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Concurrent Pneumocephalus, Pneumothorax and Pneumomediastinum in A Submarine Sailor

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Abstract

Dysbarism, also known as diver's disease, the bends or caisson disease, is usually caused by underwater activities. It bothers the divers, no matter whether they underwent scuba or just free diving, with the most frequent symptoms including joint pain, headache, visual disturbance and shortness of breath. The most dreadful, but rare, symptom is seizure with change of consciousness that could lead to submersion injuries and even death. In some circumstances, it might also happen when people underwent diving training and medical hyperbaric oxygen therapy in the recompression chamber. Herein, we present one patient who planned to work on a submarine and received hyperbaric training in the recompression chamber. Just when descent similar to pressure at 110 feet deep under sea level, sudden onset of dizziness and then loss of consciousness with generalized seizure happened. After a return of consciousness in a few minutes, the patient showed four-limb paralysis with sensory impairment and chest pain. The computed tomography of the brain and chest performed in the emergency department concluded with a diagnosis of concurrent penumocephalus, pneumothorax and pneumomediastinum. After treatment with fluid hydration, oxygen therapy and chest thoracostomy drainage, conditions above improved, but the sensory impairment remained. Recompression therapy was not performed due to rapid clinical regression of neurologic symptoms and the multiple pulmonary cysts that may lead to further barotrauma. (J Intern Med Taiwan 2017; 28: 86-90)

Key Words: Seizure, Pneumocephalus, Dysbarism

Introduction

Dysbarism refers to medical conditions resulting from changes in ambient pressure; it often happens to divers and airplane travelers when descending and ascending. Sometimes, under rare circumstances, people receiving regular underwater training or medical therapy in the hyperbaric chamber with recompression and decompression procedures will also suffer from this problem. The most serious ones were pulmonary barotrauma and arterial gas embolism during the breath-hold ascent/decompression. The rate of occurrence if followed appropriate decompression procedures is 0.015% for scientific divers, 0.019% for recreational divers and 0.095% for commercial divers. And the overall rate was about 0.03%.[1]

Case presentation

A 23-year-old man had just joined the Navy

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and was ready to serve aboard a submarine. For this reason, he was arranged for hyperbaric training in a recompression chamber. Just after descending to a simulated pressure equivalent to a depth of 110 feet under sea level for the first time training, he started to experience dizziness and then after a few seconds, generalized seizure with loss of consciousness happened.

After first aid, he was brought to the emergency department where a serum examination showed no significant abnormality (WBC:9700/μL, Hgb:15.1 g/dL, Platelet:258000/μL, Na: 137 mmol/L, K:3.2 mmol/L, Glucose: 113 mg/dL, Creatine: 0.6 mg/dL, C-reactive protein: 0.6 mg/dL, D-dimer: 1564 ng/ml, Ca: 9.0 mf/dL; ABG: PH: 7.484, PO_2:178.9 mmHg, PCO_2: 34.2 mmHg, HCO_3: 25.9 mmol/L, $O2_{sat}$: 99.9%). Chest X-ray and electrocardiogram were also checked with no abnormal finding. After a return of consciousness, the patient complained of dizziness, headache, four-limb weakness, shortness of breath and chest pain. A computed tomography (CT) scan of his brain was performed with no hemorrhage discovered, but existence of intracranial air bubbles in the both fronto-parietal and temporal lobes that probably came from the nasal cribriform plate and got into the intracranial space. (Figure 1,

