Ultrasonic Measurement of Blood Flow in Cardiovascular Systems

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Echography is based on the reflection of ultrasound and characterized as easy, non-invasive and real-time imaging. Color Doppler ultrasound imaging shows the two-dimensional (2D) distribution of blood flow in cardiovascular systems such as heart and vessels. However, conventional Doppler method merely measures the flow component along the ultrasonic beam. Several methods to obtain 2D blood flow velocity have been proposed. The first is the application of fluid dynamics theory to color Doppler imaging. Although the method requires some assumptions, 2D blood flow image of the heart provides clinically important findings. The second is Echo-PIV (particle imaging velocimetry) using contrast agents to visualize blood flow. Today, similar image is obtained by a commercially available ultrasound machine to enhance the echo of red blood cells by signal analysis without using contrast agents.

The third is to observe the blood flow from more than two different angles. The concept of this method was proposed in 1980's, however the real measurement was not available at that period. Recently, parallel beam forming in which ultrasound is consecutively transmitted and received by the controllable ultrasound platform, has enabled very fast measurement with the frame rate of 5 kHz. Ultrasound beam was transmitted by a linear array transducer with the steering angle of 30 and -30 degrees. The steering angle was quickly switched and the Doppler velocity measurement from two different angles enabled to obtain 2D blood flow vector. Development from 2D to 3D velocity measurement is also introduced.