A study of respiratory rate, tidal volume, inspiratory capacity and inspiratory reserve volume in different trimesters of pregnancy

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ABSTRACT

Background: The anatomical, physiological and biochemical adaptations in pregnancy are profound. Many of these changes begin soon after fertilization and continue throughout the gestation and changes in the respiratory system are part of the same process. However there is insufficient information regarding the changes in respiratory parameters in different trimesters of pregnancy. **Aims:** The aim of the study was designed to evaluate the pulmonary function tests in 1st, 2nd and 3rd trimesters of pregnancy and compare them with non-pregnant control group. **Materials and Methods:** A cross-sectional study was carried in 200 healthy women in the age range of 19-35 years. The subjects were distributed in four groups, as control (non-pregnant) group and 1st, 2nd and 3rd trimester pregnant groups. Number of subjects in each group was 50. Respiratory parameters in control and study groups were recorded. **Statistical Analysis:** By '*Z*' test. **Results:** There was gradual significant increase in respiratory rate in all trimesters of pregnancy. There was a gradual decrease in tidal volume in 1st, 2nd and 3rd trimesters of pregnancy when compared to non pregnant women. There was significant decrease in Inspiratory Reserve Volume and Inspiratory Capacity. **Conclusion:** The changes in pulmonary function are attributed to major adaptations in the maternal respiratory system and are influenced by the mechanical pressure of enlarging gravid uterus, elevating the diaphragm and restricting the movements of lungs thus hampering the forceful expiration and also might be due to decline in alveolar Pco_2 caused by hyperventilation which acts as bronchoconstrictor; in addition to sensitization of respiratory center due to progesterone

Key words: Inspiratory capacity, inspiratory reserve volume, pregnancy, respiratory rate, tidal volume

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INTRODUCTION

There are number of changes in the anatomical, physiological and biochemical parameters during pregnancy, which begin immediately following conception and continue for entire pregnancy.[1]

In very early stage of pregnancy, the corpus luteum secretes 17- hydroxyl progesterone. Following development of trophoblast, progesterone is synthesized and secreted in increasing amount from the placenta. The placenta can utilize cholesterol as a precursor derived from the mother for the production of pregnenolone and ultimately progesterone. The average level of plasma progesterone at 12th week, 28th week and term is approximately 25 ng/ml, 80 ng/ml and 180 ng/ml respectively. After delivery, the plasma progesterone decreases rapidly and is not detectable after 24 hours.[2]

Progesterone increases ventilation by increasing respiratory centre sensitivity to carbondioxide as a result the tidal volume and minute ventilation is increased. This results in a decrease in arterial and alveolar carbon dioxide pressure.[3-4]

Until today, plenty of studies have been done to assess the pulmonary function in health as well as in diseases such as asthma, tuberculosis and ascites.[5] This work is intended to study the effect of pregnancy on Computerized Spirometric Pulmonary function tests measuring the following Static and dynamic lung volumes and capacities.[6]

Access this article online	
Quick Response Code:	Website: www.ijhas.in
	DOI: 10.4103/2278-344X.126766

1. Tidal Volume (TV)[6]: It is the volume of air breathed in or out during quiet respiration. Normal value: 500 ml
2. Inspiratory Reserve Volume (IRV):[6] It is the maximum volume of air which can be inspired after complete normal tidal inspiration. Normal value: 2000-3200 ml
3. Inspiratory Capacity (IC):[6] It is the maximum volume of air which can be inspired after complete tidal expiration. Normal value: 2500-3700 ml.
   IC = TV ± IRV

Studies have revealed that there is a sizeable proportion of evidence indicating the relationship between pregnancy and respiratory functions from various parts of the world. Although some workers have already studied pulmonary function tests in women during pregnancy in some parts of our country,[7] there are very few reports involving subjects of South Indian origin in this field. Hence aim of this study is to evaluate the influence of pregnancy, on pulmonary function tests like TV, IRV and IC involving subjects of South Indian origin (Karnataka) and compare them with that of healthy non-pregnant age matched controls.

MATERIALS AND METHODS

A cross-sectional study was conducted in the Department of Physiology of Medical College. The study was undertaken to determine the pulmonary function changes in 1st, 2nd and 3rd trimesters of pregnancy. The observations were compared with age-matched healthy non- pregnant women.

Method of collection of data

Study group

A total of 150 pregnant women in the age group of 19-35 years who were attending the Outpatient Department of Obstetrics and Gynecology of a tertiary care hospital were included in the study group. The study group was divided into 3 subgroups and each sub group comprised of 50 women in first, second and third trimesters of pregnancy.

Control group

Apparently healthy age matched 50 non-pregnant women.

