ESTIMATION OF GESTATIONAL AGE OF FETUS IN THIRD TRIMESTER USING MEAN FETAL KIDNEY LENGTH

Dissertation submitted in Partial fulfilment of the regulations required for the award of M.S. Degree in Obstetrics and Gynaecology

THE TAMIL NADU Dr.M.G.R. MEDICAL UNIVERSITY

CHENNAI,

TAMIL NADU

OCTOBER 2017

CERTIFICATE

This is to certify that the dissertation entitled "**ESTIMATION OF GESTATIONAL AGE OF FETUS IN THIRD TRIMESTER USING MEAN FETAL KIDNEY LENGTH** " is a bonafide and genuine research work Carried out by **Dr. S. KARTHIKA** in partial fulfilment of the requirement for the degree of Master of **Obstetrics and Gynaecology** under the guidance and direct supervision of **Dr.R.MANONMANI M.D.D.G.O.,** Professor and Head of the department, Department of Obstetrics and Gynaecology, Coimbatore Medical College Hospital, Coimbatore.

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ETHICS COMMITTEE

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Course : POST GRADUATE IN M.S OBSTETRICS AND GYNAECOLOGY

Period of Study : ONE YEAR

College : COIMBATORE MEDICAL COLLEGE AND HOSPITAL

Dissertation Topic : ESTIMATION OF GESTATIONAL AGE OF FETUS IN THIRD TRIMESTER BY MEASURING MEAN FETAL KIDNEY LENGTH.

The Ethics Committee, Coimbatore Medical College has decided to inform that your Dissertation Proposal is accepted / ~~Not accepted~~ and you are permitted / ~~Not permitted~~ to proceed with the above Study.

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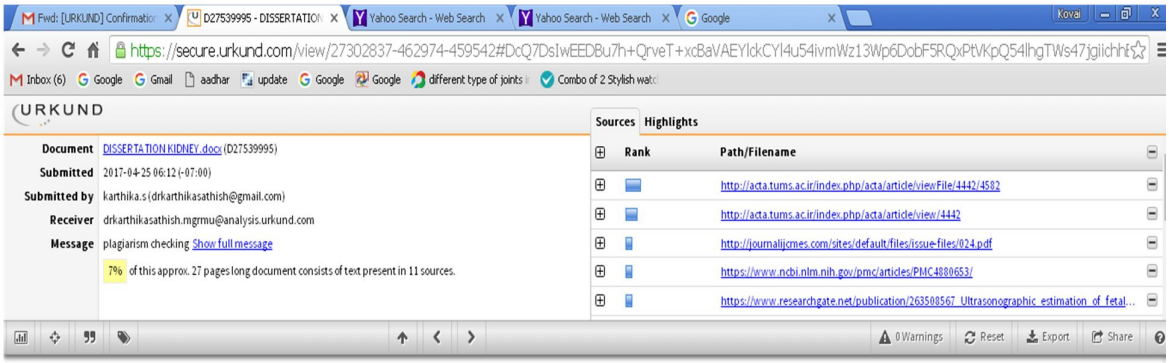
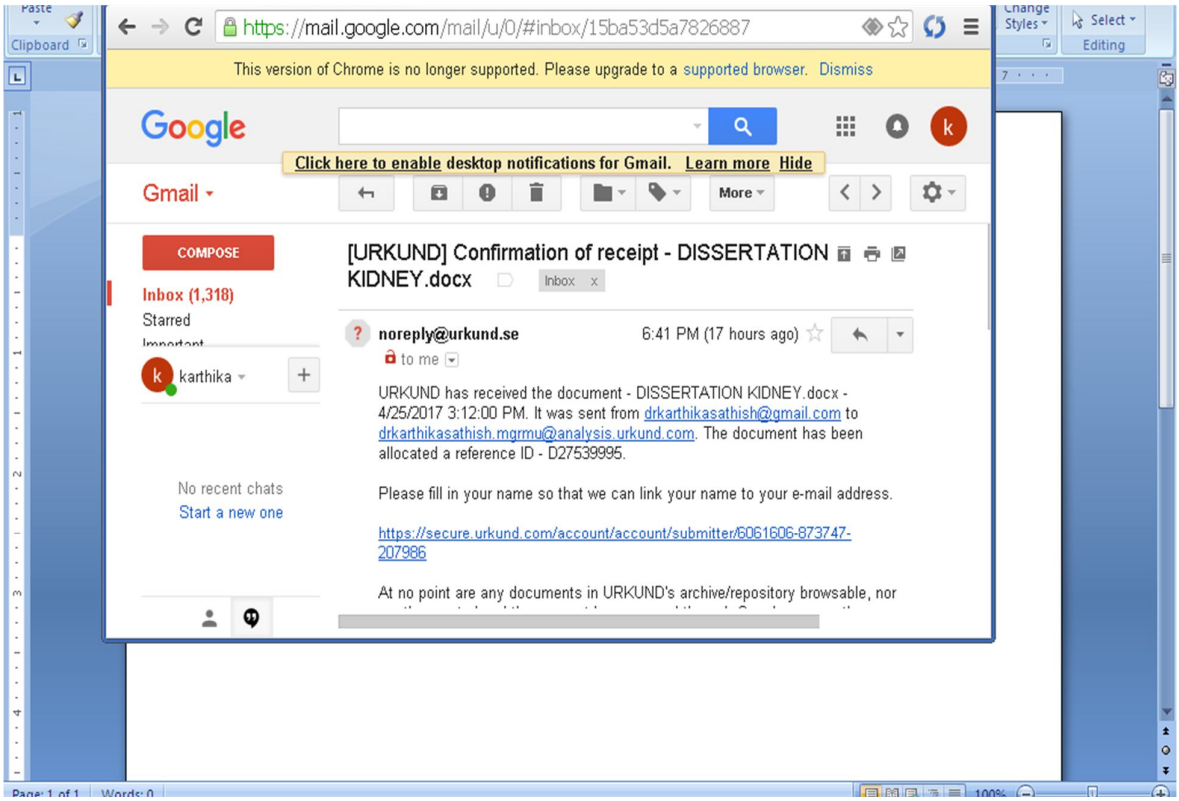


INTRODUCTION : An accurate estimation of gestational age is fundamental in the management of obstetrics. It is particularly important in high risk pregnancies eg., severe pre-eclampsia, severe Intra uterine growth restriction (IUGR), uncontrolled diabetes mellitus, central placenta praevia and sensitized Rh negative mother. Traditionally the duration of pregnancy is calculated in terms of 9 calender months and 7 days or 40 weeks or 280 days calculated from first day of last menstrual period (LMP). Sometimes the calculation of EDD (Expected date of delivery) based on LMP becomes difficult when 1.the menstrual cycle is irregular 2. Patient fails to remember LMP or reports inaccurately 3. Pregnancy occurs during lactational amenorrhea 4. If bleeding occurs during early pregnancy. Normally gestational age is determined from the history and clinical examination. After 24 weeks the symphsio-fundal height in cms approximates to the number of weeks up to 36 weeks of gestation. But a number of factors influence the measurement including multiple gestation, IUGR, pregnancy complicated by diabetes mellitus, liquor volume, maternal size, variation in fetal lie and engagement as well as intra and inter observer measurement variation. Since the introduction of diagnostic ultrasound , more reliable approaches to the dating of pregnancies have been developed. These include gestational sac (GS) and crown rump length (CRL) in the first trimester, and Biparietal diameter(BPD), Femur length (FL) , Head circumference (HC) and Abdominal circumference (AC) in second trimester. Other parameters used are Transcerebellar diameter, fetal foot length, fetal clavicular length, and epiphyseal ossification centres. Most of these parameters can predict the gestational age with a high degree of accuracy in early second trimester. However as the gestational age advances, these parameters becomes increasingly unreliable because of the biological variability of size in relation to gestational age and hence accurate dating of pregnancies in late second trimester and in third trimester becomes difficult , especially in women who consult late for maternity care and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DECLARATION

I, **Dr.S.Karthika** declare that the Dissertation titled "**ESTIMATION OF GESTATIONAL AGE OF FETUS IN THIRD TRIMESTER USING MEAN FETAL KIDNEY LENGTH "** Submitted to the Dr.MGR Medical university Guindy, Chennai is an original work done by me during the academic period from March 2016 – February 2017 at the Department of Obstetrics & Gynaecology Coimbatore Medical College Hospital, Coimbatore, under the guidance and direct supervision of **Dr.R.MANONMANI M.D.D.G.O.,** Professor and Head of the Department of Obstetrics and Gynaecology, Coimbatore Medical College Hospital, Coimbatore.

All the details of the patients, the materials and methods used are true to the best of my knowledge.

I assure that this dissertation has not been submitted to or evaluated by any other Medical University.

Date : Signature of the Candidate:

Place :

ACKNOWLEDGEMENT

It gives me immense pleasure to express my deep sense of gratitude and heartfelt thanks to **Dr.R.MANONMANI.M.D.D.G.O.,** Professor and Head of the Department ,Department of Obstetrics and Gynaecology ,Coimbatore Medical College Hospital, Coimbatore for her invaluable guidance ,constant encouragement and great care towards dissertation.

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CONTENTS

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LIST OF ABBREVIATIONS USED

GA	-	Gestational age
LMP	-	Last menstrual period
EDD	-	Expected day of delivery
BPD	-	Biparietal diameter
FL	-	Femur length
FKL	-	Fetal kidney length
MKL	-	Mean kidney length
RKL	-	Right kidney length
LKL	-	Left kidney length
HC	-	Head circumference
AC	-	Abdominal circumference
CRL	-	Crown rump length
GS	-	Gestational sac
IUGR	-	Intrauterine growth Restriction
SGA	-	Small for gestational age
ADPKD	-	Autosomal dominant polycystic kidney disease
ARPKD	-	Autosomal recessive polycystic kidney disease
SEP	-	Standard error of prediction
TAS	-	Trans abdominal ultrasound
TVS	-	Trans vaginal ulrasound
HCG	-	Human choronic gonadotrophin

INTRODUCTION

An accurate estimation of gestational age is fundamental in the management of obstetrics. It is particularly important in high risk pregnancies eg., severe pre-eclampsia, severe Intra uterine growth restriction (IUGR), uncontrolled diabetes mellitus, central placenta praevia and sensitized Rh negative mother.

Traditionally the duration of pregnancy is calculated in terms of 9 calender months and 7 days or 40 weeks or 280 days calculated from first day of last menstrual period (LMP). Sometimes the calculation of EDD (Expected date of delivery) based on LMP becomes difficult when 1.the menstrual cycle is irregular 2. Patient fails to remember LMP or reports inaccurately 3. Pregnancy occurs during lactational amenorrhea 4. If bleeding occurs during early pregnancy.

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Since the introduction of diagnostic ultrasound , more reliable approaches to the dating of pregnancies have been developed. These include gestational sac (GS) and crown rump length (CRL) in the first trimester, and Biparietal diameter(BPD), Femur length (FL) , Head circumference (HC) and Abdominal circumference (AC) in second trimester. Other parameters used are Transcerebellar diameter, fetal foot length, fetal clavicular length, and epiphyseal ossification centres.

Most of these parameters can predict the gestational age with a high degree of accuracy in early second trimester. However as the gestational age advances, these parameters becomes increasingly unreliable because of the biological variability of size in relation to gestational age and hence accurate dating of pregnancies in late second trimester and in third trimester becomes difficult , especially in women who consult late for maternity care and who are uncertain of the dates of their LMP.

In country with low resource settings like india, where the many of the patients usually seeks the initial prenatal care in the late second or third trimester and often the patients forgets to bring all the old records during late trimester, additional parameter other than routine biometric parameters is needed for accurate estimation of gestational age.

Several longitudinal studies have been performed in western countries concerning sonographic measurement of fetal kidney length. Initially these studies were done for diagnosis of renal malformations in utero and later they found out the correlation between the fetal kidney length and the gestational age.

Recent studies have shown that the fetal kidney length can be used to make an accurate estimation of gestational age of fetus, particularly in third trimester of pregnancy. Fetal kidney is easy to identify and measure in the late second and in the third trimesters and there is strong correlation between the gestational age and the featl kidney length.

An often quoted rule of thumb is that, “the renal length in millimeters approximates the gestational age in weeks”.

This study intends to determine the accuracy of fetal gestational age estimation using mean fetal kidney length and comparing its efficacy with other biometric parameters and gestational age derived from LMP taken as a standard.

AIM:

To estimate the gestational age of fetus in third trimester using mean fetal kidney length.

OBJECTIVES:

1. Estimating gestational age of fetus in third trimester using mean fetal kidney length
2. Comparing the mean fetal kidney length and other biometric parameters (BPD, FL, AC, HC) derived gestational age with gestational age derived from last menstrual period (LMP).

MATERIALS AND METHODS

SOURCE OF DATA :

100 Well dated normal pregnant patients, of different parity and ages , will be included in this study.

STUDY PERIOD :

MARCH 2016 – FEBRUARY 2017

STUDY DESIGN :

Cross sectional study

SAMPLE SIZE : 100

INCLUSION CRITERIA :

- Pregnant patients with singleton pregnancies in third trimester (28-40 weeks)
- Patients who are sure of the dates of their last menstrual period.
- Patients whose gestational age were confirmed by early ultrasound(<12 weeks)
- Normal antenatal patients with no associated risk factors.

