

Research Article

Arterial blood gas levels in high altitude Kashmiri population, India

Sheikh Imran Sayeed¹, Shazia Handoo², Hilal Ahmad Wani^{3*}, Nazia Manzoor Walvir¹,
Qazi Danish³, Rafiq Ahmad Pampori⁴

¹Department of Physiology, Government Medical College, Srinagar, India

²Haematology and Transfusion Medicine, Government Medical College, Srinagar, India

³Multidisciplinary Research Unit, Government Medical College, Srinagar, India

⁴Government Medical College, Srinagar, India

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*Correspondence:

Dr. Hilal Ahmad Wani,

E-mail: hilalbiochm2007@gmail.com

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ABSTRACT

Background: The valley of Kashmir lies at an average height of 1730 m above the sea level with a barometric pressure of 624 mmHg. The fall in atmospheric pressure at higher altitude decreases the partial pressure of inspired oxygen and hence the driving pressure for gas exchange in the lungs. At sea level the normal range of PaCO₂ is 35 mmHg to 45 mmHg and at 1500m above sea level (barometric pressure 634 mmHg), the predicted normal PaO₂ in a healthy young adult is approximately 80 mmHg; this contrasts with a value close to 95 mmHg at sea level. On these grounds this study was undertaken to formulate normal ABG values for this place as it lies at a higher altitude.

Methods: The study was undertaken to measure "arterial blood gases" (ABG) in ethnic Kashmiri population and consisted of a sample of one hundred healthy Kashmiri subjects of either sex after proper inclusion and exclusion by spirometrically measuring Vital Capacity and Forced expiratory volume in one second/Forced vital capacity (Fev1/FVC). A modified Allen's test was performed to check for adequate collateral circulation ruling out Ischemia.

Results: The average mean PaO₂ of 78.51 ± 4.40 mmHg and the average mean PaCO₂ of 33.37 ± 2.38 mmHg was obtained of the volunteers of both the sexes. The average mean pH of males (7.43 ± 0.02) was significantly lower than the mean pH of females (7.45 ± 0.021).

Conclusions: The present study might provide useful base line normal values of Arterial Blood Gases for the local population and will be beneficial to the clinicians.

Keywords: PaO₂ Partial pressure of oxygen of arterial blood, PaCO₂ Partial pressure of carbon dioxide of arterial blood, Kashmir

INTRODUCTION

ABG analysis is a blood test which is used to measure the partial pressures of certain gases in the blood that are indicators of lung and kidney function. Arterial blood gases is a collective term applied to three separate measurements (pH, PCO₂, and PO₂) generally made together to evaluate acid-base status, ventilation and arterial oxygenation. A typical ABG analysis lists the following important measurements.

pH

A pH of <7.35 indicates an acidic state and a pH of >7.45 indicates an alkaline state. The normal H⁺ concentration of 0.00004 meq/l is equivalent to a pH of 7.4.

PaCO₂

It is a measure of tension or pressure of carbon dioxide dissolved in the blood. CO₂ is an acidic gas that is largely

controlled by rate and depth of breathing, provided that the rate of metabolic production of CO₂ is constant.¹⁻³ At sea level the normal range of PaCO₂ is 35 mmHg to 45 mmHg.

PaO₂

It is a measure of the tension or pressure of oxygen dissolved in the plasma of arterial blood. The PO₂ of the arterial blood reflects the ability of the lungs to allow the transfer of the oxygen from the environment to the circulating blood. The normal predicted PaO₂ is dependent on the barometric pressure, the subject's age and the concentration or fraction of the inspired gas that is oxygen (FIO₂).^{4,5} At elevations above sea level, the partial pressure of inspired oxygen falls with the barometric pressure and the normal P_{O2} decreases concomitantly.⁶

The state of Jammu and Kashmir is located in extreme north of India between 32-15 to 37-05 latitude and 72-35 to 80-20 longitude east. The valley of Kashmir lies at an average height of 1730m above the sea level with a barometric pressure of 624mmHg. Although the O₂% in the inspired air is constant at different altitudes, the fall in atmospheric pressure at higher altitude decreases the partial pressure of inspired oxygen and hence the driving pressure for gas exchange in the lungs.⁷ On these grounds this study was undertaken to formulate normal ABG values for this place as it lies at a higher altitude.

