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Original Research Article

Development Postnatal of the Kidney and Liver in Albino Rat *Rattus Rattus*, Histological and Biochemical Study

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Abstract: ***Objective***: The primary goal of the current study was to look at histological, histochemical, and biochemical aspects of the development structure of rat's kidney and liver. ***Materials and Method***: Seventy eight samples of kidney and liver were obtained from rats at days; 1, 5, 10, 15, 36 and 90 after birth and processed for histological, histochemical and biochemical techniques. ***Results*:** Up to the fifth day, new nephron anlages develop in the renal cortex. After ten days, the final anlages form into functional nephrons, and fifteen days after the corticis forms, the cortex seems mature. The collecting ducts and loops of Henle expand longitudinally to form the renal medulla. The immature medulla is structurally similar to the later inner stripe of the outer zone and cannot be split into distinct zones. Within ten days, the inner zone was developed, and within fifteen days, the outside zone's stripe. The kidney tubule's diameter increased with age, the renal medulla was mature at 36 days, the kidney was covered in a moderate amount of collagen fiber, and the henle loops were lengthy at certain ages, but short at adult age. Adults had larger corpuscle and nephron lumens. In contrast, the thick renal capsule at other ages contained less collagen fibers. A tiny renal gap encircling the glomeruli and a notably greater quantity of fibers were visible in adult Bowman's capsules. The liver was encased in a thin capsule on the first day of birth and a thick capsule between 36 and 90 days later. On day 15, the cells surrounding the central veins began to arrange themselves in a regular fashion. The hepatic parenchyma could be seen by symmetrical hepatic cords, which emerged from the central veins as radiating columns. After five days, Von Kuffer cells began to line the sinusoids next to the endothelial cells. On the tenth day, the hepatic sinusoids took on a more regular appearance, stretching between the hepatic cords and joining the central veins. The hepatic lobules with their central vein were visible at the age of 15 days. The capsule then thickened and elastic fibers started to show up. The reticular fibers also thickened and spread, and in 36 days, collagen fibers started to show up in the portal areas. Based on histochemical data, every PAS, AB, and PAS-AB stain was highly reacted with brush in renal and hepatic cells. ***In conclusion***: The kidney and liver developed differently after birth and reached their mature, typical structures in 36 days.

Keywords: Developmental, Postnatal, Histological, Rat, Kidney, Liver.

INTRODUCTION

The animals most frequently used for studying internal organs have been laboratory animals. Beginning with models used in physiological, metabolic, and immunological research, the field of study has expanded to include pathological study, and these animals are employed in scientific and clinical testing [1-5]. The rat kidney's growth is incredibly intricate. The pronephros, mesonephros, and metanephros are the three stages of kidney development in mammals. Each stage is identified by the development of a more mature pair of kidneys [6]. The precursor cells that give rise to the mesonephric nephron are called mesenchymal condensates. These condensates rapidly develop into S-shaped structures and renal vesicles. Metanephros have been shown to go through comparable developmental stages. The collecting duct and the Wolffian duct split the mesenchymal origin of different parts of the nephron [7-9]. Domestic animal kidneys are large, firm, and bean-shaped [10]. The urinary system is responsible for regulating blood pressure, electrolyte balance, pH, excretion, ultrafiltration, and glucose and amino acid

absorption. Bradykinin and angiotensin I, which relax blood vessels, and rennin, which the kidneys produce following an inflammatory response, are other factors that influence blood vessel relaxation. The kidneys perform endocrine roles as well. The hormone erythropoetin induces erythropoiesis. Vital substances like salt chloride and glucose are preferably retained and reabsorbt by the kidney [11-13]. The primary alimentary canal gives rise to the hepatocytes found within the liver lobes that are divided by circulatory channels and subsequently extend into sinusoids. Because it performs essential tasks like metabolism, bile secretion, detoxification, and plasma protein synthesis, the liver is the main organ in charge of maintaining metabolic homeostasis [14-18]. The liver secretes two different kinds of substances: internal (a protein and amino acid secretion) and exterior (bile). This controls metabolic processes and is in charge of removing harmful substances from the body [19]. The development of the kidney, and liver, in laboratory animals is currently the subject of little published study. This will provide insight into the fascinating new research on the development and regeneration of the kidney and liver of rat.

MATERIALS AND METHODS

Ethical Approval

The Baghdad university requirements for animal care were followed throughout the entire process, during January to May 2024.

