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Role of Four-dimensional Ultrasonography in the Assessment of Amniotic Fluid Disorders of Fetal Renal Origin

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Abstract

Background: Fetal anomalies are detected in ~2 % of all fetuses and, among these, genitourinary tract abnormalities account for 30–50 % of all structural anomalies present at birth.

Aim: To assess the role of three-dimensional (3D) ultrasound in the detection of fetal causes of oligohydramnios.

Patients and methods: The study was conducted on 60 pregnant females aged between 19 and 39 years (mean \pm SD 26.6 \pm 4.9) presented with oligohydramnios at Al-Azhar University Hospital Assiut branch at Obstetric and Gynecological and Radiodiagnostic departments from December 1, 2021 to October 31, 2022.

Results: Causes of oligohydramnios: renal origin in 12 (20 %) cases, intra-uterine growth retardation (IUGR) in 18 (30 %) cases, idiopathic cause in 12 (20 %) cases, less than average amount of amniotic fluid in 12 (20 %) cases, and other causes in six (10 %) cases. There were renal abnormalities in 12 (20 %) cases. Amniotic fluid examination in studied cases were less than average in 12 (20 %) cases, oligohydramnios in 45 (75 %) cases, and anhydramnios in three (5 %) cases. Antepartum death occurred in two (4 %) cases, fetuses were born alive in 10 (100 %) cases, postnatal ultrasound examination showed renal anomalies in 10 (100 %) cases, with no cases showing normal findings.

Conclusion: Ultrasound examination is important for the detection of renal and extrarenal causes of oligohydramnios. Prenatal diagnosis of associated congenital anomalies has great importance in the care of handicapped newborns. 3D and 4D ultrasound continue to evolve as this technology becomes increasingly available in clinical practice for accurate and early detection of fetal anomalies.

Keywords: Amniotic fluid, Fetal anomalies, Oligohydramnios, Renal, Ultrasound

1. Introduction

Amniotic liquid encompasses the embryo after the initial not many long stretches of development. It has a defensive capability to protect the fetus and the umbilical line from injury and pressure.¹

The condition known as oligohydramnios is characterized by a decrease in the amniotic fluid with four quadrants of less than 5 cm or one pocket of less than 2 cm.²

Fetal causes of oligohydramnios include renal agenesis, autosomal-dominant polycystic kidney,

autosomal-recessive polycystic kidney, bilateral multicystic kidneys, and hydronephrotic changes of fetal kidneys.³

This innovation permits inspectors to move from two-layered (2D) pictures to genuine 3D and 4D representation of anatomic designs.⁴ Subsequently, sonologists are not generally obliged by impediments of static 2D pictures to lay out a determination,⁵ connect with volumetric and delivering informational indexes to look at anatomic designs of interest.⁶

This study aimed to evaluate the job of 3D ultrasound in locating fetal reasons for oligohydramnios.

2. Patients and methods

The study was carried out at Al-Azhar Assiut University Hospital, and the cases were gathered between December 1, 2021, and October 31, 2022. It was conducted on 60 pregnant women. The gestational age of the mother ranged from 19 to 39 years, spanning the second and third trimesters. The amniotic layer product was unblemished and ultrasound discoveries reminiscent of oligohydramnios at fetal onset were incorporated. Numerous pregnancies and maternal beginning of oligohydramnios disease were barred.

The research was approved by the Ethics Committee of the Al-Azhar University (Assiut), Faculty of Medicine. An educated oral and composed assent was taken from all pregnant women.

All patients underwent the following: full history taking, gestational age was determined with exceptional accentuation on family ancestry and previous history, general, neighborhood, actual assessment, and estimations that included weight, breath rate and pulse, routine obstetric assessment, oddity output, and appraisal of amniotic liquid. All pregnant women underwent routine 2D ultrasonography using a high-resolution ultrasonography machine (Rationale S8) arched 2D test and 1–6 MHz followed by a 4D test ultrasonography (Rationale S8) and voluson GE (2–4 MHz) at Al-Azhar college emergency clinic, Assiut branch.