METHODS

The study "Evaluation of ABG in normal, ethnic Kashmiri young adults" was conducted in Department of Physiology, Government Medical College, Srinagar, keeping in mind the effect of barometric pressure of the atmosphere on the driving pressure for gaseous exchange in the lungs. The study was approved by the institutional ethical committee and proper consent was taken from the participants. A pamphlet about the study was circulated to all departments of GMC Srinagar. The pamphlet included a brief description of the study and a call for voluntary participation. The study population consisted of a sample of one hundred healthy non-smoking Kashmiri subjects of either sex who presented themselves voluntarily for the study. This was done in consultation with the statistician and taking various factors into consideration like number of volunteers available for the study etc. Many of the volunteers were students, technical and non-technical personnel, hospital employees falling under Government Medical College, Srinagar. The volunteers belonged to the different regions of Kashmir. The age of the volunteers ranged between 18 to 30 years. A detailed history was taken and relevant clinical examination was done. Criteria for exclusion were:

1. History of cardiopulmonary disease or persistent cardiopulmonary symptoms (cough, sputum production, dyspnoea, wheezing)

2. History of any current bleeding disorder.
3. History of current use of aspirin or any anticoagulant.
4. Negative results of modified Allen's test indicative of inadequate blood supply to the hand and suggest the need to select another extremity as site of puncture.

The process of exclusion started with initial strength of 142 volunteers, who reported for the study. Considering the criterion the final sample size was 100. Arterial blood samples were obtained from the radial artery. This artery was preferred as puncture site since it is superficially located and is easily accessible. Moreover it is easy to stabilize after the puncture and adequate collateral circulation can be evaluated.

Spirometry was also offered to each volunteer one day after the testing session and we measured Vital Capacity and Forced expiratory volume in one second/Forced vital capacity (Fev1/FVC) which is an important tool used for generating pneumotachographs that are helpful in assessing conditions such as asthma, pulmonary fibrosis, cystic fibrosis, COPD and cardiac functions that in turn helped in inclusion and exclusion of the subjects. A modified Allen's test was performed to check for adequate collateral circulation. The test is relevant in this study to rule out ischemia from the site of sample collection.

Arterial sampling

Blood samples were drawn anaerobically from the radial artery after the subject had been in the supine position (approximate 30 degree elevation of the head and neck, horizontal thorax) for at least 10 min. Prior to the arterial puncture, the site was cleaned with 70% isopropyl alcohol. Samples of 3ml to 4ml were drawn with a self-filling, polypropylene syringe with 0.2ml of liquid sodium heparin in the syringe dead space. Air pockets were expelled immediately after the sampling, and the sample was thereafter mixed gently until testing on the analyser. None of the sample was obtained by aspiration. The site of arterial puncture was kept under pressure (to prevent hematoma formation) for about 10-20 min. Samples were usually analysed within 5 minutes in a machine called stat profile analyser, which is an automated, microcomputer based system for analysing samples for blood gas. The analytical compartment of the machine was controlled at 37.0°C. The samples were analysed for: pH, PCO₂, PO₂ and Oxygen saturation (SO₂).

RESULTS

All the volunteers who participated in the present study were young, healthy, life time non-smokers and comprised of 66 males and 34 females in the age group of 18 to 30 years and were studied in the supine position, commonly used position in the clinical practice. The demographic information is given in table 1, whereas

arterial blood gas measurements of the volunteers are given in table 2. The mean values obtained of abg parameters studied are as follows.

pH

The average means ph value obtained in healthy volunteers of 7.34 ± 0.02. Analysed on the basis of sex, the average mean ph of males (7.43 ± 0.02) was significantly lower than the mean ph of females (7.45 ± 0.021).

