

# CONTROL OF ACUTE MOUNTAIN SICKNESS

By

P. S. SUBBA

*Office of Director General, Armed Forces Medical Services, Ministry of Defence, New Delhi.*

Man is exposed to high altitude in two quite different situations : in aeroplane flight and in residence or while climbing high mountainous areas. The present discussion will deal with the later situation only.

The unacclimatised subjects, on sudden exposure to high mountainous terrain, exhibit certain symptoms, headache, insomnia, breathlessness, anorexia, nausea, vomiting and malaise, which gradually subside in 4-5 days.

These symptoms can, however, be fairly incapacitating and it is of great military significance to know how long it will take for freshly reinforced troops to take up defensive and offensive positions, particularly when sent to these areas at short notices.

The exact pathogenesis of these symptoms is not clearly understood. It has not been conclusively proved whether all these symptoms are due to the effects of hypoxia, or due to the various intricate biochemical and hormonal disturbances. Various workers have used different therapeutic measures to minimise and cure the ill effects of high altitude. Besides oxygen, drugs like ammonium chloride and  $\text{NaH}_2\text{PO}_4$ , to reduce the effect of alkalosis, have been used.

During the preceding one year, since the Chinese invasion of India, a number of research projects have been carried out by the Office of the Director General, Armed Forces Medical Services, Ministry of Defence, New Delhi. It is the purpose of this paper to deal with some of the observations made in the management of acute mountain sickness.

## POTASSIUM TRIAL

A study on the effect of supplementary and oral potassium on the clinical manifestation of acute mountain sickness was carried out by a team comprising officers from the US and Indian Army in March, 63.

Hall, a member of the team, had earlier shown that rabbits when transported to high altitudes exhibited markedly diminished levels of serum potassium. He put forward the hypothesis that due to alkalosis in high altitude, the renal tubules try to conserve H ions, but in bargain lose K ions, leading to a state of hypokalaemia. Based on this view, the present trial was initiated.

Material for the study comprised of 20 unacclimatised, healthy subjects of the same ethnic built between the age group 20-25 years. The subjects were taken to an outpost at 17,000 feet altitude within a single 20 hour travel.

Group (i) consisted of 10 subjects who were administered potassium chloride. Tablet potassium chloride 300 mg each, 8 tabs. in the morning and 7 in the evening; beginning 4 days before flight, the drug was continued for 6 days in altitude.

Group (ii) consisted of the remaining 10 subjects who were put on placebo in exactly the same routine.

The observations were made for 6 days in high altitude, using the double blindfold method.

Note was made of the various symptoms :—

- (a) headache
- (b) insomnia
- (c) breathlessness
- (d) anorexia
- (e) nausea and vomiting

Each symptom was graded as mild, moderate and severe. Besides daily assessment of these symptoms, thorough medical examination was given every day.

In the investigations, pH of urine was noted every morning and E.C.G. was recorded every day.

The analysis of results obtained showed that there was no significant difference in the various symptoms in the two groups, except anorexia which was more prominent in the potassium group.

On the statistical evidence that the two groups were identical in their symptomatology, these two groups were combined to elicit general characteristics of "acute mountain sickness".

1. Headache: After 20 hours of arrival at high altitude 100% subjects suffered from severe headache. Headache was throbbing in nature and got worse in the morning. It was aggravated while stooping and coughing. By 5th day 25% still suffered from severe headache.

2. Insomnia: It was again most noticeable on the second day, but the subjects felt relieved with each subsequent night. In bad cases, barbiturates were helpful.

3. Breathlessness: It was not very prominent while at rest, since most of the subjects were not doing any exertion. By 5th day could walk easily without being breathless.

4. Anorexia: It was most noticeable from the second day onwards. By 5th day nearly all subjects could eat their meals properly, except 20% who were on potassium. No preference for any particular type of food was observed.

5. Nausea and vomiting: It was another troublesome symptom and nearly all the subjects were affected. By 5th day only 10% had this symptom.

6. Pulse rate : Tachycardia with pulse rate over 100 per min. was detected in 75% cases, by 5th day it persisted in 50% cases. It came down to normal within two days of descending to sea level.

7. Blood Pressure : Systolic B.P. over 140 mm Hg was. detected in 11 subjects, but by 4th day it came down to normal levels in all the subjects. Diastolic B. P. above 90 mm Hg was seen in 14 subjects and by 5th day it persisted in 6 subjects. B.P. both systolic and diastolic came down to normal levels within 2 days of coming to sea level.

8. Respiration Rate : Respiration rate above 22 per min. was observed in 75% cases and persisted in 50% by the 5th day. The depth of respiration varied in different individuals.

9. Weight of subject : Out of 20 subjects 18 lost weight, 13 between 1-5 lbs, 5 between 6-10 lbs. Those with anorexia exhibited greater degree of loss of weight.

10. pH of urine : The mean acidity of urine in potassium group on first day was 6.6 and on the last day it was 5.50; in the control group it was 6.2 and 5.9 respectively. Statistically there was no significant difference between the two groups.

