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ORIGINAL ARTICLE

Pulmonary Function During Pregnancy

Nigar Sultana[1], Syed Rezaul Huq[2], Fahmida Zabin[3], Tabassum Parvin[3], Md. Khairul Hassan Jessy[4], Md. Shahedur Rahman Khan[4], Md. Rashidul Hassan[5], Kazi Farhana Begum[6], Sahedul Islam Bhuiyan[7]

Abstract:

Objective: *To record any physiological changes in lung function during healthy pregnancies,*

Design: *A Prospective cohort study was done in Obstetrics Outpatient Department of Bangabandhu Sheikh Mujib Medical University Hospital, Dhaka &Aysha Memorial Specialized Hospital, Mohakhali, Dhaka and the population was 90 healthy women with singleton pregnancies.*

Methods & Results: *The women were studied with repeated measures of lung function using spirometry at a gestational age of 14–16, 22–24, 30–32 and 36 weeks, and at 6 months postpartum. The main outcome measures were Forced Vital Capacity (FVC), forced expiratory volume in 1 second (FEV1), and peakExpiratory flow (PEF), also expressed as a percentage of predicted values according to age and height: i.e. FVC%, FEV_1%, and PEF%. Both FVC and FVC% increased significantly after 14–16 weeks of gestation (P = 0.001), as was the case for both PEF and PEF% (P <0.001). FVC, FVC%, PEF, and PEF% in early and mid-pregnancy were significantly lower compared with the postpartum value (all P < 0.05). Nulliparous women had an overall 4.4% lower value of FVC% than parous women (P = 0.039). There were no differences in FVC, FEV_p or PEF dependent upon presentational overweight or excessive weight gain.*

Conclusions: *Forced vital capacity (FVC) increases significantly after 14-16 weeks of gestation. The FVC% is significantly higher in parous compared with primigravida women, suggesting that the changes in FVC occurring during pregnancy persist postpartum. PEF increases significantly during healthy pregnancies, and should be interpreted cautiously in pregnant women with impaired lung function.*

Keywords: *Lung function, Pregnancy, Lung health.*

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1. Assistant professor, Obstetrics &Gynaecology,Bangabandhu Sheikh Mujib Medical University, Dhaka.
2. Assistant Professor, Respiratory Medicine, National Institute of Diseases of the Chest & Hospital, Mohakhali, Dhaka.
3. Associate Professor, Obstetrics &Gynaecology,Bangabandhu Sheikh Mujib Medical University, Dhaka.
4. Associate Professor, Respiratory Medicine, National Institute of Diseases of the Chest & Hospital,Mohakhali, Dhaka
5. Director cum Professor. Respiratory Medicine, National Institute of Diseases of The Chest & Hospital,Mohakhali, Dhaka
6. Medical Officer, Obstetrics &Gynaecology, Bangabandhu Sheikh Mujib Medical University, Dhaka
7. Assistant Professor, Mainamoti Medical College, Comilla

Correspondence to: Dr. Nigar Sultana, Assistant professor, Obstetrics &Gynaecology,Bangabandhu Sheikh Mujib Medical University, Dhaka, Cell: 01715011749, Email: rezanigar@gmail.com

Introduction:

In pregnancy, hormonal changes and the progressive increase in abdominal volume may have mechanical and functional impact on respiratory function. However, an increased transverse diameter of the chest, resulting from a widened subcostal angle, opposes the effect of the enlarging pregnant uterus and elevated diaphragm, leaving pulmonary function altered, but not compromised, during pregnancy.[1]

Previous studies evaluating the effect of pregnancy on pulmonary function have shown that both minute ventilation (VE) and tidal volume (VT) are increased, whereas the functional residual capacity (FRC) and expiratory reserve volume (ERV) are decreased.[2-4]

Earlier studies addressing changes in pulmonary function during pregnancy have various methodological weaknesses, such as small sample size, cross-sectional study design or insufficient statistical methods, which may have limited the validity of their conclusions. When seeking to describe the natural course of physiological changes in lung function during pregnancy, the study design and choice of statistical methods and tests are of importance. A cross-sectional study design cannot provide data on individual changes over time, which limits the ability to elucidate the influence of advancing gestational age on the variablesof interest. A longitudinal study design with repeated measures of the variables of interest through- out pregnancy, although time-consuming and prone to withdrawal, allows the observation of changes during pregnancy. An analysis of longitudinal data should be per- formed using statistical methods that take into account the dependency between repeated measures from the same subject.[5]

