High Altitude Pulmonary Edema: A Case Report

Wei-Ber Liao¹, Hui-Chung Yang², Mei-Chaan Ku², Jyi-Jyh Hung³

Our patient was a 46 year-old man with high altitude pulmonary edema accompanied with hyperthermia, hypertension and tachypnea which subsequently progressed to acute respiratory failure as evident by a drop in SpO2 after ascending a 3742 meter mountain. Pulmonary edema was secondary to increased vascular permeability leading to extravascular lung fluid as proven by this patient’s pulse continuous cardiac output (PiCCO) values. Due to massive fluid retention in the pulmonary interstitial spaces, hyperthermia and hemoconcentration ensued.

Key words: acute mountain sickness, hypoxic pulmonary vasoconstriction, high altitude pulmonary edema, hyperthermia, PiCCO

Introduction

High altitude pulmonary edema (HAPE) is categorized as a form of non-cardiogenic pulmonary edema that can occur in healthy individuals who ascend rapidly to altitudes above 3500-4000 meters (1-2). In a random population, about 5-6% develop HAPE, usually within a period of 2-3 days. Individuals with a previous history of HAPE who ascend rapidly to 4500 meters have a 60% chance of a recurrence (3). The pathophysiology of HAPE is due to exaggerated hypoxic pulmonary vasoconstriction (HPV) with an abnormal increase in pulmonary vascular resistance as well as pulmonary artery and capillary pressure (4-5). The mechanism by which this occurs is partly via hypoxic sensitive channels expressed in pulmonary endothelial and smooth muscle cells. Hypoxia reduces the activity of voltage-gated potassium channels and downregulates their expression which leads to membrane depolarization and calcium ion influx into the pulmonary artery smooth muscle cells causing vasoconstriction (6-7). Susceptible individuals have an exaggerated rise in pulmonary artery pressure in response to hypoxia and exercise (8-10). A rise in pulmonary capillary pressure of more than 19 mmHg has been found in susceptible subjects who developed HAPE, leading to fluid leakage and alveolar hemorrhage (11-13).

Case Report

A 46 year old man was mountain climbing with his colleagues for 4 days, averaging 600 to 800 meters per day. They reached the summit at 3742 meters on the 4th day, but after 20 minutes, high winds forced them to descend to a mountain cabin at 2600 meters where they stayed overnight. That night, he became dyspneic and coughed out yellowish fluid, unrelieved by intake of ginger soup. The following morning he was too weak to move and was carried down to 2000 meters by his
companions. Emergency Medical Technician (EMT) personnel arrived after two hours and he was carried down the trail and taken to the emergency room (ER) of our hospital. On initial assessment by EMT personnel at 2000 meters, his pulse was 92 beats per minute (bpm), respiratory rate was 21/min and blood pressure was 178/125 mmHg, and he was noted to be febrile. Upon arrival in the ER, he was tachypneic with a respiratory rate of 38/min, pulse of 115 bpm, and blood pressure of 241/202 mmHg. His body temperature was 39.9°C and coarse rales were heard over both lung fields. Pertinent past history revealed that this patient had two previous episodes of high altitude sickness. Meanwhile, his chest radiograph revealed massive left lung infiltration (Fig. 1A), prompting immediate admission to the intensive care unit (ICU).

In the ICU, he was immediately intubated (Fig. 1B) and light amber fluid was obtained. His SpO₂ dropped from an initial 91% to 70%. Manual ventilation with a bag valve mask raised the SpO₂ back to 90% after which he was connected to a ventilator. His initial arterial blood gas (ABG) results were pH: 7.384, PCO₂: 29.9 mmHg, PO₂: 52.8 mmHg, HCO₃⁻: 17.5 mEq/L, SBE: -6.6 mEq/L, and SO₂%: 88.9; Other tests conducted included complete blood count with differential which showed leucocytosis WBC: 23,270/μL with 90.4% segments; RBC: 6.32 × 10⁶/μL, Hgb: 19.5 g/dl, Hct: 57.4%. while other biochemistry tests included CRP: 7.00 mg/dl, Glucose 198 mg/dl, GOT 37 IU/L, Bil T/D: 1.5/0.2 mg/dl, NH₃: 53 umol/L, Alb: 3.5 g/dl, BUN: 27 mg/dl, Cr 1.2 mg/dl, Na: 143 mEq/L, K: 3.9 mEq/L, and Ca: 7.7 mg/dl. His initial electrocardiogram (EKG) showed persistent RV-strain (Fig. 2A). A cardiac B-mode echocardiogram showed a flattened interventricular septum (D-shaped left ventricle) with normal left ventricular function. PiCCO parameters were as follows:

