Diagnostic imaging in pediatric nephrology

IPNA-ESPN Master Glasgow September 2017

Melanie Hiorns
The basic tools

- Plain film Xrays
- Ultrasound
- Micturating cystogram
- IVU
- Nuclear medicine – MAG3 and DMSA
- CT
- MRI
- Angiography
Plain X-ray films

• Probably only indicated in stone disease
• Ultrasound more sensitive but X-rays can be useful for ureteric stones
• Augmented bladders
• Unexpected calculi
• Associated skeletal abnormalities – VATER, bladder extrophy
Main applications of ultrasound:

- Key first line investigation in children
- Superb tool for looking at structure
- Useful screening tool to exclude pathologies
- Less good for functional assessment
- No cellular information
• Congenital abnormalities
• Kidney architecture/echogenicity/size
• Dilatation
• Calcification
• Blood flow
• Bladder
Congenital abnormalities

• How many kidneys?
• What shape are they?
• What size are they?
• Where are they?
• Are there associated abnormalities?
• Can I bring this together as a diagnosis?
Crossed fused ectopic kidney
Pelvic kidney

Melanie Hiorns, UK
Posterior urethral valves

Melanie Hiorns, UK
Kidney architecture/echogenicity/size

- Small / large / normal size?
- Echobright?
- Duplex?
ADPKD – new born
Duplex kidney

Melanie Hiorns, UK
Dilatation

• Collecting system
• Ureters
• Obstruction?
Supine versus prone

Melanie Hiorns, UK
Prone

Post op nephropexy

Melanie Hiorns, UK
PUJ obstruction
PUJ obstruction
Renal transplant – ureteric stricture
Dilated ureters - stones

Melanie Hiorns, UK
Calcification

• In the parenchyma?
• In the collecting system?
• In the ureter?
• In the bladder
• Anywhere else?
In the parenchyma

Nephrocalcinosis

Melanie Hiorns, UK
Nephrocalcinosis AND calculi

Hyperoxaluria and stones in ureter

Melanie Hiorns, UK
In the collecting system

Immobility stones – and 4 months later

Melanie Hiorns, UK
XPN with collection

Melanie Hiorns, UK
In the ureter

With or without ureteric dilatation

Melanie Hiorns, UK
In the bladder

Reconstructed bladder

Cysteinuria

Melanie Hiorns, UK
Other places

Stoma stones
Melanie Hiorns, UK
Blood flow
Pitfalls

- In tiny infants avoid interpreting the contralateral kidney and the ‘second’ kidney when only one kidney present – ‘look through’
- Misinterpreting a hydrocolpos for bladder
- Misinterpreting slightly echogenic kidneys as abnormal in the new born
- Misinterpreting gross hydronephrosis for bladder or cystic kidneys including MCDK
- Distinguish PUJ from duplex

Melanie Hiorns, UK
‘Look through’ in neonates

Don’t misinterpret as one kidney – you could be looking right through

Melanie Hiorns, UK
Hydrocolpos

Looking for the ureteric jets can help
Or fill the bladder by the catheter and see which cavity increases in size
Check if the ‘bladder’ is directly anterior to the sacral spine – it shouldn’t be!

Melanie Hiorns, UK
MCDK versus hydronephrosis

Melanie Hiorns, UK
MCDK ....  

... not MCDK - hydronephrosis
PUJ not duplex

Melanie Hiorns, UK
Bilateral ureteroceles and bilateral dilated ureters. Make sure dilated ureters are not mistaken for ureteroceles and vice versa.

Melanie Hiorns, UK
Renal pelvis dilatation

• Usually diagnosed antenatally
• General agreement that it should be followed up postnatally
• **AP** pelvis diameter measurement is crucial
• If extra renal dilatation we state the ‘true’ renal pelvis measurement and the ‘extra renal pelvis’ measurement
• We must comment on the dilation (or not) of the calyces, renal pelvis and the ureters, length of kidney, thickness of renal cortex, and echogenicity
PUJ obstruction

- Male, and left sided, predominance
- Most commonly at the exact point the renal pelvis joins the ureter
- Possibly an abnormal deposition of muscle and collagen resulting in an aperistaltic segment
- Degree of distension cannot be used as an indicator of the degree of obstruction or of residual renal function
Neonatal PJ obstruction
Bilateral PUJ obstruction
Duplex kidneys

• Duplex: unilateral/bilateral, complete/partial, associated ureterocele or not

• Ureterocele is a cystic dilatation of the submucosal portion of the upper moiety of the duplex (but can also occur in a simplex kidney) and is associated with an ectopic insertion

• Caecoureterocele is a variation where the ureterocele involves the upper part of the urethra – and can cause obstruction on voiding

Melanie Hiorns, UK
6 week old – infected duplex
Specific pitfalls with duplexes

Bubble not ureterocele!

