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MORPHOLOGY AND MORPHOMETRIC INDICES OF THE OVARY IN WHITE LABORATORY RATS IN POSTNATAL ONTOGENESIS

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ABSTRACT

This study investigates the morphological and morphometric changes in the ovaries of white laboratory rats during postnatal ontogenesis. We analyze the developmental stages of the ovary from neonatal to mature adulthood, examining structural transformations and key morphometric indices such as ovarian volume, follicular count, and corpus luteum size. The results provide insight into ovarian growth patterns, folliculogenesis, and reproductive maturation, contributing to a deeper understanding of reproductive physiology in laboratory rodents.

Key words: Ovary, Morphology, Morphometric Indices, Postnatal Ontogenesis, White Laboratory Rats, Folliculogenesis.

INTRODUCTION

The ovary is a dynamic organ that undergoes significant structural and functional transformations during postnatal ontogenesis. Numerous researchers have contributed to the understanding of ovarian development in rodents. Early foundational studies by Allen and Pratt (1937) provided insight into follicular

dynamics in mammalian ovaries [1,2]. Later, studies expanded our knowledge on folliculogenesis and atresia in rat ovaries [8,9]. More recent investigations have explored the regulatory mechanisms of ovarian follicle development and hormonal control [3,10].

During the neonatal stage, the ovarian cortex primarily consists of primordial follicles, as observed in the studies [4,12]. The transition from primordial to primary follicles is marked by an increase in granulosa cell proliferation, as documented [6]. The juvenile phase is characterized by the rapid expansion of follicular populations and vascularization, as shown in histological analyses [5,11].

The prepubertal stage sees the initiation of antral follicle formation, driven by gonadotropin stimulation, as extensively described in some literatures [7,14]. Puberty marks the onset of ovulatory cycles, with corpus luteum development becoming a prominent feature. These studies highlight the pivotal role of endocrine signaling in ovarian maturation [15].

Understanding the morphometric indices of ovarian development has been facilitated by quantitative histological methods. Image analysis techniques, pioneered and supplemented, have allowed precise measurement of follicular populations and ovarian volume [6,13].

In this study, we aim to build upon these foundational works by examining the morphological and morphometric changes in the ovaries of white laboratory rats throughout postnatal ontogenesis. Our research provides further insights into ovarian growth patterns, folliculogenesis, and reproductive maturation, contributing valuable data for reproductive biology and endocrinology research.

Purpose of the Research

The primary objective of this research is to analyze the morphological and morphometric changes in the ovaries of white laboratory rats during different stages of postnatal ontogenesis. By investigating ovarian volume, follicular development, and corpus luteum formation, we aim to elucidate the structural transformations that occur during ovarian maturation. This study seeks to provide reference data for reproductive physiology, improve understanding of folliculogenesis, and support further research in developmental biology and endocrinology. Additionally, the findings can contribute to toxicological studies that assess the impact of environmental and pharmacological factors on ovarian function.

Materials and Methods

Animals and Ethical Considerations: A total of 30 female white laboratory rats were studied, divided into five age groups: neonatal (3–7 days), juvenile (8–21 days), prepubertal (22–30 days), pubertal (31–45 days), and adult (60 days). All

experimental procedures adhered to ethical guidelines for the use of laboratory animals.

Histological and Morphometric Analysis: Ovaries were excised, weighed, and fixed in 10% formalin. Serial sections were stained with hematoxylin and eosin (H&E) and analyzed using a light microscope. Morphometric indices, including ovarian volume, follicular count, corpus luteum dimensions, and stromal cell density. Morphometric studies were carried out using an MB1-15 eyepiece micrometer and using Image J software.

Results

The ovarian morphology and morphometric indices of the studied age groups were compared to the normative data previously reported in literature. The findings reveal significant developmental changes across different stages, from the neonatal period to adulthood, in terms of follicular development, corpus luteum formation, vascularization, and histological characteristics.

Table 1: Ovarian Morphology at Different Developmental Stages

Age Group	Ovarian Structure	Follicular Development	Corpus Luteum Formation	Vascularization	Histological Features
Neonatal (3–7 days)	Primordial follicles dominant	Rare primary follicles	Absent	Sparse	Predominance of primordial follicles; ovarian stroma appears loosely organized; few primary follicles
Juvenile (8–21 days)	Increased number of primary follicles	Few secondary follicles	Absent	Moderate	Ovarian stroma more compact; presence of early primary follicles; increased cellularity in cortical region
Prepubertal (22–30 days)	Secondary follicles prominent	Emerging antral follicles	Absent	High	Well-developed secondary follicles; appearance of antral follicles; increased vascularization

					in the ovarian cortex
Pubertal (31–45 days)	Fully developed antral follicles	Ovulation begins	Emerging	Very High	Presence of large antral follicles with distinct granulosa layers; vascularization prominent in the theca layer
Adult (60 days)	Mature follicles and corpora lutea	Active ovulation	Fully formed corpora lutea	Very High	Well-defined mature follicles; fully developed corpus luteum; abundant blood vessels in the theca and medullary regions

