The effect of time from last food intake on arterial blood gases: implication on reference values

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Abstract - Arterial blood gas parameters were analyzed in forty-nine healthy persons (31 males, 18 females) to determine reference values for those parameters and their relation to the time from last food intake to arterial puncture (T). The mean±standard deviation of arterial oxygen pressure, arterial carbon dioxide pressure and pH at core body temperature were 34.4±7.6 mmHg (Males: 38.0±6.5, Females: 30.7±7.5), 37.7±2.8 mmHg (Males: 38.5±3.7, Females: 36.2±2.4), respectively 7.41±0.02 (Males: 7.41±0.02, Females: 7.42±0.03). The mean P_{CO_2} was lower in comparison with most of the studies at sea level. The difference between males and females was significant in P_{CO_2} and pH (P=0.004, P=0.02 respectively) but it was not significant in P_{O_2} (P=0.07). The P_{CO_2} and pH had no statistically significant relationship with age (P=0.42, P=0.25 respectively). The relationship between P_{O_2} with age, P_{CO_2} and T was significant (P=0.02, P=0.014, and P=0.019 respectively). The best linear predictive equation was:

\[ P_{O_2} = 12.8 - 0.29 \times T \quad \text{for} \quad T < 10 \text{ hours} \]
\[ P_{O_2} = 0.21 \quad \text{(Baro. 47)} \quad \text{for} \quad T > 10 \text{ hours} \]

Key Words: Arterial oxygen pressure; blood gas parameters; metabolism; predictive equation; respiratory exchange ratio; respiratory quotient

INTRODUCTION

In current clinical practice, blood gas analysis is performed with increasing frequency as part of respiratory assessment. Nevertheless, most of the reference values of blood gas parameters used worldwide have been obtained in the past (1) and there is little data about blood gas reference values in Iran. It is generally accepted that alveolar oxygen pressure difference (P_{A\text{a}}O_2) is a reliable indicator of ventilation-perfusion (V/Q) mismatch (2,3). Calculation of (P_{A\text{a}}O_2) requires the determination of ideal alveolar oxygen pressure (P_{A\text{a}}O_2). The most commonly used equation for ideal alveolar oxygen pressure uses the measured or estimated respiratory exchange ratio (RER). In the steady state, RER equals respiratory quotient (RQ) and depends on the main fuels of metabolism (2,4). Thus it is hypothesized that the time from the last food intake to arterial puncture (T) can alter blood gas parameters by changing main fuels of metabolism. The aim of this study was to determine the reference values of blood gas parameters in our center, the effect of T on arterial gas parameters, and the validity of assumed value of R.E.R = 0.8 for clinical purposes.

MATERIALS AND METHODS

This study was performed on 188 non-paid volunteers in Imam-Khomeini Medical Center located in the central part of Tehran, where the barometric pressure is 604 mmHg. The study population comprised of medical students, patient attendants and other people who were informed about the study by a public announcement. All volunteers signed a consent form after the purpose and procedures used in the study were explained to them. Subjects were excluded if they had any significant problems on the basis of history, physical examination, chest X-ray, spirometry, urinalysis and blood chemistry. Five persons were excluded because their FVC or FEV1 were below the 5th percentile of predicted values (5).

Arterial blood was obtained after five minutes of rest (sitting and breathing room air). Arterial blood samples were obtained in disposable preheparinized 2 ml syringes from the radial artery after Allen's test according to Sahin's method (6). The samples were analyzed in less than two minutes by AVL-995 blood gas analyzer. The analyzer was calibrated according to the manufacturer's guidelines with tonometric ammixture (7). The standard gas mixtures for calibration were not available. The results were recorded according to 37°C and the core body temperature (oral temperature +...
RESULTS

Of the 188 subjects examined, 49 were found to be eligible according to the criteria described above. Table 1 shows the anthropometric variables and blood gas results by sex distribution of arterial oxygen pressure (PO$_2$) and arterial carbon dioxide pressure (PCO$_2$) and pH. The difference between males and females was significant in PCO$_2$ and pH (P = 0.004, P = 0.02 respectively) but it was not significant in PO$_2$ (P = 0.07). The PCO$_2$ and pH had no statistically significant relationship with age (P = 0.42, P = 0.25 respectively).

Table 2 shows the correlation coefficient between PO$_2$ with age, PCO$_2$, T and body mass index (BMI). The correlation between PO$_2$ with age, PCO$_2$ and T were significant.

