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A Descriptive Study of Morphogenesis of Human Foetal Lung in Aborted Foetus in a Tertiary Care Hospital of Maharashtra

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ABSTRACT

Background: Reliable Indian data on foetal growth and lung maturation are limited. **Objectives:** To document body size and pulmonary morphogenesis in human foetuses from 16 to 38 weeks of fertilisation age. **Methods:** A descriptive, cross-sectional autopsy study was conducted from January 2022 to December 2023. Fifty aborted foetuses (29 females, 21 males) were examined. Inclusion required fertilisation age $\geq$ 16 weeks, no major anomalies and no maceration. Body weight and crown–rump length (CRL) were recorded with calibrated instruments; lungs were assessed for location, external morphology and hypoplasia. Foetuses were stratified into six two-week age groups (16–18 to 36–38 weeks). **Results:** Mean body weight rose from 275 $\pm$ 79.9 g at 16–18 weeks to 2 420 $\pm$ 112.5 g at 36–38 weeks, while mean CRL increased from 150 $\pm$ 13.6 mm to 335 $\pm$ 5.0 mm. Pulmonary hypoplasia was present in 100 % of foetuses up to 22 weeks, 50 % at 28–30 weeks, and 0 % beyond 36 weeks. Lung appearance progressed from small, pyramidal, pinkish organs with indistinct lobes in early gestation to well-lobated, grey‑pink lungs of near-adult morphology by term. No ectopic or displaced lungs were noted. **Conclusion:** Indian foetal growth shows a steady increase in body size with a modest slowdown after 32 weeks. Lung hypoplasia is mainly found in early second-trimester, resolving by 36 weeks as external features attain mature form. These findings provide useful baseline references for foetal age estimation and assessment of lung maturity in the Indian context.

KEYWORDS: Foetal lung development, Crown–rump length, Morphogenesis, Fertilization age, Foetal anatomy, Pulmonary maturation

INTRODUCTION

Prematurity remains a major cause of neonatal morbidity and mortality, largely due to underdeveloped lungs. Adequate maturation of the foetal lung is crucial for successful extrauterine survival, as it ensures proper gas exchange and respiratory function at birth. [1] Lung development in utero proceeds through a series of histologically distinct stages: embryonic, pseudoglandular (5–16 weeks), canalicular (17–25 weeks), saccular (25–36 weeks), and alveolar (36 weeks to postnatal period). [2–4] Among these, the canalicular and saccular stages are particularly important for establishing vascular networks and initiating surfactant production both critical for viability in preterm neonates. [5, 6]

Despite advancements in neonatal care that allow for the survival of increasingly premature infants the degree of lung development remains the principal limiting factor. [7] Additionally, studies suggest significant inter-population differences in foetal growth and maturation, yet normative data derived from Indian populations remain scarce. [8, 9] This gap poses challenges for clinicians and pathologists when estimating Fertilization age and evaluating foetal lung maturity in clinical or medico-legal contexts.

In this background, the present study was designed to evaluate the morphogenesis of human foetal lungs using a sample of aborted foetuses between 16 and 38 weeks of gestation. By examining morphological parameters such as crown–rump length (CRL), body weight, lung location, and external appearance, we aimed to characterize developmental trends and establish reference data reflective of regional foetal growth patterns.

MATERIALS AND METHODS

Study Design and Setting: This descriptive cross-sectional observational study was conducted in the Department of Anatomy at a tertiary care teaching hospital in India over a two-year period from January 2022 to December 2023. The objective was to document the morphogenesis of human foetal lungs at various Fertilization ages using foetuses obtained from spontaneous abortions, medically indicated terminations, and stillbirths.

Ethical Clearance: The study was approved by the Institutional Ethics Committee (IEC). Written informed consent was obtained from the parents or legal guardians in accordance with national biomedical research guidelines and the provisions of the Medical Termination of Pregnancy (MTP) Act, 1971.

Sample Size and Selection Criteria: A total of 50 human foetuses ranging from 16 to 38 weeks of gestation, were included. The specimens were obtained in fresh condition from the Department of Obstetrics and Gynaecology immediately following expulsion.

