ACUTE ALTITUDE SICKNESS*

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We do not learn much about altitude diseases in our Medical schools, and I am surprised to find that even doctors on high altitude expeditions are often ignorant of these conditions.

I would like to discuss briefly the two main types altitude disease, Acute Pulmonary Oedema and Acute Cerebral Oedema. First of all, however, let us look at the ordinary physiological responses to the stresses of altitude, of which of course the main one is **HYPOXIA**. They are summarized in table 1 :

TABLE 1

Main acute Physiological Changes at Altitude (14)

Respiratory :

Hypoxaemia	—	Sea level	—	Barometric pressure	760 mm Hg.—
					PaO ₂ = 94 mm Hg.
		12,000 ft.		" "	483 mm Hg.—
					PaO ₂ = 52 mm Hg.
		18,000 ft.		" "	379 mm Hg.—
					PaO ₂ = 40 mm Hg.

Hyperventilation, low pCO ₂ , high pH, i. e. respiratory alkalosis	Pulmonary Artery
Pressure raises e. g. Sea level	— 15 mm Hg.
	5000 ft. — 17 mm Hg.
	15,000 ft. — 25 mm Hg.

Cheyne Stokes Respiration.

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Cerebral: Blood Flow is increased, e. g. by 40% at 11,500 ft. (2) Blood Volume is increased. Brain tissue hydration and CSF pressure are increased. (2), (6)

Body Fluids: Diuresis and probable shift from intravascular to extravascular space cause an early rise in haematocrit (PCV). (2), (9)

What we do not know is whether acute mountain sickness is an exaggeration of normal physiological response or a qualitatively different and abnormal response to the stress of hypoxia. Various observations have been made especially by the Indian Army group, suggesting that those persons susceptible to altitude sickness have an abnormal response to anoxia:

- a) Antidiuresis (2)
- b) Hypercoagulability of blood (15)
- c) Rise in immunoglobulins, IgA, IgM and IgE. (15)

We may divide the severe clinical forms of altitude sickness into two types, named according to what we believe to be the dominant pathological mechanism, cerebral oedema and pulmonary oedema. One or both may be present in the same patient, as the following examples will show.

Pulmonary Oedema.

A young Spaniard flew to Lukla, 9000 feet, and ascended towards the Everest Base Camp (17,500 ft.). On the 5th day he was anorexic, vomited and was very dyspnoeic. However he continued to ascend and reached base camp on the next day, confused, lethargic and complaining of dyspnoea and headache. He was cyanosed, he had fine crepitations at both bases and his speech was slurred. He required continuous O_2 overnight and passed very little urine. Next day he was evacuated by helicopter to Kathmandu. After 20 minutes flight he proclaimed himself cured, removed his oxygen mask and started to photograph the mountain. On arrival at Shanta Bhawan, no abnormality could be detected.

Other similar cases have been well studied and documented. (3), (4), (5). They showed severe hypoxaemia, marked pulmonary hypertension (50 mm. Hg.), but normal pulmonary wedge pressures, left atrial, and left ventricular pressures.

Clearly this pulmonary oedema is not due to left ventricular failure, and the generally unsatisfactory response to digoxin has confirmed this conclusion. The immediate cause is likely to be capillary leakage of fluid, though the exact pathogenesis is unknown. Possible factors include excessive arteriolar vasoconstriction, sludging of blood in the capillaries, immunological changes and the reduced intra-alveolar pressure. The condition may be analogous to that of the systemic circulation in systemic shock.

Treatment - I. V. Morphine, Oxygen, aminophylline and I. V. diuretics are all of value as emergency treatment, (2), (12), but the most important aspect of management is to get the patient down to a lower altitude as soon as possible, as is adequately shown by the example given.

Cerebral Oedema.

Many people going to high altitudes, especially if they do not acclimatise gradually, will get headache, anorexia, nausea, vomiting, sleeplessness, dizziness and weakness, which may even prove incapacitating. This has been known by different names in different parts of the world, and we know that it is associated with raised CSF pressures⁽²⁾. It is usually self-limiting and fairly harmless, but a few people progress to frank cerebral oedema with unconsciousness, decerebrate-type rigidity and papilloedema, usually with retinal haemorrhage. It seems reasonable to suppose that this is the extreme end of a spectrum of response to altitude, but on the other hand a qualitatively different response, that is an idiosyncratic change, can not be entirely ruled out. I have been very much impressed by the fact that in a given party, one member may become unconscious and even die, while others perform normally.

Examples: -

Case 1. A 39 years old Japanese female flew from Kathmandu to Lukla at 9000 ft., and in the next two days climbed to 11,000 ft., where she developed a severe headache. On the 4th day after leaving low altitude she began to vomit while walking to 12,700 ft., and on the 5th day ascending to 13,000 ft., she needed assistance because of dyspnoea, weakness, and vomiting. On the afternoon of the 6th day, she lost consciousness, and was carried down to the Kunde hospital at about 12,500 ft. There examination showed a deeply unconscious, cyanotic woman with temperature 105°, pulse 140/min., respirations 25/min., and B.P. 120/70. Both lungs were filled with crepitations. There was no peripheral oedema or elevation of Jugular venous pressure. Reflexes were brisk and symmetrical, and the plantar flexor. The neck was not stiff. The pupils were equal and reactive. The fundi showed slight papilloedema. She was given oxygen, penicillin, and frusemide. On the next day, the 8th, the chest was much better, but her conscious state was unchanged. She was flown to Shanta Bhawan Hospital here in Kathmandu, where the only change was found to be the appearance of extensor plantar responses. Lumbar puncture showed an opening pressure of 27Cmm., and the clear colourless fluid contained no cells, normal sugar and protein and no organisms on Gram stain. During the next two weeks, she improved only very slowly. On the 25th day she began to speak, but was emotional labile. On the 31st. day after leaving low altitude she was flown to Japan and according to some reports, at least, regained normal mental function.

