Echocardiographic examinations II.

Complications of myocardial infarction, stress echocardiography, TEE

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1. COMPLICATIONS OF MYOCARDIAL INFARCTION

1.1 Myocardial ischaemia

Coronary artery obstruction leads to acute ischaemia of the corresponding myocardial area. Functional changes and subjective complaints as consequences of ischaemia develop in a definite order. In early diastolic dysfunction (within 5 seconds of the obstruction) myocardial relaxation is impaired. On account of hemodynamic changes develops systolic dysfunction (within 8 seconds) with reduced ejection fraction and cardiac output and segmental wall-motion abnormality. ECG changes occur in the acute phase of the obstruction within 18 seconds, chest pain appears within 25 seconds.

The outcome of myocardial ischaemia depends on the length of the period in which blood supply is blocked. After the obstruction is reversed (e.g. by thrombolysis, PTCA, aorta dissection surgery), blood flow returns to the coronary circulation. This is called reperfusion. During early reperfusion, the symptoms ease in a reverse order: the pain lessens, pathological ECG signs disappear, wall motion abnormality and diastolic dysfunction are restored. Approximately 30 minutes after the onset of total ischaemia, segmental myocardial dysfunction may persist for a time ranging hours to days even after ischaemia is relieved. This phenomenon is called myocardial stunning and may be engendered by intracellular Ca^{2+} accumulation. When reperfusion is incomplete, myocardial contraction breaks off but myocytes remain alive (their metabolism is maintained). This is called hibernation. Functional recovery of the hibernating myocardium may be expected in 3-6 months after myocardial blood flow returns to normal. When reperfusion fails to come, irreversible ischaemic damage occurs.

1.2 Echocardiographic methods in the diagnosis of ischaemia

There are several diagnostic procedures to assess myocardial circulation and perfusion. (1) Coronarography allows visualization of the epicardial arteries. Coronary catheterization is an invasive procedure during which a radiocontrast agent is injected into the arteries. Fluoroscopy allows visualization of the coronary arteries, their anatomy and also intraluminal narrowing. Contrast echocardiography and isotopic techniques (γ-camera, SPECT) are suitable for the assessment of myocardial microcirculation.

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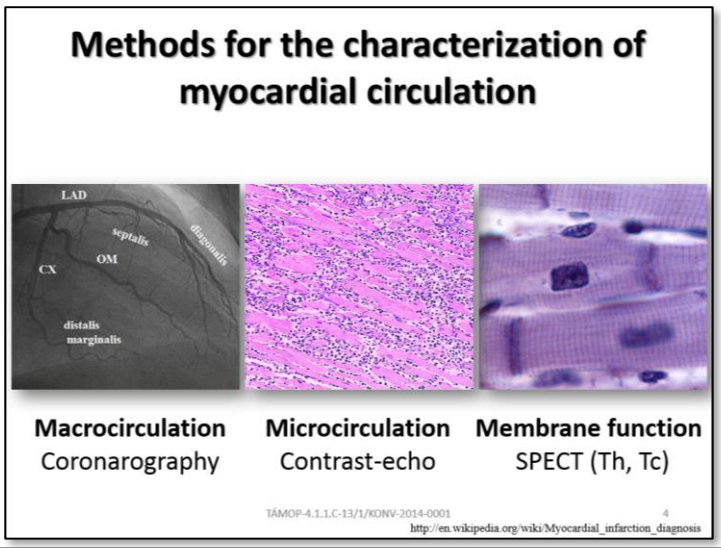

Figure 1

Methods for the characterization of myocardial circulation

(2) Contrast echocardiography applies ultrasound contrast medium as compared to traditional sonography. A traditional sonogram of the heart chambers is made before the contrast medium reaches and visualizes the cardiac tissue through the coronaries. Myocardial cells are not permeable to the ultrasound contrast medium. (3) Conversely, the radiotracer used for myocardial perfusion SPECT enters the cell-membrane, hereby characterizes membrane function and allows differentiation between reversible and irreversible perfusion defects.

Commonly, four methods are used for the assessment of ischaemic heart disease: (1) two-dimensional echocardiography (implemented with Doppler-techniques) detects the signs of a preceding myocardial infarction like wall motion abnormality, ventricular wall thinning, reduced systolic wall thickening and its complications; (2) stress echo utilizes physical stress to provoke or exacerbate existent wall motion abnormality; (3) contrast echocardiography reveals more detailed assessment of the heart chambers, severity and extent of wall motion abnormality and it is also suitable to evaluate blood flow. (4) Coronary arteries can be visualized only in restrained quality. Transoesophageal echo allows imaging and Doppler evaluation of the left main coronary artery segment and bifurcation into left anterior descending and circumflex coronary branches.

Myocardial ischaemia causes regional wall motion abnormality that can be visualized accurately by echocardiography (normokinesis: normal wall motion; akinesis: no detectable myocardial excursion in the affected region; hypokinesis: localized decrease in the amplitude and rate of myocardial excursion; dyskinesis: outward systolic bulging). The ischaemic region is thinner and shows reduced systolic wall thickening compared to the surrounding intact myocardium.

1.3 Mechanical complications of myocardial infarction

Most common mechanical complications of myocardial infarction are: pericardial effusion, left ventricular aneurysm, cordae tendineae rupture, papillary muscle rupture, ventricular septal rupture, rupture of the left ventricular free wall and mitral regurgitation.

