Antenatal Diagnosis and Congenital Uropathies
Dr Lesley Rees
Gt Ormond St Hospital, London, UK
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Points to Discuss

• The importance and implications of antenatal US scanning for renal tract anomalies
• The common findings postnatally and their management

Antenatal diagnosis of renal anomalies
Antenatal US scans

- UK: routine at 12-14 and 20 weeks gestation
- Findings:
  - Renal tract dilatation:
    - pelvis and/or calyces (hydronephrosis)
    - and/or ureter (hydroureteronephrosis)
  - Abnormal bladder:
    - Diverticulae
    - thick walled and/or poor emptying
    - a dilated posterior urethra
  - Absent, large or small kidneys, MCDK
  - Ectopic, horseshoe and duplex kidneys
  - Echogenic or cystic kidneys
- Overall incidence of 1 in 200

Why is antenatal diagnosis of renal abnormalities important?

Abnormalities may:
- Be associated with abnormal renal development or function
- Predispose to postnatal infection
- Cause urinary obstruction which requires surgical treatment
- Rarely be associated with aneuploidy or syndromes

Advantages and disadvantages of antenatal US scanning

- Early treatment of urinary tract anomalies provides an opportunity to minimise or prevent progressive renal damage

  But

- Dilatation does not necessarily mean obstruction
- Detects minor abnormalities that do not require intervention and may lead to:
  - over investigation
  - unnecessary treatment
  - unwarranted parental anxiety

Overall incidence of 1 in 200
Types of renal antenatal diagnoses and their frequency

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>Transient hydronephrosis (normal postnatal scan)</td>
<td>50%</td>
</tr>
<tr>
<td>Hydronephrosis with no evidence of obstruction; or extrarenal pelvis</td>
<td>15%</td>
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<tr>
<td>PUJ obstruction</td>
<td>11%</td>
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<tr>
<td>Vesico-ureteric reflux (VUR)</td>
<td>9%</td>
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<tr>
<td>Megaureter</td>
<td>4%</td>
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<tr>
<td>Renal dysplasia</td>
<td>3%</td>
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<tr>
<td>Multicystic Dysplastic Kidney (MCDK)</td>
<td>2%</td>
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<tr>
<td>Duplex kidney</td>
<td>2%</td>
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<tr>
<td>PUVs</td>
<td>1%</td>
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<tr>
<td>Others</td>
<td>5%</td>
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Antenatal US assessment

- Liquor volume
- Renal length: ↑ by 1mm/week of gestation
- Renal pelvic dilatation: maximum antero-posterior pelvic diameter in the transverse plane (not including the calyces)
  - the transverse pelvic diameter (TPD)
- Calyceal and/or ureteric dilatation
- Assessment of the bladder
- It is possible to mistake the adrenal gland for the kidney in cases where the latter is absent

Indications for antenatal referral to a fetal therapy unit

- Oligohydramnios
- Abnormal bladder:
  - thick wall, diverticulae, poor emptying
- Abnormal renal parenchyma:
  - echogenic, large or small kidneys, cystic change
- Bilateral renal tract dilatation
  - TPD is >15mm
- Solitary kidney if the TPD is >15mm
- Other major anomalies
Antenatal referral unit

Multidisciplinary approach
• Obstetrician
• Fetal Medicine specialist
• Paediatric nephrologist
• Paediatric urologist
• Geneticist

Reasons for Prenatal Interventions for Lower Urinary Tract Obstruction

• Lung development:
  – Early delivery
• Bilateral hydronephrosis, a dilated bladder, and oligohydramnios
  – Vesicoamniotic shunt
• One of the main goals of intervention is to achieve normal amniotic fluid levels to promote lung development

If considering antenatal intervention:

• Search for other fetal abnormalities:
  – Karyotype
• Evidence that the kidneys are not already severely abnormal:
  – Renal parenchyma
  – Favourable urinary indices by vesicocentesis:
    • sodium <100 mmol/L
    • chloride <90 mmol/L
    • calcium <8 mg/dL
    • osmolality <200 mmol/L
    • β-2 microglobulin <6mg/L
Antenatal intervention: risks to the fetus

- Premature delivery or fetal death
- Chorioamnionitis
- Spontaneous rupture of membranes
- Intestinal herniation
- Amniotic fluid leak

PLUTO

- Percutaneous shunting for Lower Urinary Tract Obstruction randomized controlled trial
- Does prenatal vesicoamniotic shunting improve perinatal mortality and renal function?

