Original Article

Study of Pulmonary Function Tests During Pregnancy At Physiological Variable Conditions

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ABSTRACT

Pregnancy is one of the most critical states of physiological adaptation during which many physiological adjustments occur to meet the requirement of foetus as well as mother. Such studies are the key to understand and help in prevention of abnormal foetal growth. The study was conducted in 120 normal pregnant cases which were divided in to three groups having 40 cases in each group and were compared with that of control group of another 40 non pregnant women. The different static and dynamic lung volumes and capacitities like tidal volume (TV), forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), percentage FEV₁/FVC, peak expiratory flow rate (PEFR), mid expiratory flow rate (MEFR), maximum mid expiratory flow rate (MMEFR) and maximum voluntary ventilation (MVV) were determined by the instrument medspiror. The observed values were compared to those of different groups. It is observed and also concluded that there is definite increase in respiratory rate and tidal volume during pregnancy. There is no significant change in FVC and FEV₁ percentage FEV₁/FVC during pregnancy even though there is a slight reduction of FVC in some cases. The MMEFR get reduced during 1st trimester but goes on rising in subsequent course of pregnancy. The MEFR, PEFR and MVV show a decrease value in pregnancy as compared to normal. The age, height, weight, parity and body surface area showed no significant relation with pulmonary function tests. The changes are mostly due to the anatomical, biochemical, hormonal as well as psychological changes during pregnancy.

Key Words: pulmonary function test, lung volume & capacities, pregnancy.

Introduction

Nowhere in physiology is human adaptation more purposefully or teleologically directed than in a woman's adjustment to pregnancy. It can even be argued that the pregnant woman, in making all these adjustments, becomes a different person, with every physiological system altered in some way. With every normal maternal physiological adjustment...
there is likely to be a corresponding pathophysiology or disease state that leads to abnormal foetal growth. Thus studies on normal maternal physiology are the key to understanding and preventing abnormal foetal growth. Pregnancy constitutes one of the most severe states of physiological adaptation (Clive et al 1961), which is an unique event in the life of a woman which needs a vast physiological adjustment to meet the requirements of a new life from the day of fertilisation till the delivery and thereafter. Among all changes, the cardiovascular, haematological, excretory and metabolic demands and adjustments have been studied extensively by Ureland K, Metacalfe et al2, Pritchard JA3 and Hyten FC4.

Regarding respiratory adaptations less work has been done to study pulmonary function tests especially pertaining to ventilation in pregnancy in South Eastern India. The studies so far done do not give adequate reference to the various conditions influencing ventilation changes in pregnancy. Therefore the present study is undertaken with the aim to establish a complete assessment of physiological changes in pregnancy for the different lung volume and capacities and flow rates like Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV1), FEV1/FVC %, Maximum Expiratory Flow Rate (MEFR), Maximum Mid Expiratory Flow Rate (MMEFR), Peak Expiratory Flow Rate (PEFR) and Maximum Voluntary Ventilation (MVV) were recorded.

**Results**

The distribution of control and pregnant study group cases according to age group is shown in table No. 1.

| Age group in years | Control cases n=40 | Study cases 20-30yrs n=40 | Study cases 30-40yrs n=40 | Control 30-40yrs n=40 |
|--------------------|---------------------|---------------------------|---------------------------|------------------------|
| Mean ± S.D         | 25.45±3.06          | 25.1±3.33                 | 33.65±2.43                | 33.75±2.05             |
| Number of cases    | 20                  | 60                        | 20                        | 20                     |
| Percentage         | 12.5%               | 37.5%                     | 37.5%                     | 12.5%                  |

| Age group in years | Control cases n=40 | Study cases 20-30yrs n=40 | Study cases 30-40yrs n=40 | Control 30-40yrs n=40 |
|--------------------|---------------------|---------------------------|---------------------------|------------------------|
| Mean ± S.D         | 150.93              | 151.78                    | 151.75                    | 151.25                 |
| S.E                | 4.32                | 3.64                      | 0.58                      | 2.97                   |
| P                  | <0.05*              | >0.5*                     | >0.5*                     | >0.5*                  |
| Mean ± S.D         | 52.75               | 51.95                     | 55.175                    | 57.45                  |
| S.E                | 3.51                | 1.68                      | 0.265                     | 2.60                   |
| P                  | >0.05*              | <0.05**                   | <0.05**                   | <0.05**                |
| Mean ± S.D         | 1.47                | 1.497                     | 1.498                     | 1.524                  |
| S.E                | 0.06                | 0.0395                    | 0.035                     | 0.038                  |
| P                  | >0.05*              | >0.05*                    | >0.05*                    | >0.05*                 |
| Mean ± S.D         | 17.025              | 18.25                     | 18.67                     | 19.275                 |
| S.E                | 1.928               | 1.409                     | 1.327                     | 1.484                  |
| P                  | 0.222               | 0.209                     | 0.234                     | 0.234                  |
| Respiratory rate/min | 0.305              | <0.001**                  | <0.001***                 | <0.001***             |

