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Original Research Article

Respiratory Function in Normal Singleton Pregnancy, Multifetal Gestation and Polyhydramnios

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Abstract:

Background: Study of respiratory functions of four groups of women: Nonpregnant, early pregnancy, singleton pregnancy at 36 weeks and twin/polyhydramnios at 36 weeks reveal that inspiratory capacity (IC), tidal volume (TV) and expiratory reserve volume (ERV) in different group pairing have statistically significant difference. This is very important during the assessment of pregnant mother suffering from respiratory or cardiopulmonary disorder.

Objectives: This study aims to observe the additional demands placed on the maternal respiratory system in cases of advanced normal pregnancy or over distended uterus, like multifetal gestation and polyhydramnios, and whether the average Indian woman is able to cope with these respiratory changes.

Methods: Around 80 women were divided into four equal groups which included non-pregnant controls, normal early pregnancy (< 20 weeks), and normal singleton pregnancy at 36 weeks and multifetal gestation/polyhydramnios, underwent spirometry for static lung volume measurement. The overall comparison was done by using the Kruskal-Wallis test whereas the individual comparison by Mann-Whitney tests. Final statistical computing was performed with SPSS statistical package.

Results: The groups were comparable on the basis of age, height and hemoglobin levels. Comparisons of various groups show statistically significant difference in tidal volume, in spiratory capacity and expiratory reserve volume especially in advance pregnancy with control nonpregnant mothers without significant adverse effect on respiratory system.

Conclusions: Results of the study indicate that though there are significant respiratory functional changes, healthy women, even having twin/polyhydramnios, can tolerate this well. But this knowledge is very important to assess and to formulate management of pregnant women with respiratory or cardiopulmonary compromise.

Keywords: Singleton pregnancy, Twin polyhydramnios, Tidal volume, Inspiratory capacity, Expiratory reserve volume.

Introduction

The study of anatomic and physiologic adaptation of respiratory system in pregnancy is necessary for proper diagnosis and appropriate intervention in case of respiratory pathology associated with pregnancy. Estrogen causes hyperemia, hyper secretion and mucosal edema leading to nasal obstruction especially in third trimester.

On the other hand, progesterone resets chemoreceptors at a lower partial pressure of carbon dioxide leading to slight increase in partial pressure of oxygen in arterial blood (PaO_2) and decreases that of carbon dioxide ($PaCO_2$). It results in a state of respiratory alkalosis which is compensated for increased excretion of bicarbonate via urine to maintain normal acid base balance. [3] Respiration in pregnancy is more diaphragmatic where diaphragm is elevated by 4 cm. With compensatory increase in the transverse and anteroposterior diameters of chest caused by hormonal effects that loosen ligaments. It has been found that tidal volume (TV) increases progressively throughout pregnancy by increased excursion of diaphragm but inspiratory capacity (IC) and vital capacity (VC) remain almost unchanged in pregnancy.

Decreased expiratory reserve volume (ERV) and functional residual capacity (FRC) cause lungs to empty near completely during expiration leading to low defense against development of hypoxia. [3] Respiratory rate is unchanged, so the increased oxygen demand is met by increased depth of respiration and increased diaphragmatic excursion. Assisted reproduction increases the incidence of multifetal gestations which impose greater oxygen demand. On the other hand, these cases along with conditions like polyhydramnios causes more diaphragmatic elevation with much relaxed ligamentous attachment leading to more pronounced respiratory changes. This study aims to observe the additional demands of oxygen on above-mentioned cases, and whether the average Indian mother is able to cope with these respiratory changes.

Material and Methods

Present cross-sectional study was done at Department of Obstetrics and Gynecology, Sri Krishna Medical College and Hospital, Muzaffarpur, Bihar from December 2019 to November 2020. All women recruited were in the age group of 18 to 31 years, of moderate income group, mostly housewives with sedentary life style or limited physical activity.

All women are healthy having no current or past history of any cardiorespiratory illness, non-smoker and not taking any medication other than iron and calcium that is believed to alter respiratory function. Women with acute pregnancy complications, like pre-eclampsia, acute polyhydramnios, were excluded from this study. Four groups were studied: Nonpregnant, normal singleton pregnancy < 20 weeks, Normal singleton pregnancy at 36 weeks, Multifetal pregnancy and/or polyhydramnios at 36 weeks, each comprising 20 subjects.

Detailed history, physical examination and baseline investigations were done for each subject to rule out any cardiorespiratory illness and anemia. All women underwent spirometry at resting state, preferably few hours after meal. Tidal volume (TV), inspiratory capacity (IC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV) and vital capacity (VC) were measured on a system incorporated precision heated pneumatochograph manufactured by Medi Soft, Belgium, with proper calibration according to the ATS guidelines, and a racial correction factor of 0.85 is incorporated for Indian subjects. Parameters of lung functions were measured thrice and the best values were taken.

