Blood flow in the vessels – ultrasound estimation

New task - theory

Ultrasound - principles

- Ultrasound examination is one of the standard examination methods of the arterial system. It is a non-invasive method in which ultrasound waves and the Doppler effect can be used to visualize the morphology of arteries and the nature of blood flow in arteries. With good anatomical conditions, up to 80% of the arterial system can be examined in this way. . Ultrasonic waves are generated in the UZV probe, created by the piezoelectric effect when crystals vibrate by alternating voltage of a suitable frequency (most often from 2-15 MHz, representing 2-15 million oscillations per 1s). The best examiners are in the neck area of a. carotis, on the upper limb a.brachialis, a. radialis, a. ulnaris; on the lower limb are a. femoralis, a. poplitea, a. tibialis posterior and anterior (a. dorsalis pedis).
- The resulting waves enter the tissues and propagate in them as longitudinal waves. The molecules into which the waves collide transfer its energy – this happens in two phases - compression when the molecules thicken and relaxation return to the original state (at a frequency of 5 MHz, these phases alternate five million times in one second). The environment through which the wave passes puts resistance=bioimpedance . Part of the waves are reflected from the tissue interface of different impedances, part bends in other directions, part is dispersed into the surroundings, and the rest is absorbed into the tissue while simultaneously surrendering energy in the form of heat.
- For diagnostics, the part of the wave that is reflected back to the probe from which the wave was sent is used. Reflected waves are again registered in the probe (sending waves is only 1% of the probe's work, the rest of the time is for registration) – again the piezoelectric effect – crystals in the probe are deformed by reflected waves and generate pulses that are further processed by the instrument's computer - – amplified and displayed on the monitor in different degrees of gray depending on the intensity of the reflection (the greater the intensity of the reflection, the lighter the shade is used; for each reflection, the time delay with which it returns to the probe is also determined and from which the depth from which it is reflected is calculated – the corresponding gray shadows are placed on the screen on the vertical axis.
- This creates a two-dimensional ultrasound image (B-mode)

Doppler principle

- Two-dimensional ultrasound image (B-mode) is further combined with measurement of blood flow velocities in the vessel (PW pulsed wave) - commonly known as duplex sonography. Then color flow mapping (CFM) was added to create triplex sonography. All based on:

Doppler effect - Mr. Johan Christian Doppler (1803-1853) - professor at the Prague Polytechnic

- which is based on the registration of moving particles of blood
- Doppler principle: if a source of an acoustic wave of constant frequency moves in a straight line relative to a stationary observer, then if the sound source approaches, the frequency of the sound is perceived as higher (than it is actually transmitted) and if it moves away from the observer, the frequency is perceived as lower.

- This principle also applies vice versa: if there is a stationary source of waves and a reflector that reflects the sound (i.e. the blood flow in the vessel) is moving

- Calculated blood flow rates can be captured in two ways: pulse wave doppler or color flow mapping

Ultrasound measurement of the wall thickness of the carotid artery

- Carotid intima-media thickness (CIMT) is used to supplement the risk factors for cardiovascular disease associated with atherosclerosis and to predict cardiovascular disease. CIMT values vary with age, smoking, blood pressure, diabetes mellitus and blood lipid levels.
- CIMT is related to cardiovascular mortality and morbidity. This is a non-invasive, painless method of examination. During the examination, care must be taken not to exert excessive pressure on the carotid arteries (carotid sinus), which could cause bradycardia and hypotension.

- The artery wall consists of three layers (adventitia, media, intima). With B imaging, we get a two-dimensional image formed by these layers, which differ in their acoustic impedance.

- The measurement is performed 5 – 10 mm proximal from carotid bifurcation in a.carotis communis. We use a linear ultrasonic probe with a frequency of approximately 7 MHz.
- We exert appropriate pressure on the probe (danger of vagal reaction). The depicted wall is from the probe: adventitia, media, intima, then the lumen of the vessel and again intima, media, adventitia. We detect the desired section of the carotid artery with the probe and freeze the image. With the distance measurement function, we measure the intima-media complex. We record the value.
- Pato/physiological values: The normal upper limit is 0.8 to 1.0 mm according to age and sex (see table below), atherosclerosis is values above 1.2 - 1.5 mm.

