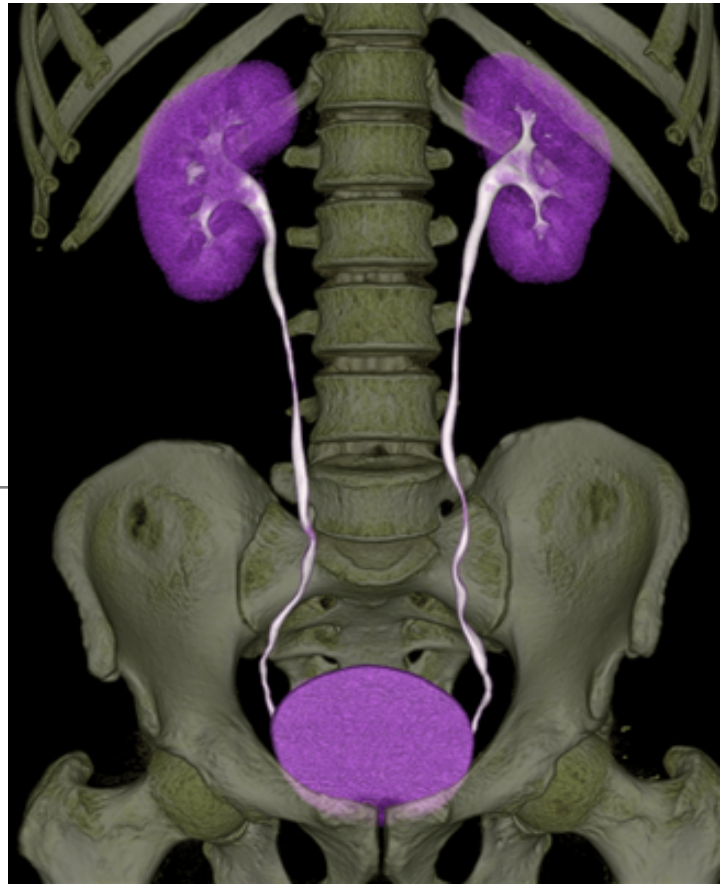
Radiological Anatomy & Investigations of Urinary System



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Objectives

To know the different types of modalities used in imaging the urinary tract

To know the anatomic location and sizes of the structures of the urinary tract

To identify the kidneys, ureters, urinary bladder and urethra on different imaging modalities

Urinary System

Kidneys

Ureters

Urinary bladder

Urethra

Imaging Modalities

Plain X-Ray

Intravenous Urogram (IVU)

US

CT

MRI

Nuclear medicine

Plain X-Ray

First imaging modality

Cheap

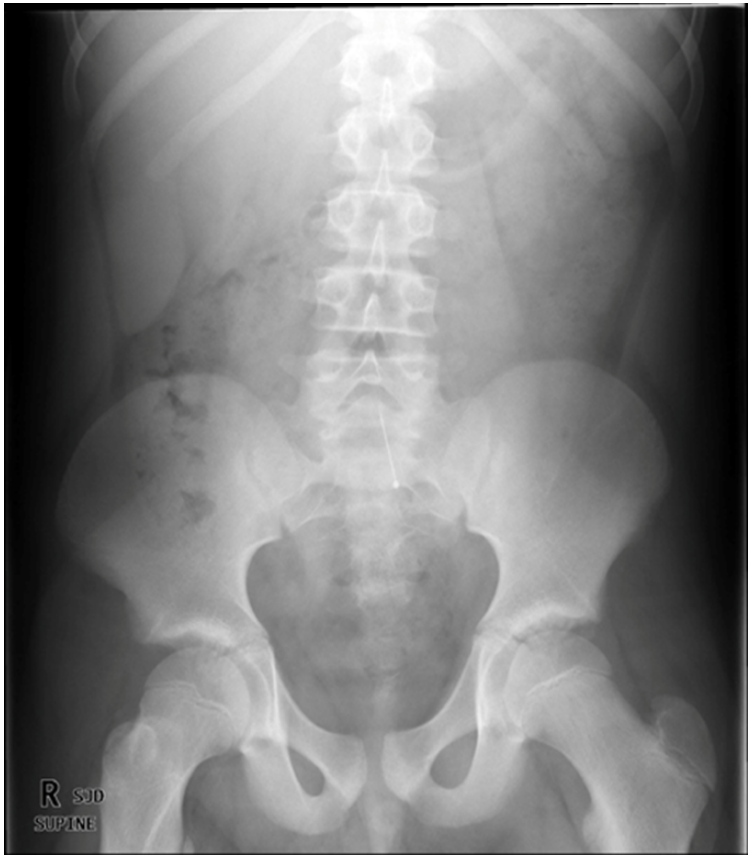
Useful for radio-opaque stones

Image features:

Projectional image

Image contrast determined by tissue density

Good evaluation of radio-opaque stones



IVU

Conventional x-ray + IV contrast

Cheap

Recently replaced by CT and MRI

Useful for radio-opaque stones

Image features:

Projectional image

Image contrast determined by tissue density and IV contrast

Good evaluation of collecting system and radio-opaque stones

US

Uses high frequency sound waves

Contrast between tissue is determined by sound reflection.

Image features:

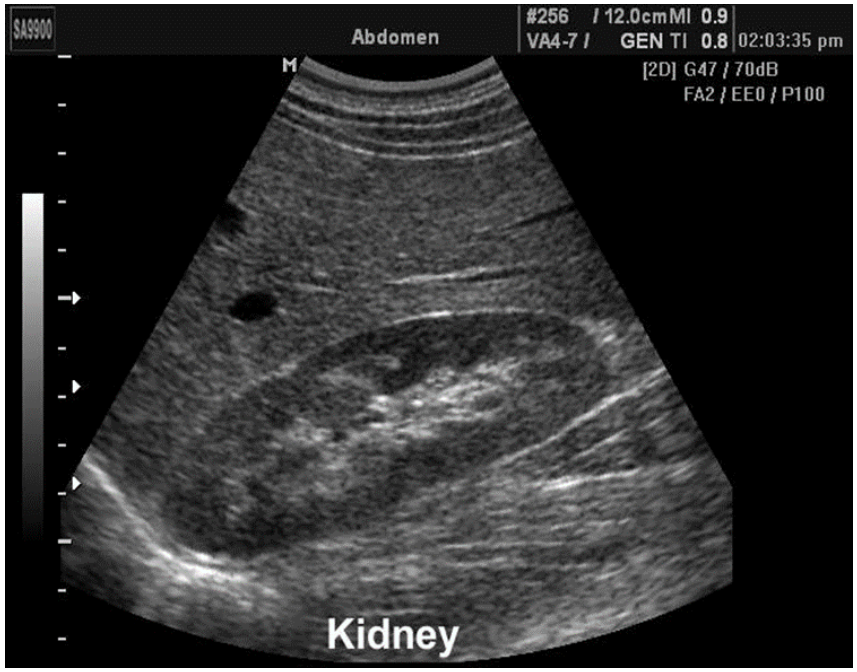
Operator dependant

Projectional image

Good resolution

Used for stones, hydronephrosis,

and focal lesions



CT

Same basic principle of radiography

More precise

Costly

+/- contrast

Useful for trauma, stone, tumor and infection

Image features:

Cross sectional images

Image contrast determined by tissue density +/- contrast

Better evaluation of soft tissue

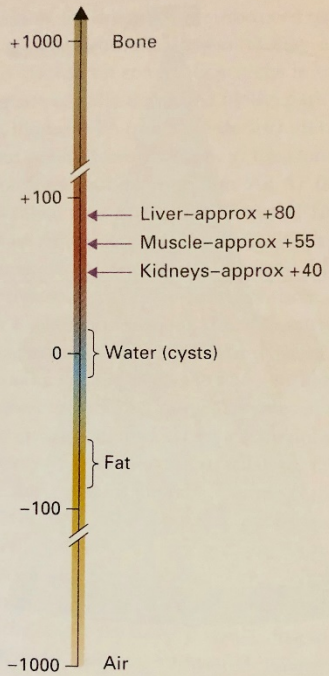


Fig. 1.2 Scale depicting the CT density (Hounsfield units) of various normal tissues in the body.

Box 8.1 Main indications for urography

Intravenous urography or CT urography

- When detailed demonstration of the pelvicaliceal system and ureters are required
- In suspected ureteric injury, e.g. following pelvic surgery or trauma
- Assessment of acute ureteric colic

CT urography

- Investigation of renal calculi
- Investigation of haematuria
- Characterization of a renal mass
- Staging and follow-up of renal carcinoma
- To delineate renal vascular anatomy (e.g. suspected renal artery stenosis or prior to live related kidney donation)
- To diagnose or exclude renal trauma

MRI

Better evaluation of soft tissue

Expensive

Useful for soft tissue pathology:

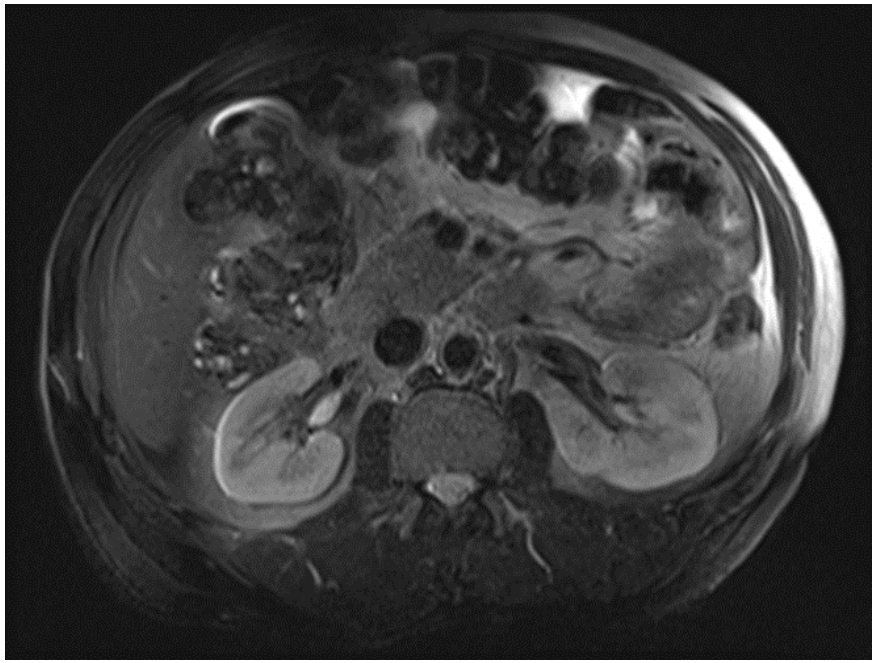
tumor, infection

Image features:

