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High incidence of mild acute mountain sickness in conference attendees at 10 000 foot altitude

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An epidemic of mild acute mountain sickness (AMS) occurred at a 4-day meeting of epidemiologists held at an altitude of 3000 m (9800 ft) in the Rocky Mountains of Colorado, USA. Questionnaires from 96% of the 105 attendees documented the following symptom frequencies: headache, 59%; shortness of breath, 59%; difficulty in sleeping, 45%; weakness or dizziness, 40%; and nausea, 12%. AMS, defined as three or more symptoms, occurred in 42% of the respondents, and 90% had at least one symptom. One third felt the illness interfered with their concentration at the meeting, and 31% would not plan another meeting at this altitude, although only one person missed meeting sessions as a result of the AMS. AMS should be anticipated by those planning meetings of short duration at high altitude, and by physicians advising travelers to altitudes over 2000 m.

Keywords: altitude, mountain sickness, epidemiology, epidemic, meetings

Introduction

Acute Mountain Sickness (AMS) is a syndrome of headache, nausea or anorexia, weakness or dizziness, insomnia, and shortness of breath that occurs in persons who ascend rapidly from low altitudes to those over about 2000 m (6000 ft) [1–3]. High altitude pulmonary and cerebral edema are severe, life-threatening forms of AMS. AMS was found in 53% of 278 trekkers in the Himalayas at 4200 m [4], 12% of 3906 winter visitors to Colorado ski resorts at 2400–2900 m [5], 12–25% of medical education class attendees at 2100 m [3], and 80–100% of military personnel transported rapidly to 3900 m [6]. Reduced exercise, high fluid intake, and avoidance of alcohol and sedatives are recommended as preventive measures. Symptoms can be prevented or ameliorated by acetazolamide or dexamethasone treatment; a high incidence of minor side effects occurs with these medications [7], [8].

An epidemic of AMS occurred at a 3-day meeting of State and Territorial Epidemiologists held in Colorado in early June 1988 at an altitude of 3000 m (9800 ft). In general, the symptoms of AMS at this altitude were mild, but affected nearly all attendees. In contrast to previous studies of AMS in mountaineers or skiers, almost all the epidemiologists had arrived within two days of questionnaire administration, and incidence rather

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than prevalence could be studied. We believe this is the second reported survey of AMS designed to measure incidence in a civilian cohort not engaged in skiing or mountain-climbing. The incidence of mild AMS was considerably higher than in most previous studies.

We obtained information on symptoms and possible risk or protective factors, and examined the amount of disability. Nearly a third of respondents said they would not plan another meeting at this altitude; the remaining two thirds said that altitude would not be a factor or would be weighed against other factors in their decisions.

According to the literature, the incidence and severity of AMS can be reduced by prophylactic acetazolamide or dexamethasone and other measures[2]. Only one member of this group took prophylactic medication. Many complied with other recommendations without appreciably reducing the overall incidence of symptoms.

Methods

The annual meeting of the Council of State and Territorial Epidemiologists was held June 1–4, 1988 in a Colorado hotel at an altitude of 9800 ft. The registrants arrived from most of the states and territories of the US. During the meeting, it became apparent that many members suffered headaches and/or felt dizzy or weak and had difficulty sleeping. No prior plans for a study had been made, but the illness seemed so prevalent that we developed a questionnaire and began a systematic investigation.

On June 2, the questionnaire was distributed to all attendees and accompanying dependents. The form included a description of the study and asked for demographic information, a description of travel to the meeting, symptoms and possible risk factors, such as previous history of AMS, exercise, and alcohol and cigarette consumption. By the end of the meeting, 75 of 105 individuals had responded. Mail and telephone follow-up raised the response rate to 96%; the results are based on information from 98 attendees and three spouses.