**Table. No 2 Comparison of control & study groups of different trimesters.**

**Material & Methods**

The study was carried in the Department of Physiology of a Medical College of South Eastern India. 120 healthy pregnant women of age group from 20-40 years were selected while attending the Antenatal Clinics in the department of Obstetrics & Gynaecology. All the cases were subjected to computerised spirometry, using the instrument MEDSPIOR. Forty non pregnant cases were taken as control cases. Cases with clinical cardio-respiratory abnormalities were excluded from study. All the cases were divided to four groups each group comprising of 40 cases. Group-I included non pregnant healthy women, group II included normal pregnant women in 1st trimester of pregnancy, group III included normal pregnant women in 2nd trimester of pregnancy and group IV included normal pregnant women in 3rd trimester of pregnancy. All the cases were having average socio economic status, average nutritional status with haemoglobin more than 10gm% and were free from any disease. Apart from recording of the age sex, height, weight, the body surface area was calculated using the Du Bois Normogram taking the room temperature and barometric pressure. Using the Medspirometer the different lung volume and capacities and flow rates like Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV1), FEV1/FVC %, Maximum Expiratory Flow Rate (MEFR), Maximum Mid Expiratory Flow Rate (MMEFR), Peak Expiratory Flow Rate (PEFR) and Maximum Voluntary Ventilation (MVV) were recorded. **Table. No 1 Distribution of control and pregnant study group cases according to age group.**

| Age group in years | Control cases n=40 | Study cases 20-30yrs n=40 | Study cases 30-40yrs n=40 | Control 30-40yrs n=40 |
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| Mean ± S.D         | 150.93              | 151.78                    | 151.75                    | 151.25                 |
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| P                  | <0.05*              | >0.5*                     | >0.5*                     | >0.5*                  |
| Mean ± S.D         | 52.75               | 51.95                     | 55.175                    | 57.45                  |
| S.E                | 3.51                | 1.68                      | 0.265                     | 2.60                   |
| P                  | >0.05*              | <0.05**                   | <0.05**                   | <0.05**                |
| Mean ± S.D         | 1.47                | 1.497                     | 1.498                     | 1.524                  |
| S.E                | 0.06                | 0.0395                    | 0.035                     | 0.038                  |
| P                  | >0.05*              | >0.05*                    | >0.05*                    | >0.05*                 |
| Mean ± S.D         | 17.025              | 18.25                     | 18.67                     | 19.275                 |
| S.E                | 1.928               | 1.409                     | 1.327                     | 1.484                  |
| P                  | 0.222               | 0.209                     | 0.234                     | 0.234                  |
| Respiratory rate/min | 0.305              | <0.001**                  | <0.001***                 | <0.001***             |