Cross sectional images

Image contrast determined by tissue properties

Excellent for soft tissue evaluation



Nuclear medicine

Utilizes a gamma camera and radioactive isotopes

Functional test

Less expensive

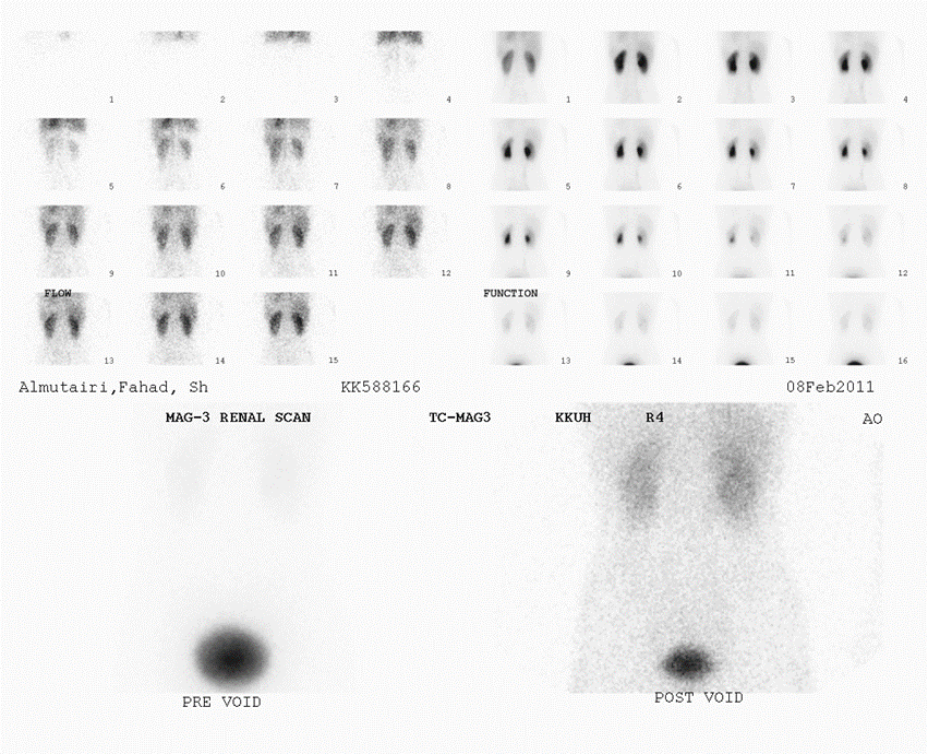
Useful for: obstruction and ***split function***

Image features:

Projectional image

Image contrast by tissue uptake

and metabolism



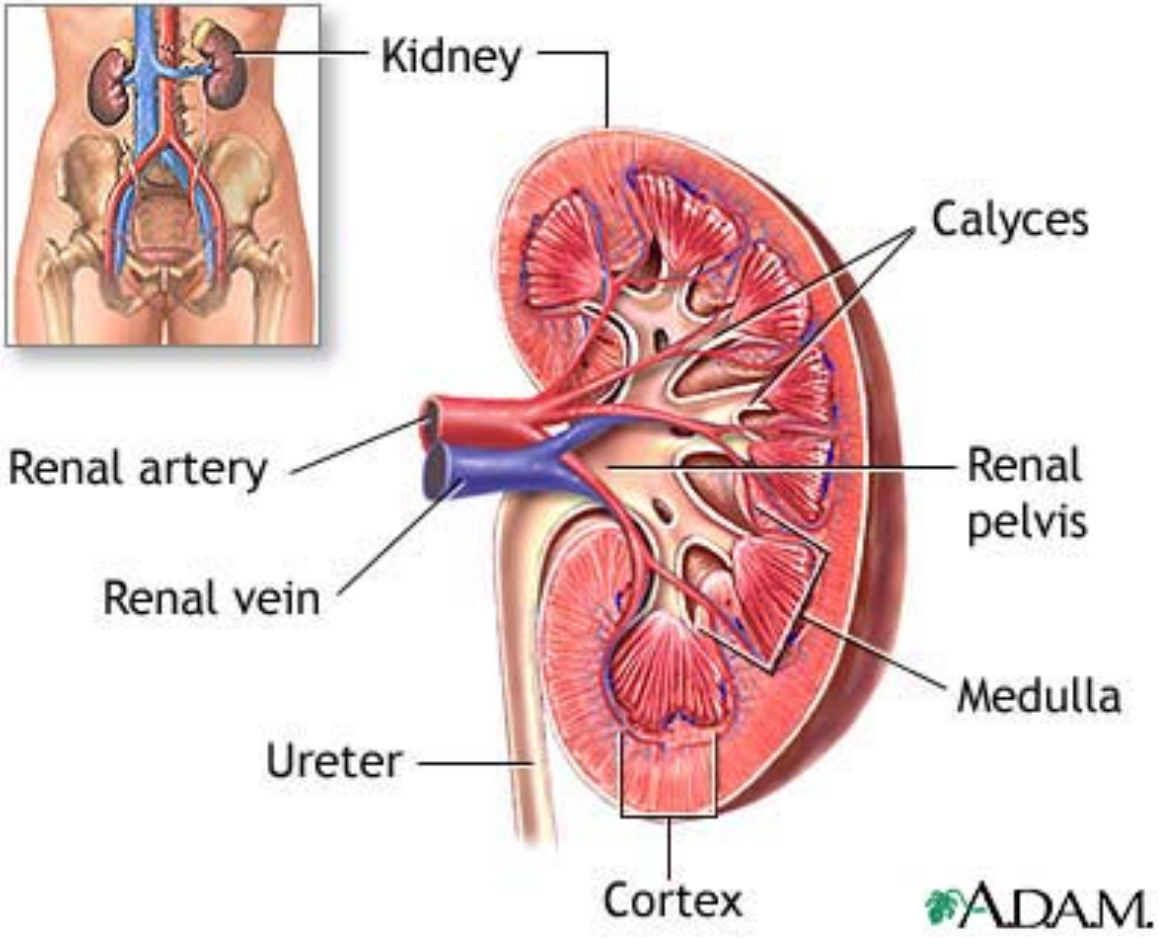
Anatomy

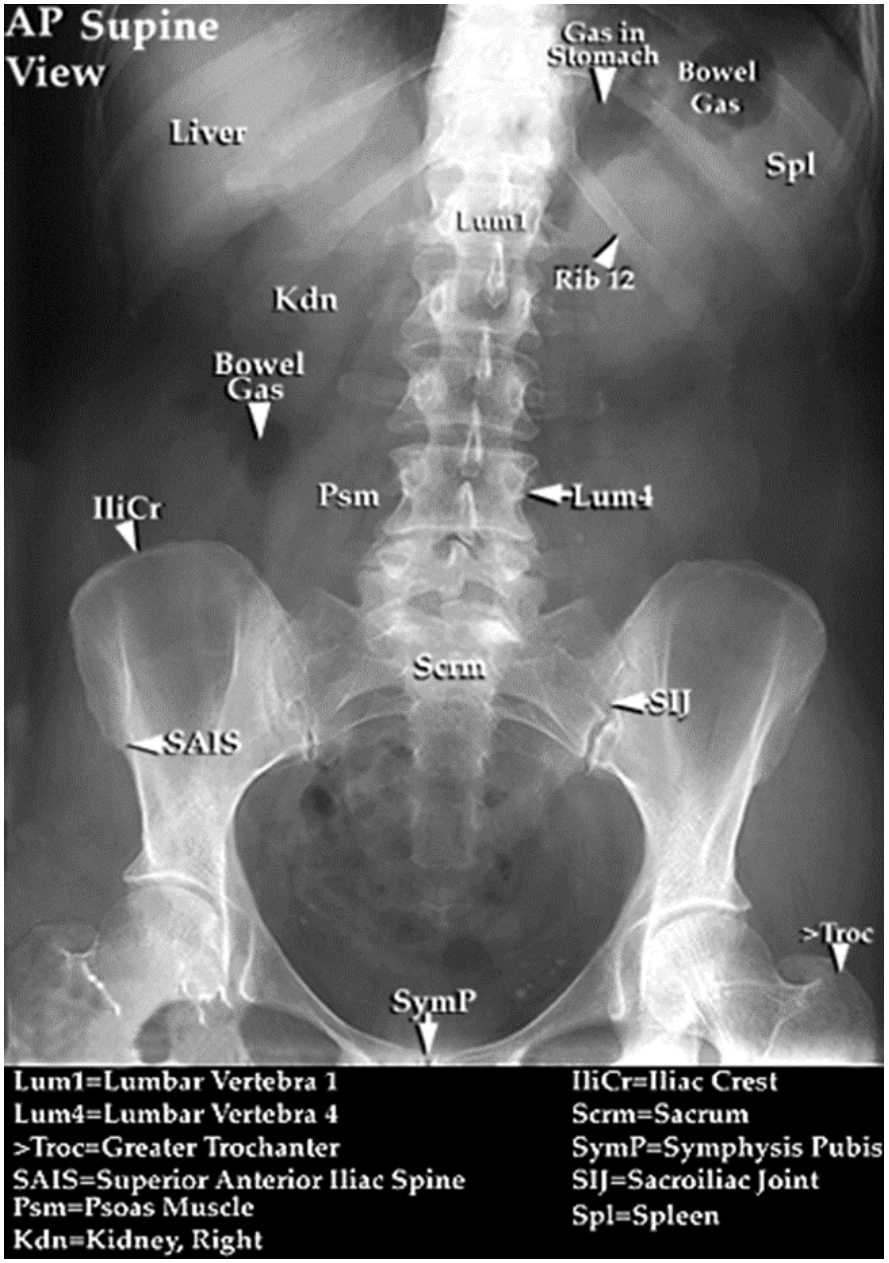
Kidneys

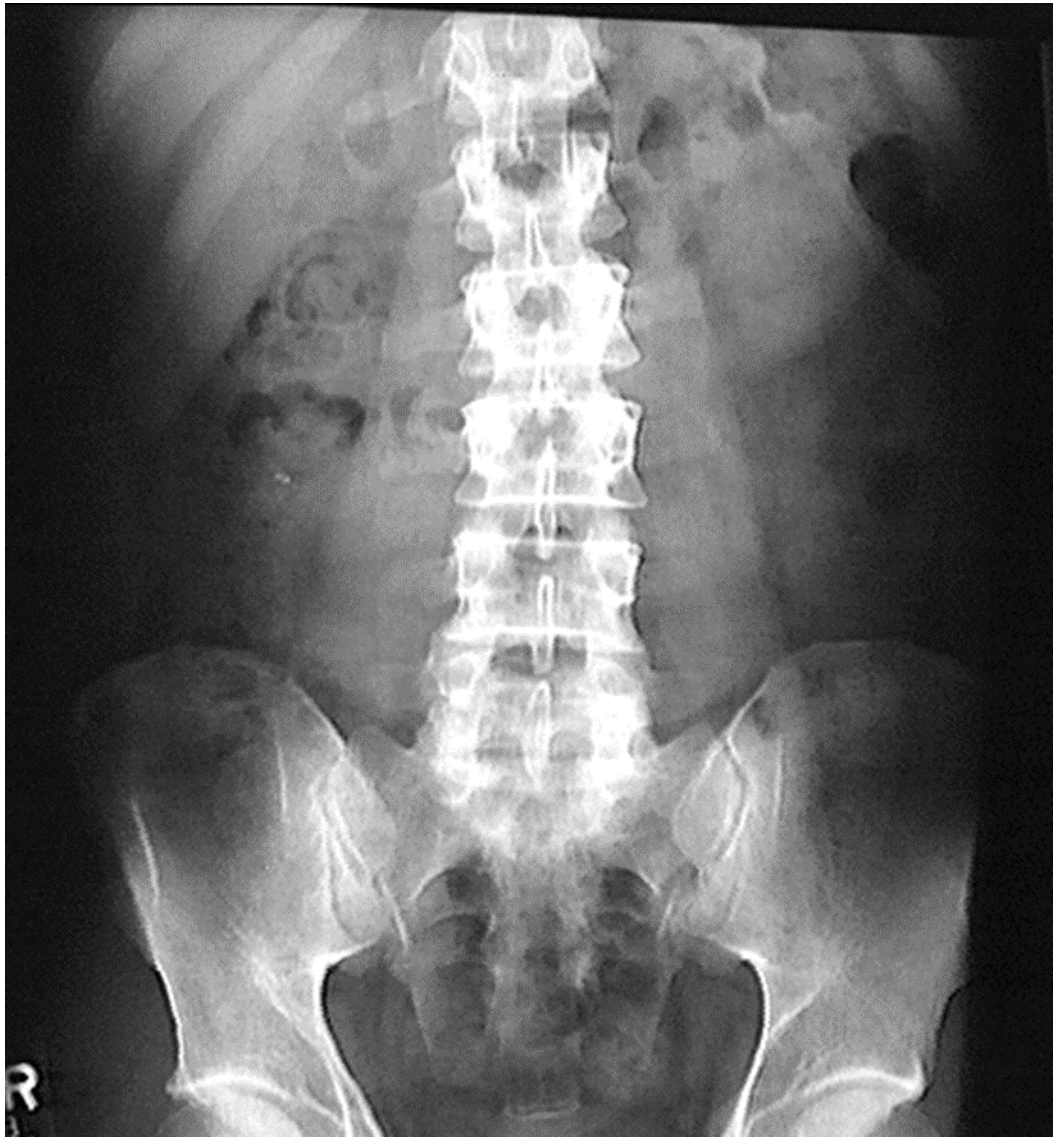
Bean shaped structure

On either side of the lower thoracic and upper lumbar spine

Usual location – between (T11-L3)


Kidney
Calyces
Renal artery
Renal pelvis
Renal vein
Medulla
Ureter
Cortex
A.D.A.M.


AP Supine View
Gas in Stomach
Bowel Gas
Liver
Spl
Lum1
Rib 12
Kdn
Bowel Gas
IliCr
Psm
Lum4
Scrm
SIJ
SAIS
>Troc
SymP
Lum1=Lumbar Vertebra 1
Lum4=Lumbar Vertebra 4
>Troc=Greater Trochanter
SAIS=Superior Anterior Iliac Spine
Psm=Psoas Muscle
Kdn=Kidney, Right
IliCr=Iliac Crest
Scrm=Sacrum
SymP=Symphysis Pubis
SIJ=Sacroiliac Joint
Spl=Spleen



Kidneys are retroperitoneal organs and may be obscured by bowel loops

Kidneys

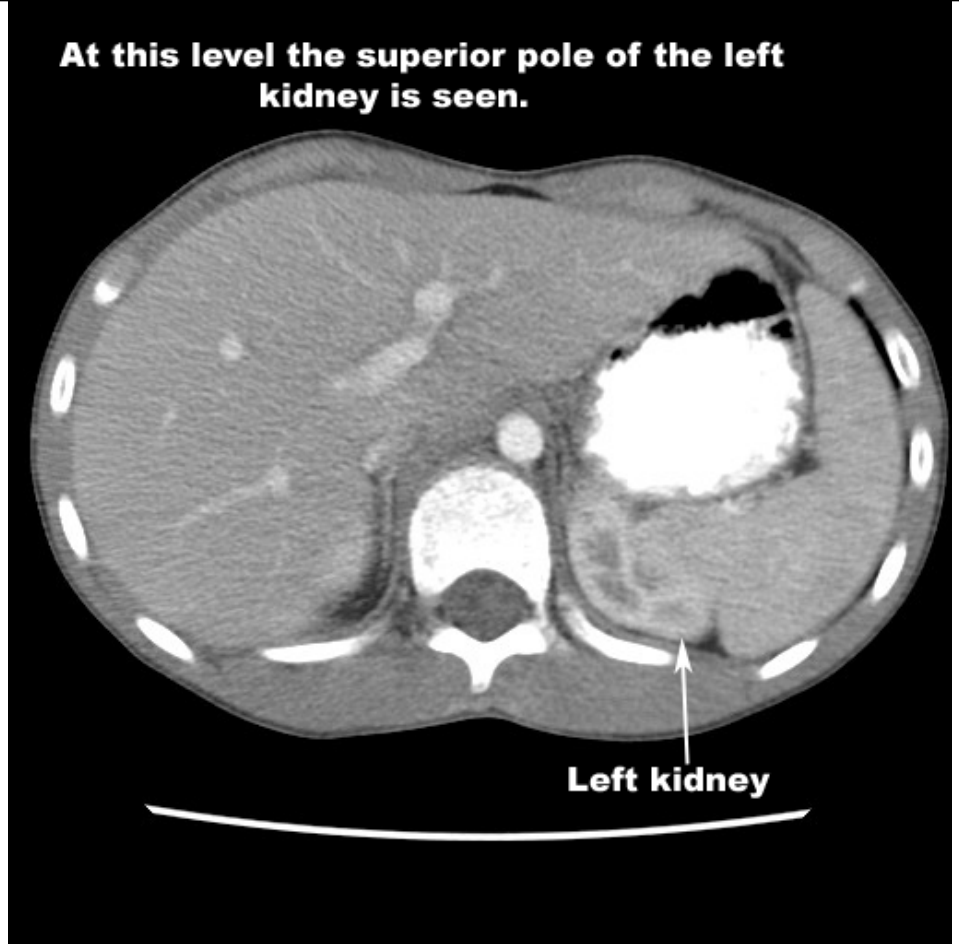
Right kidney is 2 cm lower than the left kidney

Long axis of the kidneys is directed downward and outward, parallel to the lateral border of the psoas muscles

Lower pole is 2-3 cm anterior to the upper pole

Upper pole of left kidney is higher than the upper pole of right kidney.

Coronal section MRI showing Left Kidney higher than Right Kidney



CT Scan showing left kidney higher than right

Long axis of the kidneys is directed downward and outward, parallel to the lateral border of the psoas muscles

Kidneys

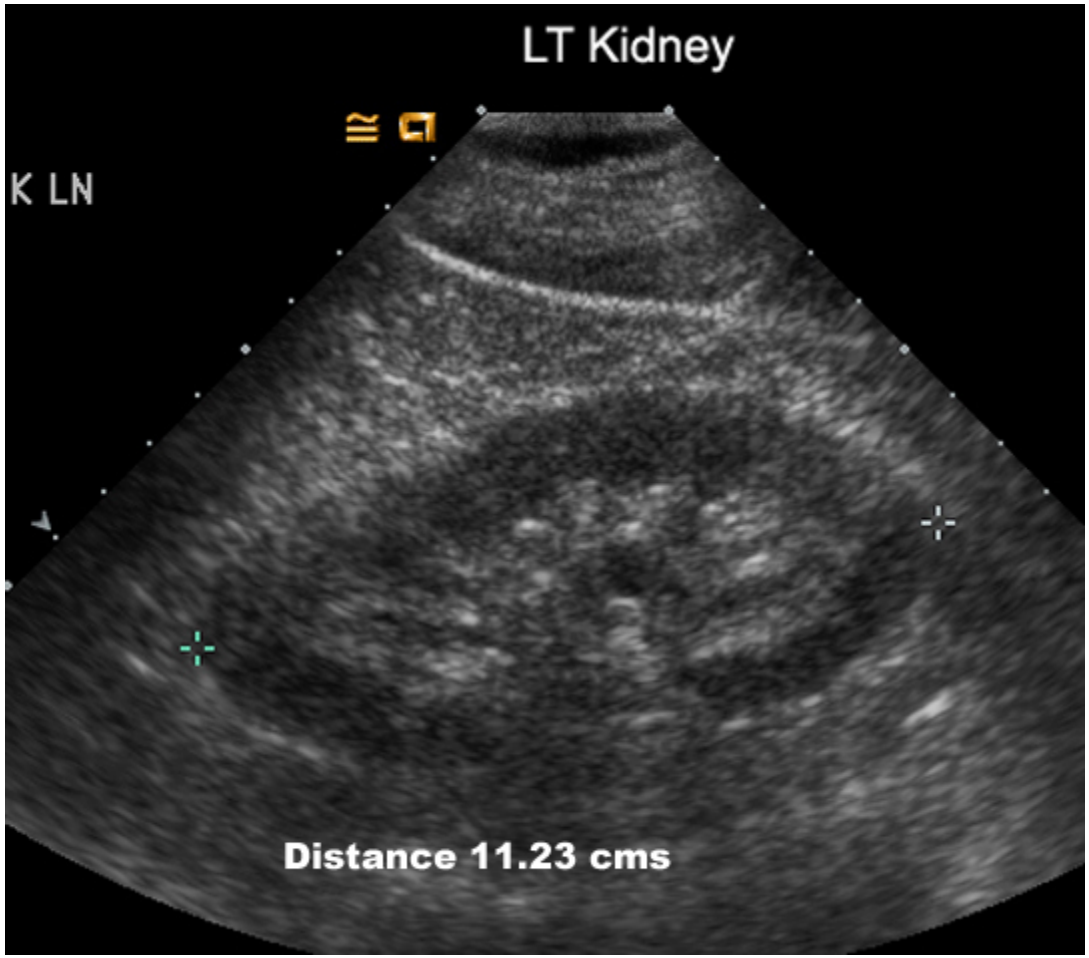
Normal size : in adults 10-12 cm

Table 8.2 Conditions associated with enlarged kidneys

	Diagnosis	Imaging
Always unilateral	Compensatory hypertrophy	Opposite kidney small or absent
May be unilateral	Bifid collecting system	Diagnosis obvious from abnormalities of collecting systems
or bilateral	Renal mass	Mass is seen
	Hydronephrosis	Visible distension of the renal collecting systems
	Lymphomatous infiltration	May show obvious masses; the kidneys may, however, be large but otherwise unremarkable
Always bilateral	Renal vein thrombosis	No Doppler signal is visible in the renal vein and thrombus may be evident
	Polycystic disease	Characteristic imaging appearance (see Fig. 8.52)
	Acute glomerulonephritis	Non-specific enlargement
	Amyloidosis	Non-specific enlargement (rare)

