PHYSIOLOGICAL ADJUSTMENT OF ARTERIAL BLOOD GASES AND BICARBONATE ION DURING PREGNANCY IN HUMAN

DIPOK KUMAR SUNYAL[1], MD. RUHUL AMIN[2], ABIDA AHMED[3], MIR RABAYA AKHTER[4], GOLAM MORSHED MOLLA[5], ABM OMAR FARUQUE[6]

Assistant Professor, Department of Physiology, Enam Medical College, Savar, Dhaka[1], Professor, Department of Physiology, Dhaka Medical College, Dhaka[2], Professor, Department of Physiology, Comilla Medical College, Comilla[3], Assistant Registrar, Department of Gynaecology and Obstetrics, Moulana Bhasani Medical College and Hospital, Dhaka[4], Assistant Professor, Department of Biochemistry, Enam Medical College, Savar, Dhaka[5], Assistant Professor, Department of Anatomy, Tairunnessa Memorial Medical College, Gazipur[6]

ABSTRACT

In the present study the partial pressure of oxygen (PaO_2), carbon dioxide ($PaCO_2$) and bicarbonate ion ($HCO3^-$) in arterial blood were estimated in 32 women in Dhaka city. For this purpose a total of 32 women subjects with age ranged from 25 years to 35 years without any recent history of respiratory diseases were selected. Of those, 8 healthy non-pregnant women were included as control and 24 normal pregnant women as experimental group. The PaO_2, $PaCO_2$ and $HCO3^-$ were estimated during the first, second and third trimester by using 'easy blood gas auto analyzer'. The PaO_2 was significantly higher during entire pregnancy period. However, the $PaCO_2$ and HCO_3^- were significantly lower in first, second and third trimester of pregnant women than that of non-pregnant women. There were no statistically significant difference of PaO_2, $PaCO_2$ and HCO_3^- ion among first trimester, second trimester and third trimester. The progressively increased PaO_2, decreased $PaCO_2$ and HCO_3^- ion throughout the pregnancy is possibly due to the effect of progesterone causing hyperventilation.

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INTRODUCTION

During normal pregnancy hyperventilation and increased respiratory minute volume result in decreased maternal alveolar and blood PCO_2. In pregnant women progesterone may act directly on the respiratory centers and cause hyperventilation[1]. Progesterone can also induce changes in smooth muscle tone and connective tissue elastance which may alter the mechanical properties of the respiratory system[2]. It has been well documented that maternal ventilation and blood gases undergo substantial changes in pregnancy. There was a 40% increased in minute ventilation resulting in a rise in PaO_2 and fall in $PaCO_2$ and HCO_3^-. This increased ventilation is thought to be mediated by progesterone which lowers the threshold of respiratory center and increases the sensitivity of the respiratory center. Several other studies have shown that hyperventilation during pregnancy causes increase in PaO_2, decrease in $PaCO_2$ and a compensatory fall in serum bicarbonate ion in pregnant women[5,6,7]. It is therefore important physiologically as well as clinically to observe the PaO_2, $PaCO_2$ and HCO_3^- in pregnant women. Although several studies have been carried out in different populations no established data is available in Bangladeshi population. In the present study we evaluated the changes in PaO_2, $PaCO_2$ and HCO_3^- during the different trimesters of normal pregnant women and healthy non-pregnant women in Dhaka city.

Address of Correspondence: Dr. Dipok Kumar Sunyal, Assistant Professor, Department of Physiology, Enam Medical College, Savar, Dhaka

MATERIALS AND METHODS

The PaO_2, $PaCO_2$ and $HCO3^-$ ion was measured in normal pregnant and healthy non-pregnant women. For this purpose 32 subjects were recruited among which 8 non-pregnant women were selected as control and 24 pregnant women as experimental group with age ranged from 25 years to 35 years. Experimental group was further divided into first trimester (n=8), second trimester (n=8) and third trimester (n=8) of pregnant women. All the subjects were taken from different areas of Dhaka city that belonged to lower-middle and poor socioeconomic classes. The subjects were selected by careful history taking and physical examination which revealed no evidence of past or recent significant respiratory diseases.

The measurement of PaO_2, $PaCO_2$ and $HCO3^-$ were done both in healthy non-pregnant women and normal pregnant women during first trimester (1st to 12th weeks), second trimester (13th to 28th weeks) and third trimester (29th to 40th weeks). The PaO_2, $PaCO_2$ and $HCO3^-$ were measured by "easy blood gas auto analyzer". The mean of measured values of PaO_2, $PaCO_2$ and $HCO3^-$ were statistically analyzed by unpaired Student's "*t*" test between and among the study groups. A *p* value <0.05 was accepted as significant.

RESULTS

The mean (±SD) of measured values of PaO_2 were 86.38±5.37, 98.13±11.01, 102.00±9.13 and 106.50±4.38 in non-pregnant control women and in pregnant women during first, second and third trimester (table-I). The mean (±SD) of measured values of PaO_2 were significantly higher in first trimester, second trimester and third trimester of pregnant women than that of non-pregnant women as shown in table-II and Figure 1.

The mean (±SD) of measured values of $PaCO_2$ were 36.89±3.70, 32.73±3.16, 32.46±3.61 and 31.03±3.20 in non-pregnant women and in pregnant women during first trimester, second trimester and third trimester (table-III). The mean (±SD) of measured values of $PaCO_2$ were significantly lower in first trimester, second trimester and third trimester of pregnant women than that of non-pregnant women as shown in table-IV and Figure 2.