<table>
<thead>
<tr>
<th>Normal Values</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac index (C.I.)</td>
<td>3.5-5.5 L/min/m²</td>
<td>2.36</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Systemic vascular resistance (SVR)</td>
<td>1700-2400 dynes.sec.cm⁻²/m²</td>
<td>1471</td>
<td>1289</td>
<td>1471</td>
</tr>
<tr>
<td>Extravascular Lung water Index (ELWI)</td>
<td>3-7 ml/kg</td>
<td>15</td>
<td>8.5</td>
<td>9</td>
</tr>
<tr>
<td>Pulmonary vascular permeability index (PVPI)</td>
<td>1-3</td>
<td>4.7</td>
<td>1.8</td>
<td>2</td>
</tr>
</tbody>
</table>

The patient had persistent high grade fever >39°C so antimicrobial therapy with Moxifloxacin (Avelox) 400 mg once a day was started but later shifted to Piperacillin/Tazobactam (Tazocin) 4.5 g every 8 hours, Amikacin(Amikin) 250 mg every 12 hours and Doxycycline 100 mg once a day on his third hospital day (HD). Doxycycline was continued until he was discharged. He was also given Furosemide (Lasix) 40 mg intravenously every 8 h), Acetazolamide (Diamox) 250 mg every 6 hours. On his 2nd hospital day, (HD), chest radiograph showed slight resolution of the butterfly appearance (Fig. 1C) .On his 3rd HD, Furosemide (20 mg/amp) was tapered to 1 amp every 8 hours, Oral Acetazolamide (Diamox) 250 mg/tab 1 tablet twice a day & Dobutamine 250 mg were also added thus he was successfully extubated bringing about improvement in his clinical condition. (Fig. 1D).Normal findings found radiographically on his 4th HD while ABG results were pH: 7.46, PCO₂: 23.5 mmHg, PO₂: 86.3 mmHg, HCO₃⁻: 16.9 mEq/L, SBE: -7.2 mEq/L, A-aDO₂: 34.4 mm Hg, and SpO₂%: 97.2. Furosemide was discontinued while Acetazolamide was tapered to 250 mg every 12 hours. Hypertension was treated with Nifedipine(Adalat) 5 mg every 8 hours. On his 5th HD, the EKG showed S1Q3T3 with an Incomplete right bundle branch pattern (Fig. 2B) and no pulmonary embolus seen on computerized chest tomography. Serum chloride level was found to be 100 mEq/L and was corrected with 250 cc normal saline . ABGs on his 6th HD were pH: 7.445, PCO₂: 32.4 mmHg, PO₂: 109.7 mmHg,
Fig. 1  A Left hilar area shows a more severe patchy infiltrations than the right side with massive alveolar infiltration extending to the periphery. There is no noticeable Kerley B line over the costophrenic angle nor any visible vessels along the outer third of the lungs. These findings are consistent with non-cardiogenic pulmonary edema
B Four hours after intubation, there is increased density over the left hilar area and infiltration in the right upper lung
C On the second day after intubation, the butterfly appearance is less severe
D The first day after extubation, the butterfly appearance has resolved
Fig. 2  

A Electrocardiogram (ECG) on admission shows tachycardia, poor R wave progression over the precordial leads, clockwise rotation, left axis deviation and low voltage over the limb leads

B ECG on the 5th ICU day shows sinus rhythm with a S1Q3T3 pattern, incomplete right bundle branch block and a flattened T wave
SpO2\%: 98.4\%, HCO3−: 22.5 mEq/L, and SBE: -1.8 mEq/L. He was clinically stable until his discharge on the 8th HD. Complete blood count at discharge were WBC: 22,540/μL, segmenters: 91.0%; RBC: 4.95 x 10^6/μL, and Hemoglobin: 15.1 g/dl and CRP < 0.5 mg/dl. Two weeks later, on his out patient follow-up complete blood count results were WBC: 6.05 x 10^3/μL, segmenters: 72.2%; RBC: 4.05 x 10^6/μL, and Hemoglobin: 12.7 g/dl.