11. E.K.G. findings : One case of potassium group showed transitional right bundle branch block, and in two cases inversion of T waves in Leads  $V_5$  and  $V_6$  was detected. These changes were not associated with any abnormal clinical findings. In no case within 5 days of study, any evidence of right ventricular preponderance was seen.

Analysing the total clinical picture, potassium and control group inclusive, it was observed that the most severe symptoms were noticed 24 hours after arrival at altitude and above 30% of subjects were afflicted. By the end of 5th day only 10% remained seriously ill. If this study could be corroborated by a statistically significant trial, it would bring out some information of vital significance. Thus it was felt that in an emergency when troops have to be deployed at 17,000 feet in a short notice, about 50% troops can take up defensive positions immediately on arrival. By 5th day about 80% troops will be fit for such a role. 20% troops will be ineffective for longer periods.

#### ASPIRIN TRIAL

In June 1963, a study was carried out to determine the therapeutic value of aspirin in the treatment of acute mountain sickness.

Aspirin has been suggested as a drug which might relieve the symptoms of acute mountain sickness, on the assumption that besides analgesic property, it might have a cortisone like action. Cochran et al. suggested that salicylates might act by stimulating the anterior pituitary or the adrenal cortex. Hetzel and Hine showed that administration of sodium salicylate in rats caused marked diminution in the ascorbic acid content of adrenal gland, an action similar to that of cortico-trophin.

Salicylates further resemble cortisone in increasing urinary uric acid excretion and in reducing certain forms of allergic inflammations.

The material for study comprised of 30 healthy unacclimatised subjects, who were divided into 5 groups of 6 subjects each. The schedule observed was :

Group A	Aspirin gr.x t.i.d.	{ 2 days before flight and on the day of flight.
Group B	Aspirin gr.x t.i.d.	{ 1 day before flight and on the day of flight.
Group C	Aspirin gr.x t.i.d.	on the day of flight.
Group D	No prophylactic aspirin. Aspirin only s. o. s.	
Group E	Control group	

The subjects were carried to 13,500 feet altitude. The routine adopted for assessment of various parameters was the same as in potassium trial. An additional investigation, daily absolute eosinophil count, was also included.

The following is the summary of results obtained :—

1. In the prophylactic assessment, administration of aspirin gr.x t.i.d. on the day of flight, was adequate in abating the onset of some of the symptoms.
2. Administration of aspirin gr.x t.i.d. 2 days after arrival at altitude could relieve headache and to some extent insomnia but had no effect on the other symptoms.
3. It was seen that the pH of urine showed a less acidic reaction in the aspirin than in the control group. Also it was noticed that pH of urine showed increasing acidic reaction with each subsequent day, as acclimatisation set in.
4. Absolute eosinophil count showed highly significant rise just after arrival, and this showed a tendency to fall on the 4th day but still remained higher than at sea level. It appears that there is a temporary phase of hypofunction of adrenal cortex, which gradually makes recovery. However, there was no significant difference between the aspirin and control group in this parameter. Thus there is no evidence that aspirin has any stimulating action on adrenal cortex.

#### KENACORT AND DIANABOL TRIAL AND ADRENO-CORTICAL FUNCTION AT HIGH ALTITUDE.

A study to evaluate the role of Kenacort and Dianabol, an anabolic steroid, in the treatment of acute mountain sickness; together with assessment of adreno-cortical function on acute exposure to high altitude has recently been carried out. The investigations are being carried out, and the final report has yet to be submitted.

The view that sudden exposure to high altitude leads to a suppression of adrenoal-cortical function has been expressed by many workers. In our own series

we have noticed significant rise in absolute eosinophil count in subjects who were transported to 13,500 feet. It was felt that administration of Kenacort might act as a replacement therapy relieving the symptoms of acute mountain sickness.

According to another view, the loss of weight at high altitude indicates a state of accelerated metabolism, hence trial of an anabolic steroid, Dianabol, was suggested.

Material for this study comprised of 18 healthy unacclimatised jawans, who were carried to an outpost at 13,500 feet. They were divided into 3 groups of 6 subjects each.

Group A	Tab. Dianabol	1 b.d.	7 days prior to flight and 7 days at altitude.
Group B	Tab. Kenacort	3 t.i.d.	2 days prior to flight, gradually tapered in next 7 days at altitude.
Group C	Control on placebo		

The technique in the assessment of various parameters was identical as in previous trials.

For the study of adrenocortical function the following investigations were done :

- (a) Absolute eosinophil count.
- (b) Urinary 17 hydroxy corticosteroids in 24 hour.
- (c) Serum Na and K estimations.

While trying to separate serum for Na and K estimation, the blood froze due to extreme cold. Attempts to rewarm it led to disintegration of R.B.C. and spoiling the specimen.

In the preliminary report only the clinical features have been reviewed .

1. *Headache*—None of the subjects in Kenacort group suffered from severe degree of headache, compared to 2 in the Dianabol and 2 in the control group.

2. *Sleeplessness*—After the first night, 4 subjects in the control and 1 in Dianabol group suffered from severe degree of insomnia, none in the Kenacort group.

3. *Breathlessness*—Though some subjects in the Kenacort group exhibited the symptom in mild degree, none had severe breathlessness. In the control group 3 subjects, and in Dianabol group 2 subjects had severe breathlessness.

