Oxygen saturation at different altitudes in Nepal among adults

Sabina Shrestha[1], MD; Aparajita Manoranjan[2]; Sushan Man Shrestha[3]
[1]Department of Ophthalmology, Kathmandu Medical College, Kathmandu, Nepal
[2]Professional Support Service Nepal, Kathmandu, Nepal
[3]Central Department of Public Health, Institute of Medicine, Kathmandu, Nepal

Corresponding author
Sabina Shrestha, MD
Email: sabina_drs@hotmail.com

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ABSTRACT

Introduction:

The partial pressure of oxygen in the atmosphere decreases proportionately with an increase in the altitude. The study was done to compare the oxygen saturation of non- acclimatized adults going to different altitudes in Nepal.

Materials and Methods:

It was a descriptive observational study conducted on ten individuals of a medical team traveling to Humla district of Nepal for a multi-disciplinary medical camp. Oxygen saturation was measured at different altitudes i.e. in Kathmandu, Nepalgunj, in the flight at an altitude of 3360 meters and in Bargaun village of Humla district located at an altitude of 3300 meters. Mean pulse oximetry reading was calculated and compared.

Results:

Among the participants, age ranged from 24-57 years. Male to female ratio was 1.5:1. The mean SPO2 at Nepalgunj, Kathmandu, Bargaun of Humla and in the flight (at an altitude of 3360 meters) were 99.67 %, 97%, 91% and 87.4% respectively among the study participants. However, the difference in Oxygen saturation values at different altitudes among different gender and different age was not statistically significant.

Conclusions:

Oxygen saturation decreased linearly with the rise in altitude among all the study participants irrespective of age and gender.

Key words: **Adults, high altitude, oxygen saturation**

Introduction

There is a fall in atmospheric pressure at high altitude causing decrease in the partial pressure of inspired oxygen (SPO2). This fall in SPO2 is roughly linear with altitude. It is 50% of that of sea level value at 8848 meters.

Higher altitude increases ventilation and this hypoxic ventilatory response varies widely among different subjects[1]. The human brain is capable of recognizing its structural and functional networks according to environmental pressures and physiological changes[2,3]. High altitude has an environment of chronic hypoxia. Compensatory processes for brain structure have been revealed in neuro imaging studies in indigenous residents and residents born and raised in high altitude[4,5].

The study was done to compare the oxygen saturation measure with pulse oximeter of non-acclimatized adults traveling to different altitudes in Nepal. Pulse oximetry is a non- invasive beat to beat transcutaneous measure of arterial oxygen

saturation of hemoglobin. It is a commonly used simple diagnostic tool and gives the oxygen saturation reading within seconds after application of transducer[6].

Humla is has many villages lying at about 3000-5000 meters above the sea level. Bargaun village in Humla district in Karnali Province sits at an elevation of 3330 meters. Nepalgunj is a sub-metropolitan city of Banke district of Nepal lying at an altitude of 150 meters above sea level. Similarly, Kathmandu, the capital of Nepal stands at an elevation of 1400 meters above sea level.

Materials and Methods:

A descriptive observational study was conducted at four different altitudes - 150 meters (Nepalgunj), 1400 meters (Kathmandu), 3300 meters (Humla) and 3360 meters (flight) above the sea level. A medical team of 10 persons traveling to Bargaun village of Humla district for a multi-disciplinary health camp were enrolled in the study. Oxygen saturation was measured using the pulse oximeter. Informed consent was taken from all the participants for enrollment in the study.

The pulse oximeter was placed on the index finger of the study participants and several readings were taken until a consistent value was displayed. The finger was made warm before taking the reading. Mean pulse oximetry reading was calculated and was compared. The readings at different altitudes were recorded in a participant specific proforma and the data were analyzed using SPSS program (version 25).

Results and Discussion

A total of 10 participants were enrolled in the study among which 6 were male and 4 female. Age ranged from 24-57 years with the mean age of 36 years.

