National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

Relationship of dynamic lung function parameters in pregnant women with different degrees of anemia: A cross-sectional study in Odisha

Priyadarsini Samanta[1], Laxman Kumar Senapati[2], Bhaskar Thakur[3]

[1]Department of Physiology, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India, [2]Department of Anaesthesia, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India, [3]Department of Community Medicine, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India

Correspondence to: Priyadarsini Samanta, E-mail: dr.priyasamanta@gmail.com

Received: April 04, 2018; **Accepted:** April 25, 2018

ABSTRACT

Background: Anemia has potential adverse effects on mother and fetus. Moderate-to-severe anemia in pregnancy reduces diaphragmatic strength and leads to exertional dyspnea. **Aims and Objective:** In the present study, we tried to establish a relationship between dynamic lung functions and different degrees of anemia in pregnant women of Odisha. **Materials and Methods:** A cross-sectional study was conducted during the year 2015–2016, consisting of 90 anemic pregnant females (30 in each trimester) within the age group of 20–35 years. 110 age-matched healthy pregnant women (35 in first and second and 40 in third trimester) were taken as controls. The dynamic lung function assessment was done in the subjects by Medspiror with Helios 401 software, and hemoglobin (Hb) was estimated. Forced vital capacity (FVC), forced expiratory volume (FEV_1), FEV_1/FVC, forced expiratory flow ($FEF_{25–75\%}$), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV) were the parameters studied. The statistical tests employed were the student's *t*-test, analysis of variance, Bonferroni, Univariate linear regression, and multiple linear regression. **Results**: With increasing severity of anemia, a progressive decline in dynamic lung functions was seen in anemic pregnant women. FVC, FEV_1, $FEF_{25–75\%}$, PEFR, and MVV values showed a significant decline ($P < 0.001$), while FEV_1/FVC value was increased from control to severe anemic pregnant subjects ($P < 0.001$). With *post hoc* Bonferroni, all the parameters were not significant when compared within control and mild anemic pregnant. FVC, FEV_1, PEFR, and MVV values were significantly reduced in moderate-to-severe anemia compared to control ($P < 0.001$) and in severe anemia compared to mild and moderate group ($P < 0.001$). FEV_1/FVC was significantly increased in moderate-to-severe anemia compared to control ($P < 0.001$) and in severe anemia compared to mild group ($P < 0.01$). $FEF_{25–75\%}$ value was only reduced in severe anemic versus control. When linear regression analysis and multiple linear regression for dynamic lung function parameters were applied, by considering Hb% as an independent variable and adjusting the effect of age, body mass index, and trimester, there was a significant positive association in all the parameters ($P < 0.001$), except FEV_1/FVC with significant negative association with one unit change in Hb% ($P < 0.001$). **Conclusion**: Moderate-to-severe anemia adversely affects pulmonary functions in pregnant women. Proper interventional strategies and anesthesia should be carried out to prevent adverse outcomes in anemic pregnant women.

KEY WORDS: Anemia; Dynamic Lung Functions; Pregnancy; Dyspnea

Access this article online	
Website: www.njppp.com	Quick Response code
DOI: 10.5455/njppp.2018.8.0412625042018	

INTRODUCTION

Anemia is the most common hematological disorder in pregnancy. The physiologic anemia of pregnancy reduces maternal blood viscosity and therefore increases placental perfusion, helps oxygen and nutrients delivery to the fetus, and anticipates the blood loss that attends normal

childbirth.[1,2] However, chronic severe anemia has potential adverse effects on the mother and the fetus. It results in impaired work capacity, hypoxemia, reduced transfer factor, impaired immune response, delayed wound healing, and recovery.[3-6]

In moderate-to-severe anemia, major maternal deaths occur due to antepartum hemorrhage, postpartum hemorrhage, pregnancy-induced hypertension, puerperal sepsis, and thromboembolic complications. Severe anemia (hemoglobin [Hb] <5 g/dl) in pregnancy is associated with circulatory failure and obstetric shock.[7,8]

The fetal adverse effects of maternal anemia are 3-fold risk of low birth weight babies, 2-fold risk of prematurity, lowered cognitive function, and more recently autism spectrum disorder (ASD).[9-13]

80% of maternal deaths due to anemia is contributed by India in South Asia.[14] The prevalence is highest in the eastern states, especially Bihar, Jharkhand, Odisha, Bengal, and Assam. High parity, low socioeconomic status, poor nutrition, and worm infestations are common predisposing factors.[15,16]

During pregnancy, expiratory muscle strength is in a lower normal range which is further weakened by anemia. It also reduces diaphragmatic strength, the main inspiratory muscle leading to exertional dyspnea.[17]

Changes in dynamic pulmonary function in anemic pregnancy have been sparingly reported. Thus, the objective of our study is to establish a relationship between dynamic pulmonary function and different degrees of anemia in all three trimesters of pregnancy.