Assessing fetal weight is a simple and straightforward method for checking fetal development and for screening intra-uterine growth retardation (IUGR). Undergoing scheduled second-trimester or third-trimester ultrasound assessment at 20–36 weeks' incubation is a component of routine antenatal consideration.

Calculation of the amount of amniotic fluid present: most extreme vertical pocket or the most profound pocket of amniotic liquid that does exclude fetal umbilical string or body parts.

Evaluation of the urinary system of the fetus includes assessing the kidneys for site, number, size, position, shape, presence or absence of cysts or masses, and the presence or nonattendance of dilatation of the pelvicalyceal framework and urinary bladder, presence or nonappearance and vacant or full.

Three scanning planes are available for kidney system anatomical analysis: axial, sagittal, and coronal views.

Two-layered ultrasound renal assessment: fetal kidneys were not difficult to distinguish due to their moderately hyperechogenic appearance in the main trimester. The sonographic cortico-medullary

separation begins at multi week. At the 20th week of pregnancy, it was easy to tell the outer, more hyperechogenic renal cortex from the inner, more hypoechogenic medulla.

3D and four-layered ultrasound renal assessment: fetal kidneys and bladder were examined in each of the three planes (X, Y, and Z) in a 3D multiplanar mode to affirm urinary lot irregularity and get volumetric information. Reversal method of the three-layered and four-layered ultrasound assessment was used to identify hydronephrotic changes. A relatively new method for displaying fluid-filled structures using the 3D and 4D ultrasound is called the inversion mode.

Appraisal of the urinary bladder: the fetal bladder was pictured from 13 weeks on. It appeared as an anechoic cystic structure in the pelvic area, surrounded by both umbilical arteries. The average diameter of the urinary bladder based on the used A-P diameter was more than 7 mm in the first trimester, more than 30 mm in the second, and more than 60 mm in the third.

In other images, a variety of Doppler ultrasound was performed to look for renal corridors in those renal agenesis was suspected. Echogenicity of the lungs to analyze pneumonic hypoplasia was determined by lung volume. Abnormality check was done for different frameworks. Postnatal ultrasound confirmed the diagnosis. The same machine was used for the postnatal ultrasound.

Information were investigated involving Factual Program for Sociology (SPSS, Chicago, USA), version 24. Quantitative information were communicated as mean \pm SD. Frequency and percentage were used to describe qualitative data.

3. Results

The review was conducted on 60 pregnant women aged between 19 and 39 years (mean \pm SD 26.6 ± 4.9) presented with oligohydramnios, during their routine antenatal care at Al-Azhar College Medical clinic Assiut branch at the Obstetric and Gynecological and Radiodiagnostic departments from December 1, 2021 to October 31, 2022.

Reasons for oligohydramnios in the study participants were investigated. It was of renal beginning in 12 (20 %) cases, IUGR in 18 (30 %) cases, idiopathic reason in 12 (20 %) cases, not exactly normal measure of amniotic liquid in 12 (20 %) cases, and different causes in six (10 %) cases. There were renal irregularities in 12 (20 %) cases. The most predominant oddity finding in 4D ultrasound assessment was posterior urethral valve presenting with hydronephrosis in three (25 %) cases, followed by

two-sided renal agenesis in three (25 %) cases. Then, at that point, polycystic kidney (Potter I) was observed in two (16.7 %) cases, multicystic dysplastic kidney (Potter II) in two (16.7 %) cases. The most uncommon abnormality finding in assessment was Mackle related anomalies as opposed to renal oddities observed in three (5 %) cases, then again 57 (95 %) cases had no other related anomalies. Amniotic liquid assessment in the study cases were not exactly normal in 12 (20 %) cases, oligohydramnios in 45 (75 %) cases, and anhydramnios in three (5 %) cases. Antepartum demise occurred in two (4 %) cases, babies were born alive in 10 (10 %) cases; postnatal ultrasound assessment showed that 10 (100 %) cases had renal irregularities, and none of the cases were typical (Tables 1–7, Fig. 1).