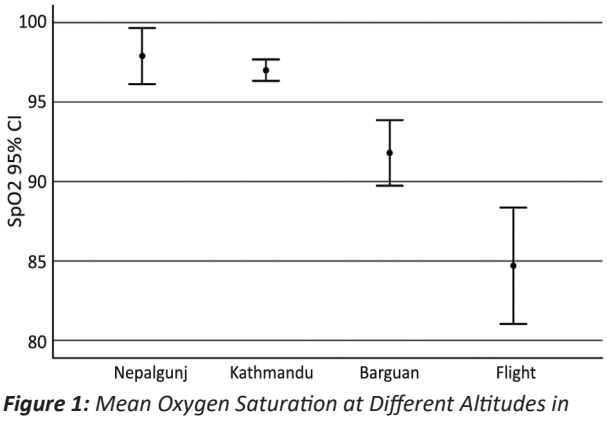

Figure 1: *Mean Oxygen Saturation at Different Altitudes in Nepal*

The mean SPO_2 in Nepalgunj was 99.67 % (CI 96.13 -99.67), in Kathmandu was 97% (CI 96.32 -97.67), in Bargaun of Humla was 91% (CI 89.73 -93.87) and in the flight (at an altitude of 3360 meters) was 87.4% (CI 81.04 -88.36) among the study participants. However, the difference in oxygen saturation values at different altitudes among the different gender and different age was not statistically significant.

Oxygen saturation dropped to 12.27% and 9.6% in all the participants in the flight at an attitude of 3360 meters as compared to 150 meters above the sea level and 1400 meters above the sea level respectively.

According to mountain medicine three altitude regions have been identified reflecting the lowered amount of oxygen in the atmosphere; namely - high altitude (1500-3500meters), very high altitude (3500-5500) and extreme altitude (above 5500 meters) [7]. The atmosphere contains ~21% of oxygen. The barometric pressure decreases with an increase in the altitude. Therefore, the number of oxygen molecules at high altitude is less than at low altitudes. The amount of oxygen available for respiration is reduced causing fall in oxygen saturation in the arteries[8].

When a person travels to high altitude, both immediate and long-term adaptation to high altitude can be achieved by the body through acclimatization. However, for full acclimatization, it takes days or even weeks[9]. SPO2 is usually lower on first arrival at a given altitude and rises somewhat with acclimatization[10]. At high altitude, hypoxia increases ventilatory response especially when the inspired oxygen pressure is reduced to about 13.3 KPa (3000m altitude) [1]. There is a constant percentage of oxygen in the inspired air at different altitudes. The partial pressure of oxygen in the atmosphere decreases proportionately with an increase in the altitude[11]. This is reason for decreased oxygen saturation at high altitude.

In a study by Goldberg et al., even at moderate elevation from sea level at an altitude of 725 meters, a significant difference in arterial hemoglobin oxygen saturation was found[12]. However, at 150 meters above the sea level, oxygen saturation was normal (99.67%) in the present study.

Commercial aircrafts are pressurized only to an altitude of 1800-2500 meters and inspired oxygen pressure will be lower than at sea level. But due to less mobility, it does not have any significant effect

in healthy adults[1]. In Nepal, the aircrafts going to mountain flights and high altitudes are usually small unpressurized high-wing, twin-engine Twin Otter. In the present study, the flight used for going to Humla from Nepalgunj was also unpressurized Twin Otter.

It has been observed that among both healthy passengers and those with coexisting medical conditions, there was reduction in the fraction of inspired oxygen at altitude leading to decrease in oxygen saturation[13-17]. In a study done in UK among 84 passengers during flights of at least 1 hour with a maximum altitude of 27000-37000 feet (8230m - 8840m), oxygen saturation levels dropped 4% than at the ground level[18]. In the present study, oxygen saturation dropped by 12.27% and 9.6% in all the participants in the flight at an attitude of 3360 meters as compared to 150 meters above the sea level and 1400 meters above the sea level respectively. Despite the drop in oxygen saturation, none of the participants were symptomatic which could be due to short flight time of 45 minutes.

Conclusion

Oxygen saturation decreased linearly with the rise in altitude in all the study participants irrespective of age and gender.

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