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Some Information about the Morphology and Anatomy of the Human Kidney

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Abstract

Human kidney is a basic and very important organ of the body. It has many important function inside the human body, among all work, filtration of blood and urine formations are the major important functions. Kidney forms the urinary system and it is also known as the major excretory organ of human body. The anatomical development of human kidney undergoing several process of development from the antenatal life till the end, and a brief description about kidney anatomy in several stages of life was discussed here in this review.

Keywords: Kidney; Anatomy; Excretory Organ; Urine

Introduction

The two kidneys constitute one of the basic urine excretory systems inside human body which can help in excretion of nitrogenous waste of basic protein metabolism from the blood. By removing all these waste materials, excess nutrients and harmful stuffs from our body kidneys help to maintain the electrolyte and water balance of the body. Inside the kidney, filtration and reabsorption of blood is done. During the filtration blood enters by means of the afferent arteriole and directed to flows towards the glomerulus of kidney. Inside the glomerulus both the filterable and non-filterable blood is present. The filterable blood contain some components like nutrients, water, salts such as ions and nitrogenous wastes; these things were taken by form of plasma called as glomerular filtrate, while the non filterable components of blood which is including elements such as plasma proteins, blood cells and platelets. These non-filterable blood components are bypassed by the process of filtration and through the way of efferent arteriole these things are exiting from the glomerulus. The reabsorption occurred when the filtrate passes through the tubules of the nephron which is known as the basic functional unit of the kidney.

Here inside the kidney reabsorption of blood is done, where some of the important molecules and ions of the blood get reabsorbed. Kidneys also reabsorbed Sodium Chloride into the human body system which can increases the osmolality of blood in comparison to the glomerular filtrate. Due to this process of reabsorption water (H_2O) is allowed to pass from the glomerular filtrate back into the circulatory system. Due to this process to the circulatory system, several kinds of important amino acids and molecules of glucose are also reabsorbed. All of these nutrients having some carrier molecules which can help to release molecule from glomerular filtration and again reabsorbed these molecules back into the circulatory system but in case of total used of carrier molecules and absence carrier molecule the nutrients as well as glucose is called as excess amount for the body and are removed from the body by eliminate them in the form of urine [1]. So the kidney is a very important organ to study, several studies have already established many facts regarding the basic morphology and anatomy of the kidney as well as its functional approach, and several studies are still going on. Here the brief description of morphology and anatomy of human kidney and its process of development is given from antenatal to old age, how the kidney developed and how its structure changes.

Before going to study the development of the kidneys the basic criteria of kidney are given below.

Structure of Kidney

The structure of kidney consists of its location, its specific weight, shape and size.

The location of kidney in the human body system

Every human being need the help and support of kidneys, there are two number of kidneys or these are the paired retroperitoneal organs which are present inside the abdominal cavity specifically in the posterior region of the abdomen. They are present at both the left and right side of the spinal cord (vertebral column). It is well known that, the kidney present in the right side is usually little bit more caudal in position than the kidney present in the left side. The portion of the kidneys also having a significance place and position like the upper poles of both of kidneys are lies in the opposite to the twelfth number of the thoracic vertebral column and the lower pole of both of the kidneys lies in the opposite to the third number of lumbar vertebral column [2].

Weight, shape and size of the kidney

Weight of human kidney: The kidney has a specific shape, size and weight. The shape of human kidney is a bean-shaped structure having a convex and a concave border. In human, the weight range in adult male kidneys varies from 125 g to 170 g and the kidney in adult female varies from 115 g to 155 g [3]. The Median renal volumes were 146 cm^3 on the left and 134 cm^3 on the right.

A brief description about the Shape and size of the human kidney: The human kidneys have a specific range of thickness, length and breadth. The range of thickness varies from approximately 2.5 cm to 3.0 cm; the range of width varies from approximately 5.0 cm to 7.5 cm the range of length varies from 11 cm to 12 cm. The kidney is surrounded by a tough fibrous capsule, in normal condition this cover can be easily removable. There is a slit present on the concave surface of each kidney which is called as hilus. By means of the hilus the renal

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artery, renal vein, renal pelvis, a nerve plexus and the lymphatic are passing into the area of the kidney called as sinus [4].

A brief anatomy of human kidney: The kidney parenchyma majorly divided into two structures such as the inner renal medulla and the outer renal cortex. These structures modified to form cone-shaped renal lobes specifically from eight to 18 numbers. Each of cone-shaped renal lobes consists of renal cortex which is surrounded by a portion of medulla which is called as the renal pyramid. the projections of cortex in between he renal pyramids are defined as renal columns. The nephrons, the structure known as the major functional unit of kidney as well as the urine-producing unit of kidney, span the medulla and cortex. In the cortex, the renal corpuscle is located which is known as the initial filtering portion of a nephron which is followed by a renal tubule. The renal tubule generally passes from the cortex and enter deep into the pyramids of the medulla. Medullary rays are one of the important part of the renal cortex. The medullary ray is a collection of renal tubules which is drain into a single collecting duct. Each renal pyramid having tip or papilla which is helping to empties urine into a minor calyx. Again the minor calyces undergo a process of emptification of urine into the major calyces. Then the major calyces undergo a process of emptification of urine into the renal pelvis. Then finally the urine moves to the ureter. At the hilum of the kidney renal artery enters whereas the ureter and renal vein exit from the kidney.

