# Examination of arterial system

# Methods:

- Invasivity:
  - Invasive
  - Non-invasive
- Modality used in the method
  - Physical examination
  - Acoustic
  - Electromagnetic
  - Magnetic resonance
- Most methods try to verificate or visualise stenosis caused by atherosclerotic lesion

# Physical examinations

- Can be used in the neck or extremities
- Inspection – trophic changes in ischemia, pale to „marbled“ periphery of an extremity
- Auscultation – stenosis can be manifested by a murmur (turbulent flow)
- Palpation – pulse can‘t be palpated distally of obstruction, difference in temperature between healthy and ischemized extremity

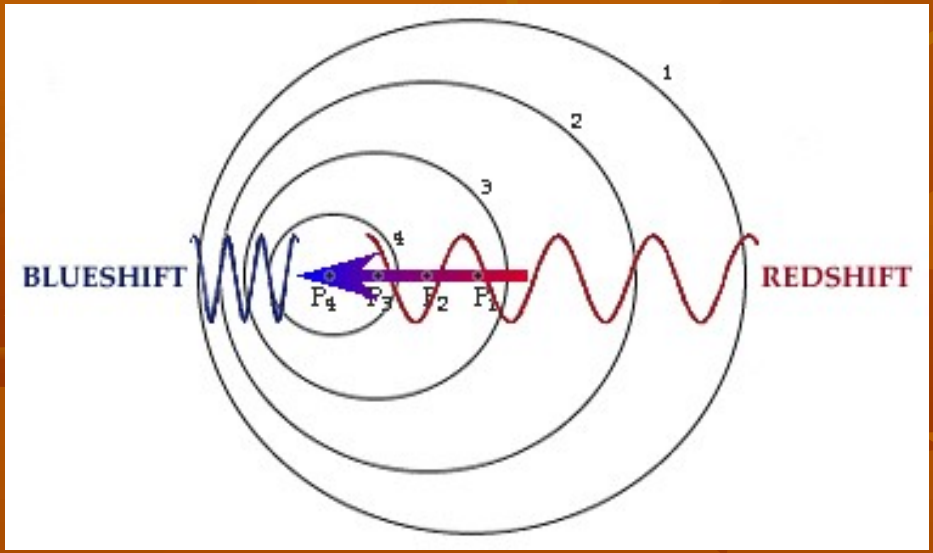
# Stress tests

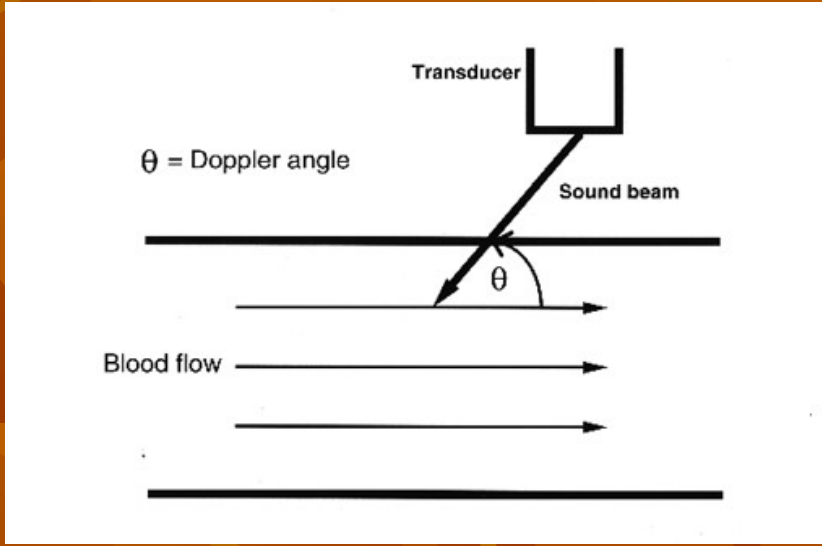
- Are used to triggering ischemia during the labour of skeletal or heart muscle, which leads into ischemic pain
- Treadmill or exercise bike can be used to provoke ischemia
- If  there is a suspicion for IHD, 12-lead ECG can be recorded to verificate ischemic changes

