Ultrasound Phantoms Mimicking the Vessels of the Vessels

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Millions of people around the world suffer and die every year due to diseases related to blood circulation. This number could be decreased significantly if better and early detection methods were developed. In order to develop advanced methods, it is important to have access to a controlled environment that mimic the phenomena of interest. Arteries are blood vessels responsible of carrying oxygenated blood from the heart out to the body and are elastic, moveable and stretchable. Since the 1970s it is known that there is an arterial diameter change, and it is what is looked for when care takers want to measure blood pressure. On the other hand, not until recently an ultrasound method was developed to detect and show that the arterial wall moves in the direction of the blood flow as well. Ultrasound is a high frequency sound and images are created from the reflected soundwaves by the different body structures. Ultrasound equipment is frequently used in medical diagnosis, for example on pregnant women to check their babies.

Researchers would like to develop ultrasound methods to understand how the arterial wall movements might affect the blood circulation within the micro vessels that provide blood supply and nourishment to the walls of vessels. These micro vessels are also called *vasa vasorum* which comes from Latin and means the vessels of the vessels and is a network of small vessels.

We wanted to design and fabricate suitable and realistic *vasa vasorum* ultrasound phantoms. Ultrasound phantoms are devices made of materials that simulate body tissue in its interactions with ultrasound waves.

Two vessel-like ultrasound phantom prototypes were fabricated of oil based materials. In one prototype, micro vessels were made in the phantom using small glass capillaries. This phantom had a simple rectangular shape meant to simulate a part of an artery. Figure 1 Shows ultrasound images of a micro vessel being gradually filled with water.

In a more complex phantom, a 3D printer was used to print the moulds. The artery-like channel had a cylindrical shape with a gradual diameter decrease similar to that of a realistic artery. The phantom was fabricated in three parts (see Figure 2): one part representing the moving artery in which a *vasa vasorum* like channel was placed, the second part representing the connective tissue between the moving artery and the third part which is representing the outer arterial wall and the surrounding tissue. The arterial movements are then generated by connecting the phantom to a pump. The arterial movements were seen using ultrasound and later analyzed to evaluate the arterial movements.

The results showed that the oil based phantom materials were easy to work with, various micro channels were fabricated and that a flow of water was seen by ultrasound. In the case of the more complex phantom, the movement along the blood flow was less than the diameter change.

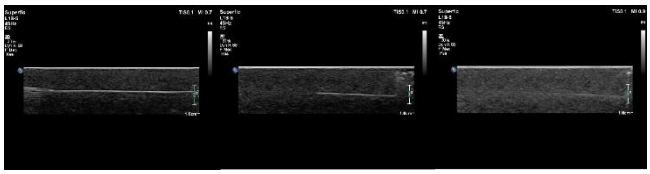

Figure 1: Ultrasound images indicating that capillary channels are seen via ultrasound. The channel was gradually filled with water. Artefacts from the needle used to inject the water Is seen in the left part of the imaget.

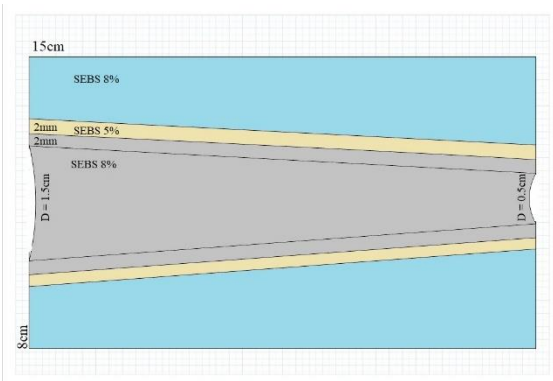

Figure 2: Section of the complex phantom; the first part (grey) in which the micro vessel is placed, the second part simulating the connective tissue (yellow) and the surrounding tissue (blue). Each layer is made of a certain phantom material with properties that are similar to those for the arterial wall.

The fabricated phantoms can now be used by researchers for the development of ultrasound methods to understand how the blood circulation within the *vasa vasorum* is effected by the arterial wall movements. However, the morphology, as well as the biology in living vessels is too complex to be fully mimicked by phantoms.