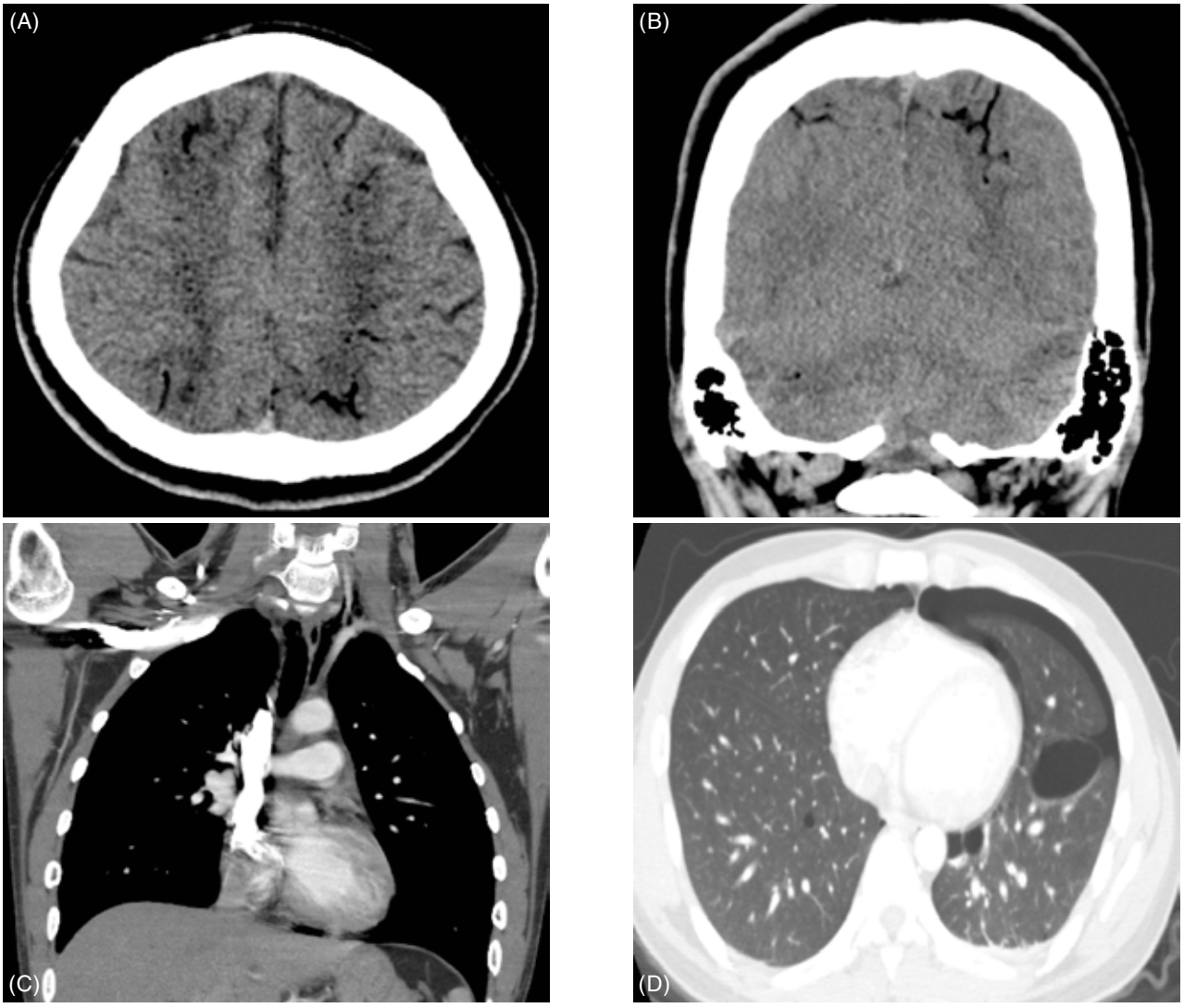

Figure 1. CT of brain and chest of the patient: (A) and (B) intracranial gas in both upper aspects of bilateral fronto-parietal and occipital lobes. (C) pneumomediastinum and subcutaneous emphysema. (arrow) (D) dilated air cysts, both lungs with pneumothorax.

A and B) With the impression of dysbarism-related pneumocephalus, he received oxygen therapy and intravenous fluid hydration. However, the dyspnea and chest pain got worse, and, therefore, the CT of chest was done. Surprisingly, multiple thin-walled and dilated air cysts over both lungs, the largest one measuring 4.5 cm in width, were found with left pneumothorax and pneumomediastinum that caused by rupture of air cysts. (Figure 1, C and D) By the above CT findings, decompression sickness with pulmonary barotrauma was diagnosed.