Statistical methods adopted in the study. Since the sample size in this study is small and hence may not follow a normal distribution, comparison may be made using nonparametric methods. The overall comparison was done by using the Kruskal-Wallis test. For individual comparison, Mann-Whitney test was applied. Statistical computing was performed with SPSS statistical package. Assuming that tidal volume is the primary variable of interest, it was calculated that a minimum of 17 subjects in each groups were required in order to detect a difference of 100 ml in TV with 80% power and 5% probability of type one error.

Results

The four groups were comparable on the basis of age, height, weight, blood pressure and hemoglobin levels. Except weight other parameters had no significant differences (Table 1). Weight gain during pregnancy is not significant for lung function testing as standard ATS guidelines for lung function test in March 1991 was based on height, age, sex and race of the individual.

In the present study, TV progressively increased with advancement of pregnancy (mean 0.56 to 0.88 lt, p = 0.002) but IC showed an increase especially in latter weeks (mean 1.65 to 1.95 lt, p = 0.016). On the other hand, ERV started falling in the later weeks of pregnancy (mean from 0.76 to 0.49 lt, p =0.000). As the gravid uterus enlarges, pushing the diaphragm up, VC and IRV showed insignificant difference during the course of pregnancy (Table 2). Same table shows no significant difference of lung function test between normal singleton pregnancy and multifetal pregnancy/ polyhydramnios group. The comparison between various groups pairing showed that the change of TV of groups 0-2, 0-3 and 1-3 show significant statistical importance (p-values 0.015, 0.000 and 0.044 respectively) . The statistical analysis of ERV of group pairing 0-2, 0-3, 1-2 and 1-3 also shows statistically important decrease (p-values 0.000, 0.000, 0.011 and 0.011 respectively). The IC in different groups pairing of 0-1, 0-3 and 1-3 also reveals statistically important increase (p-values 0.023, 0.007 and 0.034) (Table 3).

Table 1: Descriptive statistics of numeric variables of different groups

Variable	Nonpregnant (n=20)		
	Mean(min-max)	SD	SE
Gestational Age (days)	-	-	-
Age (years)	25-45 (18-31)	4.73	0.97
Height (cm)	150.35 (144-160)	5.05	1.13
Weight (kg)	53.45 (42.60)	4.18	0.93
Blood Pressure			
Systolic	118.30 (110-140)	9.11	2.03

Diastolic	76 (60-70)	7.53	1.68
Hb (gm/dl)	11.53 (10.80-12.40)	0.44	0.09 (10.9-12.2)

Variable	**Early pregnancy (<20 weeks) (n=20)**		
	Mean(min-max)	**SD**	**SE**
Gestational Age (days)	75.90 (65-84)	5.49	1.22
Age (years)	24.60 (18.31)	3.91	0.87
Height (cm)	151.20 (135-162)	7.35	1.64
Weight (kg)	50.30 (40-61)	5.31	1.18
Blood Pressure			
Systolic	113 (110-130)	5.71	1.27
Diastolic	74.5 (60-80)	6.04	1.35
Hb (gm/dl)	11.48	0.56 (10.8-12.2)	0.08

Variable	**Singleton Pregnancy (36 weeks) (n=20)**		
	Mean(min-max)	**SD**	**SE**
Gestational Age (days)	252 (252-252)	0	0 (252-258)
Age (years)	24.95 (21-31)	2.54	0.56
Height (cm)	153.15 (146-161)	4.15	0.93
Weight (kg)	60.20 (50-70)	6.85	1.53
Blood Pressure			
Systolic	118.50 (110-140)	9.33	2.08
Diastolic	76 (60-90)	7.53	1.68
Hb (gm/dl)	11.50 (11-12.5)	0.43	0.96

Variable	**Multifetal gestation and or polyhydramnios (36 weeks) (n=20)**			**p-value**
	Mean(min-max)	**SD**	**SE**	
Gestational Age (days)	255	2.17	0.46	
Age (years)	25.1 (18-30)	3.66	0.82	0.835
Height (cm)	153.05 (145-160)	4.24	0.95	0.237
Weight (kg)	60.25 (45-79)	8.64	1.89	0.000
Blood Pressure				
Systolic	123.10 (110-140)	9.11	2.03	
Diastolic	75 (60-80)	7.60	1.70	
Hb (gm/dl)	11.50	0.40	0.09	0.996

Table 2: Descriptive statistics of lung function tests of different groups

Variable	**Nonpregnant (n=20)**		
	Mean(min-max)	**SD**	**SE**
TV (Lt)	0.56 (0.39-1.08)	0.18	0.04 (0.34-1.30)
IRV (Lt)	1.04 (0.53-1.80)	0.28	0.06 (0.54-1.78)
ERV (Lt)	0.76 (0.42-1.06)	0.15	0.03 (0.23-1.20)
IC (Lt)	1.61 (1.84-3.29)	0.41	0.09 (0.88-2.49)
VC (Lt)	2.35 (1.84-3.29)	0.36	0.08 (1.77-3.12)

