

Impact of Age on the Thyroid Gland of Guinea pig at Different Stages

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Abstract

The age-related changes in the thyroid gland are also progressive and structural and functional changes. Recognizing these changes that are normal with aging is crucial in differentiating normal changes in physiology from abnormal changes in thyroid gland. In the present study, the histological architecture of the thyroid gland in guinea pigs (*Cavia porcellus*) was investigated at various stages of life. Thirty-six clinically healthy guinea pigs were grouped into four age sets, juveniles (6 months), young (12 months), adult (24 months) and old (36 months). There was a high degree of thyroid age-related histomorphological changes. Juvenile group: the follicles were relatively small, follicular and parafollicular cells were poorly differentiated and there were wide connective tissue septa. The young group had well organized follicles with cuboidal epithelial cells and a lot of colloid, suggesting increased functional activity. Thyroid gland in the adult group exhibited enlarged follicles with abundant colloid and well developed glandular structure, indicating that thyroid gland was mature and stable functional. The old group on the other hand showed severe histological changes such as enlarged and irregular follicles with the presence of foamy colloid, flattening of the follicular epithelial cells, vascular congestion and degenerative changes in the glandular parenchyma. Histomorphometric assessment comprised follicular size and diameter, morphology of the follicular epithelial cells, distribution of the parafollicular cells, thickening of the basement membrane and organization of the interstitial connective tissue. Results have shown that the thyroid gland has different physiological activity during different periods of life and it has progressive modifications in its structure with ageing. Such changes could be responsible for changes in thyroid function and susceptibility for thyroid diseases in aging .

Key words: Aging, Thyroid Gland, Histology, Guinea Pig (*Cavia porcellus*), Thyroid Follicles, Colloid

خلاصة:

تُعدّ التغيرات المرتبطة بالعمر في الغدة الدرقية تغيرات تدريجية، هيكلية ووظيفية. ويُعدّ إدراك هذه التغيرات الطبيعية المصاحبة للشيوخوخة أمرًا بالغ الأهمية للتمييز بين التغيرات الفسيولوجية الطبيعية والتغيرات غير الطبيعية في الغدة الدرقية. في هذه الدراسة، تمّ فحص البنية النسيجية للغدة الدرقية في خنازير غينيا (*Cavia porcellus*) في مراحل عمرية مختلفة. تمّ تقسيم ستة وثلاثين خنزير غينيا سليمًا سريريًا إلى أربع مجموعات عمرية: صغار (6 أشهر)، وشباب (12 شهرًا)، وبالغون (24 شهرًا)، وكبار (36 شهرًا). لوحظت درجة عالية من التغيرات النسيجية الشكلية المرتبطة بالعمر في الغدة الدرقية. في مجموعة الصغار: كانت الجريبات صغيرة نسبيًا، والخلايا الجريبية والمجاورة للجريبات ضعيفة التمايز، مع وجود حواجز نسيج ضام واسعة. أما في مجموعة الشباب، فكانت الجريبات منظمة جيدًا، ذات خلايا طلائية مكعبة الشكل، وغنية بالغرواني، مما يشير إلى زيادة النشاط الوظيفي. أظهرت الغدة الدرقية لدى البالغين تضخمًا في الحويصلات مع وفرة في الغرواني وبنية غنية متطورة، مما يشير إلى نضج الغدة الدرقية واستقرار وظائفها. في المقابل، أظهرت المجموعة المسنة تغيرات نسيجية حادة، مثل تضخم الحويصلات وعدم انتظامها مع وجود غرواني رغوي، وتسطح الخلايا الظهارية الحويصلية، واحتقان الأوعية الدموية، وتغيرات تنكسية في نسيج الغدة. شمل التقييم النسيجي المورفومتري حجم الحويصلات وقطرها، وشكل الخلايا الظهارية الحويصلية، وتوزيع الخلايا المجاورة للحويصلات، وتثخن الغشاء القاعدي، وتنظيم النسيج الضام الخلالي. أظهرت النتائج أن الغدة الدرقية لها نشاط فسيولوجي مختلف خلال مراحل الحياة المختلفة، وأنها تخضع لتعديلات تدريجية في بنيتها مع التقدم في السن. قد تكون هذه التغيرات مسؤولة عن تغيرات في وظائف الغدة الدرقية وزيادة قابلية الإصابة بأمراضها مع التقدم في السن.

الكلمات المفتاحية: الشيوخوخة، الغدة الدرقية، علم الأنسجة، (*Cavia porcellus*)، بصيلات الغدة الدرقية، الغروانية

Introduction

The thyroid gland is the largest endocrine gland, its hormones, and calcitonin, are important for growth and development, metabolism, thermogenesis, and calcium homeostasis. The gland produces two main hormones, thyroxine (T4) and triiodothyronone (T3), which control basal metabolic rate, protein synthesis, lipid metabolism, carbohydrate use, and the normal growth and development of tissues. Also, in addition, there are parafollicular (C) cells that

secrete calcitonin, which plays a role in calcium and phosphorous metabolism. The thyroid is a butterfly-shaped gland in the front of the neck, just below your voice box (larynx) and above your windpipe (trachea). It is composed of two lateral lobes and is very vascular for hormone production and release. The thyroid gland is histologically organized into a large number of spherical follicles which are the structural and functional units of the gland. They each have a single layer of follicular epithelial cells with a central lumen

containing a protein-rich substance called colloid, which is mainly made of thyroglobulin. The interfollicular connective tissue contains a few scattered parafollicular (C) cells which produce calcitonin. The thyroid gland is a life-long organ of dynamic morphology and function. It has been previously shown that ageing may impact thyroid follicular architecture, thyroid epithelial cell morphology, the characteristics of the colloid, thyroid vascularity and organisation of the connective tissues. The histological changes of aging involve changes in the size and shape of the follicles, flattening of the epithelium, accumulation of colloid, fibrosis, vascular congestion, and distribution of the parafollicular cells. Such changes of the structure can play a role in the changes of thyroid function observed with age and could affect the sensitivity of the gland to different pathological conditions. Some studies have investigated the age-related histological features of the thyroid gland in humans, but there are only a few studies related to the age-related characteristics of thyroid in guinea pigs (*Cavia porcellus*). To teach the normal histological changes during ageing, is essential to differentiate physiological from pathological alterations, and to enhance the understanding of the development and senescence of the thyroid. The present study was, therefore, conducted to examine the age-related histological changes in the thyroid gland of guinea pigs during various ages of life and to assess age-related changes in the follicular morphology, follicular colloid characteristics, distribution of parafollicular cells and stromal organization.

