

# Doppler ultrasonography

synonyms: *Doppler ultrasound, Doppler sonography, Doppler test, Doppler study*

**Doppler ultrasonography** is a non-invasive procedure that uses detectable changes in high frequency sound waves (2-20 MHz), based on the **Doppler effect**, to create clear digital images in real time. As a medical imagery method it is used for diagnostics, during medical procedures or for pathology research. It has been in medical use for several decades with no or little report of long-term side effects.

World Health Organization. *Training in Diagnostic Ultrasound: Essentials, Principles and Standards : Report of a Who Study Group*. WHO, 1998. , pp. 2.

Thus is characterized as harmless, painless, cost-effective and generally widely available. It requires little or no prior patients' preparation or aftercare. Predominantly, it is used to monitor the circulatory system by detecting direction, velocity and turbulence of blood flow, in order to provide information on possible blood clots, blocked vessels, cardiac or valve insufficiency.

## Physical principles

Doppler ultrasonography is based on two basic principles:

### 1. Ultrasound principle

high-frequency sound wave aimed at a target will be reflected back and detected

### 2. Doppler principle

effect of changes in the sound pitch depending on the movement of the object in relation to the detector (positive or negative shift - the speed of sound in blood is 1570 m/s)

Piezoelectric crystals within the **transducer** or probe produce electrical pulses when vibrated by the returning wave (as with all ultrasonography gel medium is used). The transducer will send thousands of series of waves, which may be continuous or pulsed. If pulsed then pauses for detection of the returning waves are necessary. Upon detection, ultrasonograph calculates and determines the direction and depth of each returning sound wave. Thousands of such pulses sent and detected are computed and displayed in order to produce an image of the studied object, each detected wave displayed as pixel on the screen. Use of color helps in depicting direction and rate of blood flow, assisting the physician interpreting the results. It is important to note that there is no standard on colors used for depiction of effect or type of vessel, thus colors vary between manufactures or operating modes.

## Artifacts and errors

"An error in a sonographer's ability to estimate the Doppler angle in a real-time B-mode display affects the estimated value of blood velocity. The same error has a greater effect at angles near 90 degrees than at angles near 0 degrees."

HENDEE, William R – RITENOUR, E. Russell. *Medical Imaging Physics*. Fourth edition. John Wiley & Sons, 2003. ISBN 0-471-38226-4.

"Aliasing can occur due to the under sampling of the Doppler signal when using Pulsed wave Doppler systems. If the pulse repetition frequency is set to low the Doppler signal with frequency higher than Nyquist limit will be incorrectly displayed in the reverse channel." Also, "if the Doppler angle is near 90° the ambiguity of the flow direction can be observed – in one part of the vessel the blood flows towards the probe, in other part of the vessel the blood flows away from the probe and where the Doppler angle is equal to 90° no flow is detected."

Univerzity Palackého v Olomouci, Lékařská fakulta, Ústav lékařské biofyziky. <http://ulb.upol.cz/tutorial/doppler.pdf> [online]. [cit. 2012-12-12]. <<http://ulb.upol.cz/tutorial/doppler.pdf>>.

Patients also play a significant role, as their inability to stay still may result in distorted images and results. Use of vasoconstricting or vasodilating substances can have the same effect. In some instances bones can block the ultrasound signals. In obese patients it may be more difficult to obtain clear results or images. Likewise, the same can be observed in obese patients with irregular heart-beat.

## Types

### Color flow Doppler ultrasound

B-mode imaging, using color in pulsated system to depict positive or negative shifts, allowing simultaneous visualization of anatomy and flow dynamics.

### Continuous wave Doppler ultrasound

continuous emissions from transducer, enabling the measurement of high velocity blood flow (like in valve stenosis).

### Duplex Doppler ultrasound

combination of previous two types, in order to allow accurate anatomical location of studies blood flow.

BLOOD, Douglas C – STUDDERT, Virginia P – GAY, Clive C. *Saunders Comprehensive Veterinary Dictionary*. Third edition. 2006. ISBN 978-0702027888.

# Clinical uses

Continuous or pulsated waves Doppler systems can provide information on the flow and movement of blood and inner areas of the body. Common use in clinical practice covers **echocardiographs**, **transcranial** and **3D in-utero Doppler untrasonography**, but it may also be used for visual examinations of tendons, joints and muscles. In the recent years it has become a helpful tool for early detection of clots, bleeds, stenosis signs or aneurysms, particularly for intervention radiologists and neurologists, assisting in minimizing brain damage with early interventions.

WisegEEK. *What is digital Doppler* [online]. [cit. 2012-12-12]. <<http://www.wisegEEK.com/what-is-digital-doppler.htm>>.

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### Bibliography

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