Melanie Hiorns, UK
Missed duplex

Melanie Hiorns, UK

and PUV!
Missed duplexes
Collapsing ureterocele
Ectopic ureters

• Often associated with a duplex and ectopic (and low) insertion of the upper moiety ureter
• In girls it can insert into the lower bladder, the urethra, vestibule or vagina
• If infrasphincteric this will mean the girl is always dribbling and never achieve continence
• Always above the sphincter in boys so don’t have this problem, but may present with epididymo-orchitis
• MRU very useful for examining ectopic ureters
Ectopic insertion in a duplex
Renal cystic disease in neonates

- MCDK – must distinguish from hydronephrosis
- Cystic dysplasia
- Autosomal recessive polycystic kidney disease – PKHD1 gene mutation or deletion – affects cilia of the biliary ducts and collecting tubules of the kidneys – fusiform dilatation and ectasia of the collecting tubules – symmetrically enlarged echogenic kidneys with random small cysts
- Cystic diseases associated with syndromes

Melanie Hiorns, UK
MCDK

Melanie Hiorns, UK
Autosomal recessive polycystic kidney disease - ARPKD

Melanie Hiorns, UK
Table 6.13 Recommended imaging schedule for infants younger than 6 months

<table>
<thead>
<tr>
<th>Test</th>
<th>Responds well to treatment within 48 hours</th>
<th>Atypical UTI&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Recurrent UTI&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound during the acute infection</td>
<td>No</td>
<td>Yes&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Yes</td>
</tr>
<tr>
<td>Ultrasound within 6 weeks</td>
<td>Yes&lt;sup&gt;b&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DMSA 4–6 months following the acute infection</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MCUG</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 6.12 Definitions of atypical and recurrent UTI

**Atypical UTI includes:**
- seriously ill (for more information refer to ‘Feverish illness in children’ (NICE clinical guideline 47)
- poor urine flow
- abdominal or bladder mass
- raised creatinine
- septicemia
- failure to respond to treatment with suitable antibiotics within 48 hours
- infection with non-<i>E. coli</i> organisms.

**Recurrent UTI:**
- two or more episodes of UTI with acute pyelonephritis/upper urinary tract infection, or
- one episode of UTI with acute pyelonephritis/upper urinary tract infection plus one or more episode of UTI with cystitis/lower urinary tract infection, or
- three or more episodes of UTI with cystitis/lower urinary tract infection.
Contraindications and antibiotics

- If child is clinically suspected or proven to have a current UTI
- Essential if have prosthetic valve, valvular lesion, septal defect or PDA that get antibiotics in advance
- If allergic to contrast medium

Antibiotics are to be given for 3 days, starting one day before procedure.

**Trimethoprim** (oral dose)

< 1 month  
2mg / kg bd

> 1 month  
4mg / kg bd

In renal failure  
15-30 mL/min/1.73 m²

Normal dose for 3 days only

<15 mL/min/1.73 m²  
Use half above doses
Dose reduction

- Low frequency pulsed fluoroscopy – 3p/s
- Low magnification
- Image grab
- No grid

<table>
<thead>
<tr>
<th>Procedure</th>
<th>DAP (cGycm²)</th>
<th>DAP (cGycm²)</th>
<th>DAP (cGycm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age 0-1</td>
<td>Age 1-7</td>
<td>Age 8 +</td>
</tr>
<tr>
<td><strong>UPPER GI SERIES</strong></td>
<td>8</td>
<td>12</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>3.6</td>
<td>6.3</td>
<td>18.7</td>
</tr>
<tr>
<td><strong>DYSPHAGIA SWALLOW</strong></td>
<td>16</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9.3</td>
<td>13.5</td>
</tr>
<tr>
<td><strong>MICTURATING CYSTOURETHROGRAM</strong></td>
<td>5</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>4.3</td>
<td>21.8</td>
</tr>
</tbody>
</table>

Melanie Hiorns, UK
Posterior urethral valves

- Congenital folds of Wolffian duct origin located at the junction of the posterior and the penile urethra, and obstruct the male urethra
- Present with poor urinary stream, sepsis, shock, hyperkalaemia, maternal oligohydramnios or antenatal bilateral hydronephrosis
- Any male infant with bilateral hydronephrosis must have PUV excluded

Melanie Hiorns, UK
Ultrasound findings in PUV

- Thick walled bladder
- Bilateral hydronephrosis
- Urinary ascites
- Perirenal urinomas
- Renal dysplasia
- Renal cysts
‘classic’ PUV
Missed valve picked up at age 7

Presented at birth with bilateral hydro, MCU reported as normal, re-presented age 7 with left pyelonephritis and obstruction.