Aim of the Study

The present study is designed to study the age related histological changes in the thyroid gland of guinea pigs (*Cavia porcellus*) at various stages of their life. To this end, the

study aims at describing the microarchitecture of the thyroid gland and analyzing the alteration of the morphology of thyroid follicles, follicular epithelium, follicular colloid, distribution of parafollicular (C) cells, microarchitecture of the connective tissue and of the vascular organization with age advancement. Additionally, this study will give a detailed description of the normal aging process of the thyroid gland, help to determine a baseline histological data for the guinea pig and enhance understanding of the relationship between aging and structural changes which could affect function and predispose the gland to pathological changes in the old animal.

Objectives of the Study

- 1- explain the changes that occur in the thyroid follicles with age.
- 2- assess the effect of the aging on the follicular epithelial morphology.
- 3- evaluate the differences in the appearance and organisation of the follicles.
- 4- study the age distribution of the cells that line the intestines (C cells).
- 5- study the histological architecture of the thyroid gland in juvenile, young, adult and old guinea pig.

Literature review

The thyroid gland is one of the largest of endocrine organs, it is brownish red color, firm in consistency and often glistening on its cut surface. The thyroid gland consists of two large lateral lobes, right and left lobes which are united by a narrow thin isthmus and the gland is located in the root of cervical region anterior to the laryngeal prominence (Adam's apple) or between larynx and trachea. In addition, the apex of the thyroid gland starts at the oblique line on the lamina of thyroid cartilage and the base extending to the 5th or 6th tracheal ring (14,15).

The thyroid gland has an abundant blood

supply; it appears redder than surrounding tissues because it is a rich blood supply, receiving (80 – 120 ml) of blood per minute⁽¹⁶⁾. reported that the thyroid gland contains a rich lymphatic network which communicates with tracheal plexus and capsular network of lymphatic vessels. From here, the vessels pass initially to perlaryngeal, pretracheal, and paratracheal lymph nodes, which drain in to the superior and inferior deep cervical node⁽¹⁶⁾.

The thyroid gland receives fibers from both sympathetic and parasympathetic divisions of the autonomic nervous system. In addition, the storm encloses a number of nerve fibers, some of which are parasympathetic, but most are sympathetic fibers. These nerves terminate on blood vessels or in a position to follicular cell⁽¹⁷⁾.

The endocrine secretion from the thyroid gland is normally regulated primarily by the anterior pituitary glands hormones, thyroid stimulating hormone (TSH), and secondarily by hypothalamus; the latter secretes thyrotropin releasing hormone (TRH) and stimulates the pituitary gland, and hence the thyroid gland^(18,19).

The thyroid follicles are the structural and functional units of thyroid gland. Most endocrine cells, tissues, or organs are arranged in cords or clumps, and store their secretory products within their cytoplasm. While the thyroid gland is a unique endocrine organ in that its cells are arranged into spherical cyst – like, called follicles and stored whose secretory product is in great quantity extracellularly in the lumina of follicles, this mean that the thyroid gland store its secretory products in itself⁽²⁰⁾.

Alan & Lowe⁽²¹⁾ stated that in routine hematoxylin and eosin (H&E) preparation, under the light microscope, the follicular cells exhibit a slightly basophilic cytoplasm with spherical nuclei containing one or more

prominent nucleoli, the Golgi apparatus has a supranuclear position, lipid droplets, and PAS-positive droplets can be identified in the basophilic cytoplasm.

The main function of thyroid gland is to secrete thyroid hormones, which are three hormones. Two of them thyroxine (T4) and triiodothyronine (T3) hormones are synthesized and secreted by the follicular cells which stimulate thyroid stimulating hormone (TSH). While the calcitonin hormone is produced from parafollicular cells. It was secreted if the blood concentration of calcium ions becomes too high, and it causes calcium ion levels decrease to their normal range in the blood^(22, 23).

Histological studies of apparently normal gland show increased interlobular & interfollicular fibrosis, reduction in number and size of follicles. The follicles become irregular in outline and their diameter decreased in the older subjects, decreased the volume of colloid, degeneration and flattening of epithelial cells, and various degrees of lymphocytic infiltration. There is also an increased prevalence of non-functioning follicles in old age. In addition, the measurements of internal and external surface area of acini showed an increase in early stage and adolescence and decline in older age, also the glandular isthmus was replaced by fibrous tissue with aging^(24, 25). The morphological and functional change could be due to age – developed failure of endocytosis, as suggested by the marked reduction in the density and polymerization of microtubules and microfilaments in thyroid follicular cells of aged human, and decreased number of the microvilli and pseudopods at the apical surface of the follicular cell with aging⁽²⁶⁾.

