Simulated descent *v* dexamethasone in treatment of acute mountain sickness: a randomised trial

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Abstract

***Objective*—Evaluation and comparison of the therapeutic efficacy of a portable hyperbaric chamber and dexamethasone in the treatment of acute mountain sickness.**

***Design*—Randomised trial during the summer mountaineering season.**

***Setting*—High altitude research laboratory in the Capanna Regina Margherita at 4559 m above sea level (Alps Valais).**

***Subjects*—31 climbers with symptoms of acute mountain sickness randomly assigned to different treatments.**

***Interventions*—One hour of treatment in the hyperbaric chamber at a pressure of 193 mbar or oral administration of 8 mg dexamethasone initially, followed by 4 mg after 6 hours.**

***Main outcome measures*—Symptoms of acute mountain sickness (Lake Louise score, clinical score, and AMS-C score) before one and about 11 hours after beginning the different methods of treatment. Permitted intake of mild analgesics before treatment and in the follow up period.**

***Results*—After one hour of treatment compression with 193 mbar caused a significantly greater relief of symptoms of acute mountain sickness than dexamethasone (Lake Louise score: mean (SD) −4·6 (1·9) *v* −2·5 (1·8); clinical score: −4·0 (1·2) *v* −1·5 (1·4); AMS-C score: −1·24 (0·51) *v* −0·54 (0·59)). In contrast after about 11 hours subjects treated with dexamethasone suffered from significantly less severe acute mountain sickness than subjects treated with the hyperbaric chamber (−7·0 (3·6) *v* −1·6 (3·0); −4·1 (1·9) *v* −1·0 (1·5); −1·78 (0·73) *v* −0·75 (0·82) respectively). Intake of analgesics was similar in both groups.**

***Conclusion*—Both methods were efficient in treatment of acute mountain sickness. One hour of compression with 193 mbar in the hyperbaric chamber, corresponding to a descent of 2250 m, led to short term improvement but had no long term beneficial effect. On the other hand, treatment with dexamethasone in an oral dose of 8 mg initially followed by 4 mg every 6 hours resulted in a longer term clinical improvement. For optimal efficacy the two methods should be combined if descent or evacuation is not possible.**

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Introduction

Climbing and trekking to altitudes above 2500 m have recently become more popular. Modern methods of transportation facilitate a rapid gain in altitude for unacclimatised low land dwellers, who are often forced into tight time schedules that do not allow sufficient time for acclimatisation. This is the main reason why many tourists develop the unpleasant symptoms of acute mountain sickness.[1]

The main symptoms are headache, nausea, vomiting, dizziness, and difficulty in sleeping.[2] Usually these symptoms resolve spontaneously after one or two days without further ascent. In severe cases, however, acute mountain sickness may progress to life threatening high altitude cerebral oedema or high altitude pulmonary oedema, or both.[3,4] Incidence and severity of these illnesses depend on absolute altitude, rate of ascent, and the degree of individual susceptibility and may be prevented in most cases by graded ascent[5,6] and prophylaxis with acetazolamide.[7,8] Immediate descent or evacuation to a lower altitude, the treatment of choice for patients with fully developed severe acute mountain sickness, may occasionally be impossible because of weather, danger of avalanche, or topographical reasons. Thus a simple emergency treatment is desirable.

Dexamethasone has been proved to be efficient as a prophylactic[9] as well as a therapeutic measure for this condition.[10-12] Recently, portable hyperbaric chambers have been advocated as an emergency treatment for acute mountain sickness.[13] Simulated descent of 1500-2500 m is achieved by an increase of pressure up to 220 mbar in the chamber, which leads also to an increase in oxygen tension. Early uncontrolled studies reported rapid and long lasting relief of symptoms by this method.[14] Under controlled circumstances, however, improvement of symptoms at 4559 m by a simulated descent of 2250 m was only short lived, and there were almost no long term (12-16 hours) beneficial effects of this treatment.[15]

We compared these two different methods of treatment under controlled circumstances in a randomised trial to establish the best emergency treatment for severe acute mountain sickness.

Subjects and methods

LOCATION AND SUBJECTS

The study took place in the high altitude research laboratory located at the Capanna Regina Margherita at an altitude of 4559 m above sea level (barometric pressure 430-440 mm Hg) on the Monte Rosa in the Alps Valais.

