Exercise stress testing in cardiology

II Katedra i Klinika Kardiologii
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Objectives of exercise stress testing (ExST)

Diagnostics of coronary artery disease (CAD)

Estimation of risk and prognosis in subjects with diagnosed CAD or typical symptoms of CAD.

Absolute contraindications:

acute myocardial infarction (within 48 hours)

unstable coronary disease in high risk patients

uncontrolled cardiac arrythmia leading to hemodynamic disturbances or ischemic symptoms

acute endocarditis

symptomatic severe aortal valve stenosis

clinically relevant, symptomatic heart failure

acute pulmonary embolism or pulmonary infarction

acute noncardiac disease, which may negatively affects stress testing performance or which may worsen during stress testing

acute myocarditis or pericarditis

physical disability

lack of subject consent

Relative contraindications:

(test may be performed if benefits are greater than test-related risk)

left main coronary artery obstruction or its equivalent
moderate heart valve stenosis
electrolite disturbances (eg. hypo- or hyperkalemy)
tachyarrythmias and bradyarrythmias
atrial fibrillation with uncontrolled ventricule response
hypertrophic cardiomyopathy
mental disability with lack of cooperation during testing
advanced atrioventricular conduction blocks
uncontrolled hypertension (SBP>200mmHg, DBP>110mmHg)

Exercise stress testing - related risk

- According to meta-analysis: 10 myocardial infarction (MI), sudden cardiac deaths (SCD) or both for 10 000 tests
- According to Stuart - 1 MI or SCD for 2500 tested subjets
- Review of 8 studies: SCD- 0,0-5/100 000 tests
- Higher risk at myocardial infarction and arrythmia diagnostics

Methodes of stress testing performance

stationary exercise

bicycle ergometer

Methodes of stress testing performance

treadmill

Protocols used at exercise stress testing

- Clinical protocols of ExST include warm-up (small loading), escalation and continuation of exercise with increasing workload in a given time periods on every exercise level and in the rest phase.
- Bruce protocol, modified Bruce protocol and ramp- test performed on treadmill
- 50/50W protocol – bicycle ergometer

Bruce protocol on treadmill

- Disadvantages:

  - significant workload differences between exercise levels

  - eventuality of walking and running in fourth level

  - musculosceletal concerns

Advantages:

  - numerous publications

  - 3-minute levels

Ramp test - treadmill

- slow pass $\rightarrow$ long-step walking
- gradual (every 10-60 sec) increase of slope
- Workload increase calculated on subject-estimated exercise ability (6 to 12 minutes)
- Continuous increase of workload without stationary levels

Bicycle ergometer

Protocols:

- Initial workload 10 or 25 W (150 kpm/min)
- 25W increase of loading
- every 2-3 minutes

Prepare of the patient before ExST

Patients are not allowed to:

