Renal Ultrasound

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Objectives

- Anatomy
- Technique
- Indications for Renal USS in emergency & critical care
Background – Renal Ultrasound

- Renal tract frequently viewed as part of other ultrasound examinations e.g. FAST
- Especially useful when CT not immediately available
- Rule in policy
- Specific but not highly sensitive test
- If you perform a renal USS for flank pain in pt > 50 always look at and measure aorta
Clinical Applications

- Acute loin pain
- Renal Failure
- Haematuria
- Pyelonephritis - slow recovery
- ROU - ? Bladder

Focus your scan on your question

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Anatomy
Anatomy and Landmarks: Kidneys

- Paired retroperitoneal organs
  - length 10 (9-13) cm,
  - T12 to L3.
  - R lower than L
  - Move 3 cm inspn
Relations – R Kidney

Anteriorly
adrenal gland, liver,
second part of
duodenum, right colic
flexure

Posteriorly
diaphragm, 12th rib,
costodiaphragmatic recess;
psoas, quadratus lumborum
muscles

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Relations L Kidney

Anteriorly:
- adrenal gland
- spleen
- stomach
- pancreas
- jejunum
- descending colon

Posteriorly:
- diaphragm
- 11th rib
- costodiaphragmatic recess
- psoas
- quadratus lumborum muscles

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Renal veins anterior to renal arteries

Renal arteries L2

Renal veins anterior to the aorta

Left renal vein anterior to the aorta

Left kidney lateral to aorta

Right kidney lateral to IVC

Liver

Spleen

Hepatic Veins

Celiac axis

SMA

AORTA

IVC

Renal artery L2

Renal vein

Left kidney

Right kidney

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Anatomy: kidney
External structures

- **Gerota’s fascia** — anchoring connective tissue between the kidneys & psoas muscles & lumbar spine.

- **Perinephric fat** — layer of extracapsular fat surrounding kidney.

- **Perihilar fat** — fat in the renal hilum.

- **Capsule** — dense fibrous covering of kidney + ureters
Anatomy: Kidney Parenchyma

- Solid part of the kidney, where the process of waste excretion takes place.
  - **Cortex**—the outer / intermedullary layer of the parenchyma consisting of connective tissue & vessels.
  - **Medulla**—where filtration and concentration of wastes takes place - Henle’s loops.
Anatomy: Kidney Collecting system

- **Renal Sinus**: the central portion of the kidney
  - *Major & minor calyces* — collecting area for urine within kidney before it is passed through to renal pelvis.
  - *Pelvis* — central collecting system of kidney.
  - *Hilum* — area of convergence of the renal collecting system, ureter,
Sonographic Appearance & Image Acquisition
Image Acquisition

- Probes
  - Generally a 3-5MHz curvilinear probe is used
  - Occasionally a high frequency probe is used in thin adults or children
    - Better resolution for stones

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Sonographic Appearance

- Renal sinus is echogenic due to fat
- Renal pelvis is black when visible
- Medullary pyramids are hypoechoic
- Cortex is mid-gray, less echogenic than liver or spleen.
- Capsule is smooth
- Echogenic ureters are always not seen
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Approach to Scanning

- Right kidney scanning approach: anterior, lateral, posterior
- Liver is the acoustic window
- Left kidney: requires a posterior approach, through the spleen
- Air-filled bowel impedes anterior scanning
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Renal USS Protocol
- focus on question

Both kidneys should be scanned – start with “normal” side

- Each kidney should be scanned entirely (pole to pole, side to side) in 2 planes
  - sagittal / long axis – 10 o clock R & 2 O clock L
  - transverse / short axis – 90 to above

- Identify relations
- identify
  - Capsule, Cortex, Medulla, Sinus/Pelvis

- Measure length of each kidney
- label the scan (right or left)

- Bladder in 2 planes & ureterovesicular jn

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Technique

- Begin supine
- Mid or ant axillary line; L more posterior
- Use pt breathing maximise views
- Turn patient into lateral decubitus position
- Prone position if no other view
- Transthoracic scanning with a phased array
Longitudinal (Long axis) view right kidney
Transverse (short axis) view right kidney
Left Kidney Long Axis

Probe position
4. LS: left kidney/spleen

Anterior
Superior
Rib Shadow
Kidney
Posterior
Inferior
Spleen
Left Kidney Short Axis