Study Animals

The study was performed on Seventy eight samples of the kidney and liver from rats *Rattus rattus* were use in a experiment during January to May 2024, thirteen animals at each age; the animals collect from animal house in the college of veterinary medicine - University of Baghdad as following; one day (1) old as freshly born animals; five (5) day age as nursing animals, ten (10) day age as pre-weaning animals, fifteen (15) day age as weaning animals, thirty six (36) day age as post-weaning or young animals and ninety (90) day age as adult animals.

Samples Collection

Blood samples were spun in a centrifuge for five minutes at 3000 rpm. A Cobas Mira Plus CC Chemistry Analyzer (Switzerland) was used to analyze the quantities of K, Na, Mg, creatinin, uric acid, urea, ALT, and AST after sera were collected. With the exception of one day, an excessive amount of injectable ketamine is utilized to produce anesthesia in all age groups. Every animal had its kidney and liver removed from the wall of its ventral abdomen. To make it easier to reach the kidney and liver, the midline of the abdomen had been sliced, and the visceral organs had been removed. The study's organ samples were examined histologically [20].

Histological Technique

Ethyl alcohol for dehydration, xylene for cleaning, paraffin wax for the infiltration and embedding, and sectioning using a microtome [21].

Tissue Staining: Routine stain; Hematoxylin and Eosin (H @ E); verhofes; Masson's trichrome and mallory trichrome stains [21].

Histochemical Staining

The treatment of glycoproteins and mucopolysaccharides was done with Periodic Acid Schiff (PAS). Sections were immersed in an aqueous solution containing 1% periodic acid for thirty minutes. The slices were subjected to twenty minutes of Schiff's reagent and one minute of potassium metabisulfite 0.55% after being cleaned to remove any residual acid. Blue alcian (pH 2.5): To create acidic mucopolysaccharides, follow these steps: To deparaffinize the substance, use xylene. Rehydrate in graded ethanol following thirty minutes with Alcian Blue, for five minutes with the Waters, and ten minutes with Nuclear Fast Red. Give the water a minute of your time. Employing an ethanol gradient to achieve dehydration. Then, both neutral and acidic mucopolysaccharides were compared using the Alcian Blue Addition Periodic Acid Schiff (AB-PAS) method, which involved rehydrating with water. Alcian blue, pH 2.5; microwave. Give five minutes to stand and forty-five seconds to exert maximal force. Rinse in distilled water following a five-minute wash under the faucet. Work with 0.5% periodic acid for five minutes. When washing, use de-ionized water. Use Schiff's Reagent and microwave to recover for two to five minutes following a 45-second burst of vigorous activity. After washing with running water for five minutes, rinse with distilled water [21].

Statistical Analysis

The test of one-way analysis of variance (ANOVA) used to examined study at the 5% significant level. Data handled and examined using social science statistical software [22].

RESULTS AND DISCUSION

At one day of age, the subcapsular blastemic band appears to contain the terminal ampullae of collecting ducts exhibiting fork-like bifurcations, undifferentiated nephrogenic mesenchyma, renal vesicles, and S-shaped structures, from which Bowman's capsule and all future nephron segments emerge. There are many nephrons and hemispherical glomeruli and primitive tubules in the primitive midcortical layer. Bowman's capsule in these early nephrons does not yet have a patent lumen, The primitive tubules feature a columnar epithelium with nuclei positioned basally, as well as a small lumen. There are several mature renal corpuscles in the layer of the renal cortex that is immediately next to the medulla, but it is impossible to discern between the proximal and distal convoluted

tubules (Fig. 1). This is consistent with [2]. Up to the fifth day; layer of the renal cortex, new nephron anlages develop (Fig. 2). After ten days, the final anlages to form become functioning nephrons (Fig. 3), and once the cortex corticis forms around age 15, the cortex appears mature (Fig.4). In agree with [7]. We discover that a nephronogenic blastema only manifests at the age of five days (Fig. 2). This contradicts other writers' claims [2], that new nephron anlage appearances occur after five days of age.

Our results, however, indicate that the final nephron anlages to form differentiate and mature during the time after 5 days of life. This process lasts for roughly ten days (Fig. 3). Loops of Henle and collecting ducts expand longitudinally to form the renal medulla. The developing medulla is physically similar to the outer zone's later inner stripe and cannot be separated into distinct zones. Ten days formed the inner zone (Fig. 3), and fifteen days formed the outer stripe of outer zone (Fig. 4). At 36 days, the renal medulla was fully developed (Fig. 5). The kidney was covered in a moderate amount of collagen fiber, and the diameter of the renal corpuscles increased with age, which is consistent with [23, 24].

