ORIGINAL RESEARCH PAPER

Medicine

KEY WORDS: Expiratory Reserve Volume, Tidal Volume, Vital Capacity

STUDY OF LUNG FUNCTION TESTS IN DIFFERENT TRIMESTERS OF PREGNANCY

Dr. Biswajit Sarkar

(M D)Assistant Professor Department of Physiology, Midnapore Medical College & Hospital, Pashchim Midnapore, West Bengal, India

ABSTRACT

Introduction: Pregnancy is associated with physiological changes in the control of respiration, in lung volumes, in the mechanics of breathing and in fluid electrolyte as well as in acid base balance. The different static lung volume changes during pregnancy rapidly goes to the normal after delivery along with descent of diaphragm and decompression of lungs. Our objective in this study was different lung volume changes in different trimester of pregnancy by spirometry. **Materials & Methods :** The study consists of recording of lung function tests of 4 groups of female subjects including pregnant women of various phages of pregnancy period i.e., 12 weeks (1st. trimester), 24weeks (2nd. Trimester), 36 weeks (3rd. trimester) and control group of non-pregnant women. The different static lung function parameters measured in this study were Expiratory Reserve Volume (ERV), Tidal Volume (TV), Vital Capacity (VC), Residual Volume (RV), and Minute Volume (MV). **Results :** We observed a statistically significant decrease in ERV and RV and a significant increase in TV, VC and MV in different trimesters in pregnancy. **Conclusion :** From the results of this study, it can be concluded that significant changes in lung function physiology occur during pregnancy which are necessary to meet the increased increase metabolic needs of the mother and fetus.

INTRODUCTION:

Pregnancy is characterized by sequence of dynamic events (physiological) that impact on multiple organ system functions and is associated with various changes in lung functions. Three important changes of the thorax that occur during pregnancy were an increase in the Circumference of the lower chest wall (with increase in anteroposterior and transverse diameters); elevation of diaphragm (4-5cm) and 50% widening of the costal angle[1-3]. These changes peak around 37th week of pregnancy and become normal within 6 months after delivery. Pulmonary function is affected by changes of airway, thoracic cage, and respiratory drive. Additionally, capillary engorgement throughout the respiratory tract results in mucosal oedema and hyperemia[4-5]. Multiple biochemical alterations like increase in progesterone, oestrogen, prostaglandin, corticosteroid and cyclic neucleotide levels occur concomitantly during the course of pregnancy. The thoracic circumference increases about 6cm but not sufficiently to present a marked reduction in the residual volume of air in the lungs controlled by the elevated diaphragm.

Diaphragmatic excursion is actually greater during pregnancy than during non-pregnancy state. At any stage of normal pregnancy the amount of oxygen delivered into lungs by the increase in tidal volume clearly exceeds the oxygen needs imposed by pregnancy. Moreover the amount of hemoglobin in circulation increases as a consequence of the maternal arteriovenous oxygen difference.

Pregnancy is associated with physiological changes in the control of respiration, in lung volumes, in the mechanics of breathing and in fluid electrolyte as well as in acid base balance. Maternal respiratory alterations in turn affect metabolism and well-being of fetus through their influence on placental gas exchange.

The most striking alteration in lung function is an increase in Minute Ventilation which increases by 36% by the eighth week of pregnancy and ultimately reaching levels which are 50% above the non-pregnant need. This adjustment is required to satisfy the increase in oxygen consumption of 30-35% by the growing fetus. However the timing and magnitude of the increase in Minute Ventilation is in excess of the oxygen requirement for fetal development which may be due to the stimulatory effect of progesterone on the respiratory center. This expansion in Minute Ventilation leads to a slight decrease in alveolar PCO_2 and lower $PaCO_2$ from 38 torr to approximately 30 torr at term. The kidney compensates metabolically by an increase in the excretion of bicarbonate partially affecting changes in the blood pH. Mild respiratory alkalosis occurs and pH rises from 7.35 to 7.4 near term. The increase in ventilation occurs without an increase in respirarory rate and this is accomplished mainly by a rise in Tidal Volume from 500ml to 700ml and this explains the frequent sighing observed in pregnant women.

The physiological changes induced by pregnancy have been summarized by de Swiet[6] : Vital Capacity may be increased by about 100-200ml ; Inspiratory Capacity increases by about 300ml by the late pregnancy; Expiratory Reserve Volume decreases from a total of 1300ml to 100ml; Residual Volume decreases from a total of 1500ml to 1200ml; Functional Residual Capacity is reduced by 500ml; Total Volume increases about 500ml-700ml; Minute Ventilation increases by 40%, from 7.5L/min to a total of 10.5L/min; this is primarily due to increase in Tidal Volume as the respiratory rate is remain unchanged. These changes are induced to help the increased supply of oxygen as basal oxygen consumption increase incrementally by 20-40ml/min every month in the second half of pregnancy. As a result arterial PO_2 falls very slightly. PCO_2 averages 28mmHg, plasma pH is slight alkaline at 7.45 and bicarbonate decreases to about 20meq/L.