Institutional ethical committee approval was obtained before the commencement of the study. The nature and purpose of this study were explained to the subjects who had volunteered for the study and a written consent was obtained. A proforma was used to record the relevant information from each selected individual who had fulfilled the inclusion criteria. A thorough physical and systemic examination of each subject was done (in particular, cardiovascular and respiratory system). Recordings were taken during morning hours between 9 am and 12 Noon.

Inclusion criteria

Apparently healthy pregnant subjects of South Indian origin were included in the study. The apparent health status of the subjects was determined through thorough clinical examination and history taking.

Exclusion criteria

Subjects with acute respiratory infection in the previous 3 months, chronic respiratory infection including asthma, history or clinical signs of cardiovascular diseases, diabetes mellitus, hypertension, tobacco consumption in any form, alcohol intake, endocrine disorders, obesity and moderate to severe anemia were excluded from the studies.

Following parameters were recorded in each subject:

- Record of physiological parameters
  Pulse Rate (beats/min), blood pressure (systolic blood pressure and diastolic blood pressure in mmhg), respiratory rate (cycles/min) were recorded
- Record of pulmonary function parameters
  The subjects were informed about the procedure. For each test, three readings were taken. The highest reading of the three was taken for calculation. All tests were recorded in a sitting posture at room temperature, in morning hours.

The following pulmonary parameters were recorded by Computerized Spiropac (Medicad)[6]

1. TV (L)
2. IRV (L)
3. IC (L).

Statistical analysis

The results were expressed as mean ± standard deviation (SD). *Z* test was used for comparison between control and study groups in consultation with a statistician. The analysis of data was performed using the satistical package for social sciences windows version 16 and a '*P*' < 0.05 was considered as statistically significant.

RESULTS

Respiratory rate (cpm)

Mean RR ± SD of control and pregnant women in 1st, 2nd and 3rd trimesters were 16 ± 3, 22 ± 3, 23 ± 4.3 and 26 ± 3.7 cpm respectively. There was statistically very highly significant gradual increase in RR from 1st to 3rd trimester as compared with control as shown in Table 1.

Tidal volume (L)

Mean TV ± SD of control and pregnant women in 1st, 2nd and 3rd trimesters were 0.84 ± 0.41, 0.72 ± 0.95, 0.57 ± 0.23 and 0.58 ± 0.24 liters respectively. There was a gradual decrease in TV of 1st, 2nd (P = 0.001) and 3rd (P = 0.001) trimesters of pregnancy when compared to non-pregnant women and the decrease is maximum in 2nd trimester as shown in Figure 1.

Inspiratory Reserve Volume (L)

Mean IRV ± SD of control and pregnant women in 1st, 2nd and 3rd trimesters were 1.02 ± 0.60, 0.78 ± 0.47, 0.75 ± 0.54 and 0.92 ± 0.55 liters respectively. There was a statistically highly significant decrease in IRV in 1st (P = 0.012) and 2nd (P = 0.008) trimesters of pregnancy and insignificant decrease in 3rd trimester of pregnancy when compared with non- pregnant women as shown in Figure 1.

Inspiratory Capacity (L)

Mean IC ± SD of control and pregnant women in 1st, 2nd and 3rd trimesters were 1.82 ± 0.82, 1.47 ± 0.95, 1.27 ± 0.7 and 1.43 ± 0.6 L respectively. There was a statistically significant decrease in IC in 1st (P = 0.024), 2nd (P = 0.001) and 3rd trimesters of pregnancy when compared with non-pregnant women. Maximum decrease in IC is seen in 2nd trimester of pregnancy as shown in Figure 2.

DISCUSSION

A cross-sectional study was carried in 200 healthy women in the age group of 19-35 years. The subjects were distributed in four groups as: Control (non-pregnant) group and 1st, 2nd and 3rd trimester pregnant groups. Number of subjects in each group was 50. Various physiological and respiratory parameters were recorded in control and study groups.

In the present study, there was a significant increase in RR from 1st trimester to 3rd trimester of pregnancy as compared with control group which was in agreement with a study carried out by Heidemann, who stated that $PaCO_2$ falls and then levels off at 4.1kPa (31mmHg) by the end of the

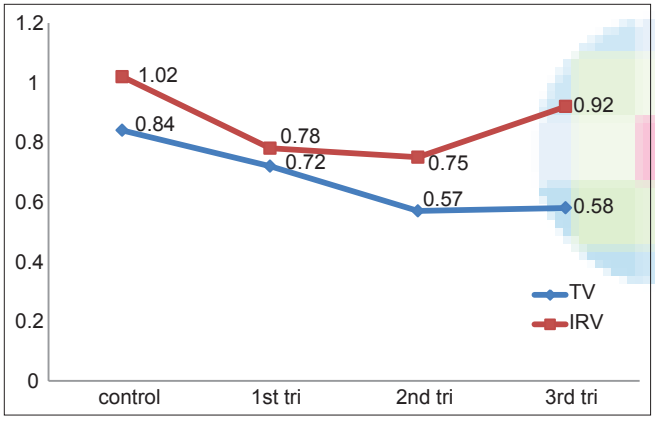

Figure 1: Comparison of tidal volume (L) and inspiratory reserve volume (L) in different trimesters of pregnancy and control group