MATERIALS AND METHODS

Sample Size

It was calculated using software nN Master. Since very few literature were available related to the current study, we had done power analysis by considering different standard deviations (SD) in both the groups for lung function parameters. At 5% level of significance with a minimum of 80% of study power, required sample size was 60 in the two groups (total 120). However, we had taken 200 subjects (90 cases and 110 controls) to increase the power of the study.

Study Design

With the approval from the Institutional Ethical Committee of S.C.B Medical College, Cuttack, and after obtaining written informed consent of patients, a cross-sectional study was conducted in the Department of Physiology, S.C.B Medical, College, Cuttack, Odisha, during the year 2015–2016. It included 90 anemic pregnant women (30 in each trimester) in the age group of 20–35 years. 110 healthy pregnant women (35 in first and second and 40 in third trimester) were taken as control in the same age range. All the cases and controls were selected from antenatal outdoor and indoor of Obstetrics and Gynaecology Department of S.C.B. Medical College and Hospital, Cuttack. A detailed history was taken, and complete systemic examination was done. The healthy subjects were judged on the following criteria:

- With Hb level >11 g/dl.
- No history of chronic cardiopulmonary disease during the 6 months period, before the testing or frequent colds. No obesity, history of smoking or tobacco chewing, evidence or history of disease, which affect pulmonary function (e.g., neuromuscular disorder or arthritis of spine). No obvious sign of malnutrition or skeletal deformities affecting normal expansion of lungs.

The Hb level in the anemic pregnant patients was in the range of 10.9 g/dl–4 g/dl. The cases were again subdivided into mild, moderate, and severe anemia based on the WHO criteria for Hb.

- Mild anemia in pregnancy: 10–10.9 g/dl
- Moderate anemia in pregnancy: 7–10 g/dl
- Severe anemia in pregnancy: 4–6.9 g/dl.

Assessment of Parameters

1. The anthropometric parameters such as age, height, and weight of subjects were measured.
2. Hb estimation: was done by Sahli's Acid Hematin method.
3. Pulmonary function test: The dynamic pulmonary function assessment was done by Medspiror with Helios 401 Software (by Recorders and Medicare Systems RMS, Chandigarh, Version 0.1, January 2004). Before the test, the subject was asked to relax for 5 min. The tests were carried out in a quiet room in sitting position. A fixed time schedule between 10 am and 12 noon was chosen to avoid diurnal variation. Dynamic lung function parameters: Forced vital capacity (FVC), forced expiratory volume (FEV_1), FEV_1/FVC, forced expiratory flow ($FEF_{25–75\%}$), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV) were recorded.

Statistical Analysis

All data were expressed as mean ± SD. Statistical analysis was done using SPSS (version 21.0; SPSS Inc., Chicago, IL, USA) by student's *t*-test, one-way analysis of variance, Bonferroni multiple comparison, univariate linear regression, and multiple linear regression. A level of $P < 0.05$ was used to indicate statistical significance, and $P < 0.001$ was considered as highly statistically significant in all analyses.

RESULTS

Both the study and control groups were comparable with respect to age and body mass index (BMI), except for height,

weight, and Hb% which were significantly less in the study group [Table 1].

When dynamic lung function parameters were compared in control and study group pregnant females, all the parameters were reduced significantly except FEV_1/FVC (%) which was significantly increased in anemic pregnant women compared to healthy pregnant women ($P < 0.001$) [Table 2].

With increasing severity of anemia, a progressive decline in dynamic lung functions was seen in anemic pregnant women. FVC, FEV_1, $FEF_{25–75\%}$, PEFR, and MVV values showed a significant decline ($P < 0.001$) while FEV_1/FVC value was increased from control to severe anemic pregnant subjects ($P < 0.001$) [Table 3a].