All the structures are surrounded by hilar fat having contiguous with a fat-filled cavity called the renal sinus and lymphatic tissue with lymph nodes. The renal pelvis and calyces are collectively contained by the renal sinus the and separates these structures from the renal medullary tissue [5].

Blood supply to the kidney

Inside the kidney blood circulation occurs by means of pair of renal arteries and approximately 20% of the cardiac output is received by the kidneys [3].

Connection of nerves with the kidney

By means of the renal plexus, the nervous system is connected with the kidney [6]. The vasoconstriction inside the kidney triggered due to the input from the sympathetic nervous system which causes reduction in renal blood flow.

The process of development of kidney in various stages of human life: The initiation of kidney development inside human being occurred by the process of nephrogenesis, or it is the term which is described as the process of development of mammalian kidney from the intermediate mesoderm. Nephrogenesis has three developmental phases such as pronephros, mesonephros, and metanephrons. The permanent kidneys are developing from metanephros [7].

The primary development inside human kidney initiate during antenatal life, especially at the end of the first month kidney starts to develop and during the second month kidney is able to function. Involute changes are noticed inside the fetal kidney during the last trimester. Then the processes of maturation inside the adult kidney are noticed according to the growing age [8].

Development of kidney inside embryo and fetus stage with few anatomical highlights: During the start of human life, several developing processes are undergoing inside the human embryo, the antenatal life is one of them which includes several developing periods like pre-embryonic period, embryonic period and fetal period. During these period of development several stages of is development such as pronephros, mesonephros and metaphors, mainly observed in the excretory systems; all together develop from the nephrogenic cord from the intermediate mesoderm. The metaphors is a permanent excretory organ in future and the temporary form are Pronephros and mesonephros [7-15].

The development of pronephros

During pre-embryonic period especially at the end of third week, the initialization of the progress and development of pronephros occurred in nephrotomes from the first five segments of the cranium. Seven to ten solid cell clusters represents the Pronephros inside the embryo of human being which are later on changes to vesicles and tubules. The tubule especially the tips of the lateral tubule ends ongoing to extend caudally, this caudal extension of tip of lateral tubule to reach and connect the nearest tubule below to it. These tubules having holes called nephrostomies at their end of medial region which help in the process of communication with coelomic cavity. The Pronephric tubules are short, not fully developed as well as differentiated; the development of glomeruli has not occurred because the aorta does not branch into the pronephric tubules. The pronephric tubules are going on a process of regression in a very early time period which causes disappearance of the cranial tubules before the appearance of caudal ones [9]. The complete disappearance of pronephros occurs at the end of fourth week of the embryonic development in human being [10].

The development of mesonephros

At the starting of the fourth week of the embryonic stage can initiate the appearance of mesonephros [5] which can cause a little change inside the nephrogenic cord especially it stretches from the sixth segment of cranium to the third lumbar segment. The solid cell clusters from the nephrogenic cord, caudally from pronephros undergoing a successful differentiation to form mesonephros. These mesonephros are initially vesicular later on they changed into S shape mesonephric tubule.

The nature of mesonephric duct, it is caudally elongated then ventrally curved which is opens into a cloaca. During the age of fifth and sixth weeks there are maximum 30 numbers of glomerular tubular units called as nephrones present inside the mesonephros [11]. During this period mesonephros extends to its maximum length and developed into a oval, large organ which is lying by the dorsal wall of the body cavity, on both sides of the middle line [7]. The mesonephric or Wolffian collecting duct is present in the lateral part where as Malpighian corpuscles, the curves of mesonephric tubules are found to be present in the medial part. At the end of the eighth week of antenatal life mesonephros disappeared. The development of glomeruli begins and cranial tubules are degenerated before the caudal ones are appeared.

Disappearance of Mesonephric Duct in Male and Female Fetuses

Male fetuses

In case of the fetuses, stage of the male gender some of the organs like epididymis canal, ejaculatory duct, ductus deferens, seminal vesicle are developed from the mesonephric duct and some of the remaining mesophrenic tubules are developed into organs like efferent ductules of testis, the paradidymis, caudal aberrant and rostral ductules [7].

Female fetuses

In fetuses of the female gender some of the remaining caudal

tubules become non-functional structures such as epoöphorone and paroöphorone found to be located in the uterine ligaments and the complete disappearance of the mesonephric duct occurred [7].