3.1. Case 1

History: a 32-year-old woman, G1 Para 0 + 0, ± 24 weeks of gestation not having any complaints; the fetal anomaly scan is the only concern.

Ultrasonography findings: both kidneys were nonvisualized and color Doppler revealed the absence of both renal vessels. UB: nonvisualized. Oligohydramnios was observed. Postnatal diagnosis: bilateral renal agenesis (Fig. 2).

3.2. Case 2

History: a 37-year-old woman G5P4+0, at 15 weeks and has come for antenatal care.

At 15 weeks, ultrasonography findings revealed the normal appearance of both fetal kidneys. UB: was overdistended with a caudal keyhole sign. Normal amniotic fluid. At 25 weeks,

Table 1. Description of demographic data in all studied patients.

	Studied patients (N = 60) [n (%)]
Age (years)	
Mean \pm SD	26.6 \pm 4.9
Minimum–maximum	19–39
Age categories	
≥ 30 years	20 (33.3)
<30 years	40 (66.7)
Gravidity	
PG	15 (25)
MG	45 (75)
BMI	
<30 (nonobese)	46 (76.7)
≥ 30 (obese)	14 (23.3)
Consanguinity	
Positive	25 (41.7)
Negative	35 (58.3)

Table 2. Distribution of studied participants according to fetal weight (N = 60).

Estimated fetal weight	n (%)
Normal	39 (65)
Low	21 (35)

Table 3. Causes of oligohydramnios in studied participants (N = 60).

Causes	n (%)
Renal origin	12 cases (20)
IUGR	18 cases (30)
Idiopathic cause	12 cases (20)
Less than the average amount of amniotic fluid	12 cases (20)
Other causes intra-uterine growth retardation	6 cases (10)

Table 4. Finding of two-dimensional and four-dimensional ultrasonographic renal anomalies.

Renal abnormalities types	Studied patients (N = 12)
Bilateral renal agenesis	3 25 %
Autosomal-recessive polycystic kidney (Potter I)	2 16.7 %
Posterior urethral valve with hydronephrosis	3 25 %
Multicystic dysplastic kidney disease (Potter II)	2 16.7 %
Mackle-Gruber syndrome	1 8.3 %
Unilateral renal agenesis	1 8.3 %

Table 5. Other ultrasonographic findings in studied participants (N = 60).

	n (%)
Associated anomalies	
No	57 (95)
Yes	3 (5)
Associated anomaly types	
Anencephaly	1 (33.3)
Cardiac anomalies	1 (33.3)
Encephalocele, polydactyl	1 (33.3)

Table 6. Amniotic fluid examination in studied cases (N = 60).

Amniotic fluid examination	n (%)
Less than average	12 (20)
Oligohydramnios	45 (75)
Anhydramnios	3 (5)

Table 7. Fate of the fetuses of the studied pregnant women and findings of postnatal ultrasonography (N = 12).

	n (%)
Fate of the fetus N=(12)	
The fetus alive	10 (96)
Antepartum death	2 (4)
Fetal renal anomalies	10 (100)

