3D data acquisition

Off-line analysis
Real-time 3D-echocardiography

Franke et al. MedicaMundi 2003
Measurement of LV mass

TomTec

QLAB

RT3DE vs. CMR

van den Bosch et al. Am J Cardiol 2006
RT3DE

EDV = 160.7 ml
ESV = 81.0 ml
EF = 49.6 %
SV = 79.7 ml

Regional
Tmsv Sel-SD = 20 ms
Tmsv Sel-Dif = 94 ms
Tmsv Sel-SD = 1.95 %
Parametric Imaging

Before CRT

- R-R Time: 638 ms
- Excursion Avg: 1.1 mm
- Excursion SD: 7.4 mm
- Excursion Max: 19.7 mm
- Excursion Min: -17.4 mm

After CRT

- R-R Time: 789 ms
- Excursion Avg: 7.1 mm
- Excursion SD: 4.0 mm
- Excursion Max: 14.9 mm
- Excursion Min: -4.3 mm
RT3DE

- 3-dimensional speckle tracking
- Ventricular contraction dynamics
- Torsion and twist
- Dysynchronia analysis
Intravascular ultrasound (IVUS)

- Invasive technique - microtransducer

- Diagnostic applications
  - detection of wall structure
  - measuring plaque volume
  - angiographically uncertain lesions
  - tissue characterization

- Postinterventional applications
Vessel anatomy
IVUS

Mechanikus greyscale pullback
Virtual histology


RF signal

VH colour code

<table>
<thead>
<tr>
<th>Material</th>
<th>Colour</th>
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<tbody>
<tr>
<td>MEDIA</td>
<td>Grey</td>
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<tr>
<td>FIBROSUS</td>
<td>Green</td>
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<tr>
<td>FIBROFATTY</td>
<td>Yellow</td>
</tr>
<tr>
<td>CALCIUM</td>
<td>White</td>
</tr>
<tr>
<td>NECROTIC CORE</td>
<td>Red</td>
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Optical Coherence Tomography (OCT)

- Near-infrared light
- High resolution
- Art conservation → diagnostic medicine
Coronary function tests

- Coronary flow reserve (CFR)
- Fractional flow reserve (FFR)
- Index of microvascular resistance (IMR)
MDCT

◆ Multidetector system - at least 16, 64 (256, 320)

◆ Heart anatomy, myocardial function

◆ CT coronary angiography
  ■ coronary stenoses
  ■ coronary anomalies
  ■ bypass grafts and stents

◆ Exclusion of suspected coronary disease - low or intermediate risk - high negative predictive value
Plaque anatomy and structure
- calcified, soft plaque - dual source CT

Vulnerable plaque detection - TCFA
- thin cap, lipid rich necrotic core - ACS
MDCT

◆ Emergency unit - “triple rule-out”

◆ chest pain
  ▪ myocardial infarction
  ▪ pulmonary embolism
  ▪ aortic dissection

◆ 24/7 service
MDCT
MDCT
MDCT
MDCT
Cardiac MR

- Magnetic resonance imaging
- 1.5 Tesla minimum
- Both anatomy and function
- No radiation
- Excellent image quality
Cardiac MR

- Left and right ventricular volumes and ejection fraction
- Systolic and diastolic function
- Coronary anatomy, anomalies
- Myocardial perfusion
- Myocardial infarction and damage - late enhancement
Cardiac MR

- Informative in all heart diseases
- Uniquely diagnostic in
  - ARVC
  - non-compaction CM
- MR angiography
MR

s3p1  s2p1  s1p1
Novel development

VScan - GE
New technologies

- Newer and newer techniques emerging
- New technologies are expensive
- Unnecessary studies are costly
- Adequate indications can improve healthcare and decrease patient’s burden
- Students should know indications and drawbacks of these new technologies without knowing technical details
Summary

- Besides physical examination routine investigational methods should be tought in details
- For basic methods (ECG) diagnostic capability required
- Basic knowledge of echocardiography (TTE, TEE, stress) - diagnostic value, limitations
- 3D-Echo, MDCT, MR - role in decision making
- Newer techniques - research tools, future implementation
- These new technologies might become widely available soon, therefore students must know about them!
Thank you for your attention!
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