Sudan University of Science and Technology

College of Graduate Studies

Measurement of Fetal kidney and Renal Pelvis among Sudanese using Ultrasonography

قياس كلية و حوض كلية الجنين لدي السودانيين باستخدام التصوير بالموجات فوق الصوتية

A thesis Submitted for Partial Fulfillment for the Requirement of M.Sc. Degree in Medical Diagnostic Ultrasound.

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الآية

قَالَ رَبِّ إِنِّي وَهَنَ الْعَظْمُ مِنِّي وَاشْتَعَلَ الرَّأْسُ شَيْبًا وَلَمْ أَكُن بِدُعَائِكَ رَبِّ شَقِيًّا (4)
وَإِنِّي خِفْتُ الْمَوَالِيَ مِن وَرَائِي وَكَانَتِ امْرَأَتِي عَاقِرًا فَهَبْ لِي مِن لَّدُنكَ وَلِيًّا (5)
يَرِثُنِي وَيَرِثُ مِنْ آلِ يَعْقُوبَ ۖوَاجْعَلْهُ رَبِّ رَضِيًّا (6))

صدق الله العظيم

سورة مريم

Dedication

To my parents who always stay behind me

To my sister and brothers

To my friends and colleagues

To my husband and my children

To all my lovers

To those who wished me success

Acknowledgement

First of all I would like to thank God who helps me completing this effort. Thanks also extended to my supervisor Dr. Ahmed Mostafa who gave me perfect advice, ideas, and motivations to complete this research in success.I owe my deepest gratitude and thanks to sudan university specially collage of medical radiological science and collage of graduate studies.Also I would like to thank Dr. Saadia Ibrahim whohelps me collecting the data.And thank to all members of department of radiology in alshifa modern medical collecter. My thanks to all people who helped me in this thesis.

Abstract

Accurate estimation of normal antenatal fetal kidney size is very important, thus determination of normal measurements was help in early diagnose of fetal renal abnormalities. This crossectional studywas done tomeasure fetal kidnysonographically during pregnancy.

The aim of this study was to establish reference charts for fetal kidney length, width and renal pelvis diameter. The study was carried out in AlshifaModern Medical Centre from November 2016 to March 2017. The study includes 50 normal pregnant womenwith singleton pregnancy between (17-39) weeks of gestation. Sonographic examination was performed, longitudinal and transverse diameter of fetal kidney and antero posterior diameter of renal pelvis were measured, with the average being used for analysis.

The study demonstrated that the mean kidney length in (17-39) weeks of gestational age was ±3.61 cm;the mean width of kidney was±1.7210 cm,while the mean renal pelvis diameter was ±0.9528 cm. These measurements correlated significantly with gestational age.It was noticed that the increase in renalvolume during pregnancy is exponential until birth.

In conclusion, given that renal pathology often presents late in pregnancy, our reference charts for size and volumeof the fetal kidney may be useful in cases of diagnostic problems. This finding may alsobe useful for the detection and evaluation of abnormal growth.

المستخلص

التقدير الدقيق لحجم كلى الجنين الطبيعي قبل الولادة مهم جدا . وبالتالي تحديد القياسات العاديه تساعد في التشخيص المبكر لتشوهات كلى الجنين . هذه الدراسة أجريت لقياس كلى الجنين أثناء فترة الحملز

الهدف من هذه الدراسة هو إنشاء مخططات مرجعيه باستخدام طول وعرض كلى الجنين وقطر الحوض الكلوي. أجريت هذه الدراسة في مجمع الشفاء الطبي الحديث في الفتره من تشرين الثاني / نوفمبر 2016 إلى آذار / مارس 2017. شملت الدراسة 50 سيدة حامل بحمل جيد مفرد , تتراوح أعمار أجنتهن ما بين 17 و39 إسبوع جميعهن أخضعن لفحص الموجات فوق الصوتية بغرض الكشف الروتيني . تم قياس القطر الطولي والقطر العرضي للكلى , والقطر الأمامي الخلفي لحوض الكلى عند كل حالة . وأخذ المتوسط منها لأجل التحليل .

كشفتالدراسة أن متوسط طول الكلى بين (17-39) أسبوعا من عمر الحمل كان 3.61± سم ، متوسطعرض الكلى كان 1.7210± سم , قطر الحوض الكلوي كان 0.9528± سم. هذه القياسات ذات ارتباط وثيق بعمر الحمل. و أن الزيادة في حجم الكلى خلال فترة الحمل أسية حتى الولادة.

خلصت الدراسة الي أن المخططات الجديدة مهمة في تقييم الكلى للأجنة في العقد الثاني والثالث من العمر الذين يعانون من تشوهات الكلى، وتساعد في التشخيص و الكشف المبكر لتأخر النمو.

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List of Abbreviation

EDD	Expect Delivery Date
LMP	Last Menstrual Period
GA	Gestational Age
CRL	Crown Rump Length
BPD	Biparital Diameter
HC	Head Circumference
AC	Abdominal Circumference
FL	Femur Length
AvW	Average Weeks
US	Ultrasound
SPSS	Statistical Package for the Social Sciences

Chapter one
Introduction

Chapter one

Introduction

1.1 Introduction

Normal development of the fetal kidneys is crucialto neonatal outcome and knowledge of the normal range of dimensions of the fetal kidney, renal pelvisand adrenal gland is important for the identification of abnormalities(Van Vuuren et al., 2012).

The kidneys in the second and third trimesters typically have the same configuration as in post natural life, their appearance depend on gestational age. Accurate estimation of normal antenatal fetal kidneys size is great importance, thus determination of normal measurements was help in early diagnosis and optimize fetal safety then reduce the high prenatal morbidity and mortality.Sonographic fetal biometry is the most widespread method used to establish GA; varioussonographic biometric parameters commonly used are Crown Lump Length (CRL), Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC) and Femur length (FL)(Gloor et al., 1997).

During the first trimester the kidney appear as hyperechoic oval structure at both sides of spine .this echogenicity will progressively decrease. During second and third trimesters, the kidneys are easy to identify by imaging the dorso-lumbar spine and scanning in parasagittal and transverse axial section(Bakker et al., 2014).

Various papers on intrauterine renal growth have been published, but many of these studies sufferedfrom methodological issues, such as failing to validate gestational age by measuring crown–rump length,not covering the whole of the second and third trimesters of pregnancy or using preterm infants or postmortem specimens. Several studies used a mixture of cross-sectional and longitudinal data(Ugur et al., 2016).

The distinction between size and growth is frequently ignored in studies using a mixture of cross-sectional and longitudinal data. Cross-sectional data can only be used for size reference curves, while longitudinal data obtained by measurements of fetuses on a series of occasions may be used for size and growth reference curves. Standard normogram of fetal kidney dimentions is considered as useful tool for evaluating growth disorders of fetal kidney(Chiara et al., 1989).

Fetal kidney grows progressively along with GA and, therefore,ultrasonography examination can predict GA at any trimester. Parameters suchas BPD etc. are thought to compute GA more correctly when performed at an earlier gestation(Sagi et al., 1987).

The fetal kidney is easy to identify and measure, but has not beenstudied extensively as a biometric index for GA estimation. The aim of this study was todeterminenormaldimensions of fetal kidney,including length, width and renal pelvis, at various gestational ages .to construct reference curves for these dimensions.