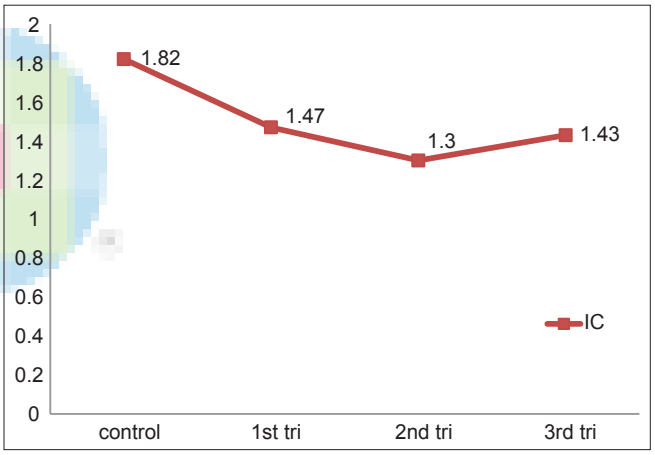

Figure 2: Comparison of inspiratory capacity (L) in different trimesters of pregnancy and control group

Table 1: Mean±SD and range of physiological parameters of subjects in control and study groups

Parameters	Mean±SD			
	Control	1st Trimester	2nd Trimester	3rd Trimester
PR (beats/min)	76±9.4	89±10 (P=0.054)	77±5.5 (P=0.167)	78±7.7 (P=0.053)
SBP (mm Hg)	118.66±4.4	115.60±7.67 (P=0.0146*)	109.56±5.68 (P=0.001***)	117.56±7.94 (P=0.17)
DBP (mm Hg)	74.32±4.75	73.36±5.97 (P=0.378)	66.52±5.68 (P=0.001***)	75.60±7.41 (P=0.441)
PP (mm Hg)	44.34±5.47	42.44±7.81	43.20±5.33	42.44±8.33
MAP (mm Hg)	88.94±5.72	88.32±5.80	80.90±4.19 (P=0.001***)	89.45±7.26
RR (cpm)	16±3	22±3 (P=0.001***)	22±4.3 (P=0.001***)	26±3.7 (P=0.001***)

P>0.05: Not Significant, *P: <0.05: Significant; **P: <0.01: Highly significant; ***P: <0.001: Very highly significant. SD: Standard deviation; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PP: Pulse pressure; MAP: Mean arterial pressure; RR: Respiratory rate

first trimester. This is caused by a 10% increase in the RR, secondary to progesterone mediated hypersensitivity to CO_2 and an increase in alveolar and minute ventilation, secondary to increased RR and TV.[8]

Present study showed a significant decrease in TV from 1st trimester to 3rd trimester as compared to control with maximum decrease in 2nd trimester. In contrast to present study, a study by Kolarzyk *et al.,* have showed that there was an increase in the TV in all trimesters. The increase in TV is due to increase in carbondioxide tension and reflected a fall in systemic arterial blood CO_2 tension.[9]

Present study showed a significant decrease in IRV in 1st trimester and 2nd trimester as compared to control. This statistical significant decrease in IRV in all trimesters might be due to decrease in inspiratory muscle power.

Present study showed a significant decrease in IC from 1st trimester to 3rd trimester as compared to control with maximum decrease in 2nd trimester. In contrast to present study, Phatak and Kurhade showed an increase in the IC during pregnancy due to mechanical changes in thoracic cage increasing its volume.[7,10] Another possible cause is the heightened response to nervous stimuli because intensity and duration of nervous stimuli required to produce the muscular contraction are shortened during pregnancy.[7]

Use of Computerized Spiropac (Medicad) has additional advantages of quick, accurate and discrete measurement of these above mentioned parameters which help for better differentiation of respiratory diseases from normal pregnancy changes.

CONCLUSION

The significant increase in RR by 4 cpm might be due to sensitization of respiratory center due to progesterone and is compensated by a decrease in TV ultimately maintaining the constant MV even during all trimesters of pregnancy. The statistical significant decrease in IRV seen in first and second trimesters might be due to decrease in inspiratory muscle power. Decrease in IC seen in all trimesters might be due to heightened response to nervous stimuli. Computerized method helps in better assessment of respiratory changes in different trimesters.

To establish the cause of decrease in respiratory parameters 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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How to cite this article: Teli A, Doddamani P, Bagali S. A study of respiratory rate, tidal volume, inspiratory capacity and inspiratory reserve volume in different trimesters of pregnancy. Int J Health Allied Sci 2013;2:294-7.

Source of Support: Nil, **Conflict of Interest:** None declared