EXCLUSION CRIERIA :

- Anomalous fetuses
- Suspected IUGR
- Patients with unknown dates
- Multiple gestation
- Patients with associated risk factors such as diabetes, pre eclampsia, eclampsia, chronic renal disease.
- Renal pelvic dilatation of > 4 mm
- Abnormal renal morphology
- Obscured adrenal & renal borders or margins

METHODOLOGY :

Well dated normal pregnant patients attending to the department of obstetrics and gynaecology in Coimbatore medical college hospital, during the third trimester of pregnancy will be included in this study who are age matched between 20- 35yrs and BMI matched between 18-25 kg/m^2

After obtaining written informed consent , a thorough history is collected from each patient and clinical assessment of gestational age was done by palpating the fundal height of the patient. Following this using third trimester ultrasonography ,mean kidney length along with fetal head circumference, femur length, abdominal circumference, and biparietal diameter will be measured. Gestational age will be calculated from mean fetal kidney length using nomogram by Cohen et al. and gestational age from other multiple biometric parameters using nomogram by Hadlock et al.

These values are then compared with actual gestational age derived from excellent dates taken as a standard. The length of fetal kidney will be measured from outer to outer margin using gray scale real time ultrasonographic scanner with 3.75 mhz transducer.

REVIEW OF LITERATURE

Estimation of gestational age plays an important role in quality maternity care such as assessment of fetal growth and scheduling the labour date. Ultrasonographic fetal biometry is the most wide spread method used to establish gestational age.

It is most important for the patients who are not sure of their dates , those who were conceived during the period of lactational amenorrhea and those who seek late prenatal care.

Anderson et al demonstrated in a cohort of women only 71% could accurately recall their dates of last menstrual period. Studies done by Wegienka et al 2005, Waller et al 2000 showed that about 30% of women forget their accurate LMP or misunderstand early pregnancy bleeding as normal menstruation.

There are studies comparing ultrasonographically estimated gestational age during first trimester and gestational age predicted by LMP, of which sonography has shown to be more accurate (Krishnendu,1998, Pekka ,2001, dela verga , 2002)

Extensive studies have done by Hadlok et al in the field of ultrasound guided gestational age determination which has now become an integral part of obstetric care.

Gonzales et al ,1981 studied the rate of growth of fetal kidney by examining 390 anatomical specimens from 26- 41 weeks of gestation. Statistical analysis of results established a significant correlation between the length of the fetus and its weight and relationship to the growth in weight and throughout the three dimensions of the fetal kidneys.

In the study done by Lawson et al, 1981, ultrasonographic evaluation of fetal kidneys regarding their normal size, frequency of visualization as related to stages of pregnancy were evaluated and they concluded that the measurement of fetal kidney length in millimeters is approximately the same as gestational age in weeks and kidneys weresomewhat difficult to identify from 15 -30 post menstrual weeks. One or both kidneys were identified in 90% of cases from 17 -22 weeks and in 95% of cases after 22 weeks

Bertagnali L .et al 1983, evaluated the time dependent change in the anteroposterior diameter and the length of the fetal kidneys in 280 pregnant women between 22 – 40 weeks of gestation. The result

obtained showed that the fetal kidney length increased from 29mm at 30 weeks to 38 mm in 40 weeks of gestation. The measurement of fetal kidney could therefore used as an additional parameter for gestational age estimation.

Cohen et al , 1991 studied the ultrasonographic measurement of normal fetal kidney length between 18 – 41 weeks of gestation in 397 fetuses. According to this study, there was a strong correlation between renal length and the gestational age determined by BPD, FL, AC and the average of the three. No significant difference was noted between right and left renal length. No correlation was seen between parental height, weight and fetal renal length. The fetal kidney length measured in this study were longer than previously reported.

Kim and park in 1995 evaluated 299 fetuses between 20 weeks to term. Fetal kidney size i.e length and width were measured and they reported that fetal kidney length increased as the pregnancy progressed. They established the growth rate of fetal kidney length and width was 0.87 mm and 0.47 mm per weeks after 20^{th} gestational weeks respectively.

Ansari et al in 1997 studied the ultarsonographic measurements of normal fetal kidney length in 793 bangladesh women between 16 – 40 weeks of gestation and they found that the average fetal kidney length at full term was 39.5 mm. an excellent correlation was seen between the gestational age , BPD, FL , and renal length measurements.

Konje et al in 1997, did a cross sectional study of change in fetal renal size with gestation in appropriate and small for gestational age (SGA) fetuses in 219 singleton fetuses between 22 – 38 weeks of gestation and they concluded that the differences in fetal kidney size with gestation manifest from early as 26 – 28 weeks. Kidney lengths at different gestational ages were similar in the two groups and there was a good correlation between fetal renal length measurement and the gestational age.

Konje J.c et al in 2002 conducted a study in 73 women with singleton uncomplicated pregnancies between 24 – 38 weeks of gestation . Here ultrasound fetal biometry and the kidney length were measured every 2 weeks. These measurements were used to date the pregnancies relative to CRL dating between 8 – 10 weeks of gestation and concluded that the kidney length is the more accurate method of determining gestational age with standard error of 10.29 days than the other fetal

biometric indices between 24 – 38 eeks . when combined with BPD, HC , FL the precision of dating is improved by 2 days.

Yusuf et al in 2007 conducted a prospective study to establish a correlation between the fetal kidney length and the gestational age in third trimester in Bangladesh population and found a strong correlation between between the mean fetal kidney length and the gestational age predicted by BPD, FL, ACand HC. The results confirmed that the fetal kidney length in millimeter can be used as an additional parameter for determination of gestational age in third trimester and also as an early means of detection of abnormal renal development.

Kansaria JJ et al in 2009 conducted a study in 70 pregnant women between 22 – 38 weeks of gestation to evaluate the accuracy of fetal kidney length measurements in determining gestational age of fetus and they found that the fetal kidney length grows at the rate of 1.7 mm fortnightly and they demonstrated that by measuring kidney length pregnancy could be dated within 9.17 days. The mean fetal kidney length has increased from 23.87 mm at 24 weeks to 36.25mm at 38 weeks.

Sulak et al in 2011 determined the morphometric development and location of fetal kidney on 172 human fetuses between 9 – 40 weeks of gestation and revealed that the length, width, and thickness of fetal

kidneys increased with gestational age and there was no significant difference between the right and left kidney measurements.

Adam at al in 2013 conducted studies in 100 sudanese pregnant ladies between 28 – 40 weeks of gestation and found that the mean fetal kidney lengths in the third trimester in Sudanese was 34.2 mm and 40.9 mm and 44 mm in premature , mature and the full term fetuses respectively. The mean renal thickness was 17.6 mm , 22.2 mm, 24.5 mm in premature, mature and full term fetuses respectively. The mean renal volume of fetal kidneys was 5.6 mm, 9.8 mm, and 10.5 mm in premature, mature, and fullterm fetuses respectively.

In a study conducted by Nirmalendu Das et al in the dept of Anatomy, Regional institute of medical sciences Manipur in 2015, kidneys of 60 spontaneously aborted and still born human fetuses were examined and the length, breadth, thickness and weight were measured. The result showed a significant and positive correlation between length, breadth, thickness and weight of the kidneys with the gestational age. All parameters show linear growth from 11- 38 weeks of gestation with growth spurts during 18 –22 weeks and 24 -26 weeks.

THEORETICAL BACKGROUND:

EMBRYOLOGY OF FETAL KIDNEY:

Kidneys being bilateral structures, development involves both left and right kidneys. During fetal development, three separate nephric structures develop in succession. Pronephros forms first, followed by mesonephros and metanephros. The associated urinary bladder and urethra develop from urogenital sinus, a derivative of embryonic hindgut.

The first formed pronephros is not active in production of urine and rapidly undergoes complete regression. The mesonephros forms second kidney, body of which regresses, but parts of mesonephric duct remains to form the drainage system of male gonad.

The third and definitive kidney, metanephros, forms two rudiments, that make up the complete adult kidney and ureter, which produces urine during the period of fetal development.

Development of Urinary System:

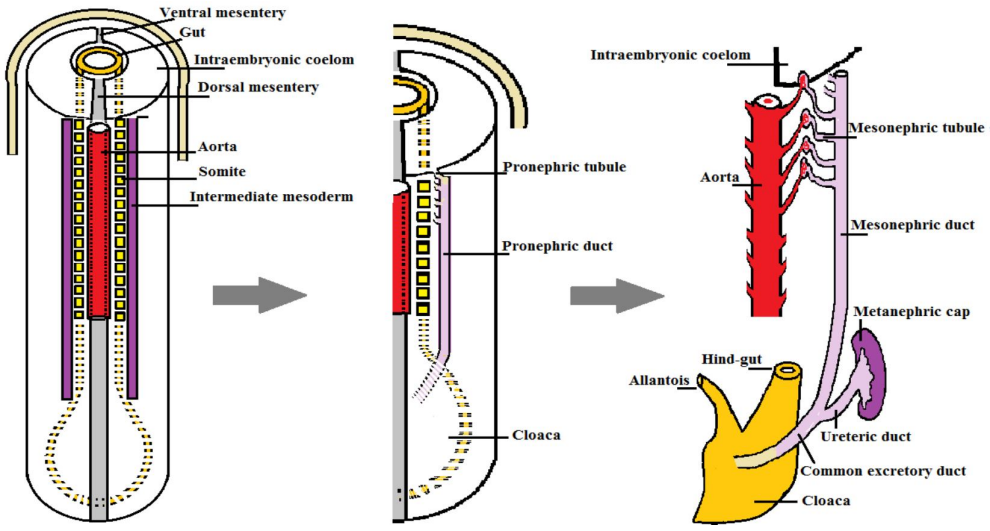
Introduction:

The intra-embryonic mesoderm is divided into 3 regions:

- Medial (para- axial) mesoderm: segmented to form somites
- Intermediate mesoderm: It separate from somites to form urogenital ridge, which gives rise to urogenital systems.
- Lateral plate mesoderm: Here intra-embryonic coelom appears which gives rise to body cavities.

The kidneys arises from the urogenital ridge. It has 3 stages of development in craniocaudal sequence

- **Pronephros:** It is rudimentary and non-functional.
- **Mesonephros:** It is a temporarily fuctional embryonic kidney.
- **Metanephros;** The definitive and permanent functional kidney.



Diagrams showing development of the 3 kidneys

Pronephros:(The primitive kidney)

It is a transient structure which developes from intermediate mesoderm in the cervical region during day 21 of intrauterine life.

- The mesoderm on each side is segmented in to 7-10 solid segments which are canalized to form pronephric tubules.
- The pronephric tubules open ventrally in to the intra-embryonic the coelom,while dorsally they join together to form a duct on each side called pronephric duct which grows caudally to open in to the cloaca.
- By the end of the fourth week, all indications of pronephric system have disappeared except the caudal part of pronephric duct .

Mesonephros: (Second kidney)

- It first appears early in week 4 from the thoracic and lumbar segments of intermediate mesoderm.
- The mesoderm on each side is segmented to form 70-80 solid clusters which are canalized to form S-shaped mesonephric tubule.
- The dorsal ends of mesonephric tubules join the pronephric duct to form mesonephric duct.
- The ventral ends of each mesonephric tubules enlarge and becomes invaginated by branches of dorsal aorta to form a glomerulus(tuft of blood capillaries) surrounded by Bowman's capsule.
- In the week 5, the thoracic segments regress but the mesonephric kidney continues functioning until week 10.
- Most of the mesonephric tubules disappear except for few of them which forms efferent ductules, superior and inferior aberrant ductules, paradidymis and appendix of epididymis in males and epoophoron and paroophron in females.

- Mesonephric duct gives rise to ureteric bud in both the sexes. In addition it gives rise to epididymis, vas deferens, seminal vesicles and ejaculatory ducts in males and duct of epoophoron and paroophron and gartner duct (or cyst) in females.

Metanephros:(The definitive kidney)

- It develops during 5^{th} week of intrauterine life from 2 sources.

1.Ureteric bud

- It begins as an outgrowth from the distal mesonephric duct.
- It elongates to form ureter and its cranial end dilates to form pelvis of the ureter.
- Then the pelvis divides in to major calyces which then divide into minor calyces and collecting tubules.

