Radiologic Diagnosis of Fetal Hydronephrosis:
Associated Abnormalities and Fetal Outcome

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Fetal Imaging Modalities

- **Ultrasound:**
  - Fast and safe (no ionizing radiation)
  - Allows for good visualization of fetal anatomy and live, real-time imaging
  - Efficient method to survey for fetal anomalies

- **MRI:**
  - Better soft tissue contrast for characterization of anomalies
  - Better than US in patients with oligohydramnios
  - Currently no known adverse effects

Diagnosis of Fetal Hydronephrosis on Ultrasound

- Index patient:
  - Mrs. S. is a 34 y.o. G2P1 who presented to BIDMC at 29+6 weeks GA for a follow-up fetal ultrasound after a routine fetal survey at an outside hospital documented unilateral fetal hydronephrosis.
**Mrs. S.’s Ultrasound**

**US findings:** mild hydronephrosis on the right with central dilatation of 8-9 mm and severe hydronephrosis on the left with a large extrarenal pelvis measuring 2.8 cm.
Normal Fetal Kidneys

- Fetal kidneys are ovoid bilateral paraspinous structures:
  - Renal pelvis – “slit-like” lucency within central portion of kidney.
  - Medulla – hypoechoic regions surrounding renal sinuses.
  - Cortex – thin and difficult to visualize on US.
  - Retroperitoneal fat – echogenic density surrounding kidneys.

S = spine
Kidneys outlined by arrowheads

Renal Development
Timeline and Important Structures

- **Ureteral bud** (week 4) → mesoderm, arises from oupouching of mesonephric/Wolffian ducts, opens into urogenital sinus. Gives rise to *ureter, renal pelvis, calyces and collecting system*

- **Metanephric cap** (week 5-6) → mesoderm, interacts with structures of ureteral bud to form *functional renal parenchyma*

- **Cloaca** (week 4) → endoderm, divides into urogenital sinus (cranial) and anorectal canal (caudal). Urogenital sinus gives rise to *bladder and urethra*

- Fetal kidneys begin to function at the start of the 2nd trimester. By week 16-18 they become the major source of amniotic fluid for the fetus
Renal Development

Embryo 5-6 weeks

- Mesonephric Duct
- Urogenital Sinus
- Ureteric bud
- Metanephric cap

Migration of the fetal kidneys

- Week 6
- Week 8
- Week 10

Fetal Anatomy

Bladder  Kidney  Spleen

Iliac Wing

Liver

Lungs

Amniotic fluid

Hydronephrosis

- **Hydronephrosis (HN)** → dilatation of the pelvis and/or calyces of the kidney
- Diagnosis of fetal HN is increasing with increased use of ultrasound in pregnant women
- 1-2% of pregnancies may show evidence of HN, and it accounts for 50-75% of prenatally diagnosed renal abnormalities.
- Degree of dilatation required for diagnosis of HN varies with gestational age, and is determined using the *anteroposterior diameter* of the renal pelvis.
Measuring Renal Dilatation

Anteroposterior diameter (APD): Size of the renal pelvis measured in the anterior → posterior direction on a transverse view through the abdomen.

For a diagnosis of hydronephrosis, APD must be greater than:
- 6mm at < 20 weeks GA
- 8 mm at 20-30 weeks GA
- 10mm at > 30 weeks GA

Close-up of a mildly dilated right fetal kidney on ultrasound

(Short arrows outlining kidney)
S = Spine

Image from BIDMC PACS
# Grades of Fetal Hydronephrosis

<table>
<thead>
<tr>
<th>Grade</th>
<th>Calyceal dilatation</th>
<th>Size of pelvis (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Physiological</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>Normal calyces</td>
<td>1-1.5</td>
</tr>
<tr>
<td>III</td>
<td>Slight dilatation</td>
<td>&gt; 1.5</td>
</tr>
<tr>
<td>IV</td>
<td>Moderate dilatation</td>
<td>&gt; 1.5</td>
</tr>
<tr>
<td>V</td>
<td>Severe dilatation + atrophic cortex</td>
<td>&gt; 1.5</td>
</tr>
</tbody>
</table>

*Gloor, J.M. Mayo Clinic Proceedings. 70: 145-152, 1995*
Natural History of Fetal Hydronephrosis

• Most cases of prenatally diagnosed HN (~90%) will resolve spontaneously before birth or after delivery.