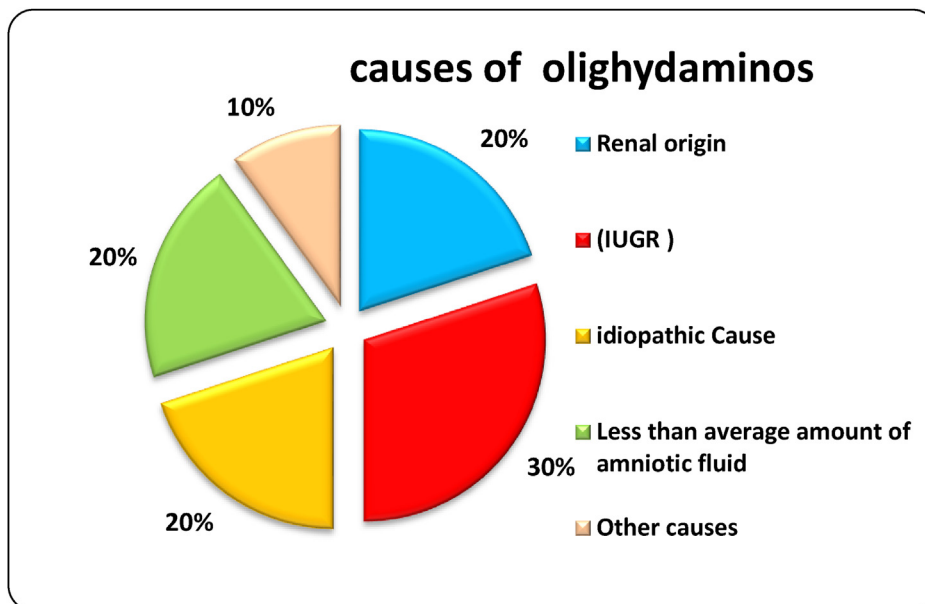


Fig. 1. Causes of oligohydramnios in studied participants.

ultrasonography findings revealed bilateral enlarged both kidneys with a dilated pelvicalyceal system and a hydroureter. UB was overdistended with mural trabeculation and a thickened wall associated with a caudal keyhole sign. 4D ultrasound revealed distended bladder and dilated both ureteric orifices with a caudal keyhole sign and oligohydramnios. Postnatal ultrasound diagnosis: bilateral hydronephrosis secondary to outlet obstruction by posterior urethral valve (Figs. 3-8).

4. Discussion

Oligohydramnios is defined as a decrease in the amniotic fluid that surrounds the fetus with an AFI of 5 cm in four quadrants or amniotic fluid measuring 2 cm in one quadrant.⁶

We conducted our study on 60 pregnant women between the ages of 19 and 39 years. Adel et al.⁷

conducted their study on 250 pregnant females aged between 19 and 45 years and their mean age was 33, and in the study by Sholkamy et al.,⁸ their ranged of age was 20–35 years and the mean age of the included cases was 26.3 ± 5.2 years. Similar to Hussein et al.⁹ our study found that 35 (58.3 %) cases had negative consanguinity, while 25 (41.7 %) cases had positive consanguinity. A positive relationship was observed in 20 (66 %) cases and a negative association was observed in 10 cases. In addition, a positive relationship was seen in 106 cases and a negative connection was observed in 144 cases.



Fig. 2. Two-dimensional ultrasound axial view image showing absence of renal tissue with anhydramnios indicating bilateral renal agenesis.



Fig. 3. Two-dimensional ultrasound axial view showing dilated urinary bladder with a keyhole sign at 15 weeks.



Fig. 4. Two-dimensional ultrasound axial view showing dilated urinary bladder with a keyhole sign at 25 weeks.

Oligohydramnios has fetal or maternal causes. In our study, we only talked about the causes in the fetus. In 12 (20 %) cases, oligohydramnios was caused by anomalies in fetal scans, and the estimated fetal weight was average. Sholkamy et al.⁸ recorded 37 (37.0 %) cases from 100 cases in the study. In Adel et al.,⁷ out of the 250 cases in the study, 150 cases were reported, accounting for 60 %.