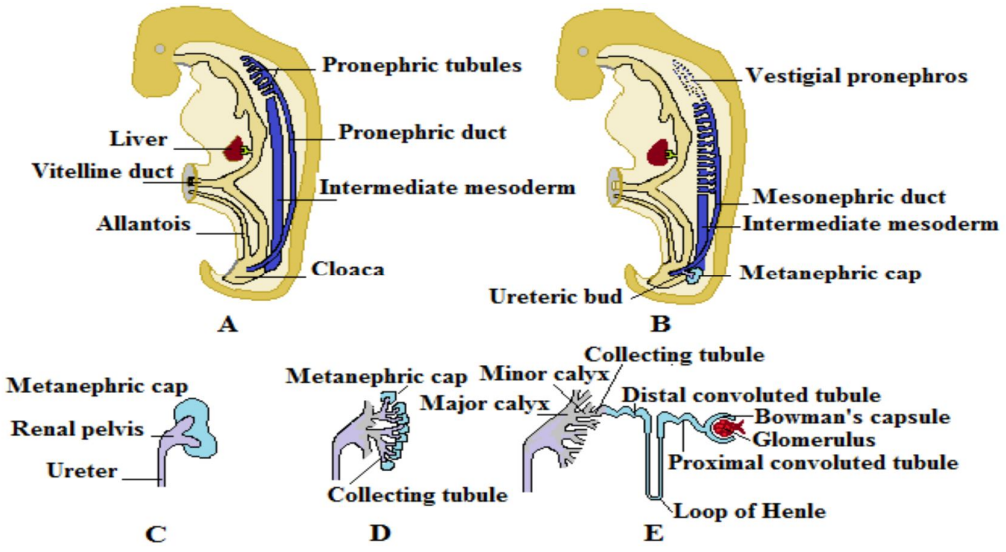
2.Metanephric blastema(metanephric cap)

- Formed from the condensation of the intermediate mesoderm around the cranial end of the ureteric bud.
- It divides in to small masses so that each collecting tubule has its own small cap which is differentiated in to S-shaped tubule.

- The continuous growth of which results in the formation of proximal convoluted tubule, loop of henle and distal convoluted tubule.

- Proximal “dorsal end” of the proximal convoluted tubule is invaginated by a branch of dorsal aorta to form glomerulus surrounded by Bowman’s capsule.

- Distal “ventral” end of the distal convoluted tubule communicates with (opens into) the corresponding collecting tubule



Diagrams showing development of kidney: A)pronephros B)mesonephros and appearance of ureteric budc C) ureter and metanephric cap D)metanephric cap of the collecting tubules E) derivatives of metanephric cap

To summarize, the kidney is formed from 2 main portions from 2 embryological sources which are:

1. The **excretory portion** of the kidney develops from the metanephric blastema (condensation of intermediate mesoderm) which gives rise to Bowman's capsule, proximal convoluted tubule, loop of henle, and distal convoluted tubule.
2. The **collecting portion** of the kidney develops from the ureteric bud which gives rise to collecting tubules, major and minor calyces, renal pelvis and ureter.

KIDNEY ARCHITECTUE:

Nephron is the structural and functional unit of kidney. Each nephron consists of a renal corpuscle (glomerulus and Bowman's corpuscle) and renal tubules(proximal convoluted tubule ,loop of Henle, and distal convoluted tubule)

- Renal cortex:

  Renal corpuscle

  Convoluted tubules

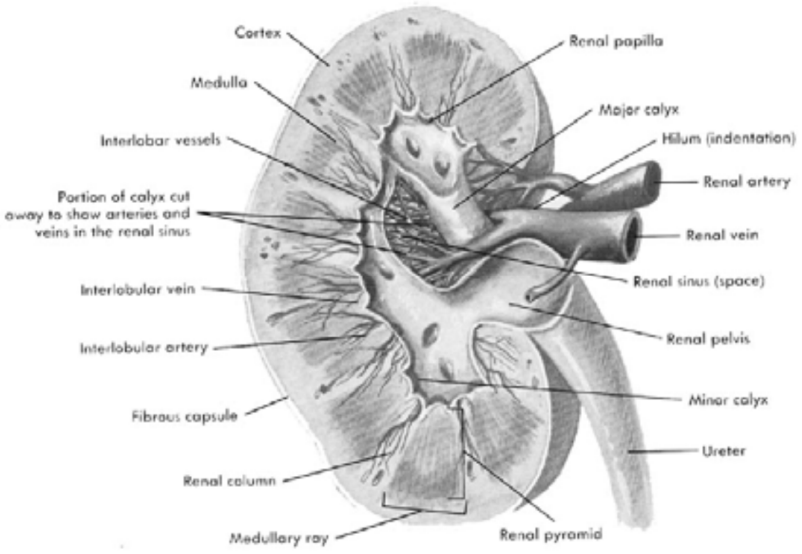
- Renal medulla:

  Collecting ducts

  Loop of Henle

- Each minor calyx drains a tree of collecting ducts within a renal pyramid
- Pyramids are separated by columns of cortical tissues called renal columns.
- The renal pyramids converge to form the renal papilla.

Diagram showing the architecture of the kidney:



POSITION OF THE KIDNEYS:

- The metanephros forms at the level of the upper sacral segment and receives its blood supply from sacral branches of the dorsal aorta.
- Between sixth to eighth week of fetal development, the kidneys begins to ascend from their sacral region to reach its final position in the abdomen (opposite to the T12 – L3 vertebra)
- As it ascends it changes its blood supply from median sacral artery to common iliac artery and finally from abdominal aorta.
- At the level of the second lumbar segment , the renal arteries become the definitive supplier of blood to the kidney.

- Kidneys also undergo lateral displacement which brings them in contact with the developing adrenal glands that fuse to the cranial pole.
- As the kidney ascends it rotates medially to 90 degree,so that its hilum becomes directed medially from its ventral position.

Some salient features of fetal kidney:

- Kidneys develop within the fetal pelvis in 7^{th} menstrual week
- Ascend in to the posterolateral retroperitoneum by week 11
- Nephrons form at about 10 weeks and urine production starts by weeks 13-15.
- Urine output increases from 2.2 ml/ hour at 22 weeks to 12.2 ml/ hour at 32 weeks and 28ml/hour at term.
- Can be visualized in the ultrasound early in the second trimester. Initially kidneys are difficult to see but increased perinephric fat improves sonographic contrast.
- Kidneys appears as a paired hypoechoic structure on either side of the fetal spine and as the development progresses it shifts more laterally away from the spine.

- Renal cortex is initially thin and difficult to visualize but it becomes easier in the third trimester as the medullary pyramids and the cortex are visualized as separate entities.

- Medulla align along the pelvic sinus in the sagittal plane. It has a relative hypoechoeic appearance might be due to abundance of fluid filled tubules.

- Renal sinus is located centrally appears as a linear area of medium echogenicity.

- Fetal lobulation , medullary pyramids and the collecting system can be readily visualized in the third trimester.

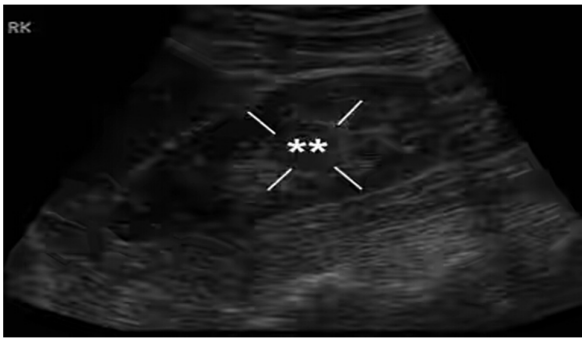
- The typical fetal kidney is made up of discrete anterior and posterior lobes that eesntially fuse into 1 unit which occurs around 28 weeks of gestation. Some postnatal kidneys may appear with irregular borders due to retained fetal lobulations.

- The medullary areas of individual renal lobes also tend to fuse which prevents cortical tissues from extending its position.

- When the fusion is less than complete , cortical tissue may extend inferiorly and centrally, adjacent to medullary tissue as a column of Bertin.

- Yeh et al described the hypertrophied column of Bertin as a normal variation because of unresorbed polar parenchyma of the 2 subkidneys that fuse to form a normal kidney. Junctional parenchyma is the preferred term for this variation.

Columns of Bertin:



NORMAL FUNCTION OF THE URINARY SYSTEM:

KIDNEYS:

- Kidneys produce urine, a blood filtrate, and regulate urinary volume and composition.
- Maintains water and electrolyte balance, conserving nutrients and eliminating waste products.
- Secretes the hormone rennin, erythropoietin and 1,25-dihydroxyvitamin D.
- Renin helps to regulate blood pressure and erythropoietin regulates erythrocyte production and 1,25-dihydroxy vitamin D plays a role in calcium metabolism.

URETERS:

- Conveys urine from kidney to urinary bladder

URINARY BLADDER:

- Temporary urine storage.

URETHRA:

- Conveys urine from bladder to outside.

An important function of the fetal kidney is to maintain a urine output sufficient to maintain amniotic fluid volume. Daily urine production is approximately 30% of the fetal weight. The excreted urine does not serve excretory or homeostatic function because the urine via the amniotic fluid, is recycled back to the fetus by swallowing.

At 20 weeks the fetal kidneys produce most of the amniotic fluid. The fetal urine is hypotonic because of lower electrolyte concentration. The fetal urine contains more urea, creatinine and uric acid. The osmolality of the amniotic fluid decreases with advancing gestational age.

Amniotic fluid is the clear fluid that collects within the amniotic cavity and increases with gestational age. The amount of amniotic fluid varies from about 50 ml at 12 weeks of gestation to 1000 ml around 36 weeks. The composition andvolume of amniotic fluid changes as the pregnancy advances.

In the first half of pregnancy, the amniotic fluid is the same as extracellular fluid of the fetus, devoid of particulate matter. It is produced by amniotic membranes also by the transudation through the fetal skin.

By the fourth month , the fetus contributes to amniotic fluid via;

- Urinating
- Swallowing

- Movement of the fluid in and out of the respiratory tract

The volume of the amniotic fluid is evaluated by dividing the maternal abdomen in to 4 quardrants taking pubic symphysis, umbilicus and uterine fundus as reference points. The largest vertical pocket in each quardrant is measured in cms. Total volume is calculated by adding these values. AFI < 5 cm is called as oligohydramnios and > 24 cm is called as polyhydramnios. Most of the renal anomalies usually causes oligohydramnios.

CONGENITAL ANOMALIES OF THE KIDNEY AND URINARY TRACT:

It occurs in about 1 in 500 newborns and constitute 20-30% of all anomalies identified in the prenatal period. About 15% of congenital urogenital anomalies are secondary to an underlying chromosomal disorder. In children about 20% of chronic renal failure is due to renal dysplasia or hypoplasia. In adults about 10% of chronic renal failure is due to adult polycystic kidney disease.

These anomalies are classified in to :

1. Dysgenesis of the kidney:
    - Renal agenesis (absent kidney)
    - Renal Hypoplasia
    - Renal aplasia
    - Renal Dysplasia
2. Abnormalities in shape and position:
    - Ectopic kidney
    - Fusion Anomalies:

      -horseshoe kidney

-crossed fused ectopia

3. Abnormalities in the collecting system:

- Renal pelvis:

  -Uretero pelvic junction obstruction

- Ureter :

  -Congenital megaureter

  -Ectopic ureter

  - Vesicoureteral reflux

- Bladder:

  -Bladder exstrophy

- Urethra :

  -Posterior urethral valve

RENAL AGENESIS:

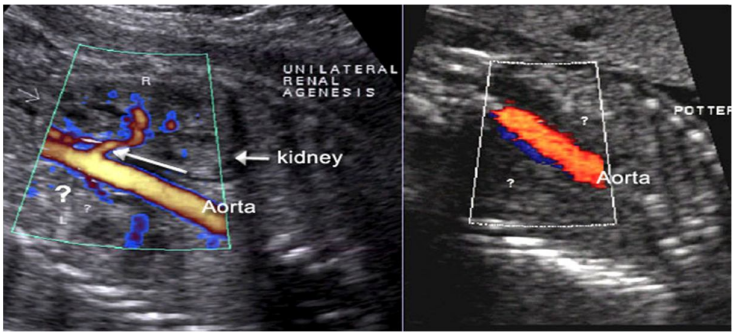
- Complete absence of one or both kidneys.
- Due to failure of formation of ureteric bud or mesenchymal blastoma differentiation of final mesenchymal condensation

- Occurs in about 1:500 – 1:3200 live births
- In 20-36% of cases, there is a genetic cause.

UNILATERAL RENAL AGENESIS:

- Absent kidney on one side.
- It is often asymptomatic and is found incidental.
- It is associated with increased incidence of mullerian duct abnormalities and single umbilical artery.
- Compensatory hypetrophy in other kidney may cause glomerulosclerosis in adults
- Ultrasound shows empty renal fossa on that side.

Ultrasound showing image of unilateral and bilateral renal agenesis:



BILATERAL RENAL AGENESIS:

- It is an uncommon lethal anomaly and there is failure of both fetal kidneys to develop during embryonic period.
- Occurs in about 1 :4000 births with male preponderance.
- The malformations associated with this condition is known as Potters Syndrome. Oligohydramnios occurs due to the absence of kidneys which place an extra pressure on developing fetus resulting in further malformations.
- Most of the infants that are born alive do not live beyond 4 hours.
- In fetal ultrasound there will be lack of amniotic fluid and absent renal arteries.
- Renal arteries are generally easy to visualize in longitudinal section. It is visible as lateral branches and its absence indicates absent kidney on that side.

