Right cardiac chambers echo-bubble contrast in a patient with decompression sickness: A case report and a literature review (1446 words)

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Abstract

Background: The diagnosis of decompression sickness (DCS) relies mostly on clinical suspicion, and so far there is no available modality to fully confirm the diagnosis, however, the application of echocardiography in suspected DCS cases has been more frequently used, in this case transthoracic echocardiography (TTE) was used to detect micro-bubbles in the right cardiac chambers and monitor the patient after hyperbaric oxygen therapy (HBOT); which proposes the possible applicability of TTE in diagnosing and monitoring DCS patients.
Case presentation: This report describes a 54-year-old fisherman who was referred to the emergency department with dyspnea and mild confusion after rapid ascend of a saturation diving of 50m sea depth. After the initial evaluation, he was assessed using TTE to exclude the presence of structural heart diseases, where it surprisingly showed spontaneous echo contrast inside the right cardiac chambers similar to agitated saline echo testing, the patient then was admitted for HBOT and follow-up; rapid improvement was noticed after the first HBOT session and the TTE findings were fully resolved.
Conclusion: TTE could be considered in the initial workup when DCS is suspected, and it might have a role in monitoring DCS patients if echocardiographic findings of bubbles formation were documented in the pre-hyperbaric therapy settings.

BACKGROUND

Decompression sickness (DCS) is caused by the rapid change of the surrounding pressure while ascending[(1)]; as during descend, increased environmental pressure leads nitrogen to reach the bloodstream through the alveoli, which usually present in a dissolved form; while rapid ascend cause nitrogen to form bubbles[(2)], leaving a small-time window for these bubbles to be resolved and reabsorbed[(3)]. Bubble's entrapment in specific tissues could lead to blood flow obstruction and vessels spasm, also the activation of the platelets and the clotting cascade[(4)] causing tissues hypoperfusion. DCS usually classified into two types, DCS I is characterized by mild cutaneous manifestations as mottled or marbled rashes together with musculoskeletal pain; and DCS II is considered a more severe form with neurological symptoms of poor coordination and confusion, together with cardiopulmonary manifestations that could present as dyspnea and retrosternal pain[(5)].

CASE PRESENTATION

A fit and well 54-year-old Fisherman, who is a moderate smoker, an occasional alcoholic with no notable medical history or chronic medications, was referred to the emergency department with dyspnea, lethargy, severe generalized arthralgia, and mild confusion after rapidly ascending of a saturation diving of 50m sea depth. On initial assessment, the patient was dyspneic, alert, responsive with a Glasco coma scale of 14. On examination, there was bilateral joints pain, which was aggravated by movement without signs of inflammation. Neurological, chest, cardiac and abdominal examination was unremarkable, with a blood pressure of 90/60 mm Hg, pulse of 95 Bpm, saturation of 90%, respiratory rate of 24/minute and temperature of 36.6°; calculated well's pulmonary embolism score was 3.

INVESTIGATIONS

At the time of presentation, the patient was evaluated by the emergency core medical trainee, where high-flow oxygen was initiated and a multi-disciplinary team of cardiology, pulmonology and neurology was gathered to assess the patient symptoms. The initial investigation was Electrocardiography (ECG) and it showed a normal ECG, the patient then was escorted to the radiology division, and a posterior-anterior chest X-ray (PA-CXR) was obtained and it showed a normal CXR; meanwhile, the ordered blood tests showed the following: normal D-dimer, normal haemoglobin, platelets, glucose, ESR, creatinine, urea, potassium, and sodium; however, it revealed elevated white blood cells of 13 (normal value 4500-11000) and CRP of 73 mg\l (normal

value 0-7 mg/l). Arterial blood gas (ABG) showed metabolic acidosis, with PH of 7.32, PCo2 of 28, Hco3 of 15, Po2 of 63 mm Hg. After ensuring the patient was stable, he was escorted by the cardiology intern for emergency transthoracic echocardiography (TTE) to exclude the presence of structural heart diseases; where it showed normal left ventricular, normal right ventricle, no valvular disease; yet, spontaneous echo contrast inside the right cardiac chambers was witnessed, similar to agitated saline echo testing; during the exam, the patient was asked to do the Valsalva manoeuvre by taking a deep breath and hold it, and the aim waso evaluate the presence of patent foramen ovale (PFO) using colour-flow doppler, which could have an important role in DCS, and no flow was appreciated.

DIFFERENTIAL DIAGNOSIS

After evaluating the clinical picture, together with the patient's history, physical examination and relevant investigations, a differential diagnosis of pneumothorax, pulmonary embolism, aspiration pneumonia, and DCS were established. **Pneumothorax** was excluded due to the normal chest auscultation and normal PA-CXR, **aspiration pneumonia** was also excluded due to the normal examination and normal PA-CXR; while **pulmonary embolism (PE)** was excluded due to well's PE score, normal D-dimer and the ABG findings.

TREATMENT

Following admission, the patient was initially treated with 100% oxygen, Intravenous saline solution was also used for rehydration with a dose of 100 ml/h; and finally, due to the joints pain and the inability to walk, prophylactic subcutaneous (S.C) Enoxaparin was initiated with a dose of 40 mg/day; meanwhile, the HBOT centre was immediately contacted, and the first session was arranged.