1.3.1 Pericardiac fluid

In 20-30% of transmural infarction cases moderate-severe pericardial effusions occur. Ultrasonography reflects a dark zone between the parietal and visceral layers of the pericardium. Severe effusion may result in cardiac tamponade with the echocardiographic findings of right ventricular diastolic or right atrial early systolic collapse. Pericardial tension temporarily exceeds the intracavital tension in the right side of the heart causing diastolic right atrial/ventricular collapse.

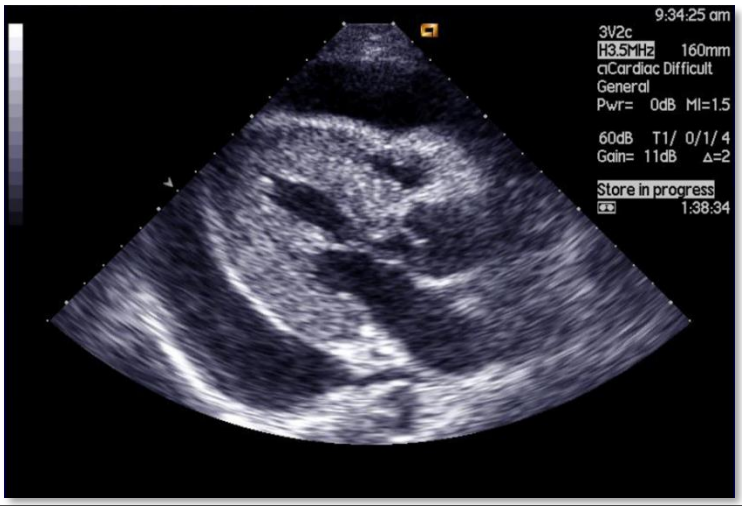

Figure 2

Pericardiac fluid

1.3.2 Left ventricular aneurysm

Aneurysm is thinning of the ischaemic region, which usually grows in the left ventricle. It may not cause symptoms, but an intraaneurysmal thrombus is prone to be formed on its inner surface and tends to spread systemic emboli. The left ventricular systolic function is reduced and heart failure may develop due to ventricular remodelling and total ventricular dilation. Ischaemic marginal regions of the aneurism may appear as arrhythmic foci.

Figure 3

Left ventricular thrombi

1.3.3 Papillary muscle rupture

Papillary muscles may also be affected by ischaemia. Papillary muscle rupture is followed by serious acute mitral regurgitation with symptoms of pulmonary oedema. It has a very high mortality rate, 3/4 of the patients die within 24 hours despite the adequate medical therapy. Surgical treatment associated with artificial mitral valve implantation must be carried out on an emergency basis.

Figure 4

Chordal rupture

1.3.4 Postinfarct ventricular septal rupture

After myocardial infarction septal perforation may occur in the necrotic tissue and a left-to-right shunt develops. Hemodynamic instability is not present in all cases, but for the defect there is a great risk of expansion. Unless surgical repair is provided, the 1-month mortality rate is more than 95%.

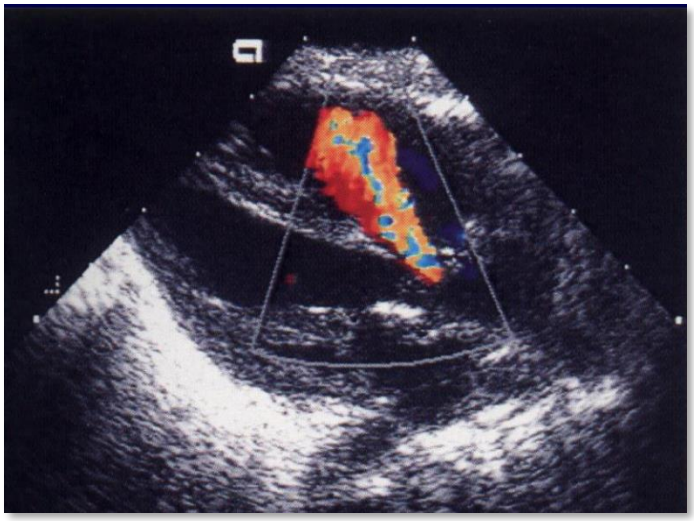

Figure 5

Postinfarct septal defect with left-right shunt (red Doppler-jet)

1.3.5 Rupture of the left ventricular free wall

Left ventricular free wall rupture is related to myocardial infarction with the clinical presentation of a sudden, strong chest pain with ST-segment and T-wave alterations due to pericardial tamponade and a rapid onset of cardiogenic shock. In most instances, it presents

within 24 hours or 4-7 days of an AMI. Complications may include an extended pericardial hematoma. The echocardiographic diagnosis of a pseudoaneurysm refers to free wall rupture. Ventricular free wall rupture means absolute indication for surgical treatment.

2. STRESS ECHOCARDIOGRAPHY

2.1 Indications

Stress echocardiography is a useful tool for the assessment of ischaemic heart disease. This method is suitable for the evaluation of cardiac ischaemia and consequent wall motion during stress provoked by exercise or a pharmacologic agent.

Main indications for stress echocardiography:

- Setting up the diagnosis of IHD
- Evaulate of IHD progression
- Assess myocardial viability
- Assess perioperative risk
- Reveal causes of dyspnoea of effort
- Localize ischaemic regions
- Diagnose diastolic heart failure
- Estimate IHD prognosis

Figure 6

Main indications for stress echocardiography

Major indications for stress echocardiography are the followings: setting up the diagnosis of ischaemic heart disease, when there is a relative contraindication for exercise stress testing (e.g. arthralgia) or when the result are ambiguous; risk assessment in preoperative settings; late prognosis assessment (e.g. after AMI); or myocardial viability assessment.

