

## CASE REPORTS

## Acute pulmonary oedema on the Ruwenzori mountain range

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### Abstract

**A 40 year old man had an episode of severe pulmonary oedema at 4000-5000 m during the ascent of the Margherita peak (5109 m) of Mount Stanley on the Ruwenzori. He had taken acetazolamide and high dose dexamethasone to treat symptoms of acute mountain sickness. Six years before he had been studied by right heart catheterisation as a healthy volunteer during hypoxic breathing at sea level. His pulmonary vascular reactivity had been within the normal range for 32 healthy subjects.**

**This man had high altitude pulmonary oedema despite currently recommended treatments for acute mountain sickness and normal pulmonary vascular reactivity to hypoxia at sea level.**

High altitude pulmonary oedema is an uncommon but dangerous complication of acute mountain sickness that occurs in individuals rapidly ascending to > 3000 m. High altitude pulmonary oedema is believed to be caused by excessive and uneven pulmonary vasoconstriction in response to hypoxia.<sup>1</sup> Whether susceptibility to high altitude pulmonary oedema can be reliably detected by testing pulmonary vascular reactivity to hypoxia at lower altitudes remains uncertain.<sup>1-3</sup>

A low rate of ascent and limited exertion usually prevent the development of acute mountain sickness and its complications. This is not always practical, especially during mountain rescues and military activities, nor is it an acceptable strategy when recreation time is limited. Many mountaineers attempt prophylaxis with pharmacological agents. Only acetazolamide and dexamethasone are known to be effective.<sup>4</sup>

We report a man with normal hypoxic pulmonary vasoconstriction at sea level in whom severe high altitude pulmonary oedema developed despite treatment with acetazolamide and dexamethasone.

### Case report

This healthy 40 year old man flew from Brussels (sea level) to Kigali (Rwanda) (1500 m). He was susceptible to acute mountain sickness

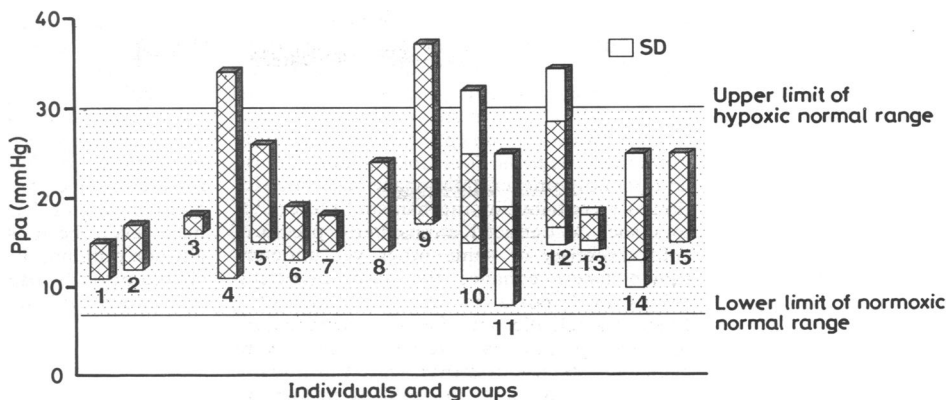
above 3500 m, but he had completed several difficult climbs in the European Alps. The day after his arrival he crossed into Zaire and drove 350 km in two days on a dust track to Mutuanga (about 1000 m), near the Ruwenzori range. For four days he marched through dense and boggy forest and over the muddy peat hags leading to the Margherita peak (5109 m) on Mount Stanley. With a party of two climbers and 10 porters, he carried a heavy pack up to the Kalonge hut (2138 m) on the first day of the march, to the Mahangu hut (3310 m), on the second, and to the Kiondo hut (4100 m) on the third. The next day he walked down to the Green Lake (3900 m) and up again to the Gray Lake (4200 m), at the edge of the West Stanley Glacier where the party set up a base camp. Since his arrival in Kigali he had been taking longacting acetazolamide (500 mg per day). On the third day of the march, he had a headache, lost his appetite, and slept poorly.