RENAL HYPOPLASIA:

- This occurs due to partial development of kidney. Failure of kidney to develop to normal size without scarring.

- Usually unilateral with reduced number of pyramids.
- Oligomeganephronia : A type of hypoplasia with a small kidney but hypertrophied nephrons.

RENAL APLASIA:

- Rudimentary kidney

RENAL DYSPLASIA:

It is due to the abnormal metanephric differentiation which causes abnormality in the structure cartilages, cysts.

Renal cystic disease:

- Dysplastic cysts
- Hereditary cysts:

-Autosomal dominant: Tuberous sclerosis, Von Hipple-Lindau, ADPKD (Autosomal dominant polycystic kidney disease)

-Autosomal recessive: Meckel Gruber, Bardet Biedel ,short rib polydactyly, ARPKD (Autosomal recessive polycystic kidney disease)

- Chromosomal: Trisomy 13, 18

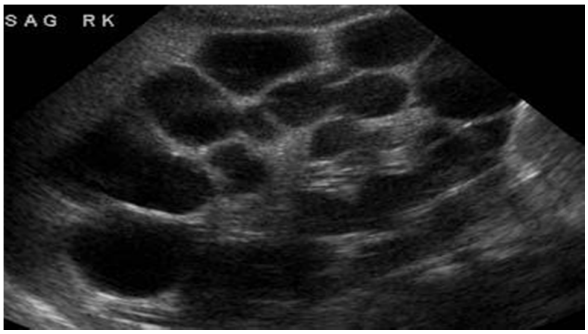
- Non– dysplastic non hereditary cysts

MULTICYSTIC DYSPLASTIC KIDNEYS:

- More common type of renal cystic disease and more severe form of renal dysplasia.
- It results from the abnormal induction of metanephric mesenchyme
- Renal volume is replaced by multiple irregular cysts of varying sizes with dense stroma in between but no renal parenchyma.
- Mean age at the time antenatal diagnosis is about 28 weeks.
- Usually unilateral, sporadic, and the affected kidney is nonfunctional and it is associated with ureteral atresia.
- Bilateral disease often have other severe deformities or polysystemic malformation syndromes.
- Newborn with bilateral disease will have the classical characteristics of potter's syndrome. The bilateral condition is incompatible with survival, as the contralateral system is frequently abnormal.

- Involutes over time, follow up with serial ultrasound and if cysts doesn't involute then nephrectomy is indicated.
- Vesicoureteral reflux is common (20%) in the contralateral kidney.

Multicystic dysplastic kidney:



POLYCYSTIC KIDNEY DISEASE:

It is the genetic disorder characterized by the growth of numerous cysts filled with fluid in the kidneys. These cysts can reduce the function of the kidneys leading to kidney failure. The fetus with polycystic kidney disease can also have cysts in the liver,may have associated pathology in the heart and blood vessels of brain.

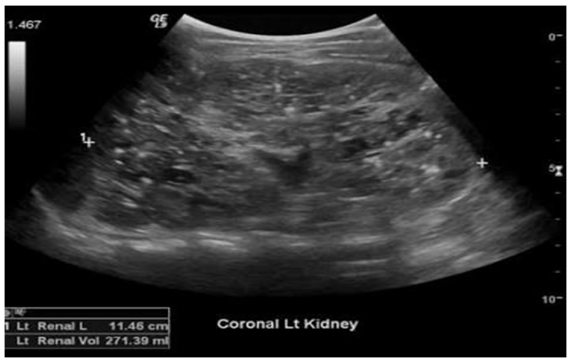
There are two primary inherited forms of polycystic disease

1. Autosomal dominant polycystic kidney disease (ADPKD)
2. Autosomal recessive polycystic kidney disease (ARPKD)

AUTOSOMAL RECESSIVE POLYCYSTIC KIDNEY DISEASE:

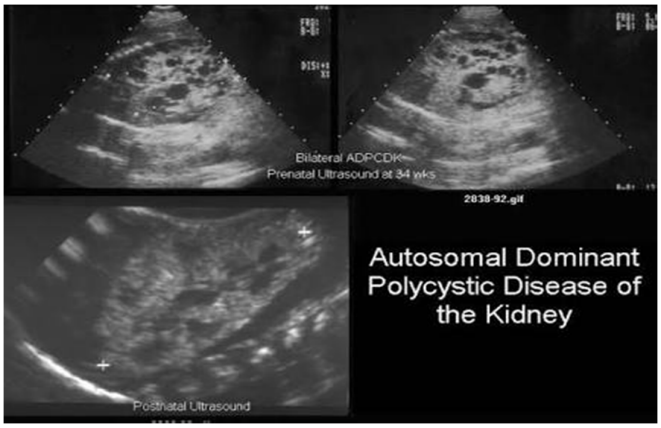
- Rare inherited form of polycystic kidney disease.
- Bilateral with very large kidneys with microcysts.
- Occurs in about 1 in 40,000 births.
- Males and females are equally affected.
- Ultrasound shows increased echogenicity with poor parenchymal differentiation
- Oligohydramnios is the rule. Lungs may be hypoplastic
- There are four different types of ARPKD, which are
    - Perinatal form
    - Neonatal form
    - Infantile form
    - Juvenile form
- Children born with ARPKD will usually develop renal failure within few years of life.

Autosomal recessive polycyctic kidney:



AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE:

- Commonest hereditary renal cystic disease accounting for about 90% of all polycystic kidney disease.
- Occurs in about 1 in 10,000 births.
- Associated with cysts in liver, lung, pancreas and spleen.
- Usually not diagnosed antenatally as kidneys in utero appear normal.
- Rarely symmetrically enlarged kidneys with small cysts are noted.
- Liquor volume will be normal.



ABNORMALITIES IN POSITION:

Ectopic kidney:

Renal ectopia or ectopic kidney describes a kidney that is not located in its usual position. It results from the failure of the kidney to ascend from its origin in the true pelvis(pelvic kidney) or from a superiorly ascended kiney located in the thorax. Left kidney more likely to be abnormal. Frequently associated with abnormalities of other organ systems.

Pelvic kidney:

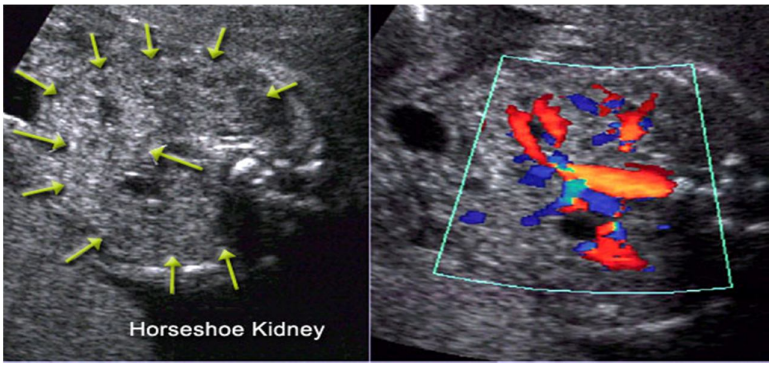
ANOMALIES OF FUSION:

These anomalies are thought to result because of an abnormally located umbilical artery which prevents normal cephalic migration from occurring. The arterial supply and the venous drainage in all fused kidneys are mostly abnormal.

Horse shoe kidney:

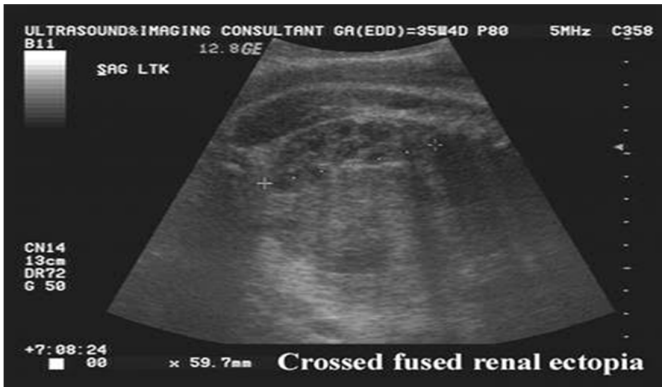
It develops when the lower poles of the kidneys are fused in the midline due to fusion of ureteric buds during fetal development. Connecting isthumus can be renal parenchymal or fibrous tissue. Usually ureters drain medially and anteriorly to isthumus. Asymptomatic in majority of cases but sometimes it may be associated with reflux nephropathy if the ureters implant more superiorly.

Horse shoe kidney:



Crossed fused Ectopia:

Here kidneys fuse early in development due to abnormal development of the ureteric bud and the metanephric blastema durind 4^{th} – 8^{th} week of gestation. Both kidneys lie on one side of the spine with two separate ureters arising from each kidneys. The ureter arising from the crossed over kidney enters the bladder after crossing the midline.



ABNORMALITIES OT THE COLLECTING SYSTEM:

Hydronephrosis:

It is the dilatation of the renal pelvis which may be unilateral or bilateral. Commonest antenatal renal condition noted on ultrasound and most often a transient finding. It may be due to the obstruction of urine flow in the distal urinary tract or reflux of urine up in the ipsilateral ureter or due to bladder neck obstruction or urethral obstruction.

Hydronephrosis – dilatation of renal pelvis > 1 cm

Pyelectasis - mild enlargement of renal pelvis 4 – 10 mm

Image showing normal right kidney and left side hydronephrosis

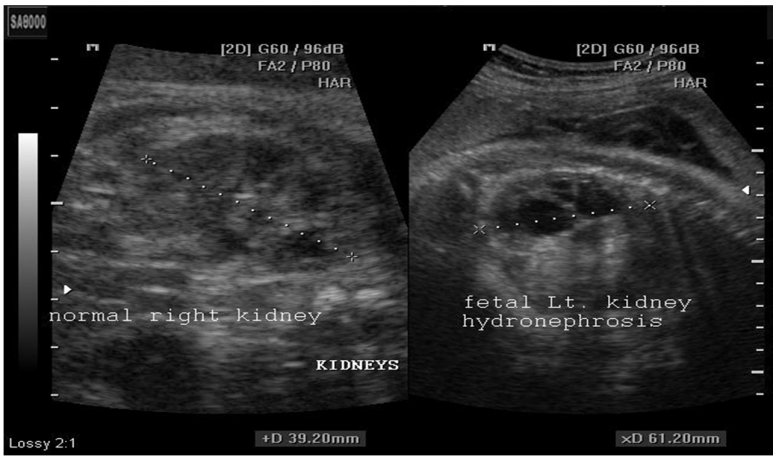
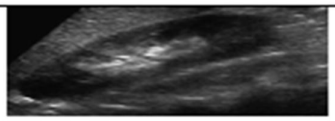
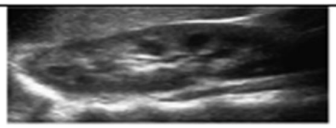
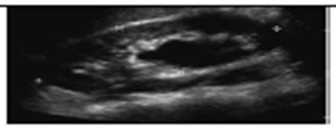
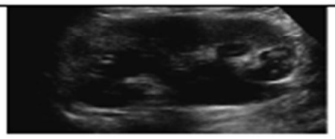
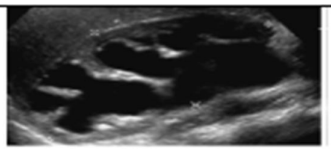


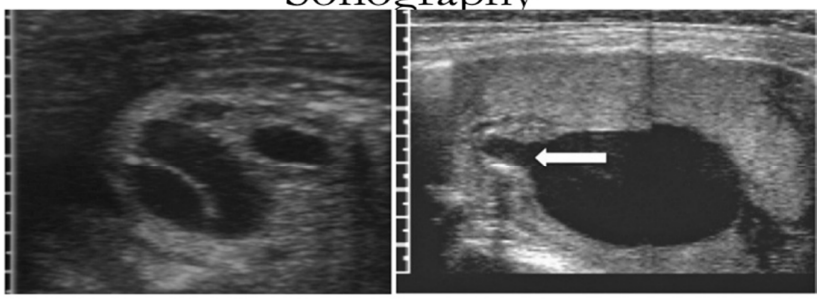
Table 1 Society of Fetal Urology grading system of congenital hydronephrosis

Grade	Central renal complex	Renal parenchymal thickness	Ultra sound scan
0	intact	Normal	
I	Slight splitting of pelvis	Normal	
II	Evident splitting of pelvis and calices	Normal	
III	Wide splitting of pelvis and calices	Normal	
IV	Further splitting of pelvis and calices	Reduced	

Posterior urethral valve:

It is the most frequent cause of distal urinary tract obstruction. It occurs as a result of persistent obstructing urogenital membrane. The valves are usually found at the point of junction of posterior urethra with anterior urethra.

Posterior Urethral Valves
Sonography



Dilated ureter and renal pelvis and dilated bladder with a dilated posterior urethra

Exstrophy of bladder:

Here the lower portion of the abdominal wall and the anterior wall of the bladder are missing so that the bladder is everted through the opening and may found on the lower abdomen with continuous passage of urine to outside.