After two days of oxygen therapy, rehydration and surgical intercostal tube thoracostomy, the condition was subsiding. The muscle power of the limbs returned to normal, but the patient still felt numbness of the right side limbs. The repeated CT of brain and chest showed improvement of pneumocephalus, pneumomediastinum and pneumothorax, but the dilated air cysts over both lungs remained. (Figure 2, A, B and C) Also, surprisingly, several

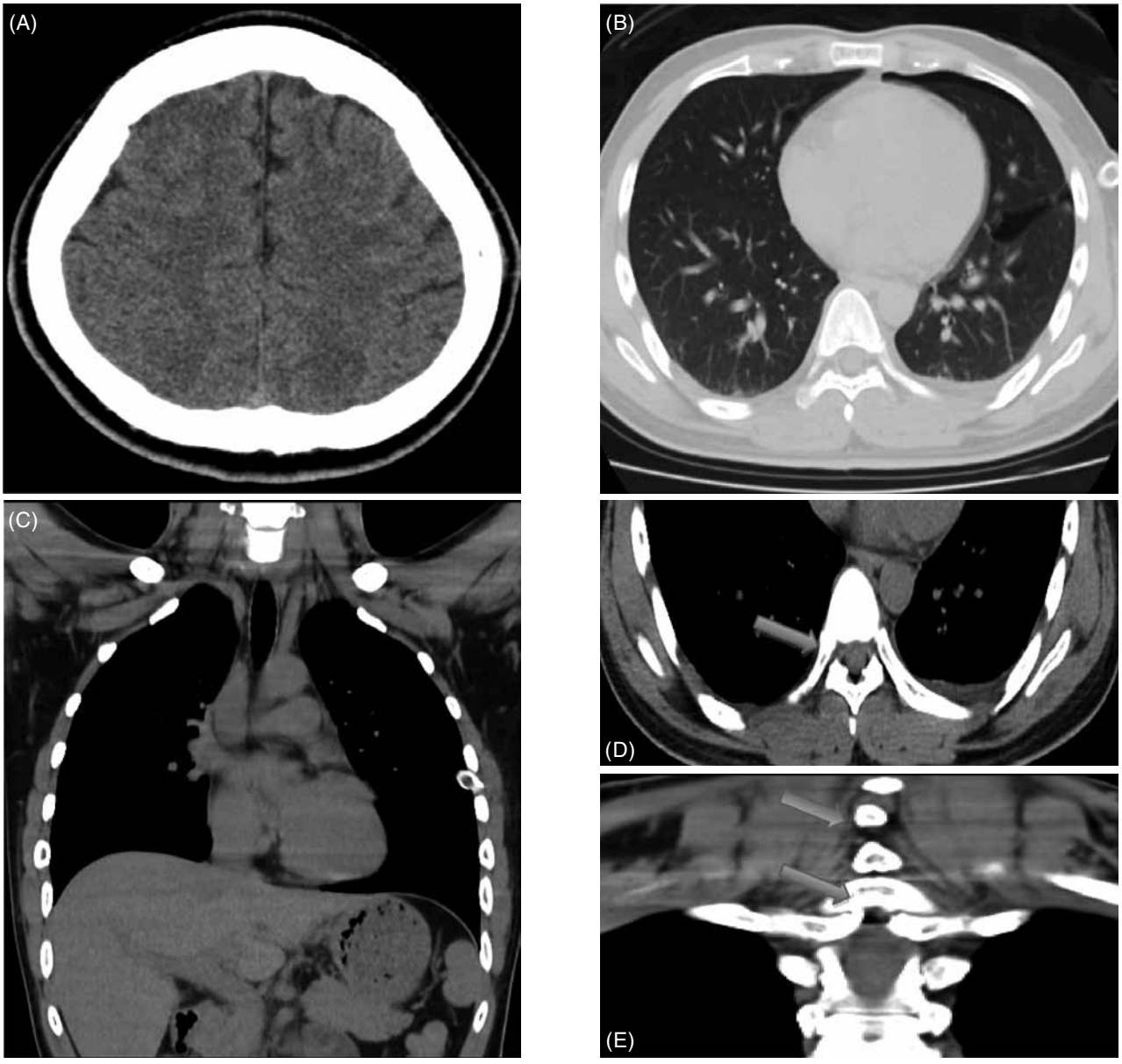

Figure 2. CT of brain and chest of the patient after oxygen therapy: (A) freedom of intracranial gas. (B) and (C)smaller air cysts with improving pneumothorax and freedom of pneumomediastinum. (D) and (E) gas in spinal canal (arrow).

air bubbles were found in the spinal canal that might originally due to decompression sickness. (Figure 2, D and E)

Discussion

Dysbarism is caused by change of ambient pressure and encompasses decompression sickness, arterial gas embolism, nitrogen narcosis, high-pressure nervous syndrome and barotrauma. It is caused mostly by underwater activities, no matter whether during free diving, scuba diving or caisson work. But sometimes, it might be caused by a rapid change of altitude, such as aircraft and spacecraft flying. In rare circumstances, like this case, the underwater training or medical treatment in a recompression chamber could lead to this life-threatening decompression sickness and barotrauma, including pneumomediastinum, subcutaneous emphysema, pneumothorax and pneumocephalus. [1,2]