The high columnar epithelium, conspicuously marked cell nuclei, and short brush border are characteristics of the new convoluted sections of the proximal tubules. The age-related arrangement of the collecting ducts and Henle loops in the medullary rays places the ontogenetically oldest Henle loops of the differentiated nephrons within the juxtamedullary cortical layer at the outer edge of the medullary rays. The pars convoluta of the proximal tubules and the epithelium of the descending limbs are similar in terms of cell height and brush border narrowness and weaker staining. The midcortical layer is made up of these loops' ascending limbs. The The collecting duct epithelium is cuboideal. The ascending and descending limbs of these primordial loops, the tip of which is usually still in the medullary ray and has not yet entered the medulla, are made of a consistently constructed cuboideal epithelium. The lower limb of these loops does not yet show a brush border. It is noteworthy that the Henle loops that are the shortest, and appear to be the least mature are consistently found closest to the collecting ducts, the terminals of Henle loops of the juxtamedullary nephrons, and the collecting ducts with a strong columnar epithelium and several bifurcations. Low, very basophilic squamous epithelium makes up the descending limbs, and there isn't much connective tissue in between the individual tubules (Fig.4). In agree with [2-25], mention the already differentiated proximal straight tubules expand for variable distances into the medulla and only a few proximal tubules develop to a given age in the Henle loops, there is no clear distinction between the inner and outer stripe within the primitive outer medullary zone. The primitive glomeruli seem to be where they are most prevalent.

The presence of this structure accounts for the reason that the cortex and inner medullary zone appear adult while the outer zone between them appears immature during the process of medullary maturation, when they become so tightly apposed that they are no longer recognizable at age 15 days. In cortical and subcortical regions of the renal cortex, there were differences in the glomerular condensation. More development was observed in the medulla, which included a collecting duct enclosed by cuboidal epithelium, intercellular membranes, slightly stained cytoplasm, and nuclei in the center. Bowman's capsules and a noticeable parietal layer in corpuscles (Fig. 5,6). The medulla is distinctly divided into an inner and an outer zone at 36 days of life. The papilla's medullary material is where the inner zone forms. Here, the characteristic thin epithelium of mature, thin ascending limbs eventually replaces the thick epithelium of the lengthy ascending loops of Henle. In the outer zone, Henle loops become significantly more common. Additionally, the number of differentiated proximal tubules increases, primitive subcapsular layer vanishes when the primitive nephrons mature, and the renal cortex seems to adopt a homogeneous structure. All nephrons now have renal corpuscles that roughly resemble spheres. Bowman's capsule has enlarged, and podocytes are covering the glomeruli's capillary loops (Fig.4). The presence of loose connective tissues in the primordial outer medullary zone sets it apart from the growing inner zone. The collecting ducts and loop of Henle within this connective tissue form loose groupings known as medullary ray bundles, which extend the cortex's medullary rays into the medulla. The medullary ray bundle found in the immature kidneys are strikingly similar to those found in other animals [2-5].

The adult's renal pelvis is where the boundary is located. The vascular bundle were embedded within the collecting duct and thick ascending limbs of loops of Henle, thin descending limbs of Henle separated from thick ascending limbs, the loose connective tissue of the primitive outer zone disappears, and the medullary ray bundles thicken and come into close apposition at their edges. The renal medulla's visible subdivision into medullary ray bundles is lost. Through a gradual, descending process of differentiation, the primitive squamous epithelium of aged Henle loops gives rise to the straight proximal tubule epithelium (Fig. 7). The tubules' interstitial longitudinal development increases the volume of renal cortex. The thickness of the whole cortical layer grows, and tubule loops are repositioned over the medullary ray apices. The inner and outer stripes are more clearly characterized because of the abrupt rather than continuous transition of the straight proximal tubule epithelium into the thin epithelium of descending limb of Henle [26-28].

Liver was encased in a tiny capsule on its first day of life and then a thick capsule between 36 and 90 days later. Hepatocytes, which were encircled by a

central vein, made up the parenchyma. The hepatic sinusoids surrounded the endothelial cells close to the Kupffer cells that protruded, further dividing the parenchyma, It wasn't until the tenth day following birth that the cells around the core veins began to take on their regular pattern. At ten days, typical hepatic cords were indicative of the hepatic parenchyma; some of these cords were created from a single cell layer, while others had two cell layers. From the center veins, these cords emerged as radiating columns. Von Kuffer cells began to line the hepatic sinusoids at day 15, right next to the endothelial cells. By day 36, the hepatic sinusoids had taken on a more regular appearance, extending along the hepatic cords and connecting to the central veins. The hepatic lobules were clearly visible, with a central vein at their center and multiple portal areas at their angles. Collagen fibers started to form in the portal regions, reticular fibers thickened and dispersed, and the capsule got thicker and more elastic fibers (Fig. 8-12).