Table 1: Baseline characteristics in control and study group pregnant females

Characteristics	Control group (*n*=110)	Study group (*n*=90)	*P*
Age (years)	25.68±3.064	25.81±3.17	0.77
Height (mt)	1.53±0.042	1.516±0.048	0.011*
Weight (Kg)	58.527±5.43	56.24±4.27	0.0014*
BMI (Kg/m^2)	24.95±2.57	24.50±2.109	0.1895
Hb (g/dl)	11.93±0.748	8.33±1.88	0.0000**

All data presented are in mean±SD. $P<0.05$*, $P<0.001$**.
SD: Standard deviation, Hb: Hemoglobin, BMI: Body mass index

With *post hoc* Bonferroni, all the parameters were not significant when compared within control and mild anemic pregnant females. FVC, FEV_1, PEFR, and MVV values were significantly reduced in moderate-to-severe anemia compared to control ($P < 0.001$) and in severe anemia compared to mild and moderate group ($P < 0.001$). FEV_1/FVC was significantly increased in moderate-to-severe anemia compared to control ($P < 0.001$) and in severe anemia compared to mild group ($P < 0.01$). $FEF_{25–75\%}$ value was only reduced in severe anemic versus control [Table 3b].

When linear regression analysis [Table 4] and multiple linear regression [Table 5] for dynamic lung function parameters were applied, by considering Hb% as an independent variable and adjusting the effect of age, BMI and trimester, there was a significant positive association in all the parameters ($P < 0.001$), except FEV_1/FVC with significant negative association with one unit change in Hb% ($P < 0.001$).

DISCUSSION

In the present study, when dynamic lung function parameters were compared in control and study group pregnant females, all the parameters were reduced significantly except FEV_1/FVC (%) which was significantly increased in anemic pregnant women compared to healthy pregnant women. Similar findings were documented by other investigator who observed a significant lower PEFR in anemic pregnant women as compared to normal pregnant women in third

Table 2: Dynamic lung function parameters in control and study group pregnant females

Parameters	Control group (*n* =110)	Study group (*n* =90)	*P*
FVC (L)	2.51±0.26	2.16±0.31	0.0000**
FEV_1 (L)	2.12±0.24	1.88±0.26	0.0000**
FEV_1/FVC (%)	84.49±3.14	86.9±2.71	0.0000**
$FE_{F25–75\%}$ (L/s)	2.69±0.25	2.55±0.29	0.0003**
PEFR (L/s)	5.13±0.62	4.21±0.72	0.0000**
MVV (L/m)	67.5±7.44	54.87±10.09	0.0000**

All data presented are in mean±SD, $P<0.05$*, $P<0.001$**. SD: Standard deviation, FVC: Forced vital capacity, FEV: Forced expiratory volume, FEF: Forced expiratory flow, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation

Table 3a: Dynamic lung function parameters in control and study group with different degrees of anemia (ANOVA)

Parameters	Control (*n*=110)	Mild anemia (*n*=30)	Moderate anemia (*n*=30)	Severe anemia (*n*=30)	*F*	*P*
FVC (L)	2.51±0.25	2.41±0.26	2.18±0.21	1.89±0.16	57.29	0.0000**
FEV_1 (L)	2.12±0.24	2.06±0.25	1.91±0.18	1.67±0.17	33.62	0.0000**
FEV_1/FVC (%)	84.49±3.13	85.47±2.55	87.11±2.34	88.11±2.62	15.85	0.0000**
$FE_{F25–75\%}$ (L/s)	2.68±0.25	2.61±0.29	2.56±0.31	2.46±0.26	6.00	0.0006**
PEFR (L/s)	5.13±0.61	4.86±0.46	4.12±0.52	3.63±0.55	65.57	0.0000**
MVV (L/min)	67.5±7.44	65.23±5.98	54.8±5.92	44.6±4.63	107.00	0.0000**

All data presented are in mean±SD. $P<0.05$*, $P<0.001$**. FVC: Forced vital capacity, FEV: Forced expiratory volume, FEF: Forced expiratory flow, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, ANOVA: Analysis of variance

Table 3b: Dynamic lung function parameters within control and study group with different degrees of anemia (Bonferroni)

Parameters	Control versus mild	Control versus moderate	Control versus severe	Mild versus moderate	Moderate versus severe	Mild versus severe
FVC (L)	0.365	0.000**	0.000**	0.002*	0.000**	0.000**
FEV_1 (L)	1.000	0.000**	0.000**	0.043	0.000**	0.000**
FEV_1/FVC (%)	0.605	0.000**	0.000**	0.170	1.000	0.003*
$FEF_{25–75\%}$ (L/s)	1.000	0.129	0.001*	1.000	1.000	0.233
PEFR (L/s)	0.145	0.000**	0.000**	0.000**	0.007*	0.000**
MVV (L/min)	0.603	0.000**	0.000**	0.000**	0.000**	0.000**