# UltraSonoGraphy (USG)

- In the diagnostics of atherosclerosis, two-dimensional image together with doppler examination is used (duplex USG)
- By common devices, large vessels, vessels of extremities or neck, and renal arteries can be investigated (also the heart)
- In brain arteries, modified transcranial doppler can be used

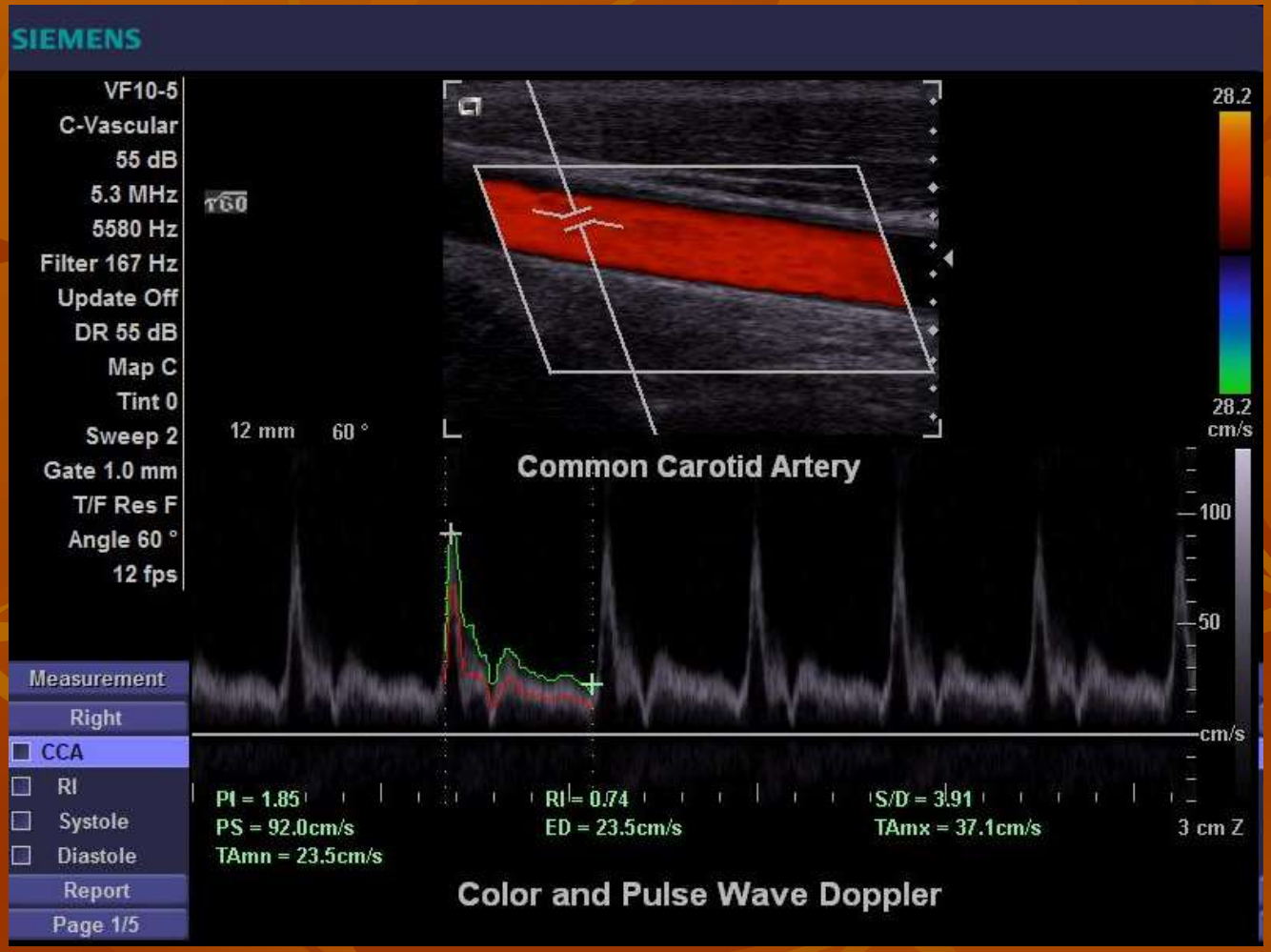
# Doppler effect




- The principle is different frequency of waves in front of and behind moving source