Outcome of patients for whom TOP was recommended

- TOP was proposed for
  - bilateral renal abnormalities with oligohydramnios
  - bilateral renal abnormalities with severe parenchymal abnormalities
- 10 patients TOP was refused by the parents
  - 5 died in the first month
  - 5 had a normal serum creatinine at median age 29 months
- Oligohydramnios did not differ

These result demonstrate the difficulty in evaluating renal outcome

Ulinski, Ped Nephrol 2012
Predictors of respiratory outcome in infants with oligohydramnios

- 23 infants who required ventilation for lower urinary tract obstruction:
- Best predictors of survival were:
  - Timing of first development of oligohydramnios
  - Respiratory state on day 1 (inspired O2 and mean airway pressure)

Mehler, NDT 2011

Postnatal management of antenatally diagnosed renal anomalies

Potters syndrome

- Pulmonary hypoplasia
- Postural defects
  - Dislocation of the hips
  - Talipes
- Characteristic facial appearance
  - Low-set malrotated ears
  - Facial and nasal flattening
  - Underdeveloped chin with a receding jaw
Who needs antibiotic prophylaxis from birth?

- Broader view:
  - Those where postnatal investigation is indicated

- Some would be more selective as follows:
  - All infants who will need a MCUG
  - Hydronephrosis with dilated calyces
  - Renal pelvic diameter >20mm

After birth, who needs urgent investigations?

US with a MCUG within 3 days of birth if the largest TPD was >10mm and:

- Bilateral hydro(uretero)nephrosis
- Distended or thick walled bladder
- Hydronephrosis in a solitary kidney

US should include:

- Renal
  - Lengths and centiles
  - Echogenicity and cortico-medullary differentiation
- Measurement of the maximum TPD (not including the calyces)
- Measurement of ureteric dilatation
- Assessment of the calyces
- Appearance of the bladder
  - measurement of wall thickness
  - presence of diverticulae and ureterocoeles
  - post micturition residue if lucky
  - views of the posterior urethra in boys
- Spinal views if a neuropathic bladder is suspected
Posterior urethral valves

- Malformation of the posterior urethra
- Back-pressure of urine may result
  - Hydronephrosis
  - VUR
  - Calyceal rupture (the weakest point) causing a urinoma
  - Renal dysplasia
- Bladder wall hypertrophy
  - Thickened and trabeculated
  - Diverticulae
  - Secondary VUJ obstruction

Baby boy

- Antenatal diagnosis of one bright kidney and one hydronephrotic kidney with oligohydramnios and thick walled bladder at 22 weeks gestation in a male infant
- Spontaneous onset of labour at 33 weeks gestation, BWt 2.34 kg
- Pneumothorax on day 1, ventilated for 8 days
- Creatinine rose to 200+ mmol/l by day 15; polyuric
- MCUG showed a posterior urethral valve, which was ablated urethrally
- His renal function progressively declined so that he needed a renal transplant at the age of 16 years
Presentation of PUVs

- Antenatal US in 50%
  - but may be missed if no 3rd trimester scan
- UTI
  - Tubular damage dominates:
    - Hyponatraemia and hyperkalaemia
    - AKI
- Later childhood
  - Poor urinary stream
  - Straining to pass urine
  - Palpable bladder
  - Enuresis
  - CKD
Diagnosis and treatment of PUV

• SFG feeding tube to relieve obstruction
• Micturating Cystourethrogram (MCUG)
• Cystoscopy and ablation of PUVs
  – spontaneous filling and emptying of the bladder during infancy is crucial to its normal development

Pelvi-ureteric junction (PUJ) anomalies

• Commonest abnormality of the upper urinary tract
• Incidence ≈ 1:1000
• US: Renal pelvic dilatation with no dilatation of the ureter
• Not all renal pelvic dilatation means significant outflow obstruction
  – i.e. the pelvis may be dilated but non obstructed
  – If the calyces are not dilated obstruction is unlikely
• May be intermittent, depending on the rate of urine flow

Antenatal renal pelvic dilatation
What measurements are significant?

• AP diameters of 5-15mm have been proposed as the cut-off point above which postnatal investigation should be performed
• Lower cut off points will:
  – increase postnatal investigations (higher false positive rate) and enhance parental anxiety
  – Increase the number of abnormalities detected which are unlikely to be of clinical significance
**Key issue for PUJ anomalies**

To distinguish cases which may lead to progressive deterioration in renal function from cases of non-obstructive hydronephrosis which are very likely to undergo spontaneous resolution.

**MAG3 scan (dynamic renography)**

- Produces information on:
  - Differential renal function
    - Good function: >40%
    - Moderate: 20-40%
    - Poor: <20%
  - The clearance of the isotope: drainage
  - The anatomy of the collecting system. This will allow distinction between:
    - PUJ obstruction (no isotope seen in ureters)
    - VUJ obstruction (isotope in ureters)
In the presence of obstruction, isotope accumulates within the kidney and the drainage curve continues to rise even after change of posture or diuretic to encourage drainage.