P<0.01*, *P*<0.001**. FVC: Forced vital capacity, FEV: Forced expiratory volume, FEF: Forced expiratory flow, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation

Table 4: Linear regression analysis for dynamic lung function parameters by considering Hb% as an independent variable

Outcome parameters	"β" coefficient	*P*
FVC (L)	0.11	0.000**
FEV_1 (L)	0.08	0.000**
FEV_1/FVC (%)	−0.73	0.000**
$FEF_{25–75\%}$ (L/s)	0.048	0.000**
PEFR (L/s)	0.29	0.000**
MVV (L/min)	4.13	0.000**

P<0.05*, *P*<0.001**. FVC: Forced vital capacity, FEV: Forced expiratory volume, FEF: Forced expiratory flow, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, Hb: Hemoglobin

Table 5: Multiple linear regression for dynamic lung function parameters by considering Hb% as an independent variable and adjusting the effect of age, BMI, and trimester

Parameters	"β" coefficient	*P*
FVC (L)	0.10	0.000**
FEV1 (L)	0.073	0.000**
FEV1/FVC (%)	−0.598	0.000**
FEF25–75% (L/s)	0.044	0.000**
PEFR (L/s)	0.256	0.000**
MVV (L/min)	3.738	0.000**

P<0.05*, *P*<0.001**. FVC: Forced vital capacity, FEV: Forced expiratory volume, FEF: Forced expiratory flow, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, Hb: Hemoglobin, BMI: Body mass index

trimester. Due to the decline of oxygen-carrying capacity of blood, tissue hypoxia occurs and anaerobic metabolites like lactate gets accumulated which causes exhaustion and fatigue of respiratory muscles. The PEFR is more sensitive to muscular element in respiration.[18]

Another study found a significant decline in PEFR values in anemic children as compared to healthy children. The reduced concentration of myoglobin and cytochrome C in skeletal muscle is directly related to degree of anemia.[19]

Blumgart *et al*. documented a decrease in FVC in anemic patients which may be attributed to reduced lung distensibility and congestion in anemia.[20]

Our study results also corroborate with some other researchers in the same field.[21,22]

In contrast to our study, Gupta P *et al*. documented normal PEFR and FEV_1 and reduced $FEF_{25–75\%}$ in their study.[23] Guleria *et al*. documented no significant change in FEV_1 and $FEF_{25–75\%}$ in anemic patients. Patients having clinical or radiological evidence of pulmonary congestion were excluded from the study. The low value of MVV in their study is comparable with the present study and shows similar findings.[24]

With increasing severity of anemia, a progressive decline in dynamic lung functions was seen in anemic pregnant women. With *post hoc* Bonferroni, all the parameters were not significant when compared within control and mild anemic pregnant females. FVC, FEV_1, PEFR, and MVV values were significantly reduced in moderate-to-severe anemia compared to control and in severe anemia compared to mild and moderate group. This may be due to tissue hypoxia and deficient myoglobin and cytochrome C resulting in striated respiratory muscle dysfunction.

FEV_1/FVC was significantly increased in moderate-to-severe anemia compared to control and in severe anemia compared to mild group which shows restrictive defect. $FEF_{25–75\%}$ value was only reduced in severe anemic versus control as it is a marker of small airway obstruction and is effort independent.

When linear regression analysis and multiple linear regression for dynamic lung function parameters were applied, by considering Hb% as an independent variable and adjusting the effect of age, BMI, and trimester, there was a significant positive association of all the parameters with Hb% except FEV_1/FVC with significant negative association. It means that with one unit reduction in Hb%, all the dynamic lung function parameters decline significantly except FEV_1/FVC, which increases with significant "β" coefficient.

Limitations of the Study

Multicentric studies are required.

CONCLUSION

Thus, the present study highlights the observation that moderate-to-severe anemia in pregnancy adversely affects dynamic pulmonary functions. Reduction in Hb% is strongly associated with detrimental effect on dynamic lung functions. Proper interventional strategies should be carried out to prevent adverse outcomes of surgery and anesthesia during parturition. Intake of iron supplements should be advised in early pregnancy.

ACKNOWLEDGMENTS

We are very much thankful to the Head of the Department of Physiology and O and G, S.C.B Medical College, Cuttack, Odisha, for their guidance and support.