- eat
- smoke cigarettes

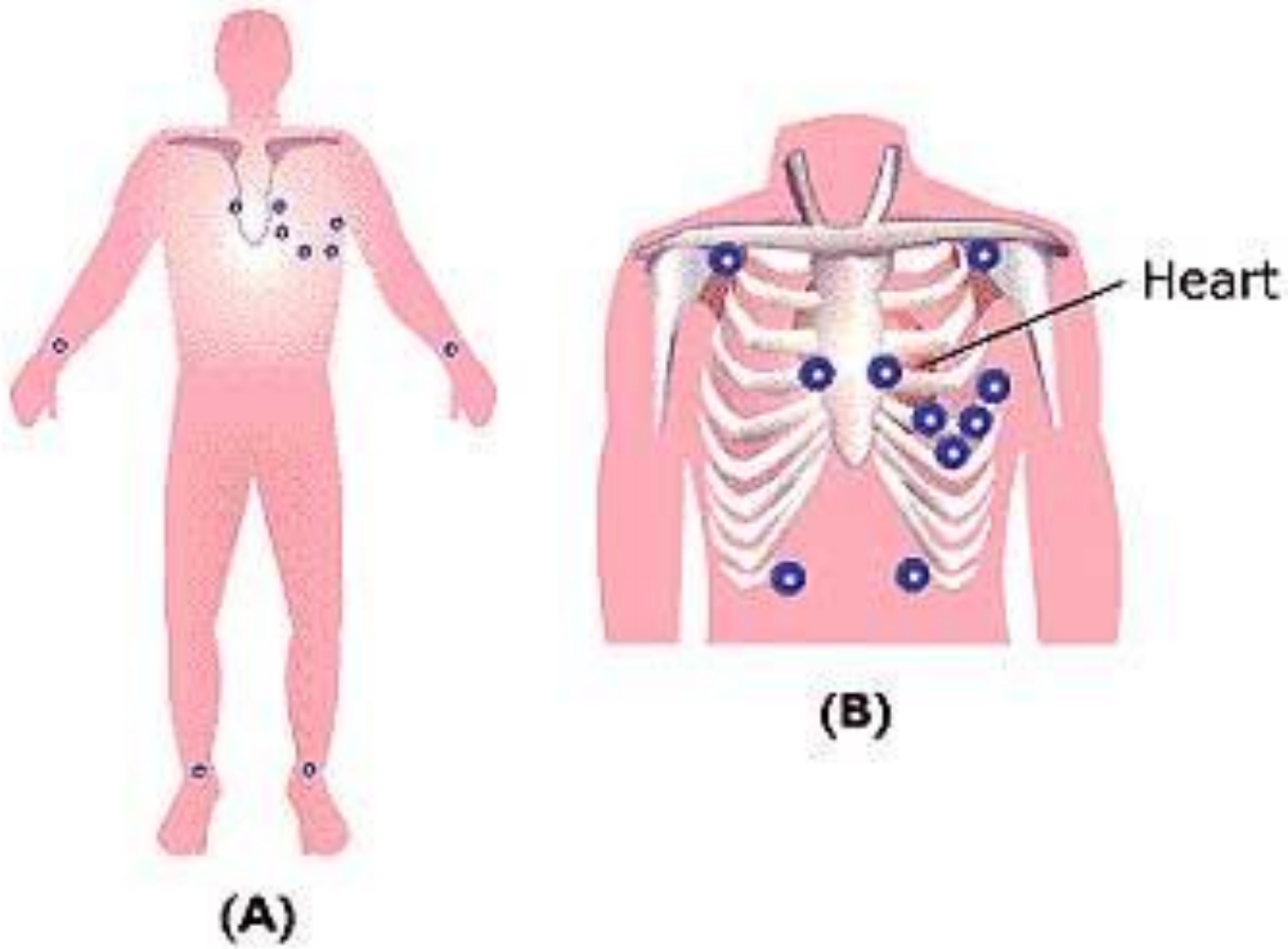
within 3 hours before

- undertake greater efforts

within 12 hours before

- take β-adrenolitic drugs (5xT1/2)
- take digoxin within 2 weeks before

Electrode placement



Electrode Placement for a Resting, Routine ECG (A) vs. Exercise Stress ECG (B)

Absolute indications for ExST discontinuation

- ST segment elevation (>1 mm) in non-Q leads (except forV_1 and aVR)
- systolic blood pressure decrease >10 mm Hg (maitaining below preexercise values) regardless workload increase if any ischemic symptoms occuring
- anginal pain (level 3-4)
- Symptoms of central nervous system disturbances, decreased peripheral perfusion symptoms (cyanosis or paleness)
- sustained ventricular tachycardia
- ECG or blood pressure monitoring difficulties
- patient request

Relative indications for ExST discontinuation

- ST segment changes or QRS disturbances: ST segment depression (horizontal or decline >2 mm) or significant changes in electric heart axis
- Systolic blood pressure decrease >10 mm Hg without other symptoms of myocardial ischemia
- Increasing chest pain
- Fatigue, dyspnoe, lung wheezes, lower limbs muscle cramps or intermittent claudation, cardiac arrythmia other than sustained ventricular tachycardia, bundle branches blocks or intraventricular conduction disturbances
- Excessive blood pressure increase (systolic pressure >250 mm Hg and[or] diastolic pressure >115 mm Hg)

Post-exercise period

- 6-8min monitoring/SBP, HR, ST segment returning nearly to preexercise period values

- 85% of abnormal post exercise reactions appear during exercise or within 5-6 minutes of resting phase

Exercise-Induced Hypotension EIH

Drop of blood pressure or low BP increse < 20-30mm Hg comparing to standing preexercise BP

- Myocardial ischemia
- Severe impairment of left ventricle function
- Left ventricle outflow tract obstruction
- Using some drugs (eg. Beta-adrenolytics)
- Prolonged and intensive physical exercise
- Dehydration

