DOI: 10.14260/jemds/2015/854

ORIGINAL ARTICLE

GROWTH RATE OF HUMAN FETAL LUNG WITH INCREASE IN GESTATIONAL AGE: A MORPHOLOGICAL STUDY

Rajkumari Ajita[1]

HOW TO CITE THIS ARTICLE:
Rajkumari Ajita. "Growth Rate of Human Fetal Lung with Increase in Gestational Age: A Morphological Study". Journal of Evolution of Medical and Dental Sciences 2015; Vol. 4, Issue 34, April 27; Page: 5827-5833, DOI: 10.14260/jemds/2015/854

ABSTRACT: AIM: The present study was designed to find out a relationship between growth rate of lung of the human fetuses at different gestational weeks and that of lung weight/body weight ratio with increase in gestational weeks. **SETTINGS AND DESIGN:** This morphological study was carried out at the Department of Obstetrics and Gynaecology of Regional Institute of Medical Sciences Hospital, Imphal, Manipur with the permission of the Medical Superintendent. **MATERIALS AND METHODS:** The study was carried out on 63 (Sixty three) fetuses of different gestational ages ranging from 11th to 36th gestational weeks obtained from the Department of Obstetrics and Gynaecology of Regional Institute of Medical Sciences Hospital, Imphal. The gross morphological parameters such as weights of fetuses and lungs were noted. The mean±SD values of the fetuses and lung weights were measured. The data were statistically and graphically analyzed. **RESULTS:** The growth rate of left and right lungs showed a minimal value of about 1.80 gm upto 13th gestational week and thereafter showed a gradual increase from 13th to 20th week and then showed a moderately steep rise and was found to be almost similar upto 24th week showing an average weight of about 18 gm. From 24th week, the growth rate of right lung was found slightly faster than that of left lung upto the 36th gestational week. The differential rate of the lung weight/body weight ratios was observed as follows: a steep fall from 11th to 12th week, then a gradual increase from 12th to 14th week, then a moderately steep fall from 14th to 16th week and then a gradual fall upto 20th week, a gradual increase from 20th to 24th week, then a gradual fall from 24th to 31st week and then remained almost constant upto 36th week. **CONCLUSION:** The present study revealed that the growth rate of both the lungs increased gradually upto 20th week and then a moderate steep rise from 20th to 24th week. A significant and an unique finding of the present study was that there was a steep fall in the lung weight/body weight ratio from 11th to 12th week. These findings have been corroborated and correlated with findings of other workers.

KEYWORDS: Human fetus, fetal weights, lung weights, organ weight/bodyweight ratios, gestational weeks.

INTRODUCTION: The lungs are the essential organs of respiration. They are situated on either side of the heart and other mediastinal contents. Each lung is free in each plural cavity except for its attachment to the heart and trachea at the hilum and pulmonary ligaments. When removed, a lung, being spongy can float in water and crepitates when handled, due to the air within its alveoli. It is also highly elastic and retracts when removed from the thorax. Its surface is smooth, shiny and separated by fine, dark lines into numerous small polyhydral domains, each crossed by numerous finer lines indicating the areas of contact between its most peripheral lobules and plural surface. The weight of the lung is dependent on the amount of blood or serous fluid in proportion to body stature, the lungs are heavier in men than women.[1]

DOI: 10.14260/jemds/2015/854

The lungs contain a high proportion of elastic tissue, the fresh lungs will contract and expel most of the air within it. This elasticity is responsible for most of the expiratory force in quiet respiration.[2]

Human lung growth starts as a primitive lung bud in early embryonic life and undergoes several morphological stages which continue into postnatal life. Each stage of lung growth is a result of complex and tightly regulated events governed by physical, environmental, hormonal and genetic factors. Fetal lung liquid and fetal breathing movements are by far the most important determinants of lung growth. In the human embryo, development of lung starts as early as 3 weeks of embryonic life and continues into postnatal life upto early adulthood. The structural and vascular development of the lung is closely related and progresses simultaneously in human fetuses. Lung development is a complex process with a host of regulatory factors. The events of antenatal growth and development of human lung have traditionally been divided into five stages viz. embryonic, pseudoglandular, canalicular, saccular and alveolar.[3,4,5,6,7 & 8]