Suboptimal pulmonary function in pregnancy has been associated with adverse pregnancy outcome. Pulmonary disease can affect pregnancy outcome and pregnancy can affect the course of pulmonary disease. The pregnancies of women with asthma are more likely to be complicated by pre-eclampsia, preterm birth, and lower birth weight than pregnancies in non-asthmatic women.[6] Studies have reported a direct relationship between maternal FEV_1 during pregnancy and infant birth weight,[7,8] and an inverse relationship with intrauterine growth retardation,[7] gestational hypertension, and preterm birth in asthmatic women.[6] As a consequence, pregnant women with pulmonary disease need regular monitoring of symptoms and measures of lung function by spirometry in order to optimize their lung function throughout pregnancy. Hence, understanding pulmonary changes in pregnancy through the evaluation of spirometry in normal pregnancy is of major clinical importance when facing pregnant women with pulmonary disease.

Based on these considerations, we endeavored to perform a more extensivestudy with repeated measures of healthy pregnant women in order to provide pertinent data on the physiological changes in lung function during pregnancy. Furthermore, we sought to evaluate the influence of parity, presentational overweight and excessive weight gain on lung function during pregnancy.

Materials and Methods:

A prospective longitudinal study of respiratory function was performed in 90 healthy women with singleton pregnancies. Exclusion criteria were asthma or other self-reported pulmonary disease, current tobacco use, hypertension (i.e. systolic/ diastolic blood pressure >140/90 mmHg), or other cardiovascular disease. The women were without current respiratory infection at the time of each measurement. The women were recruited by an open invitation to all patients at obstetric outpatient department of the Bangabandhu Sheikh Mujib Medical University & Aysha Memorial Specialized Hospital from October 2009 to August 2010. The follow-up period lasted until February 2011. And the women gave their written informed consent to participation. Respiratory function was measured repeatedly: four times during pregnancy (14-16, 22-24, 30-32, and 36 weeks of gestation), and at 6 months postpartum, thus allowing the women to serve as their own controls. Gestational age was estimated from an ultrasonography test, performed up to 18 weeks of gestation. Spirometry data, including FVC, FEV_1, and PEF were recorded using a Medgraphics Cardiorespiratory diagnosis,

Model CPSF/D USB; Medical Graphics Corporation, Minnessota, USA. The volume signal of the equipment was calibrated once daily with a 3L syringe. Tests were performed under calm conditions with the subject in a sitting position according to American Thoracic Society (ATS) guidelines.[18] After oral instruction the subjects exhaled forcefully until three acceptable curves were obtained. The highest values achieved were selected for analysis. These values are referred to as FVC%, FEV1%, and PEF%, respectively.

