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CASE REPORT

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Cardiac arrest during a diving session: A case report and differential diagnosis

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Abstract

We report a case of out-of-hospital cardiac arrest occurred in a 61-year-old recreational female diver. After resuscitation, the patient was referred to the hospital. With data provided by witnesses and appropriate medical investigations, drowning related to a failed rebreather system was the most plausible explanation. Patient outcome was favorable.

KEYWORDS

ARDS, cardiac arrest, decompression illness, drowning, ICU

1 | INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) may occur in special circumstances, including open seawater setting. This specific setting may involve recreational swimmers, free divers, and scuba divers, each exposed to different pathophysiological mechanisms for triggering a cardiac arrest. Particularly in scuba divers, cardiac arrest may occur secondary to drowning, decompression illness, or the occurrence of internal disease. Current European guidelines on the management of cardiac arrest specifically addressed cases of drowning among special circumstances,[1] but lack a specific algorithm for diagnosing and treating cardiac arrest in dive casualties.[2] Indeed, despite the most common cause of cardiac arrest in drowned people being hypoxemia due to pulmonary edema, the setting of diving may pose the need for differential diagnosis with decompression illness.[3]

Here, we present the case of an OHCA occurred in a recreational female diver using a semiclosed rebreather system during a recreational diving session aimed at reaching 40 m with adequate pauses but ended at 24 m due to the event. She was rescued and transferred to the emergency department of a tertiary hospital staffed with a hyperbaric medicine service available 24/7.

2 | CASE PRESENTATION

A 61-year-old woman with a history of cigarette smoking and arterial hypertension treated with bisoprolol was admitted to the Emergency Department (ED) of a tertiary hospital after a witnessed cardiac arrest. The event occurred during a group diving session in seawater, at a depth of 24 m and using a semiclosed rebreather system equipped with soda lime. The woman was rescued by other divers performing basic life support (BLS), then medical emergency system was alerted, and advanced cardiovascular life support (ACLS) was initiated. In total, 3 mg of adrenaline was administered and a defibrillation delivered. A laryngeal mask was also positioned for providing ventilation with a bag valve device.

Return of spontaneous circulation (ROSC) was finally achieved (no flow and low-flow duration unknown), and the patient was transferred to a tertiary hospital staffed with a hyperbaric medicine service, given the suspicion of decompression illness as a cause of cardiac arrest.

During transportation, the patient regained consciousness and the laryngeal mask was removed. At ED presentation, the patient was conscious and alert, spontaneously breathing but disoriented, unable to recall the recent events.

Vital signs were respiratory rate of 18 bpm, noninvasive blood pressure 110/60 mmHg, heart rate 75 bpm, and SpO_2 84% in room air. Physical examination showed bibasilar crackles. Two peripheral veins were cannulated and O_2 therapy 6 L/min via oxygen face mask was then started, achieving SpO_2 95%. Several episodes of watery diarrhea occurred during patient's stay in the ED.

An arterial blood gas (ABG) was performed and revealed mixed metabolic acidosis, with pH 7.19, $cHCO_3^-$16.1 mmol/L, pCO_2 43 mmHg, pO_2 85.3 mmHg, BE −11.6 mmol/L, and Lac 6.2 mmol/L.

A total of 1.5 L of crystalloids were administered. After stabilization, the ABG showed pH 7.33, pCO_2 49.7 mmHg, pO_2 74.1 mmHg, $cHCO_3^-$ 25.6 mmoL/L, BE −0.73 mmol/L, and Lac 4.2 mmol/L. Subsequent ABG is available in Table 1.

Meanwhile, information about the event was further investigated by a patient's friend who had seen the dive profile screenshot. Both descent velocity and pauses timing had respected safe schemes, suggesting that sickness happened in depth and not during the ascent.

TABLE 1 Arterial blood gas analyses performed during the emergency department and intensive care unit stay and timeline.