The predictive equation of PO$_2$ according to PCO$_2$, age, AO$_2$ and [PAO$_2$]$_b$ was compared (Table 3). As shown in table 3, the best linear prediction is by AO$_2$ (R$^2$ = 0.39, SEE = 5.5, Fig. 1).

\[ \text{Fig. 1. Simple Regression Plot} \]
Table 3. Predictive equation of PO₂ according to PCO₂ age, 

<table>
<thead>
<tr>
<th>Equation</th>
<th>R²</th>
<th>SEE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO₂ = 117.08 - 0.07*PCO₂</td>
<td>0.12</td>
<td>0.58</td>
<td>0.0140</td>
</tr>
<tr>
<td>PO₂ = 91.78 - 0.24*Age</td>
<td>0.11</td>
<td>0.62</td>
<td>0.0195</td>
</tr>
<tr>
<td>PO₂ = 1.1<em>PAO₂ - 0.16</em>Age + 4.34</td>
<td>0.27</td>
<td>5.99</td>
<td>0.0809</td>
</tr>
<tr>
<td>PO₂ = 1.28*AO₂ - 29.38</td>
<td>0.39</td>
<td>5.68</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

* [PAO₂]₂₈ = 0.21 (Baro - 47) - 1.2 PCO₂  
** For T < hours AO₂ = 0.21 (Baro - 47) - (1 + 0.027) PCO₂  
For T > 10 hours AO₂ = 0.21 (Baro - 47) - 1.2 PCO₂

DISCUSSION

The mean ± SD of PCO₂ was 37.7 ± 2.8 mmHg (Baro = 664 mmHg, Mean temperature = 37.5°C). Although hyperventilation at sea level should be considered but the reported PCO₂ at sea level and highlands shows very broad variation (e.g. there was no significant difference between PCO₂ mean in this study and Cerveri's study at altitude of sixty meters (1).

The reported PCO₂ in the northern part of Tehran (Baro = 550 mmHg) and in Salt Lake City (Baro = 640 mmHg) were 32.3 ± 4.1 mmHg and 30.6 ± 3.6 mmHg respectively (8,9) were significantly lower than our results. For this reason we suggest that spirometry arterial blood gas results should be interpreted by the individual laboratory's reference values, which are influenced by the center's methods, altitude, and cases.

There are many reports that PO₂ decreases with age. The coefficient of age in our predictive equation is almost equal to Raini's and Conway's studies (11,12) but it is lower than others (1,13,14). One of the main differences between our study and most other studies is our younger population. Only 12% of our cases were above forty years.

In a recent study (1) Cerveri reported the relationship between PO₂ and PCO₂ in subjects younger than 75 years. However in subjects older than 75 years, there was no correlation between PO₂ with age, BMI and PCO₂. He attributed this PO₂ and PCO₂ relationship to different magnitudes of oxygen and carbon dioxide stores. However he did not explain why there was no correlation between PO₂ and PCO₂ in subjects older than 75 years.

In our opinion the relationship between PO₂ with PCO₂ originates the relationship between alveolar oxygen and carbon dioxide pressures that can be presented by Riley and Courmand's model (2). The fact that Riley and Courmand's model is a better model to explain the relationship between PO₂ with PCO₂ is reflected in the better correlation between PO₂ with AO₂ than PCO₂.

We proposed the AO₂ concept according to the idea of ideal alveolar air of Riley and Courmand and we compared it with [PAO₂]₈ as proposed by Begin and Renzetti (9).

The proposition of (1 + 0.02 T) as PCO₂ coefficient in AO₂ definition relies on the following points:

1. Tissue carbohydrate consumption is maximum after half to one hour of carbohydrate ingestion (15). In the studies with high carbohydrate ingestion, the mean RQ was little above one (16-18). In Saltzman's study, it was between 0.98 ± 0.05 to 1.1 ± 0.06 and in Askanzi's studies it was 1.07 for healthy men, and 1.0 ± 0.03 and 1.04 for malnourished men. However it should be considered that in actual life the person takes food for about 1/4 - 1/2 hours, several times throughout day and the amount of carbohydrate is less than these studies. Therefore the assumption that RQ is about 0.98-1 in the first hour after taking food is acceptable.

2. After 12-15 hours of fasting the mean RQ is about 0.8 (15,19). Consequently PCO₂ coefficient [(1 + [PACO₂]₈)/R (according to Riley and Courmand model)] is about 1.2. After 36 hours of fasting the mean RQ mean is about 0.7 (19) (PCO₂ coefficient is about 1.25). Therefore it is assumed that after 10 hours of fasting, the PCO₂ coefficient is about 1.2 and there is no further significant change.

3. Although the relationship between PCO₂ coefficient and T is probably not linear in real life, this could be a useful simplifying approximation.

The significant correlation between PO₂ and T and the better prediction of PO₂ by AO₂ in comparison with [PAO₂]₈ demonstrates the role of T. This finding is anticipated by the dependency of RQ on metabolism (2,4). The effect of nutritional status on PO₂ standard values has previously been emphasized by Saltzman and Saltzmann (16). In conclusion, the time from last food intake to arterial puncture can alter PO₂ probably by an effect on the main (need of metabolism). In our study PO₂ prediction improved when T was introduced in the prediction equation. Further studies are required to determine the significance and applicability of our estimation of ideal alveolar oxygen pressure (AO₂) in clinical situations.

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