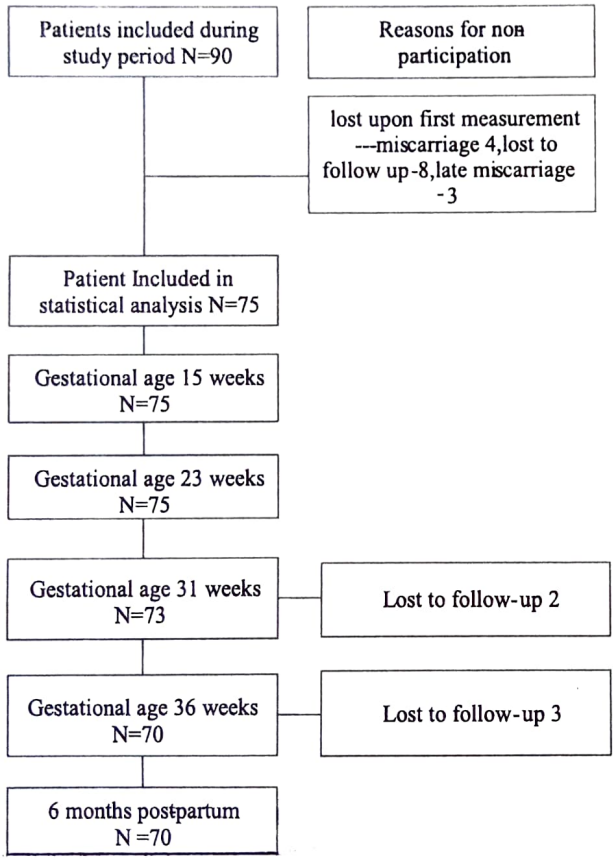

Fig.-1: *Flowchart of patient participation and follow-up throughout the study period. Subjects lost to follow-up between the first and second measurements were not included in the statistical analyses. The count at each time point represents the number of subjects examined. The counts in square brackets [] represents the number of subjects whose data were included in the statistical analyze. *Time of examination according to the mean value for the study population.*

Data analysis was carried out using SPSS 16 (SPSS Inc., Chicago, IL, USA). Data normality was investigated using the SPSS exploration option with summary statistics and graphical display.

Results:

A total of 100 women wereinvited to participate in the study, of which 90 women agreed to participate and were included. The repeated measurements of 75 women wereanalyzed. The statistical analyses were performed based on measurements repeated on fiveoccasions in 90 women. Figure 1 shows a flow diagram illustrating the number of data analyzed at each consultation and the various reasons for non-participation. The main characteristics of the study population are shown in Table 1. Two of the pregnant women developed late-onset pre-eclampsia (PE), these women are included in the analyses. The repeated measures of the women who developed late-onset PE were analyzed separately. There were no statistically significant differences between the pulmonary function of these two women and the women with uncomplicated pregnancies.

The mean values of FVC, FEV_1, and PEF, and their corresponding values expressed as the percentage of the predicted values, were within normal limits at alltimes inpregnancy (Table 2). FVC and FVC% increased significantly during pregnancy (P=0.001), and were significantly lower in early and mid-pregnancy compared with the post-partum value. Furthermore, nulliparous women had an overall 4.4% lower FVC% than parous women (P = 0.039; Figure 3). PEF and PEF% also increased during pregnancy (both P<0.001). The mean difference between the post-partum PEF and that at 14-16 weeks of gestation was 0.44 L/second, with a 25-75 percentile range of -0.03 to 0.87 L/second.

Forced expiratory volume in 1 second and FEV_1% did not show any alterations during pregnancy compared with the postpartum values. Values for FEV_1 and PEF did not show any differences between nulliparous and parous women. Figure 2 demonstrates the observed changes in FVC, FEV_1, and PEFduring pregnancy.

Table-I

Basiccharacteristics ofthestudypopulation (n=70)

	Number (%)	Mean or median*	SD	Range or 10–90 percentiles**
Maternal characteristics				
Age (years)		29	4.3	20–38
Height (cm)		157.5	5.2	145-170
Weight (kg)		54	11.3	38-70
Gravidity				
Para 0	51 (58.6)			
Para 1+	36 (41.4)			
Para 1	31 (35.6)			
Para 2	5 (5.8)			
GA at first measurement (weeks)		15*		14–17**
GA at second measurement (weeks)		23*		22–24**
GA at third measurement (weeks)		31*		30–32**
GA at fourth measurement (weeks)		36*		35–37**
Postpartum measurement (months)		6.0*		5.5–6.5**
Pregnancy outcome				
Vaginal delivery	58 (77.3)			
Caesarean section (elective/urgent)	17 (22.66)			
Fetal birth weight (g)		3326		
Fetal Apgar score at 1 minute/5 minutes		9/9*		

BMI, body mass index; GA, gestational age.