2.2 Stress echocardiography with pharmacologic agents

Two types of pharmacological agents are widely available for cardiac stress testing. (1) Normal coronary vessels are responsive to vasodilators (dipyridamole, adenosine), while stenotic vessels much less. Dilation increases blood flow rate in normal vessels, while decreases in stenotic vessels (steal-effect). This leads to poorer oxygen supply in the affected area. Consequently, ischaemia and wall motion abnormality may develop. (2) In response to positive inotropic agents (dobutamine), improved contractility and increased heart rate can be seen. Increased oxygen demand does not meet reduced oxygen supply carried through the stenotic coronaries. This leads to ischaemia and wall motion abnormality. Dobutamine in a low dose (5µg/kg/min) increases myocardial contractility while exerts no effect on heart rate, therefore it is suitable to differentiate between hibernating and stunning myocardial segments. The contractile response to low dose dobutamine improves in both cases, nevertheless, increasing doses of dobutamine (i.e. increasing heart rate) impairs contractility in the hibernating myocardium, while contractility is retained in the stunning myocardium.

Theophylline-containing medications (e.g. aminophylline) should be withheld 24 hours prior the vasodilator stress echocardiography and coffein-containing beverages should be avoided 12 hours before the test (These are competitive antagonists of the adenosine A2A receptors). After a venous access is established, 0.56 mg/kg dipyridamole is administered, followed by four minutes of no dose. If an adequate response is not achieved, then an additional

0.28 mg/kg dipyridamole is given over two minutes. If no endpoint is reached following the second infusion, atropine (doses of 0.25 mg, up to a maximum of 1 mg) may be administered. When required at the end of the test, dipyridamole effect can be suspended with aminophylline (240 mg intravenously).

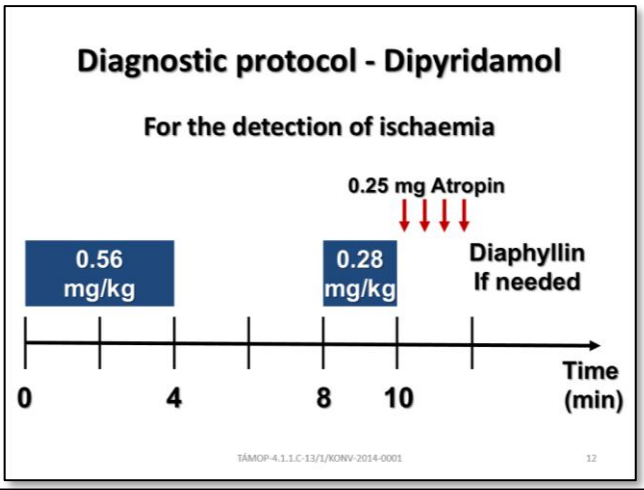

Figure 7

Protocol of dipyridamole stress echocardiography

For dobutamine stress echo, graded dobutamine infusion is administered in three-minute stages starting at 10 µg/kg/min, followed by 20, 30, up to 40 µg/kg/min. When dobutamine does not provoke wall motion abnormality, 0.25 mg atropine (repeating 3 times to a maximum of 1 mg) can be used to provoke symptoms. When required at the end of the test, dobutamine effect can be suspended with beta-blockers.