To maintain comparability with at least one previous epidemiologic study[5], cases were defined with respect to the presence of the following symptoms: headache, nausea, weakness or dizziness, shortness of breath, and difficulty sleeping. Persons with three or more symptoms were considered to have AMS. The 101 questionnaires were processed on a microcomputer using the Epi Info questionnaire-processing program[9]. Tabulations were done for attendees with AMS and also for those having one or more symptoms of AMS.

Two persons said they had had symptoms of upper respiratory infection before arrival, and one other attributed symptoms to 'food poisoning'. They were included in the case group, since there was no way to exclude the possibility of mild AMS in conjunction with the other conditions, and excluding these three cases would not have changed the final results significantly. There was no evidence of other intercurrent infectious disease.

The frequency of many risk factors in the 'ill' and the 'non-ill' by both definitions was examined, using two-by-two tables, odds ratios, chi-square and Cornfield confidence limits for categorical data. One-way analysis of variance (ANOVA) and Kruskal-Wallis tests were used for continuous or ordinal variables, such as age.

Results

The 77 men and 24 women ranged in age from 30 to 62 years (mean, 42). All respondents except two had arrived at the meeting site the day before or during the meeting. Seventy percent had travelled to 3000 m from altitudes below 1000 m in less than 12 h.

During the meeting, 59% had headache; 49% felt weak, dizzy, or 'whoozy'; 12% had nausea or vomiting; 45% had difficulty sleeping; 59% were short of breath; and 40% experienced thirst. Forty-two percent had three or more of these symptoms excluding thirst, thus fulfilling the case definition for AMS, but 90% had at least one symptom and 70% had at least two symptoms. Case rates for the entire group and for the 71 persons who came from below 1000 metres in less than 12 h were very similar (42% v. 45% with ≥ 3 and 90% v. 90% with ≥ 1 symptom). Six of the eight persons normally living at above 5000 ft altitude had at least one symptom, but none met the case definition for AMS. The difference in AMS rates in the two groups was statistically significant ($p = 0.01$, Fisher exact 1-tailed test).

The median time from arrival at the meeting to onset of symptoms was 6–10 h for all symptoms except 'swelling of hands or ankles,' experienced by eight persons, with a median onset at 18 h. Many other symptoms occurred within the first hour of arrival in some individuals.

The median duration of headache, feeling 'weak, dizzy or whoozy,' and nausea was 14–15 h; median durations for the other symptoms were 26–28 h. All symptoms except swelling occasionally lasted less than 1 h, but the range extended to 94 h. At the time of departure from high altitude (median 65 h, range 11–186 h after arrival), each symptom was still being experienced by some persons, and 59% of those affected by thirst departed with this symptom.

Whether illness was defined as the presence of one symptom or at least three symptoms, significant associations were not found with the following potential risk factors: age, sex, height, weight, hours en route to the meeting site, number of previous climbs over 8000 feet with symptoms, presence of symptoms on any previous exposure to this altitude, usual exercise pattern (times per week of vigorous exercise or exercising 30 min 3 times per week), self-assessed pulse rate at the meeting site, reported pulse rate at low altitude, difference between low- and high-altitude pulse rate, change in diet at the meeting site, exercise at the meeting site, or time of departure from the meeting site. Similarly, no association with AMS was found for usual consumption of red or other meat, coffee, tea, caffeine-containing beverages, alcohol, or cigarettes. Only two of the 101 subjects smoked regularly.

Factors that were associated with the development of one or more symptoms included length of stay at the meeting site. The attack rate for one or more symptoms was 57% for those staying less than 48 h and 93% for those staying longer ($p = 0.02$, Fisher exact test). The presence of one or more symptoms was strongly associated with taking non-steroidal anti-inflammatory agents, antihistamines, or bronchodilators at the meeting site (42% of those with symptoms, none of the 10 without symptoms; $p=0.009$, Fisher exact test).