1.2. Problem of the study:

Only limited data on reference values for fetal renal measurements have been published; no studiescovered the entire second and third trimesters. Moreover, ultrasound-validated gestational age was not used in anyof these studies. Also fetal kidney measurement was not used as dependent parameter for estimating gestational age.

1.3 Objectives of the study:

1.3.1 General objective:

Measurement offetal kidney, and renal pelvisamong sudanese

1.3.2 Specific objectives:

- To determine the normal measurements of the fetal kidney in second and third trimester.
- Tomeasure the fetal kidney length and width.
- To measure renal pelvic diameter.
- To construct reference curves for the fetal kidney, renal pelvis.

1.4 Overview of the study:

The study contains five chapters; chapter one: is an introduction, problem of the study, objectives of the study and overview of the study. Chapter two contains literature review: anatomy, physiology, abnormalities, equipment, techniques and previous studies. Chapter three encompasses the Methodology, while chapter four represents the results of the study. Finally, chapter five includes the discussion, conclusion and recommendations

Chapter two
Literature review

Chapter two

Theoretical background and Literature review

2.1. Anatomy of the kidney

2.1.1. Location:

In humans, the kidneys are located high in the abdominal cavity, one on each side of the spine, and lie in a retroperitoneal position at a slightly oblique angle. The asymmetry within the abdominal cavity, caused by the position of the liver, typically results in the right kidney being slightly lower and smaller than the left, and being placed slightly more to the middle than the left kidney. The left kidney is approximately at the vertebral level T12 to L3, and the right is slightly lower. The right kidney sits just below the diaphragm and posterior to the liver. The left sits below the diaphragm and posterior to the spleen. On top of each kidney is an adrenal gland. The upper parts of the kidneys are partially protected by the 11th and 12th ribs. Each kidney, with its adrenal gland is surrounded by two layers of fat: the perinephric fat present between renal fascia and renal capsule and paranephric fat superior to the renal fascia(El-Galley and Keane, 2000).

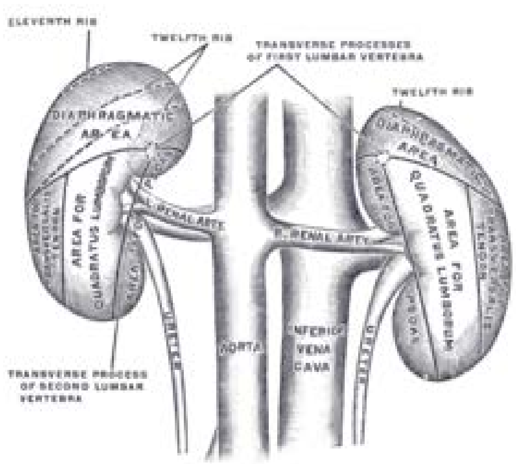


Figure (2-1): Human kidneys viewed from behind with spine removed.(El-Galley and Keane, 2000).

2.1.2. Structure:

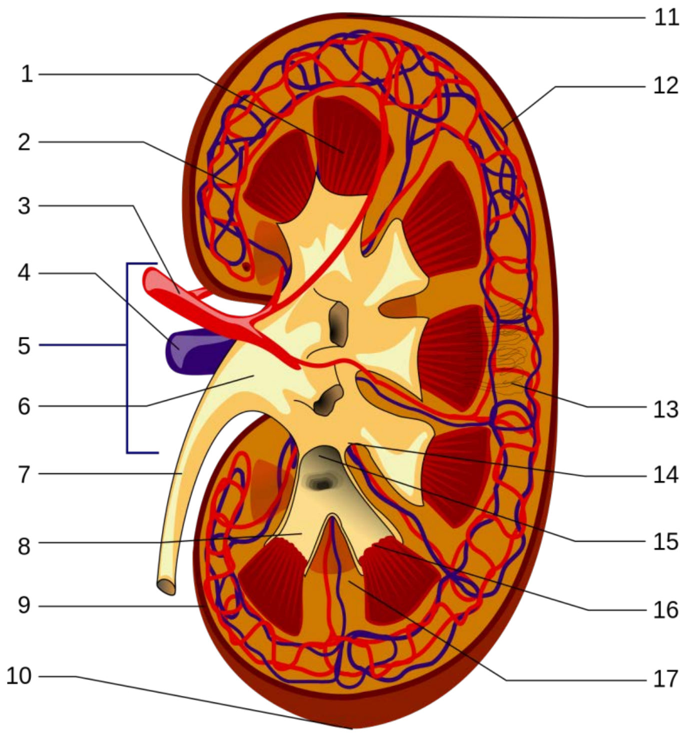


Figure (2-2) : show kidney structure(Marieb, 2000).

1. Renal pyramid • 2. Interlobular artery • 3. Renal artery • 4. Renal vein 5. Renal hilum • 6. Renal pelvis • 7. Ureter • 8. Minor calyx • 9. Renal capsule • 10. Inferior renal capsule • 11. Superior renal capsule • 12. Interlobular vein • 13. Nephron • 14. Renal sinus • 15. Major calyx • 16. Renal papilla • 17. Renal column

The kidney has a bean-shaped structure with a convex and a concave border. A recessed area on the concave border is the renal hilum, where the renal artery enters the kidney and the renal vein and ureter leave. The kidney is surrounded by tough fibrous tissue, the renal capsule, which is itself surrounded by perirenal fat (adipose capsule), renal fascia, and pararenal fat (paranephric body). The anterior (front) surface of these tissues is theperitoneum, while the posterior (rear) surface is the transversalis fascia(Marieb, 2000).

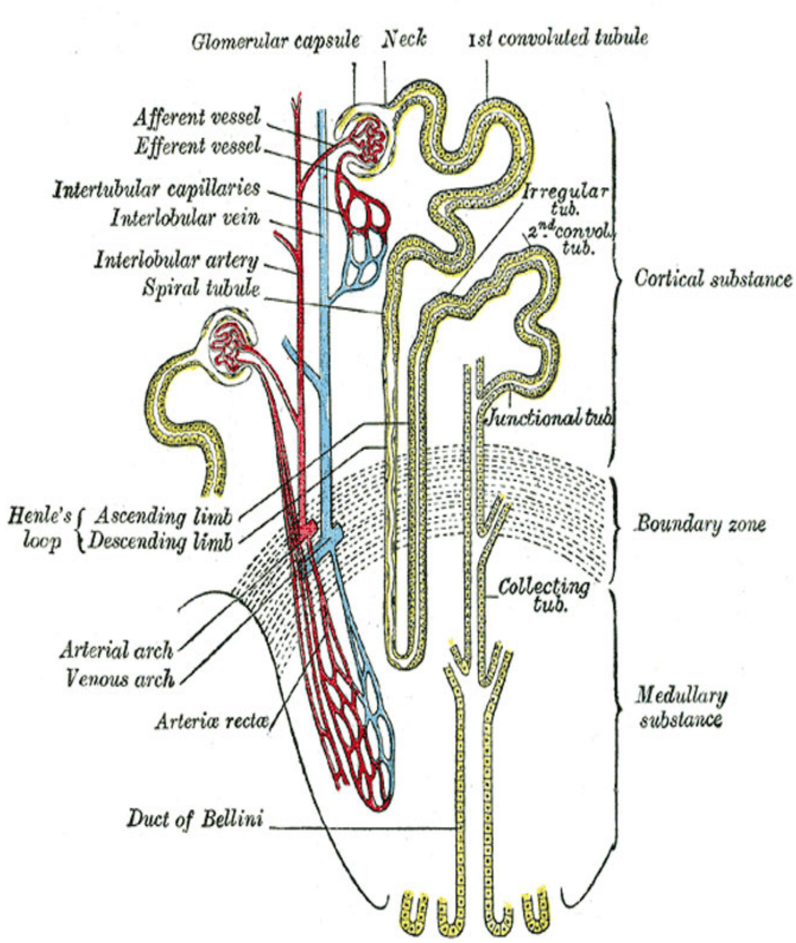
The superior pole of the right kidney is adjacent to the liver. For the left kidney, it's next tothe spleen. Both, therefore, move down upon inhalation.