The primary cause of super fetal conditions in our review was IUGR (low fetal weight) was attributed to feto-placental deficiency. We estimated the fetal weight using the Hadlock formula and performed fetal Doppler during the second or third trimester ultrasound examination at 20–36 weeks of gestation. In our study, 18 cases were reported in 18 (30 %) cases, accounting for 11 (11 %) cases. We recorded

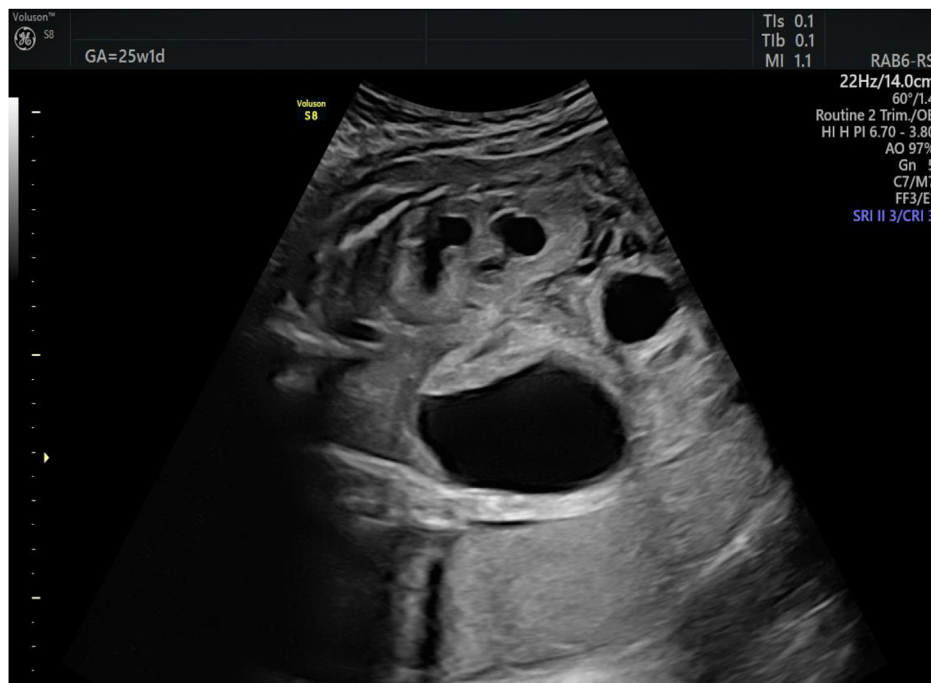


Fig. 5. Two-dimensional ultrasound coronal view showing bilateral hydronephrosis at 25 weeks.



Fig. 6. Tomographic ultrasound imaging (TUI) showing dilated PCS of the right kidney.

12 (20 %) cases as renal anomalies. In Adel et al.,⁷ 89 (35.6 %) cases were accounted for, and Sholkamy et al.⁸ reported 37 cases, representing 37 %.

Back urethral valve was kept in three (25 %) cases. However, Adel et al.⁷ reported 13 (13 %) cases, and Hussein et al.⁹ reported that out of 54 cases, 42 (or