Having three or more symptoms was associated with coming from altitudes less than 1500 m (100% of 39 ill v. 86% of 57 'well,' $p = 0.01$, Fisher exact test), fewer previous trips over 2400 meters (means of 6 for ill and 13 for 'well', $p = 0.01$, Kruskal-Wallis

test), hours of exercise per typical week (but not times per week) (means of 4.2 for ill and 2.9 for 'well', $p = 0.04$, Kruskal-Wallis test), and completing forms earlier than non-ill counterparts (109 h rather than 219 h; $p = 0.004$, Kruskal-Wallis test).

Before the meeting, attendees had received a letter discussing the possibility of altitude sickness and recommending increased fluids, avoiding overexertion, a 70% to 80% carbohydrate diet, avoiding heavy alcohol intake on the first day, and considering taking acetazolamide (Diamox) 250 mg twice a day for 1 or 2 days. Only one person actually took acetazolamide; he suffered only a mild headache and diarrhoea, the latter conceivably a side effect of the drug.

The other recommended precautions apparently were taken by many of the attendees, since 51% normally drink very little or no alcohol, and many commented on having reduced alcohol consumption while they increased carbohydrate and fluid intake. Only 15% did any jogging or strenuous walking at the meeting site, although 56% normally exercised three or more times per week when at home. Of those known to have avoided vigorous exercise and alcoholic beverages while at the meeting, 87% had at least one symptom.

Discussion

Most previous epidemiologic studies of the frequency of AMS have been studies of prevalence (symptoms at the time of interview), not incidence (cumulative case rate over a defined period in a defined population). Himalayan trekkers at 4200 m had a prevalence of AMS of 53% using a scoring system in which two or more of the symptoms we monitored would count as illness[4]. Questionnaires given to 3906 visitors to six Colorado ski resorts at 2400 to 2900 m revealed that 17% had symptoms at the time of interview, with 12% having three or more symptoms[5]. In a prospective study of army volunteers flown to a Colorado site at 3900 meters, all respondents had headache, and 80% of those not taking acetazolamide had nausea or vomiting and insomnia. Our population differed from the groups in the first two studies in having arrived recently (within 48 h of first questioning), in being engaged in sedentary activity rather than skiing or mountaineering, in having no members under age 30, in being in close social contact with one other, in having a professional interest in medical symptoms and in questionnaire surveys, and in being exposed in early June, when the weather was fair and cool to warm during the day, rather than during the winter. The higher rates we found may also be due to the greater sensitivity of medically trained subjects who were aware of the problem in advance or to differences in survey instruments.

A recent study by Mongomery, Mills, and Luce [3] describes the experience of medical education class attendees at 2100 m (6900 ft) in Colorado and Utah. Even at this relatively low altitude, 25% of the attendees reported three or more symptoms of AMS. Half of these persons took medication for the symptoms, a finding similar to our observation that 42% of those with one or more symptoms took medication. The Montgomery study suggests that symptoms may be common even at an altitude of 2100 m, although it is possible that many of their subjects spent part of the days at higher altitudes. The 60% response rate set a lower limit for AMS of 12%, rather than the 25% found for the respondents. The higher (42%) incidence of AMS in our study is consistent with the study having been conducted at an altitude 1000 m higher.

What is the most useful epidemiologic definition for AMS? Although we defined

AMS as the presence of three or more symptoms, we cannot clearly separate the group having one symptom from the group having three or more symptoms. The presence of one symptom correlated strongly with taking medication. There is not a sharp break in frequencies among those having at least one (90%), two (70%), or three (42%) symtoms. No group had a significantly higher tendency to say they would not plan another meeting at this altitude. Hence, although the presence of one symptom may not be a usable definition except in the presence of a group outbreak, it appears that those with one symptom, for the most part, were suffering from a mild form of AMS. This is further supported by the work of Montgomery, Mills, and Luce [3], who found only a 5% frequency of one or more symptoms in a control group studied at a medical meeting at sea level. The practical difficulties with definition of AMS may remain until more specific laboratory or clinical tests are developed, but a uniform questionnaire and case definition for future studies would resolve at least some problems.

