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Original Article

Study of Pulmonary Function Tests During Pregnancy At Physiological Variable Conditions

Authors
Dr Sulata Mohapatra[1], Dr Umakant Satapathy[2], Dr Niharika Panda[3]
[1]Associate Professor, Department of Physiology, VIMSAR, Burla, Odisha
Email: *drsulatamohapatra@gmail.com Mob No. +91 9437167990*
[2]Associate Professor Physiology, Joint Director, Medical Education &Training India,
[3]Associate Professor, Radiation Oncology, AH Regional Cancer Centre, Cuttack, Odisha, India,
Email: *niharika.panda@yahoo.co.uk Mob. +919437487842*
Corresponding Author
Dr Umakant Satapathy
Associate Professor Physiology, Joint Director, Medical Education &Training,
N-3/462, IRC Village, Nayapalli, Bhubaneswar, Odisha, India 751015
Email: *uksatapathy@yahoo.co.uk Mobile Number: 91-9437410842*

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 capacities like tidal volume (TV), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), percentage FEV_1/ 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 FEV_1/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 patho-physiology 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[1]), which is an unique event in the life of a women 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 al[2], Pritchard JA[3] and Hyten FC[4].

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 pulmonary function tests especially tests of ventilation during pregnancy under physiological variable conditions and compare the results with that of non pregnant states.

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 MEDSPIROR. 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 Medspiror machine the different lung volume and capacities and flow rates like Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV_1), FEV_1/ 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.

Table. No 1 Distribution of control and pregnant study group cases according to age group.

Age group in years	Mean + SD	Number of cases	Percentage
Control 20-30yrs	25.45±3.06	20	12.5%
Control 30-40yrs	33.75±2.05	20	12.5%
Study cases 20-30yrs	25.1±3.33	60	37.5%
Study cases 30-40yrs	33.65±2.43	60	37.5%

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

	Control cases n=40	1st trimester n-40	2nd trimester n=40	3rd trimester n=40
Height (cm)				
Mean	150.93	151.78	151.75	151.25
± SD	4.32	3.64	3.229	2.97
S.E	0.68	0.58	0.51	0.47
P		>0.5*	>0.5*	>0.5*
Weight (kg)				
Mean	52.75	51.95	55.175	57.45
± SD	3.51	1.68	2.32	2.60
S.E	0.55	0.265	0.37	0.411
P		>0.05*	<0.05**	<0.05**
Body surface area(per m^2)				
Mean	1.47	1.497	1.498	1.524
± SD	0.06	0.0395	0.035	0.038
S.E	0.009	0.006	0.006	0.006
P		>0.05*	>0.05*	>0.05*
Respiratory rate/min				
Mean	17.025	18.25	18.67	19.275
± SD	1.928	1.409	1.327	1.484
S.E	0.305	0.222	0.209	0.234
P		<0.001**	<0.001***	<0.001***

* = Not significant, ** = Significant, ***=highly significant

Table. No 3 Comparison of respiratory rate in the study groups.

	Gr II 1st trimester vs Gr III 2nd trimester		Gr III 2nd trimester vs Gr IV 3rd trimester		Gr II 1st trimester vs Gr IV 3rd trimester	
	II	III	III	IV	II	IV
Mean ± SD S.E	18.25 1.409 0.222	18.67 1.327 0.209	18.67 1.327 0.209	19.275 1.484 0.234	18.25 1.409 0.222	19.275 1.484 0.234
P	>0.05*		>0.05*		<0.01**	

* = Not significant, ** = Significant, ***=highly significant

Discussion

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 1st trimester of pregnancy the respiration rate is slightly increased to 18.25 and reached the value of 19.275 in 3rd trimester of pregnancy. Such change is significant when comparison is made between 1st trimester and 3rd 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], Berrry 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 3rd 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 1st 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 1st trimester was further decreased in 2nd and 3rd 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 respiratory muscles. Simultaneous monitoring of airway resistance, $PaCO_2$ 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 1988[13] and Saxena 1978[7] 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	FEV_1	$\%FEV_1$/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	269.5	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	1.36	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	FEV_1	$\%FEV_1$/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	269.5	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***	<0.05**
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***

