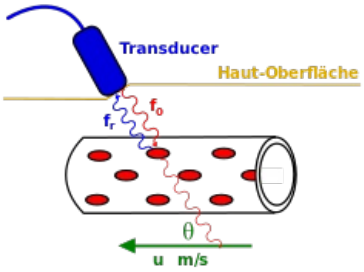
Doppler ultrasonography in medicine

Doppler ultrasonography (also known as doppler ultrasound, DUS) is imaging techniquethat allows us to visualize blood flow through the arteries. It is a non-invasive and painless method that uses the principle ultrasound a Doppler effect. The examination is usually performed on the large veins and arteries of the upper or lower limbs or on the neck. It can be used as an alternative to imaging methods based on the use of X-ray such as venography or arteriography, in which a contrast substance is injected into veins/arteries before the X-ray is used.

Basic principles



Principle of Doppler ultrasonography

Physical principle

Principle Doppler ultrasonography is based on Doppler effect, which describes the change in frequency and wavelength of the received versus the transmitted signal, caused by the non-zero mutual velocity of the transmitter and receiver. The first reflection occurs on the wall of the vessel, and further, when passing through the blood (suspension of blood cells), the effect of scattering occurs, especially on erythrocytes. The amount of waves that reach back to the probe is small (blood is almost anechoic), but it is enough to determine the frequency shift and also the speed of blood flow and the nature of the flow (laminar, turbulent) can be inferred from it. It is also based on the principle of ultrasound. Ultrasound waves with a frequency of 1 to 18 MHz pass through the body and are reflected from individual organs, or from transitions between tissues with different acoustic impedance.

Doppler systems

🔎 *For more information see Doppler ultrasonography.*

Doppler ultrasonography measurements can be performed in two basic groups of systems:

- CW mode working with **unmodulated** (continuous) carrier wave
- PW mode working with **impulse modulated** carrier wave

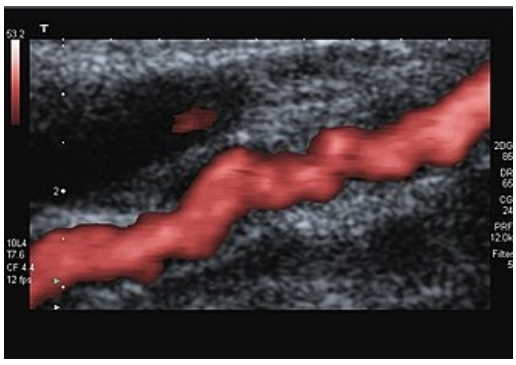
CW mode is technically simpler, but only provides information about the average speed. It is mainly used to measure blood pressure in superficial vessels on the lower limbs.

PW mode allows you to determine, in addition to the flow rate, also the depth at which the reflection occurred. The measurement result in PW mode is displayed as a 2D image of the measured speeds. Current Doppler systems are **directional**, meaning that the velocity flow rate away from the probe is referred to as backward and toward the probe as forward.

Doppler imaging

🔎 *For more information see Doppler imaging.*

Depending on how the measured speed is displayed on the monitor, we distinguish several different displays. In general, we can divide them into spectral and color, but there are also other specific methods.



Color Doppler

Duplex ultrasonography

It represents a combination of two-dimensional dynamic imaging and pulsed Doppler velocity measurement. The image of color duplex ultrasonography is composed of two parts - black & white and color. The black & white part contains morphological information and the color part information about the movement in the observed section.

Triplex ultrasonography

Triplex ultrasonography (color assisted duplex sonography) is a combination of B-imaging, color-coded blood flow and spectral recording. This detects the entire speed spectrum.

Doppler flow meter

🔎 *For more information see Doppler flow meter.*

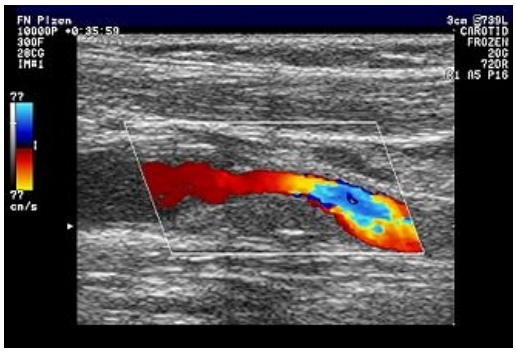
A so-called **Doppler flow meter** is used to measure the volume flow of blood liquid through a vessel . It consists of several parts and works in PW mode.