The time course of symptoms is generally in accord with that in a previous study of army volunteers taken rapidly to an altitude of 3900 meters in Colorado[6]. The occurrence of symptoms within the first hour of arrival suggests that AMS is produced very rapidly in some individuals.

AMS is related to low partial pressure of oxygen. Physiologic theories about the detailed mechanism do not provide clear explanations, although much work has focused upon metabolic changes, particularly of acid/base balance. Acetazolamide causes excretion of bicarbonate, potassium, and sodium leading to metabolic acidosis, mimicing the acclimatization process that otherwise takes 2–5 days [1]. Dexamethasone has also been shown to have preventive and therapeutic value[2, 10, 11]. Increasing the carbon dioxide concentration in inspired air to 3% alleviates symptoms [12, 13], but a practical application has not been suggested.

The value of prior written information in preventing AMS in our group was limited. Most members had seen the letter, and even those abstaining from alcohol and exercise had an 87% incidence of at least one symptom. Only one person actually took acetazolamide for prevention, even though the letter had recommended that this be considered.

Acetazolamide, according to previous studies, in doses of 250 mg twice per day, could have prevented some of the symptoms in 50% to 74% of our subjects [7, 14]. Side effects in previous studies have included nausea in 20% of 15 Mt Rainier climbers before ascent[8], and numbness of fingers or face in six of seven Nevada climbers [14]. Dexamethasone (4 mg four times per day) was also effective, but half of the climbers reported fatigue and depression after the trip, and the majority of these said they would not take dexamethasone again. Dexamethasone produces euphoria and rarely steroid psychosis, neither of which promotes safety among mountain climbers. Concern has been expressed about a false sense of security while taking either drug, since ascent in the face of symptoms can result in fatalities [15].

The symptoms of AMS in our group were mild. Of those with one or more symptoms, for example, 63% said that the illness did not interfere with their concentration at the meeting. Whether all travellers to moderate altitudes should take acetazolamide prophylactically remains an open question. In our study, previous experience of illness at high altitude did not predict illness accurately, and prophylaxis could not have been confined to a particular 'target group.' Reported side effects, mainly tingling of fingers or face, are mild but frequent. Acetazolamide and dexamethosone are contraindicated for persons taking certain medications or having particular chronic disease conditions, further

narrowing the possibility of their use on a universal basis.

A more conservative approach would be to provide acetazolamide or dexamethasone for use when symptoms develop. Controlled studies of treatment of existing AMS with acetazolamide have apparently not been reported, although dexamethasone was effective in two studies[11, 16]. Treatment with acetazolamide or dexamethasone at moderate altitudes has not been evaluated in large groups.

When asked if they would plan another meeting at this altitude, 31% of the participants said they would not. Although only one person was ill enough to miss some sessions, only 19% said they would not consider altitude a factor in choosing a meeting site. Half (50%) would weigh it as one among many factors in reaching a decision. Although the benefits of meeting at high altititude sites were not explored on the questionnaire, one participant expressed the feeling of many of the group that the site was breathtaking, and that it is much better to meet in beautiful surroundings, than at a less interesting low-altitude location.

This study suggests that mild AMS commonly affects groups that travel rapidly from low altitudes to meetings at 3000 m or above. At this altitude, the problem is noticeable but not incapacitating for most participants. Preventive efforts without medication did not preclude symptoms in 80% to 90% of individuals. The value of acetazolamide prophylaxis for such groups should be assessed more carefully. The literature suggests that prophylaxis or therapy with acetazolamide (or dexamethasone) would considerably reduce the number and severity of symptoms but be accompanied by appreciable side effects, even among subjects selected for the absence of other disease or medication. Physicians and epidemiologists dealing with travelers should be informed about acetazolamide use and side effects. Controlled studies of acetazolamide therapy after symptoms occur, rather than prior to onset, would be useful.

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