Exercise-induced drop of blood pressure

- Poor prognosis when symptoms of ischemia occure - in 50% - left main artery obstruction or three-vessel coronary disease
- Higher rate of complications during stress test
- Improvement after coronary artery by-pass graft procedure

Cardio-pulmonary exercise test (CPET)

Physical capacity

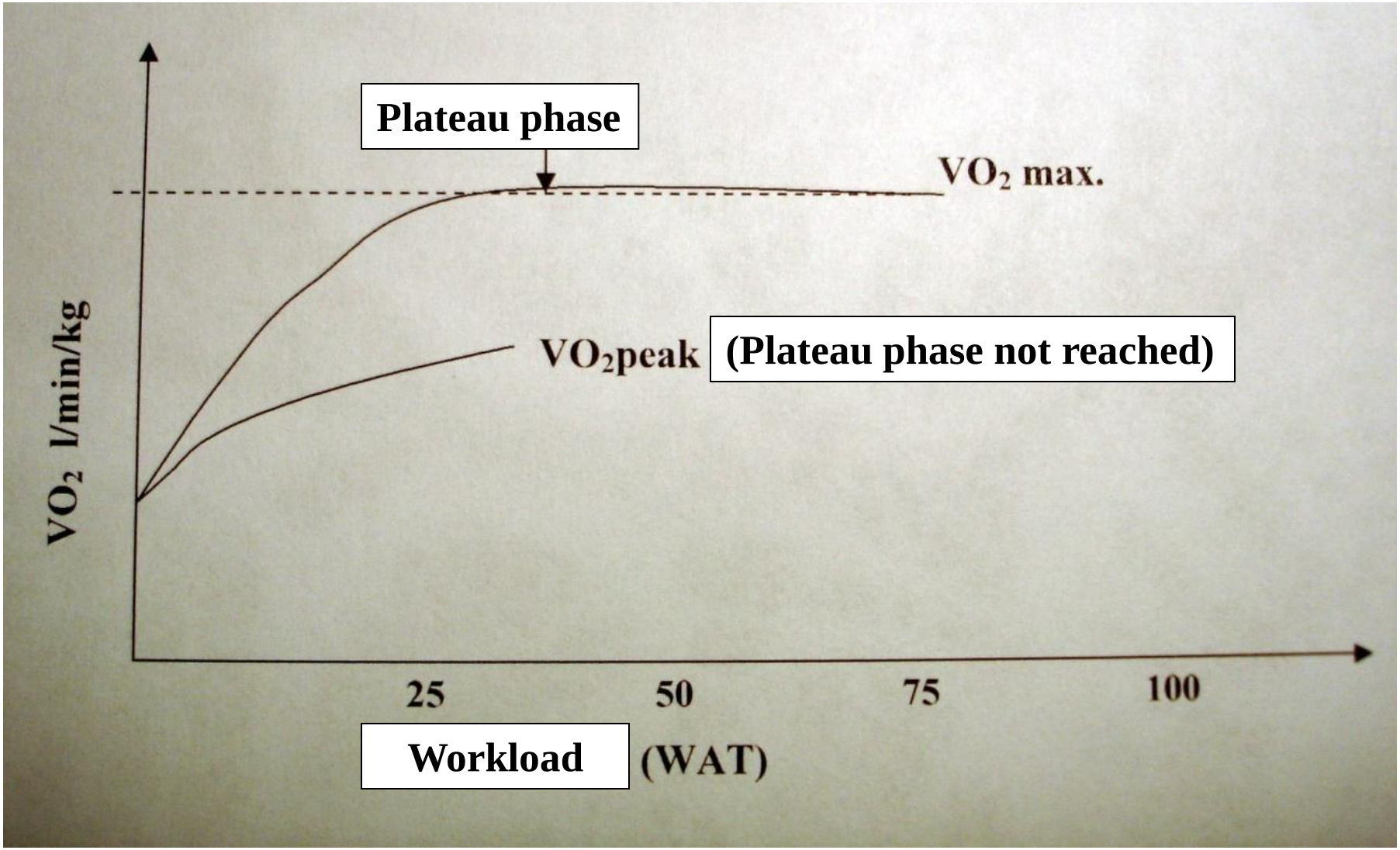
- Ability to perform physical activity using large groups of muscles which cause energy consumption greater than in rest and leads to changes in internal body environment.

- Measurement of physical capacity – total time of exercise untill maximum effort.