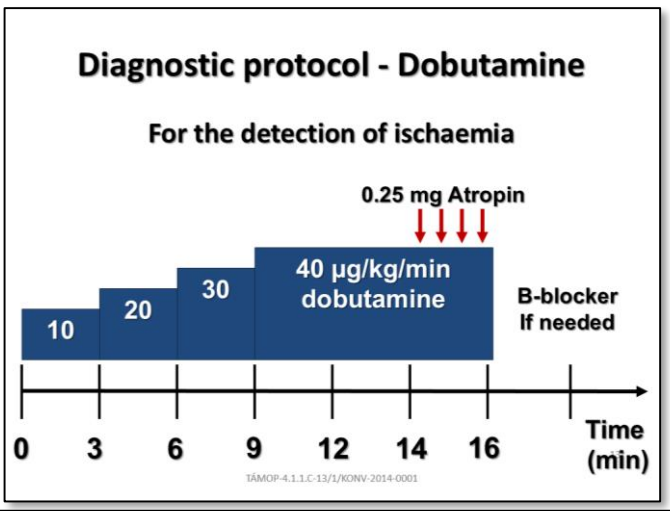

Figure 8

Protocol of dobutamine stress echocardiography

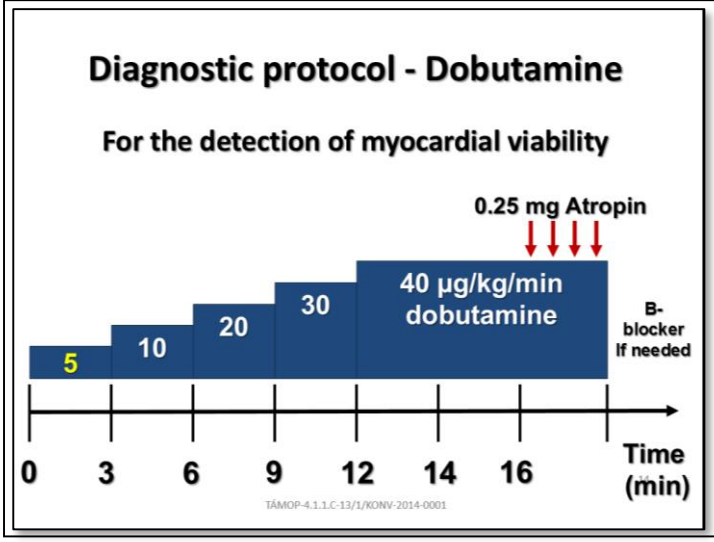

Figure 9

Diagnostic protocol for the detection of myocardial viability

2.3 Wall motion-score

Wall motion-score index is a less widely used semi-quantitative method for evaluating regional left ventricular function. All segments of the left ventricle are evaluated and scored on the basis of motion and thickening. Hiperkinetic segments: 0 score, normokinetic segments: 1 score, hipokinetic segments: 2 scores, akinetic segments: 3 scores, diskinetic segments: 4 scores, aneurysm: 5 scores.

Wall motion scoring:

Hyperkinesis	**0**
Normokinesis	**1**
Hipokinesis	**2**
Akinesis	**3**
Dyskinesis	**4**
Aneurysmatic wall motion	**5**

Figure 10

Wall motion scoring

Wall motion-score (WMSI) index is derived as a sum of all scores divided by the number of sements. 1 score refers to normal wall motion, while greater score indicates abnormality. Greater WMSI score indicates more impaired ventricular function and greater extent of wall motion abnormality.

Calculation of wall motion score index (WMSI):

$$\text{WMSI} = \frac{\text{Wall motion score}}{\text{Number od segments}}$$

Figure 11

Calculation of wall motion score index

3. MYOCARDIAL DOPPLER-ECHOCARDIOGRAPHY

Colour Doppler-echocardiography is a suitable method to assess the direction and velocity of wall motion. Flow toward the transducer is encoded in red and flow away from the transducer is encoded in blue. Lighter shades are assigned to higher velocities, while darker shades are assigned to lower velocities. Ultrasound scanners evaluate only segments of low velocity (5-30cm/sec), thus high velocity blood flow (0.3-8m/sec) is not visualized.

Main indications for myocardial Doppler-echocardiography:

- Assessment of global myocardial systolic and diastolic function in rest
- Arrhythmia analysis
- Assessment of cardiomyopathy
- Estimation of increased left ventricular preload (mitral E / annular Ea ratio increased)
- Assessment of local ischeamia and viability (combined with dobutamine stress-echo)
- Optimization and follow-up of resynchronization therapy

Figure 12

Indications for Myocardial Doppler-echocardiography

Indications of colour Doppler-echocardiography include qualitative assessment of wall motion at rest and during stress, analysis of arrhythmias, diagnosing cardiomyopathies and optimization of resynchronization therapy. Colour-Doppler is a very sensitive method for the recognition of acute myocardial ischaemia. Late systolic contraction is characteristic for the ischaemic region. Early diastolic velocity decreases while late diastolic velocity increases when relaxation is abnormal. Decrease in the velocity gradient, determined by the epicardial and endocardial velocities, is related to certain diseases (e.g. amiloidosis).

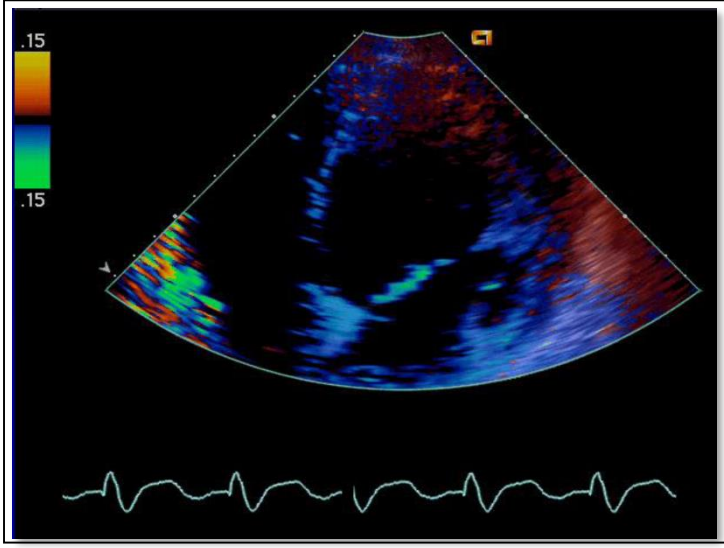

Figure 13

Myocardial Doppler-echo: 4-chamber view, ischaemia in the lateral wall

Pulse-wave tissue Doppler allows exact measurement of velocity of the myocardial segments. Sound signals are calculated at arbitrary points in the 2D image and velocity is represented vs. time. Systolic velocity is above, while diastolic velocity is under the zero

frequency line. Pulse-wave tissue Doppler enables evaluation of diastolic disfunction, thus this method is useful in the diagnosis and characterization of diastolic heart failure.