- Electromagnetic waves are used e.g. in astronomy or in police radars (speed measuring), acoustic waves e.g. in sonars or in medical applications
- In USG, the source and reciever is stationary, but it is reflected by moving particles (blood cells). Frequency is higher when cells move towards the source, lower when they move away

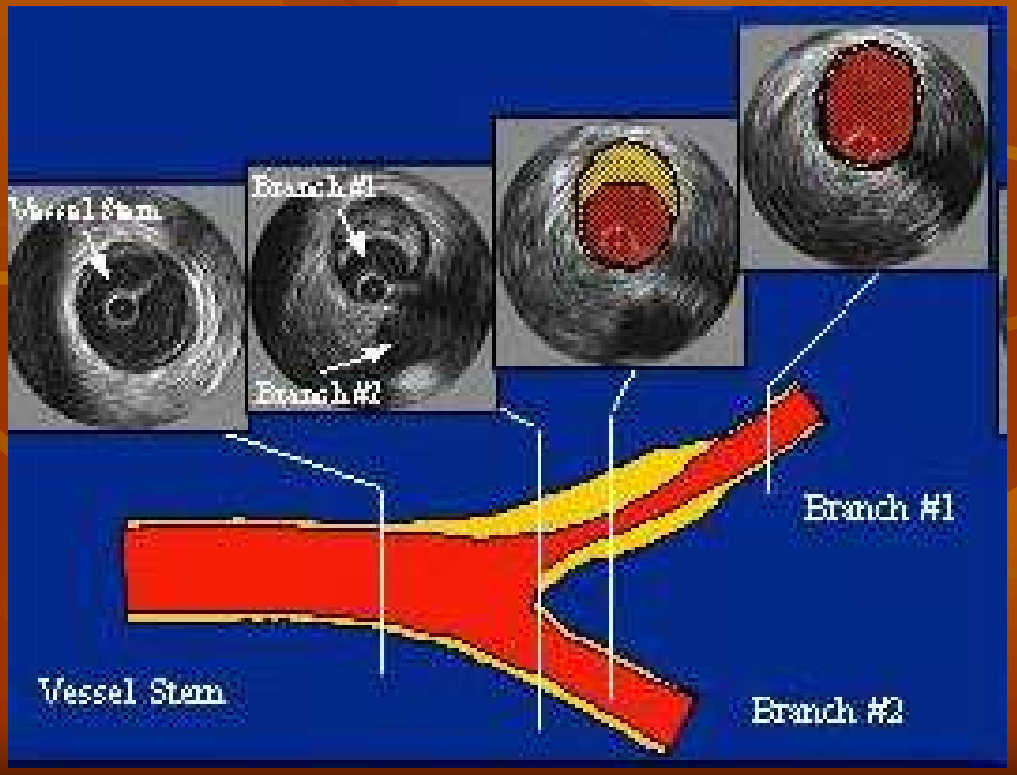
# Duplex USG – combination of 2D image and Doppler USG




! The thinner is the stenosis, the faster is the blood flow!