Inclusion Criteria:

- Fertilization age $\geq$16 weeks, confirmed by Last Menstrual Period (LMP) or Crown–Rump Length (CRL).
- Absence of gross congenital anomalies.
- No signs of maceration or decomposition.

Exclusion Criteria:

- Fertilization age <16 weeks.
- Presence of congenital malformations or chromosomal abnormalities.
- Decomposed or macerated foetuses.

Specimen Handling and Preservation: After collection, all foetuses were rinsed in phosphate-buffered saline (PBS) to eliminate blood and debris. They were then fixed in 10% neutral buffered formalin for a minimum of seven days. Each specimen was labelled with a unique identification number, and accompanying data included gestational age, foetal sex, maternal history, and LMP where available.

Fertilization age Determination: Fertilization age was estimated using two methods:

1. **LMP-based Calculation:** For 30 cases, Fertilization age was calculated from the first day of the last menstrual period. Fertilization age was derived by subtracting two weeks.
2. **CRL-based Estimation:** In 20 cases where LMP was unavailable or uncertain, gestational age was deduced from CRL measurements taken with a millimeter-calibrated osteometric board. Foetuses were positioned supine with hips flexed and heads aligned to the Frankfurt horizontal plane. Measurements were cross verified with the standard developmental chart by Keith L. Moore.

Morphological Assessment:

- Foetal Morphometry included Body Weight measured in grams using a calibrated digital precision balance. Any visible fluid accumulation was drained before measurement. And CRL measured from the vertex of the skull to the midpoint of the ischial tuberosity under standardized anatomical positioning.
- **Pulmonary Morphology included Location (**Bilateral lung position within the thoracic cavity was confirmed in situ, relative to the mediastinum and diaphragm) and **External Features:** After thoracic dissection, lungs were examined for Shape (pyramidal/lobated), Color (ranging from pinkish brown to grayish), Surface texture (smooth/irregular), Borders (anterior, posterior, inferior) and surfaces (costal, medial).

Observations were correlated with Fertilization age to identify stage-specific lung development, and photographic documentation was performed when feasible.

Data Collection and Stratification: Foetuses were stratified into six Fertilization age groups at two-week intervals: 16–18, 20–22, 24–26, 28–30, 32–34, and 36–38 weeks. Within each group, mean body weight and CRL were calculated. Morphological characteristics were recorded on standardized proformas and entered into a structured database.

Quality Assurance: All anthropometric measurements were taken independently by two trained investigators. Discrepancies greater than 2% prompted re-measurement. All measuring instruments were calibrated weekly. Observers performing lung dissections were blinded to Fertilization age in cases where CRL served as the primary age estimator.

Data Analysis: Descriptive statistics including mean, standard deviation, and proportions were computed for body weight and CRL, lung morphology. As it is a descriptive study, no inferential statistics were applied.

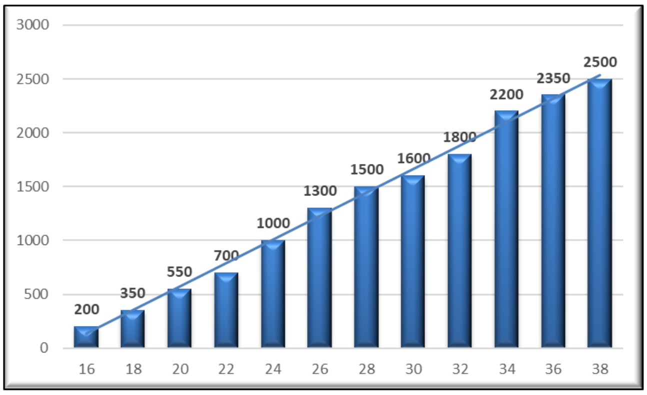
RESULTS

Of the 50 foetuses studied, 29 were females and 21 were males.