Gas bubbles, whether intravascular or extravascular, were long thought to be the main pathophysiological factor of dysbarism. The expanding gas when ascent wound stretch and rupture the pulmonary alveolus and capillaries. Therefore, it allows the gas to get into the arterial circulation and also the extrapulmonary space. But some studies showed that the micro-particles, cell-derived membrane vesicles and also neutrophil activation might lead to vessel endothelial dysfunction and therefore decompression sickness.[2,3] The onset of dysbarism varied from 1 to 48 hours and the symptoms could be classified into two types. First, the simple type is induced by extravascular air bubbles spreading into joint space, the lymphatic system, mediastinum, pericardium, subcutaneous tissue and the brain; it might cause pain and dyspnea. Second, the serious type is intravascular air bubbles forming in the arteries or veins which can lead to acute gas embolism frequently involving the pulmonary and central nervous systems.

The predisposing factors are classified into individual and environmental ones. The individual factors include older age, high body fat content, previous injury, existence of patent foramen ovale or interatrial shunts, under cold ambient temperature and dehydration. The environmental factors include rapid rate of ascent, repetitive exposure and flying or traveling to high altitude soon after underwater diving.[1,4,5,6]

The diagnosis of dysbarism should be kept in mind when symptoms occur after exposure to change in ambient pressure, whether flying or diving. CT or magnetic resonance imaging may help by detecting air bubbles inside the body, but is not as good as taking a proper history and description of symptoms. All cases of dysbarism should be treated with 100% oxygen support and rehydration. In circumstance of decompression sickness and arterial gas embolism, recompression is the standard treatment.[1,7] But if concurrent pulmonary barotrauma, recompression therapy should be performed after chest thoracostomy tube insertion and, if not, the recompression could leads to life-threatening tension pneumothorax. The prognosis of decompression sickness and gas embolism after prompt treatment with hyperbaric oxygen therapy is good, but long term injury remains possible.

Detection of patent foramen ovale or interatrial shunts as a way of reducing serious arterial gas embolism before underwater activities has been of interest since the estimate relative risk arrange from 2.5-6.6. But, it is not performed routinely due to low rate of serious neurologic symptoms (<0.02%) and high cost.[1] As for pulmonary barotrauma, chest X-ray is the mostly used screening tool for possible cysts and other disease before hyperbaric oxygen therapy, training and underwater activities. Since the coexisted pulmonary cyst without previous symptom is not the absolute contraindication and the prevalence rate of barotrauma is low (<0.004%), neither CT of chest is routinely performed due to high cost.

In this case, the symptom of seizure and paralysis subsided soon after 48 hours, but the sensory deficit of the right side limbs remained, which might be due to air bubbles in the spinal canal with related spinal cord damage or high-pressure nervous syndrome.[7,8,9] The dilated thin-walled air cysts in both lungs remained. The advice was to avoid rapid change of air pressure, no matter whether flying, mountain climbing or diving.

Conclusion

Diagnosing dysbarism is not easy and is usually expensive. The treatment, including hyperbaric oxygen therapy, is also high-priced. Obeying the decompression schedule could reduce the probability to a very low level.

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高壓艙訓練引發氣腦症併發氣胸及縱膈腔氣腫

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摘　要

減壓症，俗稱潛水夫病，指的是當進行水下或任何有壓力變化的活動時，如果沒有經過適當的減壓程序，就容易導致氣體從血液中或肺泡跑到身體其他部位，進而引起關節疼痛，頭痛，視力模糊，呼吸喘，意識喪失或抽搐等症狀，嚴重的甚至會導致死亡。這篇病例報告是有關一位男性因預期將至潛艦服役，所以接受例行性的潛水壓力艙訓練，但訓練途中發生突發性的意識喪失併抽慉現象，而當病患清醒後就出現四肢無力，感覺異常及胸痛等症狀，經檢查後確認其罹患減壓症，包括了氣腦，氣胸及中縱膈腔氣腫。在一連續的治療過程，其中包括大量水分補充，高濃度氧氣及胸管引流治療後，病情迅速獲得明顯改善，但仍存有局部肢體感覺異常的後遺症。