Timeline	Ventilatory support	pH	$PaCO_2$ (mmHg)	PaO_2 (mmHg)	FiO_2	SO_2	HCO_3^- (mmol/L)	Lac (mmol/L)	BE (mmol/L)	PaO_2/FiO_2
Arrival to ED	O_2 low flow	7.19	43	85	0.4	94%	16.1	6.2	−11.6	212
30 min after arrival	O_2 low flow	7.33	49.7	74	0.4	94%	25.6	4.2	−0.73	185
90 min after arrival	CPAP (PEEP 5 cmH_2O)	7.33	49	83	0.5	96%	25.5	1.3	−0.73	166
After intubation	Volume-controlled ventilation (Vt = 6 ml/kg, PEEP 10 cmH_2O)	7.22	63.3	134	0.6	99%	25.2	<1	−3.5	225
Protective ventilation day 1	Volume-controlled ventilation (Vt = 6 ml/kg, PEEP 10 cmH_2O)	7.34	43.2	277	0.6	100%	23	<1	−2.7	462
Protective ventilation day 2	Volume-controlled ventilation (Vt = 6 ml/kg, PEEP 10 cmH_2O)	7.33	60.8	97	0.3	99%	31.1	<1	4.1	325
After Extubation	Helmet CPAP (PEEP 10 cmH_2O)	7.42	50.7	166	0.5	99%	32.4	<1	7.1	332
ICU day 3	Helmet CPAP (PEEP 10 cmH_2O)	7.44	45.7	97	0.5	99%	31	1.1	6.2	242
ICU day 4	Venturi mask	7.45	41.6	80.8	0.5	97.9	28.8	1.3	4.5	161
ICU discharge	Helmet CPAP (PEEP 10 cmH_2O)	7.42	43.7	106.2	0.5	98.5	28.3	1	3.3	212

Abbreviations: CPAP, continuous positive airways pressure; ED, emergency department; FiO_2, inspired fraction of oxygen; HCO_3, bicarbonate; HD, hospitalization day; ICU, intensive care unit; Lac, lactate; BE, base excess; NIV, non-invasive ventilation; $PaCO_2$, arterial partial pressure of carbon dioxide; PaO_2, arterial partial pressure of Ooxygen; SO_2, oxygen saturation.

Hyperbaric medicine consultation ruled out the need for any recompression treatment. Other causes of cardiac arrest were then investigated with the aid of focus assessment with sonography in trauma (FAST) ultrasound, and pneumothorax and cardiac tamponade were excluded. Cardiological consultation excluded acute coronary syndrome and the need for urgent coronary angiography. Head CT scan excluded visible ischemic processes and intracranial hemorrhages. CT pulmonary angiography excluded pulmonary embolism, while basal chest CT revealed areas of consolidation in both lower lung lobes and diffused interlobular septal thickening, especially in the upper lobes (Figure 1). Moreover, gastric overfilling with air-fluid content was noted, confirming that the cardiac arrest was probably secondary to drowning of unknown cause. A nasogastric tube was positioned with dark fluid leaking without blood content. After positioning, a brief period of spontaneous breathing at room air determined a rapid desaturation to SpO_2 of 76%. Thus, also considering CT findings and the worsening in respiratory rate and dyspnea, continuous positive airway pressure (CPAP) ventilation via Ventumask was started, applying 5 cmH_2O of positive end-expiratory pressure (PEEP) and FiO_2 of 50%. The following ABG showed a P/F ratio of 166 mmHg, and intensive care unit (ICU) admission was then disposed with admission diagnosis of acute respiratory distress syndrome and drowning syndrome. At arrival, the patient was sedated, paralyzed, and subjected to protective invasive volume-controlled ventilation for 48 h. During the period of ICU stay, a restrictive fluid regimen was adopted, and respiratory mechanics daily assessed aiming at the lowest $P_{driving}$. The clinical course after extubation showed the need for sessions of continuous positive end-expiratory airway pressure (CPAP),[4] noninvasive ventilation via Helmet interface, and O_2 therapy