In adult males, the kidney weighs between 125 and 170 grams. In females the weight of the kidney is between 115 and 155 grams. A Danish study measured the median renal length to be 11.2 cm (4.4 in) on the left side and 10.9 cm (4.3 in) on the right side in adults. Median renal volumes were 146 cm3on the left and 134 cm3 on the right (Marieb, 2000).

The substance, or parenchyma, of the kidney is divided into two major structures: the outerrenal cortex and the inner renal medulla. Grossly, these structures take the shape of eight to 18 cone-shaped renal lobes, each containing renal cortex surrounding a portion of medulla called a renal pyramid (of Malpighi). Between the renal pyramids are projections of cortex called renal columns (or bertin columns). Nephrons, the urine-producing functional structures of the kidney, span the cortex and medulla. The initialfiltering portion of a nephron is the renal corpuscle which is located in the cortex. This is followed by a renal tubule that passes from the cortex deep into the medullary pyramids. Part of the renal cortex, a medullary ray is a collection of renal tubules that drain into a single collecting duct(Marieb, 2000).

The tip, or papilla, of each pyramid empties urine into a minor calyx; minor calyces empty into major calyces, and major calyces empty into the renal pelvis. This becomes the ureter. At the hilum, the ureter and renal vein exit the kidney and the renal artery enters. Hilar fat and lymphatic tissue with lymph nodes surrounds these structures. The hilar fat is contiguous with a fat-filled cavity called therenal sinus. The renal sinus collectively contains the renal pelvis and calyces and separates these structures from the renal medullary tissue (Marieb, 2000).

2.1.3 The functional unit



(Marieb, 2000).

Figure (2-3): Detail of the functional unit of the kidney

The functional unit is the nephron ,which compose of the renal corpuscle; glomerulus and bowman capsule,proximal convluted tubules (PCT), located in the renal cortex, descending loop of henle (LOH), thick ascending limb, distal convoluted tubule, collecting duct(which opens into the renal papilla),blood from the afferent from glomerular arteriole passes through the juxtamedullary apparatus to the glomerulus. The glomerulus is a network of capillaries that filter blood across.this filtrate then reaches the PTC, which reabsorbs glucose and various electrolytes along with water as the filtrate passes through .Mean while,after being filtrated at the glomerulus the blood pass in to the efferent glomarular arteriole and then descends in to the renal paramid(Silverthorn et al., 2009).

2.1.4. Blood supply

The renal circulation supplies the blood to the kidneys via the renal arteries, left and right, which branch directly from the abdominal aorta. Despite their relatively small size, the kidneys receive approximately 20% of the cardiac output. The renal artery enters into the kidney at the level of the first lumbar vertebra just below the superior mesenteric artery. As it enters the kidney, it divides into branches: first the segmental artery, which divides into 2 or 3 lobar arteries, then further divides into interlobar arteries, which further divide into the arcuate artery, which leads into the interlobular artery, which form afferent arterioles. The afferent arterioles form the glomerulus (network of capillaries enclosed in Bowman's capsule). From here, efferent arterioles leaves the glomerulus and divide into peritubular capillaries, which drain into the interlobular veins and then into arcuate vein and then into interlobar vein, which runs into lobar vein, which opens into the segmental vein and which drains into the renal vein, and then from it blood moves into the inferior vena cava(Marieb, 2000).

2.1.5 Innervation:

The kidney and nervous system communicate via the renal plexus, whose fibers course along the renal arteries to reach each kidney. Input from the sympathetic nervous system triggers vasoconstriction in the kidney, thereby reducing renal blood flow. The kidney also receives input from the parasympathetic nervous system, by way of the renal branches of the vagus nerve (cranialnerve X); the function of this is yet unclear. Sensory input from the kidney travels to the T10-11 levels of the spinal cordand is sensed in the correspondingdermatome. Thus, pain in the flank region may be referred from corresponding kidney(Marieb, 2000).

2.1.6.Renal lymphatic:

The lymphatic drainage parallels the venous drainage system. After leavingthe renal hilum, the left primary lymphatic drainage is into the left lateral aortic lymph nodes, including nodes anterior and posterior to the aorta between the inferior mesenteric artery and the diaphragm. On the right, itdrains into the right lateral caval lymph nodes (Marieb, 2000).

2.2. Renal physiology:

Renal physiology is the study of kidney functions.Their main function is to regulate the balance of electrolytes in the blood, along with maintaining pH homeostasis. They also remove excess organic molecules from theblood, and it is by this action that their best-known function is performed: the removal ofwaste products of metabolism. Kidneys are essential to the urinary system and also serve homeostatic functions such as the regulation of electrolytes (including salts), maintenance of acid–base balance, maintenance of fluid balance, and regulation of blood pressure (via the salt and water balance). They serve the body as a natural filter of the blood, and remove water-soluble wastes which are diverted to the bladder. In producing urine, the kidneys excrete nitrogenous wastes such as urea and ammonium. They are also responsible for the reabsorption of water,glucose, and amino acids.(Silverthorn et al., 2009).

The kidneys also produce hormones including calcitriol anderythropoietin.An important enzyme, renin, is also produced in the kidneys; it acts innegative feedback(Silverthorn et al., 2009).

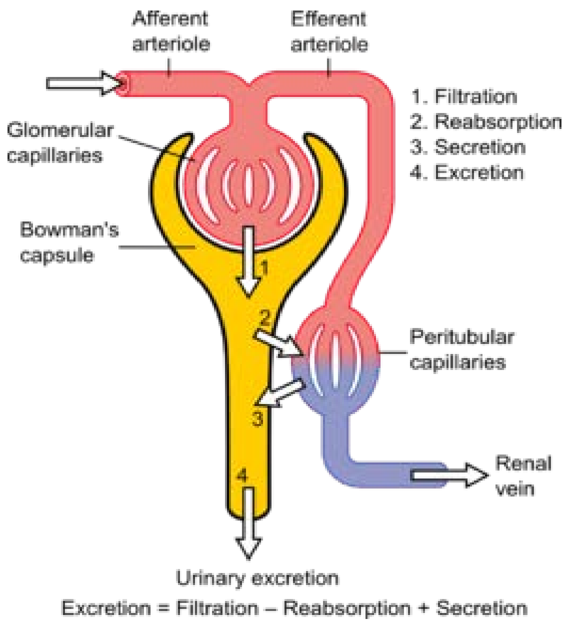


Figure (2-4):physiology of the kidney(Silverthorn et al., 2009).