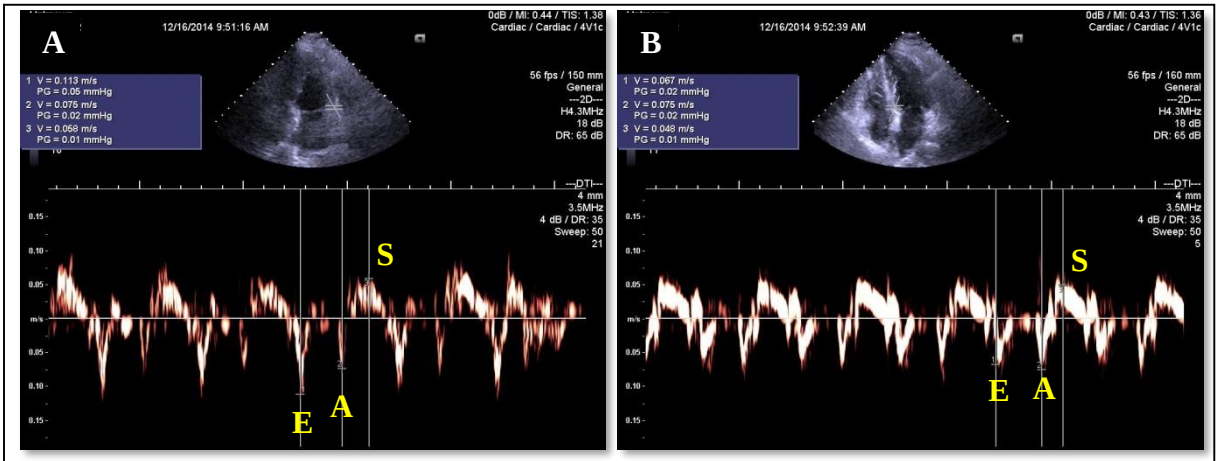

Figure 14

Pulse-wave tissue Doppler, A: normal B: impaired relaxation; S: systolic velocity E: early diastolic velocity, A: late diastolic velocity

4. CONTRAST ECHOCARDIOGRAPHY

The basic concept of this technique is underlied by the following phenomenon: when the contrast agent is injected intravenously several microbubbles evolve. Ultrasound is scattered from the gas/blood interface and is displayed as a white signal. Physiological or isotonic saline solutions, macromolecular agents (e.g. polygelin) or stabilized microbubble contrast agents (e.g. Optison, Sonoview) are also suitable for this use.

Circulating contrast agents allow imaging of the four heart chambers. Contrast echocardiography enables assessment of heart anatomy, identification of cardiac shunts and more precise description of wall motion abnormalities. The contrast agent enters the myocardial tissue hence provide information on myocardial perfusion. Contrast echocardiography, similar to perfusion scintigraphy, is a suitable technique to localize hypoperfused or not perfused myocardial areas after infarction. In contrast to SPECT (thallium scintigraphy), myocyte cell membrane is impermeable to the contrast agent, therefore contrast echocardiography in not an adequate tool for the assessment of membrane function.

Main indications for contrast echocardiography:

- Visualization of shunts
- Visualization of wall motion disturbances
- Examination of no-reflow after thrombolysis
- Visualization of hibernated myocardium

Figure 15.

Main indications for contrast echocardiography

Despite the advantages of contrast echocardiography, like safety (no radioisotopes are used), low cost (at present no subsidies are granted for contrast agents by the Hungarian Healthcare Insurance Fund) and lower risk (e.g. renal insufficiency) compared to other non-invasive diagnostic techniques, it remains limited by low persistence of contrast agent in the

blood stream (after 5-15 minutes repeated injection may be necessary when image quality is suboptimal).

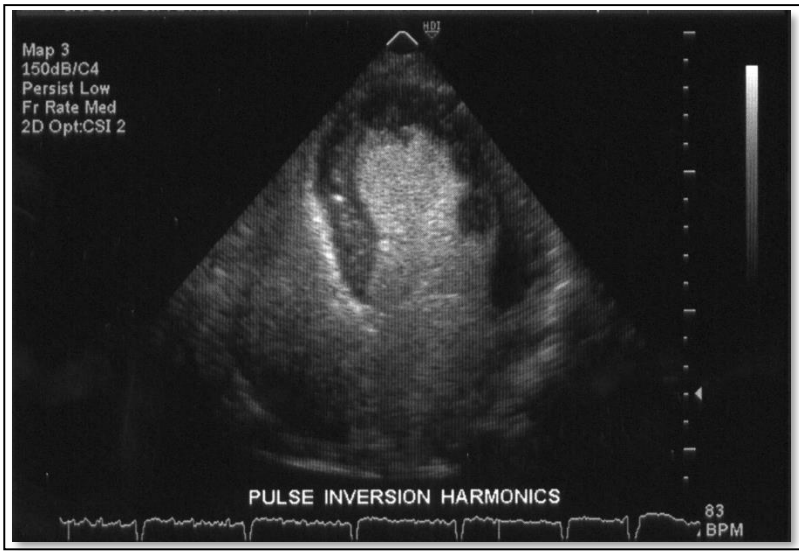

Figure 16

Contrast agent improves visualization of the left ventricle

5. TRANSOESOPHAGEAL ECHOCARDIOGRAPHY

Transoesophageal echo is a semi-invasive, alternative way to perform an echo. Patient preparation includes at least 4 hours of fasting, established venous access (for contrast agent injection, premedication and side effect treatment) and local anesthesia. During this procedure a probe containing an ultrasound transducer is passed into the patient's oesophagus. Commonly, a rotating multiplane 12-14 mm TEE probe is used for the procedure.

5.1 Indications, contraindications

Transoesophageal echo is reserved for suspected pathologies, when cardiac structures could be less well visualized on transthoracic echocardiography and TEE is the initial test of choice for a variety of clinical indications.