The parenchyma around the liver, that was coated in a basic squamous epithelium, was made up of hepatocytes. Next within the endothelial cells lining the sinusoids that divided the main vein surrounding the parenchyma were protruding kupffer cells (Fig. 12). There are age-related differences in the hepatic artery, hepatic duct, and central vein thickness, with adulthood showing a greater variance than other ages (Table 1). At thirty days of life, the liver displayed accelerated morphogenesis and hepatic cell structure development. The liver is made up of lobules that are separated by very few connective tissue septa. The location of the central veins within the lobules is unexpected. The hepatocyte possessed a polyhedral shape and spherical nuclei arranged in non-uniform cords. The bile duct, hepatic artery, and branch of portal vein comprise the portal triads, which are situated in the angles of the hepatic lobules (Fig. 8-14). According to [29], Compared to livers of other ages, the adult liver possesses a broader portal triad (Table 1). This may be due to increased hepatocyte and metabolic activities, which support the preservation of body homeostasis and are linked to age-related variations in surface area as well as size. Numerous research on the liver have shown that environmental factors and embryonic development influence the liver's form, as seen by way animal adapt to their surroundings [17]. Kuffer cells provide a defensive physiological role, as demonstrated through their absorption of foreign items and harmful substances that enter through the portal artery [18].

Histochemical findings indicated that the kidney and liver accepted PAS, AB, and PAS-AB stains. The mature structure of the renal components was observed where the renal tubules surrounded renal corpuscle in renal cortex, parietal and visceral layers of Bowman's capsule were seen to encircle the glomerular capillaries. Renal tubules of different widths filled the spaces between the renal corpuscles. Distal tubules having a large lumen were found near the renal corpuscle's vascular pole, within the juxtaglomerular apparatus. The brush border of the kidney and the hepatic cells responded favorably to AB, PAS, and PAS-AB. PAS was used to stain the glomerulus basement membranes and renal tubules (Fig. 2, 6, 8, 12, 13), which is in line with earlier research [4-29].

Table 1: Measurements of kidney and liver in rat *Rattus rattus*, µm ($X^- \pm$ S.E)

Measure Age	Capsule		glomerulus	Proximal tubules	distal tubules	Central vein	Hepatic duct
	kidney	Liver					
1 day	22.4±0.2A	42.7±0.1 B	113.4±0.1A	44.3±0.02 a	82.5±0.03 B	514.1±0.1 A	162.6±0.4 A
5 day	28.6±1.1A	49.2±1.1 B	117.2±0.5A	53.2±0.01 a	91.6±0.04 B	536.1±2.3 A	175.1±0.1 A
10 day	33.4±0.1A	52.6±0.3 B	124.6±0.2A	58.5±0.04 a	95.4±0.05 B	558.1±0.5 A	184.3±0.2 A
15 day	49.3±0.1A	69.4±0.4B	129.6±0.5A	67.2±0.03 a	112.1±0.06 B	587.1±0.7 A	197.1±0.1 A
36 day	52.1±0.4A	76.3±1.2 B	132.8±0.3A	81.2±0.03 a	143.4±0.07 B	602.1±3.4 A	203.6±0.4 A
90 day	56.6±1.2A	83.1±0.5 B	145.7±0.2A	87.2±0.03 a	153.5±0.08 B	614.1±1.3 A	216.4±0.3 A

The values columns with capital letters in same column denote for significant difference (P>0.05), while column values with small letters denote to nonsignificant differences (p<0.05).

Table 2: The biochemistry parameters in *liver and kidney of rat and rabbit* Mg-dl

Measure Age	K	Uric acid	AST	ALT	Ammonia	Urea	Na	Mg^{2+}	Creatinin
1 day	3.1±0.01 A	2.17±0.2A	15.9±0.2A	17.6±0.3 a	51.6±0.6 A	30.3±0.2 A	116.3± 1.1 B	1.2±0.06 A	1.26±0.2A
5 day	3.7±0.02 A	2.58±0.6A	16.8±0.2A	18.2±0.2 a	54.7±0.1 A	33.1±0.5 A	120.4± 1.3 B	1.3±0.05 A	1.38±0.4A
10 day	4.1±0.07 A	2.74±0.4A	16.4±0.4A	18.7±0.2 a	58.4±0.2 A	35.4±0.6 A	122.5± 1.5 B	1.4±0.03 A	1.59±0.2A
15 day	4.8±0.03 A	3.18±0.5A	17.2±0.8A	19.3±0.2 a	59.3±0.4 A	39.6±0.8 a	130.4± 1.4 B	1.6±0.02 A	1.88±0.3A
36 day	6.2±0.08 A	3.76±0.8A	18.1±0.9A	19.8±0.4 a	60.6±0.9 A	41.1±0.4 a	142.6± 1.6 B	1.7±0.04 A	2.1±0.5A
90 day	6.8±0.04 A	3.97±0.1A	18.6±0.3A	20.7±0.1 a	62.4±0.3 A	42.4±0.7 a	148.4± 1.2 B	1.8±0.02 A	2.73±0.4A

The value with capital letter in same column denote to significant difference (P>0.05); whereas value with small letter denote to the nonsignificant differences (p<0.05).