Many of the kidney's functions are accomplished by relatively simple mechanisms of filtration, reabsorption, and secretion, which take place in the nephron. Filtration, which takes place at the renal corpuscle, is the process by which cells and large proteins are filtered from the blood to make an ultrafiltrate that eventually becomes urine. The kidney generates 180 liters of filtrate a day, while reabsorbing a large percentage, allowing for the generation of only approximately 2 liters of urine. Reabsorption is the transport of molecules from this ultrafiltrate and into the blood. Secretion is the reverse process, in which molecules are transported in the opposite direction, from the blood into the urine.the kidneys receive blood from the paired renal arteries, and drain into the paired renal veins. Each kidney excretes urine into a ureter which empties into the bladder.(Silverthorn et al., 2009).

2.3. Development of kidney:

In the embryo, nephron development, nephrogenesis, occurs through several stages involving classical epithelial/mesenchyme type of interactions. Nephrogenesis continues into the late fetal period (GA week 34–35) and while the fetal kidney does produce urine, not until after birth does the glomerular filtration rate (GFR) increases rapidly due to a postnatal drop in kidney vascular resistance and an increase in renal blood flow (el-Galley and Keane, 2000).

2.3.1.Phases of development of kidny:

The development of the kidney proceeds through a series of successive phases, each marked by the development of a more advanced kidney: the pronephros, mesonephros, and metanephros. The pronephros is the most immature form of kidney, while the metanephros is most developed. The metanephros persists as the definitive adult kidney.(el-Galley and Keane, 2000).

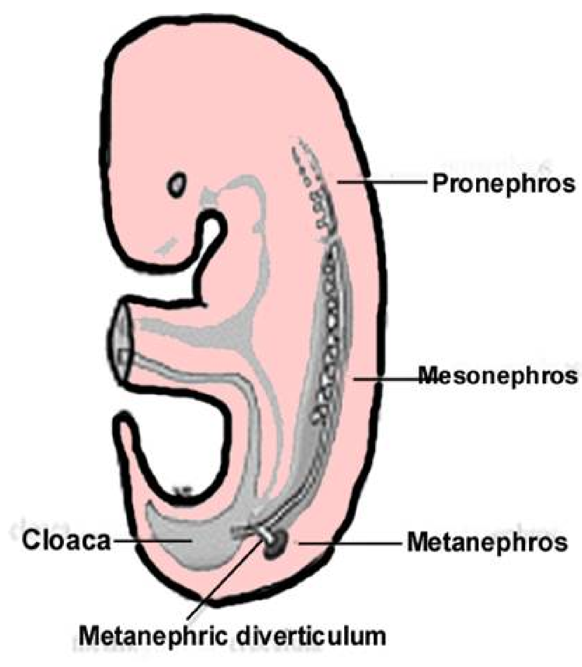


Figure (2-5) :three stages of kidneys develop in cranial to caudal sequence.

2.3.1.1 Pronephros:

The pronephros develops in the cervical region of the embryo. During approximately day 22 of human gestation, the paired pronephri appear towards the cranial end of the intermediate mesoderm. In this region,epithelial cells arrange themselves in a series of tubules called nephrotomes and join laterally with the pronephric duct. This duct is fully contained within the embryo and thus cannot excrete filtered material outside the embryo; therefore the pronephros is considered non functional in mammals(el-Galley and Keane, 2000).

2.3.1.2 Mesonephros:

The development of the pronephric duct proceeds in a cranial-to-caudal direction. As it elongates caudally, the pronephric duct induces nearby intermediate mesoderm in thethoracolumbar area to become epithelial tubules called mesonephric tubules. Each mesonephric tubule receives a blood supply from a branch of the aorta, ending in a capillary tuft analogous to the glomerulus of the definitive nephron. The mesonephric tubule forms a capsule around the capillary tuft, allowing for filtration of blood. This filtrate flows through the mesonephric tubule and is drained into the continuation of the pronephric duct, now called the mesonephric duct or Wolffian duct. The nephrotomes of the pronephros degenerate while the mesonephric duct extends towards the most caudal end of the embryo, ultimately attaching to the cloaca. The mammalian mesonephros is similar to the kidneys of aquatic amphibians and fishes.(el-Galley and Keane, 2000).

2.3.1.3 Metanephros :

During the fifth week of gestation, the mesonephric duct develops an out pouching, the ureteric bud, near its attachment to the cloaca. This bud, also called the metanephrogenic diverticulum, grows posteriorly and towards the head of the embryo. The elongated stalk of the ureteric bud, called the metanephric duct, later forms the ureter. As the cranial end of the bud extends into the intermediate mesoderm, it undergoes a series of branching to form thecollecting duct system of the kidney. It also forms the major and minor calyces and the renal pelvis(el-Galley and Keane, 2000).

The portion of undifferentiated intermediate mesoderm in contact with the tips of the branching ureteric bud is known as the metanephrogenicblastema. Signals released from the ureteric bud induce the differentiation of the metanephrogenicblastema into the renal tubules. As the renal tubules grow, they come into contact and join with connecting tubules of the collecting duct system, forming a continuous passage for flow from the renal tubule to the collecting duct. Simultaneously, precursors of vascular endothelial cells begin to take their position at the tips of the renal tubules. These cells differentiate into the cells of the definitive glomerulus(el-Galley and Keane, 2000).

In humans, all of the branches of the ureteric bud and the nephronic units have been formed by 32 to 36 weeks of gestation. However, these structures are not yet mature, and will continue to mature after birth. Once matured, humans have an estimated two million nephrons (approximately 1,000,000 per kidney) but this number is highly variable ranging widely from approximately 300,000 to over 2 million per kidney(el-Galley and Keane, 2000).

2.3.2. Nephron development:

In the empryo, nephron development occurs through several stages involving classical epithelial/mesenchyme type of interactions. Nephrogenesis continues in to the late fetal period(GA week 34-35) and while the fetal kidny dose produce urine, not until after birth dose the glomerular filtration rate(GFR)increase rapidly due to a post natal drop in kidney vascular resistance and an increase in renal blood flow.

The morphological events and localization of renal progenitors occurring during nephron development in the adult human kidney.Mesenchymal cells near the tips of the branching ureteric bud undergo epithelial transition and differentiate through a series of forms made up of renal progenitor (el-Galley and Keane, 2000).

a - condensed aggregate forms

b - Renal vesicle forms

c - S-shaped body, renal progenitorsarelocalised, at this stage podocyte-committed progenitors (red + blue) as well as tubular-committed progenitors (orange) can already be seen.(el-Galley and Keane, 2000).

d - Mature nephron, renal progenitors, podocyte-committed progenitors (red + blue), as well as tubular-committed progenitors (orange) are distributed along the nephron.

e - Glomerulus, renal progenitors (Briceno et al.) are localized at the urinary pole of the Bowman capsule. Podocyte-committed progenitors (red + blue) localize along the Bowman capsule.

1-Vesicle (V) stage (13-19 weeks, second trimester)

2-S-shaped body (S) stage (20-24 weeks, second trimester)

3-Capillary loop (C) stage (25-29 weeks, third trimester)

4-Maturation (M) stage (infants aged 1-6 months, neonatal and postnatal).