Echocontrast substances

It si not absolutely necessary to to use contrast substances for a Doppler ultrasound examination. Nevetherless, they are sometimes used, for example for liver examination or transcranial examination. Called echocontrast substances, they are given intravenously and take the form of **gas microbubbles**. They increase the echogenicity of the flowing blood, which causes an increase in the amplitude odf the Doppler signal and thus an improvement in the signal/noise ratio. The condition is that these microbubbles are able to pass through the pulmonary capillaries. Their use increases the diagnostic yield of ultrasonography.

Use in medicine

Doppler ultrasonography is widely used in medicine, mainly due to the non-invasiveness of the procedure, easy availability and low price, and it also does not require patient transport. It can, for example, diagnose liver cirrhosis or Budd-Chiari syndrome. It is used to recor the heartbeat of the fetus (so called fetal doppler), to find the place of origin of a blood clot, aneurysm or to discover possible damage to the function of the heart valves. Among the **disadvantages** of this method are the low permeability of areas with interfaces with different acoustic impedances (eg gas in the intestine, lung parenchyma, compact bone, subcutaneous fat, etc.) and also the dependence of determining the correct diagnosis on the experience of the doctor.



Color Doppler of internal carotid stenosis

Transcranial Doppler examination

Transcranial Doppler examination (TCD) is an examination of the flow through the intracranial arterial bed. It represents one of the simplest methods of this examination. Sectoral probes with a low frequency of about 2-2.5 MHz [1] , are used for this, due to the large attenuation of ultrasound in bones. The TCD method is performed through access windows in the skull that are permeable to ultrasound waves. **The transtemporal window** enables visualization of **the circle of Willis** in axial or coronary plane. **Through the suboccipital window** through the foramen magnum the distal sections of the vertebral arteries and the basilar artery are shown. Submandibular and transorbital access windows are used only exceptionally. Using this method, stenotic and occlusive changes that often occur in the proximal section of the middle cerebral artery are diagnosed. [1] It is also possible to detect the presence of secondary circulation through the circle of Willis.

Diagnostics of the liver and portal circulation

Today, Doppler ultrasonography is part of every ultrasound examination of the abdomen. In the diagnosis of the liver a portal circulation computed tomography (CT) or nuclear magnetic resonance (NMR). This allows us to detect **portal hypertension**, collateral circulation or reversed direction of flow, which are the main criteria in the diagnosis of **liver cirrhosis**, portal trombosis or **Budd-Chiari syndrome**.

Diagnostics of the urogenital system

This imaging examination is also very suitable for diagnosing **renovascular hypertension**, examining a transplanted **kidney** and examining the **scrotum** when torsion of the testes is suspected. For examination of the renal arteries, due to the depth of their placement, are used low-frequency probes (2-3 MHz) [2] , while a high-frequency probe with a frequency of around 7 MHz [2], which can capture even very slow flows.

Doppler echocardiography

🔎 *For more information see Doppler echocardiography.*

Fetal echocardiography is a type of medical imaging that allows visualization of the heart of a developing fetus. It is one of the most important ultrasound examinations during pregnancy. Congenital heart defects are among the most common congenital developmental defects, and their presence can alert us to more complex impairments in the fetus (genetic or chromosomal syndromes). The ideal time to perform a detailed heart examination is between the 20th and 23rd week of pregnancy.

Fetal Dopplerometry

🔎 *For more information see Fetal Dopplerometry.*

The result of the examination is an image on the ultrasound monitor, as well as the sounds of blood flow through the vessels, umbilical cord and heart. Using fetal Doppler, we can make sure that the fetus is alive and developing as it should. Fetal doppler designed to detect echoes (heart activity) of the fetus. Intended for use in gynecology, obstetrics and home care after the 12th week of pregnancy.

Links

Related articles

- Doppler ultrasonography
- Doppler imaging
- Doppler echocardiography
- Fetal Dopplerometry

External links

- Lékařská ultrasonografie
- Medical ultrasonography

Used literature

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1. HRAZDIRA, Ivo. *Úvod do ultrasonografie : v otázkách a odpovědích pro studenty lékařské fakulty* [online]. ©2008. [cit. 2013-11-29]. <http://www.med.muni.cz/dokumenty/pdf/uvod_do_ultrasonografie1.pdf>.
2. ELIÁŠ, Pavel – ŽIŽKA, Jan. *Dopplerovská ultrasonografie.* 1. edition. Hradec Králové : Nucleus, 1998. ISBN 80-901753-5-X.