• Of those cases that do not resolve on their own, the majority are amenable to surgical or medical correction after delivery.

• Surgery is best performed within the first year of life to minimize irreversible damage.
Causes of Fetal Hydronephrosis

- **Physiologic:**
  - Urine production 4-6x greater before delivery
  - Increased compliance of fetal ureter
  - Partial/transient obstructions associated with development

- **Pathologic:**
  - Almost always due to obstruction, which can occur anywhere in the urinary tract
  - Degree of dilatation depends on the severity and location of obstruction
  - Severe or longstanding obstruction of the urinary tract can lead to permanent renal damage and to systemic problems for the fetus
  - Non-obstructive causes of HN include vesicoureteric reflux (VUR), prune belly syndrome and renal cysts.
Radiologic Findings

• Can be unilateral or bilateral
• Severity of dilatation depends on the level of obstruction. Common locations include:
  – *Ureteropelvic junction* → most common location of obstruction
  – *Vesicoureteral junction* → with or without reflux
  – *Vesicouretheral junction* → often due to posterior urethral valves

• Renal parenchymal changes
• Amount of amniotic fluid:
  – With severe obstruction and renal atrophy, the fetus can’t produce or excrete amniotic fluid, leading to *oligohydramnios*
  – Oligohydramnios is a poor prognostic sign for the fetus → risk of *pulmonary hypoplasia* - lack of amniotic fluid causes compression of fetal lungs which prevents lung development.
Radiologic Findings – US
Dilatation of Renal Pelvis and Calyces

- **Patient A:** Follow-up US for known HN, 27 weeks GA
  - **US Report:** “Worsening bilateral central renal collecting system dilatation, left greater than right, which is out of proportion to caliectasis and suggests **UPJ obstruction**”.

- **Patient B:** Routine fetal survey, 22 weeks GA
  - **US Report:** “Mild bilateral hydronephrosis. Follow-up is recommended in six weeks and post partum.”

* = dilated renal pelvis

All images from BIDMC PACS
Radiologic Findings – US
Dilatation of Renal Pelvis and Ureters

• Patient C: US with biophysical profile for post-dates at 40 weeks GA
  – US report: “Bilateral hydroureteronephrosis. Follow up study of the kidneys is recommended after the baby is born”.

• Patient D: Routine fetal survey, 28 weeks GA
  – US Report: “Central renal dilatation of 11 mm on the left and 8 mm on the right, out of proportion to caliceal dilatation along with intermittent visualization of the ureters, which appear mildly dilated. Findings are suggestive of vesicoureteral reflux”.

* = dilated renal pelvis

All images from BIDMC PACS
Radiologic Findings - MRI

T2W MRI scan at 32 weeks GA showing moderate fetal HN

Sagittal MRI showing severe HN in a 33 week old fetus with obstruction due to posterior urethral valves. US study limited by severe oligohydramnios.


Amount of Amniotic Fluid

Normal amniotic fluid

Severe oligohydramnios

Normal fetus

Fetus with renal agenesis

All images from BIDMC PACS
Why is prenatal diagnosis important?

• With severe obstruction and oligohydramnios:
  – Fetus at risk of renal dysplasia and pulmonary hypoplasia which is often fatal
  – Prenatal intervention can be lifesaving:
    i. Percutaneous fetal shunt catheters – a route for amniotic fluid to leave the urinary tract and return to the amniotic cavity
    ii. Surgical exteriorization of fetal urinary tract

• Knowledge of moderate→severe cases of HN antenatally allows for appropriate follow-up and prompt correction after birth
Management of Hydronephrosis
In the Fetus and Neonate

Management of Hydronephrosis in the Neonate

- Prophylactic antibiotics to prevent UTI and pyelonephritis associated with reflux
- Follow-up ultrasound, at least 72 hours after birth
- Other imaging studies include voiding cystourethrogram (VCUG) or DMSA scan
- Prompt surgical correction of obstruction if necessary, to prevent irreversible renal parenchymal damage
Radiologic Work-up of Hydronephrosis in the Neonate

**Ultrasound**

- **Right kidney**
- **Left kidney**

- **US**: Bilateral dilatation of the renal collecting system
- **VCUG**: Significant reflux bilaterally
- **DMSA scan**: Decreased uptake bilaterally, L>R

**Voiding cystourethrogram**

**DMSA scan**

*All images from ACR Pediatric Learning File, 1998.*
References

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