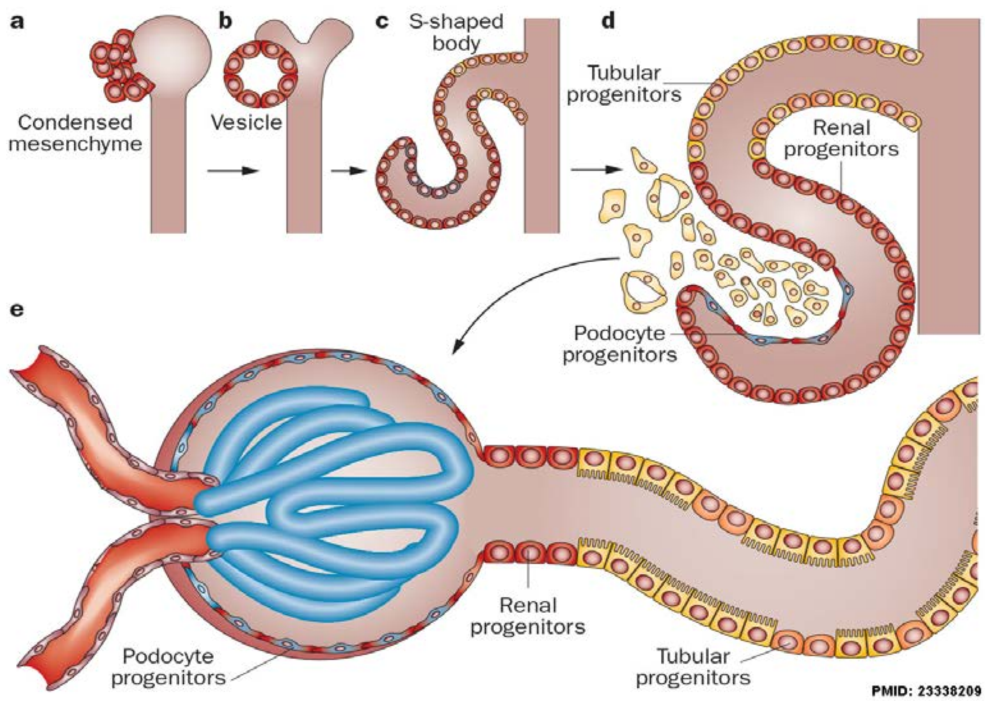


Figure (2-6) :nephron development.(el-Galley and Keane, 2000).

Accessory renal arteries are common findings in life, because of persistence of the embryonic vessels, which fed the metanephros during its embryologic ascent (30-34). The metanephrosbecomes functional near the 12th week of gestation. By then, swallowed amniotic fluid is recycled through the kidneys and excreted as urine into the amniotic cavity that surrounds the fetus (el-Galley and Keane, 2000).

2.3.3 Migration:

After inducing the metanephric mesenchyme the lower portions of the nephric duct will migrate caudally (downward) and connect with the bladder, there by forming the ureters. The ureters will carry urine from the kidneys to the bladder for excretion from the fetus into the amniotic sac. As the fetus develops, the torso elongates and the kidneys rotate and migrate upwards within the abdomenwhich causes the length of the ureters to increase(Bruce M.Carlson,2004).

As the kidney develops in the elongating fetus, it 'ascends' from its original location (adjacent tothe developing bladder) to its mature location (in the retroperitoneum just caudal to the diaphragm).

As the kidney moves cephaladrelative to the bladder, it takes new arterial supply from the aorta and new venous drainage into the vena cava. This "ascent" is also accompanied by medial rotation. Early in development, the renal pelvis lies anterior to the renal parenchyma. As the kidney moves into the lumbar region, the renal pelvis rotates medially so that the renal parenchyma lies lateral to the pelvis.

- Develop within the fetal pelvis in 7th menstrual week
- Ascend into the postero-lateral retroperitoneum by week 11
- Nephrons form at about 10 weeks and urine production begins by weeks 13-15.
- Urine output increases from 2.2ml/hr at 22 weeks to 12.2ml/hr at 32 weeks and 28ml/hr at term.(T.W.sadler.Langman 2004).

2.3.4. Size and location of the kidneys:during the fetal period

The level of the left kidney was higher than the level of the right kidney in the fetal period. The posterior surface relations to the ribs showed certain ascendance during gestation, corresponding to vertebral levels. However, fetal kidneys do not reach the same level as adults at full term. The kidneys move farther apart from the midline of the body during the fetal period. The dimensions, weight, and volume of the kidneys increased with gestational age during the fetal period. The ratio between kidney weights and fetal body weights were determined, and we observed that the ratio decreased during the fetal period. There were no sex or laterality differences in any parameter.(Osman Sulak et al 2011).

2.4Ultrasound imaging:

- Onsonography, fetal renal structures cannot be reliably imaged during the early empryologic events of the first trimester
- Can be visualized early in the second trimester. Initially difficult to see, but increasedperinephric fat improves sonographic contrast.
- Routinely seen by 16-18 weeks GA.
- Paired hypoechoic structures on either side of the fetal spine and shifts more laterally away from the spine as development progresses.

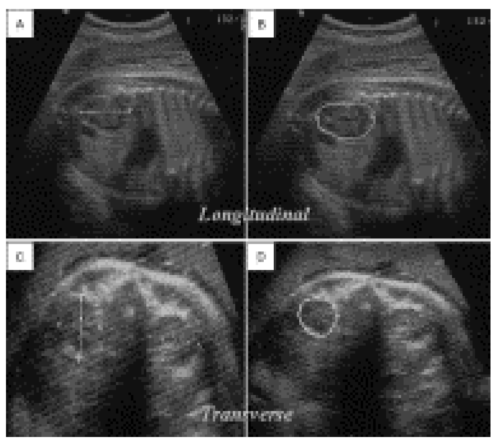


Figure (2-7) Longitudinal and transverse view of fetal kidney

- Renal cortex is initially thin and difficult to visualize until the third trimester when the medullary pyramids and cortex can be visualized as separate entities. The medullae align along the pelvic sinus in a sagittal plane. Their relative hypoechoic appearance may be caused by the abundance of fluid-filled tubules(Chitty and Altman, 2003).