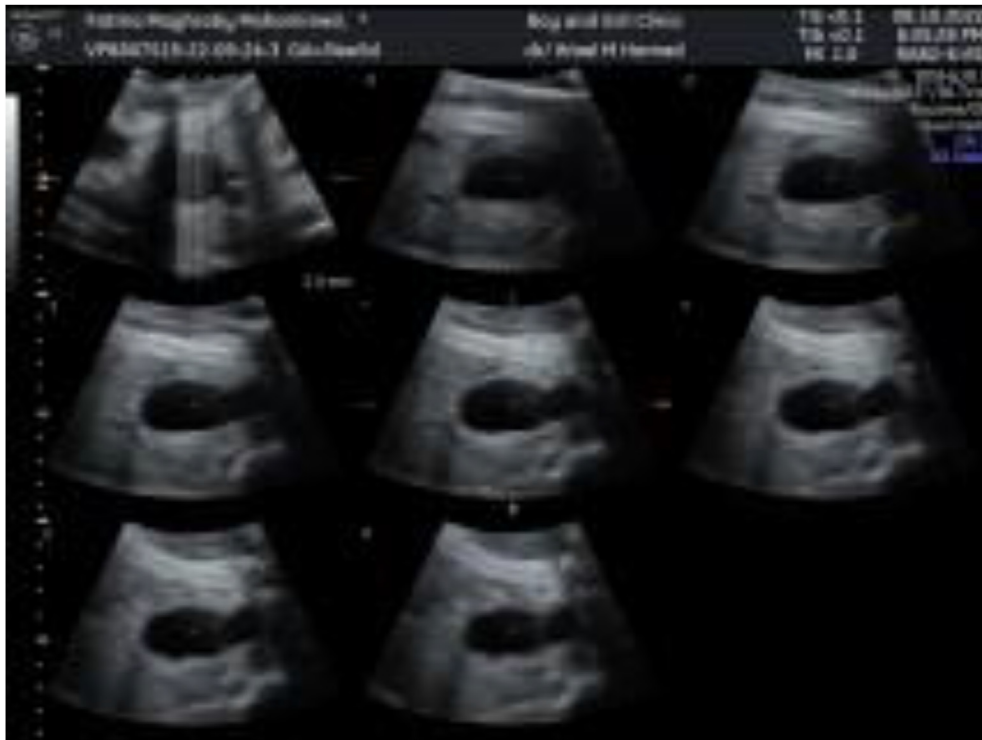


Fig. 7. Tomographic ultrasound imaging (TUI) megacystis and a keyhole sign.

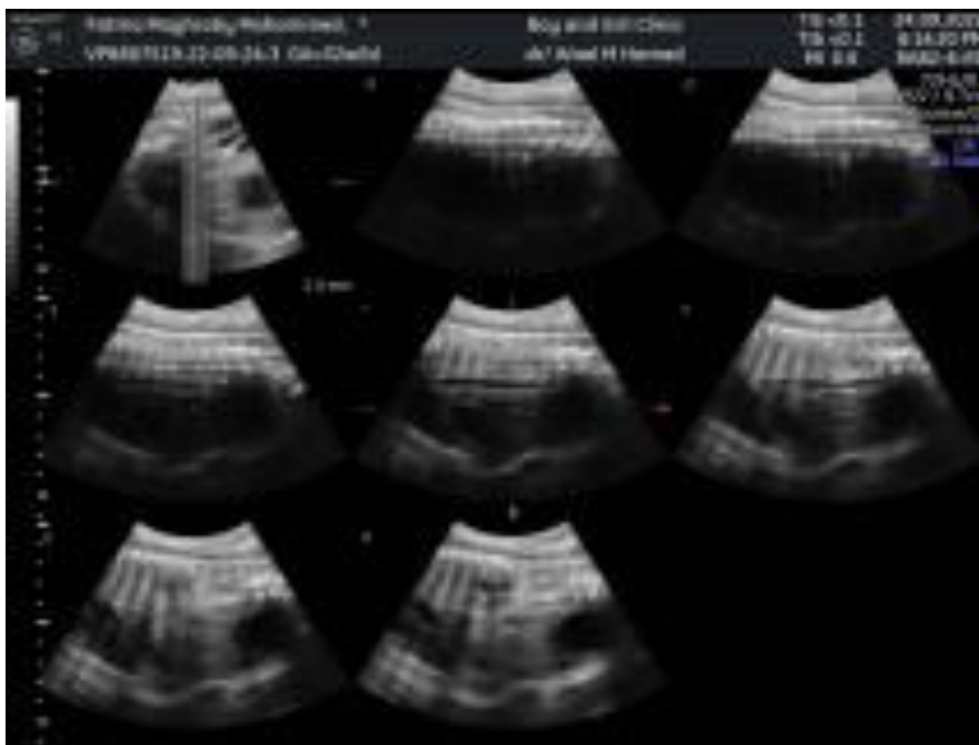


Fig. 8. Tomographic ultrasound imaging (TUI) showing dilated PCS of the left kidney.