# IntraVascular UltraSonography (IVUS)

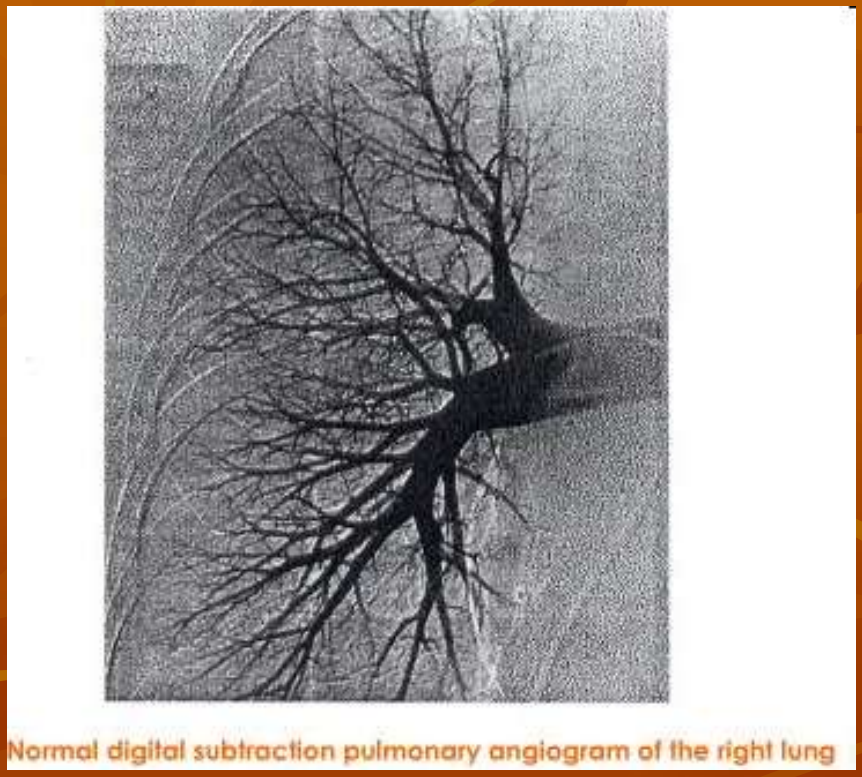
- Invasive method, used as supplement of angiographic examination
- The probe is carried by a catheter directly into the vessel to gain more exact information about the morphology of atherosclerotic lesion



# Angiography

- In wide sense all methods, where the vessels are visualized using contrast matter
- In narrow sense, it is used for skiascopy-based methods
  - Advantages: detailed view of long vessel sections
    real-time picture
  - Disadvantages: invasive method – risk of an injury (on the other hand, this can be an advantage – angioplasty)
    needs expensive equipment
    radiation load on both patient and staff
- Less invasive alternatives are CT and MR angiography

# Angiographic picture

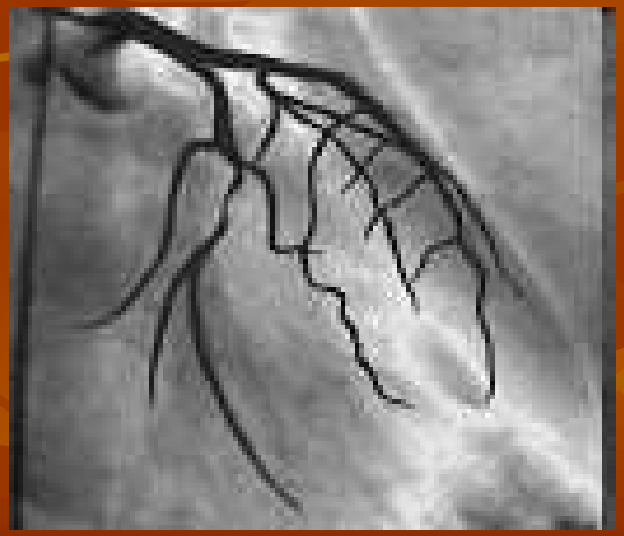


Normal digital subtraction pulmonary angiogram of the right lung

- Digital subtraction angiography – the signal noise of other tissues is digitally removed

# Coronary angiography

- After cathetrization, the contrast matter (mostly iodine) is injected into left and right coronary artery
- The examination of arteries is usually followed by visualization of left ventricle (ventriculography)
- In case of need, therapeutic intervention on the artery can be performed