* = Not significant, ** = Significant, ***=highly significant
Physiologic changes during pregnancy regarding breathing, lung volumes and capacities and other mechanics of respiration occurs due to a number of hormonal and mechanical factors. In the present study attempt has been made to study the changes in the pulmonary function tests in different trimesters of pregnancy with relation to age and parity. The study showed no significant difference in mean age and mean height. But a difference did exist between the mean weights of the groups. Shaikh RN et al\(^5\) also showed in their study that lung volumes and capacities are not dependent upon the height weight and surface area of the pregnant women. In the present study the mean respiration rate was 17.025 which is little higher than the observation of Dasgupta S 1975\(^6\) and Saxena 1979\(^7\). In 1\(^{st}\) trimester of pregnancy the respiration rate is slightly increased to 18.25 and reached the value of 19.275 in 3\(^{rd}\) trimester of pregnancy. Such change is significant when comparison is made between 1\(^{st}\) trimester and 3\(^{rd}\) trimester of pregnancy. The resulting hyperventilation is attributable to the increased abdominal girth, upward displacement of diaphragm and changes in lung volumes, lowered oxygen saturation, inadequate gas mixing in lungs, augmented dead spaces, poor diffusion through the alveolo capillary membrane. Cugell et al\(^8\) in their work could not substantiate the above causes. Howel, Fluton and Ruch, Patton\(^9\) showed a positive response regarding role of effect of progesterone on the hypothalamus. In our study the tidal volume is significantly increased as the pregnancy advanced. Pandya & Nishith in 1972\(^10\), Berry MJ et al 1989\(^11\) have also observed similar findings in their studies. Progesterone exerts and influence the total minute ventilation and its sub components like Tidal Volume and Respiratory Rate. Puranik BM 1994\(^12\) observed that the rise in tidal volume is at the expense of expiratory reserve volume. The increase in tidal volume is also attributable to the increased breathing even at rest. The increased tidal volume is related to greater amount of diaphragmatic breathing. FVC in the control group was little more than the study group. Chabbra S 1988\(^13\), Mokkapati R et al 1991\(^14\), and Puranik BM et al 1994\(^12\) showed similar result. FEV\(_1\) is seen to be reduced in pregnancy but was insignificant which is also showed in the studies of Singh S et al 1995\(^15\) and others. Mokkapati R et al\(^14\) showed a significant reduction only in 3\(^{rd}\) trimester of pregnancy. The change in the FEV\(_1\)/FVC\(_%\) was insignificant in our study which is also consistent with the findings of Cugell DW et al\(^8\), Rubin Russo et al 1956\(^16\). The possible explanation is due to the relaxation of smooth muscles by progesterone leading to decrease airway resistance and impaired airway conductance. The MMEFR was seen to be low in 1\(^{st}\) trimester of pregnancy which increased gradually as the pregnancy advanced. Similar findings were also observed by others but the changes were not significant. The cause was attributable to the relaxation of smooth muscles leading to broncho dilation by the progesterone, relaxin, and low PaCO\(_2\). The decrease in the MMEFR agree with the concept of modern pulmonary medicine that the changes of MMEFR is the earliest event to occur in relation to, peripheral airways, Walter S 1992\(^17\). The PEFR which was seen to be 333.42 l/min in 1\(^{st}\) trimester was further decreased in 2\(^{nd}\) and 3\(^{rd}\) trimester of pregnancy. The comparison between other groups was very significant as also found in studies of Mokkapati R et al\(^14\). But the cause of this gradual decrease could not be established in term of progesterone level or anthropometric parameters. The possible mechanism could be mechanical effect of enlarging gravid uterus affecting vertical dimension resulting in diaphragmatic movement; Ganong WF 1999\(^18\). The other mechanisms may be due to hyperpnoea due to decrease in PaCO\(_2\) and due to increased progesterone affecting the

| Gr II 1\(^{st}\) trimester vs Gr III 2\(^{nd}\) trimester II | Gr III 2\(^{nd}\) trimester vs Gr IV 3\(^{rd}\) trimester III | Gr II 1\(^{st}\) trimester vs Gr IV 3\(^{rd}\) trimester II | Mean |
|--------------------------------|---------------------|---------------------|---------------------|
| ± SD                          | S.E                 | P                   |                    |
| 18.25                         | 1.409               | >0.05*              | >0.05*             |
| 19.67                         | 1.327               | >0.05*              | 18.25              |
| 19.275                        | 1.484               | <0.01**             | 19.275             |

* = Not significant, ** = Significant, ***=highly significant
respiratory muscles. Simultaneous monitoring of airway resistance, PaCO₂ and blood level of progesterone can help in ascertaining the exact mechanism. The value of MEFR was also seen to decrease with advancement of pregnancy. The decrease in MEFR in comparison to the control group is found to be significant. No other workers are seen to have studied the MEFR earlier. The same changes in biochemical and hormonal parameters might be influencing the values during pregnancy. The MVV shows a significant reduction as the pregnancy advanced as compared to control. MVV is a good test for overall performance of respiratory pump. Other factors like morning sickness and nausea may produce a state of alkalosis during hyperventilation which interfere the respiratory performance. The findings also correlate with the work of others. The decrease in MVV is attributable to the defective iron containing enzymes in the mitochondria of muscles. In our study direct relation of the changes in lung volumes or capacities with regard to physiological parameters like age, height, and surface area are not established. Chhabra et al 1988¹³ and Saxena 1978⁷ also in their studies could not establish any similar direct relation of the changes in lung volumes or capacities with regard to physiological parameters like age, height, surface area.

