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Short Communication

Alterations in minute ventilation, maximum voluntary ventilation and dyspneic index in different trimesters of pregnancy

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Abstract

Respiratory function in pregnancy is of special importance since the life of fetus depends primarily upon its oxygen supply. Thus this study was designed to evaluate the Minute ventilation (MV), Maximum Voluntary Ventilation (MVV) & Dyspneic Index (DI) in different trimesters of pregnancy & compare the results with non-pregnant control group. A cross-sectional study was carried out in 200 healthy women in the age range of 19-35 years with 50 subjects each in 1st, 2nd, 3rd trimesters of pregnancy and non-pregnant control group. We recorded respiratory parameters in study and control groups. Statistical analysis was done by ANOVA and Tukey Krammer post Hoc tests. It was observed that there was a significant decrease in MVV and dyspneic index in all trimesters of pregnancy and an insignificant variation in MV when compared to the control group. The changes in pulmonary function are influenced by the mechanical pressure of enlarging gravid uterus, elevating the diaphragm and restricting the movements of lungs thus hampering forceful expiration. The decrease seen in MVV in 1st trimester might be due to bronchoconstriction effect of decreased alveolar Pco_2 on the bronchial smooth muscles.

Introduction

Respiratory function in pregnancy is of special importance since the life of fetus depends primarily upon its oxygen supply. There is raise in the diaphragm by four centimeter, widening of sub-costal angle thereby increasing transverse diameter by two centimeters & thoracic circumference increasing by six centimeters. These changes begin before the size of uterus can have an effect (1). Pregnancy induced changes in respiratory control and acid-base regulation have been studied extensively in the resting state. These include increases in minute ventilation (VE), tidal volume, alveolar ventilation and a reduction in arterial PCO_2 ($PaCO_2$) (2, 3). In accordance with conventional acid-base theory, these changes are accompanied by renal excretion of bicarbonate, resulting in a state of partly compensated respiratory alkalosis (arterial pH 7.43–7.47) (4). These effects appear in the first trimester and may promote placental gas exchange before development of an effective fetal circulatory system (4).

Pulmonary function tests permit accurate reproducible assessment of the functional state of the respiratory system and allow quantification of the severity of disease, thereby enabling early detection as well as

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assessment of the natural history and response to therapy (5). Although plenty of work has been done on pulmonary function tests in many parts of our country (6), there are very few reports involving these parameters in subjects of South Indian origin. So the aim of the study was to evaluate the effect of pregnancy on Static & dynamic lung volumes and capacities in the subjects of South Indian pregnant women in the age range of 19-35 years in different trimesters of pregnancy and compare them with healthy age matched non-pregnant control group.

Material and Methods

The present cross sectional study was conducted in the Department of Physiology of a tertiary care hospital to determine the pulmonary function changes in 1st, 2nd & 3rd trimesters of pregnancy and to compare the results with age matched healthy non pregnant women.

Method of Collection of data

Study Group : Comprised of 150 pregnant women in the age group of 19-35 years attending the OPD of OBGy of a tertiary care hospital. The study group was further subdivided into 3 subgroups. Each sub group comprised of 50 women in 1st, 2nd and 3rd trimesters of pregnancy.

Control Group : Comprised of 50 apparently healthy age matched (19-35 years) non pregnant women.

Institutional ethical clearance was obtained. Purpose of the study was explained to the subjects who had volunteered for the study. An informed written consent was obtained. A thorough physical & systemic examination (cardiovascular and respiratory system) of each subject was done. Recordings were taken between 9 am to 12 Noon.

Inclusion criteria : Apparently healthy subjects were included in the study. The apparent health status of the subject was determined by history taking and thorough clinical examination.

Exclusion criteria : Subjects with acute respiratory infection in the previous three months, chronic respiratory infection including asthma, history or clinical signs of cardiovascular diseases, diabetes mellitus, hypertension, tobacco consumption, alcohol intake, endocrine disorders, obesity & moderate to severe anemia were excluded from the study.

The following parameters were recorded in each subject :

A. Physical Anthropometric parameters

   Height (in centimeters)

   Weight (in kilograms)

   Body Mass Index

B. *Respiratory parameters* : The subjects were informed about the procedure. For each test, three readings were taken. The highest of the three was considered for calculation. All tests were recorded in a sitting posture at room temperature, in morning hours.

   I. Respiratory Rate (RR) (cycles /minute) was recorded.

   II. The following pulmonary parameters were recorded by Computerized Spiropac (Medicaid)

1. MV (Minute Ventilation = TV × RR in L/min) (7)

2. MVV (Maximum Voluntary ventilation in L/min) (8)

3. DI {Dyspneic index = [(MVV-MV)/MVV] ×100} (9)

Minute Ventilation (MV) or Pulmonary Ventilation (PV) : This is the volume of air expired or inspired by the lungs in one minute. Normal value: 6 L/minute.

Maximum Voluntary Ventilation (MVV) : It is the largest volume of air that can be moved in and out of the lungs in one minute by maximum voluntary efforts. Normal: 120-170 liters/minute.

Dyspneic index (DI) : Refers to breathing reserve percentage of MVV. Breathing reserve is the difference between MVV & MV. Normal value – 70-95% and DI <60% is dyspnea (9).

