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Original article

Objective criteria for diagnosing high altitude pulmonary edema in acclimatized patients at altitudes between 2700 m and 3500 m

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ARTICLE INFO

Article history:
Received 18 April 2013
Accepted 8 September 2015
Available online 21 October 2015

Keywords:
Altitude sickness
Pulmonary edema
ROC curve

ABSTRACT

Background: The criteria used for diagnosing high altitude illnesses are largely based on Western literature. This study was undertaken to define objective, simple and reliable diagnostic criteria for high altitude pulmonary edema (HAPE) in Indian soldiers at altitudes between 2700 m and 3500 m.

Methods: Clinical data of 235 cases of HAPE that occurred between 2700 m and 3500 m were analysed. Receiver operator characteristic (ROC) curve analysis was used to select simple clinical parameters suitable for the diagnosis of HAPE at peripheral medical facilities. Cut-off values and their reliability for the diagnosis of HAPE were defined.

Results: HAPE occurred 2.8 ± 2.2 days after arrival at altitudes between 2700 m and 3500 m. Breathlessness, cough, chest discomfort and headache were the commonest symptoms. Low pulse oximetry (SPO_2) values than normal for this altitude were seen in 89% of patients. ROC analysis of clinical parameters identified a heart rate more than 95 beats per minute (bpm), respiratory rate more than 21 per minute and SPO_2 less than 86% while breathing ambient air at this altitude as diagnostic of HAPE. The sensitivity and specificity of these cut-offs was 0.66, 0.83 and 0.82 and 0.94, 0.95 and 0.93 respectively.

Conclusion: A heart rate of more than 95 bpm, respiratory rate more than 21 per minute and SPO_2 less than 86% breathing room air in individuals complaining of breathlessness, cough, chest discomfort or headache within the first 5 days of arrival at altitudes between 2700 m and 3500 m is highly suggestive of HAPE.

Introduction

High altitude (HA) medicine and physiology remains highly relevant to the Indian Armed Forces. A large number of troops, not native to HA, serve at altitudes greater than 9000 ft above mean sea level. The HA environment, with its low partial pressure of oxygen, low temperature, low atmospheric humidity and high levels of ultraviolet radiation challenges human physiological function. A better understanding of

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http://dx.doi.org/10.1016/j.mjafi.2015.09.002

these physiological responses through both laboratory-based and field studies has resulted in a dramatic reduction in the incidence of high altitude illnesses (HAIs) over the last decade.

It is an accepted fact that some individuals are susceptible to HAI more than others, and hence, HAI would continue to occur, although with a lower incidence, as long as troops live and work in the HA environment.[1] The first point of contact between patients and medical facilities is usually the regimental medical officer (RMO), upon whose judgement and competence, the management of these patients depends. Since the diagnosis of HAI is often at remote locations without access to laboratory and imaging facilities, certain field-based diagnostic criteria, like the Lake Louise (LL) Consensus Criteria, have been described for the field diagnosis of acute mountain sickness (AMS), high altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE).[2]

Existing field-based diagnostic criteria for HAI have largely been arrived at from Western data gathered from mountaineers and tourists who develop HAI. This population may not be comparable with the Indian soldier population and hence the generalisability of these criteria requires study. Additionally, the LL criteria, such as tachycardia and tachypnoea, are non-specific and do not ascribe cut-off values for these parameters at a given altitude. The availability of more objective criteria for diagnosing HAPE at a given altitude would be beneficial, especially for paramedical staff at remote medical facilities. The present study was undertaken to examine the applicability of the LL Consensus Criteria for the diagnosis of HAPE in the Indian soldier and to suggest diagnostic criteria which could be more specific for a given altitude.

Material and methods

The HAI database of a HA Research Laboratory located at 3350 m above mean sea level was analysed. Clinical records of cases of HAPE available in the database were selected for analysis. The following cases of HAPE were included for analysis:

a. Altitude of occurrence between 2700 m and 3500 m.
b. Diagnosis of HAPE confirmed by a trained physician.
c. Records that were 'complete' (containing details of ascent profile, onset of symptoms and documented signs on clinical examination at the time of presenting to a medical facility).

The following records were not included in the analysis:

a. Where the diagnosis of HAPE was suspected but not confirmed.
b. Incomplete records.
c. Patients with documented history of having being administered drugs/oxygen prior to being examined by a medical professional.

Based on the above criteria, a total of 235 cases of HAPE were included for the analysis.

The acclimatisation medical data of 235 healthy soldiers at 3350 m, available with the HA Research Laboratory, was also analysed to determine values of heart rate, respiratory rate and pulse oximetry values during the first 6 days at an altitude of approximately 3000 m. A daily record of these parameters over the first 6 days of arrival at HA is maintained by the centre. This database contains data of more than 1000 healthy soldiers. Based on the mean day of occurrence of HAPE in the study group, acclimatisation medical data of the healthy soldiers for the corresponding day were chosen for analysis. The sampling was done using the 'Random' function in Microsoft Excel. These data served as healthy controls. Since the study and control group comprised a mixed soldier population, it was assumed that the groups were comparable in ethnic composition. A detailed matching for the same was not carried out.

The heart rate, respiratory rate and SPO_2 values of HAPE cases and controls were compared for statistically significant differences using an unpaired *t*-test and then subjected to a receiver operator characteristic (ROC) curve analysis.[3] This was done to identify which of these easily measurable clinical parameters would serve as good diagnostic criteria for HAPE occurring between 2700 m and 3500 m. This identification was done using the area under the curve (AUC) value for each of the parameter recorded.[3,4] The best operating point on the ROC curve was then identified to suggest cut-off values for diagnosing HAPE occurring between 2700 m and 3500 m. The best operating point in an ROC analysis is that point where the highest possible sensitivity and specificity are obtained for the given data. The value of a clinical parameter corresponding to this point is the logical choice for a cut-off value proposed as criteria for diagnosis of the clinical condition being studied.

The existing LL criteria for diagnosis of HAPE were applied to the HAPE cases and the sensitivity, specificity, positive and negative predicted values of the LL criteria calculated for this cohort. Since the LL criteria mention tachycardia and tachypnoea as two signs in patients with HAPE but do not specify values for the same, a heart rate of greater than 100 beats per minute (bpm) and a respiratory rate greater than 20 breaths/min were used to define tachycardia and tachypnoea respectively, as is the norm in clinical practice. A similar calculation was done using the cut-off values of HR, RR and SPO_2 obtained from the ROC analysis. The two sets of data obtained were analysed to compare the performance of the existing and proposed cut-off values for the diagnosis of HAPE in the Indian soldier.

Results

The mean time of onset of symptoms of HAPE was 2.8 ± 2.2 days after arrival at altitudes between 2700 m and 3500 m. The frequency of various clinical symptoms reported by HAPE patients at the time of diagnosis is shown in Table 1. Breathlessness, headache and cough were the commonest symptoms. The least common symptom was fatigue. The findings on clinical examination in patients of HAPE at the time of reporting to a medical facility and in the healthy acclimatising controls on day three at HA are shown in Table 2. Patients of HAPE had significantly higher heart rates and respiratory rates and lower SPO_2 values compared to healthy acclimatising soldiers at a comparable altitude. A frequency distribution of heart rate, respiratory rate and SPO_2 values in