REFERENCES

1. Greer JP, Foerster J. Anemias During Pregnancy and the Postpartum Period. Wintrobe's Clinical Hematology. 12th ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins Health; 2009. p. 1239-46.
2. Hytten F. Blood volume changes in normal pregnancy. Clin Haematol 1985;14:601-12.
3. Rankin J, McNeill RS, Forster RE. The effect of anemia on the alveolar-capillary exchange of carbon monoxide in man. J Clin Invest 1961;40:1323-30.
4. Ramachandran R. Nutrition in Pregnancy. Women and Nutrition in India, Special Publication No.5. New Delhi: Nutrition Foundation of India; 1989. p. 153-93.
5. Ramachandran P. Anaemia in pregnancy. In: Ratnam SS, Rao KB, Arulkumaran S, editors. Obstetrics and Gynaecology for Postgraduates. Vol. 1. Madras: Orient Longman; 1992. p. 42-53.
6. Prema K, Ramalakshmi BA, Madhavapeddi R, Babu S. Immune status of anaemic pregnant women. Br J Obstet Gynaecol 1982;89:222-5.
7. Menon MK. Observations on anaemia in pregnancy. Proc Nutr Soc India 1967;2:1-11.
8. Kalaivani K. Prevalence and consequences of anaemia in pregnancy. Indian J Med Res 2009;130:627-33.
9. Lister VG, Rossiter CE, Chong M. Perinatal Mortality. Br J Obstet Gyn 1985;92 Suppl 5:88-99.
10. Scholl TO, Hediger ML, Fischer RL, Shearer JW. Anemia vs iron deficiency: Increased risk of preterm delivery in a prospective study. Am J Clin Nutr 1992;55:985-8.
11. ACC/SCN. Controlling Iron Deficiency. Geneva: World Health Organization; 1991.
12. Prevention and Management of Severe Anaemia in Pregnancy. Report of a Technical Working Group, Geneva, May 1991. Geneva: World Health Organization; 1993.
13. Rebecca J, Daniel JS, Robin LT, Ozonoff HS. Maternal intake of supplemental iron and risk of autism spectrum disorder. Am J Epidemiol 2014;180:890-900.
14. Ezzati M, Lopus AD, Dogers A, Vander HS, Murray C. Selected major risk factors and global and regional burden of disease. Lancet 2002;360:1347-60.
15. Padhi M, Padhi PK. Anaemia in pregnancy. The Indian Scenario. Orissa Med J 2012;32:3-12.
16. Khandal D, Korum M, Vasudeo N. Risk factors for anaemia in pregnancy. J Obstet Gynaecol India 2001;51:42-45.
17. Derenne JP, Macklem PT, Roussos CH. The respiratory muscles: Mechanics, control and pathophysiology. Am Rev Respir Dis 1978;118:119-33, 373-90, 581-601.
18. Singhal U, Saxena K. Effect of anaemia on respiratory and metabolic parameters during IIIrd trimester of pregnancy. Indian J Physiol Pharmacol 1987;31:130-5.
19. Dutt SN, Yeshwanth M, Raghuveer TS. Effect of iron deficiency anaemia on pulmonary function in children. Lung India 1944;12:168-73.
20. Blumgart HL, Garill SL, Gilligan DR. Studies in the velocity of blood flow. XV, velocity of blood flow and other aspects of the circulation in patients with primary and secondary anemia and in two patients with polycythemia vera. J Clin Invest 1931;9:679-92.
21. Kumari AK, Kranthi TR, Soni S. Pulmonary function tests in Indian women with Iron deficiency anemia. Sch J App Med Sci 2014;2:3409-11.
22. Jain S, Agarwal JL. Pulmonary function assessment in young female medical students suffering from anemia. Acta Med Int 2014;1:3-5.
23. Gupta P, Pande JN. Pulmonary and diaphragmatic functions in chronic severe nutritional anaemia. Natl Med J India 1989;2:266-8.
24. Guleria JS, Pande JN, Markose MM, Gupta RG, Jain BP. Pulmonary function in chronic severe anaemia. Clin Sci 1971;40:317-25.

How to cite this article: Samanta P, Senapati LK, Thakur B. Relationship of dynamic lung function parameters in pregnant women with different degrees of anemia: A cross-sectional study in Odisha. Natl J Physiol Pharm Pharmacol 2018;8(8):1166-1170.

Source of Support: Nil, **Conflict of Interest:** None declared.