Table-II

Forced spirometry values during pregnancy and postpartum

	GA15 weeks (n=75)	GA23 weeks (n=75)	GA31 weeks (n=73)	GA36weeks (n=70)	6 months postpartum (n=70)
FVC (l)	3.89 ± 0.48**	3.92 ± 0.48***	3.96 ± 0.51	4.00 ± 0.53	4.00 ± 0.51
FVC nulliparous	3.84 ± 0.43	3.89 ± 0.45	3.92 ± 0.49	3.93 ± 0.47	3.97 ± 0.51
FVC parous	3.96 ± 0.55	3.98 ± 0.52	4.02 ± 0.53	4.08 ± 0.59	4.06 ± 0.51
FVC%	104.5 ± 10.6**	105.4 ± 11.0***	106.6 ± 11.6	107.6 ± 11.9	107.7 ± 11.9
FVC% nulliparous	102.9 ± 9.7	104.0 ± 10.5	105.1 ± 11.8	105.6 ± 11.1	106.1 ± 12.7
FVC% parous	106.8 ± 11.4	107.4 ± 11.5	108.8 ± 11.1	110.1 ± 12.7	110.0 ± 10.3
FEV1 (l)	3.18 ± 0.44	3.16 ± 0.39	3.20 ± 0.43	3.21 ± 0.43	3.20 ± 0.41
FEV1%	98.2 ± 11.1	97.6 ± 10.0	99.1 ± 11.4	99.3 ± 11.3	98.9 ± 10.9
PEF (l/second)	6.71 ± 1.19*	6.92 ± 1.13***	7.19 ± 1.10	7.24 ± 1.15	7.18 ± 1.05
PEF%	93.5 ± 15.5*	96.5 ± 14.9***	100.3 ± 13.8	101.0 ± 14.6	100.2 ± 13.1

FEV1, forced expiratory volume in 1 second; FEV1%, forced expiratory volume in 1 second, expressed as a percentage of the predicted value; FVC, forced vital capacity; FVC%, forced vital capacity expressed as a percentage of the predicted value; GA, median gestational age at measure- ment; PEF, peak expiratory flow; PEF%, peak expiratory flow expressed as a percentage of the predicted value. Values are means ± SDs.*P < 0.001; **P < 0.01; ***P < 0.05 for the comparison with postpartum value.

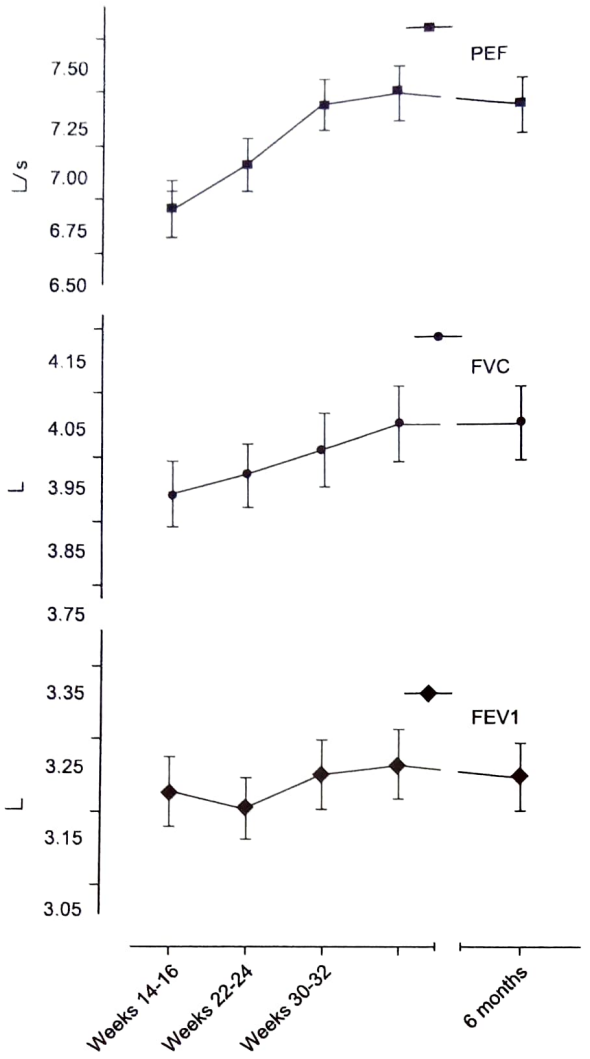

Fig.-2: *Changes in forced vital capacity (FVC), peak expiratory flow (PEF), and forced expiratory volume in 1 second (FEV1) during pregnancy and postpartum. Data are expressed as means ± SE. Significant changes: *P < 0.01, compared with the postpartum value;£P <0.05, compared with the postpartum value. The number of women analyzed at each time point appears in Figure 1 and Table 2*

Discussion:

The main finding is that FVCand PEF increase progressively after 14-16 weeks of gestation. As the parous women in our study had an overall significantly higher FVC% than the primigravida women, the increase in FVC occurring during pregnancy may be permanent. Although the magnitude of increase itself may be small, our findings may have impact on the clinical assessment and management of pregnant women with pre-existing pulmonary disease. The measured data for FVC, FEV_1, and PEF are all within the normal range of predicted values, and are in concordance with values measured in studies with a comparable group of pregnant women.[3,5]

Previous studies have concluded that forced spirometry values largely remain unchanged in normal pregnancy, compared with a non-pregnant control group,[2,3,7] or with a postpartum value.[5,6] However, these studies may not have had sufficient statistical power to detect minor differences, or may have had other methodological weaknesses.

We found that both FVC and FVC% increased during pregnancy. Furthermore, there was a significantly higher FVC% at any time point during pregnancy in parous compared with nulliparous women. This may suggest that the increase in FVC observed during pregnancy is permanent, persisting further in childbearing age. A similar statistical significant association between parity and lung function was found in an epidemiological study by Harik- Khan et al.[9]

In our study FVC% was 4.4 percentage points higher in parous compared with nulliparous women.

We found PEF to increase progressively with advancing gestational age. However, Brancazioet al.[10]measured PEF longitudinally during pregnancy using a handheld portable flow meter, and did not find any change during pregnancy. The measured values for both PEF and PEF% in each trimester are otherwise comparable between the two studies. Different measurement devices, differences in the timing of each measurement, differences in how the study is con- ducted, and differences in statistical methods may in part explain these differing findings and conclusions with respect to changes in PEF during pregnancy. Two studies have found PEF to decline during pregnancy.[10, 11]using a portable flow meter Harirahet al.[10]found PEF to decline with advancing gestational age. They explain their findings on a mechanical basis, pointing out the effectof the uterine enlargement and maternal weight gain. That the women in their study are of mixed ethnic origin is not fully appreciated, given its well-recognised influence on spirometry

values.[27] in addition, PEF unexpectedly continued to fall postpartum. Puranik et al.[11] measured PEF with a portable flow meter in an Indian population, and found PEF to decline throughout the course of pregnancy. They attribute their findings to inadequate nutritional status and developing muscular weakness because of poor socio-economic status in the studied population. The observations of that study would not apply to all populations because of variations in ethnic, social, and economic conditions. Hence, further studies would be warranted in different populations.

We did not find any significant difference in either PEF or PEF% between parous and nulliparous women. We suggest that the observed increase in PEF after 14-16 weeks of gestation represents a restoration of lung function after an initial drop in early pregnancy, rather than an actual increase in PEF from an even lower pregestational value. This topic needs further study, including reliable pregestational measurements, before we can fullyunderstand the impact of pregnancy and advancing gestational age on PEF measurements. The progressive increase in PEF after 14– 16 weeks of gestation is in concordance with previously reported bronchodilatation occurring during pregnancy.[12]

The physiological mechanisms of broncho-dilatation in pregnancy remain unclear, but pregnancy-induced reduction in pulmonary vagal efferent activity,[12] and progester-one-mediated alteration in airway smooth muscle tone,[13-14] may separately or in combination be responsible.

Brancazio et al.[10] found that PEF did not change during pregnancy, and concluded that PEF measurements by inexpensive portable flow meters may reliably be used to evaluate respiratory diseases such as asthma during pregnancy. Our results suggest that there is a natural course of change in PEF during pregnancy, increasing with advancing gestational age. Although the mean increase in PEF is small and may seem to have limited clinical relevance, the range indicates that some women experience a substantial increase in PEF during a healthy pregnancy. A study evaluating the influence of advancing gestational age on values obtained by forced spirometry, respiratory symptoms, and the use of medication in pregnant women with respiratory disease is warranted. Until such data are available, we are left to merely speculate that women with pre-existing pulmonary disease might experience the same changes in pulmonary function during the hormonal and mechanical influence of pregnancy as healthy women. If this is the case, measurements of PEF in the assessment and management of obstructive lung disease during pregnancy should be used and interpreted cautiously, and in the context of the women's gestational age, a progressive increase during pregnancy should be anticipated. The current study supports the hypothesis that any change in FEV1 during pregnancy in women with pulmonary disease can be ascribed to the pulmonary disease, as FEV1 remains unchanged during the course of a normal pregnancy.