Mountaineers who had climbed to the Capanna and who planned to stay overnight were invited by a posted message to participate in this study if they suffered from symptoms or signs of acute mountain sickness. Most subjects had ascended to high altitude without prior acclimatisation from the Italian side of Monte Rosa by using a cable car to an altitude of 3200. They had stayed for one or two nights at lower huts on the mountain at altitudes between 2800 and 3600 m; four subjects had spent the last night below 1000 m. On the day of ascent they climbed to the Capanna Regina Margherita in 3-5 hours over glaciers without technical difficulties. (For the number of previous episodes of acute mountain sickness and the altitude exposure during the previous 2 months see table II). After obtaining informed consent, a brief interview and a clinical examination were performed. Climbers with a score of 3 or more for clinical acute mountain sickness entered the trial.[1,10,15] Patients with frank clinical signs of high altitude pulmonary oedema were excluded from the study. The study was approved by the ethics committee of the University Hospital Zurich.

STUDY DESIGN

The volunteers completed a questionnaire on environmental symptoms[16] and the Lake Louise self

assessment questionnaire directed towards the symptoms of acute mountain sickness (table I). The responses were checked with the investigator, and subsequently a clinical examination for peripheral oedema, pulmonary rales, and ataxia (Romberg test and heel to toe walking test) was performed. The subjects were weighed, and after 10 minutes of rest in supine position arterial oxygen saturation was measured with an ear oximeter (Biox II, Ohmeda). After they entered the trial subjects were allowed to take mild analgesics (paracetamol) for headache, but this had to be reported to the investigator.

TABLE I—*Details of the Lake Louise scoring system*

Symptom	Score	Definition
AMS self assessment questionnaire:		
1 Headache	0	None at all
	1	Mild headache
	2	Moderate headache
	3	Severe headache
2 Gastrointestinal symptoms	0	Good appetite
	1	Poor appetite or nausea
	2	Moderate nausea or vomiting
	3	Severe, incapacitating nausea or vomiting
3 Fatigue and/or weakness	0	Not tired or weary
	1	Mild fatigue/weakness
	2	Moderate fatigue/weakness
	3	Severe fatigue/weakness, incapacitating
4 Dizziness/lightheadedness	0	Not dizzy
	1	Mild dizziness
	2	Moderate dizziness
	3	Severe dizziness, incapacitating
5 Difficulty in sleeping	0	Slept as well as usual
	1	Did not sleep as well as usual
	2	Woke many times, poor night's sleep
	3	Could not sleep at all
Clinical assessment:		
Change in mental state	1	Lethargy/lassitude
	2	Disoriented/confused
	3	Stupor/semiconscious
	4	Coma
Ataxia (heel to toe walking)	1	Balancing manoeuvres
	2	Steps off line
	3	Falls down
	4	Can't stand
Peripheral oedema	1	One location
	2	Two or more locations

Subsequently, the subjects were randomly allocated to the two different treatments. Randomisation was performed in blocks of eight by drawing lots from an envelope containing the assignments of one block. Overall, 31 subjects participated in the trial; 15 were treated with pressure of 193 mbar in the hyperbaric chamber for one hour and 16 were treated with dexamethasone.

One hour and about 11 hours (193 mbar group mean 11·2 (SD 2; range 8·5-14·6) hours; dexamethasone group 11·3 (2; 8·5-15) hours) after initiation of treatment all procedures were repeated. Interviews and clinical examinations were always performed by the same investigator.

TREATMENTS

For pressurisation a fabric hyperbaric chamber (Certec, F-69210 Sourcieux-les-Mines, France) was used, allowing the treatment of a single person.[15] The chamber, made of polyamide material coated in polyurethane with an airtight zip, is 220 cm long with an average diameter of 65 cm. The patient in the chamber can be observed through a window.

In the present investigation pressure was supplied by an electrically operated compressor, and the air flow was controlled by a built in flowmeter. Treatment pressure was 193 mbar (equivalent to a descent of 2250 m), regulated at the adjustable valve with a constant air flow of 50 l/min. Pressure was built up and released within 5 minutes, and for control an additional altimeter (Thommen, Waldenburg, Switzerland) held by the patient was used. During pressurisation the patient was permanently supervised by the investigator.

As in previous studies dexamethasone was administered by mouth in a dose of 8 mg initially, followed by 4 mg every 6 hours. Because of severe vomiting in four subjects the initial dose was injected intravenously.