MATERIAL & METHODS :

This study consists of recording of Pulmonary Function Tests in four group of female subjects including pregnant women of various phases of gestational period 12weeks, 24weeks, 36weeks and control group of non-pregnant women of child bearing age (20-40), mainly lady doctor, nurse and lady medical students. The subjects considered for this study are with Hemoglobin level 10gm% or more. The study was approved by the Institutional Ethical Committee. Informed consent was taken from all subjects. All subjects were called for spirometry procedure between 3 to 4pm (3-4hr.after meal), in the post absorption stage in order to keep uniform condition for recording the tests. All the subjects were given proper instruction and demonstration regarding performance of the tests. The tracing in the Spirograph were taken after being fully satisfied. Three tracings were taken out of which the best is taken as final reading. The female subjects who are non-smoker and free from cardiovascular and respiratory disorders were grouped into four groups as:

Group1- Female normal subjects aged 20-30 years; Group 2- pregnant subjects of 1st trimester period aged 20-30 years; Group 3–pregnant subjects of 2nd trimester period aged 20-30 years; Group 4- pregnant subjects of 3rd trimester period of

aged 20-30 years.

The different lung function parameters measured in this study include ERV, IRV, TV, VC, RV, and MV. Statistical analysis done by using Graph pad prism 6 software. Unpaired t test was used to compare the mean value's.

RESULTS :

Table 1 : Mean Value's of ERV, TV, VC, RV & MV in different trimester of pregnancy

	CONTROL MEAN±SD	1st. Trimester MEAN±SD	2nd. Trimester MEAN±SD	3rd. Trimester MEAN±SD
ERV in Litres	0.7620± 0.008660	0.7336± 0.003964	0.7062± 0.004381	0.6858± 0.004661
TV in Litres	0.3232± 0.003450	0.3546± 0.003535	0.3885± 0.004890	0.4267± 0.01372
VC Lit./min	3.011±0.02 022	3.116±0.0343 4	3.122±0.03 923	3.207±0.03 687
RV in Litres	1.120± 0.009420	0.9624± 0.01882	0.9495± 0.008944	0.8468± 0.007921
MV Lit./min	6.224±0.03 842	6.345±0.0514 9	6.558±0.08 005	6.824±0.04 522

Table 2 : Comparison of Mean value's of different lung function parameters between control and 1st. trimester pregnant women.

	CONTROL MEAN±SD	1st. Trimester MEAN±SD	P-VALUE
ERV	0.7620±0.008660	0.7336±0.003964	0.0045**
TV	0.3232±0.003450	0.3546±0.003535	<0.0001****
VC	3.011±0.02022	3.116±0.03434	0.0116*
RV	1.120±0.009420	0.9624±0.01882	<0.0001****
MV	6.224±0.03842	6.345±0.05149	0.0653 NS

Table 3 : Comparison of Mean value's of different lung function parameters between control and 2nd. trimester pregnant women.

	CONTROL MEAN±SD	2nd. Trimester MEAN±SD	P-VALUE
ERV	0.7620±0.008660	0.7062±0.004381	<0.0001****
TV	0.3232±0.003450	0.3885±0.004890	<0.0001****
VC	3.011±0.02022	3.122±0.03923	0.0155*
RV	1.120±0.009420	0.9495±0.008944	<0.0001****
MV	6.224±0.03842	6.558±0.08005	0.0005***

Table 4 : Comparison of Mean value's of different lung function parameters between control and 3rd. trimester pregnant women.

	CONTROL MEAN±SD	3rd. Trimester MEAN±SD	P-VALUE
ERV	0.7620±0.008660	0.6858±0.004661	<0.0001****
TV	0.3232±0.003450	0.4267±0.01372	<0.0001****
VC	3.011±0.02022	3.207±0.03687	<0.0001****
RV	1.120±0.009420	0.8468±0.007921	<0.0001****
MV	6.224±0.03842	6.824±0.04522	<0.0001****