Patent urachus:

The urachus , which is the remnant of allantois, is a channel between the bladder and the umbilicus where the urine initially drains in the fetus during first trimester. The channel usually seals off and obliterates around the 12^{th} week of gestation and left over fibrous cord is called median umbilical ligament.

The patent urachus occurs when the urachus did not seal off, which causes leakage of the urine at the level of umbilicus.

ULTRASOUND IN OBSTETRICS:

Obstetric ultrasound is the use of medical ultrasonography in pregnancy. Since its introduction in the late 1950's ultrasound has become a very useful diagnostic tool in obstetrics. Ultrasound has become a safe, non invasive, accurate, and cost effective investigation in pregnancy.

Ultrasound uses the principle of 'SONAR' which stands for sound navigation and ranging. Ultrasound waves results from an inverse piezoelectric effect.The piezoelectric effect refers to phenomenon that takes place when the pressure is applied to the crystals (piezoelectric materials) , the mechanical pressure produces an electric current. Inversely when an electric pulse is applied to the piezoelectric material, a mechanical wave results and this mechanical wave is the ultrasound beam.

The sound waves are emitted from a transducer which is placed in contact with the maternal abdomen and is moved to look at any particular content of the uterus. As these waves meet a tissue interface, they are reflected back to the transducer and converted to electric signal, which is processed and displayed as the ultrasound image on the monitor.

Currently real- time scanners are used which produces continuous picture of the moving fetus that can be depicted on a monitor screen. Very high frequency sound waves between 3.5-7.0 megahertz being generally used for this purpose.

The international society of ultrasound in obstetrics and gynaecology(ISUOG) recommends that the pregnant women have routine obstetric ultrasound between 18- 22 weeks of gestation in order to confirm pregnancy timing and to detect growth abnormalities and to assess for congenital malformations and multiple gestations.Additionally it also recommends pregnant women to have obstetric ultrasound between 11-14 weeks of gestation in countries with resources to perform them. Research shows that routine obstetric ultrasound before 24 weeks of gestation can significantly reduce the risk of failing to recognize multiple pregnancies and improving pregnancy dating to reduce the risk of labour induction for post dated pregnancy.

Types of ultrasonography

- Trans abdominal ultrasonography(TAS)
- Trans vaginal ultrasonography(TVS)
- Doppler ultrasound

- Tissue harmonic imaging(THI)
- Three dimensional ultrasound(3-D USG)
- Four dimensional ultrasound(4 – D USG)

Trans vaginal ultrasound probe:

Trans abdominal ultrasound probe:

FIRST TRIMESTER ULTRASOUND:

Indications:

- To confirm pregnancy
- To determine whether it is intrauterine or extrauterine
- To determine multiple pregnancy
- To estimate gestational age of the fetus
- To determine ectopic pregnancy
- Suspected molar pregnancies
- To guide for prenatal diagnostic testings like choronic villus sampling

Normal first trimester ultrasound:

- Location of sac
- Number of sacs
- Crown rump length
- Embryonic cardiac activity
- Trophoblastic reaction
- Amniodecidual separation and choriodecidual separation

- Nuchal translucency
- Nasal bone ossification
- Gross abnormalities of cranium,spine and limbs
- Extra fetal evaluation (uterine anomalies, myometrium,cervical length, internal os, adnexa, size and vascularity of corpus luteum)

SECOND TRIMESTER ULTRASOUND – INDICATIONS:

- Fetal position
- Fetal viability
- Gestational age
- Biometry
- Liquor status
- Placental position
- Detailed assessment of anomaly

  (cranium, spine,face,neck,thorax,heart,abdomen and limbs)
- Sex of the baby
- Cervical length

THIRD TRIMESTER ULTRASOUND- INDICATIONS:

- Fetal presentation(cephalic/ breech/oblique/transverse)
- Attitude
- Growth
- Viability
- Amniotic fluid index
- Placental position
- Placental maturity
- Doppler for fetal well being

OPERATIONAL DEFINITION OF TERMS:

Pre and peri- ovulation (1-2 weeks):ovarian follicle matures and ovulation

Conceptus (3-5 weeks) : corpus luteum, fertilization, morula, blastocyst, bilaminar embryo.

Embryonic (6-10 weeks): trilaminar C– shaped embryo

Fetal phase : from 11 weeks onwards , where the organs become fully developed.

Clinical pregnancy: Evidence of conception from the time of fertilization to the end of the embryonic period 8 weeks after fertilization (Zegers-Hoschschid et al,2006)

Fertilization: The penetration of the ovum by the spermatozoa and fusion of genetic materials resulting in the development of a zygote (Zegers-Hoschschid et al, 2006)

Term Pregnancy: A birth that takes place at 37 or more completed weeks of gestational age, with early term being 37 and 38 weeks, full term 39 and 40 weeks, late term 41 weeks. After 41 weeks it is called post term. This includes both live and still births.

Gestational sac: A fiuid filled structure containing an embryo that develops early in pregnancy usually within the uterus (Zegers – Hoschschid et al, 2006)

Quickening: The time when the mother first feels the baby move usuallyat 16 to 18 weeks (Sanders & Winter, 2004)

Composite(average) gestational age: The mean of more than one parameter used in estimating gestational age (BPD + HC + FL/ 3).

First trimester: It is from week one through 12 and includes conception. The first trimester carries the highest risk of miscarriage.

Second trimester: It is from week 13 through 28.

Third trimester: It is from week 29 through 40 weeks.

SONOGRAPHIC ASSESSMENT OF FETAL KIDNEY LENGTH AS A PREDICTOR OF GESTATIONAL AGE:

Fetal kidney length:

The appearance of the fetal kidney changes with the advancing gestational age. The fetal kidneys are difficult to identify prior to 17 weeks of gestation. On sonography in the second trimester , the fetal kidneys appears as a ovoid retroperitoneal structure that lacks distinctive borders.

To measure the kidney length the fetus was scanned in the transverse plane until the kidneys are visualized just below the stomach. The probe was then rotated through 90 degree to outline the longitudinal axis of the kidney.

The right and left kidneylengths were measured and the mean of the two kidneys was taken. The length of the kidney was measured from outer to outer margin. Care should be taken to exclude the adrenal glands in the measurements. All the measurements are to be obtained during fetal apnea.

Ultrasound image showing fetal kidneys:

Fetal kidney length measurement:

Sonographic assessment of other parameters used to determine the gestational age of the fetus:

There are numerous parameters used to determine the fetal growth and the gestational age. The parameters used in determining the gestational age are Gestational sac diameter, crown-rump length, head circumference, biparietal diameter,abdominal circumference,femur length and transcerebllar diameter. Other parameters used are; foetal humerus

length, fetal neck circumference,fetal liver, and the axial transverse diameter of the fetal foramen magnum.

Gestational sac diameter:

The gestational sac is the earliest sonographic finding in pregnancy. The gestational sac is an echogenic ring surrounding an anechoeic centre. Double decidual sac sign represents two bright echogenic concentric rings that represent the deciduas vera (outer ring) and the deciduas capsularis (inner ring). The presence of sac alone is not a definitive marker of an intrauterine pregnancy.

Gestational sac :

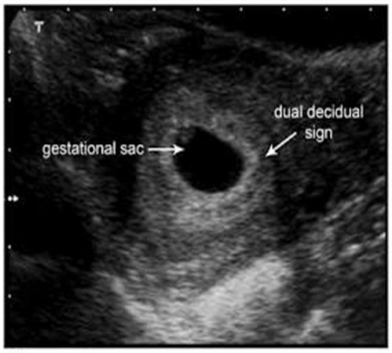


Figure 6

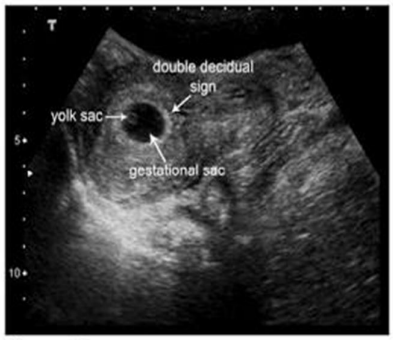


Figure 7

The gestational sac is not identifiable until approximately 41/2 weeks with transvaginal ultrasound. The gestational sac size should be determined by measuring the mean of three diameters. These difference rarely effect gestational age dating by more than a day or two.

The crown rump length (CRL):

The crown rump length was originally defined by Mall in 1967. The CRL is the sitting height, midbrain to the lowest part of breech. For ultrasound, the crown rump length is defined as the longest length excluding the limbs and the yolksac (Westerway et al., 2002). The CRL is the optimal method of establishing gestational age of fetus in the dating examination (Sanders et al., 1998). The CRL is the measurement of choice less than 12 weeks and CRL measuring discrepencies are more from 12 weeks of gestation (Westerway et al., 2002).

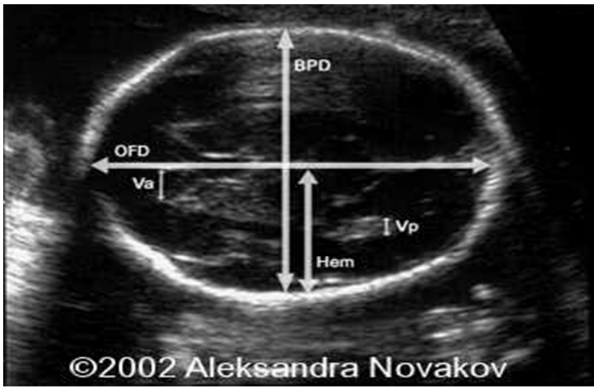
CRL measures gestational age with the difference of about 3 days, when perfomed between 7 – 10 weeks and a difference of about 5 days when performed between 10- 14 weeks. Fetal CRL in cms + 6.5 gives gestational age in weeks

Crown rump length measurement:

Biparietal diameter (BPD):

The BPD remains the standard against which other parameters of gestational age are compared. It has greatest accuracy between 12 – 28 weeks of gestation after which the accuracy can be reduced due to biological variations that affect fetal growth and pathological disorders. The variability of the BPD in predicting the gestational age after 28 weeks is too great to be reliable (Sabbagha et al., 2003)The BPD is measured from the outer surface of the anterior parietal bone to the inner surface of he posterior parietal bone (Shepherd and fill 1982; Hadlock et al., 1982 and Beigi and Zarrinkoub, 2000)

Biparietal diameter measurement:



The anatomical landmarks used to ensure accuracy and reproducibility of the measurement include;

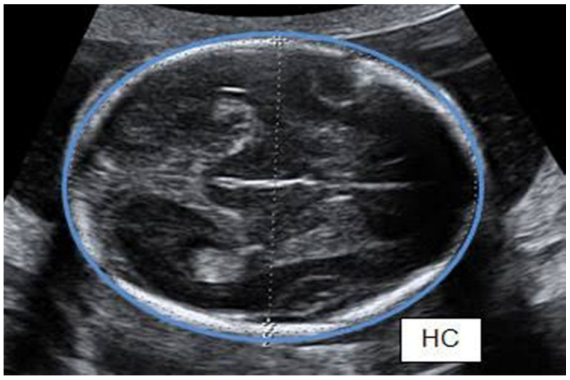
- Midline falx
- The thalami symmetrically positioned on the either side of the falx
- Visualization of the cavum septum pellucidum at one of the fronto occipital distance
- The calvaria should be smooth and symmetrical

The BPD is the distance between the parietal eminences on either side of the skull and is therefore the widest diameter of the fetal skull from side to side, the transverse section is recognized when the shape of the fetal skull is ovoid and the midline echo from the falx cerebri is interrupted by the cavum septum pellucidum and the thalami. When this plane is found gain on the ultrasound unit should be reduced and the measurement made from the outer table of the proximal skull (the part nearest to the transducer) to the inner table of the distal skull (the part farthest away from the transducer). The soft tissues over the skull are not included. This is the ‘ leading edge- to- edge’ technique (Ugwa et al., 2007). This parameter has a variability ranging from 1.5 to 2.7 weeks depending on the period of gestation(Subbarao et al.,2003).

Head circumference (HC):

It is the length of the outer perimeter of the cranium. It is measured using the same landmarks as with the BPD (Hill et al.,1991). The head circumference os more accurate in predicting gestational age than BPD (Benson and Doubilet, 1991). If the cephalic index is in normal range, then the BPD is acceptable as an estimate of gestational age. If the cephalic index is outside this limits (<70 or >86) then the BPD should not be used to determine the gestational age.Instead head circumference can be used (Ugwa et al.,2007). The HC was measured by tradeball on the outer skull vault.

Head circumference measurement:



Cephalic index:

Cephalic index is an index or ratio which is used to evaluate the shape of the head. It is calculated by measuring maximum width(BPD)

of the cranium divided by its maximum length(occipito frontal diameter) multiplied by 100.

Cephalic index = BPD/ Fronto occipital diameter x 100

Head circumference = (BPD + Fronto occipital diameter) x1.62

Abdominal circumference(AC):

It is the length of the outer perimeter of the abdomen taken on the axial plane at the level of the umbilical vein- ductus venosus complex (Hadlock et al., 1982). AC is less accurate than BPD in estimating the gestational age (Subbarao et al .,2003).