Physical capacity indicator

- Ability of body oxygen uptake or oxygen consumption (VO2)

VO_2max i VO_2peak

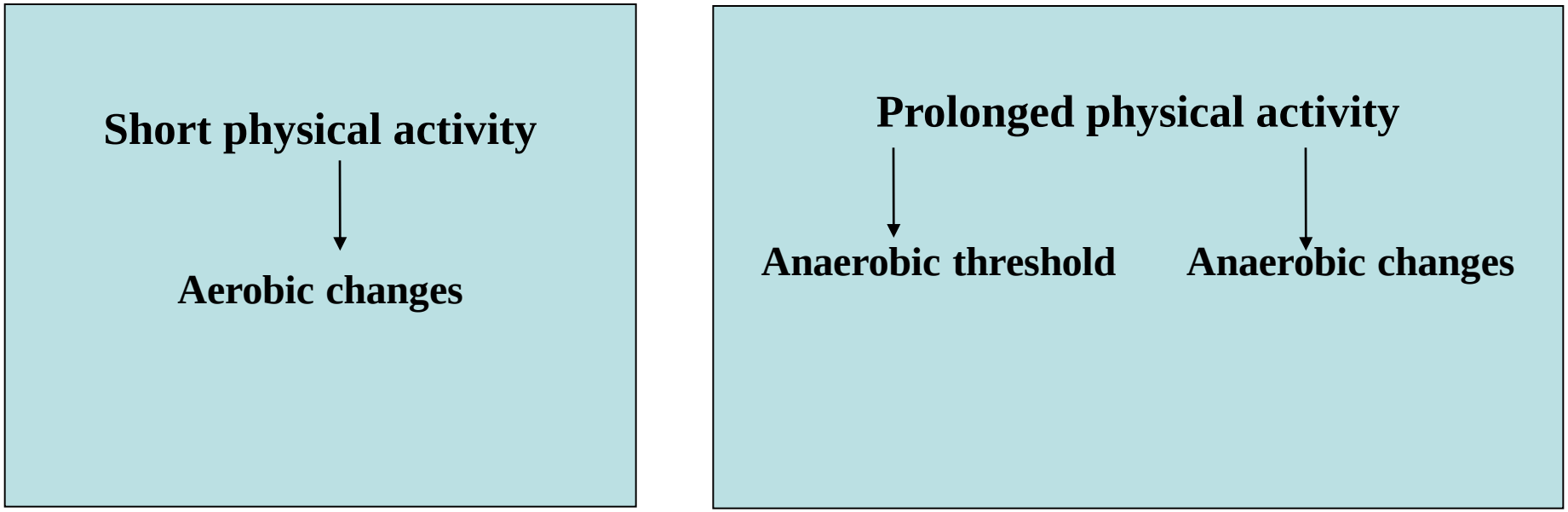


VO_2max referential values and its convert into metabolic equivalent (MET) in male and female age groups (1 MET means consumption 3.5ml/min/kg of oxygen)