Metanephros also called as definitive kidney

Metanephros stage initiates during the fifth week of embryonic life which is called as the final developmental stage of mammal kidney. Here the development by means of three sources such as the mesonephric duct is undergoing a process of evagination, the ureteric bud, the formation of nephric structure from metanephric blastema. Here the antigenic mesenchyme migrates into the metanephric blastema, after sometimes later it undergoing a process to produce the organs like glomeruli and vasa recta. It may also relate the necessity of innervations for the induction of metanephric kidney [12].

In the second month of the embryonic development organs like the ureter and ureteric bud are developed from mesonephric duct's lower part, where it has a close connection with cloaca. It penetrates into the metanephric blastema by growing dorsocranially and lost the cranial end [12]. Then the metanephros undergoes several process of development to produces side-branches for next fifteen generations which will further going to produce collecting ducts and calyces [13], progressively the full renal excretory system is formed. The connection between metanephric blastema and ureteric bud later differentiated into nephrogenic cells and stromagenic cells [8].

Nephrogenic cells and kidney development

The nephrogenic cells differentiated to meta nephric caps around the growing ends of side-branches of the ureteric bud which further develop to form the main structural and functional unit of renal system called as nephrons. Here the process of kidney development involves to form S shaped tubular structure from the condensed mass, here proximal end of S structure will form the renal corpuscle when it was along with the capillaries of blood vessels nearer to it. The remaining part constructs the loop of Henle, distal and proximal tubules. The distal tubule connects and interacts between excretory renal components and secretory component called as nephron [8].

Stromagenic cells

Stromagenic cells construct the renal connective tissue in the process of nephrogenesis for inducing the metaphors kidney the presence nerve growth factor (NGF) and NGF receptors are very important [8].

During the entire fetal life, nephrons are produced in 15 successive generations, every

Successive generations of nephrones are closer to the cortex's outward surface from the previous. During the period of gestation especially between the 28th and 36th week, production of new nephrones are completed which will so the definite number of nephrons during the birth of the child [14,15]. During birth about one million of nephrons are present in each of the human kidney, close to the medulla more number of mature nephrons is present and maturation decreases near to outward cortex but the maturation regarding both structure as well as function occurred after the birth of the child [8].

During the time of birth each of human's kidneys contains about one million of nephrons, at different stages of development. The greatest number of mature nephrons is located close to the medulla, and their maturity decreases in the direction of the outward cortex. Structural and functional maturation of the nephrons continues after birth.

During the antenatal life especially at the 14th and 16th week the growth of kidneys occurred most rapidly and they increase three times their volume. The continuous and uneven growth of Medulla, sinus and cortex occurred inside the kidney.

Anatomical Features during the Development of Kidney during the Childhood Phase, Adolescents Phase and Young Adults Phase of Human Life

During the Childhood phase, Adolescents phase and Young Adults phase of human life, the function of kidney occurred in a systematic manner. The renal structures are fully matured during this phase. During the seventh month phase of the intrauterine life the degeneration of glomeruli is initiated juxtamedullary glomeruli is degenerated during the seventh year of life [16]. The left kidney is little bit larger and longer than the right kidney. There is a correlation between the child's height and the length of kidney. In children the kidney volume is affected by the pathological changes in kidney [17,18].

In case of adults the kidney having 3 cm thickness, 5-6 cm width, 10-12 cm length. The weight of a single kidney is about 135 g and 150 g in case of adult female and adult male respectively [18]. The kidney length increase to its maximum label till age of 20th and 30th year of age, the left kidney is 2 mm longer than the right one [19].

Structural Changes of the Human Kidney in the Elderly Persons with Specific Anatomical Characteristics

During the old age many kinds of changes are observed inside the human body. So specific changes are observed in kidney also, there is a loss in kidney mass, the weight of both the kidneys decreases from 250 g–270 g to180 g–200 g till 80 years of age. The primary loss of kidney mass is observed in cortex [20]. The decrease in the number of functional nephrons indicates the atrophy of renal cortex [21]. Inside the glomeruli, meningeal matrix progressively enlarged, the arterioles are getting hyalinized, basement membrane became thicker, and the renal corpuscles are gradually less in number and their average surface increases with the increase of age [22].

It is observed from many previous studies that with the increase of age there is a decrease in glomerular volume decreases with age, there is dilation in tubular volume, the number of cells in decreases the tubular cells tend to hypertrophy and the glomerular cells tend to atrophy [23].

In higher age due to hypertension there are many changes occurred in the wall of arteries of kidney sclerotic changes are seen, Under some circumstances which can resulted into ischemic nephropathy [24,25].

Conclusion

The kidney has much kind of changes throughout the life but it can function well in normal conditions of a healthy life. In case of any abnormality it leads to develop many abnormal conditions which will lead to develop many kinds of functional abnormalities inside the organ. So for a healthy kidney we should maintain a healthy life.

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