A previously healthy 25-year-old man made a telephone call to our institute 3 h after surfacing from a self-contained underwater breathing apparatus (scuba) dive. Earlier that day, he had been spear-fishing using compressed air to a maximal depth of 9 m for approximately 2 h. Immediately after surfacing from the dive, he had noticed a significant change in his voice, and complained of dyspnea with pleuritic chest pain. Over the telephone, his voice sounded distorted with an unusual nasal quality, and a probable diagnosis was made. He was then asked to come to the emergency department. Physical examination revealed subcutaneous emphysema at the anterior triangle of the neck. Auscultation of the lungs and heart was normal, and the neurologic examination was unremarkable.

A chest radiograph (Fig 1), a lateral cervical radiograph (Fig 2), and an anteroposterior cervical radiograph (Fig 3) were obtained.

What is the diagnosis?
Figure 2. Lateral cervical radiograph showing subcutaneous emphysema and free air in the retropharynx.

Figure 3. Anteroposterior soft-tissue cervical radiograph showing subcutaneous emphysema.
Diagnosis: Pneumomediastinum secondary to pulmonary barotrauma

DISCUSSION

During descent from sea level to depth, the ambient pressure rises by one atmosphere absolute (ATA) with every 10 m. At a depth of more than a few centimeters, it would be quite impossible to breathe the surface air via a long tube (a snorkel), because the diver would have to generate a negative intrapleural pressure sufficient to overcome the difference between the ambient pressure and that at the opening of his airways. In order to be able to breathe comfortably with a minimum increase in the work of breathing, scuba divers use diving equipment designed to deliver breathing gas at the changing ambient pressure.

Scuba divers, who breathe compressed gas, are exposed to the risks of pulmonary barotrauma. According to Boyle’s law, at a constant temperature, the volume of a gas is inversely proportional to its pressure. Thus, the gas-containing cavities of the body are at risk of barotrauma. During descent, gas-containing cavities in which the pressure cannot be equalized may suffer from “squeeze” barotrauma, ie, the middle ear, sinuses, etc. At depth, tidal volume and vital capacity are very much the same as in normobaric conditions, but the same volumes contain larger amounts of gas due to its being compressed. According to Boyle’s law, the gas will expand on ascent and may cause lung expansion and barotrauma if not vented. Divers are therefore taught to exhale continuously during their ascent. If the diver holds his breath while making his ascent, or if he has regional gas trapping, the lung may overdistend to the point of rupture. The consequences of this may be pneumothorax, pneumomediastinum, subcutaneous emphysema, pulmonary tissue damage, gas embolism, or in rare cases pneumopericardium. In pneumomediastinum, after alveolar rupture gas escapes into the interstitial tissues, causing cervical and mediastinal emphysema. The free gas might reach the larynx, causing discomfort, dysphagia or voice alterations. Alteration of the voice has been reported as hoarseness, a high pitched voice, or rhinolalia. These changes in the voice have been attributed to “submucosal emphysema” of the upper airways or recurrent laryngeal nerve damage. Braverman et al suggest that hyponasality due to narrowing of the nasopharyngeal passage by air spreading into the retronasopharynx may account for the rhinolalia.

In the present case, the diver was using a spear-gun, which is loaded by pressing it firmly against the body. This action is often accompanied by a breath-holding Valsalva maneuver. Without noticing, the diver could easily have ascended a certain distance, thus causing pulmonary barotrauma. The classic sign of a change of voice was noticed during the telephone call, hence making it possible to conduct a “physical examination” over the telephone.

Many physicians, whose main interests are not in diving medicine, are often under the misapprehension that diving accidents do not occur in shallow water. There is a proportionately greater change in volume in shallow water compared to deep water for the same pressure gradient. Diving from the surface to a depth of 10 m (going from 1 to 2 ATA) doubles the ambient pressure, and therefore halves the volume of gas-containing spaces (and vice versa on ascent). Descent from 20 to 30 m (going from 3 to 4 ATA), once again a change of 1 ATA, will result in a decrease of only one fourth of the volume. For this reason, the possibility of barotrauma is greater in shallow water than on a deeper dive. Serious complications of pulmonary barotrauma such as acute gas emboli have even been reported in scuba divers in a swimming pool.

The treatment of pneumomediastinum accompanied by subcutaneous emphysema consists of oxygen via a tight facemask and observation. In the present case, a second chest radiograph obtained 12 h later showed resolution of the air in the mediastinum.

CONCLUSION

In order to prevent pulmonary barotrauma, the diver must exhale continuously during ascent and never hold his or her breath. The clinician should be aware of this phenomenon and never underestimate the risks of scuba diving in shallow water.

REFERENCES