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Alveolar Hemorrhage and Traumatic Pneumatoceles Following Breath-Hold Diving in Shallow Water

Sığ Suya Serbest Dalış Sonrası Gelişen Bir Alveoler Kanama ve Travmatik Pnömatosel Olgusu

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Abstract

Breath-hold diving, known also as freediving, is a form of underwater diving in which one holds their breath, making use of no breathing equipment. The complications associated with breath-hold diving have not been well studied in literature, in contrast to scuba diving. Hemoptysis risk is known to be correlated with deep diving. We present here the computed tomography findings of a breath-hold diver who presented with hemoptysis following a dive to 4 meters, which can be considered shallow in the sport. The patient's chest computed tomography revealed multiple pneumatoceles within the areas of pulmonary hemorrhage. To the best of our knowledge, there have been only a few cases reported to date in which pneumatoceles were identified associated with free diving.

Keywords: *Alveolar hemorrhage, barotrauma, breath hold diving, computed tomography, pneumatocele.*

Öz

Serbest dalış, nefes tutmaya dayalı ve herhangi bir solunum ekipmanı kullanılmadan yapılan bir su altı dalış şeklidir. Tüplü dalışın aksine, serbest dalışın komplikasyonları literatürde yeterince araştırılmamıştır. Hemoptizi riskinin dalış derinliğiyle ilişkili olduğu bilinmektedir. Dört metrelik sığ derinliğe dalmaya sonucu hemoptizi ile başvuran bir serbest dalgıç olgusunu ve bilgisayarlı tomografi bulgularını sunmayı amaçladık. Toraks bilgisayarlı tomografisinde pulmoner kanama alanlarında çok sayıda pnömatosel görülmüştür. Bildiğimiz üzere literatürde daha önce serbest dalışa sekonder pnömatosel gelişen az sayıda olgu bulunmaktadır.

Anahtar Kelimeler: *Alveolar kanama, barotravma, serbest dalış, bilgisayarlı tomografi, pnömatosel.*

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Breath-hold diving (BHD), known also as freediving, is an underwater sport requiring one to hold one's breath without using any breathing equipment. In contrast to scuba diving, studies of the complications of breath-hold diving are few and far between in literature. We report here on the case of a breath-hold diver who developed hemoptysis despite only diving to a shallow depth, and who developed multiple pneumatoceles within the areas of pulmonary hemorrhage. There are only a few studies in literature reporting on the development of pneumatoceles as a result of freediving (1).

CASE

A 46-year-old male freediver was admitted to the emergency room of our university hospital with hemoptysis occurring after a free dive to a depth of 3–4 meters deep. After swimming rapidly 40–50 meters out into the sea from the shore, he quickly dived to the sea floor without resting, holding his breath for longer than any previous attempt, and returned to the surface after feeling pressure on his body. He didn't lose consciousness or swallow any seawater, and there was no cough, chest pain or shortness of breath upon reaching the surface. After taking a deep breath he initially brought up around 100 ml of blood and continued to produce further 5 ml quantities of blood at a time until he swam to shore.

Upon admission to the hospital, his chest was clear on auscultation, and there were no rhonchi or rales. He was not febrile, with a temperature of 36°C and respiration was recorded at 20 breaths/minute. His oxygen saturation was 96% in air, blood pressure was 143/95 mmHg and heart rate was 60 beats/minute. blood tests values were C-reactive protein (CRP) 1.1 mg/L; high sensitivity Troponin-T (HS-TROP) at 7.2 ng/L; creatine kinase MB (CK-MB) 1.3 ng/mL; activated partial thromboplastin time (APTT) 28.86 s; International Normalized Ratio (INR) 1.02; partial thromboplastin time (PT) 11.31 s; white blood cell count (WBC) 7.5 × 103/μL; lymphocyte count 1.2 × 103/μL; neutrophil count 4.4 × 103/μL; hemoglobin 14.9 g/dL; hematocrit 43.0%; and platelet count 242 × 103/μL. A Polymerase chain reaction (PCR) test for COVID-19 was negative.

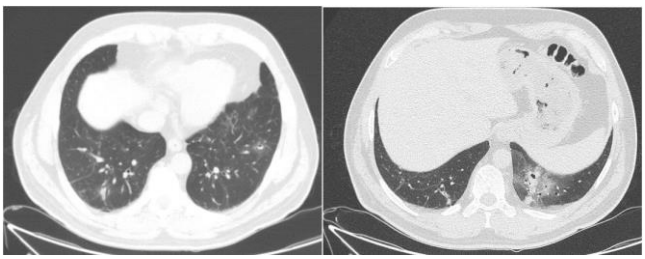

Figure 1: Axial chest CT images revealing pulmonary hemorrhage, presenting as patchy areas of ground glass opacity and consolidation in both lower lobes, and multiple pneumatoceles 3–9 mm in size within the areas of pulmonary hemorrhage

Chest CT images revealed pulmonary hemorrhage, presenting as patchy areas of ground glass opacity, consolidation and multiple pneumatoceles, as can be seen in Figure 1, contrasting a CT scan taken 2 years ago the patient was fitted with a stent following coronary artery disease which showed no consolidations, infiltration or pneumatoceles.

The patient was hospitalized for 3 days, during which there was no hemoptysis, no shortness of breath or cough, and no requirement for oxygen therapy. He was treated with intravenous ampicillin 4 g/sulbactam 2 g per day during his stay and peroral amoxicillin 1700 mg /clavulanate 250 mg per day for a week after being discharged.