The most common indications of TEE are to evaluate suspected cardiac source of embolia, to diagnose infective endocarditis, to assess the severity of mitral insufficiency, to evaluate prosthetic valve function/dysfunction, congenial heart disease, atrial thrombus or tumour, proximal segment of the coronary artery, aorta dissection and aneurysm, rupture of cordae tendinae, and to assess clinical situations with acute or chronic pulmonary embolism in the anamnesis.

Indications for TEE:

- Visualization of shunts
- Visualization of wall motion disturbances
- Cardioembolic diseases
- Infective endocarditis
- Analysis of prosthetic valve function/disfunction
- Congenital vitium
- Aortic diseases (dissection, aneurysm)

Figure 17

Main indications for transoesophageal echocardiography

TEE has no contraindications for cardiologic reasons. Certain clinical conditions (e.g. oesophagus stricture, diverticulum, tumor) predispose for increased risk of adverse outcome.

Relative contraindications of TEE

- oesophagus stricture
- oesophagus diverticle
- oesophagus tumor
- irradiation to the oesophageal region

Figure 18

Relative contraindications of transoesophageal echocardiography

5.2 Advantages and disadvantages of TEE

Main advantages of TEE are the followings: superior image quality in clinical conditions that may interfere with imaging on TTE (e.g. emphysema, obesity), more optimal penetration depth, more accurate assessment of heart structures which are not or less well visualized on transthoracic echocardiography (e.g. left auricle, aorta, coronaries). Disadvantages of TEE include discomfort during insertion of the probe, conscious sedation and possible complications (e.g. oesophagus perforation, laryngospasm, arrhythmia).

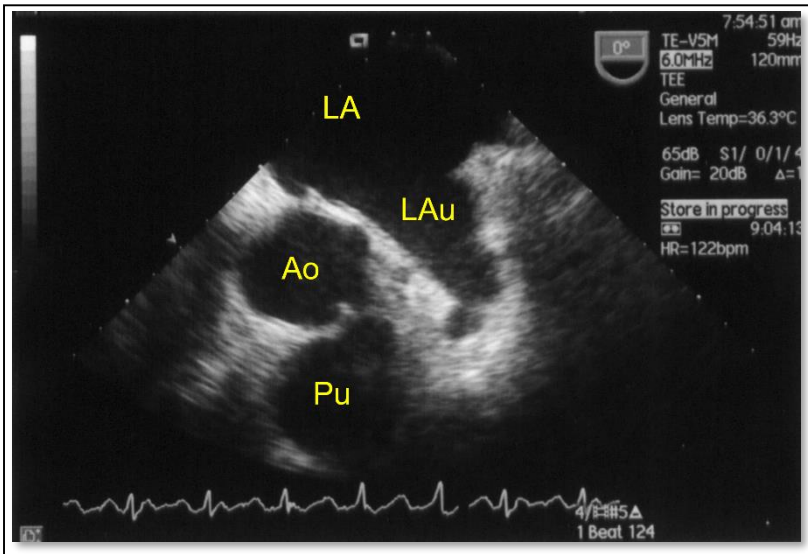

Figure 19

Vizualization of left auricle (LAu) with TEE

LA: left atrium, Ao: aorta, Pu: pulmonary artery

6. CASE PRESENTATIONS

Case presentation 1 – Atrial septal defect

Transthoracic echocardiography was performed as routine examination for a 44 year-old female patient with hypertension. The echo findings supposed the existence of atrial septal defect. The patient has no cardiac complaints. Family history is positive for acute myocardial infarction (mother) and hypertension (father). Transoesophageal echocardiography (TEE) confirmes the diagnosis. As a premedication topical lidocaine spray and 2.5mg Dormicum® intravenously are administered before TEE.

Case presentation 2 – Prosthetic valve endocarditis

A 79 year-old male patient suffered from chronic obstructive pulmonary disease (COPD) and had been treated for hypertension for 30 years. He was implanted a prosthetic aortic valve due to severe aorta stenosis in 2002. The patient presents with bronchitis like symptoms and high temperature (39-40°C) that persists for a week despite an adequate antibiotic therapy. C-reactive protein (CRP) and procalcitonine (PCT) levels in the serum are high. Blood culture test is positive for a Gram-negative bacterium. Permanent fever and positive blood culture test suggest endocarditis. As a premedication topical lidocaine spray and 2.5mg Dormicum® intravenously are administered before TEE.

Case presentation 3 – Cardiac metastasis

A 53 year-old female patient presents with weakness and dysponea. She has the history of controlled hypertension. She had surgical resection of malignant melanoma and chemotheraphy in 2009. Chest X-ray showed focal opacities at the beginning of 2014 and CT showed brain metastasis at the end of 2014. Current transthoracic echocardiography visualises a neoplasm or a thrombus in the left ventricle. Transoesophageal echocardiography is performed to set up the diagnosis. As a premedication topical lidocaine spray and 2.5mg Dormicum® intravenously are administered before TEE.

Case presentation 4 – Left auricular thrombus

Controlled hypertension, appendectomy and cholecystectomy are in the history of a 56 year-old female patient. The patient complains of irregular heartbeat which is present for a week. Atrial fibrillation can be detected on the ECG strip. Cardioversion is planned to restore sinus rhythm. Transoesophageal echocardiography is performed to exclude the presence of a cardiac thrombus. As a premedication topical lidocaine spray and 2.5mg Dormicum® intravenously are administered before TEE.