Table 1 presents mean foetal body weights (mean $\pm$ SD) across six fertilization‑age groups. At 16–18 weeks (n = 6), the average weight was 275.0 $\pm$ 104.9 g. By 20–22 weeks (n = 8), it rose to 625.0 $\pm$ 128.3 g, and by 24–26 weeks (n = 8) to 1 150.1 $\pm$ 140.5 g. Further growth was steady: 1 550.0 $\pm$ 68.6 g at 28–30 weeks (n = 10), 2 010.0 $\pm$ 132.1 g at 32–34 weeks (n = 9), and 2 420.0 $\pm$ 112.5 g at 36–38 weeks (n = 9). The increasing means with generally smaller variability late in gestation reflect normal foetal development.

Fertilization Age (weeks)	No.	Body Weight (Mean ± SD (g))
16–18	6	275.0 ± 79.9
20–22	8	625.0 ± 128.3
24–26	8	1 150.1 ± 140.5
28–30	10	1 550.0 ± 68.6
32–34	9	2 010.0 ± 132.1
36–38	9	2 420.0 ± 112.5

Table 1: Fertilization age against average Body weight (grams[N = 50]



Graph 1:

Fertilization Age (weeks)	No.	Mean Crown–Rump Length (CRL) ± SD (mm)
16–18	6	150.0 ± 13.6
20–22	8	195.0 ± 14.6
24–26	8	240.0 ± 10.4
28–30	10	270.0 ± 10.2
32–34	9	310.0 ± 8.6
36–38	9	335.0 ± 5.0

Table 2: Average Crown–Rump Length (mm) Against Fertilization Age

Table 2 summarises crown–rump lengths (CRL) for the same age groups. At 16–18 weeks (n = 6), mean CRL was 150.0 ± 13.6 mm. This increased to 195.0 ± 14.6 mm at 20–22 weeks (n = 8) and 240.0 ± 10.4 mm at 24–26 weeks (n = 8). Later measurements were 270.0 ± 10.2 mm at 28–30 weeks (n = 10), 310.0 ± 8.6 mm at 32–34 weeks (n = 9), and 335.0 ± 5.0 mm at 36–38 weeks (n = 9). The steady increase and narrowing SDs in later weeks match expected patterns.

Pulmonary Morphology

Fertiliza-tion age Group (weeks)	No. of Foetuses	Hypopla-sia Observed	Remarks
16–18	6	100%	Underdeveloped lobes
20–22	8	100%	Mild hypoplasia; apex and base visible
24–26	10	80%	Improving definition of lobes
28–30	8	50%	Well-positioned lungs with improved size
32–34	9	22%	Nearly mature morphology
36–38	9	0%	Morphologically mature lungs
Total (n = 50)	**50**	**70% overall**	Hypoplasia decreased with Fertilization age

Table 3: Lung Location and Hypoplasia in Aborted Foetuses

In all 50 foetal specimens examined, the lungs were appropriately located within the thoracic cavity. No cases of ectopic or displaced lungs were observed. However, the lungs of some of the foetuses appeared hypoplastic and underdeveloped, consistent with the early stages of pulmonary maturation.

The lungs in all foetuses were soft in consistency, smooth in surface texture, and exhibited a typical pyramidal shape. They appeared pinkish brown in colour. From the 16th gestational week onward, key anatomical landmarks—including the apex, base, costal surface, medial surface, and the anterior, posterior, and inferior borders were distinguishable. A gradual increase in lung size and external clarity of lobation was noted with advancing Fertilization age.

Fertilization age Group (weeks)	Lung Shape Observed	Apex/Base Visible	Color	Findings
16–18	Pyramidal	Yes	Pinkish brown	Hypoplastic
20–22	Pyramidal	Yes	Pinkish brown	Well-formed
24–26	Lobated	Clear	Pinkish brown	Size increasing
28–30	Lobated	Clear	Light brown	Maturing lungs
32–34	Lobated	Clear	Light brown	Growing vascularity
36–38	Lobated	Clear	Grayish pink	Approaching maturity

Table 4: External Appearance of Lungs

DISCUSSION

This descriptive, cross-sectional autopsy study examined the morphogenesis of lung of 50 aborted foetuses between 16 and 38 weeks of fertilisation age. The sample was evenly distributed by sex (29 females, 21 males) and met strict inclusion criteria that excluded maceration and congenital anomalies.