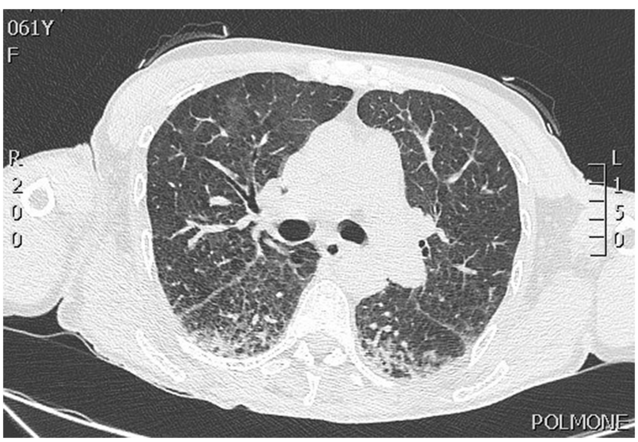

FIGURE 1 Chest computed tomography at emergency department admission.

with high flow nasal cannula in order to optimize gases exchange and work of breathing during the weaning phases.

During hospitalization, follow-up CT scans were performed. Moreover, elective coronary angiography reported no evidence of stenosis in the coronary tree. The patient was finally discharged after 11 days of hospitalization without any sequelae.

3 | DISCUSSION

Cardiac arrest may occur during scuba diving, for which many causes should be considered. While it is often associated with poor survival and/or severe sequelae, an opportune recognition and timely initiation of CPR may improve outcomes, as seen in our patient.

The entire stabilization and diagnostic phase lasted on average 2 h and included imaging and specialized consultations. This timing may be considered reasonable, but the presence of protocolized algorithms on the differential diagnosis of dive casualties and drowning could have probably been of help in further speeding up the process (see Figure 2). Of note, an accurate recording of recent history was pivotal in the out-of-hospital setting, as in the absence of a rapid ascension from depth to surface, a decompression illness able to determine cardiac arrest might be excluded.[5] An important contribution was thus given by dive profile monitoring systems.

The subsequent management in the ICU, including protective invasive ventilation for at least 48 h,[6] minimized the risks of complications and allowed for rapid management and continuous monitoring of metabolic derangements, confirming that the ICU setting is the most appropriate in cases of drowning grade 6, despite rapidness of initial recovery of cardiac and neurological functions.[7]

After ruling out DCI and other internal derangements, drowning secondary to a failed rebreather system was the most plausible explanation. Other causes of cardiac arrest in drowned have been described in the literature, including cases of sudden cardiac death,[8] carotid sinus syndrome[9] or human diving reflex,[10] but they were highly unlikely in our case. Moreover, no evidence of coronary or electrophysiological diseases was detected during in-hospital diagnostic work-up, both emergent and elective. Thus, the most probable cause remained contamination of the diving gas or malfunctioning of the rebreather system, then determining hypercarbia and culminating in unconsciousness and drowning. Indeed, CO_2 accumulation was plausible in the context of diving