Materials and Methods

Experimental Animals and Sample

Collection

Thirty-six clinically normal guinea pigs, both male and female, of various ages were used in the present study. Animals were obtained from, and maintained in the animal house of the college of Veterinary Medicine at Tikrit university, Iraq. Animals were supplied from and kept in the animal house of the college of Veterinary Medicine at Tikrit university, Iraq. The guinea pigs were divided into four age groups equally ($n = 9$) as follows: Group I (Juvenile) 6 months of age; Group II (Young) 12 months of age; Group III (Adult) 24 months of age; and Group IV (Old) 36 months of age. The animals were kept in clean polypropylene cages in standard laboratory conditions at temperature $22^{\circ}\text{C} \pm 2^{\circ}\text{C}$, relative humidity 50–60% and 12 h light/12 h dark cycle. They were fed with commercial pellets and water was offered ad libitum. All animals were adapted to the laboratory setting for two weeks prior to the start of the experiment and their health was checked regularly throughout the experiment. All experimental procedures carried out accorded the ethical guidelines of the care and the use of laboratory animals and approved by the Scientific Research Ethics Committee of the College of Veterinary Medicine, Tikrit University. The animals were chloroform-inhaled under approved institutional anesthesia for tissue collection. All the area around the cervical region was shaven, and disinfected with 70% ethanol. A midline incision was carefully made from the mandible to the lower part of the neck area to reveal the trachea and surrounding tissues. The thyroid gland was detected and divided in conjunction with a small part of the trachea which was maintained in anatomical orientation. The removed tissues were washed at once with a few cycles of physiological saline solution (0.9% NaCl) to

wash off blood residues and tissue debris. The tissues were then transferred immediately into labelled plastic containers filled with 10% neutral buffered formalin and were fixed for 48 hours at room temperature. After fixation, the specimens were transferred to ascending concentrations of ethanol, cleared in xylene and then embedded in paraffin wax in the usual way. About $5\text{ }\mu\text{m}$ thick serial sections were cut on a rotary microtome and mounted on clean glass slides. Histological examination was performed after staining the tissue sections with Periodic Acid-Schiff staining (PAS stain) for the demonstration of components of the basement membrane and the presence of colloid; Hematoxylin and Eosin (H&E) staining for general histological evaluation; and Masson's Trichrome staining for connective tissue fibers. The stained sections were investigated with light microscope and images captured with digital imaging system. The histological assessments were on thyroid follicular size and arrangement, colloid characteristics, morphology of follicular epithelial cells, distribution of parafollicular (C) cells, connective tissue organization, vascular features and degenerative changes that might occur in the aging thyroid.

Results

Juvenile Group (6 Months)

A well defined lobular organization of the thyroid gland with relatively small thyroid follicles separated by thin trabeculae of loose connective tissue was observed in juvenile guinea pigs upon histological examination of thyroid gland. The colloid was present in most follicles but in a few follicles was seen to be either partially or completely absent. There was poor differentiation of follicular epithelial cells and parafollicular cells in comparison to older age group (Figure 1).

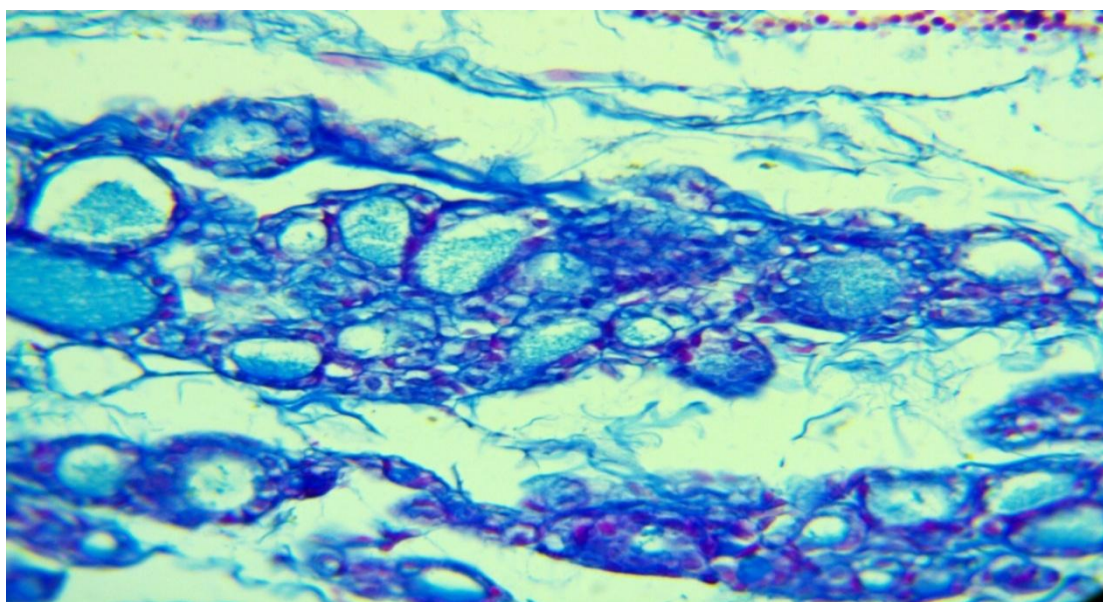


Figure 1. Histological section of the thyroid gland from a 6-month-old guinea pig stained with Masson's Trichrome (40×), showing small follicles filled with colloid and separated by loose connective tissue.

Young Group (12 Months)

Young guinea pigs had well-developed follicles of varying size in the thyroid gland with predominately simple cuboidal epithelial cells lining it. The follicles were mostly occupied with copious amount of colloid and some follicles had partial depletion of colloid. Interfollicular connective tissue was mild infiltrated with leukocytic cells, and the glandular lobules were separated by a loose connective tissue septa (Figure 2). At this time more prominent cells, known as parafollicular © cells, were seen both between and within

the olicular epithelial cells and interstitial connective tissue. The colloid filled most of the follicular lumina, but there was some shrinkage of the colloid in some follicles. Occasional intrafollicular lipid droplets were also seen (Figure 3). In addition, some follicles showed foamy colloid and other follicles showed less colloid. A large number of parafollicular cells were present in the interstitial connective tissue and glandular parenchyma, indicating a greater functional activity and maturation of the thyroid gland at this stage (Figure 4).