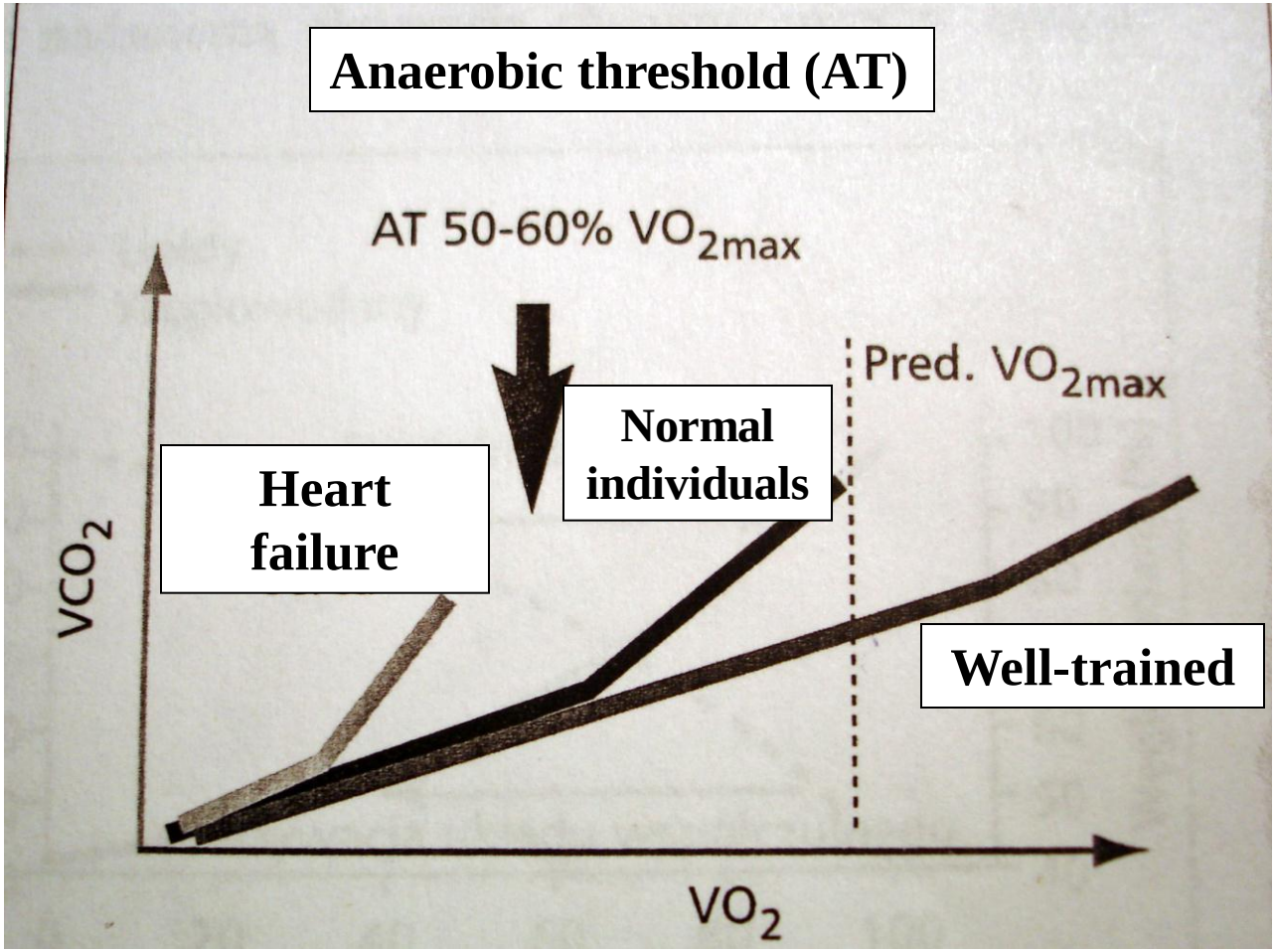
Folia Cardiol. 2004; tom 11: supl. A: A8-A19.

Age [years]	Male		Female	
	VO_2[ml/kg/min]	MET	VO_2[ml/kg/min]	MET
20-29	43 ± 7.2	12	36 ± 6.9	10
30-39	42 ± 7.0	12	34 ± 6.2	10
40-49	40 ± 7.2	11	32 ± 6.2	9
50-59	36 ± 7.1	10	29 ± 5.4	8
60-69	33 ± 7.3	9	27 ± 4.7	8
70-79	29 ± 7.3	8	27 ± 5.8	8

Metabolic changes in muscles during exercise



Próg beztlenowy AT (anaerobe threshold)