When the mean Expiratory Reserve Volume (ERV) of control subjects is compared with the mean Expiratory Reserve Volume (ERV) of subjects in the 1st. trimester pregnancy, a non-significant decrease of 3.67% is observed in subjects of 1st. trimester subjects (pvalue=0.045). In the same way, the mean Expiratory Reserve Volume (ERV) in the 2nd. trimester subjects has shown a statistically significant decrease of 7.35% when compared with that of the control subjects (pvalue<0.0001).The mean Expiratory Reserve Volume (ERV) in the 3rd. trimester subjects also has shown a statistically significant decrease of 9.97% when compared with that of mean Expiratory Reserve Volume (ERV) the control subjects (pvalue<0.0001).Thus there is a gradual decrease in the mean Expiratory Reserve Volume (ERV) in the pregnant subjects (as compared with the controls) as the pregnancy advances reaching its maximum decrease by the end of 3rd. trimester. The mean Tidal Volume(TV) of 1st.trimester pregnant subjects showed statistically significant increase of 9.72% when compared with the mean Tidal Volume of the non-pregnant subjects(pvalue<0.0001).Similar results were obtained when the mean tidal volume of the 2nd. and 3rd. trimester pregnant subjects, when compared with the mean tidal volume of the non pregnant controls showing a statistically significant increase of 20.21% and 32.51% respectively(p<0.0001). Hence, the mean tidal volume progressively increased as pregnancy advances reaching its maximum value at term which is statistically significant.

The mean residual volume (RV) of the 1st. trimester pregnant women showed a statistically significant decrease of 21.4% when compared to the mean residual volume (RV) of the controls (p<0.0001). The mean residual volume (RV) in 2nd. trimester pregnant subjects showed a statistically significant decrease of 15.27% when compared with that of the control non pregnant women (p<0.0001). The mean residual volume (RV) of the 3rd. trimester pregnant subjects showed a statistically significant decrease of 24.375% when compared with the mean residual volume (RV) of control non pregnant subjects (p<0.0001). Thus there is a gradual decrease in the mean residual volume (RV) in the pregnant subjects from the 1st. to the 3rd. trimesters which is statistically significant.

An non significant increase of 1.944% in the mean Minute Volume (MV) is noticed in the 1st.trimester pregnant subjects compared with the mean MV of the control non-pregnant subjects(p=0.0653). Likewise, the mean MV of the 2nd. and 3rd. trimester subjects has shown a statistically significant measure of 5.35% and 9.64% respectively, when compared with mean MV of the control subjects (p=0.0005 & p<0.0001).Thus there is a gradual increase in the mean MV of the pregnant subjects as they proceed to term when compared with the controls. The mean Vital Capacity (VC) of the subjects in the 1st. trimester pregnancy shown a non significant increase of 3.48% when compared with the mean VC of the control subjects (p value=0.0116). Similarly the mean VC has shown in the subjects of the 2nd. and 3rd. trimester a statistical significant increase of 3.68% and 8.60% respectively as compared with the mean VC of the control subjects (p value<0.0001.

DISCUSSION :

Our observation that there is an increase in TV and decrease in ERV is an agreement with the result of Chhabra S, Nangia V, Ingley KM et al [7]. An increase in TV and MV occurs in pregnancy was observed in the studies of Rees GB, Pipkin FB, Symonds EM[8];

Nelson Piercy C[9]. MV increases during pregnancy due to increase in TV as respiratory rate remain unchanged. The increase in MV is greater than the increase in oxygen consumption and this results in both hyperventilation and an increased ventilatory equivalent for oxygen. Subjective awareness of increased ventilation is one explanation for the sensation of dyspnea in pregnant women without cardiopulmonary limitation. Gallivan DE, Mathews H, Anthony AJ et al[10] observed that the MV increases gradually as term is approached. Actually along with the TV respiratory rate also slight increases.

Some studies (Milne JA[11]) showed significant rise in FVC while other studies [Puranik BM[12];Mokkapatti R[13];Monga U[14]]showed decrease in FVC. Root FR and Root HK[15] observed slight but true rise in the VC curve during pregnancy from third to eighth month and marked increase the same at last month. Landt CK, Widlund G and Benjamin PR[16] found an increase in VC during pregnancy. Root, Cohen, Landt and others concluded that VC is increased during pregnancy and the same is observed in our study was in accordance with this

study.

Other significant change observed in lung volume during pregnancy were increase in VC and Inspiratoty capacity, decrease in ERV and FRC (Functional Residual Capacity) but no change in TLC (Total Lung Capacity). The present observation that there is an increase of TV and IC and a decrease in ERV is consistent with this study. Plass Ed and Obersdt DW[17] observed a slight increase in TV throughout pregnancy. The increase of TV among the pregnant women observed in our study is in agreement with this study. Bernard J, Gee L, Bernard S Packer et al[18] studied about the pulmonary mechanics during pregnancy and they observed that during late pregnancy, there is a 25% reduction in FRC and 40% reduction in ERV. The FRC, the RV decreased progressively as pregnancy advanced. The MV rises markedly due to increase in TV. The decrease in RV in our study might be due to relative decrease in negativity of intrapleural pressure, caused by upward displacement of the diaphragm due to upward pushing by the gravid uterus.