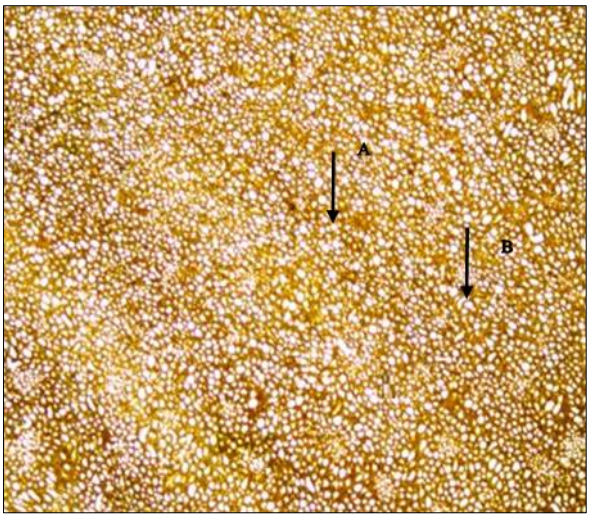

Fig. 1: Photomicrograph of rat kidney, at 1 day age; proximal tubule (A), distal tubule (B), Verhoefs stain 200X.

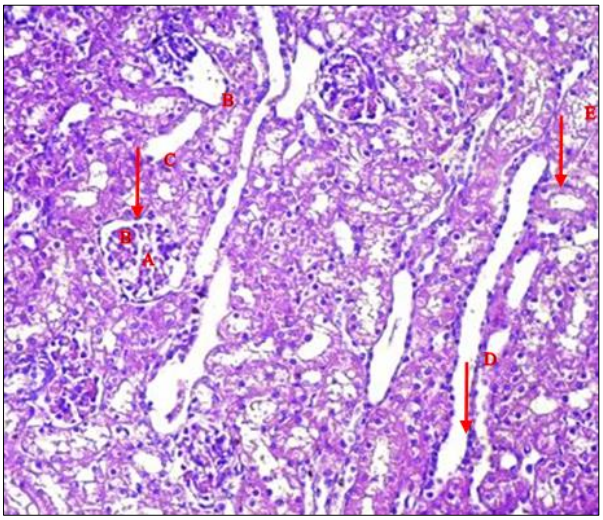

Fig. 2: Photomicrograph of rat kidney, at 5 day age; glomerulus (A), renal space (B), Bowman capsule (C), Henle loop (D), collecting duct (E), PAS 200X.

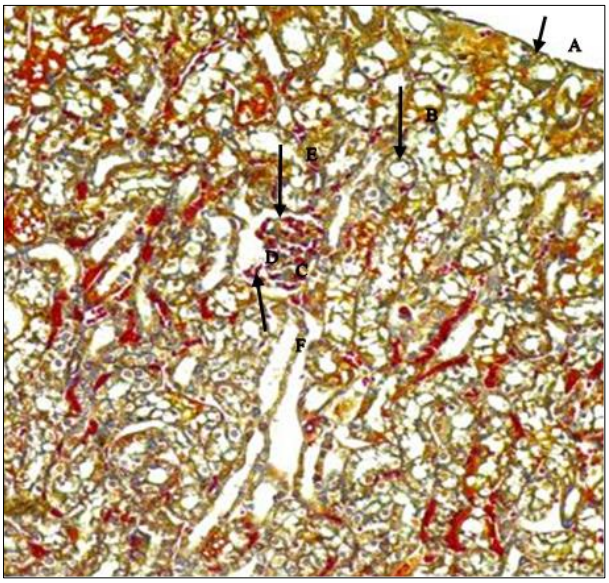

Fig. 3: Photomicrograph of rat kidney, at 10 day age; capsule (A), collecting duct (B), glomerulus (C), renal space (D), Bowman capsule (E), juxtaglomerulr apparatus (F), Mallory 200X.