# Coronary angiography 2

- Anti-radiation measures must be taken during the examination

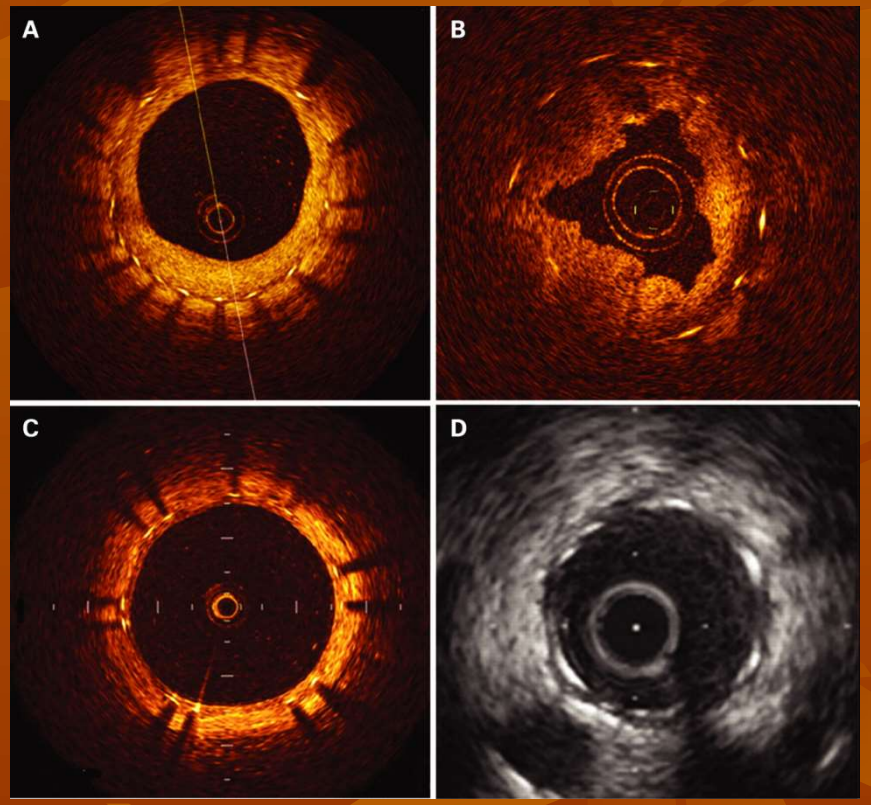
CathLab – Cathetrization Laboratory

# CT and MR angiography

- CT and MR AG can display large parts of arterial system
- In MR angiography, there is not radiation exposition
- As a disadvantage, there is not a possibility of real-time picture and of an intervention

# OCT (optical coherent tomography)

- Invasive method similar to IVUS
- Based on echolocation, instead of ultrasound waves it uses IR electromagnetic radiation ($\lambda \sim 1300$ nm)
- More exact than IVUS
- The tissue can be displayed only up to 1-2 mm




Pictures: artery after stent implantation

# NIRS

- Near infrared spectroscopy
- May be combined with IVUS or OCT
- Valuable in the detection of necrotic core, especially when hiden behind dense material (calcium deposits)

