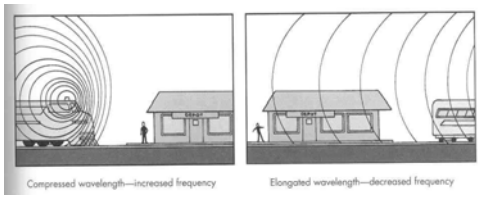
Stress Echocardiography
(Chapter 7)

History

- Johann Christian Doppler (1803-183)
  - relationship between frequency shift and velocity
  - Doppler effect
- WW11
  - development of radar and sonar
- Late 60s
  - used to monitor flow velocities in the heart

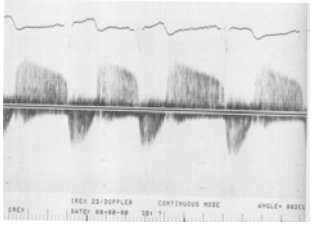
Doppler measurements



Blood flow velocity and direction of flow can be determined from the frequency of sound
increasing frequency--flow towards the probe
decreasing frequency--flow away from the probe

Clinical uses : the heart

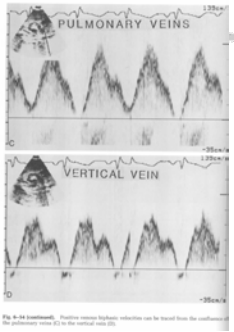
- Cardiac structures
  - chamber size, volume, wall thickness
- Cardiac function
  - cardiac output, contractility
- Wall motion
- Valve function



Aortic regurgitation

Clinical Uses : the vasculature

- Vessel wall thickness
- clots (DVTs)
- Aneurisms
- Stroke damage

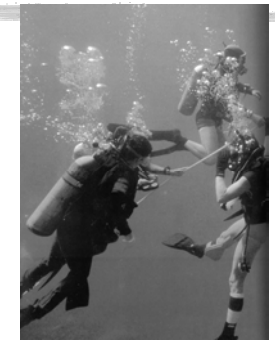


Other clinical uses:

- Identify congenital abnormalities
- Fetal imaging
- Organ imaging
- Measures of vascular function
- Cardiac hypertrophy
  - screening test for athletes

Research Applications

- Contrast echo
  - to identify patent foramen ovale
  - screening for divers
- Bubble detection
  - for decompression sickness
- Cardiac atrophy
  - spaceflight
  - disease

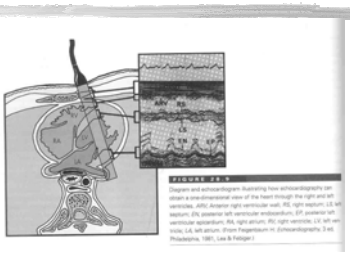


Types of Doppler imaging

- cardiac imaging
- trans-esophageal imaging
- contrast echo
- transcranial doppler
- vascular imaging

Cardiac imaging

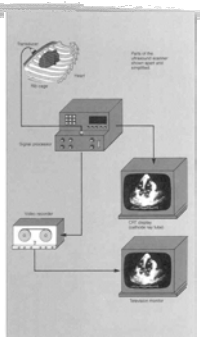
M -mode images (motion mode)



- **One dimensional slices of the heart (single beam of sound)**
- **Measures vessel and chamber diameters, wall thickness**

2-Dimensional images (D mode)

- Video or still images of the contracting heart (fan-shaped wedge of sound)
- Identifies abnormal wall motion, valve motion
- Assesses cardiac contractility
  - ejection fraction, ESV, velocity of fiber shortening
- Assesses cardiac filling



2-D image in the long axis parasternal view

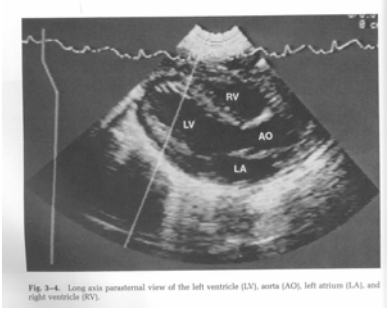
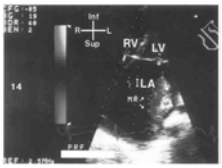


Fig. 3–4. Long axis parasternal view of the left ventricle (LV), aorta (AO), left atrium (LA), and right ventricle (RV).

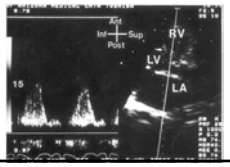
Color Doppler Imaging

Mitral regurgitation. Flow moving backward from the transducer is blue



Ventricular septal defect.