6. TS: left kidney
Measurement

- Length 9 – 13 cm
- Size within 2 cm R & L

And in clinical context
- Parenchyma - > 1.5cm??
- Pelvis in TV < 1cm??
Measurement

- Length 9 – 13 cm
  Size within 2 cm R & L

And in clinical context
- Parenchyma - > 1.5cm??
- Pelvis in TV < 1cm??
Colour Doppler

Highly skilled investigation? Any role for EM

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Image Acquisition: Bladder

- Protocol
  - The bladder should be imaged in 2 planes
  - Note volume
  - Look for stones
  - Look for other pelvic pathology
Image Acquisition: Bladder

- Thin walled structure
- 3 muscle layers and mucosa
- Anechoic interior
- Posterior acoustic enhancement
Ultrasound Findings and Disease

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Anatomical Variants
Column Bertin
Anatomical Variants
Horseshoe kidney
Anatomical Variants

? No R kidney
Anatomical Variants - Duplex kidney
Clinical Applications
Clinical applications - Loin pain

- ? AAA
- ? Calculi
- Other renal – PUJ obstruction, PCRD
- Other non renal – free fluid from abcess, 1ry peritoneal fluid
Pathology - Urolithiasis

- Renal colic – not as good as CT or IVP
  - Renal calculi
  - Ureteric calculi / hydronephrosis

- CTKUB - Gold standard
  Accurate, fast, no contrast
  Identifies presence and size of stone
  Location of stone
  Level of obstruction
  Other sources of pain

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Pathology - Stones

- **Plain radiograph** (Sharma 1989)
  - Sensitivity 62%, Specificity 67%

- **ULTRASOUND** (Sinclair 1989)
  - Sensitivity 85%, Specificity 92%

- **IVP** (Sinclair 1989)
  - Sensitivity 90%, Specificity 94%

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Pathology - Renal Calculi

- Bright calculi
- Posterior acoustic shadowing
- Assoc hydronephrosis
Pathology - calculi

Fxxx That hurts

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Ultrasound

Thin Parenchyma

Dilated Calyces

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Ultrasound

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Thin Parenchyma
Dilated Calyces
Ultrasound

Distinct Shadow

Thin Parenchyma
Dilated Calyces

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Ultrasound

Distinct Shadow

Thin Parenchyma
Dilated Calyces

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Ultrasound

Distinct Shadow

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Pitfall-Renal Angiomyolipoma

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Pitfall - Ureteric Calculi

- Don’t necessarily cause hydronephrosis, especially if dehydrated
- Don’t forget to look at ureter as enters bladder

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Hydronephrosis in Renal Colic

Sensitivity = 90%
Specificity = 93%

PPV = 92%
NPV = 90%

Smith. AJR Am J Roentgenol. 1996; 167:1109-1113

Sensitivity = 87%
Specificity = 90%

PPV = 90%
NPV = 89%


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Hydronephrosis – obstruction

- Echo-poor area in the bright renal sinus fat
- Calculi distal & not seen

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Clinical Applications – ARF

- Pre – renal
  - Volume status, IVC size?

- Renal
  - glomerulonephritis

- Post renal
  - Obstruction & its level

- Acute vs chronic – size

- Congenital abnormalities – PCRD, single kidney, duplex, horseshoe

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Renal size 9 - 13 cm
Renal parenchyma > 1.5 cm
Small kidneys may be hard to see!
Hydronephrosis

Dilatation of the urinary tract at any level secondary to intrinsic and/or extrinsic obstruction to urine flow

- **Mild** - Minimal separation of calyces
- **Moderate** - Dilation of major and minor calyceal system
- **Severe** - Marked dilation of the renal pelvis and thinning of the renal parenchyma

![Image of kidneys showing normal, mild, moderate, and severe hydronephrosis](www.emergencyultrasound.org.uk)
Mild Hydronephrosis

Hydronephrosis depends on hydration and posture

Luckily mild hydronephrosis rarely an emergent issue

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Hydronephrosis
Moderate - Severe Hydronephrosis

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Pitfalls - Parapelvic Cysts

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Clinical Applications - Haematuria