On the other hand, the mean (±SD) of measured values of HCO_3^- were 23.61±2.05, 21.68±1.45, 21.53±1.80 and 21.13±1.47 in non-pregnant women and in pregnant women during first trimester, second trimester and third trimester (table-V). The mean (±SD) of measured values of HCO_3^- were significantly lower in first trimester, second trimester and third trimester of pregnant women than that of non-pregnant women as shown in table-VI and Figure 3.

The PaO_2 value was gradually increased, the $PaCO_2$ and HCO_3^- value were gradually decreased during pregnancy from first trimester to third trimester than that of non-pregnant women.

There were no statistically significant difference of PaO_2, $PaCO_2$ and HCO_3^- ion among first trimester, second trimester and third trimester of pregnant women.

Table -I

The mean (±SD) of measured values of PaO_2 in different groups of subjects

Groups	n	Measured value (mm Hg)
A	8	86.38±5.37
B-I	8	98.13±11.01
B-II	8	102.00±9.13
B-III	8	106.50±4.38

A = Control (healthy non-pregnant women)
B-I = Pregnant women, 1st trimester
B-II = Pregnant women, 2nd trimester
B-III = Pregnant women, 3rdtrimester
n : number of subjects
P values were obtained by unpaired Student's "t" test
* = significant *** = highly significant
ns = not significant

Table-II

The statistical analysis of mean (±SD) of measured values of PaO_2 in different groups of subjects

Statistical Analysis (measured value)	
Groups comparison	P value
A vs B-I	$<0.05^{*}$
A vs B-II	$<0.001^{***}$
A vs B-III	$<0.001^{***}$
B-I vs B-II	$>0.10^{ns}$
B-I vs B-III	$>0.05^{ns}$
B-II vs B-III	$>0.10^{ns}$

Table -III

The mean (±SD) of measured values of $PaCO_2$ in different groups of subjects

Groups	n	Measured value (mm Hg)
A	8	36.89±3.70
B-I	8	32.73±3.16
B-II	8	32.46±3.61
B-III	8	31.03±3.20

A = Control (healthy non-pregnant women)
B-I = Pregnant women, 1st trimester
B-II = Pregnant women, 2nd trimester
B-III = Pregnant women, 3rdtrimester
n : number of subjects
P values were obtained by unpaired Student's "t" test
* = significant *** = highly significant
ns = not significant

Table-IV

The statistical analysis of mean (±SD) of measured values of $PaCO_2$ in different groups of subjects

Statistical Analysis (measured value)	
Groups comparison	P value
A vs B-I	$<0.05^{*}$
A vs B-II	$<0.05^{*}$
A vs B-III	$<0.01^{**}$
B-I vs B-II	$>0.50^{ns}$
B-I vs B-III	$>0.10^{ns}$
B-II vs B-III	$>0.10^{ns}$

Table -V

The mean (±SD) of measured values of HCO_3^- in different groups of subjects

Groups	n	Measured value (mm Hg)
A	8	23.61±2.05
B-I	8	21.68±1.45
B-II	8	21.53±1.80
B-III	8	21.13±1.47

A = Control (healthy non-pregnant women)
B-I = Pregnant women, 1st trimester
B-II = Pregnant women, 2nd trimester
B-III = Pregnant women, 3rdtrimester
n : number of subjects
P values were obtained by unpaired Student's "t" test
* = significant *** = highly significant
ns = not significant

Table-VI

The statistical analysis of mean (±SD) of measured values of HCO_3^- in different groups of subjects

Statistical Analysis (measured value)

Groups comparison	P value
A vs B-I	$<0.05^*$
A vs B-II	$<0.05^*$
A vs B-III	$<0.05^*$
B-I vs B-II	$>0.50^{ns}$
B-I vs B-III	$>0.10^{ns}$
B-II vs B-III	$>0.50^{ns}$

DISCUSSION

In the present study the measured values of PaO_2 were significantly higher during all the trimesters than that of non-pregnant women. Similarly the measured values of $PaCO_2$ and HCO_3^- were significantly lower in first, second and third trimester than that of non-pregnant women. The PaO_2 gradually increased and the $PaCO_2$ and HCO_3^- were gradually decreased throughout the pregnancy from first to third trimester of pregnant women. Results of the present study are in agreement with other studies[4-10].

It has been previously shown that the PO_2 is higher whereas the $PaCO_2$ and HCO_3^- ion are lower in pregnant women at sea level compared with the non-pregnant women due to maternal hyperventilation. There is also an increase in minute ventilation resulting in a rise in PaO_2, fall in $PaCO_2$ and HCO_3^-. This increased ventilation is thought to be mediated by progesterone which lowers the threshold of respiratory center and increases the sensitivity the respiratory centre[4]. It has also been demonstrated that pregnancy is associated with an increase in ventilation which consequently increases the PaO_2 and decreases $PaCO_2$[5]. Normal pregnancy is associated with a 20% increase in O_2 consumption and a 15% increase in the maternal metabolic rate. This extra demand is achieved via 40-50% increase in resting minute ventilation which causes the PaO_2 to increase and the $PaCO_2$ and HCO_3^- to falls[7].

In this study, though the PaO_2 was significantly higher, the $PaCO_2$ and HCO_3^- were significantly lower in first, second and third trimester of pregnant women than that of non-pregnant women. This can be speculated that maternal hyperventilation due to the effect of progesterone is possibly associated with the increased PaO_2 but decreased $PaCO_2$ and HCO_3^- during pregnancy.

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