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Clinico-epidemiological profile of high altitude pulmonary edema

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ABSTRACT

Background: With increase in the footfall to mountainous areas for occupational and recreational purposes, tackling the burden of high-altitude illnesses is a growing public health challenge. High-altitude pulmonary edema (HAPE) is a serious medical condition with peculiar epidemiological characteristics. HAPE is a significant cause of morbidity and mortality among Indian soldiers posted to high-altitude areas. Aims and objectives of the study were to study the common clinical presentation of HAPE among Indian army soldiers and to study the association between induction patterns and acclimatization status with the onset of HAPE.

Methods: An observational study was undertaken to study the clinical and epidemiological characteristics of all cases of HAPE from years 2016 to 2019, among Indian army soldiers posted to high-altitude areas in Ladakh. Diagnosis was made by the Lake-Louise consensus criteria. Data was entered in Microsoft Excel and descriptive and inferential statistical tools were applied to test for associations between the variables studied.

Results: The overall incidence rate of HAPE was found to be 5.91 per 1,000 soldiers with high frequency among young men. Breathlessness, cough, and headache were the common complaints. 69.45% of cases occurred among men who revisited the mountains after a brief sojourn to the plains. At higher altitudes, incidence rates were higher among acclimatized individuals.

Conclusions: HAPE occurs more frequently during the subsequent visits compared to first exposure to high altitude. At extreme altitudes, acclimatization protocols do not confer complete protection against HAPE.

Keywords: Acclimatization, Environmental medicine, High altitude illnesses, HAPE

INTRODUCTION

With rampant increase in tourist footfall to the Himalayas and already deployed Indian soldiers along the northern frontiers, high altitude-related illnesses are turning into a growing public health challenge. In public health context, the term 'high-altitude' refers to elevations of 1,500 m (4,921 ft) above sea level. Three categories of altitude have been identified: 1,500 to 3,500m as high altitude, 3,500 to 5,500m as very high altitude and 5,500 to 8,850m as extreme altitude.¹ High altitude pulmonary edema (HAPE) is a unique pulmonary condition developing over hours to days of exposure to hypoxichypobaric environment at high altitude. Even though

HAPE is a preventable consequence of rapid ascent, it continues to be a common occurrence among lowlanders on their sojourns to the hilly terrain. Sudden exposure to high altitude triggers several physiologic mechanisms that enable the individual to adapt to the prevailing environmental conditions, collectively known as acclimatisation. While the typical case of HAPE is a young individual complaining of cough and shortness of breath on second or third day of ascent with supportive auscultatory and chest radiographs, our experience with more than a lakh individuals posted to different stages of high altitude area (HAA) has provided new insights into the epidemiological and clinical characteristics of HAPE. There is a need to accumulate epidemiological evidence

on HAPE in order to reduce the preventable morbidity attributable to HAPE.

We undertook this study on all cases of HAPE that occurred over a four-year time period among Indian soldiers posted to the Ladakh ranges, with the objective of studying selected aspects of HAPE and finding out the relationship of induction pattern and acclimatization schedule with the onset of HAPE.

METHODS

The Lake-Louise consensus criteria for detection of HAPE is based on the presence of at least two chest signs among wheezing / rales in at least one lung field, tachycardia, central cyanosis, tachypnoea, and any two chest symptoms among cough, weakness or decreased exercise performance, chest tightness or congestion and dyspnoea at rest.³ Diagnosed cases of HAPE among Indian soldiers posted to various heights of the Ladakh mountain ranges of Indian subcontinent were analysed for epidemiological characteristics.

An observational study design based on data from hospital records was planned. All reported cases of HAPE during a four-year time-period from 01 Jan 2016 to 31 Dec 2019, diagnosed at secondary and tertiary care hospitals were included in the study. These hospitals are located in Ladakh and cater to the serving soldiers of the Indian Army and receive patients from a wide range of altitudes from 2,700m to 7,000m.

Data pertaining to age, induction status symptomatology was obtained from the medical records. We analysed the proportion of HAPE cases at various stages of altitude (2,700-3,600m, 3,601-4,500m and 4,501m and above). Induction pattern was analysed as the proportion of HAPE among individuals newly inducted to high-altitude (new inductees) and those who returned to high-altitude after a brief sojourn to the plains (reinductees). Acclimatization history of the cases at different stages of altitude was analysed to find out if HAPE occurred during or after acclimatization. Data on presenting symptoms and day of onset of symptoms was analysed to find out common symptoms and day of onset since induction. Data was entered in Excel spreadsheets and statistical tests were used to analyse differences between groups. A p value of less than 0.05 was set to suggest a statistically significant difference between the groups studied.