Seven days after his arrival in Africa he rested but was sick and drowsy with a headache, and ate little. He started to take dexamethasone (initial dose 8 mg then 4 mg every 6 hours). Next morning, after he had taken a total dose of 20 mg of dexamethasone, he was much improved though still anorectic. Soon after starting to lead the ice climb to the main summit he became very short of breath and coughed up blood tinged sputum. Close to the summit (5000 m) intense lassitude, dyspnoea, and a thick mist forced him to descend. Back at the base camp in the evening he was exhausted, very short of breath at the slightest effort, had an audible gurgling in his chest, blood stained sputum, and was suffocating in the supine position. He then realised he had high altitude pulmonary oedema and decided to try to get to a lower altitude while he was able to walk. Together with a companion and a porter, he reached Mutuanga the next day in the evening. For 48 hours he remained orthopnoeic and dyspnoeic on exertion or when drinking a beer. A physical examination performed by a local physician disclosed crepitant inspiratory rales over the lower half of both lungs that progressively cleared in 48 hours. The nearest x ray facility was two days drive away. Back in Brussels, physical examination, standard blood tests, electrocardiogram, chest x ray, and echocardiographic examination were normal.

Six years before he had been a healthy

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*Hypoxic pulmonary pressor responses at sea level, expressed as absolute increases in mean pulmonary arterial pressure (Ppa), induced by an acute decrease in the fraction of inspired  $O_2$  ( $FI_{O_2}$ ) from 0.21 to 0.1–0.15 (hatched columns). Limits of normal (mean  $\pm$  2 SD) in 32 healthy volunteers reported by Naeije et al<sup>2</sup> (column 14) are represented by the stippled area. Columns 1 and 2 show a subject before and after high altitude pulmonary oedema<sup>2</sup>; columns 3 to 7 are five individuals with previous high altitude pulmonary oedema reported by Hultgren et al<sup>10</sup>; column 8 is an individual with previous high altitude pulmonary oedema reported by Peñazola and Sime<sup>6</sup>; column 9 is an individual who went above 5000 m without high altitude pulmonary oedema developing<sup>2</sup>; columns 10 and 11 show the mean ( $\pm$  SD) values for 44 subjects with previous high altitude pulmonary oedema and 51 controls respectively reported by Viswanathan et al<sup>11</sup>; columns 12 and 13 show the mean ( $\pm$  SD) values for five individuals with previous high altitude pulmonary oedema and five controls respectively reported by Kawashima et al<sup>12</sup>; and column 15 is the present case with previous high altitude pulmonary oedema. It is apparent that most individuals with previous high altitude pulmonary oedema have a normal pulmonary vascular reactivity to hypoxia at sea level.*

volunteer in pulmonary haemodynamic studies in our laboratory. A detailed description of the methods used was reported elsewhere.<sup>5</sup> When he was breathing room air, arterial  $P_{O_2}$  ( $P_{aO_2}$ ) was 12.8 kPa,  $P_{aCO_2}$  5.3 kPa, arterial pH 7.42, cardiac output (Q) 6.43 l/min, mean pulmonary arterial pressure (Ppa) 15 mm Hg, and mean pulmonary capillary wedge pressure (Ppw) 11 mm Hg. After 10 minutes of hypoxic breathing (12.5% oxygen balance nitrogen)  $P_{aO_2}$  was 4.8 kPa,  $P_{aCO_2}$  4.8 kPa, arterial pH 7.46, Q 8.4 l/min, Ppa 25 mm Hg, and Ppw 12 mm Hg. These values were within a normal range (mean  $\pm$  2 SD) for 32 healthy young adult volunteers (figure). For comparison, the figure includes normobaric hypoxic and normoxic Ppa measurements in adults with previous high altitude pulmonary oedema and in a man who on several occasions had walked at 5000–5500 m in Nepal without being ill. Most of the subjects with previous high altitude pulmonary oedema had a normal hypoxic pressor response.