Table No. 4 Values of pulmonary function in different groups.

| N=40 | TV     | FVC    | FEV₁  | %FEV₁/FVC | PEFR   | MEFR   | MMEFR  | MVV   |
|------|--------|--------|-------|-----------|--------|--------|--------|-------|
| Control group |        |        |       |           |        |        |        |       |
| Observed mean | 309.75 | 2593.05| 2132.78| 82.25    | 340    | 303.9  | 222.15| 118   |
| ± SD        | 24.394 | 329.558| 280.964| 2.292    | 21.43  | 79     | 17.52 | 8.15  |
| Predicted mean | 320 | 2674.41 | 2300 | 86 | 363.27 | 396 | 258.31 | 142 |
| ± SD        | 30.6 | 280.72 | 190.86 | 2.28 | 28.64 | 84 | 26.32 | 12.20 |
| % Predicted | 96 | 96.9 | 92.72 | 95.63 | 85.85 | 76.74 | 86 | 83 |
| 1st trimester |        |        |       |           |        |        |        |       |
| Mean       | 355 | 2557 | 2115.66 | 82.74 | 333.42 | 260.5 | 200.05 | 114.57 |
| ± SD       | 40.14 | 364.017 | 328.463 | 2.487 | 6.73 | 8.584 | 6.32 | 6.759 |
| SE         | 6.368 | 57.557 | 51.93 | 0.393 | 3.338 | 1.56 | 0.997 | 1.07 |
| 2nd trimester |        |        |       |           |        |        |        |       |
| Mean       | 371.15 | 2563.75 | 2100.48 | 81.93 | 325 | 281.5 | 213.375 | 109 |
| ± SD       | 42.035 | 294.215 | 271.93 | 2.155 | 9.963 | 4.10 | 11.01 | 5.76 |
| SE         | 6.646 | 46.51 | 42.996 | 0.34 | 1.57 | 0.65 | 1.74 | 0.911 |
| 3rd trimester |        |        |       |           |        |        |        |       |
| Mean       | 382.3 | 2498 | 2048 | 82 | 319.85 | 291.8 | 22295 | 106.67 |
| ± SD       | 28.35 | 204.239 | 184.597 | 2.26 | 8.728 | 7.71 | 16.67 | 3.898 |
| SE         | 4.48 | 32.293 | 29.187 | 0.357 | 1.38 | 1.22 | 2.64 | 0.616 |

Table No. 5 Comparison of significance between different study groups.

| N=40 | TV     | FVC    | FEV₁  | %FEV₁/FVC | PEFR   | MEFR   | MMEFR  | MVV   |
|------|--------|--------|-------|-----------|--------|--------|--------|-------|
| Control group |        |        |       |           |        |        |        |       |
| Mean       | 309.75 | 2593.05| 2132.78| 82.25    | 340    | 303.9  | 222.15| 118   |
| ± SD       | 24.394 | 329.558| 280.964| 2.292    | 21.43  | 79     | 17.52 | 8.15  |
| 1st trimester |        |        |       |           |        |        |        |       |
| Mean       | 355 | 2557 | 2115.66 | 82.74 | 333.42 | 260.5 | 200.05 | 114.57 |
| ± SD       | 40.14 | 364.017 | 328.463 | 2.487 | 6.73 | 8.584 | 6.32 | 6.759 |
| 'p'       | <0.001*** | >0.05* | >0.05* | >0.05* | >0.1* | <0.01** | <0.001*** | <0.005** |
| Control group |        |        |       |           |        |        |        |       |
| Mean       | 309.75 | 2593.05| 2132.78| 82.25    | 340    | 303.9  | 222.15| 118   |
| ± SD       | 24.394 | 329.558| 280.964| 2.292    | 21.43  | 79     | 17.52 | 8.15  |
| 2nd trimester |        |        |       |           |        |        |        |       |
| Mean       | 371.15 | 2563.75 | 2100.48 | 81.93 | 325 | 281.5 | 213.375 | 109 |
| ± SD       | 42.035 | 294.215 | 271.93 | 2.155 | 9.963 | 4.10 | 11.01 | 5.76 |
| 'p'       | <0.001*** | >0.05* | >0.05* | >0.05* | <0.001*** | >0.05* | <0.001*** | <0.001*** |
The changes are mostly due to the anatomical, biochemical, hormonal as well as psychological factors during pregnancy. The information’s are useful for better antenatal care, assessment of fitness for anaesthesia and assessment of progress of pre-existing lung diseases. To find out the exact mechanism affecting the pulmonary function tests during pregnancy simultaneous monitoring of airways resistance, PaCO2 and blood level of progesterone are essential.

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Abbreviations

TV – Tidal Volume

FVC – Forced Vital Capacity

FEV1 – Forced expiratory Volume in one second

MVV – Maximum Voluntary Ventilation

MEFR – Mid Expiratory Flow Rate

MMEFR – Maximum Mid Expiratory Flow Rate

PEFR – Peak Expiratory Flow Rate

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