RESULTS

A total of 838 cases of HAPE occurred during the years 2016 to 2019. Medical records of all 838 cases were available for final analysis. A total of 1,41,790 soldiers were inducted and re-inducted to the high-altitude areas from 2016 to 2019. The overall incidence rate of HAPE

was found to be 5.91 per 1,000 individuals over four years.

Incidence rates of HAPE by age of cases

The most common individuals affected were those under the age of 25 years. Incidence rate was found to reduce with increasing age (Table 1).

Common presenting symptoms

Breathlessness was the most common presenting symptom reported by 100% cases of HAPE, followed by headache (29%) and cough (25.7%). Fever, gastrointestinal complaints and other symptoms were reported by 11% of the cases.

Time of onset of symptoms

The largest number of cases of HAPE (41%) reported the onset of symptom/s within second to sixth day of induction to HAA. 68% of cases reported onset of symptoms within first six days, or first week of induction to HAA (Figure 1).

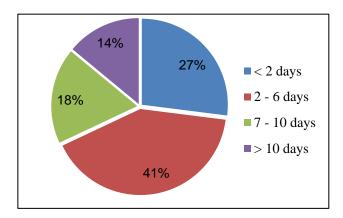


Figure 1: Time of onset of symptoms following induction to high altitude area.

Distribution of HAPE cases by age and time of symptom-onset

It was found that 67.6% of HAPE cases, irrespective of age, had their symptom-onset within the first week of induction to HAA. There was no statistically significant association between age of the patient and time of symptom-onset (Figure 2).

Table 1: Incidence rates of HAPE by age.

Age groups in years	Incidence rates (per 1,000 individuals)
Less than 25	23.34
26 - 35	12.07
36 - 45	10.17
More than 46	6.52

Table 2: Distribution of HAPE cases by induction pattern.

Incidence rate (per 1,000 individuals for 4 years)	2,700-3,600m	3,601-4,500m	4,501m and above	Overall incidence
During acclimatization	10.30	0.49	0.20	4.24
After acclimatization	1.69	1.38	2.05	1.67

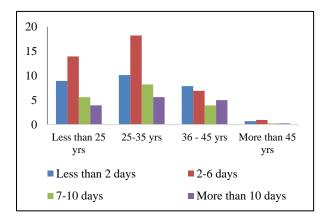


Figure 2: Distribution of cases of HAPE by age and time of onset.

Distribution of HAPE cases by induction pattern

Out of the total number of HAPE cases over four years, 69.45% occurred among individuals who were reinducted to HAA after a brief sojourn to the plains and only 30.55% cases occurred among the first visitors to HAA (newly inducted).

Distribution of HAPE cases by acclimatization pattern

The overall incidence rate of HAPE was found to be highest during the period of acclimatization at 2,700 m to 3,600 m (stage I acclimatization). Among fully acclimatized individuals, incidence rates were found to be higher at higher altitudes than at lower altitudes (Table 2). Incidence of HAPE at different altitudes was found to be significantly associated with acclimatization status (p<0.05).

DISCUSSION

Exposure to various environmental stressors continues to take a toll on individual health and loss of valuable workforce to the organization. This study was undertaken in the backdrop of the magnitude of high-altitude illnesses remaining unabated despite comprehensive acclimatization norms. The overall incidence rate of 5.91 per 1,000 individuals in the present study is comparable to findings of Menon et al.⁴ A review of incidence rates of HAPE reported from different studies is shown in Table 3.

Younger age group commonly affected

High incidence rates were observed among individuals under 25 years of age. Though no age was exempt from occurrence of HAPE, preponderance of younger age groups indicates the exposed population. Preponderance of younger age groups (Table 1) has been reported by previous workers too.^{4,6,8,11-13} Younger individuals may generally be more susceptible to HAPE as they are more often assigned physically strenuous tasks than the older individuals. This might be coupled with an inherent recklessness among the younger men.

Time of symptom onset following entry into high altitude area

Two-third of the cases in our study were young individuals who developed breathlessness, cough, and headache within first six days of reaching HAA. Similar observation was reported by several studies.^{5-7,9,11} Breathlessness was invariably found to be the most common symptom reported by 93% of cases, followed by cough and headache. Majority of cases (68%) had initially reported their complaints to a medical facility with history of onset of symptoms within a week of induction to HAA. Progressive dyspnoea and cough are predominant symptoms of HAPE resulting from impaired ventilation and oxygen diffusion. 14-18 One-third of the cases in our study had onset of symptoms after six days of induction. These cases either occurred in the time-period following acclimatization at the same height to which they were inducted or following ascent to higher altitudes of ascent. HAPE is a progressively worsening clinical condition if left untreated. Screening at health centres located at the base or at staging altitudes, by keeping a high index of suspicion among young individuals with history of recent ascent could help in reducing the complications of HAPE.