Abdominal circumference measiurement:

AC is most sensitive parameter to assess intrauterine growth disturbances, as the measurement is taken at the level of fetal liver which is very sensitive to deficient nutrition.

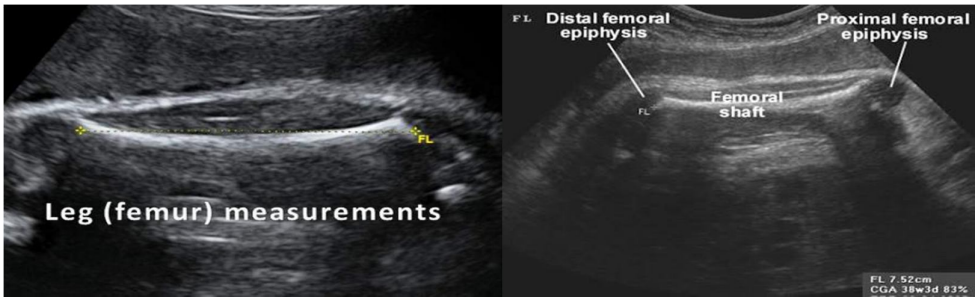
To measure AC start with the longitudinal view of the thoraco lumbar spine, then rotating the transducer through 90 degree to obtain the circular outline of the fetal abdomen. This transverse should include the fetal stomach, intra hepatic section of umbilical vein.

Abdominal circumference increases approximately 20 mm every 2 weeks after 24 weeks.

Femur length (FL):

The femur length is measured from the major trochanter to the lateral condyle along the axis of the central shaft exclusive of epiphysis. The long shaft of the femur is placed exactly perpendicular to the ultrasound beam (Beigi et al.,2000). Overall, the femur length is mostly used in the third trimester because the BPD becomes less reliable owing to the engagement of fetal head in the maternal pelvis.

Femur length has a hockey stick appearance in ultrasound and it can be used to estimate gestational age from 12 weeks to term. It is necessary when the two ends of the femur are obtained clearly and to the outline of the bone is straight (Dugoff et al .,1996)



Other parameters used for measuring gestational age:

Humerus length:

The principles of measurement corresponds to that of the femur. The insonation of the ultrasound beam is directed in a perpendicular fashion and the diaphysis alone is measured after the forearm and the shoulder region are identified.

Transverse cerebellardiameter :

It is the maximum diameter between the cerebellar hemispheres on an axial scan. The value of the transverse diameter in mm is considered to be equivalent to the gestational age in weeks, particularly from 14 to 20 weeks of gestation. It is not thought to be significantly altered by IUGR.

Clinical methods of estimating the gestational age:

Naegele's rule:

This is the most common method of pregnancy dating. The expected date of delivery (EDD) can be calculated by this rule by adding 1 year, subtracting 3 months, and adding 7 days to the first day of last menstrual period (LMP). The result is approximately 280 day. This method is based on the fact that the patient has a 28 days menstrual cycle with fertilization occurring on the 14^{th} day. Naegele's rule assumes an average cycle length of 28 days , which is not applicable for everyone.

Parikh's formula:

Here the EDD is calculated by adding 9 months to LMP ,subtracting 21 days , then adding duration of previous cycles (Parikh , 2007)

Obstetric wheel:

It has an outer wheel that has markings for the calendar, and an inner sliding wheel with weeks and days of gestation.

Reliability of gestational age estimation:

- Menstrual history of 3 or more of regular cycles without oral contraceptive pill intake.
- Pregnancy following assisted reproductive techniques
- EDD from LMP and by ultrasound between 12 – 20 weeks coincides
- EDD established by CRL between 7 -11 weeks of gestation
- EDD by 2 or more of ultrasound examinations 3-4 weeks apart between 12 – 28 weeks of gestation
- EDD corresponds to 36 weeks since positive urine pregnancy test
- Fetal heart rate documented 20 weeks before EDD by non electronic fetoscope or 30 weeks before by Doppler.

Other non- Radiological methods of gestational age estimation:

- Methods such as measurement of fundal height, and maternal abdominal circumference.
- Determination of blood beta–HCG (human chorionic gonadotrophin) concentration in early pregnancy.

- Perception of fetal movement by the patient is called quickening, is relatively a late sign of pregnancy occurring between 19- 21 and 17- 19 weeks of gestation in nulliparous and multiparous women respectively.

- Pregnancies following assisted reproductive techniques, the gestational age resulting from the invitro fertilization can be precisely calculated from the time of embryo transfer.

RESULTS

The mean fetal kidney length, Femur length, Abdominal circumference,& Head circumference had a linear and strong correlation with LMP derived gestational age. The best correlation coefficient was observed between LMP & FL. The next is between LMP & FKL.

There was no statistically significant difference between the right and left fetal kidney length measurements ($p > 0.05$).

The kidney length showed a linear correlation as the gestational age progressed. Age , parity, height & weight of the mother and the side of the kidney showed no significant influences in the assessment of renal length & its correlation to gestational age.

The most accurate was the femur length with the standard error of prediction of 8.38 days & the next being kidney length with standard error of prediction of 9.34 days. The accuracy of HC, AC & BPD are 9.48 days, 12.27 days & 13.61 days respectively.

RESULTS AND ANALYSIS:

Table 1- Pearson correlation coefficient for relation between gestational age (LMP) with biometric indices and kidney length

	LMP	FL	HC	BPD	AC
FL	.945**				
HC	.920**	.886**			
BPD	.873**	.843**	.937**		
AC	.894**	.878**	.849**	.823**	
KL	.925**	.871**	.875**	.834**	.843**

****P value<0.001**

Pearson's correlation coefficient coefficient was calculated between the gestational age and the kidney length as well as between the GA and other fetal biometric indices. P value < 0.05 is taken as significant. The best correlation was observed between the LMP & FL followed by LMP & FKL.

Table 2- Linear regression analysis of fetal biometric parameters

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-1.507	.999		-1.509	.135
FL	.434	.067	.401	6.481	.000
HC	.217	.084	.214	2.601	.011
BPD	-.016	.077	-.014	-.208	.836
AC	.133	.059	.121	2.246	.027
KL	.286	.053	.299	5.393	.000

a. Dependent Variable: LMP

The above table shows pearson's linear regression analysis for fetal biometric parameters.

Table 3- Predicted values of various parameters

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95% Confidence Interval for B		R square	SEp
		B	Std. Error	Beta			Lower Bound	Upper Bound		
	FL	1.022	.036	.945	28.509	.000	.951	1.093	.892	8.38
	BPD	.977	.055	.873	17.697	.000	.867	1.087	.762	13.61
	KL	.886	.037	.925	24.112	.000	.813	.959	.856	9.34
	AC	.987	.050	.894	19.803	.000	.889	1.086	.800	12.27
	HC	.936	.040	.920	23.180	.000	.856	1.017	.846	9.48

Independent variables: BPD, KL, FL, AC, HC

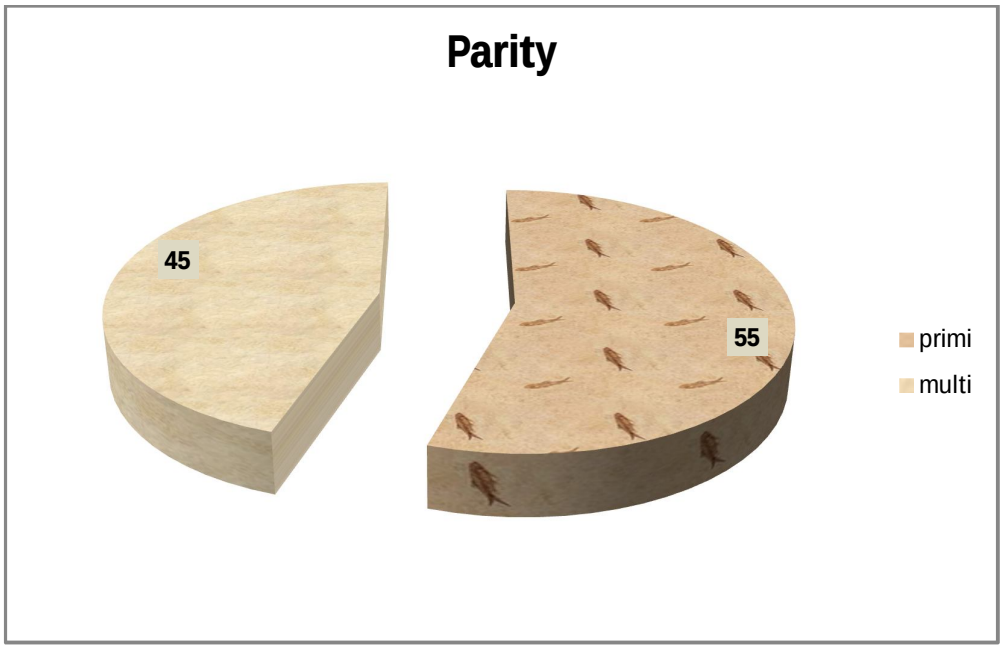
Dependent variable: GA by LMP

SEp: Standard Error of prediction

Here the upper and lower bound for each biometric parameters and their standard error of prediction for each biometric parameters are depicted. The FL has shown to have better prediction rate with standard error being 8.38 days followed by FKL & HC with standard errors being 9.34 & 9.48 days respectively.

Table 4- Parity

Parity	Frequency	Percent
primi	55	55.0
multi	45	45.0
Total	100	100.0

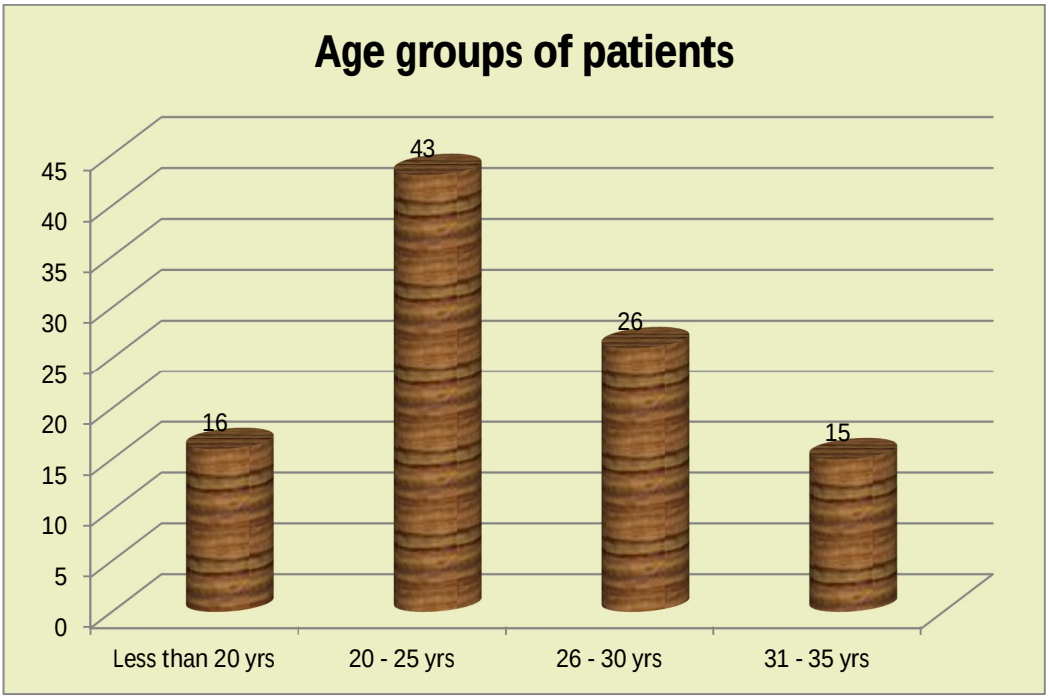


The above table & graph showing distribution of parity amongst the participants with 45% of patients being multigravida & 55% of patients being primigravida.

Table 5- Age

	Frequency	Percent
Less than 20	16	16.0
20 - 25 yrs	43	43.0
26 - 30 yrs	26	26.0
31 - 35 yrs	15	15.0
Total	100	100.0

The above table shows age distribution of the participants & most of them(43%) belongs to 20 – 25 yrs of age, about 26% belongs 26 – 30 yrs of age, 16% of patients were < 20 yrs of age & about 15% were between 31 – 35 yrs of age.



This is the graphical representation of the age distribution of the participants.

Table 6- Descriptive statistics

	Minimum	Maximum	Mean	Std. Deviation
GA (weeks)	29.00	41.00	34.2500	3.52874
BMI	18.30	24.40	21.4400	1.84648
FL	27.30	39.50	33.4040	3.26106
HC	27.00	40.50	33.0820	3.46542
BPD	27.60	41.60	34.4380	3.15216
AC	27.40	40.50	34.1160	3.19639
KL	28.00	42.00	35.1370	3.68282

The table shows the mean gestational age of the participants is around 34 weeks & the mean BMI being 21.44. The mean gestational age for FL, BPD, HC, AC & KL being 33 weeks, 33 weeks, 34 weeks , 34 weeks & 35 weeks respectively.