Metabolic changes in muscles during exercise

Short physical activity

↓

Aerobic changes

RER=VCO_2/VO_2 < 1

Prolonged physical activity

↓ ↓

Anaerobic threshold

RER=VCO_2/VO_2=1

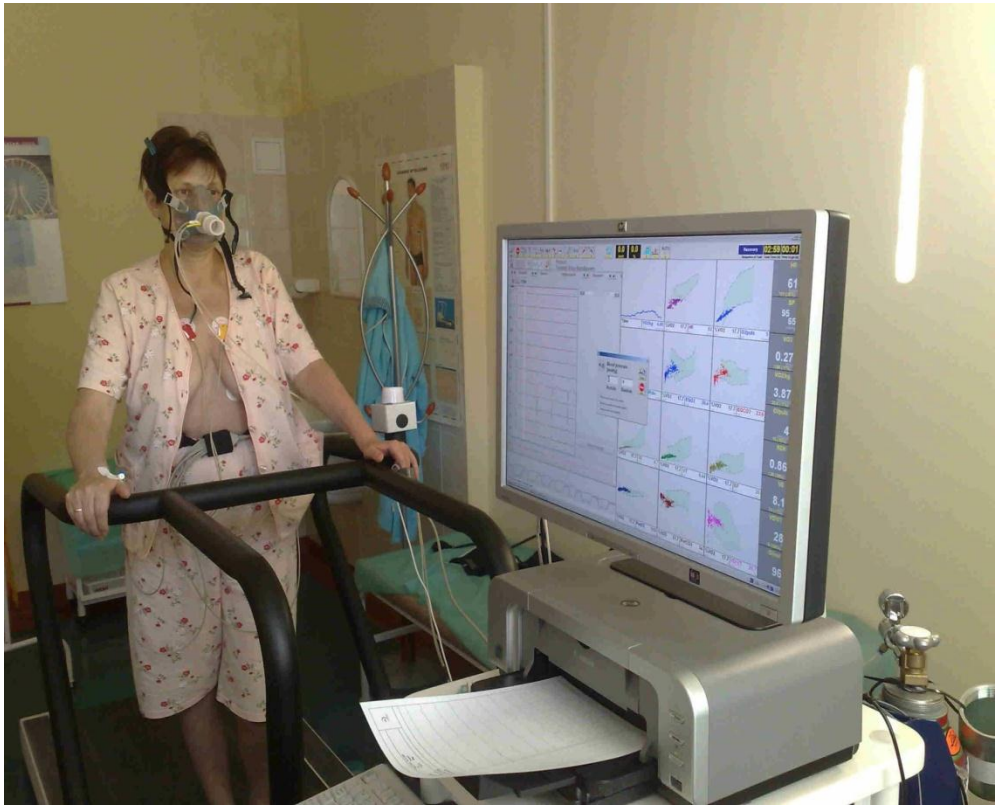
Anaerobic changes

RER=VCO_2/VO_2> 1

CPET- cardiopulmonary exercise testing)

- Combination of exercise stress test and measurement of gases in ventilatory air
- On treadmill
- On bicycle ergometer

- VO_2 3-5 ml/kg/min, RER < 0.90



Parameters determined during CPET

Cardiovascular

- **BP - blood pressure**
- **ECG** – 12-lead record
- **HR - heart rate**
- **HRR - heart rate reserve** –

  (predicted maximal HR - measured maximal HR)
  - Normal: <15 bpm
- **O_2Pulse** – O2 consumption per heart beat

Parameters determined during CPET (cont.)

Basic

- **VO_2 - oxygen uptake**
- **VO_2/kg** – oxygen uptake per weight unit
- **VCO_2 - CO_2 production**– CO2 contents in expiratory air
- **RER=VCO_2/VO_2** – respiratory exchange ratio
- **VO_2AT, VO_2/kgAT** – oxygen uptake at anaerobic therhold (when RER=1)
- **dVO_2/dWR (ml/min/W)** – physical exercise workload ratio

Parameters determined during CPET (cont.)

Ventilatory

- **VE – minute ventilation**
- **TV - Tidal Volume** –
- **BF - breath frequency**
- **BR - breathing reserve = VE max – VE reached**; difference between predictive ventilation and reached venilation
- **sat O_2** – oxygen arterial blood saturation determined by pulsoxymeter
- **EQO_2=VE/VO_2-** minute ventilation equvalent to uptake 1 litre of oxygen at given exercise level
- **$EQCO_2$=VE/VCO_2-** minute ventilation equvalent to exhale 1 litre of carbon dioxide at given exercise level
- **Wskaźnik $VE-VCO_2$-** regression curve slope

Indications for CPET

- Diagnosis
  - unexplained dyspnea
  - exercise limitation
  - documenting exercise-induced hypoxemia, titrating O2 prescription
  - exercise-induced asthma
- Assessment of **functional** exercise capacity
  - impairment or disability evaluation
  - preoperative evaluation
  - selection of patients for cardiac transplantation
  - prognosis: CF, heart or pulmonary vascular disease

Indications for CPET (cont'd)

- Exercise prescription:
  - pulmonary or cardiac rehabilitation
  - health maintenance or athletic training

- Assessing response to therapies

Contraindications to CPET

- acute ischemic changes on ECG
- unstable angina
- uncontrolled CHF
- uncontrolled dysrhythmia
- third-degree AV block
- uncontrolled hypertension (SBP>250, DBP>120)
- thrombophlebitis or intracardiac thrombi
- acute myocarditis or pericarditis
- severe AS
- acute febrile illness
- O2 saturation < 85% on RA