SOUNDS AND MURMURS

Background — Sections I and II treat flow as constant or slowly changing, but in fact flow in heart and large arteries undergoes large and rapid changes each cycle with corresponding changes in velocity. Normally even the peak flows are smooth, quiet and efficient. Conversely with incompetent valves and stenotic valves and vessels, velocity is often increased producing turbulence, vibration and noise. This noise, murmurs, is often diagnostic of the lesion and its severity.

When flowing blood is suddenly slowed or stopped vibrations may be produced causing brief oscillations, the source of normal and abnormal *heart sounds*. The following concepts aid in understanding phenomena associated with pulsatile flow.

Fluid turbulence may be considered random and chaotic motion. If the velocity of blood flowing through a given vessel is continuously increased a critical velocity will be reached where smooth laminar flow will begin to form random eddies and swirls with variation in pressure, velocity and direction (fig. 4). This is easily seen with color doppler ultrasound which will show a smooth gradation of color[1] across a vessel without turbulence, but in turbulent flow a variable matrix or scattering of colors corresponding to varying velocities and directions is seen. If pressure at the vessel wall is measured a spectrum of vibration will be found (fig. 4.2). The larger amplitude, lower frequencies may be palpated as thrills and higher frequencies may be heard as murmurs[2]. Both signs are frequently found, in aortic stenosis for example. Depending on anatomy one or both of these signs may or may not be transmitted to the surface.

Turbulence sharply increases resistance and pressure drop and produces the murmurs we use in diagnosis[3].

Reynold's number — Velocity at which turbulence begins is determined by characteristic of both of the blood vessel and blood in it and may be determined approximately from equation IV-1. For example anemia, flow murmurs are frequently heard because density and the Reynold's number are lower and cardiac output and velocity are increased.

$$\text{Reynold's number} = \frac{\rho V D}{\mu} \qquad \text{Eq. IV-1}$$

ρ = density of blood   V = velocity
μ = viscosity of blood   D = diameter of vessel

Bernouellis' theorem can explain a number of phenomena in cardiology. Bernouelli showed that the total energy in flowing fluid is constant but has two components, potential and kinetic, which may exchange their energies. If fixed blood flow moves from a larger

[1]Corresponding to velocity profile.

[2]The concept of turbulence as the cause of murmurs has a sound scientific basis and is increasingly accepted, but there are still some disagreements on their origins.

[3]For blood in normal vessels the critical Reynold's number is ≈ 1,000 and values obtained from Eq IV-1 for a given situation that are less then 1,000 should have smooth or luminar flow. Moreover the larger the Reynold's number, the greater the turbulence and louder the murmur.