Table 7- Age and KL

Age	Mean	N	Std. Deviation	P value
Less than 20	34.2750	16	4.11412	0.501
20 - 25 yrs	34.8930	43	3.86919	
26 - 30 yrs	35.5038	26	3.39382	
31 - 35 yrs	36.1200	15	3.15893	
Total	35.1370	100	3.68282	

As the p value is > 0.05 , there is no significant correlation between the age of the patients and the fetal kidney length.

Table 8- Parity and KL

Parity	Mean	N	Std. Deviation	P value
Primi	34.8564	55	3.90966	0.402
Multi	35.4800	45	3.39696	

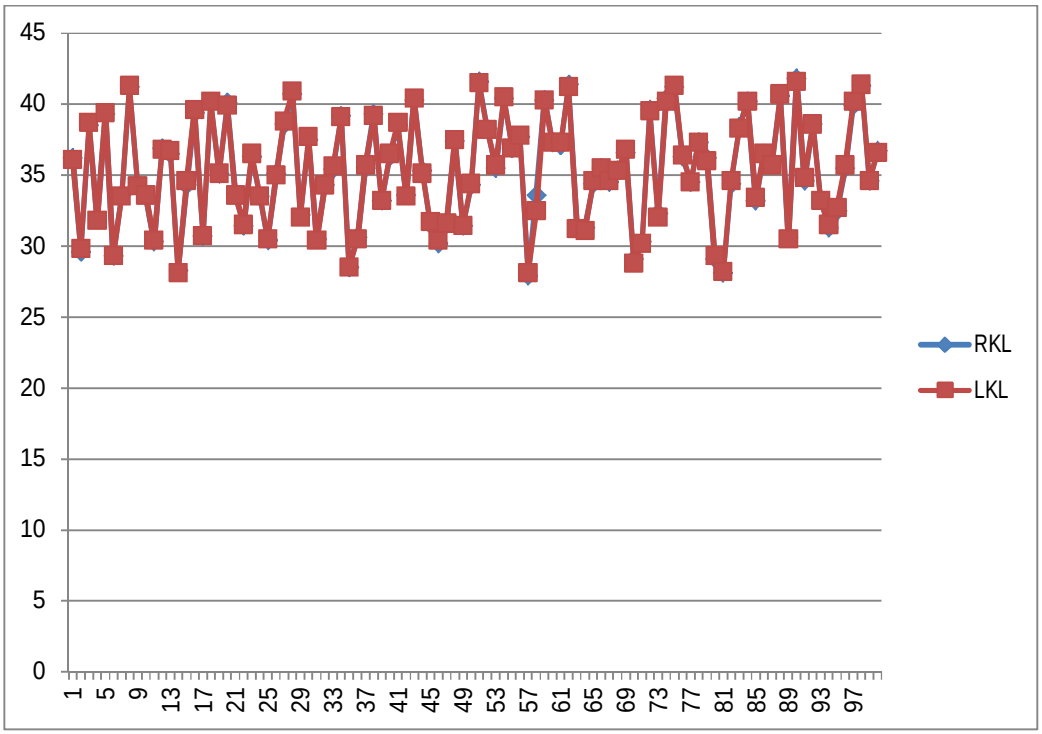
There is no significant correlation between the parity of the patients and the fetal kidney length as the p value is > 0.05.

Table 9 – RKL & LKL Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean	Difference in mm	P value
RKL	35.2640	100	3.73527	.37353	-0.02	0.279 (p>.001)
LKL	35.2840	100	3.75052	.37505		

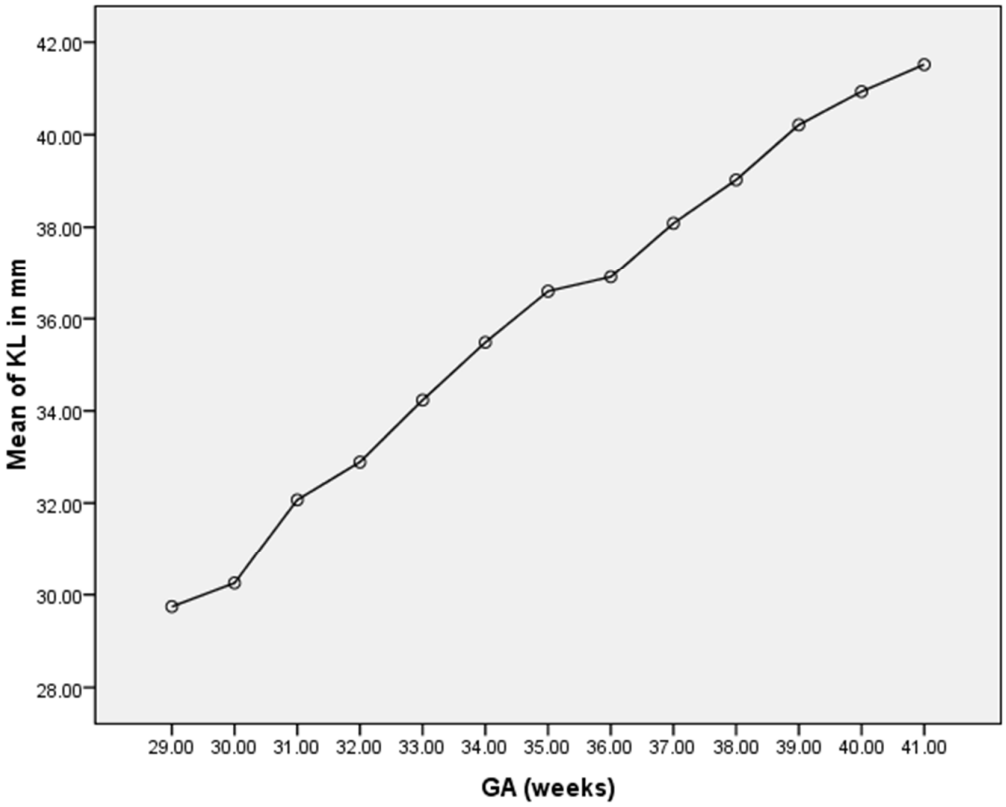
There is no significant difference between the right & left kidney length as the p value is > 0.05

Graph – Comparison of left kidney and right kidney length



This is the graphical representation of fetal right and left kidney length which almost merges with each other indicating that there is no significant difference between right and left kidney length.

Chart – Comparison of GA in weeks and kidney length in mm



The above graph shows a linear relationship between gestational age and the fetal kidney length i.e as the gestational age increases fetal kidney length also increases…

DISCUSSSION

With the advent of high resolution real time ultrasound the ability to image various organs inutero has dramatically improved. The appearance of fetal kidney changes with advancing gestational age. On sonography in the second trimester, the kidney appears as ovoid retroperitoneal structure that lacks distinctive borders. As pregnancy advances, increased echogenicity from increasing perinephric fat is said to make them more visible by allowing easier separation of the kidney from its surrounding soft tissue. By 30 weeks their size is adequate to accentuate the normal renal parenchyma and to make their identification relatively simple.

Although the fetal kidney size, as far all fetal organs is affected by growth variation , these appear to predominantly affect only the anteroposterior and transverse diameter. The length of the kidney remains largely unchanged in small for gestational age fetus. These measurements are easily reproducible and kidneys are relatively easy to be identified.

Standard measurements for renal circumference , volume, width, thickness and length heve been reported to increase throughout the gestation. Renal length and the anteroposterior diameter represent the

technically easiest measurement of the renal size to obtain. A good rule of thumb is that the menstrual age in weeks approximates the fetal kidney length in millimeters.

In our study the femur length (FL) (SEp – 8.38 days) was the most accurate single parameter for estimating gestational age closely followed by Fetal kidney length (FKL) (SEp – 9.34 days), (Head circumference (HC) (SEp – 9.48 days), Abdominal circumference (AC) (SEp – 12.27 days). Biparietal diameter (BPD) (SEp – 13.61 days) was the most inaccurate single parameter for estimation of gestational age according to our study.

No correlation was found between Fetal kidney length and the mother's age, height, weight and parity in our study. These observations were in concordance with the study of cohen et al and yusuf et al.

Unlike the study done by the Hunter et ai, the present study showed no significant difference between the right and left kiney length

We found a strong correlation between the Fetal kidney length and the gestational age and the correlation coefficient observed in our study is r = 0.925

For cohen et al r = 0.82

Mete gugur et al r = 0.947

Schlesinger et al r = 0.859

Bardhan J et al r =0.999

Kuldeep kumar et alr = 0.985

Gloor et al r = 0.90

Chiara et al for right kidney r = 0.84, left kidney r = 0.87

Konje et al r = 0.91

Wizani et al suggest that renal length measurements obtained by MRI are close to those obtained by ultrasound.

Ahmadi et al suggest that fetal kidney size can be used in dating labour, especially when accurate LMP is not available.

A little manipulation of the position of the transducer and the angle of insonation relative to the kidney plane allowed to identify both kidneys easily.which is in agreement with konje et al.

This study is compared with Gonzales et al & Grannum p et al and the results were same showing that the fetal kidney length increases as the gestational age advances.

The linear equation derived from the present study have been compared with the individual variable separately with the study done by konje et al and kansaria & parulekar. Fetal kidney length varied with a standard error of 10.29 days by konje et al and 9.17 days by kansaria & parulekar and 9.34 days by our study.

In the present study we have correlated fetal kidney length with gestational age that is calculated from the standard biometric parameters i.e BPD, FL, AC & HC. The study has demonstrated that the Fetal kidney length has significant correlation with gestational age.

CONCLUSION

The fetal kidney is easy to identify and measure and it can be used as an investigational tool in the determination of gestational age in the late second and third trimester of pregnancy. The fetal kidney length is not affected by the discrepancy of the late trimester or by the growth restriction. It could be prove to be a valuable tool in cases where other established biometric parameters are difficult to obtain or show gross discrepencies with each other or with gestational age. The present study has shown that there is a significant correlation between the renal length & the gestational age particularly in the third trimester and hence fetal kidney length can be used as an additional parameter for estimation of gestational age in the third trimester.

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PROFORMA

Name:

Age :

Occupation:

Address:

Booked at:

LMP:

EDD: Mobile No:

Period of gestation(P.O.G):

HISTORY:

Time of onset of prenatal care:

Pregnancy confirmation method :

Dating scan:

PARITY INDEX:

MENSTRUAL HISTORY:

Regularity:

Flow:

Past medical history:

Family history:

GENERAL PHYSICAL EXAMINATION:

Height: Weight: BMI:

Blood pressure: mm/Hg

Anemia : Pedal edema :

Cardiovascular system:

Heart sounds : S1 and S2

Respiratory system:

Breath sounds :

Antenatal examination:

P/A : fundal height -

Fetal heart sound -

ULTRA SONOGRAPHIC EXAMINATION:

Fetal number:

Presentation:

Amniotic fluid index:

Anomalies:

Placentation:

BIOMETRY:

Biparietal diameter in mm : P.O.G:

Head circumference in mm : P.O.G:

Femur length in mm : P.O.G:

Abdominal circumference in mm : P.O.G:

Mean fetal kidney length in mm : P.O.G:

CONSENT FORM

Xggjy gotk

bgah :

ghypdk :

taJ :

Kfthp :

muR nfhit kUjJtf fyY}hpapy kfgngW kUjJt Jiwapy gllk gapYk khz tp r. fhhjjpfh mthfs nkwbfhsSk "**fUtpy css FHeijapd rpWepuf msitf bfhzL FHeijapd gUt fhyjij fzffply**" Fwpjj Mapy braKiw kwWk midjJ tpgu'fisak nflLf bfhzL vdJ renjf'fis bjsptggLjjpf bfhznld vdgij bjhptpjJf bfhsfpnwd.

ehd ,ej Matpy KG rkkjjJld/ Ra rpejidalDk fyeJ bfhss rkkjpffpnwd.

,ej Mapy vdDila midjJ tpgu'fs ghJfhffggLtJld ,jd Kotfs MatpjHpy btspaplggLtjpy Mlnrgid ,yiy vdgij bjhptpjJf bfhsfpnwd. Vej neujjpYk ,ej MatpypUeJ ehd tpyfpf bfhss vdfF chpik czL vdgijak mwpntd.