Mag 3 - the drainage curve

- Overdiagnoses obstruction because it is dependent on:
  - Renal function
  - Hydration and urine flow rate
  - Bladder fullness
  - Posture and pooling in a dilated system

Long-term outcome of pelvic dilatation

- All kidneys deteriorating in function had a TPD > 20mm
- Increased dilatation may precede deterioration in function
- 60% risk of deterioration in function if the TPD is > 30mm
  - Pyeloplasty in the first 6 months of life is recommended
- Renal pelvic measurements 20-30 mm with good function
  - 25% remain stable
  - Some may improve by the age of 3 to 4 years
- The more severe the calyceal dilatation the greater the risk of deterioration

Dhillon, 2002
Who needs surgery?

Most would operate only if
- UTIs
- The renal pelvic transverse diameter is >30mm
- Increasing dilatation of the kidney on US
- The differential function of the affected kidney falls to <40%
- There is a fall in differential function of >10%

Megaureter

- An abnormally wide ureter
- Can be
  - Obstructed
  - Refluxing
  - obstructed and refluxing
  - non-refluxing/non-obstructed
- 25% are bilateral
- Where unilateral, 10-15% have an absent or dysplastic contralateral kidney
- Managed conservatively unless sepsis

Solitary kidney or MCDK

- Failure of the ureteric bud to communicate with the metanephric blastema in the first few weeks of gestation results in either
- Renal agenesis
  - or
- MCDK: a non-functioning kidney, replaced by large, non-communicating cysts of varying sizes with no renal cortex and an atretic ureter
Renal agenesis or MCDK

- ≈ 50% have abnormalities of the contralateral kidney
  - VUR in ≈28%
  - PUJ and/or VUJ obstruction in ≈20%
- No need for further investigation if US of contralateral kidney is normal
- The contralateral kidney should show compensatory hypertrophy
- Dysplasia may be present if no compensatory hypertrophy. Follow-up necessary
- Annual BP and early morning urine dipstick if compensatory hypertrophy

Kidneys greater than 5cm are less likely to undergo involution

Ectopic and horseshoe kidneys

- Horseshoe:
  - Kidneys fused over the midline by a narrow isthmus of renal parenchyma or fibrous tissue
- Ectopic kidney:
  - Failure of ascent of the kidney during embryogenesis
Duplex kidneys

- Duplication of the ureteric bud
- Results in a duplex kidney and collecting system
- May be complete or partial
- In both cases the kidney is usually larger than normal
- Occurs in ≈1% of the population, may be familial and usually of no significance

Complete duplex kidneys

- 2 moieties, each with its own ureter:
  - the upper pole ureter
    - may be ectopic, draining into the vagina (causing dribbling of urine) or posterior urethra
    - may have an ureterocele (which can cause obstruction)
  - the lower pole ureter may have VUR
- If there is no dilatation of the collecting system (uncomplicated) no further imaging is necessary

Other abnormalities detected antenatally

- Cystic kidneys
- Echobright kidneys
Bright kidneys on antenatal scans

• Renal dysplasia (usually small cysts)
• ARPKD (usually large with small cysts)
• ADPKD (usually large with large cysts and may be asymmetrical)
• Glomerulocystic disease (typically HNF1β deletions/mutations; usually large)
• Beckwith-Wiedemann syndrome (visceromegaly, macroglossia, hemihypertrophy, hypoglycaemia)
• Congenital Nephrotic Syndrome
• Congenital infection

Further causes of ‘bright’ kidneys diagnosed on postnatal US scans

• Bright cortices may be normal in the neonate
• May be transient, due to protein precipitation in the renal tubules
• Acute tubular necrosis
• Renal venous thrombosis
• Neonatal nephrocalcinosis:
  — Common in preterm infants, particularly if diuretics or IV feeding
  — Distal renal tubular acidosis
• Nephroblastomatosis
• Primary hyperoxaluria
• Neonatal Bartters syndrome

Key Points

• US allows detailed assessment of the kidneys and urinary tract from the second trimester of pregnancy.
• The incidence of antenatal renal tract anomalies is around 1 in 200 pregnancies.
• Around 50% of postnatal scans will subsequently be normal.
• There are many causes of antenatal renal tract dilatation; detection does not necessarily indicate obstruction, but bilateral dilatation needs urgent investigation.
• Whenever a fetus or infant is being assessed, it is essential to take a complete antenatal history including details of all of the investigations performed to date.