Pao₂

The average mean pao₂, of 78.51 ± 4.40 mmhg was obtained of the volunteers of both the sexes. The males had an average pao₂ of 78.71 ± 4.24 mmhg, while the females had average pao₂ of 78.51 ± 4.40 mmhg. A statistically insignificant difference (p>0.05) was noted on comparing the average mean pa0₂ values of the volunteers belonging to the two sexes.

Table 1: Demographic characteristics of the studied subjects.

Demographic parameters	Sex						Overall Mean ±S.D	P-value	Results
	Male			Female					
	Min	Max	Mean±SD	Min	Max	Mean±SD			
Age(years)	18	30	20.36±2.11	18	30	21.26 ±3.43	20.67 ±2.65	0.108	Not Significant
Weight(kg)	50	80	65.02±6.67	51	60	54.68 ±2.44	61.50 ±2.44	0.000	Significant
Height (cm)	160	185	173.42±5.71	152	170	161.41±5.53	169.3 ±8.02	0.000	Significant
Body mass Index(kg/m ²)	18.52	24.69	21.57±1.39	18.69	24.14	21.05 ±1.66	21.0±1.66	0.100	Not Significant

Table 2: Arterial Blood gasses of the studied volunteers.

Arterial blood gases	Sex						Overall Mean ±S.D	p value	Results
	Male(n=66)			Female(n=34)					
	min	max	Mean	Min	Max	mean			
pH	7.37	7.46	7.43 ±0.02	7.39	7.48	7.45±0.021	7.43±=0.021	0.000	Significant
PaO₂ (mmhg)	71.75	86.00	78.71±4.24	68.50	86.50	78.12±4.74	78.51±4.40	0.528	Not Significant
PaCO₂ (mmhg)	28.00	40.00	33.83±2.36	29.25	37.75	32.48±2.19	33.37±2.38	0.007	Significant
O₂ Saturation (%)	94.1	97.5	95.12±0.76	93.9	97.0	94.98±0.69	95.10±0.74	0.259	Not Significant

Paco₂

The average mean paco₂ of 33.37±2.38 mmhg was obtained in the present study. The males had a significantly higher average paco₂ of 33.38 ± 2.36 mmhg as compared to average pao₂ of 32.48 ± 2.19 mmhg in females. In the present study, paco₂ correlated only with sex (p<0.05) making it sex specific and age independent.

Sao₂ (oxygen saturation)

The average mean sao₂ of 95.10± 0.74 was obtained for volunteers in present study. The males had an average sao₂ of 95.12 ± 0.76 while the females had an average mean sao₂ of 94.98 ± 0.69%. A statistically insignificant

difference (p>0.05) was noted on comparing the average mean sao₂ values of the volunteers belonging to the two sexes.

DISCUSSION

Arterial blood gas determination the most fundamental of all tests of pulmonary performance and is indispensable for precise physiological assessment of many lung and heart conditions. The primary goal of present study was to establish reference values for arterial blood gases based on general population sample of normal young healthy adults of Kashmiri origin. The valley of Kashmir lies at an altitude of 1730m above sea level with a barometric pressure of 624.75 mmHg in contrast to sea

level barometric pressure of 760 mmHg. The lesser barometric pressure decreases the driving pressure for gaseous exchange in the lungs and in turn affects the arterial blood gasses 8-10.

pH

In the present study the overall pH value was 7.34 ± 0.021 . The pH in females was significantly higher ($P < 0.05$) than in the males. Crapo et al in their study (arterial blood gas reference values for sea level and an altitude of 1400m) on healthy life time non-smokers have reported similar findings.¹¹ Moreover, the comparison between the pH of male volunteers of present study and the sea level data showed a statistically significant difference ($P < 0.05$). The differences were however insignificant when same was compared with 1400m altitude pH in the males.¹¹ Unlike pH in the males, the pH in the female volunteers showed statistically significant ($P < 0.05$) difference, with both sea level pH and 1400m altitude pH in the same sex. In present study pH was sex specific and age dependent, which is in conformity with the study of Crapo et al.¹¹ The blood pH did not correlate significantly with height or weight also.

