Alveolar haemorrhage in a case of high altitude pulmonary oedema

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Abstract
A case of high altitude pulmonary oedema (HAPE) in a climber who made a rapid ascent on Mt McKinley (Denali), Alaska is described. The bronchoalveolar lavage (BAL) fluid contained increased numbers of red blood cells and an abundance of haemosiderin laden macrophages consistent with alveolar haemorrhage. The timing of this finding indicates that alveolar haemorrhage began early during the ascent, well before the onset of symptoms. Although evidence of alveolar haemorrhage has been reported at necropsy in individuals dying of HAPE, previous reports have not shown the same abundance of haemosiderin laden macrophages in the BAL fluid. These findings suggest that alveolar haemorrhage is an early event in HAPE.

Keywords: alveolar haemorrhage; pulmonary oedema; altitude illness; acute respiratory distress syndrome (ARDS); high altitude

Case report
A 28 year old male climber from Switzerland was previously healthy. On previous ascents up to 4800 m he had developed symptoms of acute mountain sickness but he had no history of HAPE. During the first day of an expedition to Denali he flew by plane from sea level to the 2100 m air landing strip on the Kahiltna glacier, arriving at midday, and then ascended to a camp at 2900 m. On day 2 he ascended to the 4200 m camp where, on arrival, he was fatigued but had no symptoms of HAPE. That night he developed a non-productive cough and had difficulty sleeping. On day 3 he noted a marked decrease in exercise tolerance and an increase in his cough with production of frothy sputum. He presented to the National Park Service medical tent at 4200 m late on the third night of his expedition complaining of dyspnoea at rest, cough productive of pink frothy sputum, and inability to sleep. He had taken no medications for his symptoms. On physical examination he had a pulse of 111 bpm, respiratory rate of 20 breaths/min, an arterial oxygen saturation (SpO2) of 74% as measured by a digital pulse oximeter, central cyanosis, and bilateral inspiratory crackles on chest auscultation. Heart sounds and jugular venous pressure were normal. Treatment with supplemental oxygen delivered via nasal can-
nula at 2–3 l/min increased his SpO₂ from 74% to more than 85% (normal SpO₂ at 4200 m on Denali is 85%). Total protein was 258 mg/dl, also higher than altitude controls (6 (3) mg/dl, n = 5). Total red blood cell count was 45 × 10⁶ cells/ml (controls 0.8 (1.3) × 10⁶ cells/ml, n = 5). The Giemsa stained slide smear was remarkable for numerous red blood cells and foamy haemosiderin laden macrophages (fig 1). Using the method described by Kahn and colleagues⁹ the BAL haemosiderin score was 139 or, using an alternative scoring system, 10 73% of alveolar macrophages contained haemosiderin inclusions. These scores correlate with the highest category in either system, indicating a severe degree of alveolar haemorrhage. BAL fluid from altitude controls and two climbers with acute mountain sickness (data not reported) showed no haemosiderin laden macrophages.

After completion of the bronchoscopy and BAL the patient improved while on supplemental oxygen for another 24 hours. He then descended with his climbing partner on day 5 to 3400 m for one night, then to 3000 m for two nights. He experienced complete resolution of his symptoms and on day 8 from the start of his expedition he re-ascended to 4200 m without recurrence of HAPE. After re-acclimatisation at 4200 m he reached the summit of Denali at 6194 m on day 12, one week after presenting with HAPE. Since his return home from Denali he has remained healthy and active and continues to pursue mountaineering in the European Alps.

Discussion

Increased numbers of red blood cells in BAL fluid may be the result of haemorrhage, airway inflammation and bleeding in bronchitis or pneumonia, or trauma caused by the bronchoscope. Haemosiderin laden macrophages appear 48 hours after clinical alveolar haemorrhage⁷⁸ and 72 hours after cultured human alveolar macrophages are exposed to antibody coated sheep red blood cells.⁷ The BAL findings in the patient presented here are diagnostic of alveolar haemorrhage: increasingly sanguineous fluid on sequential lavage aspirations and numerous haemosiderin laden macrophages and red blood cells on microscopic examination.

Alveolar haemorrhage and haemosiderin laden macrophages are frequently associated with immune mediated alveolitis but may be seen in other types of lung injury.¹¹ For example, they have been reported in congestive heart failure, presumably secondary to rupture of capillaries caused by high pressure,¹² and in the acute respiratory distress syndrome (ARDS) coincident with endothelial and epithelial cell injury which results in increased permeability pulmonary oedema.¹² There was no clinical reason to suspect any cause for alveolar haemorrhage other than HAPE in our subject. His clinical course was not consistent with immune mediated alveolar haemorrhage or ARDS, but was consistent with HAPE.

Figure 1 Increased red blood cells and haemosiderin laden macrophages in bronchoalveolar lavage fluid from a climber with high altitude pulmonary oedema. (a) Giemsa stained smear of bronchoalveolar lavage sample from the subject who developed high altitude pulmonary oedema with alveolar haemorrhage showing large numbers of erythrocytes (E) and numerous alveolar macrophages (AM) laden with haemosiderin inclusions (arrows) in the cytoplasm. (b) Smear of bronchoalveolar lavage fluid from a normal individual; the only cell type present are alveolar macrophages (AM) which lack haemosiderin inclusions. (a) and (b) are the same magnification.
which is characteristically an easily reversible form of increased permeability pulmonary oedema. Only one week after an episode of alveolar haemorrhage this climber had recovered sufficiently to reach the summit of the highest mountain in North America.

Schoene and colleagues did not report a similar degree of haemosiderin laden macrophages in BAL fluid from six climbers with HAPE also studied at 4200 m on Denali.4,4 There are several possible reasons for this discrepancy. Firstly, we used a different stain (Giemsa rather than Diff-Quik, Baxter Healthcare, McGaw Park, Illinois, USA) after fixing air dried slides in methanol which may have resulted in increased contrast of haemosiderin inclusions in macrophages. Schoene and colleagues do not report a fixation technique, which might decrease staining of haemosiderin inclusions.14 Secondly, we used a systematic scoring system that might have focused our observation toward haemosiderin laden macrophages. Thirdly, our subject had a faster rate of ascent, approximately 36 hours from 2100 m to 4200 m for subjects with HAPE. Schoene reported a 2–3 day ascent from 2100 m to 4200 m (and 48 hours from sea level).

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