## Radiological Skeletal Survey for Aseptic necrosis of Bone in Divers and Compressed Air Workers

Notes prepared by the Medical Research Council Decompression Sickness Panel, United Kingdom
(Chairman: Professor DN Walder, MD)

Aseptic necrosis of bone is one of the health hazards of exposure to a hyperbaric environment such as diving or working in compressed air. The signs are the formation of lesions of dead bone in the head, neck or shaft of the major long bones. These lesions may remain symptomless but should they involve the articular surface of a major joint a painful and disabling osteoarthritis may result. The condition is also known as dysbaric osteoarthritis.

The precise cause of bone necrosis is not fully understood. Results of research indicate that an infarct of bone or bone marrow may result from exposure to, or decompression from, a high ambient pressure. This results in death of those bone cells deprived of their blood supply. Bone necrosis is not usually seen radiologically until revascularization of the necrotic area occurs. When this happens new bone is laid down upon the dead trabeculae, resulting in an absolute increase in the radiological density of the involved portion of the bone. A relative increase in the density of the avascular bone may sometimes be seen at an early stage when the surrounding healthy bone is the site of disuse osteoporosis. Radiologically it is not always possible to distinguish the stage of relative increase in density from that of the absolute increase in density.

Dense areas may be vague and ill defined or they may be distinct with a circular or irregular outline. They occur in the head, neck and proximal shaft of the humerus or femur and, most frequently, in the distal end of the femur and the proximal tibia. These are the skeletal areas routinely radiographed. Lesions have also been reported in the distal shafts of the humerus and tibia and in the fibula, but the elbow and ankle are not included in the recommended routine skeletal survey. Lesions may occur unilaterally, bilaterally or in any combination of sites. There is no set pattern. The articular surfaces of the knee joint are rarely, if ever, involved but the shoulder or hip joints may become disorganised through sequestration or collapse of the articular surface of the head of the humerus or femur.

The Medical Research Council support a Decompression Sickness Research Group which is carrying out research into the aetiology of aseptic necrosis of bone at the University of Newcastle upon Tyne. Part of this research involves the collection and review of large numbers of bone radiographs of divers and compressed air workers. The MRC Decompression Sickness Panel has prepared these recommendations to promote consistency in the radiographic examination for the detection of the disease.

British diving regulations require that commercial divers working on offshore installations or from diving barges in the North Sea and around Britain’s coast must undergo radiographic examination of their bones annually as a precondition of certification of fitness to dive. Similarly in the civil engineering industry, the accepted ‘Medical Recommendations for Work in Compressed Air’ advise that men who work at gauge pressure of 14 pounds per square inch (1 bar) or more should have their bones radiographed every six months whilst continuing so to work, followed by annual examination for at least two years after they cease to work at or above that pressure.

## The Basic Radiographical Survey

The basic skeletal survey should include antero-posterior projection of the heads and proximal shafts of both humeri and both femora together with antero-posterior and lateral projections of the distal two thirds of both femora and proximal third of both tibiae including the knee joints.

The radiographic diagnosis of early lesions of aseptic bone necrosis requires high quality radiographs which demonstrate the bone trabeculae clearly. The optimum screen-film combination (using rare earth intensifying screens, if available) and good screen-film contact is required together with a grid of adequate ratio and a focal spot of 0.6 to 1.2mm. A tube with a high speed rotating anode and 0.6mm target, if available, is ideal.

Exposures should always be adequate. Probably the greatest fault lies in under penetration of the bone tissue. Increased penetration by as much as five to ten kilovolts above normal is recommended.

The recommendations of the "Code of Practice for the Protection of Persons against Ionizing Radiation arising from Medical and Dental Use" should be followed.

Gonads must always be protected by a lead shield when radiographing the hips. Estimation of the radiation dose received by the patient indicates that this basic survey can safely be repeated at intervals of not less than six months.

## Recommended Procedure

### Shoulder: Antero-posterior projection

The area to be examined is the head and neck of the humerus including the proximal third of the shaft. The radiograph should show the articular surface of the humeral head unobscured by overlying bony structures and should give good definition of the trabeculae of the head and shaft.

A 24cm x 18cm screen film is recommended with high definition or rare earth intensifying screens and a moving grid.

The examination is best carried out on a horizontal table. From the supine position the patient is rotated through about 45° towards the side under examination until the blade of the scapula is parallel to the table top. The raised shoulder is supported on sandbags.

The arm under examination should be straight, supinated and abducted 10°. An extending pull should be applied to the arm so that the humeral head is clear of the bony processes of the scapula.

The X-ray beam should be at right angles to the film and centred over the head of the humerus. The beam should be collimated to show only the head and proximal third of the humerus.

The patient should hold his breath whilst the exposure is made.

### Hip Joint and Proximal Third of the Shaft of the Femur: Antero-posterior View

The radiograph should show good definition of the articular surface of the femoral head and of the trabeculae of both head and shaft. The underlying acetabulum cannot be avoided. A separate radiograph of each hip is required.

A 30cm x 24cm screen film is recommended with fast tungstate or rare earth intensifying screens and a moving grid. Fast tungstate screens are recommended in this situation to reduce the radiation dose. 2.5 to 5 Kilovolts more than normal should be used to increase penetration. The gonads must protected but care should be taken to ensure that the protection does not obscure the femoral head.

With the patient supine the plane across the anterior superior iliac spines should be horizontal. The foot of the side under examination should be at right angles to the table top and sandbagged into position.

The X-ray bean should be at right angles to the film, centred over the head of the femur, and collimated to show the head and proximal third of the femur.

Knee joint: Antero-posterior projection to show the distal two thirds of the femur and the proximal third of the tibia

The radiograph should show clear trabecular detail in the lower two thirds of the femur and the upper third of the tibia.

There is a variation of density between the middle and lower thirds of the femoral shaft so that it is necessary to increase the kilovoltage, reduce the milliamperage and use a moving grid to produce a radiograph of even contrast. Care should be taken not to under penetrate the shaft of the femur.

A 40cm x 15cm screen film is recommended with high definition or rare earth intensifying screens and a moving grid.

The patient should sit on the X-ray table with both legs extended. Each knee should be examined separately.

The X-ray beam should be at right angles to the table top. In order that the lower two thirds of the femur are included the beam should be centred at the upper border of the patella - not through the joint space. The beam should be collimated to show only the area under examination.

Knee Joint: Lateral projection to show the distal two thirds of the femur and the proximal third of the tibia

A lateral radiograph of the lower femur and upper tibia may demonstrate slight variations in bone density and trabeculae detail which are not apparent in the AP projection.

The requirements of definition are the same as for the AP. The graduation of density along the femoral shaft is also evident in the lateral projection and the exposure should be adjusted to give a radiograph of even contrast.

Either a 40cm x 30cm or a 40cm x 15cm screen film is recommended with high definition or rare earth intensifying screens and a moving grid.

Using the wide film, positioning should be as for a normal lateral projection of the knee with the knee flexed and the tibia parallel to the long axis of the film in order to include the distal two thirds of the femur.

The X-ray beam should be at right angles to the film and centred over the femur level with the upper border of the patella. The beam should be collimated to the area under examination.