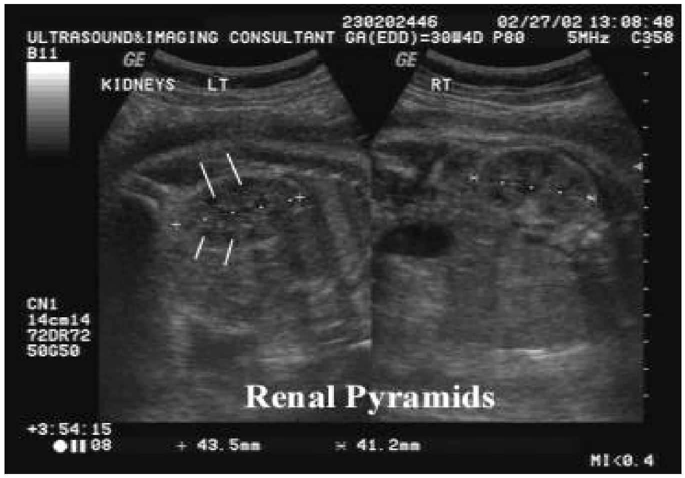


Figure (2-8) Show renal cortex and pyramids

- Renal sinus: - central.-Linear area of medium echogenicity-.Visualized more frequently as the kidney grows and perinephric fat is deposited.
- Fetal lobulation (lobation is a better term as the renal lobule is a microscopic unit), as well as the medullary pyramids and collecting system can be well visualized in the thirdtrimester.
- The typical fetal kidney is made up of discrete anterior and posterior lobes that fuse essentially 1 unit occur by the 28th week of gestation. Irregularity to the border of some postnatal kidneys may be because of retained fetal lobulations. The medullary areas of individual renal lobes also tend to fuse preventing cortical tissue from extending in position. When the fusion is less than complete, cortical tissue may extend inferiorly and centrally and be adjacent to medullary tissue as a column of Bertin which describedas hypertrophic column of Bertin as a normal variation because of unresorbed polar parenchyma of 2 sub kidneys that fuse to form a normal kidney. Because the tissue is normal and not hypertrophic, they prefer the term "junctional parenchyma." An area of concern may be noted as junctional parenchyma rather than mass via US by noting that the area of

concern contains renal cortex that is continuous and of similar echogenicity to that of the adjacent renal cortex (Chitty and Altman, 2003).

2.5. Fetal biometric parameters:

Fetal biometric parameters are antenatal ultrasound measurements that are used to indirectly assess the growth and wellbeing of the fetus. During pregnancy many different ultrasound measurements can be done .fetal ultrasound measurements include:

2.5.1.Standard biometric parameters:

-BiparietalDiameter (BPD)

-Head Circumference (HC)

-abdominal circumference (AC)

-Femur Llength (FL).

2.5.2.Additionalparamaters:

-Humeral Length (HL)

-RrenalPelves / Fetal Pyelectasis (FP)

-Ttrans-Cerebellar Diameter (TCD)

-Occipito-Frontal Diamter (OFD)

-IinterocularDistance (IOD)

-Binocular Distance (BOD)

-Ratios:

fetal cardio-thoracic circumference ratio. fetal thoracic to abdominal circumference ratio. fetal thoracic to head circumference ratio .

That as well as calculation of the estimated fetal age.(BensonCB, DoubiletPM 1991).

Measurements should be performed in a standardized manner on the basis of strict quality criteria. An audit of results can help to ensure accuracy of techniques with regard to specific reference tables(SalomonLJ 2006).

The images should be taken to document the measurements examples of still images appropriate for fetal biometries are demonstrated in Fig (2.9).

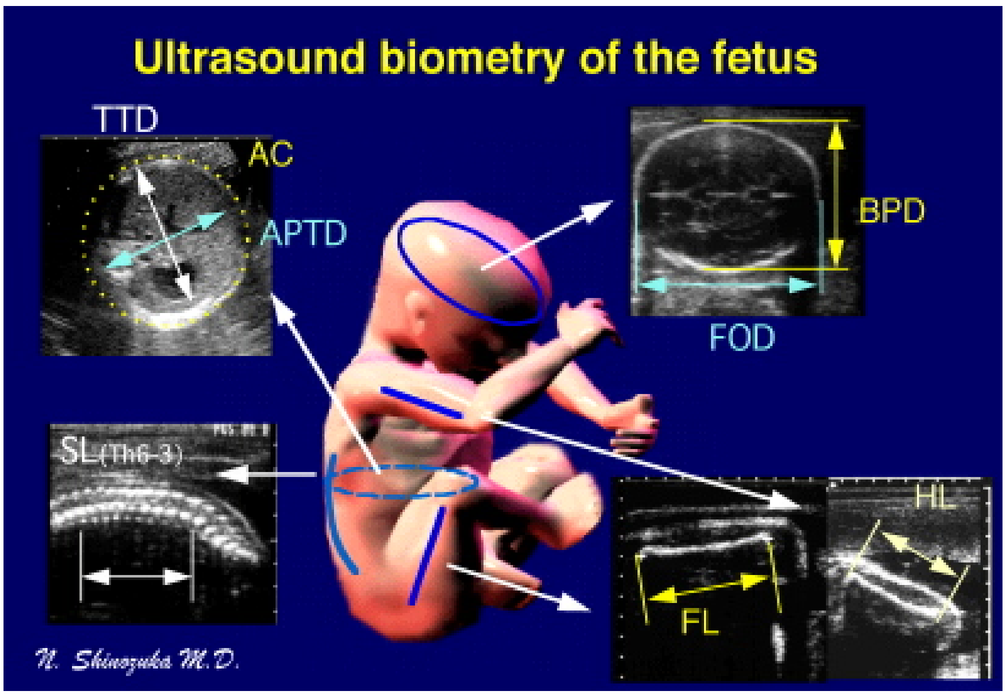


Figure (2-9): Ultra sound biometry of fetus

2.6 Previous studies:

Study conducted by Chitty et.al to construct new size charts for fetal kidney measurements and to define normal limits for renal pelvic antero-posterior diameter. A prospective, cross-sectional study was carried out in the ultrasound department of a large hospital. Six hundred and sixty-three fetuses were scanned only once for the purpose of the study at gestations between 14 and 42 weeks. Centiles for kidney dimensions were estimated by combining separate fractional polynomial regression models fitted to the mean and standard deviation, assuming that the measurements have a normal distribution at each gestational age. Centiles for renal pelvic diameter were obtained using quantile regression. Size charts for fetal kidney dimensions [antero-posterior (AP), transverse, length and volume] and renal pelvis diameter are presented and compared with previously published data. New size charts for fetal kidney size that take into consideration the increasing variability with gestational age. These data should aid the prenatal diagnosis of renal pathology by defining renal size and the upper limits of normal pelvic dilatation. They may be particularly useful in the third trimester where there is limited data available. Data confirm that it is reasonable to use an upper limit of 7 mm for the AP diameter in late pregnancy.Nomograms of fetal renal length and parenchymal area derived from ultrasound images to develop a standard for normal fetal renal growth(Chitty and Altman, 2003).

Longitudinal and transverse ultrasound renal images from 216 normal fetuses (16 to 41 weeks of gestation) were evaluated to construct growth charts. measured the parenchymal area as well as the longitudinal and transverse lengths of each kidney using computer software for image analysis. Data were separately plotted as a mean ± 2 SD determined by polynomial regression analysis.Nomograms for a renal growth chart were constructed independently for the right and left fetal kidneys. No statistically significant difference was noted between the right and left renal measurements. The polynomial regression equations for the left renal longitudinal length and parenchymal area, respectively, were $y = -0.0002x3 + 0.0139x2 - 0.2162 \times 2.3929$ ($r2 = 0.9842$), and $y = -0.0009x3 + 0.0724x2 - 1.5643 \times 11.68$ ($r2 = 0.9779$). The longitudinal and transverse fetal renal growth curves displayed significant growth associated with gestational age (p <0.001). Our data on left longitudinal renal length exhibited an intermediate level compared to 2 published Western growth charts. However, statistical comparisons revealed the differences were partially, but not universally significant(Erwin et al., 1985).