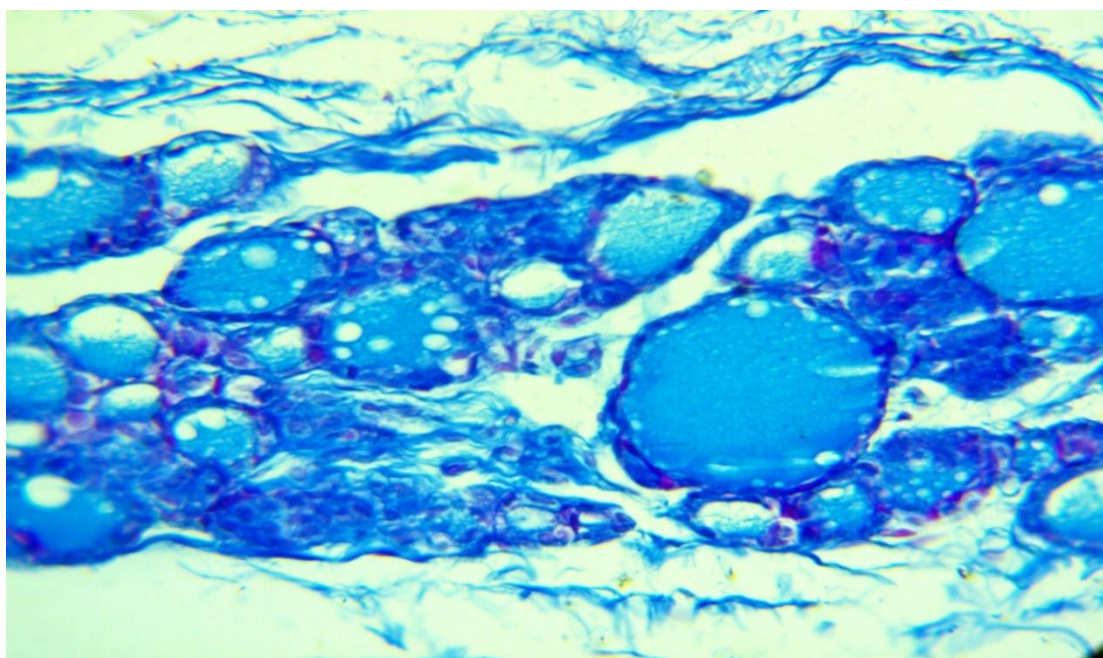


Fig. (2) Shows the thyroid lobules had small thyroid follicles with colloid (A) the thyroid follicular cells and parafollicular cells were unwell developed (B), the loose C.T between the thyroid lobules was wide (C), (6 months age B), (40X mason trichrome).

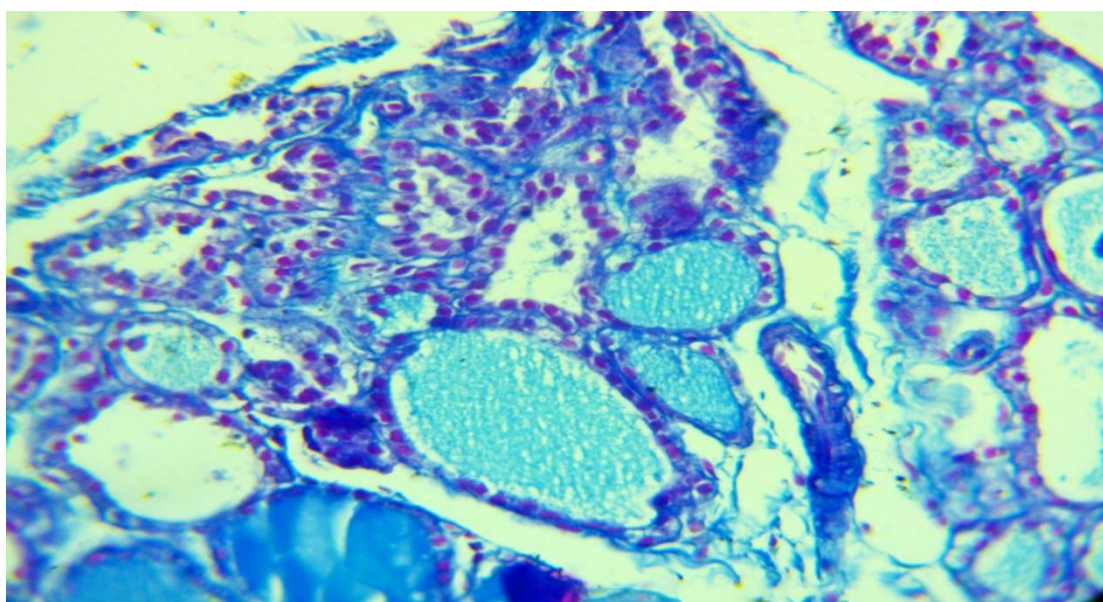


Fig. (3) Shows the thyroid follicles were variable in size and these are filled with colloid lined by simple cuboidal cells which are the colloid follicular cells (A) parafollicular cells were present in between the follicular cells and in the interstitial CT in the form of groups (B) the loose CT in between the thyroid lobules (C), (12 months age A), (X40 MTC).

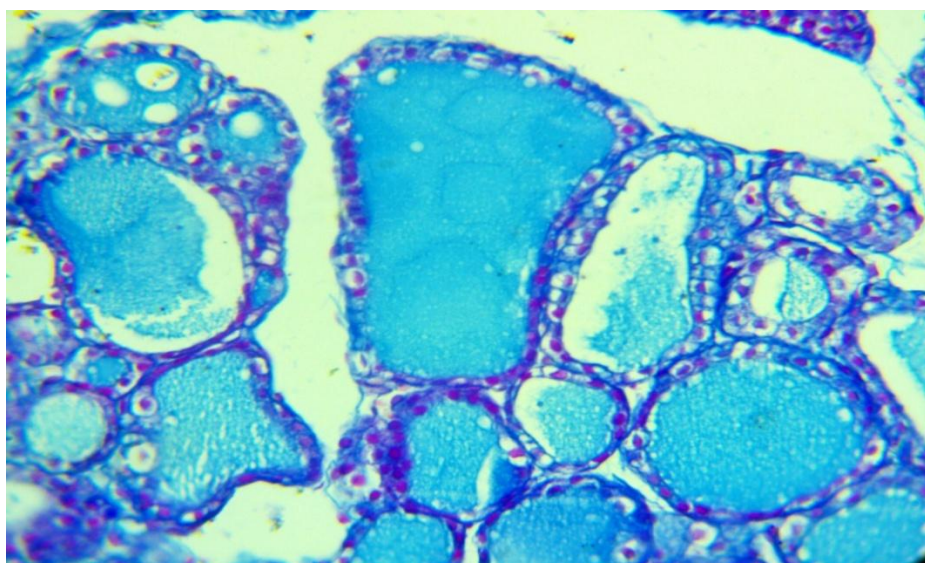


Fig. (4) The follicles were well developed occupied its lumens by colloid (A) the follicle cells were simple cuboidal cells (B) surrounded by many parafollicular cells (C), (12 months age B), (40 X MTC).