Control group Mean ± SD 3rd trimester Mean ± SD 'p'	309.75 24.394 382.3 28.35 <0.001***	2593.05 329.558 2498 204.239 >0.05*	2132.78 280.964 2048 184.597 >0.05*	82.25 2.292 82 2.26 >0.5*	340 21.43 319.85 8.728 <0.001***	303.9 79 291.8 7.71 >0.5*	222.15 17.52 222.95 16.67 >0.5*	118 8.15 106.67 3.898 <0.001***
1st trimester Mean ± SD 2nd trimester Mean ± SD 'p'	355 40.14 371.15 42.035 >0.05*	2557 364.017 2563.75 294.215 >0.05*	2115.66 328.463 2100.48 271.93 >0.05*	82.74 2.487 81.93 2.155 >0.05*	333.42 6.73 325 9.963 <0.001***	269.5 8.584 281.5 4.10 <0.001***	200.05 6.32 213.375 11.01 <0.001***	114.57 6.759 109 5.76 <0.001***
1st trimester Mean ± SD 3rd trimester Mean ± SD 'p'	355 40.14 382.3 28.35 <0.001***	2557 364.017 2498 204.239 >0.5*	2115.66 328.463 2048 184.597 >0.05*	82.74 2.487 82 2.26 >0.05*	333.42 6.73 319.85 8.728 <0.001***	269.5 8.584 291.8 7.71 <0.001***	200.05 6.32 222.95 16.67 <0.001***	114.57 6.759 106.67 3.898 <0.001***
2nd trimester Mean ± SD 3rd trimester Mean ± SD 'p'	371.15 42.035 382.3 28.35 <0.02**	2563.75 294.215 2498 204.239 >0.5*	2100.48 271.93 2048 184.597 >0.5*	81.93 2.155 82 2.26 >0.05*	325 9.963 319.85 8.728 <0.02**	281.5 4.10 291.8 7.71 <0.001***	213.375 11.01 222.95 16.67 <0.001***	109 5.76 106.67 3.898 <0.05**
20-30yrs age group Primi gravida Mean ± SD Multigravida Mean ± SD 'p'	355.5 40.502 371.116 38.325 >0.1*	2597.98 364.54 2485.48 312.214 >0.1*	2159.58 352.64 2045.83 270.55 >0.1*	82.45 2.52 82.24 1.99 >0.5*	329.916 8.203 327.75 10.99 >0.5*	274.041 11.392 282.375 10.205 >0.05*	206.66 12.27 213.625 11.802 >0.1*	113.12 6.917 110.125 6.536 >0.1*
31-40yrs age group Primi gravida Mean ± SD Multigravida Mean ± SD 'p'	367.583 43.582 364.166 37.253 >0.5*	2567.5 303.5 2542.916 256.828 .0.5*	2100.166 271.867 2098.75 262.28 >0.5	81.432 2.679 82.385 1.709 >0.1*	329 10.33 324.625 9.946 >0.1*	277.375 6.106 278.375 7.819 >0.05*	207.125 10.551 209.291 15.086 >0.5*	109.458 7.07 109.958 7.404 >0.5*

* = Not significant, ** = Significant, ***=highly significant

Conclusion

From our study of 120 pregnant women in the three trimesters of pregnancy in the age group of 20 to 40 it is concluded that there is definite increase in respiratory rate and tidal volume during pregnancy. There is no significant change in FVC and FEV1 during pregnancy even though there is a slight reduction of FVC in some cases. There is also no significant change in percentage FEV_1/FVC. 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 has no significant relation with pulmonary function tests.

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, $PaCO_2$ 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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