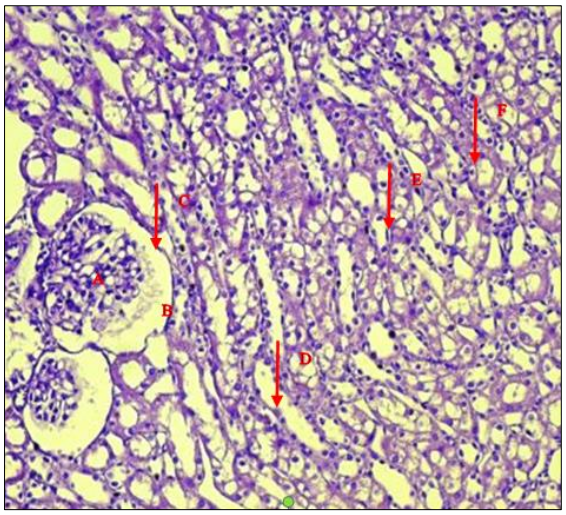

Fig. 4: Photomicrograph of rat kidney, at 15 day age; glomerulus (A), renal space (B), Bowman capsule (C), loop of Henle (D), proximal tubule (E), distal tubule (F), AB

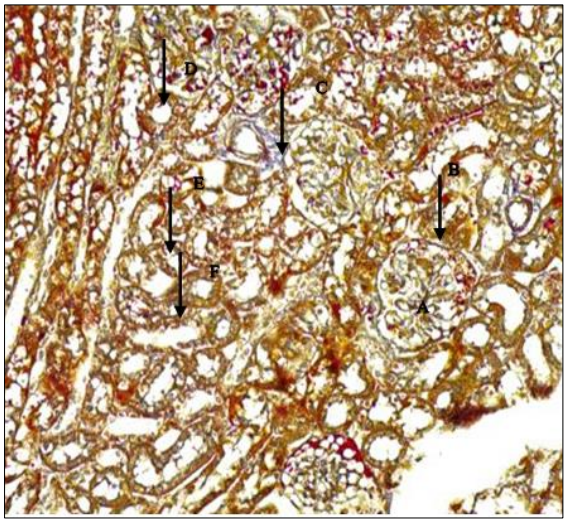

Fig. 5: Photomicrograph of rat kidney, at 36 day age; glomerulus (A), Bowman's capsule (B), connective tissue (C), collecting duct (D), proximal tubule (E), distal tubule (F), Mallory 200X.

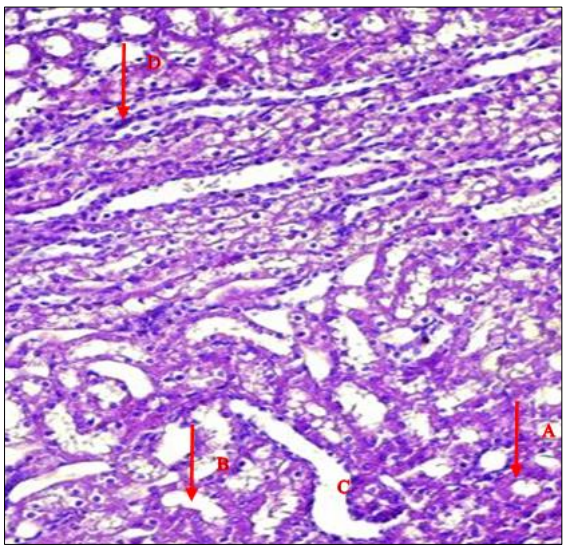

Fig. 6: Photomicrograph of rat kidney, at 90 day age; collecting duct (A), proximal tubule (B), distal tubule (C), Henle loop (D), AB-PAS 200X.

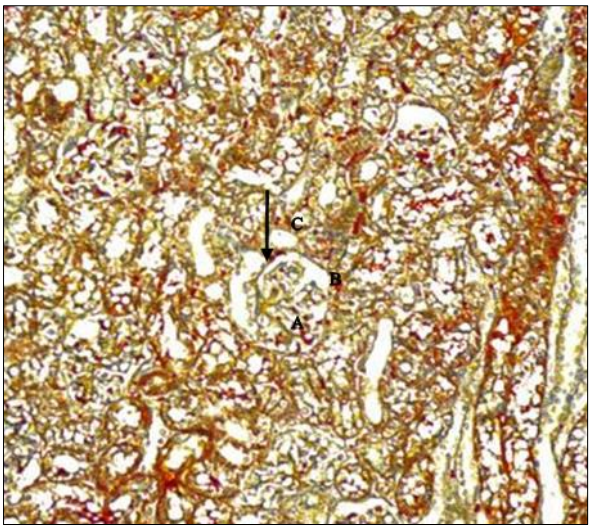

Fig. 7: Photomicrograph of rat kidney, at 90 day age; glomerulus (A), renal space (B), Bowman's capsule (C), Verhofes 200X.

