Bone Blood Supply

Blood supply is just as critical to the viability of normal healthy bone, as it is to the repair and remodelling processes that follow fracture, disease and surgical insertion of orthopaedic implants. The importance of bone blood supply in fracture repair is well accepted by orthopaedic surgeons. The third AO principle of fracture treatment by internal fixation, as set forth more than fifty years ago, was the requirement for 'atraumatic operative technique preserving the vitality of bone soft tissues and bone' (1). The importance of this third principle has achieved even greater prominence with the more recent introduction of the concept of minimally invasive plate (percutaneous) osteosynthesis (2).

Bone blood supply is not a very popular topic for orthopaedic research and investigation, in comparison to say biomechanical testing of bone and implants. The reasons behind this are several. A major problem is that bone is dense and opaque, so it is difficult to section bone or to directly visualize bone blood vessels with current imaging methods without removal of the mineral. Consequently progress for the discovery of new knowledge in this field has been slow.

Murray Brookes wrote an interesting account of the history of research into bone blood supply which can be traced back about 350 years (3). Antonie van Leeuwenhoek, a founding father of microscopy in The Netherlands, described surface veins on the shin bone of a calf, and observed small holes passing to the inside of the bone which he imaged connected to 'small pipes going longways in the bone'. Later in 1691, Clopton Havers described in his book how a large nutrient artery pieces the shaft of long bones and ramified in bone marrow. He presumed that an oily medullary substance was expelled into a system of straight pores within the bone, these pores becoming known as Haversian canals.

It is now well accepted that the nutrient artery penetrating the nutrient foramen, divides into ascending and descending branches of the medullary artery and these are the main source of centrifugal blood flow in the cortical bone of long bones. Some long bones have more than one nutrient foramen; for example about 50% of human femora have two nutrient foramina. The medullary blood vessels arborize and anastomose with both the metaphyseal vessels as well as the periosteal vessels in regions of strong soft tissue attachment. This allows increased compensatory blood flow from the anastomosing supply should one system, such as the medullary supply be knocked out. The macroscopic anatomy of vascular system of bone has been well described, using techniques of vascular injection of barium sulphate, imaging and the Spalteholz method (3–6). In this issue of the Journal, a detailed study using the Spalteholz method to compare the morphology of the medullary blood supply of the tibia of cats and small dogs is reported (7). The underlying purpose of the study was to ask if poor blood supply to the tibia could be a contributing factor to the higher incidence of delayed and non-union of tibial fractures in the cat. Surprisingly, these authors found that the absolute and relative diameters of the main medullary artery in the mid and distal regions of the feline tibia were larger than in small dogs. Sometimes such an unexpected finding that fails to support our assumptions can be more powerful in advancing our knowledge than a confirmatory outcome. It might provoke us to think again. It could be we did the right study, but have asked the wrong question, or vice versa. For example, one problem is that morphological studies of bone blood vessels can provide only limited information about haemodynamics.

Apparently the cross-sectional area of a nutrient foramen of a long bone is related to blood flow requirements of the bone. It was interesting to learn that palaeontologists found the foraminal area of ten species of dinosaurs are generally larger than in mammals (8). These investigators concluded that this indicated that dinosaurs had a highly active and aerobic lifestyle! Fortunately bone blood flow can be

doi:10.3415/VCOT-11-08-0117
measured more precisely using tracers, indicator dilution and laser Doppler techniques for example. Perhaps such in vivo studies are needed for comparative studies of bone blood supply in cats and dogs.

References