DYSBARIC OSTEONECROSIS

With A Comment On The Radiological Changes In The Lungs in Decompression Sickness

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Dysbaric osteonecrosis, or caisson disease of bone, is a major hazard to compressed air tunnel workers and an increasing hazard to divers, especially now that dives are being made to very much greater depths and for longer periods. While the acute forms of decompression sickness — 'the bends' — develop within a few hours following decompression, dysbaric osteonecrosis is a late complication and it is five months at least, usually a year, before symptoms develop or radiological changes become apparent. In a typical case a diver may have been diving to depths of 180 ft. (55 metres) for 18 to 24 months without having experienced 'the bends'. Pain in the shoulder or hip joint may commence quite suddenly usually following heavy muscular exertion such as lifting a heavy baulk of timber. Initially the pain is slight and niggling gradually increasing in severity with progressive limitation of movement. Radiological examination at this time shows the classical changes of a structural failure involving the articular surface of the head of the humerus where the joint surface has collapsed into the underlying necrotic bone. Depending on the severity of symptoms, an arthrodesis or fusion of the joint may be indicated.

Osteonecrosis occurs in several other clinical situations the commonest being a fracture of the femoral head in the elderly and approximately 20% of patients may develop osteonecrosis of the femoral head. Other causes include the steroid-induced osteonecrosis and approximately 10% of patients having renal transplantation with high doses of steroids may subsequently develop bone necrosis of the head of the humerus or head of the femur. To appreciate the clinical and radiological significance of the changes it is important to have some understanding of the underlying pathology. Osteonecrosis means that a segment of bone has lost its blood supply and died. In the process of repair, granulation tissue grows in from the living bone gradually replacing the dead bone. New bone is laid on the trabeculae of the dead bone causing an overall increase in bone bulk and because of this there is an absolute increase in radiographic density. The earliest radiological change is therefore increased density and it is five months at least before this becomes apparent. In this way radiology provides the method where osteonecrosis can first be diagnosed. When the lesion is next to a joint surface such as the head of the humerus or the head of the femur then a structural failure may develop with the onset of pain and limitation of movement in the affected joint which will eventually develop osteoarthritis. If the lesion is away from a joint surface such as in the shaft of the femur then symptoms remain absent.

In Britain since 1963 the Decompression Sickness Panel of the Medical Research Council has studied the prevalence of dysbaric osteonecrosis in symptom free men, both in tunnel workers and now in commercial divers involved in oil exploration in the North Sea. Regular radiographic survey examinations include projections of both shoulder, hip and knee joints and are carried out at intervals of about one year. The examinations are carried out in different parts of the country and the films are sent to the Decompression Sickness Registry in Newcastle-upon-Tyne for interpretation by radiologists experienced in the detection of early radiological changes. Through this registry it has been possible to gain extensive experience of dysbaric osteonecrosis.

The incidence of osteonecrosis has been shown to be 19.9% amongst 1,694 tunnel workers. 9% of these men have a disabling or potentially disabling lesion, in other words, the lesion lies next to a joint surface which may subsequently collapse. Lesions are frequently multiple.

Fig. 1. Advanced Osteonecrosis of the right femoral head in man with many years experience of work in compressed air. There is quite marked increased density of the right femoral head. In addition there is a structural failure of the articular surface of the femoral head superiorly so explaining the patient's symptoms of pain and limitation of movement.
and bilateral and the femoral shaft is the most common site followed by the head of the humerus and the head of the femur. Calcification in the femoral shaft is the most common abnormality and the next most common is increased radiological density in the head of the humerus or femur.

Amongst the 1,216 commercial divers in the North Sea, 25 have positive evidence of osteonecrosis — an incidence of 2.1%. A similar skeletal radiographic survey of 350 Royal Navy Divers in 1970 showed a 4% incidence of osteonecrosis. However a recent radiological radiographic survey of 301 Japanese divers showed a 50.1% incidence and many young men had a crippling and permanent arthritis seriously curtailing their working life. These men were diving for expensive sea food and had very little understanding of the medical and physiological problems involved. In fact several died each year and there was a high incidence of — ‘the bends’. Equipment was faulty with no compression facilities for treating the ‘bends’ and cases were managed by further immersion in water. If the man did not drown then he suffered from extreme cold. This report clearly underlines how serious a hazard dysbaric osteonecrosis may be to the diver and the value of good safety regulations.

![Fig. 2: Extensive area of calcification in the proximal shaft of the tibia in a Diver with many years experience of diving to depths greater than 180 ft. The lesion is at some distance from the joint surface and because of this there are no symptoms.](image)

The Decompression Sickness Registry has been able to relate the incidents of bone lesions to the occupational history. Amongst the tunnel workers lesions have been found to be more common at pressures over three atmospheres absolute (99 ft — 30 metres) and are more common with the greater number of exposures to compressed air. Significantly more of the men had experienced ‘the bends’. Amongst the divers the radiological changes have been related to depth and positive evidence of osteonecrosis has only been found in men who exceeded 180 ft. with the exception of 1 diver who had only been to 140 ft. (45 metres).

When a lesion is diagnosed either radiologically or because symptoms have developed the diver should be advised to cease diving. Unfortunately orthopaedic management is not satisfactory either before or after a structural failure has developed particularly in the healthy young adult. The only method presently available to ensure the earliest and correct diagnosis, before symptoms develop, is by regular radiographic skeletal survey. Early diagnosis by this means is not easy and depends very largely on the quality of the radiograph and interpretation by an experienced radiologist who can distinguish between the appearance of early damage caused by dysbaric osteonecrosis and normal variation in bone structure. It is an insidious condition and the diver is completely unaware that he has got bone necrosis until at least five months after the bone has died. The first he knows of any trouble is either by being examined radiologically or when a joint surface collapses and arthritis develops. There is no way of identifying which man will develop dysbaric osteonecrosis or where the lesion will appear.

Clearly it is important to reduce the incidence of this distressing condition and any serious attempt to control the situation must involve regular bone x-rays of those at risk. Prevention is an important aspect of this disease and can best be achieved by a continuing and comprehensive research project involving as many divers as possible.

Several interesting autopsy chest radiographs in diving fatalities have been obtained. One demonstrated a pneumothorax, mediastinal and surgical emphysema and extensive gas/air in the vessels in the diver who had got into difficulties and died following a dive to 120 ft. (35 metres) for 10 minutes. The other showed mediastinal emphysema and extensive intravascular gas/air in a man who had dived to 420 ft. (130 metres) in the North Sea. There was pathological evidence of acute traumatic emphysema with rupture of multiple alveoli.

The value of the pre-diving chest radiograph was underlined and the importance of excluding those with radiological evidence of a bulla or cyst from all forms of diving.