Melanie Hiorns, UK
Primary grade 5 reflux not valves
IVU

• Effectively obsolete
• Very occasionally useful in the specialist pre-lithotripsy/PCNL planning
• Superseded by MR
Nuclear Medicine

- MAG3
- DMSA
Mid polar ‘cyst’

Melanie Hiorns, UK
Use of CT

• Ultrasound remains the first choice investigation for almost every clinical scenario

• CT can be used for problem solving (after the US)

• CT can be used when you don't have access to MRI
CT

- Trauma if questions not completely answered by ultrasound
- Stone disease in difficult patients
- Occasionally for vascular anatomy – complex horseshoe kidney, complicated tumour vascular anatomy
CT and problem solving

• What is the clinical dilemma?
• Spatial resolution versus contrast resolution?
• Contrast or no contrast?
• Slice thickness
• How many series?
CT 4 hours post angioplasty

Melanie Hiorns, UK
Chyluria
CT and calcification

• No doubt CT is very sensitive and specific for calcification
• How sensitive do you have to be?
• If the ultrasound has not shown obstruction is there an argument for ‘sitting it out’?
• Is it OK to use the radiation does in a curable disease that may need serial imaging?
Tricky stones

Melanie Hiorns, UK
Nephrocalcinosis v. calculi
Infundibular stenosis v. cyst?

Melanie Hiorns, UK
Abscess with extension
CT in complex vascular anatomy – functioning tissue across the midline

Melanie Hiorns, UK
Surgical planning

Horseshoe kidney – 5 arteries

Melanie Hiorns, UK
Bilateral Wilms

Melanie Hiorns, UK
Tumour thrombus in Wilms

Melanie Hiorns, UK
Nephroblastomatosis

Melanie Hiorns, UK
Summary for CT

• Ultrasound remains the first choice investigation for almost every clinical scenario
• CT can be used for problem solving
• CT can be used when you don't have access to MRI
MR

- Tumours
- Problem solving
MRI Tumour protocol

Buscopan
STIRs, axial coronal, sagittal
NATIVE arterial axial (bilateral tumours only)
T2-space
ADC
T1 WE SE axial
3D VIBE
Care bolus, coronal
3D VIBE axial
T1 WE SE

Pre transplant angiography
NATIVE arterial (axial oblique, and then MIPs)
NATIVE venous (axial oblique, and then MIPs)

Melanie Hiorns, UK
Nephroblastomatosis (STIR, ADC, fusion)
Wilms pre and post chemo – the value of ADC monitoring

Melanie Hiorns, UK
T2 MR sequence showing the large Wilms’ tumor in the left kidney and nodules of nephroblastomatosis in the periphery of the right kidney. Coronal MR (BFFE sequence) showing the difference in signal between the Wilms’ tumor in the lower pole of the right kidney and the nodule of nephroblastomatosis on the lateral margin of the right kidney.
‘Crossing vessels’ causing PUJ obstruction

13 year old with intermittent right loin pain

14 year old with left sided loin pain

Melanie Hiorns, UK
ARPKD

Melanie Hiorns, UK
MRU

True FISP, coronal, sagittal, axial
Buscopan
3d T2 TSE sagittal
3D VIBE
Frusemide
Gadolinium
3D VIBE – arterial and then repeat every 5 to 10 minutes
T2 space
MRI: an unexpected right sided duplex kidney in a 7 month old girl whose anatomy could not be delineated by ultrasound, with a tiny lower moiety which is almost hidden by the dilated upper moiety (arrow).

MRI (T2 weighted sequence) demonstrating the extent of bilateral pelviureteric junction obstruction and on-dilation of the ureters confirming the obstruction to be at the PUJ.

Melanie Hiorns, UK
Angiography

- Renovascular disease
- Unexplained hypertension
- As part of more complex procedures
7 year old with neurofibromatosis type 1 and middle aortic syndrome

Melanie Hiorns, UK
9 year old girl with left renal artery stenosis

Melanie Hiorns, UK
Right renal artery stenosis

4% to 41%

Melanie Hiorns, UK
AV fistula from biopsy in a transplant kidney

Melanie Hiorns, UK
Rotational angio renal transplant - stenosis
Thank you