Statistical analysis

Statistical analysis was done using SPSS. The results are expressed as Mean±SD. Comparisons between the study (1st, 2nd and 3rd trimesters of pregnancy) and control groups were carried out using One-Way ANOVA and Tukey Krammer post Hoc tests. P≤0.05 was considered as statistically significant.

Results

Anthropometric parameters

The Mean±SD of age, weight, BMI have been shown in Table I. The four groups were similar by age. There was a decrease in weight in 1st & increase in 3rd trimester compared to control. BMI increased significantly in 3rd trimester compared to control.

Respiratory parameters

The Mean±SD of RR, MVV, MV and DI have been presented in Table I. There was a gradual increase in RR from 1st to 3rd trimesters compared to control group. There was no significant difference in the minute ventilation between the study and control groups. A highly significant (p=0.000) decrease in MVV was observed in all trimesters with a maximum decrease in 1st trimester. DI was significantly (p=0.000) reduced in all trimesters compared to control group with maximum decrease in 2nd trimester.

Discussion

The present study showed a significant increase in weight & BMI in 3rd trimester and this variation is attributable to the pregnancy (10).We observed a significant increase in RR from 1st to 3rd trimester of pregnancy as compared to control group which is in agreement with Bernhard Heidemann, who stated that $PaCO_2$ falls and then levels off at 4.1kPa (31 mmHg) by the end of the first trimester. This is caused by a 10% increase in the respiratory rate, secondary to progesterone mediated hypersensitivity to CO_2, and an increase in alveolar and minute ventilation, secondary to increased respiratory rate and tidal volume (11). Present study showed insignificant increase in MV in all trimesters as compared to control group. Contreras et al also demonstrated that during pregnancy ventilatory drive & respiratory impedance increased with consequent stabilization of MV (12).

A study by Emilia Kolarzyk showed increase in MV during pregnancy. It is worth pointing out that the increase in MV was caused by a significant increase in tidal volume (13) and another study by Aaron P also showed increase in MV which is due to changes in osmolality, (SID) strong ion differences & angiotensin II levels, which have been implicated in the control of ventilation (14).

There was a significant decrease in MVV in all trimesters compared to control group with maximum decrease in 1st trimester. A study by Usha M showed progressive decline in MVV during different trimesters

TABLE I: Age, anthropometric and respiratory parameters of different study group subjects.

Parameters	*Group 1 (n=50)*	*Group 2 (n=50)*	*Group 3 (n=50)*	*Group 4 (n=50)*	*P values*
Age (yrs)	24.08±5.76	25.02±4.41	24.76±3.57	25.84±3.39	0.252
Weight (kg)	58.78±9.61	52.34±7.09*	54.58±7.08	59.56±9.23$^{\#ƒ}$	0.000
BMI (kg/m^2)	23.19±3.5	21.93±3.86	22.39±3.79	24.73±3.08$^{\#ƒ}$	0.001
RR (cpm)	15.62±3.04	22.16±3.30*	23.28±4.29*	26.16±3.65$^{*\#ƒ}$	0.000
MVV (L/min)	71.38±20.63	40.92±13.78*	41.71±16.16*	41.45±15.72*	0.000
MV (L/min)	13.34±7.54	13.68±8.09	13.28±7.22	14.42±5.84	0.852
DI (%)	79.35±13.82	61.84±27.89	49.98±55.03*	56.66±31.57*	0.000

Data presented are mean±SD. Analysis of data was done by one-way ANOVA and post-hoc by Tukey-Krammer test. The * depicts comparison with Group 1and the # depicts comparison with Group 2, and the ƒ depicts comparison with Group 3. *P<0.05; # P<0.05; ƒP<0.05. Group 1: Control, Group 2: 1st Trimester, Group 3: 2nd Trimester, Group 4: 3rd Trimester. BMI: Body mass index, RR: Respiratory rate, MVV: Maximum voluntary ventilation, MV: Minute ventilation, DI: Dyspneic index.

of pregnancy. The decline in the MVV in first trimester is due to morning sickness (lack of nutrition) and to lodging of trophoblast cell in the alveoli from the maternal uterine sinuses. Whereas in the 2nd and 3rd trimester, it may be due to mechanical pressure of enlarging gravid uterus, elevating the diaphragm and restricting the movements of lungs and thus hampering the forceful expiration. It may also be due to bronchoconstriction effect of decreased alveolar Pco_2 on the bronchial smooth muscles (15).

Present study also demonstrates a significant decrease in DI in all trimesters as compared to control group with maximum decrease in 2nd trimester. The decrease in the DI shows that pregnant women in all trimesters are dyspneic (5) on exertion, but some individuals showed negative DI indicating dyspnea at rest in all trimesters. The prevalence of individuals with negative DI is maximum of 7 women in 2nd trimester compared to 3 women & 4 women in 1st & 3rd trimester respectively with nil in control group.

Conclusion

Even though normal MV tries to maintain the respiratory need of pregnancy at rest, at increased physiological needs of respiration as during any exercise the decreased MVV makes her dyspneic. To establish the cause for decrease in respiratory parameters particularly in first trimester of pregnancy compared to 2nd & 3rd, further longitudinal studies are to be undertaken by hormonal assay in different trimesters to know the relation between hormone and respiratory parameters.

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