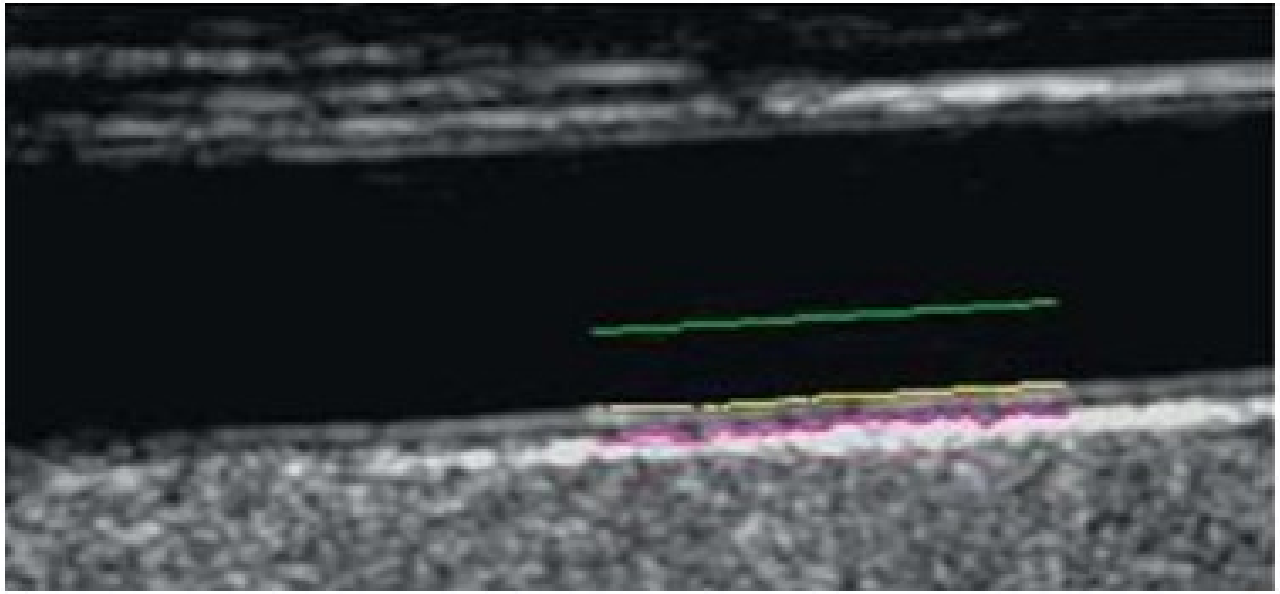
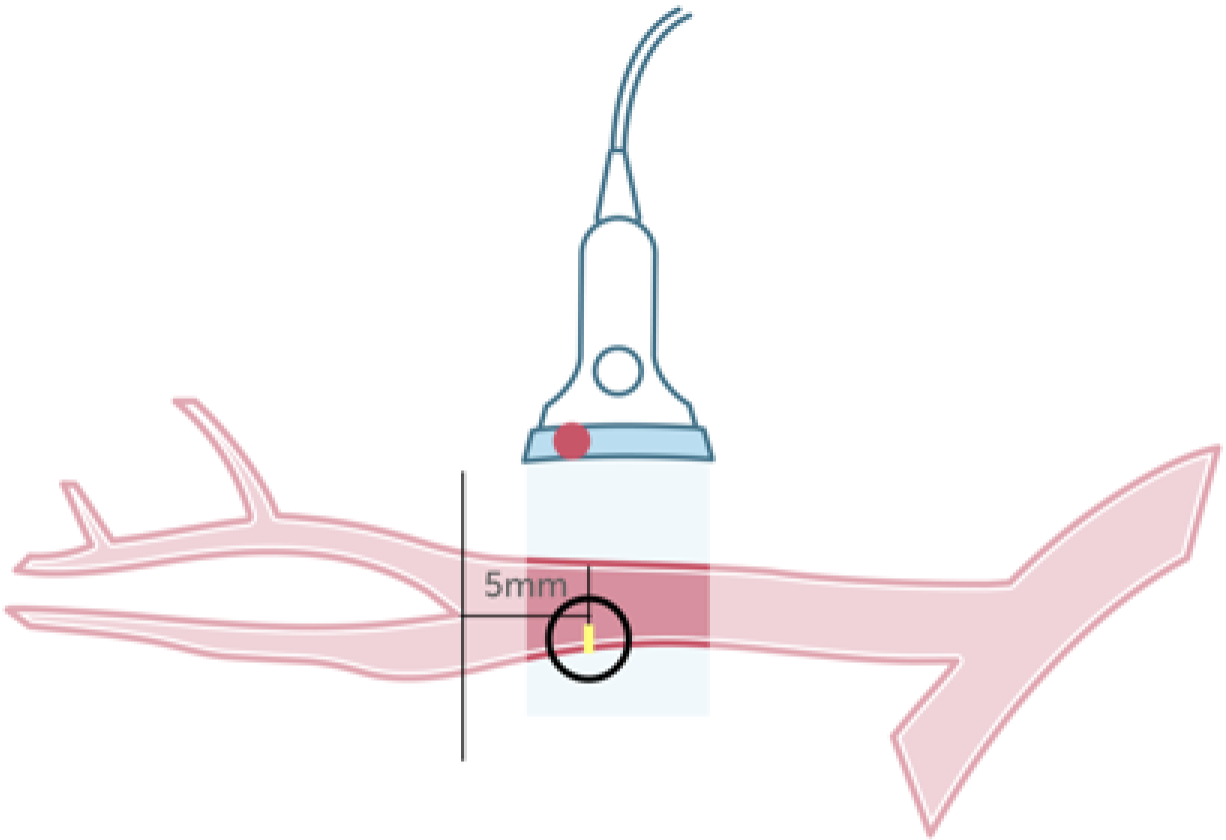


Figure 1. Intima-media thickness (IMT) definition – IMT is measured as the distance between lumen-intima (yellow line) and media-adventitia (pink line) interfaces.



IMT Where IMT. This illustration shows the region where the measurements of the intima media thickness should be performed. The measurement should be obtained 5mm from the bifurcation. Ideally both the posterior and the anterior wall should be measured

A right

Age	P25	P50	P75
Men <30	0.39	0.43	0.48
Men 31-40	0.42	0.46	0.50
Men 41-50	0.46	0.50	0.57
Men >50	0.46	0.52	0.62
Women <30	0.39	0.40	0.43
Women 31-40	0.42	0.45	0.49
Women 41-50	0.44	0.48	0.53
Women >50	0.50	0.54	0.59

B left

Age	P25	P50	P75
Men <30	0.42	0.44	0.49
Men 31-40	0.44	0.47	0.57
Men 41-50	0.50	0.55	0.61
Men >50	0.53	0.61	0.70
Women <30	0.30	0.44	0.47
Women 31-40	0.44	0.47	0.51
Women 41-50	0.46	0.51	0.57
Women >50	0.52	0.59	0.64