ASSESSMENT OF ACUTE MOUNTAIN SICKNESS

Three different scores for assessing acute mountain sickness were used.

The Lake Louise score represents the consensus on the definition and quantification of altitude illness established at the 1991 International Hypoxia Symposium held at Chateau Lake Louise, Canada.[17] Separate tools are used for self assessment and clinical assessment (table I).

The clinical score was assessed by interview and clinical examination.[10 15] A patient with a score of 3 or more was considered to suffer from acute mountain sickness.

The AMS-C score of the environmental symptom questionnaire of Sampson *et al* was also used to assess symptoms.[16] A score of 0·70 or more indicates the cerebral form of acute mountain sickness.

STATISTICAL ANALYSIS

We evaluated the results of the two different treatments by a two factor analysis of variance for repeated measurements, the between subjects factor being treatment and the within subjects factor assessment time, with the STAT VIEW II Software package (Abacus concepts, Berkely, California). Because the two treatment groups were produced by random allocation the values before treatment were not identical. Thus, for comparison of treatment a two factor analysis of variance to compare changes (that is, differences from pretreatment values) was also performed. For comparison within one treatment group we used the Scheffe F-test if the P value of the one factor analysis of variance for repeated measurements was significant. P values of less than 0·05 were considered significant.

Results

The two treatment groups were comparable with regard to age, sex, systolic blood pressure, temperature, heart rate, and respiratory rate (table II). Furthermore, there was no difference between groups in the duration of ascent to high altitude and previous episodes of acute mountain sickness. The severity of acute mountain sickness, assessed by Lake Louise score, clinical score, and AMS-C score, was not significantly different between the two treatment groups at baseline (table III, fig 1).

TABLE II—*Characteristics and drug intake of subjects treated with dexamethasone or pressurisation of 193 mbar*

Variable	Pressurisation	Dexamethasone
No of subjects	15	16
Men/women	10/5	12/4
Mean (SD) age (years)	32 (8·6)	31 (7·2)
Mean (SD) altitude exposure during previous 2 months (days above 2000 m)	6·5 (5·3)	4·8 (3·6)
Mean (SD) No of days above 2000 m before treatment	1·7 (0·8)	1·7 (0·9)
Mean (range) altitude (m) of last overnight stay	3100 (1000-3600)	3100 (200-3600)
Mean (SD) No of previous episodes of acute mountain sickness before treatment	0·2 (0·4)	0·4 (0·5)
Mean (SD) temperature (°C)	37·1 (0·9)	37·0 (0·4)
Mean (SD) systolic blood pressure (mm Hg)	124 (13)	127 (15)
Mean (SD) heart rate (beats/min)	97 (9)	94 (13)
Mean (SD) respiratory rate	22 (4)	23 (2)
No who used analgesics:		
Before treatment	8	5
During treatment	6	2

Hyperbaric treatment of 193 mbar for one hour resulted in a significant decrease of all three scores of acute mountain sickness immediately after treatment (table III, fig 1). A mean (range) of 11 (8·5-14·6) hours after initiation of treatment the mean Lake Louise score did not differ significantly from pretreatment values, whereas the clinical score and the AMS-C score were significantly lower than before treatment ($P<0·05$).

One hour after beginning treatment with dexamethasone the clinical score, Lake Louise score, and the AMS-C score already showed a significant decrease ($P<0·05$). After a mean (range) of 11 (8·5-15.0) hours dexamethasone treatment resulted in a significant reduction of all three scores ($P<0·01$). Four patients treated with dexamethasone became totally asymptomatic. The scores of the four patients initially treated with dexamethasone intravenously did not differ noticeably from scores of subjects who received the drug by mouth.

There were no significant changes in pulse rate or blood pressure in each group during the study, but mean arterial oxygen saturation had increased significantly by the second assessment in the dexamethasone group, corresponding to a non-significant increase in the simulated descent group (fig 2). Immediately after pressurisation with 193 mbar arterial oxygen saturation was significantly higher than before treatment (table III).

The acute mountain sickness scores and oxygen saturations were significantly different between the two treatments when values obtained at one and about 11 hours after treatment expressed as differences from pretreatment values (data not shown) were analysed by a two factor analysis of variance. Figures 1 and 2 show the P values of this analysis.