Adult Group (24 Months)

In the thyroid of the adult guinea pig a well-developed and organized structure was found with enlarged follicles containing homogeneous colloid in large amounts, with varying size. Simple cuboidal epithelial cells lined the follicles, the predominant cells. The cells were identified as prominent parafollicular cells between adjacent follicles, and the interstitial connective tissue. These

cells were larger than the follicular epithelial cells, had a pyramidal shape, and had pale cytoplasm (Figures 5 and 6). The connective tissue between the cells was made up of collagenous and elastic fibers, and had a few lymphocytes scattered throughout. The gland was well organized; most of the follicles were distended with colloid, which represents a stable and functionally active development phase of the thyroid gland (Figure 7).

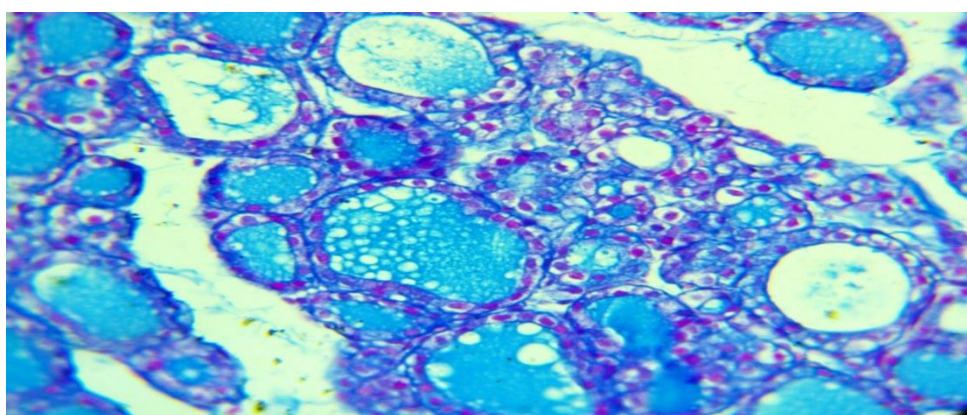


Fig. (5) Shows the large follicles and thyroids contain foam colloid (A) or empty (B) the smaller follicles were containing homogenized colloid (C) the parafollicular cells were many which were present between the follicle cells (D) and in the interstitial CT (E), (12-month age C), (40X PAS).

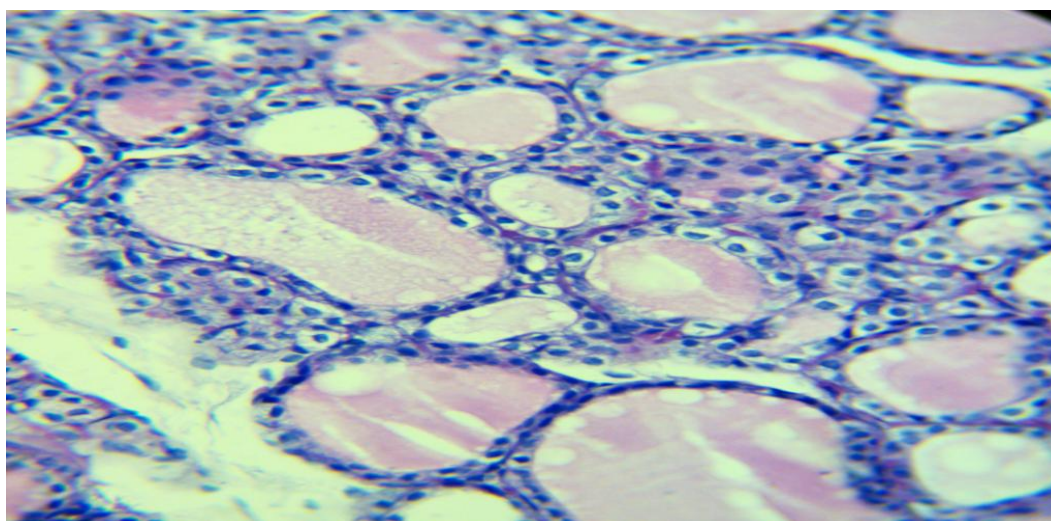


Fig. (6) Shows the parenchyma of gland had thyroid follicles of different size filed with colloid (A) surrounded by follicular cells (B) parafollicular cells (C) (24-month age A), (40X PAS).

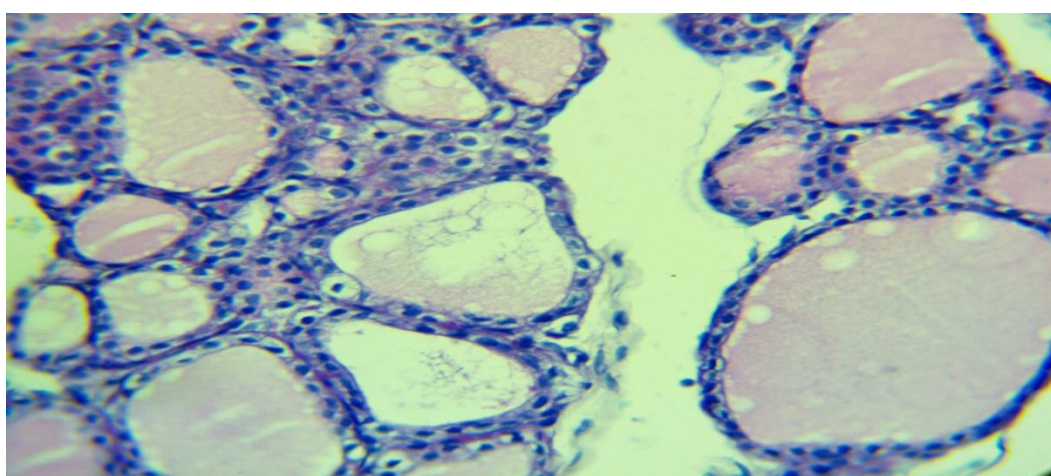


Fig. (7) Shows the thyroid gland follicular cells of simple cuboidal epithelium (A) colloid in lumen of follicle (B) shrinkage of colloid (C) parafollicular cells (D) (24-month age B), (40X PAS).