Table 8.1 Conditions associated with small kidneys

	Diagnosis	Imaging
Unilateral but may be bilateral	Chronic pyelonephritis	Focal scars and dilated calices
	Tuberculosis	See Fig. 8.42
	Obstructive atrophy	Dilatation of all calices with uniform loss of renal parenchyma
	Renal artery stenosis or occlusion	Outline may be smooth or scarred, but the calices appear normal
	Hypoplasia	Very rare; kidneys may be smooth or irregular in outline with fewer calices. Calices may be clubbed
Always bilateral	Radiation nephritis	Small in size but no distinguishing features
	Chronic glomerulonephritis of many types	Usually no distinguishing features. In all these conditions the kidneys may be small with smooth outlines and normal pelvicaliceal system
	Hypertensive nephropathy	
	Diabetes mellitus	
	Collagen vascular diseases	
	Analgesic nephropathy	Calices often abnormal



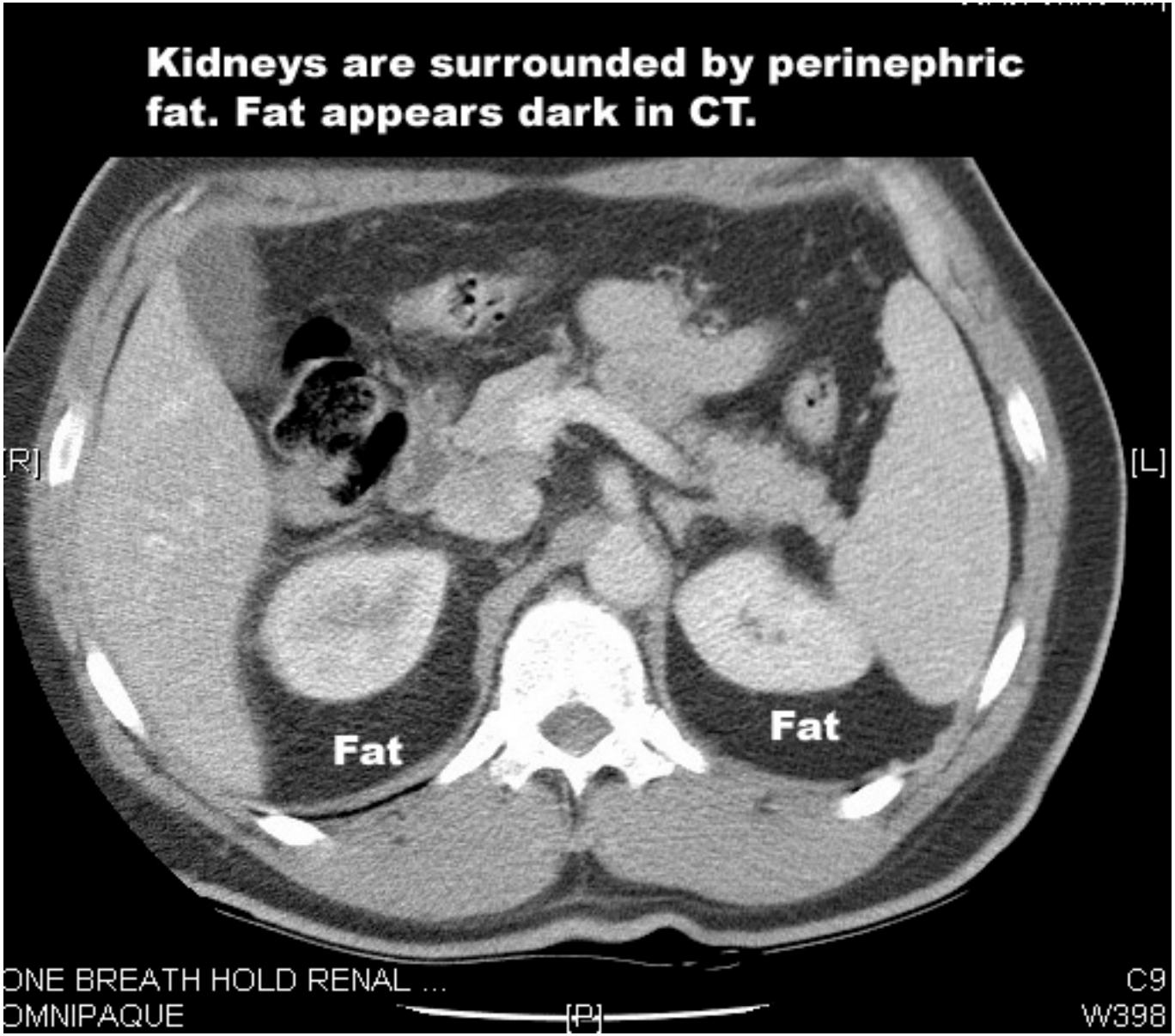
Ultrasound is the best method to measure the size of the Kidney

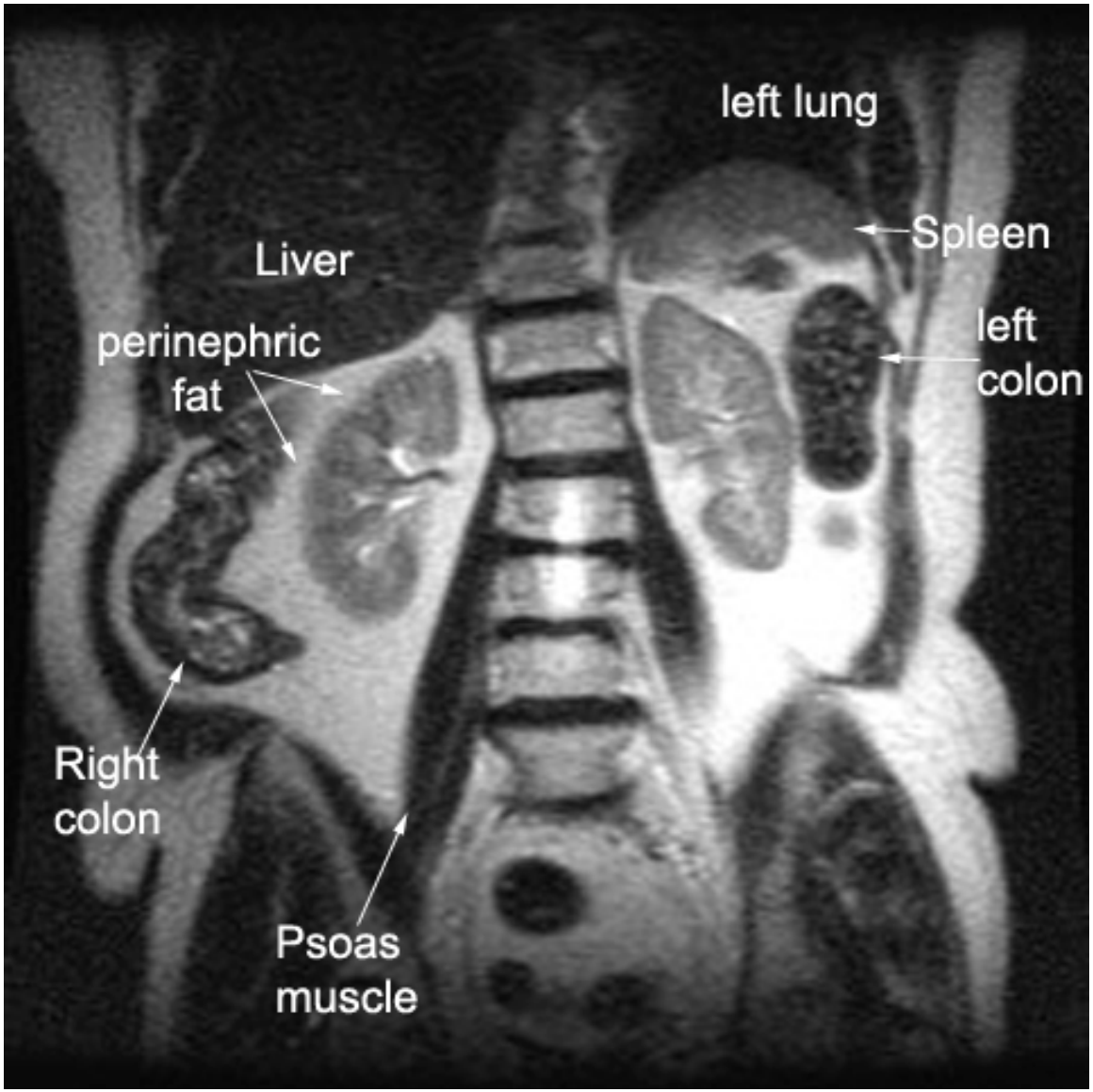
Kidneys

Kidneys are visualized on the X-Ray due to presence of perirenal fat

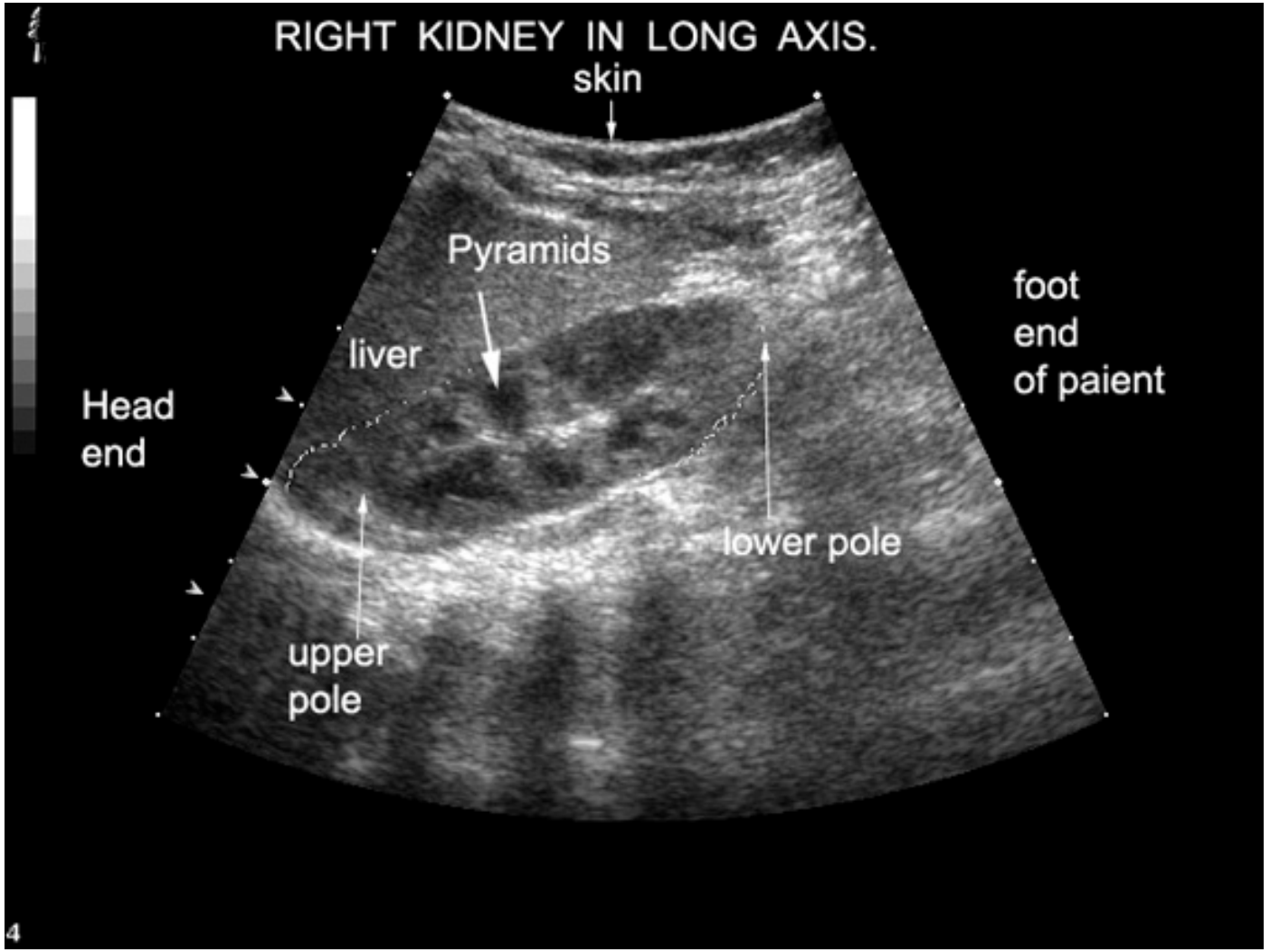
They are contained within the renal capsule and surrounded by perirenal fat and enclosed within the Gerota's fascia