Case 2. A 28 year old Korean male flew from Kathmandu to Lukla, and during the next week climbed to 14,000 ft. There he felt nauseated and lethargic but continued to climb to 16,000 ft on the 9th day. He became unconscious that night. Next day he was carried down to 11,000 ft., deeply unconscious. There his temperature was found to be 101°,

pulse 80/min., respirations periodic, and B.P. 120/70. Crepitations were heard throughout both lungs. The pupils were dilated and sluggish, and there was definite papilloedema and hyper-reflexia, though the planter responses were flexor. He was treated with ampicillin, frusemide, oxygen, and hydrocortisone. On the following day (11) he was not improved and his plantars had become extensor. He was deeply unconscious, temperature was 105°, and he was virtually anuric in spite of Frusemide.

On the 12th day, he was evacuated to Shanta Bhawan. On arrival, his lung fields were clear, the pupils equal and reactive, papilloedema was persisting and two retinal haemorrhages were observed. Spinal tap two days later showed an opening pressure of 90 mm., and the clear colourless fluid showed no cells and normal sugar and protein. He was treated with frusemide, betamethasone and mannitol, and mild diuresis resulted. During the next few days his condition improved slowly, but on the 22nd day he became wildly irrational in his behaviour. By the 31st day he had improved, and on the 35th day he began to speak. He was returned to Korea on the 52nd day, and I understand that he never fully regained his normal mentality.

These cases showed both cerebral and pulmonary oedema. The pulmonary oedema rapidly resolved but mental function was impaired for long periods and in fact may never have returned to normal.

Our first fatality was a prominent diplomat stationed in Kathmandu. I will not detail his clinical history, except that it was similar to the two previous cases. He reached an altitude of nearly 18,000 feet, and there was a delay of about 3 days between the onset of unconsciousness and evacuation to hospital. He died on the 6th day in hospital from cardiac arrest due to pulmonary embolism, having never regained consciousness.

We were fortunate in being able to do a complete autopsy, which revealed moderate focal oedema of the brain with multiple petechial and subarachnoid haemorrhages.

The Pathologist, Dr. Bond, commented as follows:

'Evidence of widespread brain damage is given by the multiple, widespread petechiae focal degeneration from previous petechiae, small intra-cerebral haemorrhages. Only moderate focal oedema remains of what was probably more severe in the acute phase.

'The immediate cause of death was embolism to many pulmonary arteries particularly to the lower lobes, and with infarction of the right lower lobe. The infarction and beginning marginal organization in a few places suggests that some emboli had arrived some time before death, perhaps several days. The possibility of actual pulmonary artery thrombosis might also be considered on this same evidence.'

Case 4: The second fatal case came to us dead without any clinical details. He was 41 years old, had been at altitude about 5 days, and became ill at 14,000 feet. The

helicopter arrived to evacuate him when he was virtually on the point of death, so that we were able to perform an autopsy about 5 hours later. The brain showed marked cerebral oedema and multiple petechial haemorrhages and there was also moderate pulmonary oedema and broncho-pneumonia.

Prevention: Of all forms of acute altitude sickness can only be fully achieved by very gradual ascent allowing adequate time for acclimatization. Figures given for this vary, the Indian Army (2) recommending one week for every 3000 feet above 9000 feet a procedure quite impracticable for trekking holidays in Nepal.

The first 3 cases of cerebral oedema that I have described all ascended very rapidly, and furthermore continued to ascent in spite of quite severe symptoms. It seems likely that this "do or die" approach is more likely to result in "die" than "do". It may be that this is one reason why deaths seem to be most common in young healthy climbers—the elderly are likely to be more cautious.

In 1968 a protective effect of acetazolamide was demonstrated in the United States (10). The theory behind this was that a carbon dioxide inhibitor would correct the respiratory alkalosis of altitude. The actual effect on PH was small, and it was later demonstrated that frusemide, a diuretic without carbonic anhydrase effects, also gave helpful prophylaxis, reducing the incidence of symptoms from 20% to 4% in a large controlled Indian series (2) which involved ascent to 11,000-15,090 feet. However a subsequent small American trial (11), while confirming benefit from Acetazolamide, appeared to show that frusemide actually made things worse! This group was flying volunteers to 17,500 feet by supercharged aeroplane, and it may be that the different conditions accounted for the different result. Frusemide is a powerful agent and the dose recommended is high 80/mg. twice daily). It carries the risks of electrolyte abnormality, especially potassium loss, collapse from hypovolaemia and severe dehydration, and may also lead to acute retention in the middle-aged male. I am therefore currently inclined to recommend Acetazolamide 250 mg tds, beginning 2 days before ascent.

Because of their effects on blood coagulation and tendency to induce fluid retention it seems wise to advise against the use of oral contraceptives at altitude,

In educating the public, we need to inform those going to high altitude of the risks involved, the need for acclimatization, the recognition of symptoms at an early stage and the importance of descending before serious trouble develops. This can, and should be done without alarming people or in any way discouraging them from their projected journeys.

Doctors should also be able to study altitude diseases in Kathmandu, especially those who come as medical officers to high altitude trekking or mountaineering groups. I would like, therefore to recommend setting up a small reading room or case containing relevant articles to which such doctors may refer.

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