Six of the 15 subjects in the pressurisation group compared with two of the 16 in the dexamethasone group took mild analgesics after initiation of treatment.

TABLE III—*Mean (SD) changes in scores for acute mountain sickness and differences in oxygen saturation after treatment*

Detail	Hyperbaric chamber	Dexamethasone	P value* for difference between treatments at 11 hours
Lake Louise score:			
After 1 hour	−4·6 (1·9)	−2·5 (1·8)	
After 11 hours	−1·6 (3·0)	−7·0 (3·6)	<0·001
Clinical score:			
After 1 hour	−4·0 (1·2)	−1·5 (1·4)	
After 11 hours	−1·0 (1·5)	−4·1 (1·9)	<0·001
AMS-C score:			
After 1 hour	−1·24 (0·51)	−0·54 (0·59)	
After 11 hours	−0·75 (0·82)	−1·78 (0·73)	<0·001
Oxygen saturation (%):			
After 1 hour	+4 (5)	+2 (5)	
After 11 hours	+3 (5)	+8 (8)	<0·01

*Two factor repeated measures Anova.

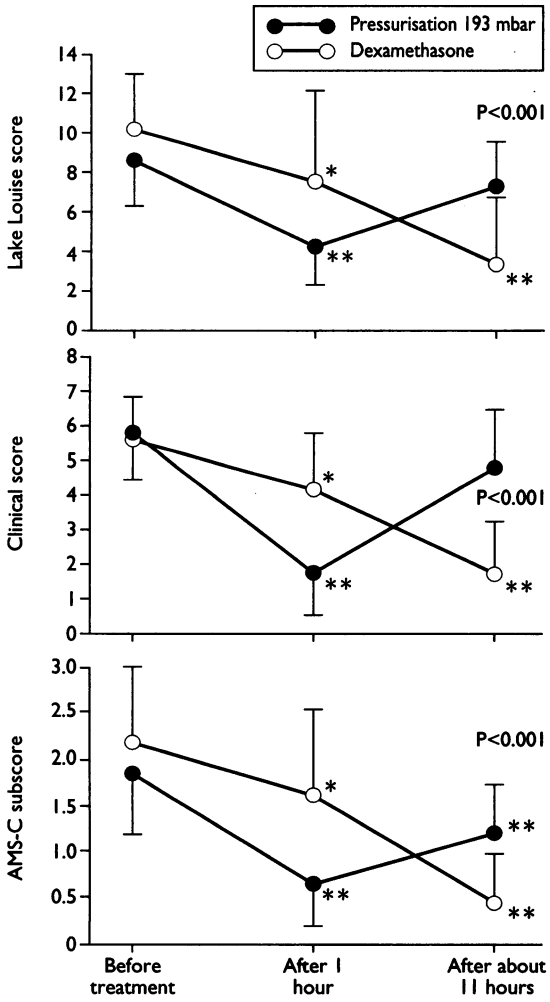

FIG 1—*Mean (SD) score of acute mountain sickness in subjects treated with simulated descent or dexamethasone. Given P values correspond to two factor analysis of variance performed with values expressed as differences from values before treatment (*P<0·05, **P<0·01; Scheffe F test)*

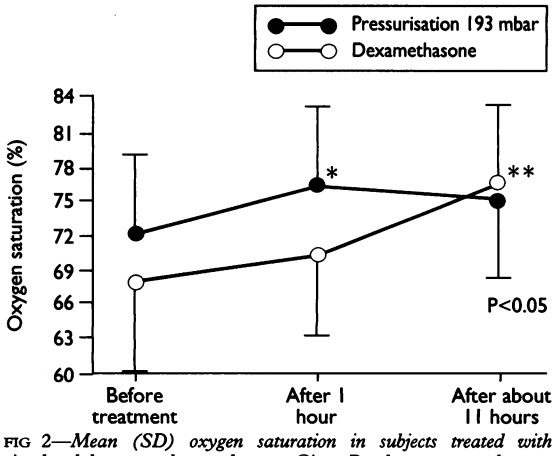

FIG 2—*Mean (SD) oxygen saturation in subjects treated with simulated descent or dexamethasone. Given P values correspond to two factor analysis of variance performed with values expressed as differences from values before treatment (*P<0·05, **P<0·01; Scheffe F test)*

Discussion

In this study both methods of treatment were efficient in treating acute mountain sickness. One hour of pressurisation with 193 mbar in a portable hyperbaric chamber, corresponding to a descent of 2250 m, reduced the symptoms and signs of acute mountain sickness immediately. After 11·3 hours, however, all symptom scores had risen again. Several patients treated in the hyperbaric chamber had to be helped to reach lower altitudes because of headache, general weakness, and confusion. On the other hand, treatment with dexamethasone 8 mg followed by 4 mg every 6 hours led to a more gradual but longer lasting relief of acute mountain sickness, and all subjects descended without assistance.