Old Group (36 Months)

Old guinea pigs showed histological changes indicative of age in the thyroid gland. Inside the glandular parenchyma, there were significantly dilated and irregularly shaped follicles, with flat or simple squamous epithelium lining the majority. The number of parafollicular cells was decreased and these cells were predominantly found in the interfollicular connective tissue. The foamy

colloid was found in most of the follicles, and there were many intrafollicular lipid droplets (Figure 8). There was considerable variation in the size of the follicles ranging from large to small some of which were very large. Most follicles were filled with foamy (foam) colloid and the interstitial connective tissue had many blood capillaries and blood vessels that were congested (Figure 9). There were also some small follicles that lacked colloid, and

congested blood vessels in the interstitial connective tissue surrounding them (Figure 10). Many follicles had areas of foamy colloid, numerous lipid droplets, and areas of increased capillary congestion and vascular structures in the surrounding connective tissue (Figure 11). In general, the thyroid gland of old guinea pig

showed a remarkable degenerative changes such as the large size of the follicles, flattening of the thyroid epithelial cells, vacuolation of the colloid, congestive changes in the blood vessels and decrease in parafollicular cells indicating the reduction of functional activity of the thyroid gland with age.

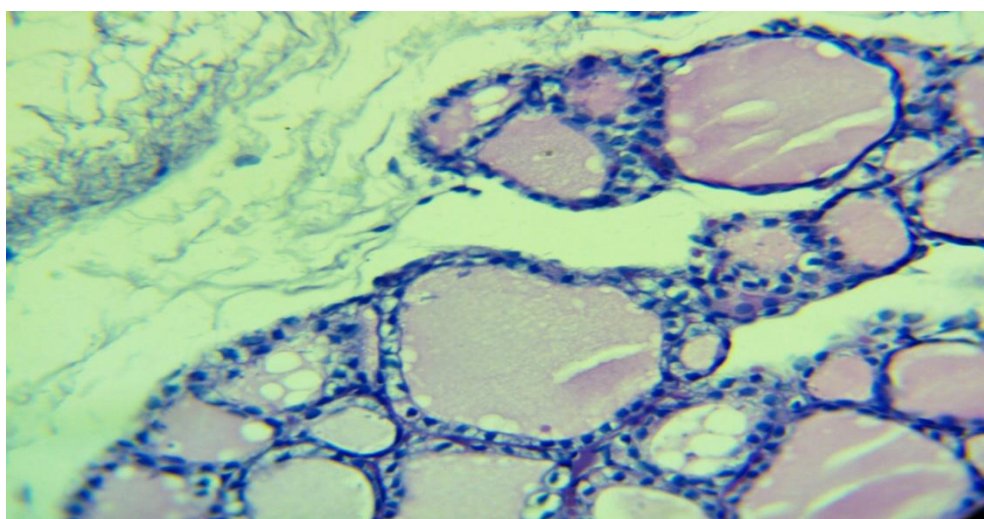


Fig. (8) Shows the fascia of loose CT (A) around the thyroid follicles, collagen fiber with elastic fibers (B) macrophage (C) thyroid follicles with colloid (D) (24-month age C), (40X PAS).

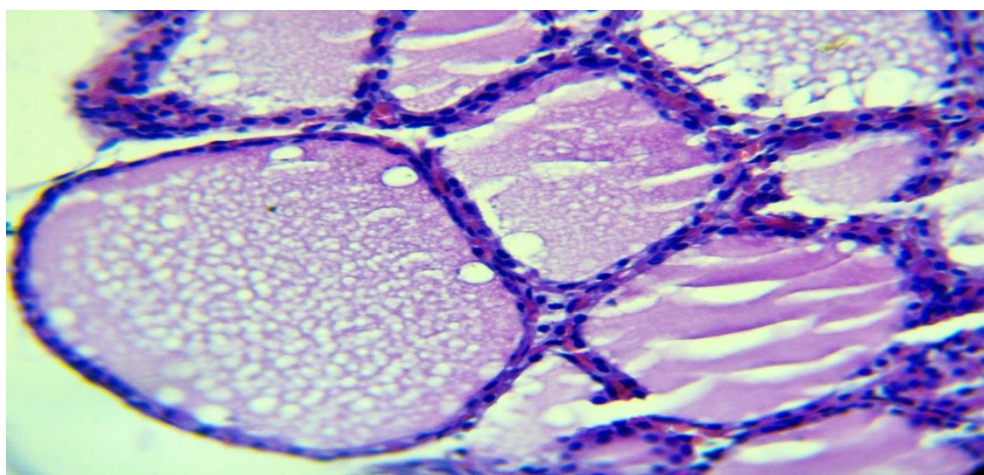


Fig. (9) Shows the thyroid follicle of great size have colloid with bubbles (A) fat droplets (B) follicle cells with are simple squamous epithelium (C) shrinkage of colloid (D), (36-month A) (40X PAS).