The patient had experienced a myocardial infarction 2 years earlier for which he was fitted with a coronary stent and had been treated with acetylsalicylic acid 100mg/d and ezetimibe 10 mg/d since then. Vasculitis markers of anti-extractable nuclear antigen antibodies (ENA), anti-smooth muscle antibodies (ASMA), anti-parietal cell antibodies (APCA), anti-neutrophil cytoplasmic antibodies (ANCA), anti- cyclic citrullinated peptide (Anti-CCP), anti-smooth muscle antibodies (ASMA), anti-mitochondrial antibodies (AMA) and anti-liver-kidney microsome antibodies (LKM) were negative in a blood test, although only the anti-nuclear antibody (ANA) test result was at the lower limit of positivity (with 1/100 titer, stained colored).

A bronchoscopy examination identified no abnormalities in the bronchi of all lobes and segments, other than in the right intermediate bronchus that was identified as aspirated coagulum. There were no endobronchial lesions nor active bleeding during the procedure. A histopathological examination of bronchial washings from all bilateral segmental bronchi was negative for malignancy. Globular iron accumulations were detected in alveolar macrophages with Prussian blue staining, suggesting alveolar hemorrhage.

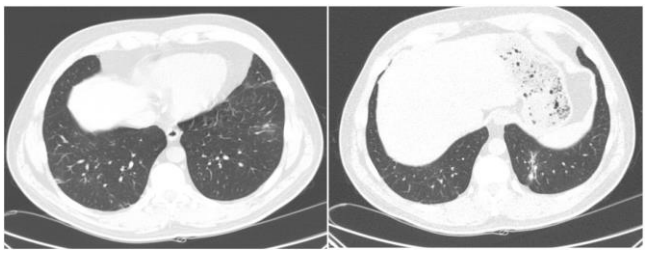

Figure 2: Control chest CT revealing regression of pulmonary hemorrhage and shrinkage of the pneumatoceles 24 days after the initial admission to hospital

The patient was clinically well and had no hemoptysis, shortness of breath or cough 12 days after being discharged from the hospital, and his chest was clear on auscultation. A control chest CT carried out 24 days after the initial presentation revealed a regression of the pulmonary hemorrhage and the pneumatoceles, as shown in Figure 2.

DISCUSSION

BHD is a form of underwater diving that requires the practitioner to hold their breath with no mechanical support. According to Cialoni et al. (2), 26.4% of breath-hold divers develop pulmonary symptoms such as hemoptysis, cough and dyspnea. Other reported complications of BHD are arterial gas embolism (3), orbital emphysema (4) and Taravana syndrome (5), and repeated BHD has been shown to cause brain damage (6).

As divers reach greater depths, the water pressure compresses the lungs and chest. Changes in lung air volume lead to pulmonary barotrauma. Pulmonary edema and hemoptysis result from fluid extravasations into the alveoli secondary to increased transcapillary pressure (7). Hemoptysis risk is known to be correlated with water pressure, and is directly proportional to the depth.

Although hemoptysis is rare when diving in shallow water, it has been found to occur at depths as low as 4 meters. To the best of our knowledge literature contains only one reported case in which hemoptysis occurred following a 3-meter BHD. In that study, the patient was a regular cannabis user and the pathophysiology was attributed to cannabis-induced lung damage (8). Although there was no such history in our case, we believe anticoagulants may have facilitated the bleeding. The fact that we cannot be certain the diver used the correct technique during the dive can be considered a limitation of the study.

Pneumatoceles are intrapulmonary gas-filled cystic spaces that can develop with various sizes and appearances. Traumatic pneumatoceles are pneumatoceles that vary in size, shape, wall thickness and number, and that occur secondary to a traumatic event. They may not be seen until a few hours or even several days after the trauma, being initially obscured by surrounding contusions. They should not be mistaken for cystic lung disease since they are typically asymptomatic and resolve in time, as was the case in our patient. The anti-nuclear antibody (ANA) test result of our patient was at the lower limit of positivity (with 1/100 titer, stained colored), although the patient had no history of chronic constitutional symptoms such as fever, fatigue, joint swelling, pain or hemoptysis that would indicate a rheumatic disease before the traumatic event. As the condition developed immediately after a traumatic event and there were no prior symptoms or radiological indicators, other cystic lung diseases were not considered in a differential diagnosis. Since the PCR test was negative, COVID-19 pneumonia was not considered.

CONCLUSION

Pulmonary hemorrhage is a common complication in breath-hold divers, and is known to be associated with water pressure. The risk of pulmonary hemorrhage rises directly proportional to depth, although it must be kept in mind that shallow diving may also lead to hemorrhage, as in our case.

Traumatic pneumatoceles may be seen on chest CT as a rare complication of BHD, and should not be mistaken for cystic lung disease since they are typically asymptomatic and resolve in time.

Main points:

- Reported complications of BHD are pulmonary hemorrhage, arterial gas embolism, orbital emphysema, Taravana syndrome and brain damage.
- Pulmonary hemorrhage risk is known to be correlated with water pressure, and the risk is directly proportional with depth, although it should be kept in mind that hemorrhage can occur even during shallow dives.
- Traumatic pneumatoceles may be seen on chest CT as a complication of BHD, and should not be mistaken for cystic lung disease since they are typically asymptomatic and resolve in time..

CONFLICTS OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

Concept - E.K., R.C.Y., N.S.G., A.O.A.; Planning and Design - E.K., R.C.Y., N.S.G., A.O.A.; Supervision - E.K., R.C.Y., N.S.G., A.O.A.; Funding - A.O.A., N.S.G.; Materials - A.O.A., N.S.G.; Data Collection and/or Processing - E.K., A.O.A., R.C.Y., N.S.G..; Analysis and/or Interpretation - E.K., R.C.Y.; Literature Review - E.K., R.C.Y.; Writing - E.K., R.C.Y., N.S.G., A.O.A.; Critical Review - N.S.G., E.K., R.C.Y., A.O.A.

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