OUTCOME AND FOLLOW-UP

A significant clinical and hemodynamic improvement was observed within 1 hour of the first HBOT session, with a blood pressure of 135/75, respiratory rate of 17/minute, heart rate of 75 Bpm and oxygen saturation of 98%. Joints pain was mildly reduced, and the patient was able to stand by himself, yet support was needed to walk around the hospital room. The patient was reevaluated using TTE within one hour after the HBOT session, and surprisingly the right cardiac chambers bubbles had fully vanished with no additional pathological findings, and he was discharged within 48 hours of admission. Upon discharge, the patient's chief complaint was mild resistant arthralgia that was alleviated using paracetamol, able to walk and support himself.

DISCUSSION

The diagnosis of DCS relies mostly on clinical suspicion; however, the patient's presentation intersects with several differential diagnoses that should be excluded before establishing the final diagnosis[6], the symptoms of dyspnea and chest pain after a rapid ascend propose the diagnoses of pneumothorax and post-diving aspiration pneumonia and chest X-ray is a useful method to exclude these conditions[7]; while pulmonary embolism should also be considered, however, this patient's ABG was not compatible with the diagnosis, and the pretest probability with normal D-dimer could help to exclude the condition. The initial management for suspected DCS is the application of oxygen, as experimental studies showed a quicker decrease of the bubble load with the use of oxygen compared to air-breathing[8]. Simultaneously, low molecular weight heparin could also be advised in DCS patients with reduced movement abilities to reduce the risk of DVT. Finally, HBOT also present as one of the most important treatment lines, the main principle of this treatment is by delivering 100% inhaled oxygen inside a pressurized both equal or above 1.4 atmosphere absolute (ATA)[9], which has a significant role in the pathology of DCS. The application of ultrasound in detecting microbubbles in DCS patients has been more common. In this case, TTE was used for three purposes, to exclude any structural heart disease, detect microbubbles and search for the presence of left/right shunts (PFO), however, it has low specificity as a bubble screening tool[10]; another drawback is obtaining a clear ultrasound image, as suitable echocardiographic windows might not be accessible in the emergency settings[11]. Yet, this modality could be used as part of the point of care ultrasound[12].

This report suggests that echocardiography is a useful screening tool to detect microbubbles in patients with suspected DCS; to support our hypothesis, a literature search was performed using PubMed and Cochrane Library to evaluate similar case reports findings (Table 1). Four published cases were identified, and the reference list of these studies was manually screened for similar

case reports. Reported symptoms varied among patients; yet, all of these studies used ultrasound as a screening tool and the was most frequent location for the detected microbubbles was the right ventricle and inferior vena cava. Three studies detected bubbles in several other locations using CT scan; three studies described the use of HBOT, and improvement was reported in two studies. Three studies concluded that the use of CT following ultrasound could be a useful method to diagnose DCS.

In conclusion, echocardiography in the current case helped in the diagnosis of suspected DCS, and the purpose of the patient admission to the cardiology department was to monitor these microbubbles behaviour using TTE after the first HBOT session and to see if the disappearance of these microbubbles could reflect clinical improvement or could be related to the overall prognosis. We found that these bubbles disappeared within one hour of HBOT, and significant improvement was noticed during the same period, which could propose possible applicability of TTE in diagnosing and monitoring DCS patient.

Case	Yanagawa et al. 2021[13]	Jitsuiki et al., 2020[14]	Kondo et al., 2018 [15]	Boussuges et al., 2008[16]
Age	53 years	26 years	65 years	Not reported
Depth	21 meters	26 meters	24 meters	Not reported
Chief complaint	Abdominal pain and dyspnea	Scotoma, headache and fatigue	Epigastric pain	Not reported
Used modalities	Ultrasound and CT scan	Ultrasound and CT scan	Ultrasound and CT scan	Echocardiography
Ultrasound bubble's location	Portal vein and right ventricle	Inferior vena cava	Inferior vena cava	Left and right ventricle
Whole-body CT scan	Bubbles in the right ventricle, inferior vena cava, portal, mesenteric and femoral vein.	Bubbles around the bladder, left hip, right knee, bilateral shoulder, joints, and right intramedullary humerus.	Bubbles in the hepatic portal venous	Not reported
Right-left shunt	Not present	Not reported	Not reported	Large patent foramen ovale
Hyperbaric oxygen therapy	Yes	Yes	Yes	Not reported
The time that bubbles diminished	Within 2 days	Not reported	Not reported	Not reported
Discharge	Within 6 days	Within 2 days	Not reported	Not reported
Reported complications	Memory disturbance	Not reported	Not reported	Not reported
Case hypothesis and conclusion	Ultrasound followed by a CT scan could be useful methods if the diagnosis of DCS was suspected.	CT scan could be a useful method if the diagnosis of DCS was suspected.	CT scan could be sensitive for the detection of bubbles in patients with suspected DCS.	PFO closure should be discussed, patients willing to continue diving could benefit from a mix of enriched oxygen to decrease the risk of DCS.

Table (1): Identified published cases of bubbles detection using ultrasound

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

A written consent was adapted; the authors ensured not to include any personal information either in the text or the images.

DATA AVAILABILITY

ata is available upon request to the corresponding author (ECG, CXR and TTE clips before and

after HBOT), please email the corresponding author: allamharf@gmail.com, it was also uploaded to be reviewed by the editorial board during submission of this case

COMPETING INTEREST

Not applicable

FUNDING

Not applicable

AUTHORS' CONTRIBUTIONS

A.H: corresponding author, M.R: Co-author, H.H: Co-author.

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