The embryonic period, during which the lung primordium is laid down as a diverticulum of the foregut, lasts for about seven weeks. From the 5th to 17th week, the lung looks much like a tubulo-acinar gland, with epithelial tubes sprouting and branching into the surrounding mesenchyme. In the last week of this pseudoglandular stage, the prospective conductive airways have been formed and the acinar limits can be recognized. The events of the subsequent canalicular phase (17th - 26th week) can be summarized as the widening of the peripheral tubules, the differentiation of the cuboidal epithelium, the formation of the first thin air-blood barriers and the start of surfactant production. During the saccular stage, which follows and lasts until birth, the growth of the pulmonary parenchyma, the thinning of the connective tissue between the airspaces and further maturation of the surfactant system are the most important steps towards life.[3]

The transition between different stages occurs gradually and that there is considerable overlap between one stage to the next and also between various areas within the lung and between various gestational ages and individuals.[6] Lung development is considered as a combination of two processes (i) lung growth (Structural development) and (ii) lung maturation (Functional development). Lung growth seems to be influenced primarily by physical factors such as intra-thoracic space, lung liquid volume and pressure and aminiotic fluid volume among others.[7] As expected, fetal weights as well as tissue weights increased with the progress of gestation. Among the tissues studied, the lung apparently enjoys an ontogenetic priority while intestine appears to be the last to develop. Fetal growth retardation seems to be associated with decreased weights of lung.[9]

During gestation, the fetal lung undergoes significant morphological changes to provide at birth an organ capable of maintaining respiration and gas exchange. Burdi AR et al[10] stated that fetal body weight rather than commonly used crown-rump length or menstrual age is the best reference parameter for assessing either growth of a single organ or in the generation of regression formulae.

As the existing literatures on the growth rate of the lung in human fetuses with respect to the different gestational weeks are found inadequate, the present study was designed to find out a relationship between growth rate of lung of the human fetuses at different gestational weeks and that of lung weight/body weight ratio with increase in gestational weeks.

MATERIALS & METHODS: In the present study, 63 human fetuses (29 males and 34 females) of different age groups ranging from 11th to 36th gestational week were procured from the Department of Obstetrics and Gynaecology of Regional Institute of Medical Sciences Hospital, Imphal, Manipur for

DOI: 10.14260/jemds/2015/854

the study with the permission of the Medical Superintendent. These fetuses were the products of terminated pregnancies and stillbirths. Those fetuses from multiple pregnancies with congenital anomalies on gross examination were excluded from the study. Only the fetuses with normal obstetrical history and free from detectable abnormality were taken into consideration for the study.

The fetuses so obtained were examined for their respective crown-rump (CR) lengths with the help of osteometric board and measuring tape and body weights by electronic weighing machine. The gestational age of the fetuses was determined by its crown-rump length and from obstetrical history. Thereafter, they were fixed in 10% formalin for 10 days. Then the fetuses were subjected to dissection. The sterno-clavicular joints were disarticulated and costal cartilages were cut. Thus the entire thoracic cavity was opened for complete exposure of the lung in its natural location for proper recording. After opening of the thoracic cavity, the root of each lung was dissected and cut off at the hilum and then both lungs were removed out of the thoracic cavity.

The organ was then examined and its weight recorded with the help of electronic weighing machine. Particulars of the sex, gestational week, body weight of the fetuses and weight of the lungs were then noted down. All the data were represented as mean ± standard deviation. The data of weights of the body and the lung as well as that of the lung weight/body weight ratios of the fetuses were prepared as group mean values ± standard deviation. All the data were then analyzed and represented graphically and appropriate statistical analysis was performed. Significance of the various parameters and inter-class significance were then analyzed by using ANOVA test.

RESULTS & OBSERVATIONS: The weights of the fetuses and their corresponding lungs were recorded. The results of the mean weights of the fetuses and the lungs (11th to 36th gestational week) along with standard deviation values were summarized. The mean±standard deviation values of the ratios of the lung weight/body weight were also calculated. Since no significant sex difference was observed in the body weight and the lung weight in the present study, the data of both sexes were combined. All these values were presented in the Table shown below:

Age in weeks	No. of fetuses	Average weights of fetuses ± S.D. (in gm)	Average lung weights ± S.D. (in gm)		Average lung weight/body weight ratio
			Right	Left	
11	4	17.80±0.22	1.39±0.063	1.24±0.085	0.148±0.00770
12	4	37.93±0.53	1.43±0.021	1.263±0.048	0.072±0.00016
13	3	45.30±0.44	1.90±0.055	1.70±0.087	0.0790±0.00028
14	3	81.63±1.17	3.77±0.225	2.90±0.606	0.0817±0.01048
16	4	207.98±1.85	4.45±0.265	4.20±0.235	0.0416±0.00219
18	3	333.67±2.23	5.77±0.2360	5.32±0.257	0.0330±0.00124
20	4	515.58 ± 1.69	8.18 ± 0.310	7.525±0.584	0.0300±0.00162
22	3	700.00±3.54	14.08±0.380	13.62±0.470	0.0500±0.00132
23	4	779.60±3.33	16.80±0.630	16.24±0.550	0.0420±0.00128
24	3	860.30±5.13	18.32±0.280	17.97 ± 0.503	0.0422±0.00103
25	3	986.87±24.77	19.02±0.076	17.33 ± 0.160	0.0370±0.00101
27	3	1221.80±19.80	19.22±0.290	17.61±0.104	0.0300±0.00064
29	4	1635.83±36.33	20.09±0.085	19.09±0.690	0.0238±0.00063
31	4	1962.80±31.41	21.64±0.042	19.75±0.534	0.0210±0.00075

DOI: 10.14260/jemds/2015/854

33	3	2354.93±39.44	23.25±0.480	22.25±0.589	0.0193±0.00046
34	4	2554.63±32.09	24.03±0.086	22.36±0.480	0.0182±0.00032
35	3	2800.37±20.35	25.36±0.520	23.91±0.144	0.0176±0.00034
36	4	2978.00±21.36	27.76±0.440	26.063±0.686	0.0181±0.00030
All mean values are statistically significant at 0.05 level: $p < 0.05$					

Table: Mean weight of the fetus, lung and fetus weight/lung weight ratio at different gestational week

Figure 1: Graph showing the comparison of growth rate of left and right lungs with increase in gestational weeks in human fetuses.

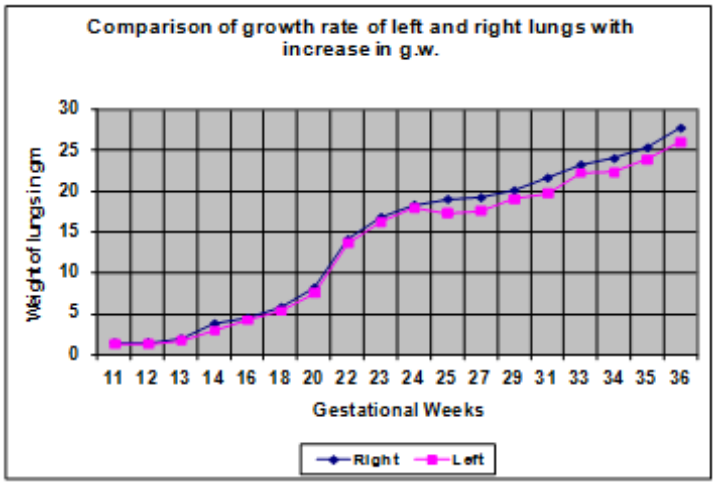

Fig. 1

Figure 2: Graph showing the relationship of lung weight/body weight ratio with increase in gestational weeks in human fetuses.

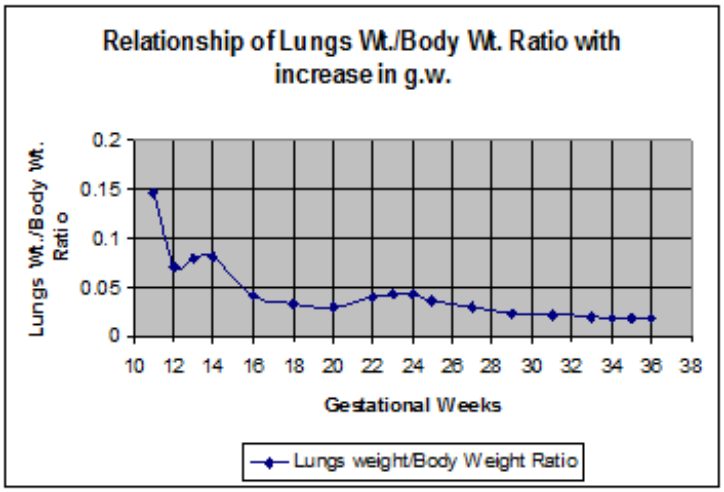

Fig. 2

DOI: 10.14260/jemds/2015/854

DISCUSSION: Study of growth rate of the lung in human fetuses at different gestational weeks was indeed an interesting area where many workers had already done some significant works and many more workers are still investigating into the matter. Discussion of the present study focused mainly upon the following sub-headings in the background of the available literatures in the field.

