Medical Problems in Scuba Diving

To the Editor:

We read with great interest the Roentgenogram of the Month by Hamad et al in a recent issue of CHEST (January 2001). Concerning the anamnesis and the chest radiograph, we agree with the diagnosis but not with some of the explanations regarding medical problems encountered during scuba diving or any other hyperbaric exposure (hyperbaric chambers, etc.). There are a number of inaccuracies in the text.

The authors mention barotrauma, decompression sickness, and nitrogen narcosis as common complications of scuba diving, going on to state that “the mechanism in all these complications is the same.” Indeed, all of these phenomena may result from breathing compressed gas under water, but the mechanisms are different. Barotrauma is due to a failure to equalize pressures between different compartments, or doing so at an insufficient rate, with the result that during descent there is a relative underpressure in these compartments. In this case, there is no relation to Henry’s law but rather to Boyle’s law. It is therefore erroneous to state that “compressed gases cause a negative pressure on the walls of the body cavities.” Common complications are middle ear and sinus barotrauma. Stomach rupture due to barotrauma is a rare event, in contrast to what may be understood from the text.

At every depth, the pressure of the air (which is the breathing mixture in most sport diving) in the lung must be equivalent to the ambient pressure. If the diver holds his breath during ascent, when the ambient pressure drops by one atmosphere for every 10 m, according to Boyle’s law the lung will expand to a point of rupture, resulting in subcutaneous emphysema, pneumothorax, cerebral gas embolism, and pneumocardiagia, as in the presented case. Again, there is no relation to Henry’s law. The gas involved is whatever gas is breathed during the dive, and not “expanding nitrogen” as mentioned by the authors.

It is our impression that the authors have confused barotrauma with decompression sickness. In the latter, nitrogen bubbles form in the tissues and blood after a certain nitrogen load is formed in the lung. This occurs by allowing more time for entrapped expanding gases to be re-equilibrated between the tissues and the blood. This causes the formation of nitrogen bubbles in the blood, which can be very extensive and result in fatal gas embolism. Although all gases expand under decreasing pressure, nitrogen is the main component (80%) of air, so it is the main gas to expand and cause barotrauma. Stomach rupture was mentioned with the rest of the complications in the first paragraph, but was stated and referred to as an infrequent complication in the third paragraph.

In our case, we think that the mechanism of pneumocardiagia was secondary to both Henry’s and Boyle’s laws. First, there was insufficient time for nitrogen gas to re-equilibrate, which caused accumulation of gas in the heart chambers and massive embolism (Henry’s law). Second, there was barotrauma with expanding air entering the left chambers of the heart through traumatic pulmonary veins (Boyle’s law). Although the US Navy and the Royal Navy protocols were designed originally and mainly to prevent decompression sickness, it does also prevent barotrauma by allowing more time for entrapped expanding gases to be exhaled from the lung during these stops upon ascending.

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References


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We read the interesting comments by Abramovich et al on our article in CHEST (January 2001), which raise some issues that need to be clarified. While the main mechanism in all the complications of scuba diving is the same (compression of gases underwater on descending and expansion under decreasing pressure on ascending), it depends on two laws to explain its pathophysiology: Henry’s law, which states that the amount of a given gas that is dissolved in a liquid is proportional to the partial pressure of that gas, which explains decompression sickness and nitrogen narcosis, and Boyle’s law, which explains barotrauma.

Cerebral gas embolism and pneumocardiagia are complications of Henry’s law, as they result from insufficient time for nitrogen to re-equilibrate between the tissues and the blood. This causes the formation of nitrogen bubbles in the blood, which can be very extensive and result in fatal gas embolism. Although all gases expand under decreasing pressure, nitrogen is the main component (80%) of air, so it is the main gas to expand and cause barotrauma. Stomach rupture was mentioned with the rest of the complications in the first paragraph, but was stated and referenced as an infrequent complication in the third paragraph.

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