Variable	**Early pregnancy (<20 weeks) (n=20)**		
	Mean(min-max)	**SD**	**SE**
TV (Lt)	0.73	0.24 (0.28-2.08)	0.05
IRV (Lt)	1.03	0.30 (0.29-2.08)	0.07
ERV (Lt)	0.74	0.31 (0.13-0.77)	0.07
IC (Lt)	1.65	0.39 (1.29-3.58)	0.09
VC (Lt)	2.44	0.41 (1.74-3.79)	0.09

Variable	**Singleton Pregnancy (36 weeks) (n=20)**		
	Mean(min-max)	**SD**	**SE**
TV (Lt)	0.88 (0.40-1.20)	0.44	0.10
IRV (Lt)	1.09 (0.26-1.65)	0.45	0.10
ERV (Lt)	0.49 (0.07-1.30)	0.16	0.03

IC (Lt)	1.95 (1.26-2.63)	0.55	0.12
VC (Lt)	2.44 (1.83-3.93)	0.51	0.11

Variable	**Multifetal gestation and or polyhydramnios (36 weeks) (n=20)**			**p-value**
	Mean(min-max)	**SD**	**SE**	
TV (Lt)	0.85	0.21	0.05	0.002
IRV (Lt)	1.09	0.33	0.07	0.593
ERV (Lt)	0.49	0.29	0.66	0.000
IC (Lt)	1.91	0.35	0.08	0.016
VC (Lt)	2.43	0.46	0.10	0.921

TV = Tidal volume; IRV = Inspiratory reserve volume; ERV = Expiratory reserve volume; IC = Inspiratory capacity; VC = Vital capacity.

Table 3: Results of Mann-Whitney Test for Different groups pair showing significant p-values for test variables

Group	**Significance (p=-value ≤0.05 is significant)**		
	TV	**ERV**	**IC**
0-1	0.029	0.957	0.588
0-2	0.015	0.000	0.023
0-3	0.000	0.000	0.007
1-2	0.310	0.011	0.070
1-3	0.044	0.011	0.034
2-3	0.543	0.343	1.000

Nonpregnant = group 0; singleton early pregnancy = group 1; singleton pregnancy (36 weeks) = group 2; multifetal/polyhydramnios (36 weeks) = group 3. IC = inspitary capacity; TV = tidal volume; ERV = expiratory reserve volume

Discussion

In our study, TV increased steadily during pregnancy due to the effect of progesterone causing hyperventilation (increase depth of breathing) but the respiratory rate is constant which is corroborative to other study. Hence, the tidal volume and subsequently minute ventilation increased as reported by other authors.

The ERV is reduced by 35.8% in this study mostly in the later part of pregnancy (p-value 0.000). As the anatomical dead space and, hence, residual volume do not alter in pregnancy, the ERV is reduced due to elevated diaphragm and enlarging uterus consistent to other studies. Inspiratory capacity is increased specially in the later part of pregnancy (p-value 0.016) mainly due to the increased tidal volume since IRV remains unchanged.

These results are consistent with many other studies on respiratory changes in abnormal singleton pregnancy as mentioned above. But, presence of cardiological illness (e.g. mitral valve disease) or respiratory compromise (e.g. bronchial asthma), a significant reduction in VC may be noted as indicated by other authers.2 Various group pairing showed that there is significant difference in the TV, ERV and IC among the various groups of which some are statistically significant and comparable to other study.

In a similar study, comparing lung function between singleton and twin pregnancy, no statistically significant differences were reported, which is comparable to our findings. It is evident that the respiratory changes in pregnancy are largely mediated by hormonal factors, especially progesterone and to a lesser extent by estrogen.

The mechanical effects of the over distended gravid uterus cause relatively little changes in the pulmonary mechanics as it is compensated by increased circumference of thoracic cage as indicated by other studies without any major change of respiratory muscle force mechanism. Though multifetal gestation is associated with higher levels of progesterone, more oxygen consumption, more demands by fetuses and uterine over distention, the lung volume changes are similar to that seen in the singleton pregnancy. As over distention as such contributes very little to the alteration of lung volumes polyhydramnios does not seem to cause significant respiratory compromise.

Conclusion

It is evident from the study that a healthy woman without any respiratory or cardiovascular pathology can well-tolerate the mechanical compression upon the diaphragm by the enlarging uterus and also the increasing demands of the growing fetus in multifetal pregnancy/polyhydramnios.

It will help in better understanding of maternal respiratory physiology, and also management of the occasional cases of respiratory or cardiac disease with compromised respiratory function, where airway management and prevention of maternal hypoxemia are most important.

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