- Tumour
- stones
- Infection
- BPH
- Renal cysts
- Infarction
- Hydronephrosis
- PCKD
- Renal vein thrombosis
- Bleeding diathesis
- Sickle cell disease

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Renal Cell Carcinoma

- RCC 85%
  - Mass, mixed echogenicity
  - Bulge in renal contour
  - Small may be brighter & appear as angiomyoma
Renal Cell tumour - Benign

- Adenomas – usu < 1cm, cortex, solid
- Haemangiomas - < 1cm, hyperechoic, pelvicalyceal jn or medulla
- Lipomas
- Angiomyolipoma (hamartoma)

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Renal Cysts

- Common over age 50 years
- Anaechoic
- Posterior acoustic enhancement
- Sharply defined thin walls

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Bladder Chronic Cystitis
TCC
- Bladder, pelvis, ureter
- Bulky hypoechoic mass but may be flat & not visible
USS
APCKD

- Adult polycystic kidney disease
- AD
- multiple cysts slowly enlarging causing cortical thinning & renal failure

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Adult polycystic kidney disease
Pathology - urosepsis

- **Pyelonephritis**
  - usually normal ultrasound
  - May have diffuse enlargement or corticol scarring
  - Emphysematous = air visible

- **Pyonephrosis**
  - (Pus distorting renal collecting system)
    - Hydronephrosis with debris

- **Renal Abscess**
  - Usu corticol/medullary, hypoechoic thick walled complex cystic mass, distortion anatomy

[www.emergencyultrasound.org.uk](http://www.emergencyultrasound.org.uk)
Renal abscess

- renal cyst with mobile debris

Emphysematous pyelonephritis - free air
Pathology - urosepsis

- Chronic Pyelonephritis
  - Small kidney, areas of normal anatomy with areas of destruction, corticol scarring, corticol atrophy, clubbed calyces, irreg outline.

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Clinical applications –
ROU, pelvis mass

- Bladder volume
  - Defining bladder volume
  - Pre & post mic
  - ?catheter in situ (if not draining)

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Urinary Retention

Volume –
L x ht x W x 0.53

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Pitfall- Ovarian Cyst
Summary

- Renal ultrasound is a useful extension to the clinical examination in patients with suspected renal obstruction
- Methodical approach, focus on your question
- Rule-in strategy
- Remember other pathology – esp. AAA

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Questions?

References & Images

- Cosby & Kendall. A Practical Guide to Emergency Ultrasound
- Alty & Hoey. Practical Ultrasound: An Illustrated Guide
- Bowra & McLaughlin. Emergency Ultrasound Made Easy

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Anatomy - vessels

- Right kidney lateral to IVC
- Left kidney lateral to aorta
- >25% of humans possess dual / multiple uni/bilateral renal arteries
- Renal artery arises from the abdominal aorta at L2
- Renal veins lie anterior to renal arteries. Left renal vein longer & passes anterior to the aorta to join the IVC

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Technique Left LS

- Begin supine
- Mid or ant axillary line, move posteriorly
- Use pt breathing maximise views
- Turn patient into lateral decubitus position
- Prone position if no other view
- Transthoracic scanning with a phased array

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Anatomy: parenchyma

- The kidneys have two functional areas:
  - the parenchyma
  - the renal sinus
"a fool with a stethoscope will still be a fool with an
Anatomy: Cross sectional (transverse)

(ii) TS anatomy

- RRV
- Pancreas
- SV
- SMA
- Renal veins → IVC
- Renal arteries → Ao
- Sinus fat
- Medullary pyramid
- Cortex
- Ureter
- RRA
- Spine
- Psoas muscle
Image Acquisition: Left Kidney
Pathology — Renal calculi

Right Kidney

Left Kidney

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Common Pitfalls in Renal Scanning

- Failure to scan both kidneys
- Mistaking prominent renal pyramids for hydronephrosis or cysts
- Mistaking cysts for hydronephrosis
- Confusing normal renal arteries for the ureter
- Failure to scan through the bladder to search for stones at the uretero-vesicular junction

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Common Pitfalls in Renal Scanning

- Hydronephrosis requires time and adequate urine output to develop
- Not all stones can be visualised
- Not all stones that are seen are the cause of pain
- Always correlate with clinical picture and exclude other important pathology eg aortic aneurysm etc.
Pathology - pitfalls
Parapelvic Cyst

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