Lung weight with respect to gestational weeks: The growth rate of left and right lung showed a minimal value of about 1.80 gm up to 13 g. w. and thereafter showed a gradual increase from 13 to 20 g. w. and then showed a moderately steep rise and was found to be almost similar up to 24 g. w. recording an average weight of 18 gm. From 24 g.w. onwards, the growth rate of right lung was found slightly faster than that of left lung. At 36 g.w., the right lung recorded 27.75 gm whereas the left lung recorded 26 gm. The graph in Fig. 1 shows the comparison of growth rate of left and right lungs with increase in gestational weeks in human fetuses.

Lung weight/ body weight ratios with respect to gestational weeks: In the present study, the differential growth rate of the lung weight/body weight ratios with increase in gestational weeks was observed as follows: a steep fall from 11 to 12g.w., then a gradual increase from 12 to 14g.w. Thereafter, a moderately steep fall is seen from 14 to 16 g. w. and then a gradual fall up to 20g.w. Then, there is a gradual increase from 20 to 24g.w. and a gradual fall from 24 to 30g.w. and finally remained almost constant up to 36g.w. Tanimura et al[11] reported that the ratio of lung weight to body weight was found increasing and then decreasing and the ratio reached the maximum at 13-14 weeks of gestation, which is almost found in conformity with the finding of the present study.

However, in the present study, an unique and interesting finding is that the lung weight/fetus weight ratio was found significantly higher at 11th gestational week as can be seen from the graph shown in Fig. 2. This unique finding may perhaps be attributed either due to selection of very few fetuses or some inadvertent mistake/error committed while measuring the weights of fetuses and that of lungs by electronic weighing machines at this 11th gestational week. Another finding is that the size of the lungs is relatively greatest at the fourth fetal month (16g.w), diminishing thereafter smoothly.[12] The growth and development of the fetal lungs can be estimated by its morphological appearance and by the amount and location of intracellular glycogen.

In the present study, the ratio of lung weights as compared to fetal weights decreased between 20 and 30 gestational weeks and then became constant. Another observation of practical importance made by G. Mitropoulos et al[13] was that all organ weights/body weights was found virtually constant after 30 weeks gestation, which is found to be in conformity with the finding of the present study. For lung, the approximate mean organ weight/body weight ratios between 30 and 43 weeks gestation was found as 0.02 and by multiplying this mean ratio by the total body weight, the approximate mean weight for a particular fetal organ can be calculated in situations where charts of normal organ weights are not at hand.[13] Whereas, in the present study, there is an overall decrease in the ratio from 20 to 30g.w. in conformity with the findings of G. Mitropoulos et al. In the present study, there is minimal increase in the ratio from 20 to 23g.w. and then decreases gradually, which is also found almost in conformity with the findings of G. Mitropoulos et al.[13] Although fetal organs (including lung) show considerable variation in their growth rates between 20 and 30 gestational weeks, after 30 weeks, there is a relatively stable state of the weights of most organs when compared with bodyweight,[13] which is also supported by the present study. Correlation between fetal body weight and lung weight was established. The ratios of lung weight to body weight were found nonlinear and gradually decreased.

This result compares closely with smaller studies in the literature.[14] Prenatal standards for organ weights during the early fetal period of 8 to 21 gestational weeks have been correlated with total body weight.[11]

The main limitation of the present study is a relatively narrow fetal age ranging from 11th to 36th weeks of gestation. Another small limitation is that all measurements were noted down by a single present author, which was also stated by Michal S et al.[15] Yet another probable limitation is that there might be some inadvertent mistake, which may be committed unintentionally by the worker while measuring the weights of fetuses and lungs by the electronic weighing machines despite the maximum care taken by the workers.