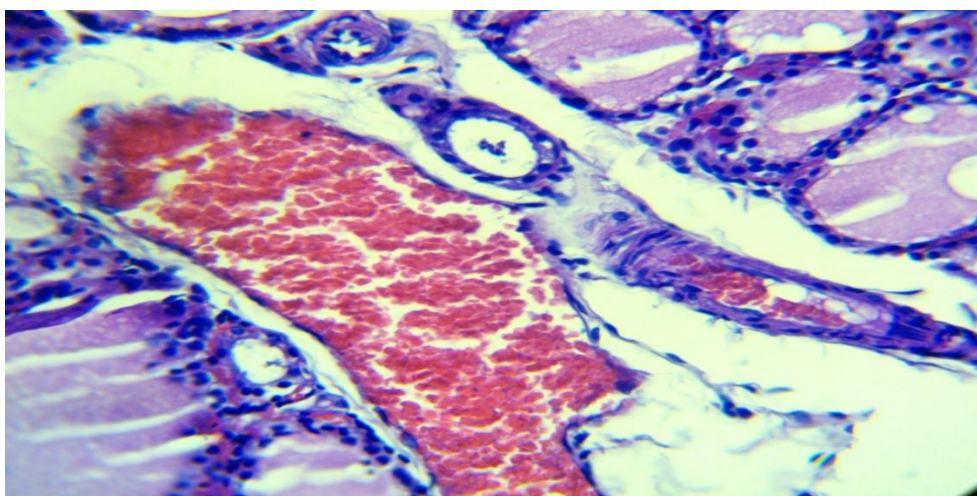


Fig. (10) Shows the interstitial CT of thyroid stroma had congested blood vessels (A) degeneration of follicular cells (B), (36 months age B), (40X PAS).

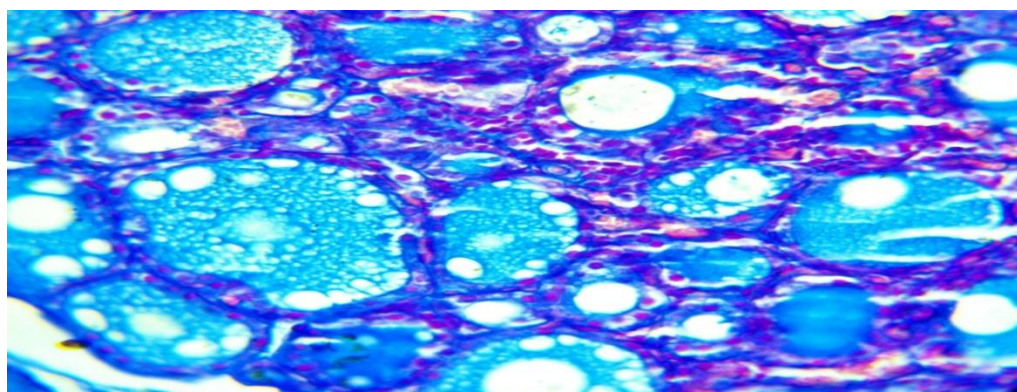


Fig. (11) Shows the whole lumens of thyroid follicles had colloid in the form of foamy appearance (A) and degenerated most of thyroid follicular cells (B) empty of follicles from colloid (C) blood capillaries in the interstitial CT (D), (36 months age C), (40X MTCH).

The histological examination demonstrated progressive age-dependent alterations in the thyroid gland of guinea pigs. The juvenile group exhibited relatively small and immature follicles, whereas the young and adult groups displayed well-developed follicles with abundant colloid and prominent parafollicular cells, indicating peak structural and functional maturity. In contrast, the old group showed enlarged and irregular follicles, foamy colloid accumulation, epithelial flattening, vascular congestion, and degenerative changes within the glandular parenchyma, suggesting a

gradual decline in thyroid functional efficiency associated with aging.

The summarized data of the changes in the thyroid gland in the guinea pig are presented in Table 1. The summarized data of the age-related histological changes observed in the thyroid gland of guinea pig are presented in Table 1. Findings showed progressive structural changes related to ageing. The thyroid in the juvenile group (6 months) showed small follicles, poorly differentiated follicular and parafollicular cells and wide connective tissue septa, suggesting an early

developmental stage. In young group (12 months), the follicles became more organized, and the lining cuboidal epithelial cells were well developed with a good amount of colloid, which showed an increase in functional activity. The enlarged follicles which were filled with colloid, prominent parafollicular cells, and well developed glandular architecture were indicative of a mature functioning state in the adult group (24 months). The old group (36 months) however,

showed significant histological changes such as enlarged and irregular-shaped follicles, foamy colloid, thinning of follicular epithelium, vascular congestion and degenerative changes in the thyroid itself. These observations suggest that morphological changes in the thyroid gland are significant with advancing age and that thyroid functional efficiency may be decreasing with increasing age.

Table 1. Summary of Histological Changes in the Thyroid Gland of Guinea Pigs at Different

Histological Feature	6 Months (Juvenile)	12 Months (Young)	24 Months (Adult)	36 Months (Old)
Thyroid follicle size	Small follicles	Variable size follicles	Enlarged follicles	Markedly enlarged follicles
Follicular arrangement	Well organized lobular pattern	Organized structure	Less regular arrangement	Irregular arrangement
Follicular epithelial cells	Poorly developed cuboidal cells	Well-developed cuboidal cells	Cuboidal cells maintained	Flattened/simple squamous cells
Colloid content	Small amount of colloid	Abundant colloid	Large amount of colloid	Foamy colloid with vacuoles
Empty follicles	Few	Present in some follicles	Rare	Frequent in small follicles
Parafollicular (C) cells	Poorly developed	Numerous and well distributed	Prominent and clearly visible	Reduced in number
Connective tissue trabeculae	Wide loose connective tissue	Loose connective tissue	Moderate connective tissue support	Increased stromal tissue
Fat droplets	Absent	Present in some follicles	Occasionally present	Frequently observed
Blood vessels	Normal	Mild vascularity	Normal vascularity	Congested blood vessels
Inflammatory cell infiltration	Absent	Presence of leukocyte infiltration	Minimal	Minimal
Histological activity	Developmental stage	High functional activity	Mature functional stage	Degenerative/aging changes