Our present study did not include preconceptional measures. Although difficult to accomplish, a future study should include preconceptional measures in addition to repeated measures of the variables of interest at frequent intervals in the first trimester, and throughout the rest of the pregnancy, to fully elucidate the influence of conception and advancing gestational age. Furthermore, we acknowledge that some women may not be fully recovered to a state of normal cardiopul-monary physiology at 6 months postpartum.

Conclusion:

We conclude that FVC increases significantly after 14-16 weeks of gestation and throughout pregnancy. FVC% is significantly higher in parous compared with primigravida women, suggesting that changes in FVC occurring duringpregnancy persist postpartum. PEF increases significantly during healthy pregnancies, and should be interpreted cautiously in pregnant women with impaired lung function.

References

1. Contreras G, Gutierrez M, Beroiza T, et al. Ventilatory drive and respiratory muscle function in pregnancy. Am Rev Respir Dis. 1991; 144: 837-41.

2. Kolarzyk E, Szot WM, Lyszczarz J. Lung function and breathing regulation parameters during pregnancy. Arch Gynecol Obstet. 2005;272:53–8.

3. Griendham G, Toska K, Estensen ME, Rosseland La. Changes in pulmonary function during pregnancy Journal of Obstetrics & Gynaecology 2011;528:94-101

4. McAuliffe F, Kametas N, Costello J, Rafferty GF, Greenough A, Nicolaides K. Respiratory function in singleton and twin pregnancy. BJOG 2002;109:765–9.

5. Puranik BM, Kaore SB, Kurhade GA, Agrawal SD, Patwardhan SA, Kher JR. A longitudinal study of pulmonary function tests during pregnancy. Indian J Physiol Pharmacol. 1994;38:129–32.

6. Kallen B, Rydhstroem H, Aberg A. Asthma during pregnancy - a population based study. Eur J Epidemiol. 2000;16:167–71.

7. Schatz M, Zeiger RS, Hoffman CP. Intrauterine growth is related to gestational pulmonary function in pregnant asthmatic women. Kai- ser-Permanente Asthma and Pregnancy Study Group. Chest 1990;98:389–92.

8. Schatz M, Dombrowski MP, Wise R, et al. Spirometry is related to perinatal outcomes in pregnant women with asthma. Am J Obstet Gynecol. 2006; 194:120–6.

9. Harik-Khan R, Wise RA, Lou C, Morrell CH, Brant LJ, Fozard JL. The effect of gestational parity on FEV1 in a group of healthy volunteer women. Respir Med. 1999; 93: 382–8.

10. Brancazio LR, Laifer SA, Schwartz T. Peak expiratory flow rate in normal pregnancy. Obstet Gynecol. 1997;89:383–6.

11. Puranik BM, Kurhade GA, Kaore SB, Patwardhan SA, Kher JR. PEFR in pregnancy: a longitudinal study. Indian J Physiol Pharmacol. 1995;39:135–9.

12. Jensen D, Webb KA, Davies GA, O'Donnell DE. Mechanical ventilatory constraints during incremental cycle exercise in human pregnancy: implications for respiratory sensation. J Physiol. 2008; 586:4735–50.

13. McAuliffe F, Kametas N, Espinoza J, Greenough A, NicolaidesK.Respiratory function in pregnancy at sea level and at high altitude. BJOG. 2004;111:311–5

14. Avery ND, Wolfe LA, Amara CE, Davies GA, McGrath MJ. Effects of human pregnancy on cardiac autonomic function above and below the ventilatory threshold. J Appl Physiol. 2001;90:321–8.

15. Foster PS, Goldie RG, Paterson JW. Effect of steroids on beta-adrenoceptor-mediated relaxation of pig bronchus. Br J Pharmacol. 1983;78:441–5.

16. National Asthma Education Program. Report of the working group on asthma in pregnancy. Management of Asthma in Pregnancy. Department of Health and Human Services; 1993.

17. Unterborn J. Pulmonary function testing in obesity, pregnancy, and extremes of body habitus. Clin Chest Med. 2001;22:759–67.

18. American Thoracic Society. Standardization of spirometry, 1994 update. Am J Respir Crit Care Med. 1995;152:1107-36.