A prospective study was done in 102 pregnant women after 30 weeks of pregnancy whose gestational ages were confirmed by early USG. (<24 weeks). The aim of this study was to establish a correlation between the fetal kidney length & gestational age in 3rd trimester. The mean length of fetal kidneys showed a linear correlation with gestational age. The mean fetal kidney length in mm approximates the gestational age in weeks in 3rd trimester as predicated by BPD, FL, AC & HC (P<0.001). Maternal height, weight & socioeconomic status did not show any effect on growth of fetal kidneys. The result obtained confirmed that measurement of fetal kidney length in mm can be used as an additional parameter for documentation of gestational age in 3rd trimester & also an early means of detection of abnormal renal development(Yusuf et al., 2007).

A determination of normal measurements was help in early diagnosis and optimizes fetal safety then reduces the high prenatal morbidity and mortality. The objectives of this study are: to rule out the normal fetal kidneys dimensions among Sudanese population and to develop a local standard with ultrasound as well as to detect the range of fetal kidneys size in third trimester among Sudanese population and comparing the results with the international standard. This study was carried out in Khartoum state Sudan at Al Ahfad center for family health, AAU Radiobiology department, and Alsalam AL Rayidhospital from 1-8-2012 until 1-11-2012, a total of 100 normal pregnant ladies with no previous delivery of fetus with congenital anomaly or obvious fetal disease at (28-40) weeks gestational age. The study demonstrated that the mean renal length of fetal kidneys in third trimester in Sudanese was 34.2 mm, 40.9 mm and 44 mm in premature, mature and full-term fetuses respectively. The mean renal width of fetal kidneys in third trimester was 18 mm,23 mm, and 25.5 mm in premature, mature and full-term fetuses respectively. The mean renal thickness of fetal kidneys in third trimester in was 17.6 mm, 22.2 mm, and 24.5 mm in premature, mature and full- term fetuses respectively. The mean renal volume of fetal kidneys in third trimester was 5.6 mm3, 9.8 mm3,and 10.5 mm3, in premature, mature and full-term fetuses respectively.The study showed proportional relationship between gestational age and fetal weight(Abdelmoneim et al., 2013).

Measurement of fetal kidney dimension (length and width) was obtained in 557 fetuses between 26 and 39 weeks gestation in normal pregnancy that were scanned. The mean age of pregnant women was 28.4 (± 4.6) years (ranging from 17- 44 years).

The mean renal length, of both kidneys from 26-39 gestational weeks were from(29,38mm-42,45mm),the mean renal width from(16,51mm-22,53mm). The length and width of the right kidney compared with that of the left kidney by using the paired sample T test. There was no significant difference in right and left kidney length (PV=0.843) but right kidney width (mean: 20.56 ± 3.01) was longer than left kidney one (mean: 20.32 ± 2.72) (PV=0.004).Mean right kidney length was 37.60 ± 4.84 mm and mean left kidney length was 37.59 ± 4.89. By linear regression analysis in stepwise model, mean fetal kidney length and width increase weekly 1.07 mm and 0.5 mm respectively.There was a significant positive correlation between the gestational age and mother'sage(Ahmadi,F et al 2015).

Chapter Three
Methodology

Chapter three

Material and Method

3.1 Materials:

3.1.1 Study design and area:

This cross section study was carried out at Elshifa Modern Medical Centre, over period of four months from November 2016- March 2017.

3.1.2 Subject:

Fifty Sudanese pregnant women in their second and third trimester of singleton gestation were enrolled in the study. Their age ranged (15 – 45), were randomly selected from group of pregnant ladies at various stages of pregnancy. The chosen study population of women selected for this study has normal pregnancy and viable singleton. Subjects with maternal disease that might affect fetal growth (diabetes mellitus or hyper tension) were excluded.

3.1.3 Machine used:

Diagnostic Ultrasound Imaging machine (MODEL UF-4100). With VOLTAG AC230V 50/60Hz 85VA, manufactured by FUKUDA, Tokyo, Japan, low frequency probe (3.5)MHz good penetration curve linear transducer and hard copy printer for documentation.

3.2. Method:

3.2.1 Technique used:

Subjects were scanned while lying comfortable on their back (supine),coupling agent was applied. Then put the transducer transverse and longitudinal. The kidnys are visulised on transverse scans of fetal abdomen as paired hypoechoic structure adjacent to fetal spine.The measurement of kidney is obtained by placing the electron calipers at the outer margins of kidney. The length was measured in sagittal plane with the full length and renal pelvis visible. Perpendicular to this, in transverse plane, the largest anteroposterior (AP) and transverse diameters of kidney were measured by placing the calipers from outer border to outer border. In the same plane, the maximal AP and transverse diameters of renal pelvis were measured, placing the calipers on the inner borders of the renal tissue. All measurements were made in centimeters and repeated three times to avoid possible bias, the operator was blinded to the display of previous measurements for each repeated one. The three repeated measurements were averaged and stored in a data sheet.

These measurements were analyzed in relation to gestational ages determined on the basis of (BPD), (FL), (AC), (HC) and an average of those four gestational ages in weeks, which we termed average weeks (AVW).

3.2. 2 Data analysis

This study has been designed as cross-sectional study. The collecting data were fed into computer,multi-level statistical analysis was performed using SPSS Software. The serial measurements of kidney and renal pelvic were modeled against the each weak of gestational age from 17 to 39, All hypotheses tests with $P<0.05$ considered significant.Data are presented as mean± standard deviation (SD) for quantitative variables and frequency and percent for qualitative variables.Reference charts were constructed and reported using the mean and SD for the overall population.

Pearson correlation coefficients were used to measure the degree of relationship among the various measurements of fetal kidny and gestational ages.

Partialcorrelation was used to determine the relationship between parental height and weight and renal measurements when age was controlled for.

Chapter Four
Results

Chapter 4
Results

The following tables and figures obtained from 50 normal Sudanese pregnant women at (17-39) week of gestation for evaluation of fetal kidney using ultrasound.

Table (4.1): the minimum ,maximum, and mean of fetal kidney length, width, and pelvis diameter .and their stander deviation ,for various gestational age.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Kidney Length	50	1.60	5.00	±3.6076	.91711
Kidney Width	50	.70	2.55	±1.7210	.48751
Kidney Pelvis Diameter	50	.25	1.90	±.9528	.35273
Gestational Age	50	17	39	±29.74	5.934

Table (4-2) :show correlation between fetal kidney length , width , and gestational age.

		Kidney Length	Kidney Width	Gestational Age
Kidney Length	Pearson Correlation	1	.743**	.878**
	Sig. (2-tailed)		.000	.000
	N	50	50	50
Kidney Width	Pearson Correlation	.743**	1	.738**
	Sig. (2-tailed)	.000		.000
	N	50	50	50
Gestational Age	Pearson Correlation	.878**	.738**	1
	Sig. (2-tailed)	.000	.000	
	N	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Table (4-3) :show correlation between gestational age and kidney pelvis diameter.

Correlations

		Gestational Age	Kidney Pelvis Diameter
Gestational Age	Pearson Correlation	1	.837**
	Sig. (2-tailed)		.000
	N	50	50
Kidney Pelvis Diameter	Pearson Correlation	.837**	1
	Sig. (2-tailed)	.000	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed)

Figure (4-1) : scatterplot shows linear relationship between fetal kidney length and gestational age.

Figure (4-2) :scatter plot shows linear relationship between fetal kidney width and gestational age.