Perirenal hemorrhage, pus and urine are contained within the fascia and detected on CT and US


Kidneys are surrounded by perinephric fat. Fat appears dark in CT.
[R]
[L]
Fat
Fat
ONE BREATH HOLD RENAL ...
OMNIPAQUE
[P]
C9
W398

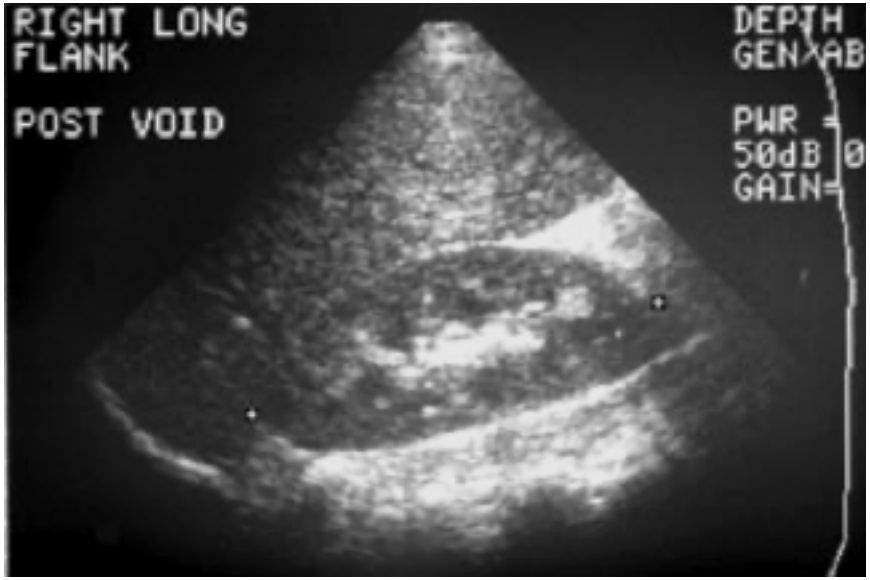


MRI: Fat is bright in T2

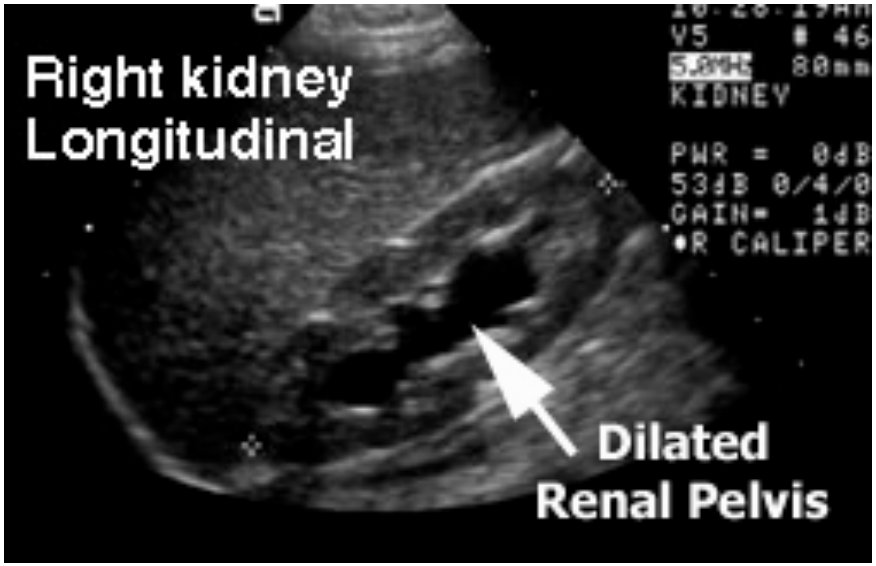


Ultrasound of Right Kidney

ULTRASOUND OF KIDNEYS

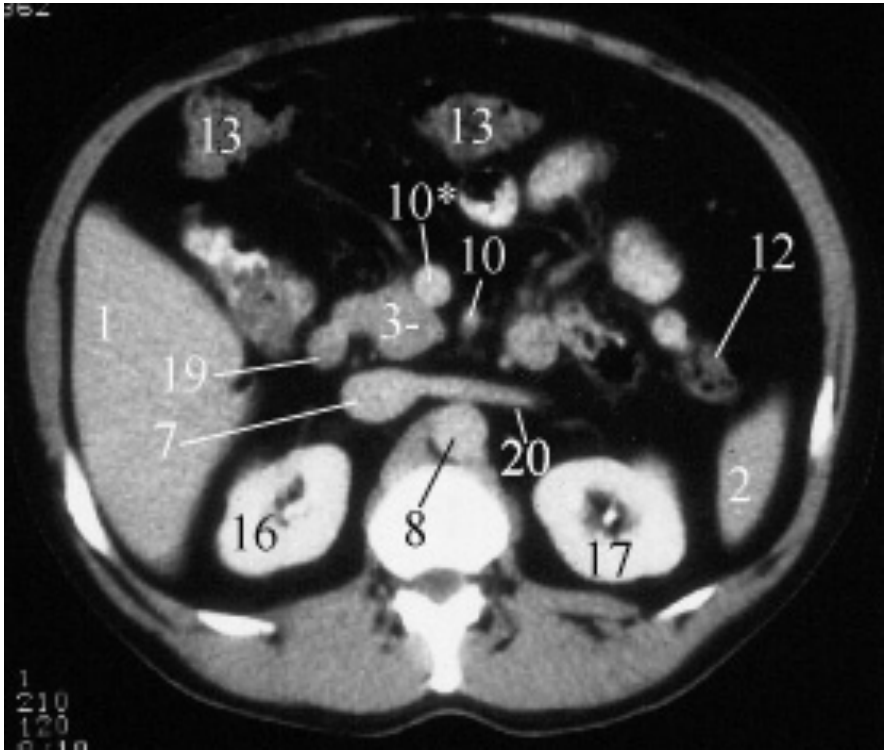


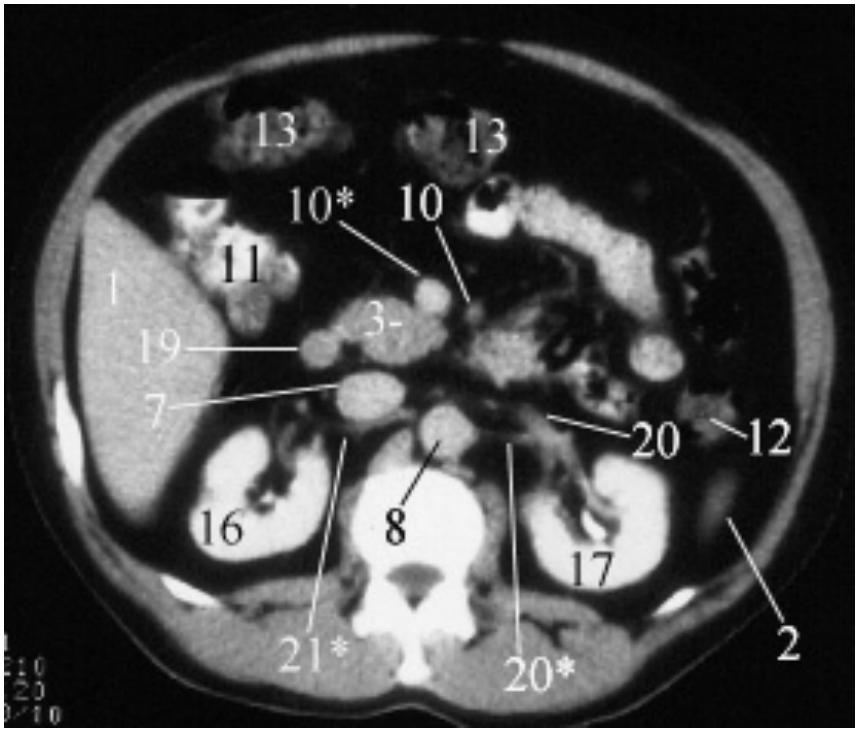
NORMAL STUDY



DILATED RENAL PELVIS

CT Scan of the Kidneys





Renal Vasculature

Renal Vasculature

Renal arteries branch from the abdominal aorta laterally between L1 and L2, below the origin of the superior mesenteric artery

The right renal artery passes posterior to the IVC

There may be more than one renal artery (on one or both sides) in 20-30% cases

Renal Vasculature

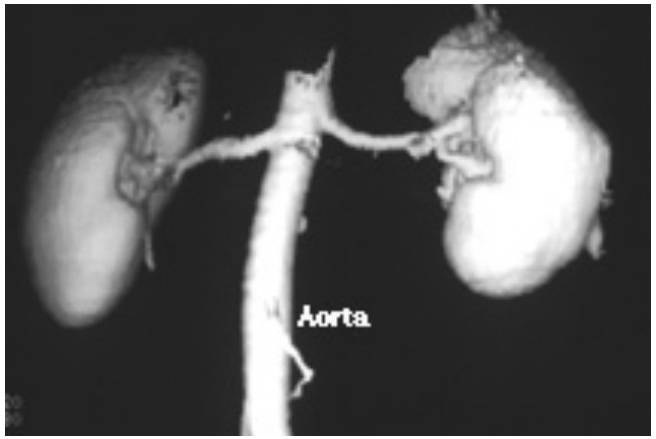
Renal veins drain into inferior vena cava

