The last two decades have witnessed unprecedented developments of new methods to diagnose vascular diseases. Over the past 2 decades, vascular ultrasound imaging has evolved to become an indispensable tool for diagnosing vascular diseases. Some of the most exciting developments have been: 1) the development of colour and power Doppler ultrasound imaging; 2) 3-dimensional vascular ultrasound; and 3) B-mode and Doppler contrast agents.

DOPPLER ULTRASOUND: In diagnostic ultrasound, the Doppler effect occurs when sound is reflected from moving scatterers, such as red blood cells. Over the past 20 years, many approaches have been developed including: spectral Doppler used to obtain the blood velocity spectrum from a small region in the vessel; colour Doppler used to obtain a 2-D image in which the anatomy is displayed in grey scale and a single component of the velocity is displayed in colour; and power Doppler in which the power in the Doppler spectrum from small regions is displayed as a 2-D image.

3-D VASCULAR ULTRASOUND: Conventional 2-D ultrasound limits our ability to quantify and visualize vascular diseases, because the diagnostician must mentally integrate multiple 2-D images to form an impression of the 3-D anatomy. In 3-D ultrasound, the transducer is mounted in a motorized assembly or its position and orientation is monitored. After moving the transducer over the skin either continuously, or with cardiac gating and collecting many 2-D images, a 3-D image can be reconstructed. Typically, 200 images are collected at 0.5 mm intervals, at a rate limited by the ultrasound machine frame rate and the type of gating used. Using this technique, 3-D B-mode, colour Doppler, and power Doppler are useful in assessing atherosclerosis, the kidney, and spleen. Also, 3-D imaging of the carotid arteries can be used for stenosis and plaque volume measurements. Imaging of tumours with 3-D Doppler demonstrates that, while it is sometimes difficult to visualize the neovasculature in 2-D, a 3-D image provides for better visualization of the tortuous neovasculature associated with tumours.

CONTRAST AGENTS: Ultrasound contrast agents are substances that produce increased signals when injected into the vasculature. Recent developments of methods to stabilize small gas bubbles has lead to an explosion of activity in the development and applications of contrast agents. The increased signal is due to the fact that bubbles of about 5μm resonate at frequencies between 1 and 10 MHz. Thus, not only do these bubbles provide strong scattering properties, but they are also sufficiently small to pass through the capillaries and pulmonary system allowing intravenous injections. These contrast agents are being used to visualize areas of reduced perfusion in the heart wall and other organs, and to enhance the visibility of angiogenic vessels found in tumours.

EDUCATIONAL OBJECTIVES: 1) learn about spectral Doppler, colour Doppler and Power Doppler and their applications. 2) learn about methods to obtain 3-D ultrasound images and their applications. 3) learn the physical reasons which cause ultrasound contrast agents to produce increased signals.