CONCLUSION: The close relationship of different stages of morphological and vascular growth of human lung with numerous phyisical, bilogical and environmental factors is complex but fascinating.[5] Organ weight correlations become of particular significance in the understanding of defect clusters involving organs seen in birth defect syndromes[10]. The developmental morphological of human lung is expected to be helpful for the management of premature infants.[16]

The present study revealed that the growth rate of both the lungs increased gradually upto 20th week and then a moderate steep rise from 20th to 24th week. Another finding was that from 24th week, the growth rate of right lung was found slightly faster than that of left lung upto the 36th gestational week. A significant and an unique finding was that there was a steep fall in the lung weight/body weight ratio from 11th to 12th week. The findings had corroborated and substantiated with the previous findings of different workers and at the same time also contrasted partially as well as moderately with the findings of different other workers as discussed above. This study might, perhaps, has provided abundant scope for further research and investigation in the field in the near future. Needless to say that there is a need for further studies and investigation by taking a larger sample of human fetuses for different gestational weeks upto the full term.

ACKNOWLEDGEMENT: The author expresses her special thanks to her husband, Shri T. Ranjit Singh for computer typing the whole of this research article.

REFERENCES:

1. Bannister LH. Respiratory System. Gray's Anatomy. 38th Edition. Edinburgh: Churchill Livingstone. 1995; 1657.
2. Romanes GJ. Cunningham's Manual of Practical Anatomy Thorax and Abdomen 15th Edition. 1986; Volume 2: 30.
3. Burri PH. Fetal and postnatal development of the lung. Annu Rev Physiol 1984; 46: 617-28.
4. Langston C, Kida K, Reed M, Thuribeck WM. Human lung growth in late gestation and in the neonate. Amer. Rev. Respir. Dis. 1984; 129: 607-613.
5. Suchita J, Sailesh K. Lung growth and development. Early Human Development 2007; 83: 789-794.
6. Laudy JAM and Wladimiroff W: The fetal lung 1: Developmental aspects. Ultrasound Obstet Gynecol 2000; 16: 284-290.
7. John WD and Jay MW. Lung Development. Seminar in Pediatric Surgery, Vol. 4 No. 4 November, 1994; 221-232.

8. Loosli CG, Potter EL. The prenatal development of the human lung. Anat Rec 1951; 109: 320-1.
9. Raksha SS and Rajalakshmi R. Studies on human fetal tissues - I. Fetal weight and tissue weights in relation to gestational age, fetal size and maternal nutritional status. The Indian Journal of Pediatrics Vol 55, Issue 2, March-April 1988; 261-271.
10. Burdi AR, Barr M and Babler WJ. Organ weight patterns in human fetal development. Human Biology September 1981; Vol. 53 No. 3: 355-366.
11. Tanimura T, Nelson T, Hollingsworth RR, Shepard TH. Weight standards for organs from early human fetuses. Anat Rec 1971; 171: 227-36.
12. Ekholm E, Niemineva K. On prenatal changes in the relative weights of the human adrenals, the thymus and the thyroid gland. Acta Paediat 1950; 39: 67-86.
13. Mitropoulos G, Scurry J, Cussen L. Organ weight/body weight ratios: growth rates of fetal organs in the latter half of pregnancy with a simple method for calculating mean organ weights. J Paediatr Child Health 1992; 28 (3): 236-9.
14. Shepard TH, Shi M, Fellingham GW, Fujinaga M, Fitz Simmons JM, Fantel AG, Barr M. Organ weight standards for human fetuses. Pediatr Pathol 1988; 8 (5): 513-24.
15. Michal S, Waldemar S, Anna S, Alina W, Celestyna MK and Marcin W. Volumetric growth of the lungs in human fetuses: an anatomical hydrostatic and statistical study. Surg Radiol Anat 2014; 36: 813-820.
16. Deepali RK and Sudhir MS. Histogenesis of human fetal lung: A light microscopic study. IOSR Journal of Dental and Medical Sciences (IOSR - JDMS) e-ISSN: 2279-0853, ISSN: 2279-0861 Vol 9, Issue 2, Jul-Aug 2013: 01-08.

AUTHORS:

1. Rajkumari Ajita

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Anatomy, Regional Institute of Medical Sciences, Imphal, Manipur, India.

FINANCIAL OR OTHER COMPETING INTERESTS: None

NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Rajkumari Ajita,
Pishumthong Oinam Leikai,
Imphal, West District,
Imphal-795001, Manipur, India.
E-mail: rajkumariajita13@yahoo.com

Date of Submission: 03/04/2015.
Date of Peer Review: 04/04/2015.
Date of Acceptance: 15/04/2015.
Date of Publishing: 24/04/2015.