Renal veins lie *anterior* to the arteries

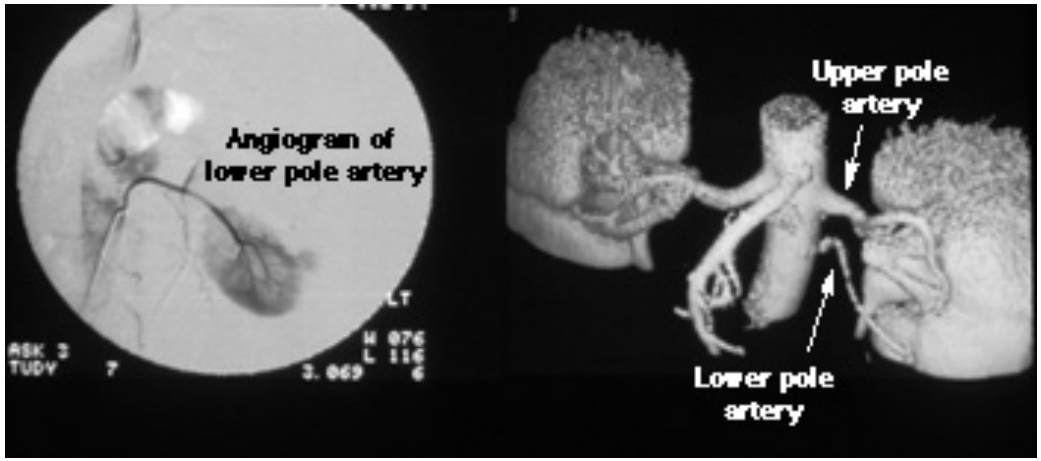
Left renal vein is longer and passes anterior to the aorta before draining into the inferior vena cava

The left gonadal vein will drain into to left renal vein while the right gonadal vein drains directly into the inferior vena cava

