Our circulatory system is made up of blood vessels of many sizes, but the vast majority - around 99 - are very small. These microvessels, including arterioles, venules, and capillaries less than 0.15 millimeters wide, play a critical role in delivering oxygen and nutrients to tissues throughout the body.

What makes these small vessels especially important is that they often undergo changes well before any symptoms of cardiovascular disease appear. In fact, alterations in microcirculation can occur simultaneously with or even precede the earliest signs of conditions like hypertension and diabetes. This means that studying microcirculation could offer a valuable early warning system, helping doctors detect cardiovascular problems before they become serious.

One of the best places to observe microvessels directly is in the retina, the light-sensitive layer at the back of the eye. The retina's blood vessels can be seen non-invasively, allowing researchers to study their structure and behavior under normal physiological conditions.

To explore this potential, our team developed a high-resolution imaging system known as a scanning laser ophthalmoscope (SLO). This device uses a near-infrared light source to capture detailed images of retinal blood vessels at a speed of 30 frames per second, with a resolution of 7 micrometers. The system also offers flexibility in its field of view, allowing to zoom in on specific vessels or capture a broader area of the retina.

The team designed an advanced image-processing pipeline to analyze these images and measure key features of the vessels, such as the diameters (outer and inner), the thickness of the vessel walls, and how these characteristics change over time with each heartbeat.

This process involves several steps. First, the images are processed to correct distortions caused by the scanning and to align the images to compensate for small movements of the eye. Then, the software isolates individual vessels and analyzes cross-sections of them to precisely locate the vessel walls. From these measurements, the system calculates important parameters like wall thickness and the ratio of wall thickness to inner diameter.

The researchers tested this method on data from 30 patients at the Center of Translational Medicine at Gdansk Medical University. This system shows promise in reliably detecting these dynamic features.

The ultimate goal of this project is to develop a robust, non-invasive tool that can accurately measure microvascular dynamics. By combining advanced image correction, stabilization, and machine learning-based vessel segmentation, the team hopes to provide doctors with a powerful new way to monitor vascular health.

Such a tool could revolutionize early diagnosis and monitoring of cardiovascular diseases, offering an affordable and efficient approach by simply looking into the eyes. This represents a promising step forward in preventative medicine and vascular health care.