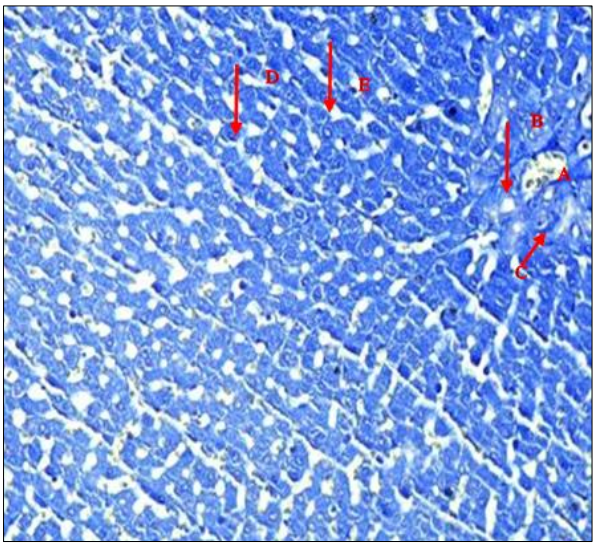

Fig. 8: Photomicrograph of rat liver, at 1 day age; central vein (A), portal artery (B), hepatic duct (C), hepatic cells (D), sinusoids (E), AB 400X.

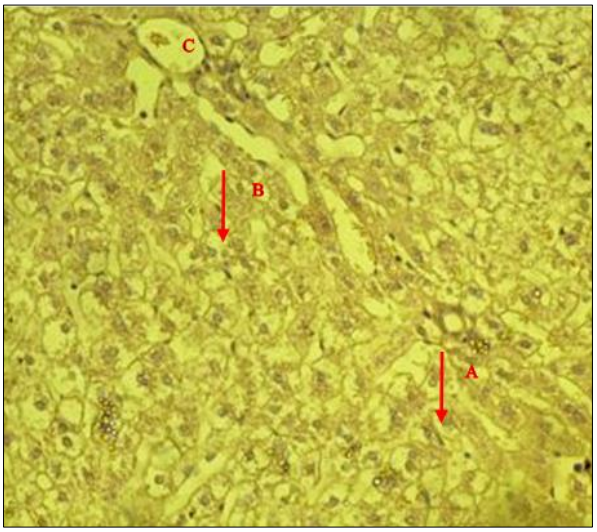

Fig. 9: Photomicrograph of rat liver, at 5 day age; hepatic cells (A), sinusoids (B), central vein (C), H@E, 400X.

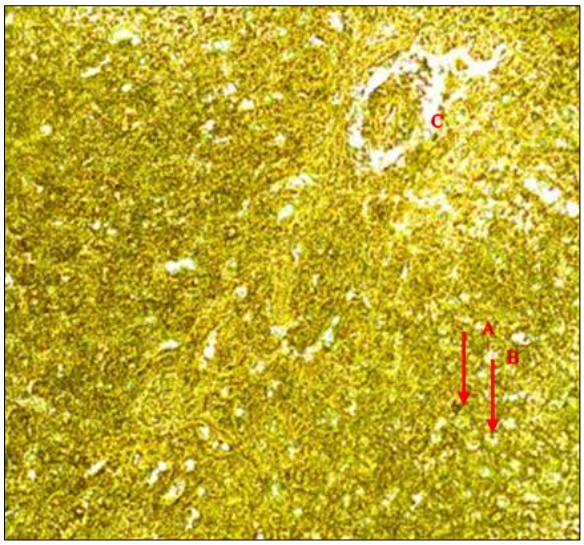

Fig. 10: Photomicrograph of rat liver, at 10 day age; hepatic cells (A), sinusoids (B), central vein (C), Verhofes, 400X.