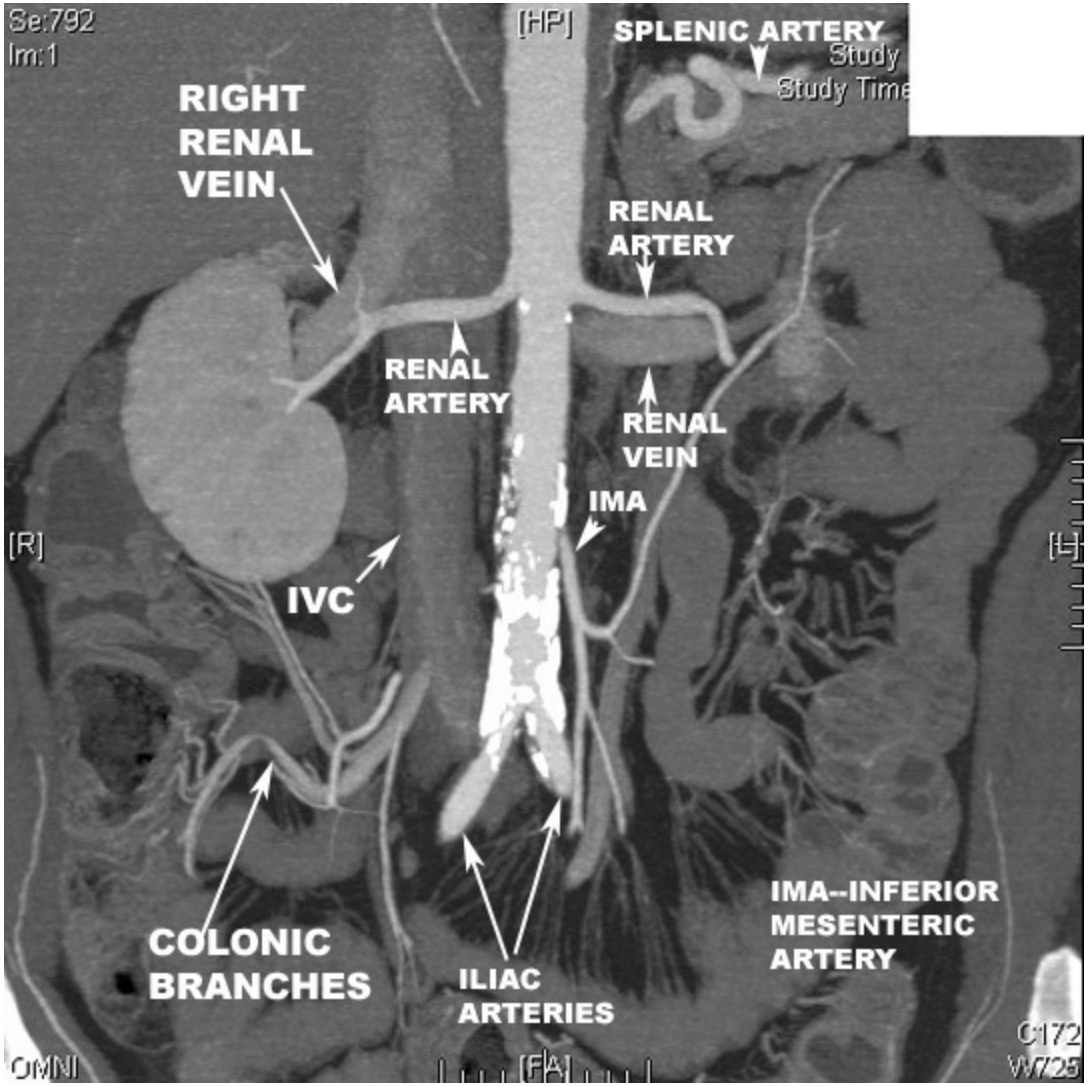
RENAL ANGIOGRAPHY



NORMAL SUPPLY OF BOTH KIDNEYS BY SINGLE RENAL ARTERY

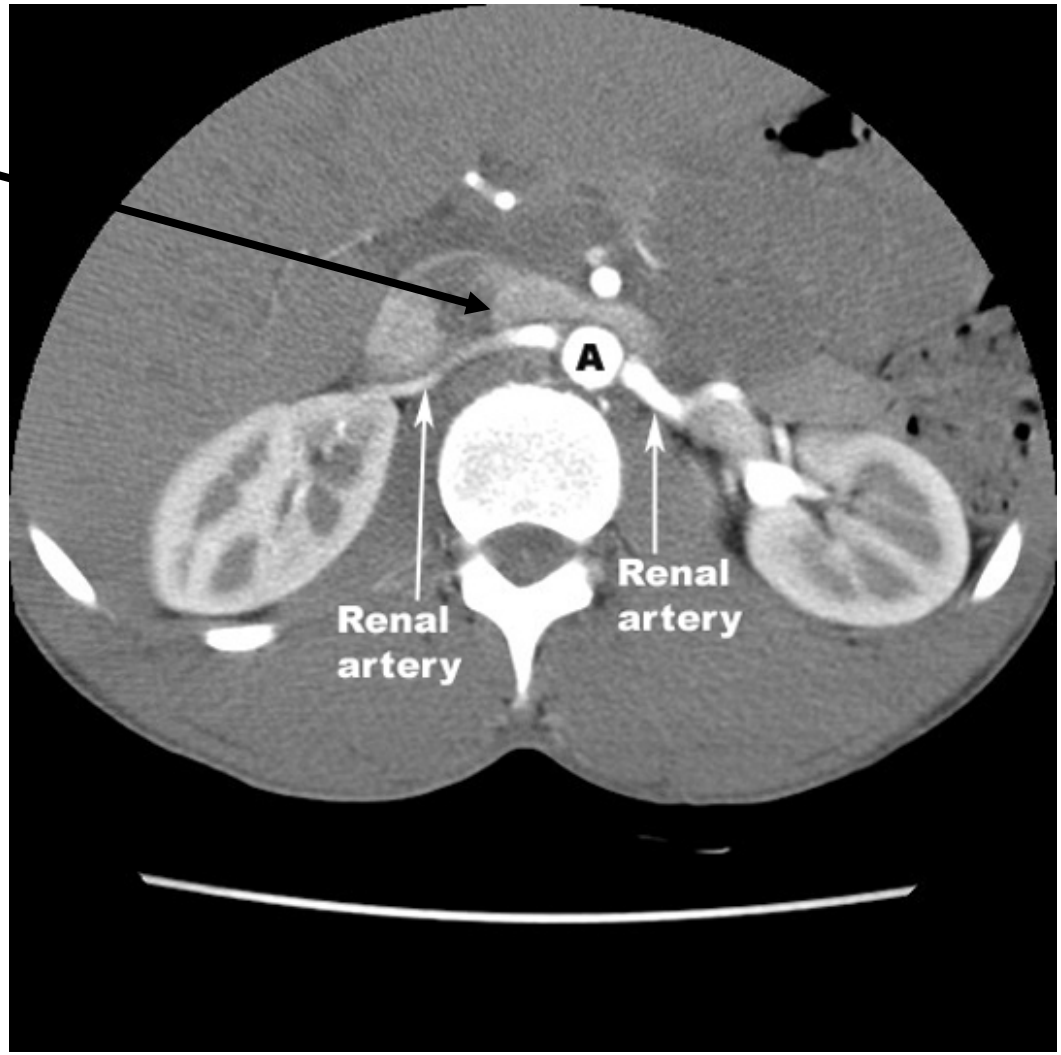


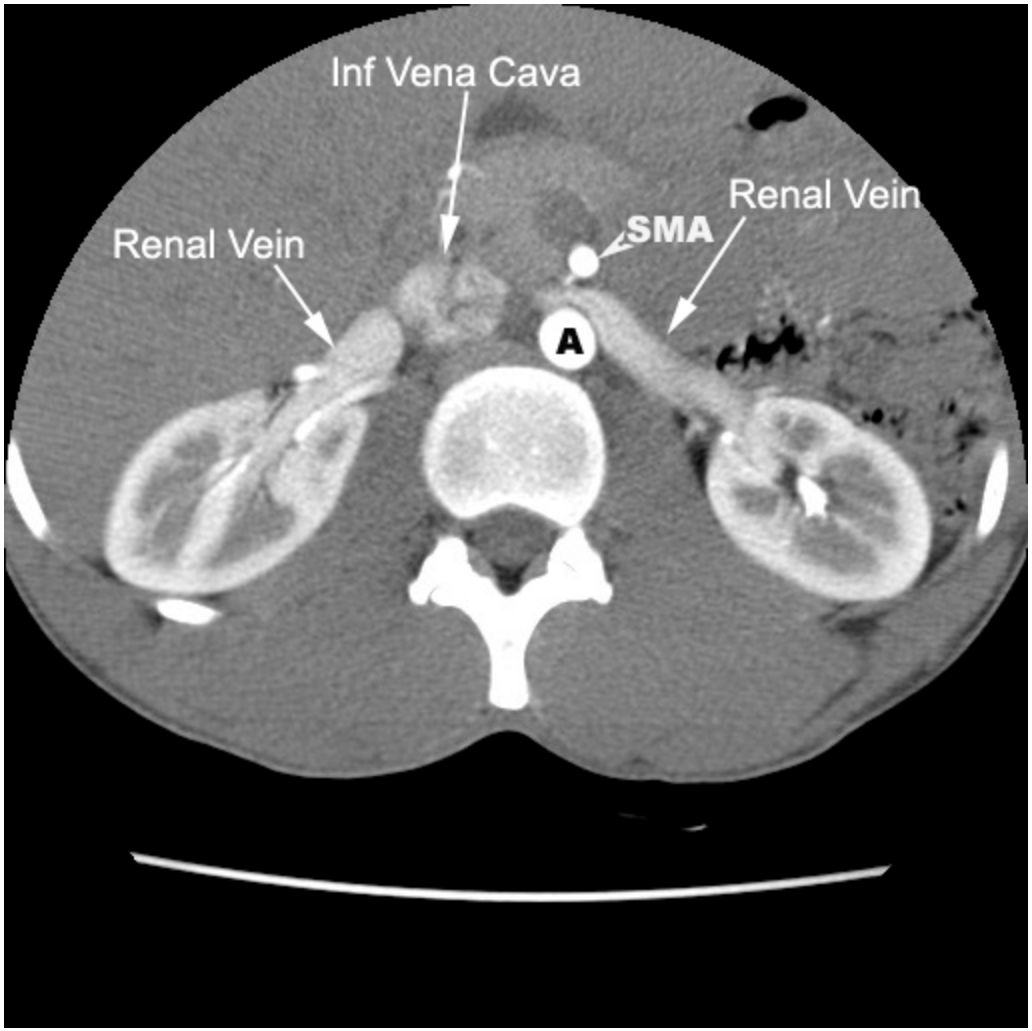
LEFT KIDNEY SUPPLIED BY TWO RENAL ARTERIES