Red jet across the septum represents the defect. Velocity curve on the right



Continuous wave Doppler to measure cardiac output

- 1. Measure diameter of the aorta (m-mode)
- 2. Measure velocity of flow from the aorta at peak systole (2-D image)
- 3. Calculate the volume of flow
  - Cross sectional area x velocity
- Assumptions
  - Probe angle is critical

Cardiac Output from 2-D measurements

1. EKG gating
2. Measure LVV at end diastole
3. Measure LVV at end systole
4. Calculate SV, (EDV - ESV)
5. Calculate Q, (HR x SV)

Assumptions:

ellipsoid shape of the heart

Stress Echo Testing: to assess cardiac function

- Treadmill
  - measurements obtained before and after exercise.
- Cycle
  - measurements before and after supine exercise. Special cycle designed to turn to the left lateral position.
- Pharmacological testing
  - dobutamine dominant stressor in US

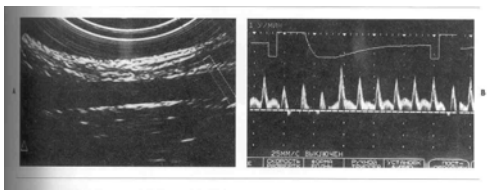
Echo Advantages over EKG

- Greater sensitivity than regular stress testing (85% vs 68%)
- Greater specificity than regular stress testing (85-90% vs 60-90%)
- Can be used in patients with BBB, WPW, on digitalis, LV hypertrophy
- Can identify specific wall motion, ischemic and valve problems

Review of applications for exercise stress testing

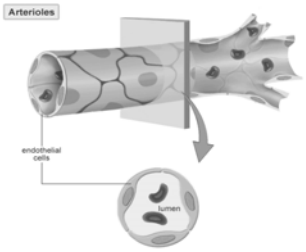
- cardiac output measurements
- cardiac function (EF)
- screening; athlete's heart vs. cardiac hypertrophy
- follow-up test for cardiac ischemia
- muscle blood flow

Vascular imaging

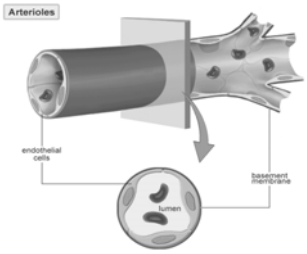


• Combines m-mode to measure vessel diameter and blood velocity to calculate blood flow (vel x area)
• Color Doppler--color varies with velocity. Useful for identifying diseased heart valves or occluded vessels

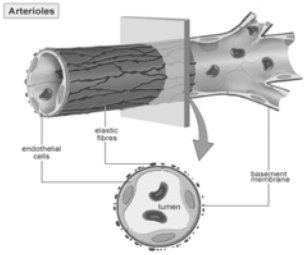
Endothelium:
Single layer of cells



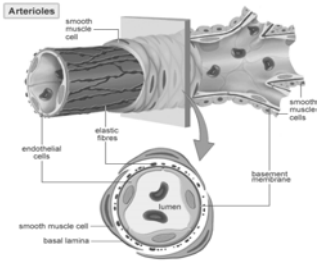
Endothelium:
Basement membrane



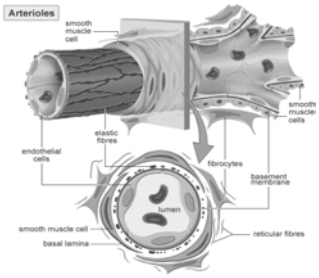
Endothelium:
Elastic fibers



Endothelium:
Smooth muscle

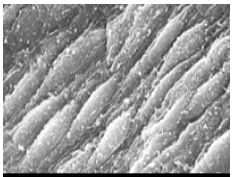


Endothelium:
Connective tissue



Endothelium: Normal Function

- Endocrine organ
  - Produces and responds to a variety of chemical and physical stimuli
- Maintains circulatory homeostasis
  - Responds to changes in hemodynamics
  - Regulates vascular tone
- Mediates anti-atherogenic properties



Inner lining of a normal artery, magnified about 2000 times.

Endothelium: Vasoactive Agents

- Vasodilators
  - NO
  - Bradykinin
  - Prostacyclin
  - C-type natriuretic peptide
- Vasoconstrictors
  - Endothelin
  - Angiotensin II

Nitric Oxide

- KEY endothelial derived relaxing factor
- Synthesized from L-arginine by action of NOS, diffuses out of cell, causes smooth muscle to relax (by indirectly activating myosin)
- Bioactivity of NO used to represent endothelial function

Assessment of Endothelial Function

- Used to test for PAD
- Vasodilatory or vasoconstrictive response
  - pharmacological agonists
    - Nitroprusside—stimulates NO and dilation
  - mechanical stimuli
    - Occlusion—increases intravascular pressure and stimulates dilation

Conclusions: echo Doppler

- Cardiac measurements
  - Assess cardiac dimensions (disease/athletes)
  - Evaluate wall motion and valve function
  - Assess cardiac contractility
    - Rest and exercise (stress echo)
- Peripheral vascular measurements
  - Assess vascular health
  - Research on exercise benefits