Letters to the Editor

Hypothesis: the influence of cavitation or vacuum phenomenon for decompression sickness

Attention has recently been focused on the vacuum phenomenon detected by computed tomography (CT), where gas in the human body is incidentally detected by CT. We introduce our hypothesis that the vacuum phenomenon increases the risk of decompression sickness (DCS) in subjects who engage in post-diving exercise.

When the screw propeller of a ship operates underwater, a swirling effect called cavitation occurs. This swirling effect is closely related to the ship's propulsive efficiency as well as propeller cracking and damage. Hydrodynamic cavitation describes the process of vaporization, bubble generation, and bubble implosion that occurs in a flowing liquid as a result of a decrease and subsequent increase in local pressure. The formation of cavitation depends on the pressure, speed, temperature, viscosity, turbulence, or existence of impurities in the fluid; the evaporation of inert gas; and the form and surface roughness of the screw. These factors also resemble risk factors of DCS.

In the human body, the cavitation effect has been recognized in radiological studies, where it is referred to as the 'vacuum phenomenon'.[1] The mechanism responsible for the formation of the vacuum phenomenon has been described recently.[2] If an enclosed tissue space is allowed to expand as a rebound phenomenon after an external impact, the volume within the enclosed space will increase. Under this condition of expanding volume, the pressure within the space will decrease. The solubility of the gas in the enclosed space will then subsequently decrease as the pressure inside the space decreases, allowing a gas such as nitrogen to leave solution. The combination of reduced nitrogen solubility and the minimal metabolism of nitrogen by the body mainly accounts for the formation of the vacuum phenomenon. The vacuum phenomenon has been observed in normal joints, degenerative intervertebral discs, the spine and spinal canal and traumatized tissues (Figure 1).[1]

Exercise induces the inflation and deflation of tissue or the extension and flexion of multiple joints. The pressure of the inflated tissue or extended joints decreases based on Henry's Law and Boyle's Law, resulting in cavitation. This phenomenon may be accelerated after diving, during the decompression phase. In an analysis of the effects of the ascent rate and post-dive exercise on the incidence of DCS in rats using ordinal logistic regression, higher rates of DCS and mortality were seen in rats which engaged in post-dive exercise than in control rats.[3] Accordingly, DCS following post-diving exercise may be induced by the vacuum phenomenon, particularly in cases with joint pains. The fact that the vacuum phenomenon is most frequently observed in the spine or spinal disc spaces may also influence the occurrence of spinal cord neurological DCS, which is rarely due to embolization from cardiac origin.

Figure 1
Computed tomography of a male with an open-book-type pelvic fracture due to a motorcycle accident shows the vacuum phenomenon in the lumbar disc space (white arrow), lumbar spine (black arrow), and left sacro-iliac joint (black triangle) (with permission)

References

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Commentary:

Dr Yanagawa and his colleagues present an interesting hypothesis, and our group has had some discussions around this vacuum phenomenon and decompression sickness (DCS). I am aware of at least one diver in whom