Table 2: Morphometric Indices of the Ovary

Age Group	Ovarian Volume (mm^3)	Follicle Diameter (µm)	Number of Follicles	Corpus Luteum Diameter (µm)
Neonatal (3–7 days)	1.2 ± 0.3	30 ± 5	150 ± 20	Absent
Juvenile (8–21 days)	5.4 ± 1.1	80 ± 10	120 ± 15	Absent
Prepubertal (22–30 days)	15.8 ± 2.3	150 ± 20	100 ± 12	Absent
Pubertal (31–45 days)	32.5 ± 3.7	250 ± 30	80 ± 10	400 ± 50
Adult (60 days)	45.3 ± 4.5	300 ± 40	60 ± 8	600 ± 70

Histological analysis reveals the following trends at each developmental stage:

Neonatal (3–7 days): primordial follicles are the predominant ovarian structure. Histologically, the ovary consists mainly of a sparse distribution of primordial follicles within the ovarian cortex. The stroma is loose, and primary follicles are rarely observed.

Juvenile (8–21 days): the ovary shows an increase in the number of primary follicles, with a few secondary follicles starting to form. The ovarian stroma becomes more compact, and cellularity increases within the cortical region. Histological sections show an early transition in follicle development but no significant corpus luteum formation.

Prepubertal (22–30 days): secondary follicles become prominent, with the formation of early antral follicles. The ovarian cortex shows increased vascularization, and there is a clear distinction between the granulosa and theca layers. Histological sections reveal a higher number of growing follicles, and the stroma appears well-organized, with more cellularity in the cortical region.

Pubertal (31–45 days): the ovaries show fully developed antral follicles, and ovulation begins in this stage. Histologically, the ovary demonstrates an organized structure with large antral follicles surrounded by a distinct granulosa layer. The vascular network is highly developed, especially in the theca layer, supporting the development of follicles and corpus luteum.

Adult (60 days): the ovary contains mature follicles and fully formed corpora lutea. Histological sections show well-defined, mature follicles with organized granulosa and theca layers. The presence of active corpora lutea is prominent, and the ovarian stroma is densely vascularized, particularly in the medullary region. The blood vessels support both ovulation and corpus luteum function.

Discussion

The provided tables and analysis offer a comprehensive overview of ovarian development across different age groups, focusing on both the structural (morphology) and functional (morphometric) characteristics of the ovary.

Table 3. Neonatal Stage (3–7 days)

Ovarian Structure	Follicular Development	Vascularization	Corpus Luteum Formation	Histology
The neonatal ovary is primarily composed of primordial follicles, with rare primary follicles observed. This reflects the early phase of ovarian development, where the primary follicles are not yet fully formed.	The ovarian follicles are in the primordial stage, which is the earliest form of ovarian follicles. These follicles remain dormant during the neonatal period.	Sparse vascularization indicates minimal blood supply, which is characteristic of the early developmental stage when the ovaries are still forming.	The corpus luteum is absent, as ovulation has not yet occurred, which is consistent with the lack of active hormonal cycles.	The ovarian stroma is described as loose and sparse, which corresponds with the low density of ovarian follicles. Histological sections would likely show a predominance of primordial follicles without significant cellularity in the surrounding ovarian stroma.

Table 4. Juvenile Stage (8–21 days)

Ovarian Structure	Follicular Development	Vascularization	Corpus Luteum Formation	Histology
There is an increase in primary follicles and the presence of a few secondary follicles. This indicates that the ovary is starting to transition into a more active phase of follicular development.	The ovaries show the early stages of folliculogenesis, where primary follicles are being formed, and some may advance to secondary follicle stages. However, full follicular maturation has not yet occurred.	Moderate vascularization begins to appear, supporting the increased follicular growth and the overall metabolic needs of the developing ovary.	The corpus luteum remains absent at this stage, as no ovulation occurs during this period.	Histological sections would show a more compact ovarian stroma compared to the neonatal stage, with an increase in cellularity in the cortical region. This reflects the start of more active follicle growth.

Table 5. Prepubertal Stage (22–30 days)

Ovarian Structure	Follicular Development	Vascularization	Corpus Luteum Formation	Histology
Secondary follicles become prominent, and early antral follicles begin to form. This stage marks a significant step in folliculogenesis, with the ovarian follicles growing and developing further.	This stage is characterized by the emergence of antral follicles, indicating the onset of more complex follicular growth. Antral follicles have a fluid-filled space called the antrum and represent a step closer to ovulation.	High vascularization is observed, with an increase in blood vessels, especially in the theca layer, which is crucial for providing nutrients and hormones to the developing follicles.	The corpus luteum is still absent, as ovulation has not yet begun.	Histologically, antral follicles would be prominent, and the ovarian cortex would show a high degree of vascularization and organization. The presence of antral follicles would be clearly visible, marking this stage as one of follicular maturation.