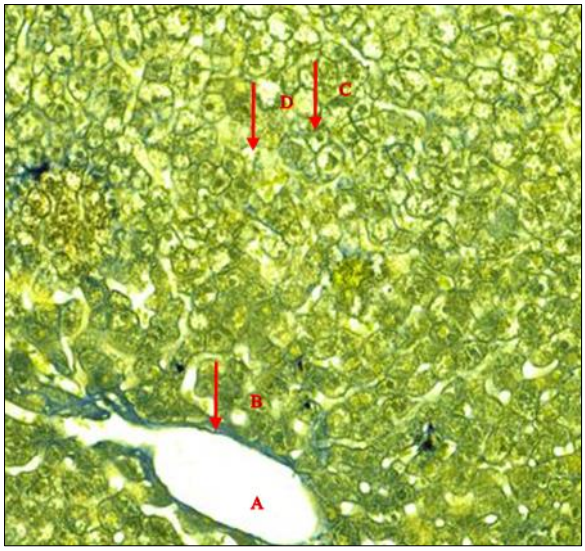

Fig. 11: Photomicrograph of rat liver, at 15 day age; central vein (A), endothelium (B), hepatic cells (C), sinusoids (D), Verhofes,400X.

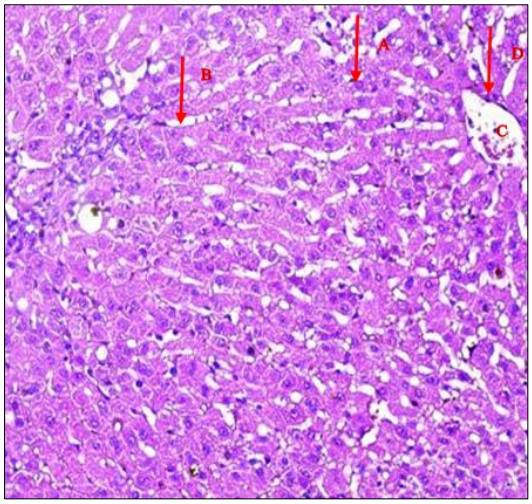

Fig. 12: Photomicrograph of rat liver, at 15 day age; hepatic cells (A), sinusoids (B), central vein (C), endothelium (D), AB, 400X.

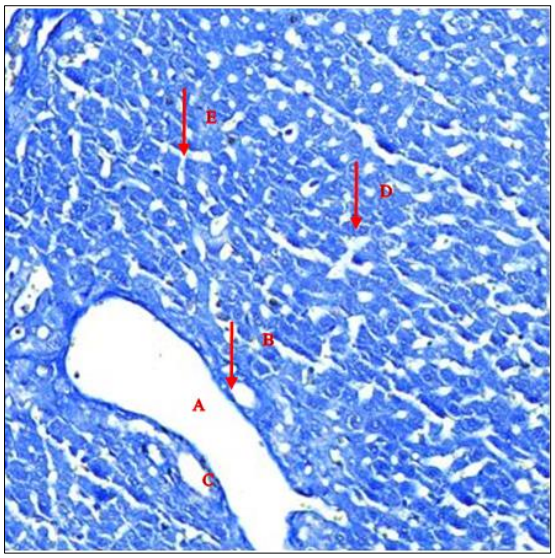

Fig. 13: Photomicrograph of rat liver, at 36 day age; central vein (A), endothelium (B), hepatic duct (C), hepatic cells (D), sinusoids (E), AB,400X.

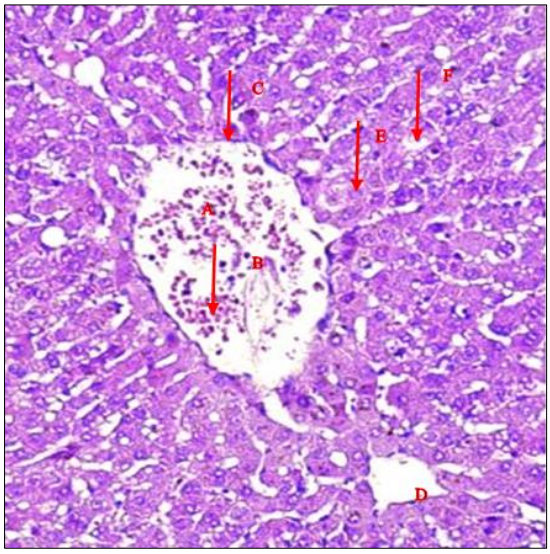

Fig. 14: Photomicrograph of rat liver, at 90 day age; central vein (A), red blood cell (B), endothelium (C), hepatic duct (D), hepatic cells (E), sinusoids (F), Masson,400X.

CONCLUSION

As animals age, their kidney and liver architectures alter. These organs experienced postnatal developmental changes for 36 days following delivery before developing into the adult kidney and liver.

Funding: Rather than obtaining outside funding, the author finances this research on an independent basis.

Availability of Data and Materials: Available data from the current study region upon reasonable request.

Competing Interest: There are not conflict of the interest between the authors.

Ethical Consideration: The ethical guidelines to study conduct have been adhered to by the University of Baghdad, Iraq.

Author Contributions: All authors contribute equally.

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