MASTER CHART

S.No	Age	parity	GA by LMP	BMI	RKL	LKL	MKL	GA	FL	GA	BPD	GA	AC	GA	HC	GA
1	23	primi	35	19.5	36.2	36.1	36.15	36.2	70	36	89	36.5	321	36.3	316	36.6
2	22	primi	29	22.3	29.6	29.8	29.7	30	55.8	29.1	75.4	30.4	262	30.2	235	27.2
3	27	multi	37	23.3	38.5	38.7	38.6	38.6	73	37.6	93.4	38.6	342	38.6	302	35.1
4	31	multi	31	24	31.9	31.8	31.89	32	60.6	31.3	74.5	30.1	284	32.3	247	28.6
5	19	primi	38	19.2	39.3	39.4	39.35	39.4	74.8	38.5	89	36.5	319	36.1	312	36.1
6	20	primi	30	20	29.3	29.3	29.3	29.3	58.7	30.5	77.6	31.4	243	28.3	269	31.2
7	25	multi	33	21.2	33.6	33.5	33.5	33.5	65.3	33.6	84.8	34.5	277	31.6	271	31.4
8	26	multi	40	22.5	41.2	41.3	41.25	41.3	74.5	38.3	91	37.4	338	38.2	322	37.2
9	22	primi	33	19.5	34.2	34.2	34.2	34.2	62.1	32.1	84.5	34.4	304	34.5	295	34.2
10	25	primi	32	20.3	33.5	33.6	33.55	33.6	58.7	30.5	74.5	30.1	293	33.3	255	29.6
11	24	multi	29	21.4	30.3	30.4	30.55	30.6	52.3	27.6	75.4	30.4	234	27.4	236	27.3
12	33	multi	36	22	36.9	36.8	36.85	37	67.7	34.4	86.3	35.2	332	37.5	296	34.3
13	24	primi	35	21.5	36.5	36.7	36.65	36.6	70.2	36.1	89	36.5	323	36.5	288	33.4
14	20	primi	29	23.4	28.3	28.1	28.2	28.2	51.8	27.3	75	30.3	265	30.5	237	27.4
15	22	primi	33	23.5	34.3	34.6	34.55	34.6	61	31.5	77.5	31.3	301	34.2	269	31.2

16	34	multi	38	21.2	39.4	39.6	39.55	39.6	70.8	36.4	88.8	36.4	350	39.5	305	35.4
17	21	multi	30	19.2	30.7	30.7	30.7	31	60.6	31.3	77.7	31.5	276	31.5	252	29.1
18	24	primi	39	22.4	40.1	40.2	40.15	40.2	72.5	37.3	97.2	40.5	328	37.1	321	37.1
19	27	primi	34	19.6	35.1	35.1	35.1	35.1	63	32.5	87	35.5	313	35.4	277	32.1
20	29	primi	39	19.9	40.1	39.9	40	40	72.5	37.3	90.6	37.3	359	40.5	324	37.4
21	30	multi	32	24.1	33.7	33.6	33.65	34	64.8	33.4	82	33.3	295	33.5	267	31
22	26	multi	30	18.6	31.4	31.5	31.45	31.5	55.8	29.1	70.8	28.6	253	29.3	239	27.6
23	24	multi	35	23.5	36.3	36.5	36.4	36.4	64.5	33.3	82	33.3	324	36.6	289	33.5
24	34	primi	33	22	33.5	33.5	33.5	33.5	62	32.1	84.5	34.4	304	34.4	272	31.5
25	21	primi	29	19.6	30.4	30.5	30.45	30.5	58	30.2	75.8	30.5	263	30.3	235	27.2
26	28	primi	34	21.4	35.1	35	35.05	35	63	32.5	87.1	35.6	311	35.2	279	32.4
27	31	multi	37	23.5	38.6	38.8	38.7	39	68.8	35.4	93.1	38.5	339	38.3	332	38.2
28	19	primi	40	19.3	40.7	40.9	40.8	41	74.6	38.4	90.6	37.3	338	38.2	324	37.4
29	20	multi	31	21.8	32.2	32	32.1	32.1	58	30.2	72.8	29.4	283	32.2	253	29.2
30	34	multi	36	24	37.5	37.7	37.6	37.6	67.2	34.6	91.1	37.5	303	34.4	322	37.2
31	25	primi	29	24.3	30.5	30.4	30.45	30.5	56.8	29.6	77.5	31.3	235	27.5	263	30.5
32	26	multi	33	22.1	34.3	34.3	34.3	34.3	62	32	84.2	34.3	281	32	269	31.2
33	19	multi	34	19.3	35.4	35.6	35.5	35.5	68.6	35.3	79.2	32.1	313	35.4	272	31.5

34	27	primi	38	20.1	39.2	39.1	39.15	39.2	70.8	36.4	88.5	36.3	323	36.5	303	35.3
35	23	primi	30	24.4	28.5	28.5	28.5	28.5	54.6	28.6	77.5	31.3	243	28.3	247	28.6
36	32	multi	29	22.5	30.6	30.5	30.55	30.6	58.5	30.3	75.5	30.5	263	30.3	264	30.6
37	25	multi	34	24.1	35.5	35.7	35.6	35.6	63	32.5	80.5	32.6	284	32.4	272	31.5
38	29	primi	38	20.3	39.3	39.2	39.25	39.3	70.6	36.3	96.8	40.3	351	39.6	346	39.6
39	30	primi	32	23.4	33.2	33.2	33.2	33.2	64.4	33.2	82.7	33.6	274	31.3	281	32.6
40	25	multi	35	18.3	36.3	36.5	36.4	36.4	65	33.5	81.5	33.1	301	34.2	280	32.5
41	21	multi	37	19.3	38.5	38.7	38.6	38.6	74	38.1	93.1	38.5	341	38.5	304	35.4
42	22	primi	33	20.1	33.6	33.5	33.55	33.6	60.8	31.4	85	34.6	302	34.3	269	31.2
43	26	primi	39	22.1	40.3	40.4	40.35	40.4	72	37.1	90.3	37.1	329	37.2	313	36.3
44	33	multi	34	23.4	35.3	35.1	35.2	35.2	63	32.5	88.6	36.3	285	32.4	307	35.6
45	24	primi	31	22.4	31.5	31.7	31.6	31.6	62.8	32.4	81.5	33.1	287	32.6	277	32.2
46	21	primi	29	18.3	30.2	30.4	30.3	30.3	53.5	28.1	68.1	27.6	264	30.4	235	27.2
47	20	multi	30	19.5	31.6	31.6	31.6	31.6	54.6	28.5	77.7	31.5	276	31.5	270	31.3
48	33	multi	36	23.5	37.4	37.5	37.45	37.5	66.7	34.4	84	34.2	331	37.4	278	33.3
49	28	primi	32	21.6	31.4	31.4	31.4	31.4	64.5	33.3	75	30.3	273	31.2	260	30.1
50	34	primi	33	22.1	34.3	34.4	34.35	34.4	66.4	34.2	86.8	35.4	306	34.6	294	34.1
51	23	primi	41	23.2	41.6	41.5	41.55	41.6	75	38.6	92.7	38.3	338	38.2	336	38.6

52	22	primi	37	18.4	38.3	38.2	38.25	38.3	68.6	35.3	94.5	39.2	342	38.6	334	38.4
53	21	multi	34	20.3	35.5	35.7	35.6	35.6	68.4	35.2	80.5	32.6	282	32.2	269	31.2
54	34	multi	39	21.4	40.4	40.5	40.45	40.5	72.4	37.2	90.6	37.3	329	37.2	315	36.5
55	25	primi	35	19.2	36.9	36.9	36.9	37	65.3	33.6	88.6	36.2	294	33.4	285	33.1
56	32	primi	36	24.1	37.7	37.8	37.75	38	66.4	34.2	91.1	37.5	302	34.3	302	35.2
57	29	multi	29	22.4	27.9	28.1	28	28	52	27.4	75.3	30.4	265	30.5	236	27.3
58	20	primi	32	18.5	33.6	32.5	33.55	33.6	64.4	33.2	82.3	33.4	296	33.6	269	31.2
59	22	multi	40	19.3	40.3	40.3	40.3	40.3	74	38.1	93.1	38.5	331	37.4	324	37.4
60	21	primi	38	20.4	37.3	37.3	37.3	37.3	71	36.5	88.5	36.2	321	36.3	303	35.3
61	19	primi	35	21.3	37.1	37.3	37.2	37.2	65.3	33.6	82.7	33.6	292	33.2	286	33.2
62	23	multi	41	22.5	41.4	41.2	41.3	41.3	75.8	39.1	92.7	38.3	347	39.2	342	39.2
63	27	multi	30	20.2	31.2	31.2	31.2	31.2	54.2	28.4	78	31.6	274	31.3	246	28.4
64	25	primi	32	18.4	31.3	31.1	31.2	31.2	64.8	33.4	75	30.3	295	33.6	260	30.1
65	24	primi	36	23.4	34.4	34.6	34.5	34.6	67	34.5	91.5	37.6	310	35.1	315	36.5
66	30	multi	37	22.1	35.5	35.5	35.5	35.6	70.2	36.1	86.5	35.3	312	35.3	297	34.5
67	29	multi	33	20.3	34.5	34.6	34.55	34.6	61.1	31.6	77.7	31.5	281	32.1	269	31.2
68	20	primi	34	24.2	35.3	35.3	35.3	35.3	62.8	32.4	87.1	35.6	283	32.3	298	34.6
69	19	multi	35	20.3	36.6	36.8	36.75	37	65.3	33.6	81.5	33.1	272	33.1	278	32.3

70	22	primi	30	19.5	29.1	28.8	28.9	29	54.2	28.4	78	31.6	253	28.2	245	28.3
71	24	primi	29	18.4	30.3	30.2	30.25	30.3	58.5	30.4	75	30.3	265	30.5	239	27.6
/72	25	multi	38	21.2	39.6	39.5	39.55	39.6	71.1	36.6	89	36.5	321	36.3	305	35.5
73	27	primi	31	22.1	32.3	32	32.15	32.2	56.5	29.5	80.5	32.6	252	29.2	272	31.5
74	23	primi	39	24.2	40.4	40.2	40.3	40.3	72.8	37.5	99.5	41.6	328	37.1	353	40.5
75	18	multi	40	23.2	41.2	41.3	41.25	41.3	74.6	38.4	92.7	38.3	339	38.3	325	37.5
76	26	primi	35	21.4	36.3	36.4	36.35	36.4	64.5	33.3	82.7	33.6	294	33.4	286	33.1
77	28	primi	33	22.7	34.5	34.5	34.5	34.5	65	33.5	86.5	35.3	303	34.4	295	34.3
78	21	multi	36	23.9	37.3	37.3	37.3	37.3	67.2	34.6	84.5	34.4	301	34.2	289	33.6
79	20	primi	34	24.1	36.2	36	36.1	36.1	68.6	35.3	87.1	35.6	314	35.5	287	33.1
80	19	multi	30	18.5	29.1	29.3	29.2	29.2	55.8	29.1	77.7	31.5	255	28.4	245	28.3
81	25	primi	29	22.3	28.1	28.2	28.15	28.2	52	27.5	75.3	30.4	265	30.5	238	27.5
82	22	multi	33	18.5	34.4	34.6	34.5	34.5	61	31.5	87.1	35.6	273	31.1	295	34.2
83	27	primi	37	20.3	38.4	38.3	38.35	38.4	69.2	35.6	93.1	38.5	312	35.3	314	36.4
84	29	primi	39	21.5	40.2	40.2	40.2	40.2	72.8	37.5	90.6	37.3	333	37.6	321	37.1
85	30	multi	32	23.4	33.2	33.4	33.3	33.3	58.5	30.3	82.3	33.4	293	33.3	268	31.1
86	32	multi	35	24.3	36.5	36.5	36.5	36.5	64.4	33.2	81.7	33.2	295	33.5	286	33.1
87	28	primi	34	22.2	35.9	35.7	35.8	36	64.2	33.1	86.5	35.3	284	32.4	288	33.3

88	21	multi	40	19.6	40.6	40.7	40.65	41	74	38.1	90.4	37.2	331	37.4	334	38.4
89	24	primi	29	20.4	30.6	30.5	30.55	30.6	53.8	28.2	75.3	30.4	265	30.5	239	27.6
90	34	primi	41	21.2	41.8	41.6	41.7	42	76.6	39.5	92.5	38.2	346	39.1	325	37.5
91	33	primi	33	20.6	34.6	34.8	34.7	35	61	31.5	85	34.6	305	34.6	277	32.1
92	19	multi	37	18.4	38.6	38.6	38.6	38.6	68.8	35.4	94.5	39.2	340	38.4	326	37.6
93	29	multi	32	19.2	33.3	33.2	33.25	33.3	58.5	30.3	82	33.3	293	33.3	287	33.2
94	20	primi	30	21.5	31.3	31.5	31.4	31.4	54.2	28.4	69.8	28.2	275	31.4	247	28.5
95	25	primi	31	22.3	32.5	32.7	32.6	32.6	56	29.2	79.5	32.2	286	32.6	248	29.6
96	22	multi	34	24.1	35.5	35.7	35.6	35.6	63	32.5	86.5	35.3	282	32.2	286	33.1
97	23	multi	39	23.4	39.9	40.2	40.05	40.1	72.5	37.3	97.5	40.6	357	40.3	333	38.3
98	27	primi	40	21.3	41.3	41.4	41.35	41.4	74.8	38.5	92.7	38.3	339	38.3	322	37.2
99	22	multi	33	22.1	34.6	34.6	34.6	34.6	67.2	34.6	84.7	34.5	305	34.6	294	34.2
100	25	primi	35	23.5	36.7	36.6	36.65	37	65	33.5	81.5	33.1	293	33.3	287	33.2