### Discussion

The Ruwenzori is a mountain range about 30 km north of the equator on the Uganda/Zaire border between lakes Mobutu (former Albert) and Amin (former Edward) in the great Western Rift Valley. These legendary mountains of the moon were known to Herodotus in 450 BC when he claimed them to be the source of the Nile. For centuries they were forgotten until Sir Henry Stanley explored them in 1876. The local people call them "the rainmaker" because they are mist shrouded and rarely visible. In the centre of

the Ruwenzori range are six major massifs carrying permanent snow and glaciers, including the Margherita peak of Mount Stanley (5109 m) the third highest peak in Africa. The slopes leading to the main climbing routes of the Ruwenzori are steep, with at least 1000 m between the huts or shelters. The trails are too steep and rough for stretchers; plane or helicopter transportation is not organised; and medical facilities are remote (at least two days of driving on rough dust tracks in good weather).

These were the conditions in which this experienced mountaineer developed a lasting acute mountain sickness that was eventually complicated by coughing, haemoptysis, exertional dyspnoea, orthopnoea, and audible pulmonary rales, all features strongly suggestive of an episode of severe high altitude pulmonary oedema. Because prophylaxis with acetazolamide and dexamethasone probably lessened his non-respiratory symptoms he may have delayed his decision to descend. His pulmonary vascular reactivity to hypoxia was normal when it was tested at sea level.

In established high altitude pulmonary oedema, mean pulmonary arterial pressure is considerably raised in the face of normal pulmonary capillary wedge pressure or left atrial pressures.<sup>6–8</sup> Recent bronchopulmonary lavage studies in patients with high altitude pulmonary oedema showed a considerable increase in proteins of high molecular weight, but without the intense neutrophil accumulation that is typical of other forms of acute lung injury.<sup>9</sup> These data together with results of necropsy clearly indicate that in high altitude pulmonary oedema there is a high permeability lung oedema, for which the most likely explanation

is a transient increase in shear forces caused by a sudden increase in mean pulmonary arterial pressure.<sup>1</sup> The finding of a normal acute hypoxic pulmonary pressor response in some children<sup>2</sup> and in many adults<sup>2,6,10-12</sup> at a lower altitude after an episode of high altitude pulmonary oedema does not exclude intense and possibly uneven pulmonary vasoconstriction as a contributing mechanism.<sup>1</sup> Other factors such as reduced atmospheric pressure, cold, exercise, or some other yet undetermined factor enhance the vasoconstricting effects of hypoxia in some individuals.<sup>10,12</sup> Even if a reliable non-invasive measurement of mean pulmonary arterial pressure were available, its use together with normobaric hypoxic testing would be unlikely to identify individuals who are susceptible to high altitude pulmonary oedema.

A stop of 2-5 days at an intermediate altitude (2000-3000 m) before climbers attempt the summit ("staging") and an ascent of less than 300 m per day above 3000 m are the conventional measures for avoiding mountain sickness.<sup>14</sup> But such advice conflicts with the desire of many travellers to arrive at their destination quickly or is impractical on mountains such as the Ruwenzori because of their height and the altitude differences between shelters. Prophylaxis with acetazolamide, an inhibitor of carbonic anhydrase, reduced the frequency of acute mountain sickness by 30%-50%.<sup>14</sup> Dexamethasone, an effective treatment of vasogenic brain oedema, has been recently evaluated because brain oedema may contribute to acute mountain sickness. At high doses this potent synthetic glucocorticoid was at least as effective a prophylactic treatment as acetazolamide.<sup>4,13</sup> Anecdotal reports recently suggested that dexamethasone might even be effective in the treatment of severe acute mountain sickness.<sup>4</sup> There are no data on the effects of combined acetazolamide and dexamethasone.<sup>4</sup> In our patient the addition of dexamethasone to acetazolamide resulted in such a subjective improvement that he undertook an ice climb, but symptoms of a life

threatening pulmonary oedema then developed. Levine *et al* showed that dexamethasone improved the symptoms of acute mountain sickness in six individuals exposed to a simulated altitude of 3700 m in a hypobaric chamber but did not prevent the development of objective physiological abnormalities related to exposure to high altitude.<sup>14</sup> Neither acetazolamide nor dexamethasone have ever been shown to improve high altitude pulmonary oedema.<sup>14</sup> Drug treatment should never be used to permit further ascent by a patient with acute mountain sickness.

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