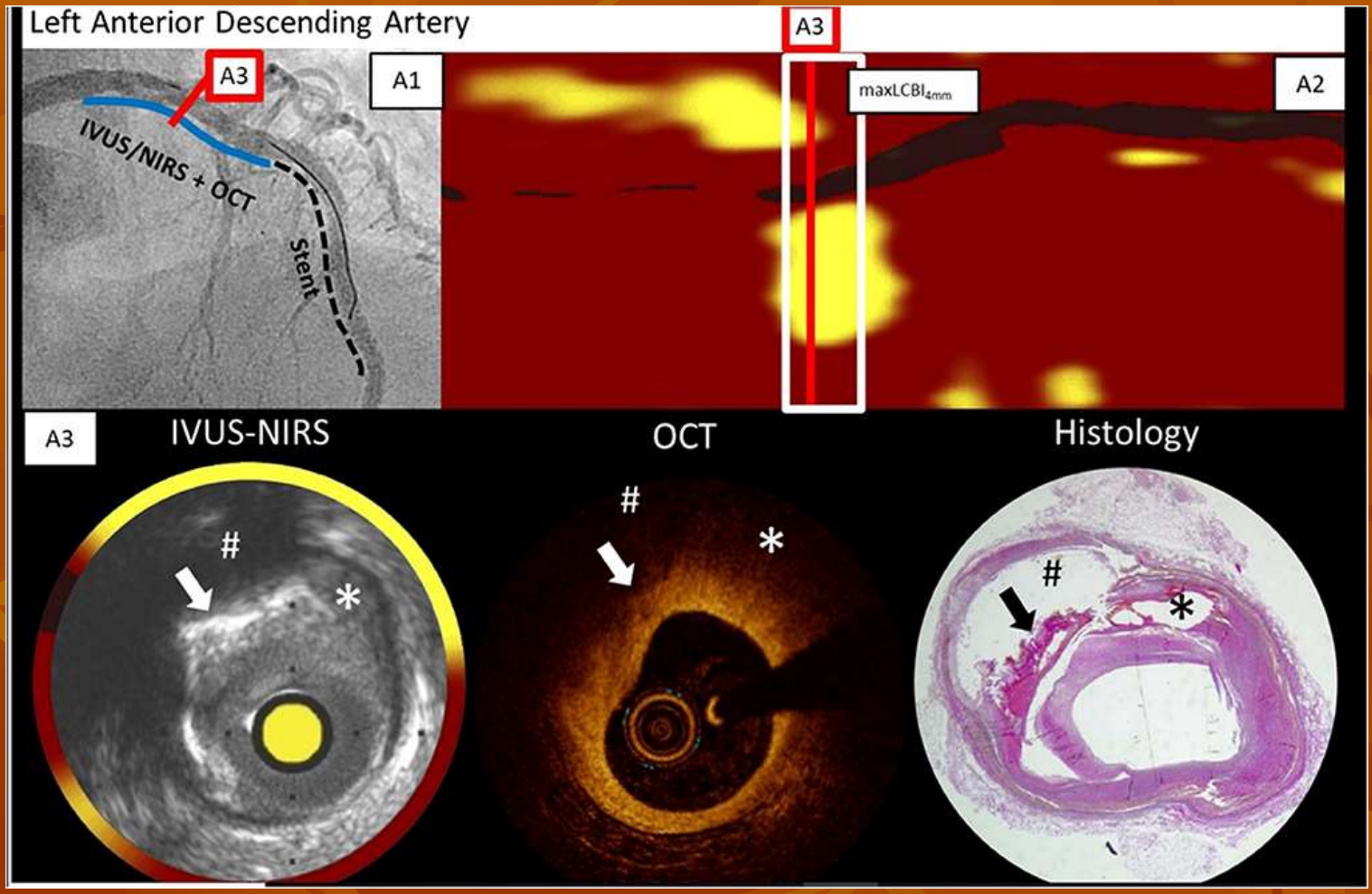
**modalities**

| | Angiography | OCT | IVUS | NIRS |
|---|---|---|---|---|
| Plaque volume | — | — | ++ | — |
| Calcification | ++ | + | ++ | — |
| Cap thickness | — | ++ | + | + |
| Thrombus | + | ++ | + | + |
| Lipid core | — | + | + | ++ |
| Remodeling | — | — | ++ | — |
| Stent strut expansion | — | ++ | ++ | — |
| Neointimal hyperplasia | + | ++ | + | — |
| Requires blood-free field of view | No | Yes | No | No |

++, Direct, robust and/or validated; +, indirect, inferred, and/or unvalidated; — not applicable

# Combination of imaging methods

NIRS




IVUS + NIRS (outer circle)

↓ - fibrous cap with calcifications; # - necrotic core; * - other lipid deposits

# Blood testing

- Focused on known risk factors (lipid spectrum, hyperglycemia)
- In familiar atherosclerosis in young age, it is suitable to perform genetic tests with respect to known risky alleles