**Discussion**

Severe high altitude sickness starts at an altitude above 2,100 meters because arterial blood oxygen saturation drops to less than 90% at this height (majority of cases occur at heights between 2400 to 3600 meters). Variable factors such as speed of ascent, the final altitude, rest time in between climbs and individual susceptibility affect its occurrence. Despite taking a Chinese herbal drug (Hung jin tian) as prophylaxis before climbing, he still suffered from HAPE. A previous history of high altitude sickness predicts its recurrence.

High altitude sickness develops because of hypoxic pulmonary vasoconstriction inducing further pulmonary hypertension and pulmonary edema. When pulmonary edema ensues, pulmonary artery pressure usually rises to levels greater than 20 mmHg which is 30% to 50% higher than that among those without pulmonary edema. Meanwhile, myocardial blood flow reserve also decreases bringing about further RV strain. This patient had persistent RV strain and S1Q3T3 with an ICRBBB pattern on EKG, although the EKG pattern returned to normal after one week. HAPE occurs because of hypoxic vasoconstriction of the pulmonary artery and permeability changes in pulmonary vessels leading to acute pulmonary edema. This was proven by the PiCCO values of this patient. When he had pulmonary edema, the patient’s PVPI of 4.7 was twice the normal value of 1.8, and the ELWI of 15 was also twice the normal value of 7. Changes in pulmonary permeability bring about fluid shift to the interstitial spaces of the lungs. Hemoconcentration follows as evident by a hemoglobin value over 15 g/dl bringing about inadequate delivery of oxygen to the hypothalamus thus inducing secondary hyperthermia due to thermoregulatory dysfunction. The patient’s body temperature was persistently elevated with leucocytosis (WBC >20,000/ul) making us doubt whether there was any underlying bacterial infection. The CRP level decreased from 7.0 mg/dl on admission to < 0.5 mg/dl after one week. Two weeks later, his WBC count was 6,000/μl and hemoglobin was 12.7 g/dl at the OPD. We presumed his leucocytosis, erythrocytosis and high grade fever were due to hemoconcentration brought about by fluid shift secondary to increased pulmonary permeability.

Although acute mountain sickness does not have the conventional inflammatory response, it can mimic systemic inflammatory response syndrome since it complies with several of its diagnostic criteria such as temperature > 38°C (39.9°C), heart rate > 90 beats/minute (92 beats/minute), respiratory rate > 20 breaths/minute (38 breaths/minute) and high WBC count >12,000/mm^3 (WBC count 23,270/mm^3). The initial response to acute pulmonary hypertension is increased pulmonary permeability leading to acute pulmonary edema, right ventricular strain, hemoconcentration and hyperthermia. A rising body temperature after rapid ascent to high altitude is an early sign of acute mountain sickness and is also associated with the severity of hypoxemia. This patient’s clinical presentation led us to a better understanding of HAPE and its treatment.
References

高山症併發肺水腫：病例報告

廖為博¹  楊惠中²  古美娟²  洪吉志³

本病例報告一位曾患高山症的病人，在攀爬3742公尺的南湖大山後，在下山第一天連續發生肺水腫和高體溫等異常生理變化。由病人的PiCCO值，我們證實高山症肺水腫是由於肺滲透壓和肺外容積顯著的增加，是屬於一種非心因性肺水腫。也因為水分大量進入肺間質組織而引起血球濃縮，並造成高血色素值和高體溫。

關鍵詞：高山症併發肺水腫，低氧性肺動脈血管收縮，高體溫，連續性心輸出量監視器