Case presentation 5 – Aortic thrombus

Controlled hypertension, renal artery stricture (30-55%) and significant carotid artery stenosis are present in the history of a 68 year-old female patient. Currently, carotid endarterectomy is planned due to the presence of an aortic arch or descending aorta thrombus. Transesophageal echocardiography is performed to exclude the presence of the thrombus. As a premedication topical lidocaine spray and 2.5mg Dormicum® intravenously are administered before TEE.

7. REVIEW QUESTIONS

1. What is the difference between myocardial stunning and hibernation?

Approximately 30 minutes after the onset of total ischaemia, segmental myocardial dysfunction may persist for a time ranging hours to days even after ischaemia is relieved. This phenomenon is called myocardial stunning. When reperfusion is incomplete, myocardial contraction breaks off but myocytes remain alive (their metabolism is maintained). This is called hibernation.

2. What echo modalities are used for detection of ischaemic heart disease?

two-dimensional echocardiography, stress-echocardiography, Doppler myocardial imaging, contrast echocardiography, transesophageal echocardiography

3. Which are the most common complications of myocardial infarction visualized on echocardiography?

pericardial effusion, left ventricular aneurysm, cordae tendineae rupture, papillary muscle rupture, ventricular septal rupture, rupture of the left ventricular free wall and mitral regurgitation

4. Which agents are used when performing pharmacologic stress echocardiography?

positive inotropic agents eg. dobutamine; vasodilators eg. dipyridamole, adenozine

5. What is wall motion score index (WMSI)?

Quotient of the left ventricular wall motion score and the number of analysed segments.

6. What are the clinical applications of myocardial Doppler echocardiography?

Ischaemic heart diseases, acute myocardial infarction, systolic and diastolic heart failure, arrhythms, cardiomyopathies, heart amyloidosis etc

7. What are the clinical applications of contrast echocardiography?

Septum defects, ischaemic heart diseases

8. What are the clinical indications and contraindications for use of transesophageal echocardiography?

Main indications for TEE: visualization of shunts, visualization of wall motion disturbances, cardioembolic diseases, infective endocarditis, analysis of prosthetic valve function/disfunction, congenital vitium, aortic diseases (dissection, aneurysm). TEE has no (absolute) contraindications for cardiologic reasons

8. TEST QUESTIONS

1. Choose one correct answer. The order of manifestation of acute ischaemia symptoms is:

a. chest pain, ECG abnormality, decreased EF, diastolic dysfunction
b. ECG abnormality, chest pain, decreased EF, diastolic dysfunction
c. diastolic dysfunction, decreased EF, ECG abnormality, chest pain
d. diastolic dysfunction, ECG abnormality, decreased EF, chest pain
e. chest pain, diastolic dysfunction, decreased EF, ECG abnormality

2. Choose one <u>correct</u> answer. The symptoms of short-term acute ischaemia disappear during reperfusion in the following order:

a. chest pain, ECG abnormality, decreased EF, diastolic dysfunction
b. ECG abnormality, chest pain, decreased EF, diastolic dysfunction
c. diastolic dysfunction, decreased EF, ECG abnormality, chest pain
d. diastolic dysfunction, ECG abnormality, decreased EF, chest pain
e. chest pain, diastolic dysfunction, decreased EF, ECG abnormality

3. Choose one <u>correct</u> answer. The order of manifestation of acute ischaemia symptoms is:

a. impaired myocardial relaxation, segmental wall motion abnormality, T-wave inversion, pressing chest pain
b. pressing chest pain, impaired myocardial relaxation, segmental wall motion abnormality, T-wave inversion
c. T-wave inversion, pressing chest pain, impaired myocardial relaxation, segmental wall motion abnormality
d. segmental wall motion abnormality, T-wave inversion, pressing chest pain, impaired myocardial relaxation
e. pressing chest pain, segmental wall motion abnormality, impaired myocardial relaxation, T-wave inversion

4. Choose one <u>correct</u> answer. The following is true for hibernating myocardium:

a. intact metabolism and intact contractile function
b. intact metabolism, abnormal contractile function
c. decreased metabolism, intact contractile function
d. decreased metabolism, abnormal contractile function
e. increased metabolism, intact contractile function

5. Choose one <u>correct</u> answer. The following is true for stunned myocardium:

a. myocardial perfusion is intact, no wall motion abnormality is detectable
b. lack of myocardial blood flow, no wall motion abnormality is detectable
c. lack of myocardial blood flow, wall motion abnormality is detectable
d. increased myocardial perfusion, no wall motion abnormality is detectable
e. myocardial perfusion is intact, wall motion abnormality is detectable

6. Choose one <u>false</u> answer. 2-dimensional echocardiography is suitable for the evaluation of the followings:

a. wall motion abnormalities
b. ventricular myocardium thickness
c. distal coronary arteries
d. complications of myocardial infarction
e. ventricular thickening during systole

7. Choose one <u>correct</u> answer. True for dyskinesis:

a. wall motion of the affected myocardial segment is normal
b. the affected myocardial segment bulges paradoxically during systole

c. the affected myocardial segment moves slower
d. the affected myocardial segment has no motion
e. the affected myocardial segment moves faster

8. Choose one <u>false</u> answer. The most common complications of acute myocardial infarction are:

a. chordal rupture
b. pericardial effusion
c. septal defect
d. aorta aneurysm
e. mitral regurgitation

9. Choose one <u>correct</u> answer. Right ventricle early diastolic collapse may associate with:

a. chordal rupture
b. right ventricular thrombus
c. septal defect
d. aorta aneurysm
e. pericardial effusion