Knox AJ, Petkova S et al[19] observed a number of physiological changes occurred during pregnancy. At the end of 1st. trimester Ventilation increased by 20-25% and was persist throughout pregnancy. A decrease in RV and FRC was observed. Also diaphragmatic extension, VC and TLC remain unchanged. Respiratory Rate may increase slightly but tachypnea more than 20/min, considered to be abnormal in pregnancy [Wise RA, Polito AJ, Krishnan V[20].

CONCLUSION :

Conflicting results could be due to observations on different subjects from many different socio-economic status at different phages of pregnancy. Alteration of many different hormonal level and their effects alters smooth muscle tone, connective tissue elasticity during pregnancy. This may cause change in mechanics of lung. The decrease in ERV due to reduction in power of muscles of expiration due to stretching of the abdominal wall during pregnancy. Rise of TV could be due to smooth muscle relaxation, altered thoracic configuration and a direct effect of progesterone increasing the sensitivity of respiratory center to CO_2.

Limitation of this study : Parity is not considered in this study as well as small sample size. It is a cross-sectional study but longitudinal study may reveal better result. So further study need to done with large sample size and longitudinal study. Routine antenatal Lung Function Tests to be done to prevent respiratory complications, if any.

ACKNOWLEDGEMENTS:

We acknowledge all the subjects who have participated in this study.

REFERENCES :

1. Wemberger SE, Weiss ST, Cohen WR et al. Pregnancy and lung. Am Rev Respir Dis 1980; 121(3):559-81.
2. Goldsmith LT, Weiss G, Steinetz BG. Relaxin and its role in pregnancy. Endocrinol Metab Clin North Am 1995,24(1):171-86.
3. Gilroy RJ, Mangura BT, Lavietes MH, Rib case and abdominal volume during breathing in pregnancy. Am Rev Respir Dis 1988;137(3):668-72.
4. Ellegard EK. Pregnancy rhinitis. Immunol Allergy Clin North Am 2006;26(1):119-35,vii.
5. Toppozada H, Michaels L, Toppozada M et al. The human respiratory nasal mucosa in pregnancy. An electron microscope and histochemical study. J Laryngol Otol 1982;96(7):613-26.
6. De Swiet M. The respiratory system. Inc: clinical physiology un Obstetrics. Hyffen FE & chamberlain GVP Eds. Blackwell scientific publications Oxford 79-100.
7. Chhabra S. Nangia V Ingley KM. Changes in respiratory function tests during Pregnancy. Indian J. of Physiology and Pharmacology 1988; Vol 32; Jan-Mar;56-60.
8. Rees GB, Pipkin FB, Symonds EM, et al. A longitudinal study of respiratory changes in normal human pregnancy with cross sectional data on subjects with pregnancy induced hypertension. Am J Obstet Gynecol1990;162:826-830.
9. Nelson Piercy C. Respiratory diseases. Handbook of Obstetric Medicine, Oxford 1997; 15-65.
10. Rowe AW, Galliwan DE, Matthews H. The metabolism in pregnancy. Am J Physiol; 1931; 96; 101.
11. Milne JA, Mills RJ, Howie AD, Pack Al. Large airways function during normal pregnancy. Br Jr of Obst and Gynaec 1977;84:448-451.
12. Puranik BM, Kaore SB, Korhade GA, Agrawal SD, Patwardhan SA, Kher JR. A longitudinal study of pulmonary function tests during pregnancy. Indian J Physiol Pharmacol 1994;38(2) : 129-132.
13. Mokkapatti R, Prasad EC, Venkatraman, Fatima K. Ventilation function in pregnancy. Indian J. Physiol Pharmacol 1991;34(4) : 237-249.
14. Monga U, Kumar K. Pulmonary function in Panjabi Pregnant Women. Indian J. Physiol Pharmacol 2000; 44(1) : 115-16.
15. Root HP & Root HK. Arch. Int. Medicine 1923; 32: 411.
16. Landt CK, Widllund G and Benjamin PR. The cardio pulmonary function during pregnancy. Acta Obstetrics Gynaecology Scand. 1945; Suppl1.
17. Plass ED and Oberst DW. American J. of Obst and Gyneacology 1938;35;441.
18. Bernard Gee JL, Bernard S Packer, Eugene Millen J and Robin E. Pulmonary mechanics during pregnancy. Journal of Clinical investigation 1967;Vol.46,No.6;
19. Knox AJ, Petcova D, Johnson S. Respiratory disease in pregnancy. Obstet & Gynaecol 1999;9;69-74.
20. Wise RA, Polito AJ, Krishnan V : Respiratory physiologic change in pregnancy. Immunol Allergy Clin North Am 2006; 26 : 1-12.