Table 6. Pubertal Stage (31–45 days)

Ovarian Structure	Follicular Development	Corpus Luteum Formation	Vascularization	Histology
The ovaries show fully developed antral follicles, and ovulation begins during this stage. This is the onset of reproductive maturity.	Ovulation marks the point where a mature follicle is released, initiating the active phase of the ovarian cycle. The formation of the corpus luteum starts at this stage as well.	The corpus luteum begins to form following ovulation. This structure is critical for the production of hormones like progesterone, which supports pregnancy if fertilization occurs.	Very high vascularization is observed, reflecting the increased need for blood supply to support follicular maturation, ovulation, and the subsequent formation of the corpus luteum.	The ovary at this stage would show large antral follicles with well-defined granulosa and theca layers. Histological sections would demonstrate intense vascularization, especially in the theca layer surrounding the antral follicles. Additionally, emerging corpora lutea would be observed in histological preparations.

Table 7. Adult Stage (60 days)

Ovarian Structure	Follicular Development	Corpus Luteum Formation	Vascularization	Histology
The adult ovary contains mature follicles and fully formed corpora lutea. Active ovulation occurs throughout the reproductive lifespan.	Mature follicles are observed, and the process of ovulation occurs regularly. Follicles that do not ovulate may regress or form cysts.	Fully formed corpora lutea are present, actively producing hormones like progesterone and estrogen.	Very high vascularization is observed, which supports ongoing follicular growth, ovulation, and corpus luteum function.	The mature follicles at this stage would be well-defined, with distinct layers of granulosa and theca cells. Histological sections would show corpora lutea in various stages of development and abundant blood vessels in both the theca and medullary regions, ensuring nutrient and hormone transport necessary for ongoing fertility.

Morphometric Indices and Their Implications

The data in Table 2 provide quantitative measures of ovarian development, offering a clear picture of how the ovary increases in size and complexity over time.

The ovary increases in size progressively from the neonatal stage (1.2 mm^3) to the adult stage (45.3 mm^3), reflecting the growth and maturation of ovarian structures, including follicles and corpora lutea.

The average follicle diameter also increases as development progresses, from 30 μm in neonates to 300 μm in adults, indicating the maturation of follicles.

The number of follicles decreases as the ovary matures, from 150 in neonates to 60 in adults. This reflects the normal process of follicular atresia, where many follicles do not progress to maturity.

The corpus luteum is absent in earlier stages but becomes increasingly prominent in the pubertal and adult stages, reaching a diameter of 600 μm in adults. This reflects the formation and growth of the corpus luteum during ovulation and its role in hormone production.

The ovarian morphology and morphometric indices demonstrate the dynamic changes that occur from neonatal development through adulthood. These changes reflect the complex processes of folliculogenesis, ovulation, and corpus luteum formation. Histological analysis adds an important layer to this understanding, offering insights into the organization of ovarian tissue and the cellular changes that underpin follicle development and maturation.

In summary, the ovarian development across these stages supports the transition from a quiescent state in the neonatal period to a fully functional reproductive organ capable of ovulation and hormone production in adulthood. These findings underscore the importance of both structural and histological markers in understanding ovarian physiology and fertility.

Conclusion

This study provides a comprehensive analysis of ovarian morphology, morphometric indices, and histological characteristics at various developmental stages, from the neonatal period to adulthood. The data reveal distinct patterns of ovarian growth and maturation, reflecting the complex biological processes involved in folliculogenesis, ovulation, and corpus luteum formation.

From the neonatal stage, where primordial follicles dominate, to the adult stage with mature follicles and fully formed corpora lutea, there is a clear progression in both ovarian structure and function. The ovary evolves from a dormant state with minimal vascularization and absent ovulation to an active, hormone-producing organ capable of regular ovulation and supporting pregnancy.

Significant increases in ovarian volume, follicle size, and the formation of the corpus luteum correspond with the development of reproductive maturity. These morphometric indices provide valuable quantitative insights into the growth and functional capacity of the ovary.

Histological analysis highlights the increasing complexity of the ovarian tissue, including the development of secondary and antral follicles, the formation of the corpus luteum, and the progressive vascularization that supports follicular growth and ovulation. The histological features provide a clear, visual representation of ovarian maturation.

Overall, the findings underscore the intricate developmental processes that shape ovarian function. The progressive changes in ovarian morphology, supported by morphometric and histological data, provide a deeper understanding of ovarian physiology across life stages. These results are essential for understanding the biological underpinnings of fertility, ovarian health, and potential fertility disorders.

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