

Diagnosis and Treatment of Decompression Sickness

A. General Survey

1. History

Decompression sickness has in the past been defined as an overt illness that may appear in a human being while diving or following a reduction in environmental pressure sufficient to cause bubble formation and/or growth from the gases dissolved in the tissues. Other terms have been legitimized by use to have an equivalent meaning, despite the opinions of experts that it would be more desirable either to not use such terms at all or else to use them only in relation to a particular type of decompression sickness: such terms include *caisson disease*, *compressed air illness*, and *the bends*. The diving medical community has been fairly successful in discouraging the use of the term *dysbarism*, which really could refer to any one of the many disorders that might result from a change in pressure, and the term *aeroembolism*, which was confusing because it was often unclear whether the reference was to air embolism or to aviators' decompression sickness. At any rate the classic definition of decompression sickness (DCS), while still applicable in the majority of cases, is no longer strictly correct. For example there is now serious doubt that DCS is overt in all cases. Although Behnke (1951) had hypothesized the "silent bubble" as early as 1951, it has only been since ultrasound detectors have achieved prominence over the past decade that a number of investigators have actually demonstrated that bubbles do exist in the venous circulation during any significant decompression, whether overt symptoms of DCS are present or not. This implies that DCS develops when there is some critical bubble effect (due to the amount of bubbles and their secondary interactions) rather than a critical supersaturation as classically defined. Furthermore, it has recently been recognized that an isobaric form of counterdiffusion can lead to bubble formation without a reduction in environmental pressure.

Robert Boyle demonstrated in 1670 that a reduction in pressure could lead to bubble formation in living tissue, and it is perhaps surprising that the significance of his findings

was not appreciated for more than two centuries, since references to the problems, diseases, and deaths of early human divers date back to well before the Christian era. It was not until the development of the first practical deep-sea diving outfit by Augustus Siebe in 1819 and the large-capacity compressors that allowed the use of caissons in securing bridge foundations on river bottoms (first used by Triger in 1841) that large numbers of men had the means to work at raised environmental pressures for significant periods of time. While a boon for construction, salvage, and other projects, it was not long before the human costs began to be appreciated. Of the Greek sponge divers who began to use the fully closed helmeted diving suit designed by Siebe in 1837, it is said that 50% died during the first year; prior to this they had for the most part used the simple expediency of breath-hold diving and, over a period of 100 generations or so, appeared to have acquired a remarkable degree of freedom from the physiological hazards of their profession. In the early 1840s, symptoms of DCS were first described by Triger, a French mining engineer, in coal miners working in shafts that were pressurized to prevent flooding (Triger 1841). Early attempts to explain the development of DCS symptoms included theories such as reflex spinal cord damage secondary to exhaustion and cold, frictional electricity caused by compressed air, toxemia secondary to increased tissue catabolism, stasis and congestion of internal organs caused by blood forced internally by the pressure, or alternatively by hypovolemia in internal organs secondary to a rapid return of blood peripherally during decompression.

In 1847 (although this work was not published until 1854), Pol and Watelle realized there was a relationship between the onset of symptoms, the depth and duration of exposure, and the rapidity of decompression. They also observed in 1847 that symptomatic relief could sometimes be obtained by returning the victim to an increased pressure environment, and they therefore suggested that gas bubbles might be involved in the development of DCS. Nonetheless, it was to be the early 1900s before the “new” treatment modes for DCS victims gained widespread acceptance as a result of these and similar observations by a number of physiologists and physicians involved in major engineering projects. In the meantime, the literature was replete with anecdotal accounts of DCS cases throughout the world and measures routinely taken for the affliction—measures that today make us shudder. For example, Dr. Graham Blick from 1900 to 1908 was an Australian district medical officer with medical responsibility for a large pearling center employing more than 400 divers who daily harvested oysters at depths from 40 to 120 ft. In reviewing more than 200 cases of “diver’s palsy” Blick writes, “The most troublesome cases were those complicated by cystitis and deep sloughing. The former complication is very frequently set up by imperfectly cleaned catheters used by the diver’s friends, often for several days, while making for port. The paralysis of micturition is so well known among the men themselves that no diver would consider his outfit complete without a soft catheter.” (Blick 1909). Those must have been the days when men were men! Perhaps even more revealing of the attitude toward DCS before the early 1900s are the words in 1871 of A. Jaminet, a physician who had medical responsibility during the construction of an arched bridge across the Mississippi river at St. Louis, Missouri. The caissons for this huge undertaking were sunk in as deep as 115 ft of water, by far the greatest depth at which this type of work had ever been performed. Between February 10 and February 19, 1870, Dr. Jaminet made three visits to the working chamber at depths ranging from 69 ft to 81 ft (21–25m). With each decompression he was increasingly affected by “severe epigastric pain” and a “feeling of great fatigue and depression of the system.” He was unable to make a scheduled visit on