PaO₂

In present study, the overall mean PaO₂ for both the sexes was 78.5 mmHg. The mean PaO₂ of males was slightly higher than that of the females but the difference did not reach a statistical significance ($P > .05$). The overall mean PaO₂ of present study was close to PaO₂ of 79.2 mmHg recorded at an altitude of 1400 m by Crapo et al but was considerably lower than sea level PaO₂ of 99.8 mmHg reported by the same study. Sorbin et al reported a PaO₂ value of 96.9 mmHg and gave a PaO₂ value of 79.3 mmHg while Begin R and Renzetti⁸ have reported a PaO₂ value of 85.0 mmHg at an altitude of 1400m above sea level.¹² Hardie et al reported a mean PaO₂ of 77.0 mmHg and 73.5 mmHg in men and women respectively in the age group of 70-90 years.¹³ Cerveri et al gave 83.4 mmHg as mean PaO₂ and 68.4 mmHg as lower limit of normal in middle aged and elderly persons.⁴ Similarly for the same age group, Guenard and Marthan¹⁴⁻¹⁵ gave 84.3 mmHg as mean PaO₂ and 71.7 mmHg as lower limit of normal PaO₂.

The PaO₂ value of present study is in close conformity with the previous studies conducted at an altitude of more than 1200m above the sea level. However the differences in the mean PaO₂ between the present study and other various studies may be due to several reasons. A study by Hansen and Casaburi has shown that different blood gas analyser may differ by up to 6.8 mmHg in the measurement of 78.6 mmHg of oxygen standardized gas solution.¹⁶ Hardie, JA in their study have shown a mean difference of sitting minus supine PaO₂ of approximately 6.0 mmHg in a sample of 46 healthy elderly.¹³ The decrease in partial pressure of oxygen in the blood (PaO₂) with age is well documented. Crapo et al reported a

decline in PaO₂ of 0.0245 mmHg/year which is consistent with the studies of Raine and Bishop (0.24 mmHg/yr).^{11,17} Sorbini¹² has reported a greater decline in PaO₂ (0.43 mmHg/yr) in his study. In the present study, the PaO₂ also showed a decrease with increase in age. The small differences in the decline of PaO₂ can also be explained by inter instrument differences. The present study showed no significant relationship between PaO₂ and the weight, height or sex of volunteers.

PaCO₂

In the present study the overall mean of PaCO₂ for both the sexes was 33.37 ± 2.38 mmHg. The mean PaCO₂ of males was slightly higher than that of the females and difference did reach a statistical significance ($P < 0.05$). Moreover the comparison between the PaCO₂ of the present study and the sea level data showed a statistically significant difference ($P < 0.05$). The difference was however insignificant when same was compared with 1400 m altitude PaCO₂ as reported by Crapo et al¹¹. Crapo gave a similar mean PaCO₂ value of 37.4 mmHg (95% CL, 36.8 to 38.0) at sea level. In the present study PaCO₂ correlated only with sex ($P < 0.05$). No significant relationship was observed between PaCO₂ and age. The reference values for PaCO₂ in present study are thus sex specific but age independent which is consistent with the earlier studies by Crapo and others.

SaO₂ (Oxygen saturation)

In present study the overall mean SaO₂ of the volunteers was $95.10 \pm 0.74\%$. The female volunteers had a lower mean SaO₂ than their male's counterparts. The difference between the two means was however not statistically significant ($P > 0.05$). Crapo et al reported a SaO₂ of 96.7% and 95.4% at sea level and 1400m altitude above the sea level respectively.¹¹ When the overall SaO₂ of present study was compared with sea level SaO₂, the difference was statistically significant ($P < 0.05$). However when same was compared to 1400m altitude data, the difference did not reach a statistical significance ($P < 0.05$). Hardie et al reported a mean SaO₂ of 95.3% and 94.8% for men and women respectively in his study on healthy elderly conducted at sea level.¹⁴ They also reported that SaO₂ was significantly lower in the females.

CONCLUSION

The present study might provide useful base line normal values of Arterial Blood Gases for the local population and will be beneficial to the clinicians.

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