Mass Transport in Arteries C.G. Caro.

As living tissue, the wall of an artery requires the supply of nutrients, removal of waste products and access of materials such as hormones which regulate function.

The walls of large blood vessels are themselves supplied with vessels (vasa vasora) which penetrate from the inner or outer surface of the vessel, form a capillary network and then drain to veins. The inner 1/3, approxiamtely of the wall of a large systemic artery is however devoid of capillaries. Presumably capillaries (pressure c. 15 mm Hg) could not remain patent close to the inner surface of such a vessel (hydrostatic pressure in lumen c. 100 mm Hg). Transport in this region is believed to be by diffusion to and from blood flowing in the lumen. Experimental results confirm such diffusion and suggest that it is coupled to the arterial fluid mechanics.

The systemic arterial system consists of the highly curved aortic arch and relatively straight thoracic and abdominal aorta and then short segments of artery intervening between branching points. For these segments $5 < l/d < 10$ approximately. For the time averaged flow the $Re = Ud/\nu$ is much greater than 1 and approximately 2000 in the aorta; hence the flow is dominated by inertia.

Considered from the point of view of steady flow the hydrodynamic boundary layer will be thin in the curved aortic arch and will grow with distance downstream. As revealed by studies of steady flow in branched models the boundary layer will also be thin downstream of junctions especially on the flow divider, and there will be insufficient length for the flow to become established.

Studies of the area ratio at junctions reveals that vascular cross-sectional area decreases for the first few branches of the aorta. Thereafter it increases, but the rate of increase may still allow a mean shear index (shear in daughter vessel/shear in parent) to increase, where shear is volume flow/radius^3.

These various studies give some indication of the spatial variation of wall shear in the arterial system.

If a material diffuses from blood to arterial wall (or vice versa) wall shear will significantly influence diffusion only if diffusional resistance in the fluid is comparable with or greater than that in the wall. Studies of the uptake of several molecular species by the wall indicate that such diffusion is appreciably influenced by wall shear.

The implications of these findings are considered.