Discussion

The present study confirmed that there are progressive histological changes in the thyroid gland in aged guinea pigs. These alterations included changes in size and organization of the follicles, in the morphology of the epithelial cells, in the nature of the colloid, in the distribution of parafollicular cells, in the connective tissue elements and in the vascular elements. The changes observed indicate that ageing can have significant effects on the functional and structural state of the thyroid gland. The thyroid gland in the juvenile group (6 months of age) appeared to have relatively small follicles with poorly differentiated cuboidal epithelial cells and loose connective tissue septa. Colloid was sparse and parafollicular cells were not as prominent. These results suggest that at this time the thyroid is still maturing and histogenizing. The relative smallness of the follicles and the lesser amount of colloid may indicate that the follicles are in an active stage of development and production of hormones and that thyroglobulin is being rapidly utilized and stored in smaller amounts. Comparable findings were found in experimental research which have shown that the endocrine organs of young animals still have structural and functional development during early life. The young group (12 months of age) showed more organized morphology of the thyroid characterized by well developed thyroid follicles lined by cuboidal epithelial cells and rich in colloid. Furthermore, the parafollicular cells were more visible and the connective tissue elements were very well organized. These results indicate that the thyroid gland is structurally and functionally most mature during this time. Numerous and well-developed follicles with abundance of colloid may suggest increased secretory activity and efficient hormone synthesis. Other

investigators have noted the same, indicating that adulthood is the time of greatest thyroid activity, with highly organized follicles, and greater metabolic efficiency. The thyroid gland had follicular enlargement and abundant colloid in the adult (24 months) group, and there were clearly defined parafollicular cells. Glandular architecture was relatively well preserved and showed a stable functional stage. Increases in the size of thyroid follicles and the proportion of colloid could reflect physiological responses to maintaining thyroid hormone reserves and responding to metabolic needs. These are well defined follicular and parafollicular cells which means that the gland is still working properly during this phase. Similar observations have been reported in other histological studies, which indicated that follicles are well formed, and that the secretory activity of the thyroid glands was normal in adults, with sufficient colloid storage. Histological changes in the old group (36 months of age) were significant such as large and irregular follicles, foamy colloid, flattened or folded epithelial cells, increased connective tissue, vascular congestion and degeneration of the glandular parenchyma. The results suggest that as age gets older, the structure of the thyroid gland gets worse. The flattening of the follicular epithelial cells may be a sign of decreased cellular activity and decreased secretory activity, while a large amount or foamy colloid may be a sign of impaired utilisation of the colloid and decreased hormone release. Stromal tissue and vascular congestion may be related to age related degenerative changes that impact the perfusion of tissue and the function of the glands. The decrease in the prominence and distribution of parafollicular cells in older animals could also have functional relevance. Parafollicular cells produce the hormone calcitonin and play a role in calcium

metabolism, so changes with age in these cells might suggest a decrease in the endocrine regulatory mechanism. Gradual changes in thyroid structure and function with age are also noted in experimental animals and humans. A progressive increase in follicular diameter seen in older animals could be due to decreased endocytosis and utilisation of colloid by the follicular epithelial cells. As the animals grow older, cell metabolism and regenerative ability decline, leading to a decrease in hormone turnover and an increase of colloid in the follicular lumen. In addition, degenerative changes may occur in the thyroid gland, due to the effects of oxidative stress, decreased vascular efficiency and cellular senescence which occur with age. The changes in the tissue may well be due to these mechanisms. The histological changes observed in the present study suggest that the thyroid gland undergoes distinct age dependent changes,

possibly related to differences in functional activity in various age groups. The juvenile stage seems to be an active phase of development with continuous differentiation and maturation of thyroid tissue; young and adult stage seem to be representative of high functional activity and structural stability of thyroid tissue. Old age is, on the other hand, related with progressive degenerative changes and gradual decrease in thyroid functional efficiency. An understanding of these normal age-related histological variations is crucial to distinguish normal aging from pathological thyroid changes, and essential for baseline data for future experimental, histomorphometry, and molecular study of thyroid aging in guinea pigs. Table 2 shows the Functional Interpretation of Age-Related Histological Changes in the Thyroid Gland of Guinea Pigs

Table 2. Functional Interpretation of Age-Related Histological Changes in the Thyroid Gland of Guinea Pigs

Age Group	Major Histological Findings	Possible Functional Interpretation
Juvenile (6 months)	The follicles are small, poorly differentiated follicular and parafollicular cells, and there is little colloid and wide connective tissue septa.	A developmental and histogenetic stage that is active and in a state of differentiation and maturation.
Young (12 months)	Well formed follicles with cuboidal epithelium, lots of colloid, and prominent parafollicular cells.	High thyroid maturity and secretory activity, optimal hormone synthesis and storage.
Adult (24 months)	Enlarged follicles with numerous colloid cells, distinct paracinar cells, with well-preserved glandular structure	Demonstrates a normal and mature thyroid gland that is able to sustain normal thyroid function and metabolic requirements.
Old (36 months)	Enlarged and irregular follicles, foamy colloid accumulation, epithelial flattening, vascular congestion, increased stromal tissue, degenerative changes	Suggests age-related decline in thyroid functional efficiency, impaired colloid utilization, reduced secretory activity, and progressive structural degeneration.

Conclusion

The present study showed that the thyroid gland of guinea pigs had a significant histological architecture change with age. The follicular size, the morphology of epithelial cells, the nature of the colloid, the distribution of the parafollicular cells and the organization of the stromal connective tissue changed progressively with age. In younger animals, the follicles were relatively small, well organized, with cuboidal epithelium which suggests that the tissue is active and in process of development. Older age groups were characterized by enlarged follicles with foamy colloid and flattening of the follicular epithelium, vascular congestion, and degenerative changes in the glandular parenchyma. The structural changes indicate a progressive decrease in thyroid activity with aging. The results offer informative insights into the normal histological ageing process of the thyroid gland and aid in the differentiation of physiological from pathological thyroid conditions. A further quantitative histomorphometric and molecular study are recommended to understand the mechanisms of thyroid ageing of guinea pigs and its correlation with any endocrinal disorder.

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