Figure (4-3) : scatter plot shows linear relationship between kidney pelvis diameter and gestational age.

Chapter Five

Discussion, conclusion & Recommendation

Chapter 5

Discussion, Conclusion and Recommendations

5.1 Discussion:

Crossectional data obtained by measurements of fetuses on a series of occasions may be used to derive reference curves for length, width and pelvis diameter. In this study the charts of the fetal kidney and fetal renal pelvis were derived from crossecitonal data obtained from investigations that were carried out specifically for the development of centilecharts for assessing renal measurements at a known gestational age between 17 and 39 weeks of gestation. Several charts of fetal kidney size have been published.Moreover, our study has the added advantage that the statistical analysis used is able to correct for missing data.

This study was showed that there was a significant correlation between GA and average fetal renal length and width at the 0.01 level (2-taild). It was noticed that the increase in renal size during pregnancy is exponential until birth, whilethe charts provided by Chitty and Altman(Chitty and Altman, 2003)suggest thatthe increase in renal volume tends to slow down at theend of pregnancy. With regards to the dimensions ofthe fetal renal pelvis, there was significant association was found in this study between GA and average of pelvis diameter ($p < 0.01$). This strong correlation between kidney dimensions and gestational age as predicted by BPD, AC, HC and FL. This study agreed with findings of the previous study of Chitty and Altmanwho published achart based on cross-sectional data from fetuses measuredonce for the purpose of the study, but examined only a low number of fetuses at each week of gestation. Their chart suggests linear growth ofrenal pelvis size, with a wide range.

The correlation cofficient between FKL and GA(r=0.878) in my study was higher as compared to chiara et al(1989) (r=0.84), and lower as compared to Erwin et al (1985) (r=0.98).

To confirm our measurements, we correlated our figures with published neonatal students. Han and Babcock noted the measurements of renal length in neonates (0-1week) as (3.9-5.9)(Han and Babcock, 1985). Erwin et al found mean neonatal renal lengths to be 4.8 cm(Erwin et al., 1985).

In conclusion, given that renal pathology often presents late in pregnancy, our reference charts for size and volumeof the fetal kidney may be useful in cases of diagnostic problems. The same holds for cases of dilatation of therenal pelvis, which is a common sonographic finding in pregnancy. This finding may alsobe useful for the detection and evaluation of abnormal growth.

5.2 Conclusion:

-the kidney dimensions easy to identifying and measurement.

-there was strong correlation between GA and fetal kidney length, width and renal pelvis diameter.

-these new charts of normal measurements of fetal kidney and renal pelvis may be useful in diagnose of fetal renal abnormalities.

-measuring of kidney size could be easily incorporating in to the model for estimating GA.

5.3 Recommendation:

- large sample size to satisfy the measurements of the fetal kidney.
- Improve resolution with current machinery and transducer.
- To image truer length subtly adjusting the angle of transducer.
- In the future for using this topic the researcher must take fetal weight.
- Fetal kidney to every pregnant should be checked because renal abnormalitymay be lead to morbidity and mortality.

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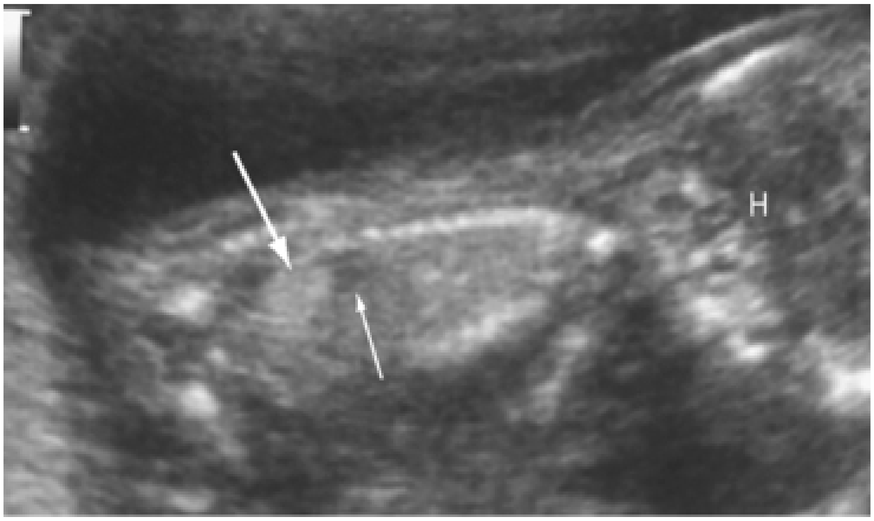
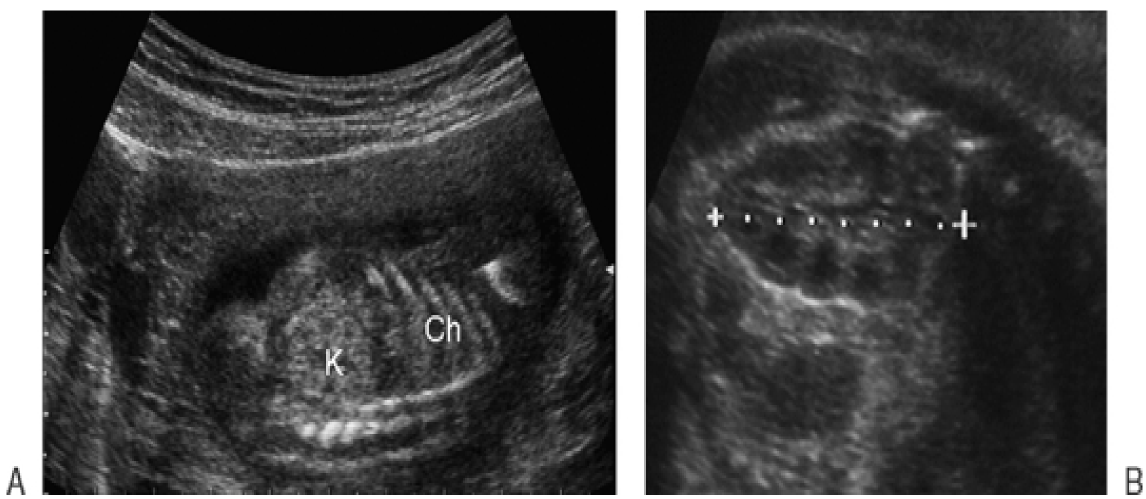
Appendices

Appendices



Fetal kidney , first trimester,parasagital scan. The kidney appears as hyperechoic small oval mass (thick arrow). The adrenal above it is hypoechoic (thin arrow) .H, fetal head.



A. Second trimester ,Sagittal scan through a kidney (K) that appears hyperechoic but with corticomedullarydifferentiation.Ch,chest. B.thirdtrimester .the kidney is limited by the crosses. Corticomeddullary differentiation is clearly visible.

Longitudinal view of fetal kidneys,29 week of gestation RT kidney length 33.8mm. LT kidney length 36.2mm.

Fetal kidneys, longitudinal view.35 week of gestation.Rtkidney length47.6mm, LT kidney length 46.1

Fetal kidney , longitudinal scan, 34 week of gestation, 37.8mm in length.

Para sagital scan of fetal kidneys, 31 week of gestation, normal RT kidney 39.2mm in length. Hydronephrosis in LT kidney 61.2mm in length