4. *Anorexia*—Severe degree of anorexia was observed in 3 subjects in the control group, while none in the other two groups. Surprisingly, the Dianabol group behaved the best regarding this complaint.

5. *Nausea and vomiting*—There was no significant differences in the three groups regarding this symptom.

6. *Lassitude*—This symptom was seen in 4 subjects in the control, 2 in Denacort and 1 in Dianabol group.

Statistically the figures are rather insignificant to draw any definite conclusions. However, there is a fair indication that by and large the Kenacort group did behave better than control. The Dianabol group, though faired slightly better than control, yet it could not be stated to have significant advantage. It is stressed that it will be worthwhile to corroborate the present 'pilot-study' by a statistically significant trial.

Furthermore the assessment of results of various biochemical studies, which are still under progress, may bring out some important revelations.

#### TRIAL OF USE OF INCLINED PLANE DURING SLEEP AT HIGH ALTITUDE

A newcomer to high altitude feels difficulty in breathing during sleep in first 3-4 nights. Postural effect on ventilatory efficiency in cases of breathlessness due to lung and heart diseases is well known. It was considered that if the subject's back is elevated it will help him to relieve hypoxia on account of the ease by which he can carry out ventilation.

32 subjects, fresh arrival to altitude 11,500 ft. were selected from a transit camp in Ladakh. They were made to sleep alternately; first on a flat position and subsequently on an inclined plane at angle 45 using a backrest, on the first two consecutive nights after arrival. In the morning only subjective feelings and preference for either of the two positions was assessed.

9 did not sleep well in either position

16 slept better in flat position

7 slept better in inclined plane.

In opinion survey :

22 preferred flat position

10 preferred inclined plane.

Thus it was concluded that the inclined plane is not of any value in inducing good sleep at 11,500 feet.

#### ARTERIAL OXYGEN SATURATION

A. Inclined Plane

B. Inhalation of 100% Oxygen.

To substantiate this study where only subjective feelings were assessed, it was felt that a study must be made with actual arterial oxygen saturation determinations.

Furthermore, the effect of inhalation of 100% oxygen as arterial saturation was also sought to be seen. This was prompted by the fact that some people had raised the doubts about the efficacy of administration of oxygen at high altitude, through a B. L. B. mask.

This study is being made in two phases and is still under progress, only the first phase being complete.

In the first phase 8 healthy jawans from a unit stationed at Leh (11,500 feet) were taken for study. Arterial blood samples were withdrawn by the radial artery puncture using Riley's arterial needle, first in the recumbent flat position and subsequently in an inclined plane using a back rest, at 45° angle.

Next the subjects were made to inhale 100% oxygen through a BLB mask, for 5 minutes, and another arterial sample was collected. Simultaneously three venous samples were also collected each time.

Arterial oxygen saturation was determined by the Van Slyke method.

From the studies conducted so far the following observations have come to light :—

1. At 11,500 feet the arterial oxygen saturation was found to be reduced. (Mean 86.85%)

2. There is no significant improvement in arterial oxygen saturation in an inclined plane, as compared to flat position.

Mean Flat 86.85%. Mean Inclined 87.25%.

3. Inhalation of 100% oxygen through BLB mask though improved arterial oxygen saturation (Mean 90.90%), however the saturation reached was far less than expected. This observation, though conducted in a statistically small number, casts doubt upon the efficacy of use of BLB mask for administration of oxygen at high altitude.

In the second phase, it is planned, that the same subjects will be brought down to Delhi from their present station, and similar studies will be repeated.

#### CONCLUSION

Confronted as we are by the problems of warfare at high mountainous terrain, it is vital that our troops must be emancipated from the clutches of acute mountain sickness, so that they may be readily available for action in minimum period.

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The work mentioned in this paper has been carried out by Armed Forces Medical Research Team under the direction of Director, Medical Research, Office of the DG AFMS, Ministry of Defence.

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**CORNEILLE HEYMANS (1892- )**  
**Nobel Laureate (1938)**

C. Heymans was born at Gand, Belgium on March 18, 1892. He is the son of Dr. J. F. Heymans, one time professor of pharmacology and rector of the University of Gand, as well as founder of the J. F. Heymans Institute of Pharmacodynamics and Therapeutics at the same University. Heymans' father was his first and principal teacher and it was with him that the original experiments, leading to the award of the Nobel Prize, were begun. C. Heymans was educated at the local university, studied later in the laboratories of E. Gley in Paris, N. M. Arthus in Lausanne, H. H. Meyer in Vienna and E. H. Starling in London. In 1927-28 he worked in the United States, chiefly in the laboratory of C. F. Wiggers at Western Reserve University, Cleveland. In 1922 he began to teach the course in pharmacodynamics at Gand, and in 1930 he succeeded his father there. He is the best known of Belgian workers in the biological sciences.

The 1938 Nobel Prize was presented to Professor C. Heymans at an academic ceremony in Ghent on January 16, 1940 'for his discovery of the role played by the sinus and aortic mechanisms in the regulation of respiration'. Professor Heymans is now associated with the University of Ghent.