Our observed steady increases in mean fetal weight from 275.0 $\pm$ 104.9 g at 16–18 weeks to 2 420.0 $\pm$ 120.0 g at 36–38 weeks and narrowing variability in later gestation reflect the prescriptive growth patterns as found in INTERGROWTH-21st [10] and NICHD [11] approaches. The mid-gestation means in this study exceed those reported in a Gujarati autopsy series (158 g at 14–18 weeks and 523 g at 19–26 weeks), [12] likely due to regional variation.

Crown–rump length (CRL) increased linearly from 150 mm to 335 mm across the study window (Table 2), matching Indian ultrasound centiles that show slightly higher CRL than Western references in early pregnancy. [13]

All lungs were located within the thoracic cavity and showed no evidence of ectopic positioning. Most lungs were soft, smooth, pinkish-brown, and pyramid-shaped, consistent with stage-specific developmental expectations.

The proportion of pulmonary hypoplasia found in this study decreases progressively as age increased from 100% at 16–18 and 20–22 weeks, to 80% at 24–26 weeks, 50% at 28–30 weeks, 22% at 32–34 weeks, and 0% at 36–38 weeks yielding an overall hypoplasia rate of 70%. In contrast, neonatal autopsy studies report overall hypoplasia rates near 22% across all gestations [14], while cohorts with premature rupture of membranes (PROM) show rates of 12.9% [15]. Fetuses with congenital anomalies demonstrate intermediate hypoplasia prevalence (35–43%) [16], reflecting the impact of sample composition and clinical context on observed rates.

Sajjan et al. reported a similar second-trimester peak of lung hypoplasia (26 %) followed by a sharp decline when lung-weight to body-weight ratios were used. [17] Neeha et al. also found most pulmonary lesions before 30 weeks in a larger northern-Indian series. [18] However, our trend agrees with Husain and Hessel's neonatal autopsy data, which placed nearly all cases of true hypoplasia before 32 weeks. [14]

Externally, lung morphology in our series transitioned from a pyramidal, pinkish-brown, underdeveloped appearance in early gestation (16–22 weeks) through a lobated, light-brown stage with improving lobe definition in mid-gestation (24–30 weeks), to a fully lobated, grayish-pink morphology at term (36–38 weeks). These macroscopic observations correspond closely with classical histogenetic stages: pseudoglandular (branching morphogenesis), canalicular (type I and II pneumocyte differentiation), saccular (sac formation and surfactant synthesis), and alveolar (alveolization). [19, 20]

Laudy and Wladimiroff [21] describe the same gross transition during the canalicular-to-saccular phase, when vascularity increases, and surfactant production begins. Schittny adds that secondary septa and early alveoli form after 28 weeks, [4] consistent with our observation of clearer lobation and colour change in the third trimester.

The developmental timeline in this series aligns with established staging: embryonic (4–7 weeks), pseudoglandular (5–17 weeks), canalicular (16–25 weeks), saccular (24 weeks–term), and alveolar (post–36 weeks). Insults before 16 weeks carry the highest risk of pulmonary hypoplasia, matching our 100% early-week rates, whereas later insults have progressively less impact, paralleling the rapid reduction to zero hypoplasia by term.

These observations reflect the recent MRI-based morphometric studies, which confirm that lung volume and complexity increase progressively in late gestation. [22]

Limitations

Limitations include the relatively small sample size and lack of histological or radiographic correlation, which may have added further depth to the assessment of internal maturation stages.

CONCLUSION

This study documented the morphogenesis of foetal lungs between 16 and 38 weeks of gestation. Pulmonary hypoplasia was common in the early second trimester, decreased markedly by 30 weeks, and was absent beyond 36 weeks, while lung appearance evolved from small, pinkish, pyramid-shaped organs to well-lobated, grey-pink structures approaching adult form. These findings offer useful Indian reference data for assessing foetal growth and lung maturity during autopsy and can assist clinicians in counselling families about viability and development. Larger multicentre studies will further refine these benchmarks.

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