Our findings agree with those of previous studies, both on hyperbaric treatment[15] and on dexamethasone treatment of acute mountain sickness.[10 11] The severity of acute mountain sickness correlates with hypoxaemia,[2 18 19] and under administration of supplementary oxygen symptoms of acute mountain sickness disappear rapidly.[20] Bottled oxygen is often not available or is limited and therefore provides only short term relief for seriously ill mountaineers. Some relief of symptoms can be achieved by hyperbaric treatment because of a comparable increase in oxygen saturation during treatment. After treatment is stopped, however, the oxygen tension decreases and the condition of the patient may again deteriorate.

A recently performed study on Mont Blanc could

Key messages

- Acute mountain sickness can be treated naturally by controlled descent or artificially in a hyperbaric chamber to increase air pressure or with drugs
- Simulated descent in a hyperbaric chamber quickly relieves symptoms but the effect is short lived
- The drug dexamethasone takes longer to work but the effect is longer lasting
- A combination of the two methods may be the treatment of choice when the subject cannot be transported to lower altitudes

not show any long term beneficial effect of a 3 hour stay in the hyperbaric chamber,[21] so prolonging treatment is unlikely to have better long term results. Nevertheless, commercially available hyperbaric chambers are widely recommended for trekking parties and expeditions to extreme altitudes. According to anecdotal reports its use in the Himalayas has not prevented death from acute mountain sickness in trekking parties.

Although the pressure bag represents a light and inexhaustible option for increasing oxygen tension, its correct handling at high altitude under difficult weather conditions is strenuous. The maintenance of a therapeutic pressure and a sufficient air flow by using manual pumps in these altitudes represents an enormous physical strain for the rescuers.

In our study dexamethasone proved to be efficient in treatment of acute mountain sickness. The reduction of symptoms of acute mountain sickness with dexamethasone coincided with an increase in arterial oxygen saturation. Compared with hyperbaric treatment the administration of dexamethasone is remarkably simple and results in slower improvement but longer lasting relief of symptoms. These observations led us to conclude that dexamethasone is the treatment of choice for the cerebral form of severe acute mountain sickness. Despite its disadvantages, the hyperbaric chamber represents an alternative to bottled oxygen in remote places and a valuable support of other treatments because of its rapid action. If dexamethasone *and* a hyperbaric bag are available both methods may be used for immediate as well as prolonged relief of acute mountain sickness. Finally, however, it has to be emphasised that this dangerous and unpleasant condition should be avoided by slow ascent and that immediate descent or evacuation remains the ultimate treatment of choice. The objective of any other therapeutic measure should be to facilitate safe descent.

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Unsuspected HIV infection presenting in first year of life

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Anonymous unlinked screening programmes in inner London have shown that up to 1 in 200 women booked at antenatal clinics is HIV positive. Most of these women, however, do not have a named HIV test during pregnancy and therefore remain unaware of their infection. Failure to identify these women not only results in the baby being denied adequate medical care but also prevents the use of measures that may reduce transmission of infection from mother to child.

Less than one fifth of pregnant women infected with HIV are being recognised. During 1992-3 anonymous testing of blood samples from newborn babies in three Thames regions identified 262 HIV seropositive infants, only 15% of whom were born to women known to be infected with HIV before delivery.[1]

Subjects, methods, and results

During 1992-3 five infants who were previously not known to be at risk of HIV infection were referred to our paediatric HIV unit with *Pneumocystis carinii* pneumonia (table). The pneumonia was the first sign of HIV infection in the family. Four of the children required ventilation, and one died of the pneumonia. Four children had had non-specific symptoms, including cough, diarrhoea, and poor weight gain, for up to six weeks before diagnosis.

Comment

All five patients presented with a life threatening complication of HIV infection as the first sign of the