10. Choose one <u>false</u> answer. Stress echocardiography is recommended:

a. to diagnose myocarditis
b. to evaluate myocardial viability
c. for perioperative risk assessment
d. when the patient is not able to perform exercise stress test
e. to localize ischaemia

11. Choose one <u>correct</u> answer. Stress echocardiography is able to differenciate between hibernating and stunned myocardium. Which of the following medications is used for the test?

a. high dose dobutamine (10μg/kg/min)
b. low dose dipyridamole (0,28mg/kg)
c. stress echo is not an option to mark out hibernating myocardium from stunned myocardium
d. high dose dipyridamole (0,56mg/kg)
e. low dose dobutamine (5μg/kg/min)

12. Choose one <u>correct</u> answer. Which drug is administered at the end of stress echo testing to suspendt dipyridamole effect?

a. adrenaline
b. adenosine
c. β-blocker
d. aminophylline
e. atropine

13. Choose one <u>correct</u> answer. Wall motion score index is derived from the values of all visualized segments. What is the value of WMSI when only normokinesis is detected in all visualized segments?

a. 0
b. smaller than 1
c. 1
d. higher than 1
e. 10

14. Choose one <u>correct</u> answer. What is the value of WMSI when akinesis is detected in 2 segments but normokinesis in all the others?

a. 0
b. smaller than 1
c. 1
d. higher than 1
e. 10

15. Choose one <u>correct</u> answer. What is the value of WMSI when aneurysmatic movement is detected in 1 segment but normokinesis in all the others?

a. 0
b. smaller than 1
c. 1
d. higher than 1
e. 10

16. Choose one <u>false</u> answer. Recommended indication for myocardial Doppler-echocardiography:

a. arrythmia assessment
b. quantitative assessment of wall motion abnormalities
c. cardiomyopathy evaluation
d. optimization of cardiac resynchronization therapy
e. detection of mitral vave prolapse

17. Choose one <u>false</u> answer. Clinical application of contrast-echokardiography:

a. assessment of heart chambers
b. diagnosing wall motion abnormality
c. membrane function assessment
d. evaluation of myocardial perfusion
e. shunt detection

18. Choose one <u>false</u> answer. The contrast agent for echocardiography:

a. physiological solutions and isotonic saline solutions can be used
b. stabilized microbubble containing solution
c. commonly, administered via a peripheral vein

d. provides durable enhanced signal delineation (approximately 1 hour)
e. unable to transverse not perfused areas

19. Choose one <u>correct</u> answer. Absolute contraindication of transoesophageal echocardiography for cardiologic reason:

a. thrombus in the left auricle
b. atrial fibrillation
c. ischaemic heart disease
d. dilatative cardiomyopathy
e. ther is no absolute contraindication for cardiologic reason

20. Choose one <u>false</u> answer. Transoesophageal echocardiography is contraindicated in case of:

a. severe oesophageal stricture
b. atrial fibrillation
c. large oesophageal diverticulum
d. neglected oesophageal tumor
e. forein body in the oesophagus

21. Choose one <u>false</u> answer. Recommended indication for transoesophageal echocardiography:

a. to evaluate suspected cardiac source of embolia
b. to evaluate atrial thrombus trombus in the left auricle
c. to diagnose an atrial tumor
d. to assess distal coronary arteries
e. to evaluate the severity of mitral insufficiency

Key:

1	***C***	**6**	***C***	**11**	***E***	**16**	***E***	**21**	***D***
2	***A***	**7**	***B***	**12**	***D***	**17**	***C***		
3	***A***	**8**	***D***	**13**	***C***	**18**	***D***		
4	***B***	**9**	***E***	**14**	***D***	**19**	***E***		
5	***E***	**10**	***A***	**15**	***D***	**20**	***B***		

9. REFERENCES

[1] HEGEDŰS Ida: Echokatdiográfiás CD-atlasz. Minerva Kiadó, 2003. ISBN 963 86297 7 0

[2] CZURIGA István, ÉDES István, MERKELY Béla, PRÉDA István: Kardiológia. Alapok és irányelvek. Medicina Kiadó, 2010. ISBN 978 96322612 0 1

[3] CSERNI István: Kardiológiai Útmutató 2010. Echokardiográfia. Medition Kiadó, 2010

[4] W. J. MANNING, J. P. KANNAN: Transesophageal echocardiography: Indications, complications, and normal views. UpToDate. Letöltve: 2015.01.28. URL: http://www.uptodate.com/contents/transesophageal-echocardiography-indications-complications-and-normal-views?source=search_result&search=transesophageal+echocardiography&selectedTitle=1%7E150

[5] W. J. MANNING: Transthoracic echocardiography: Normal cardiac anatomy and tomographic views. UpToDate. Letöltve: 2015.01.28. URL: http://www.uptodate.com/contents/transthoracic-echocardiography-normal-cardiac-anatomy-and-tomographic-views?source=search_result&search=transthroracic+echocardiography&selectedTitle=1%7E150

[6] A: M: ARRUDA-OLSON: Overview of stress echocardiography. UpToDate. Letöltve: 2015.01.28. URL: http://www.uptodate.com/contents/overview-of-stress-echocardiography?source=search_result&search=stress+echocardiography&selectedTitle=1%7E95

[7] J. GORCSAN: Tissue Doppler echocardiography. UpToDate. Letöltve: 2015.01.28. URL: http://www.uptodate.com/contents/tissue-doppler-echocardiography?source=search_result&search=tissue+doppler+echocardiography&selectedTitle=1%7E25