Higher incidence rates among re-inductees

Apte et al also reported similar finding of higher incidence of HAPE among individuals who got reinducted to HAA following varying durations of stay in the plains. The information from medical records of the diagnosed cases of HAPE was analysed and each case of HAPE was assessed for their induction status as a fresh inductee or a re-inductee.

Table 3: Review of incidence rates of HAPE.

Studies reviewed	Incidence rate	Age group commonly affected	Time of onset since ascent	Study population
Present study	5.91 per 1,000	<25 years	Within a week	Native lowlanders visiting Ladakh
Menon et al ⁴	5.7 per 1,000	20-39 years	-	Native lowlanders visiting Ladakh
Bhattacharya et al ⁵	3.4-4.1 per 1,000	-	3-5 days	Native lowlanders visiting Ladakh
Virmani et al ⁶	5.5 per 1,000	21-30 years	Within 6 hours	Native lowlanders visiting Ladakh
Apte et al ⁷	0.37%	· -	1-7 days	Native lowlanders visiting Ladakh
Ren et al ⁸	1.90%	18.6 years	2 weeks	Travellers to Tibet
Basnyat et al ⁹	5%	33±07 years (range)	2 days	Pilgrims to Gosainkund, Nepal
Cremona et al ¹⁰	15%	39.8 years (mean age)	-	Recreational climbers to Monte Rosa on Swiss- Italian border
Hackett et al ¹¹	23% (pulmonary rales)	33±12 years (range)	4-18 days	Trekkers on the trail to Mt. Everest
Croughs et al ¹²	13% (symptoms of pulmonary edema)	18-40 years	-	Tourists to mountains in Peru, Tanzania, Nepal, Bolivia, Tibet and Ecuador
Hultgren et al ¹³	0.16%	13-20 years	-	Residents of mining community in La Oraya, high altitudes of Peru

A prospective cohort study to analyse the incidence rates during every induction event and counts each event of reexposure could have more reliable findings. Majority of HAPE cases being re-inductees could have multiple reasons such as pathophysiological changes during previous exposures, individual susceptibility to HAPE and a probable role of environmental factors, behavioural factors such as rapidity of ascent and pre-existing illnesses that may aggravate hypoxemia. ²⁰⁻²²

Acclimatization status

Majority of HAPE cases were individuals who were undergoing acclimatization at altitudes below 4,500m. At altitudes of 2,700m to 3,600m, incidence rates among acclimatized individuals were ten times lower than nonacclimatized individuals. This clearly indicates the importance of acclimatization for newly inducted individuals. Additional risk factors that might have had a role in the development of HAPE during the period of acclimatization were however not explored. Previous studies have reported increased predisposition among individuals who undertook strenuous physical activity immediately after entry into high-altitude. 10,16,19 This might have resulted in high incidence rates among those who were undergoing acclimatization. However, analysis of rates of HAPE at categories of higher altitude - 3,601m to 4,500 m and above 4,500 m showed a reversal of this pattern. Unlike the rates at 2,700 m to 3,600 m, it was observed that the incidence rates were higher among the individuals who had completed acclimatization to these altitudes than among those undergoing acclimatization. Acclimatization is not an absolute process and does not confer complete compensation against hypoxia at altitudes above 5,500 m.²³ The protective role of acclimatization against HAPE at extreme altitude is debatable and requires understanding of the individual responses to hypobaric hypoxia.

Limitations

Authors explicitly state that the study population in present study comprised of healthy Indian soldiers who are certified physically fit for military duty after thorough medical examination. The sample studied is therefore, not representative of the general population at large. Acetazolamide is a drug often prescribed as prophylaxis against acute altitude diseases. Effects of prophylactic acetazolamide was not analysed in the study.

CONCLUSION

The findings of the study indicate that acclimatization does not give additional protection to individuals proceeding to altitudes above 3,600 metres. There is a need to investigate the additional factors like genetic predisposition, physical exertion and environmental triggers that play a role in acclimatized individuals

operating at extreme altitude where staged ascent protocols probably do not confer complete protection against HAPE. New research should focus on pathophysiologic mechanisms of HAPE among acclimatized individuals at very high and extreme altitudes. Individual susceptibility to high-altitude illnesses being genetic traits, there are no screening tests to predict risk.²⁴ The high risk of HAPE among young individuals and high incidence within the first few days of induction is a pointer to the fact that preventive strategies should be aimed at this group of individuals who are reinductees following a period of absence from high altitude environment.

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Ethical approval: The study was approved by the

Institutional Ethics Committee

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