77 %) were determined to be posterior urethral valve, and Sholkamy et al.⁸ recorded six (16.2 %) cases.

In both our study and Adel et al.,⁷ bilateral renal agenesis was observed in three (25 %) cases, 10 (4 %) cases was recorded. In addition, Sholkamy et al.⁸ only reported one (1 %) case of autosomal-recessive polycystic kidney disease. Adel et al.⁷ announced 24 (9.6 %) cases, and Hussein et al.⁹ reported 31 (33 %) cases from 93 studied cases. Furthermore, in Sholkamy et al.⁸ was accounted for 13 (35.2 %) cases.

The majority of cases have a positive history of a previous baby with similar abnormalities, with a 25 % chance of recurrence, and an association with one or more innate anomalies such as the Mackle-Gruber syndrome. In our review, one case had associated congenital peculiarities including polydactyly and encephalocele and was diagnosed as Mackle-Gruber condition. The use of 3D and 4D ultrasound helped evaluate the mind deformity promotion and its association. In Adel et al.,⁷ another congenital anomaly, Mackle-Gruber syndrome was associated with five cases of ARKD.

Meckel-Gruber disorder is an autosomal latent problem described by something like two of the three exemplary appearances: renal cystic dysplasia, occipital encephalocele or some other focal sensory system oddity and postaxial polydactyly. The illness is often fatal in the perinatal or in early stages.

Multicystic dysplastic kidney (MCKD) (Potter II) was tracked down in two (16.7 %) cases, revealed by ultrasound as various, nonimpacting sores of variable sizes, seen disposed of in all renal parenchyma, and utilizing 3D-layered ultrasound, which has shown exact images with details. Potter II cases have a normal pelvis and appear as multiple noncommunicating cysts. Potter II might be one-sided or reciprocal infection. Adel et al.⁷ recorded 19 (19 %) cases with reciprocal multicystic kidney illnesses, which had poor prognosis and 17 cases resulted in intrauterine death and two cases died soon after birth. In addition, 21.6 % of the cases identified by Sholkamy et al.⁸ were MCKD. Also, Hawkins et al.¹⁰ reported 10 cases of MCKD.

One case was reported as one-sided renal agenesis. The primary cause of oligohydramnios was fetoplacental insufficiency (IUGR) not one-sided renal agenesis. We reported oligohydramnios in 45 (75 %) cases and anhydramnios in three (5 %) cases. Conversely, Hussein et al.⁹ and Hawkins et al.¹⁰ reported 19 (63 %) cases of oligohydramnios or anhydramnios, which are frequently associated with congenital renal anomalies.

In our review, when the fetus had inherent renal illness, intra-uterine death happened in two (16 %) cases, exceptionally in cases that had related intrinsic irregularities, embryos were born alive in 10 (83 %) cases and some of them died soon after

birth team due to renal failure or cut off aspiratory hypoplasia. In Adel and colleagues 31 of the cases had IUFD.

In our review, postnatal ultrasound assessment showed renal irregularities in 10 cases. One of them exhibited respective multicystic kidney with one-sided PUJ hindrance. In another case, one-sided renal agenesis was diagnosed, and postnatal ultrasound showed the ectopic kidney located in the right iliac fossa. In Hussein et al.⁹ and Hawkins et al.¹⁰ 66.7 % experienced fetal renal inconsistency and the rest four (33.3) living babies were typical when analyzed by postnatal fetal ultrasound.

4.1. Conclusion

Ultrasound assessment is significant for the recognition of renal and extrarenal reasons causes of oligohydramnios. Prenatal analysis of related innate abnormalities holds great significance in the care of impaired infants. 3D and 4D ultrasound technology continues to advance as this innovation opens up in clinical practice for precise and early recognition of fetal abnormalities.

Conflicts of interest

None declared.

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