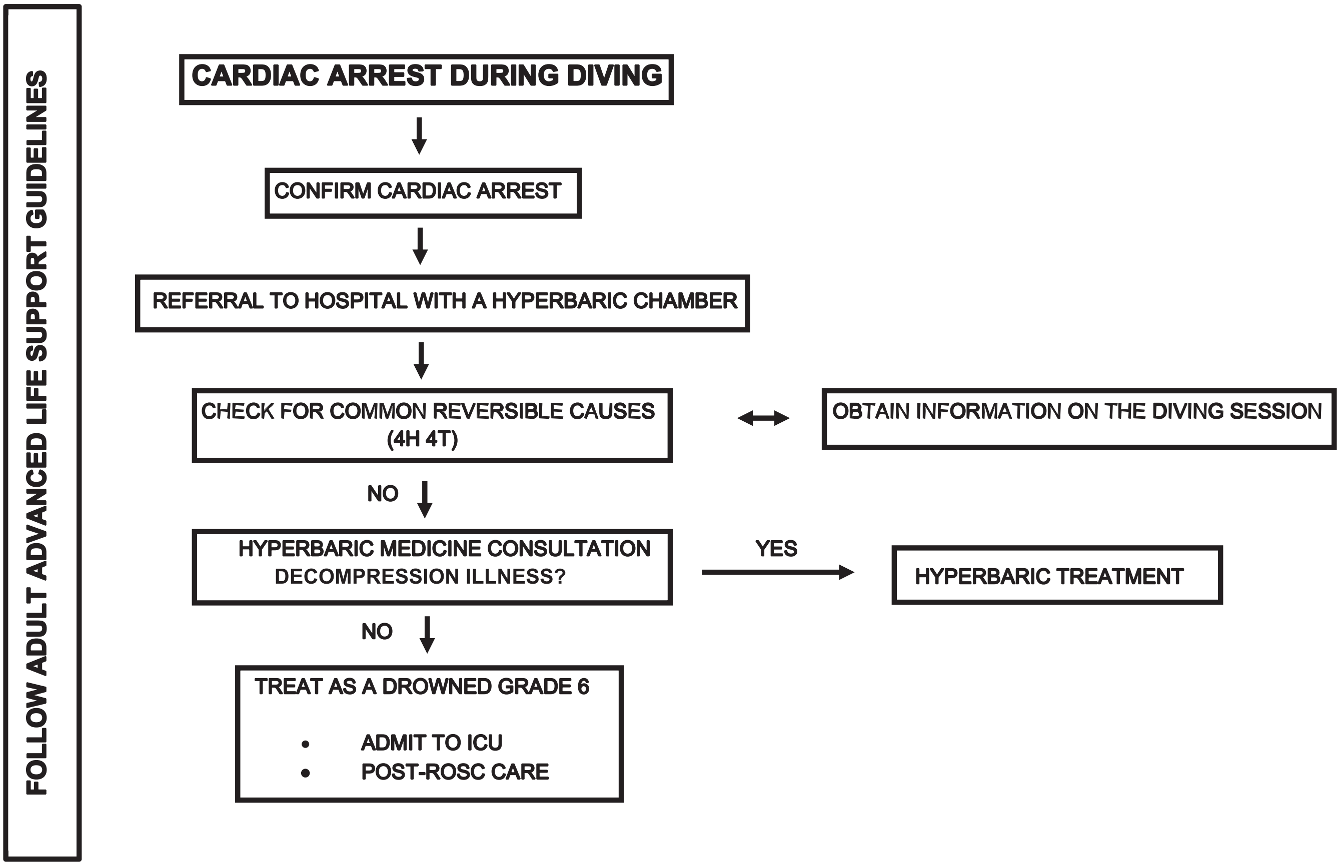

FIGURE 2 Proposed algorithm for the management of cardiac arrest during diving.

with a rebreather system and the risks of such occurrence may be underestimated by experienced divers, used to the activity and confident about it.

4 | CONCLUSIONS

Cardiac arrest may occur in the setting of open seawater. The causative mechanisms may be relevant for both the achieving of ROSC and the subsequent management of post-ROSC phases. An accurate collection of information from the bystanders may reveal important details, especially in peculiar contexts, such as diving sessions or swimmers who drowned. Algorithms may be implemented to help clinicians rapidly focus on key elements for differential diagnosis in this setting.

AUTHOR CONTRIBUTIONS

Mariachiara Ippolito: Conceptualization; data curation; investigation; validation; visualization; writing – original draft; writing – review and editing. **Martina Tubiolo:** Data curation; investigation; validation; writing – original draft; writing – review and editing. **Angelo Falletta:** Data curation; investigation; validation; writing – review and editing. **Antonino Federico:** Data curation; investigation; validation; writing – review and editing. **Barbara Simone:** Data curation; investigation; validation; writing – review and editing. **Giulia Ingoglia:** Data curation; investigation; validation; writing – review and editing. **Cesare Gregoretti:** Data curation; supervision; validation; writing – review and editing. **Santi Maurizio Raineri:** Data curation; supervision; validation; writing – review and editing. **Andrea Cortegiani:** Data curation; supervision; validation; writing – review and editing. **Antonino Giarratano:** Data curation; supervision; validation; writing – review and editing.

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None.

CONFLICT OF INTEREST

MI is an Associate Editor for Clinical Case Reports. All the other authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data are available upon reasonable request to the corresponding author.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

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