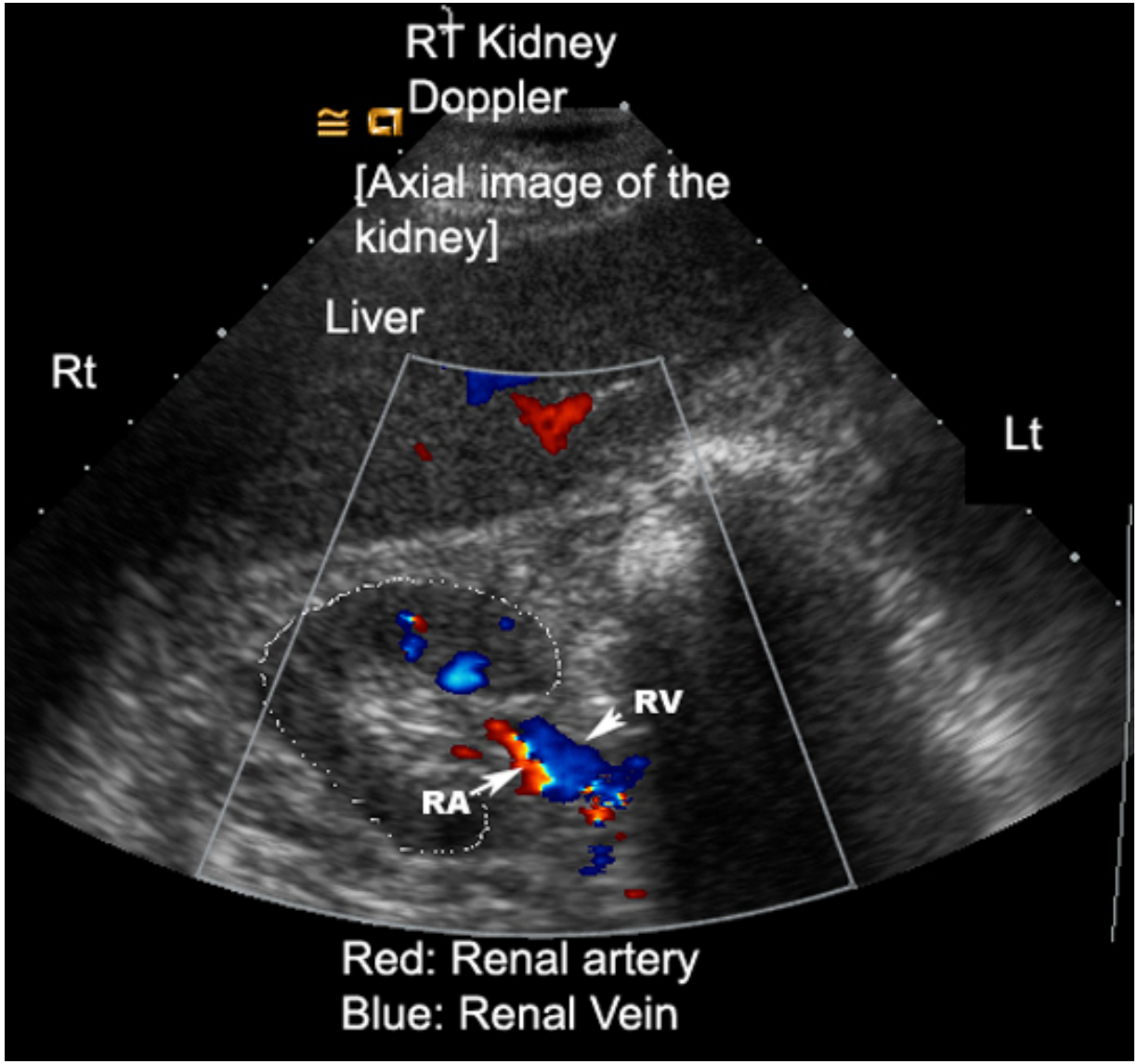
Coronal CT reformat

IVC

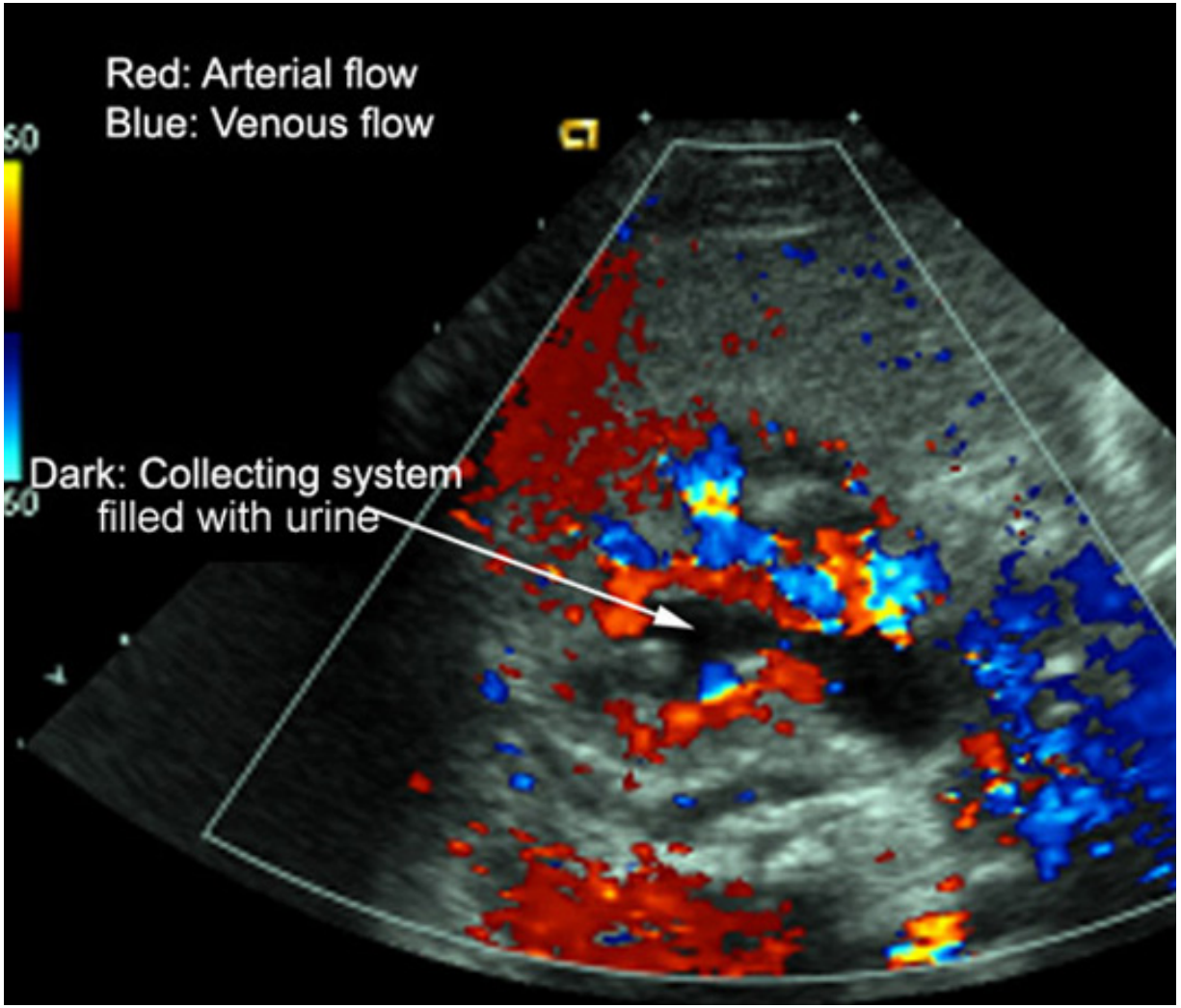




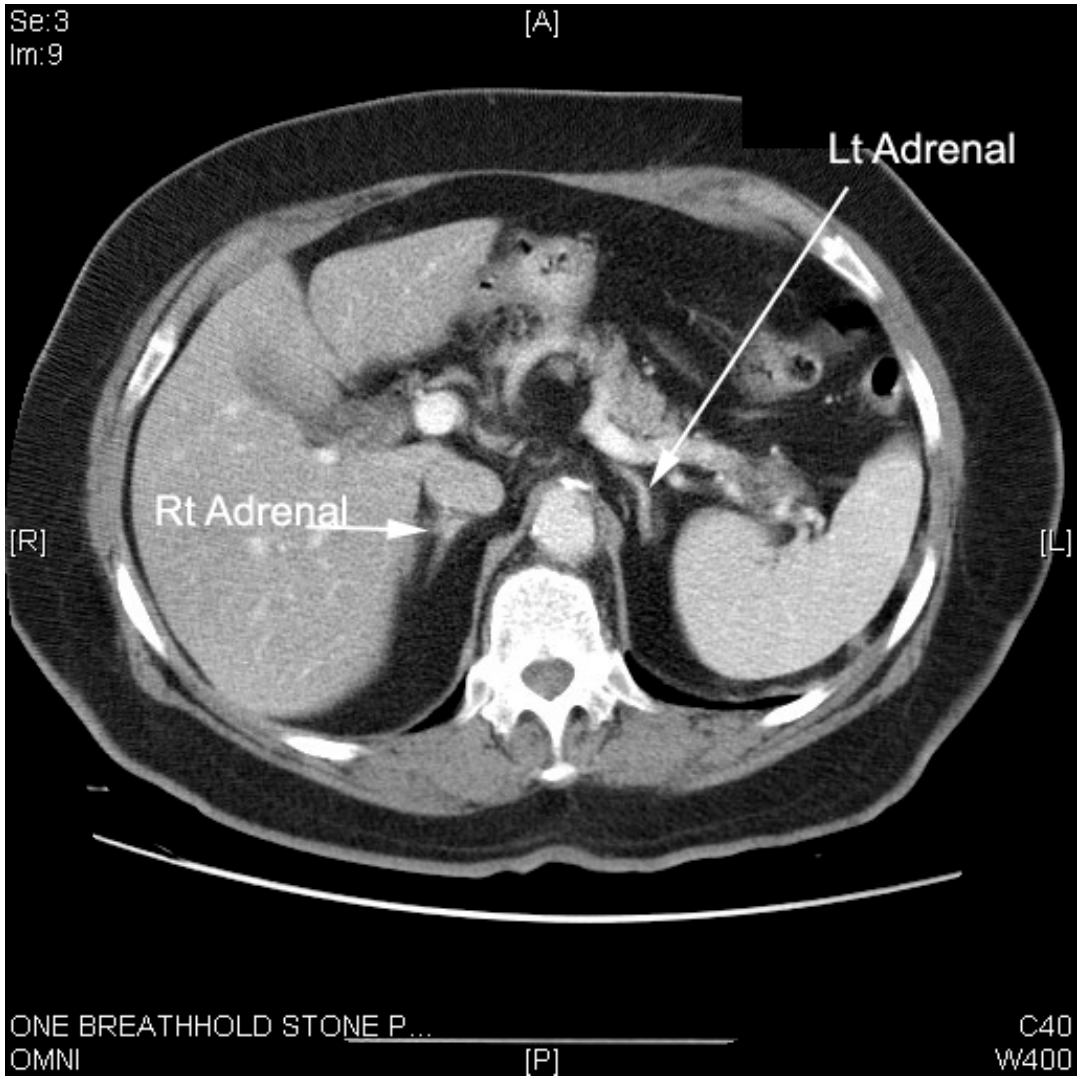
Left Renal Vein Passes Anterior to the Abdominal Aorta



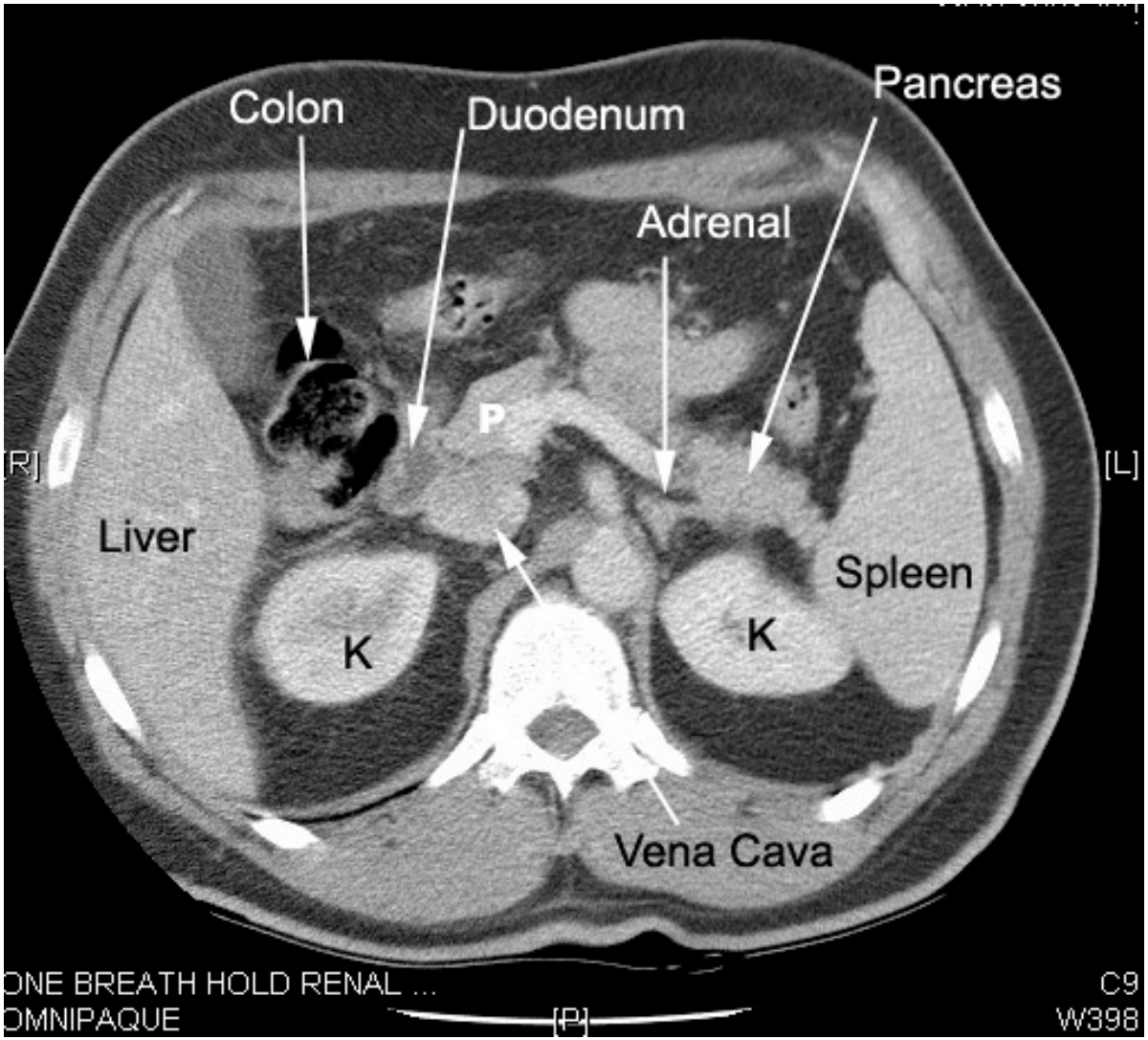
Renal Veins Lie Anterior to the Arteries

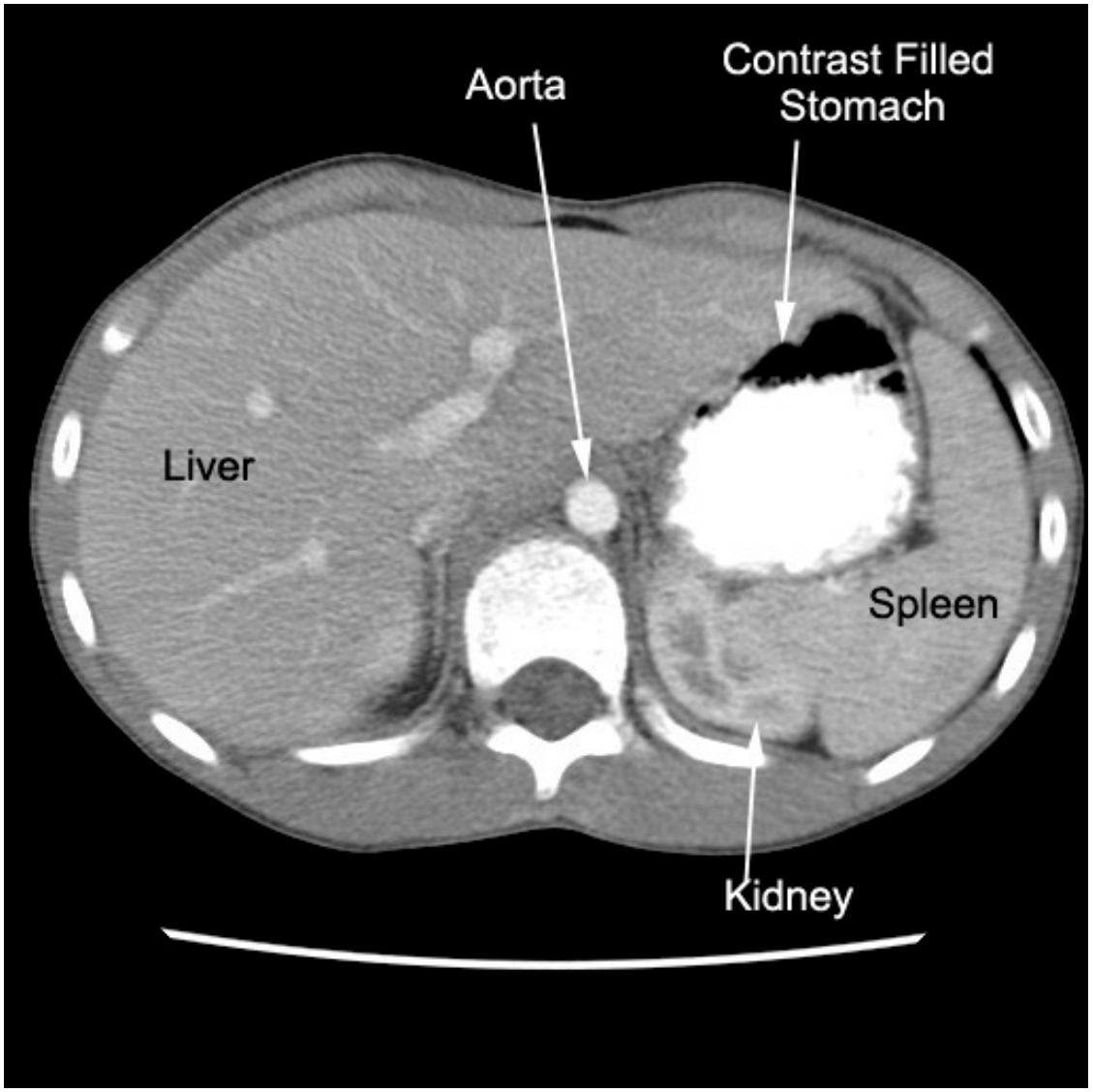

Red: Arterial flow
Blue: Venous flow
Dark: Collecting system
filled with urine

Relationships of the Kidneys



Adrenal Glands are superior to the Kidneys


Colon
Duodenum
Pancreas
Adrenal
P
[R]
[L]
Liver
Spleen
K
K
Vena Cava
ONE BREATH HOLD RENAL ...
OMNIPAQUE
[P]
C9
W398


Aorta
Contrast Filled Stomach
Liver
Spleen
Kidney

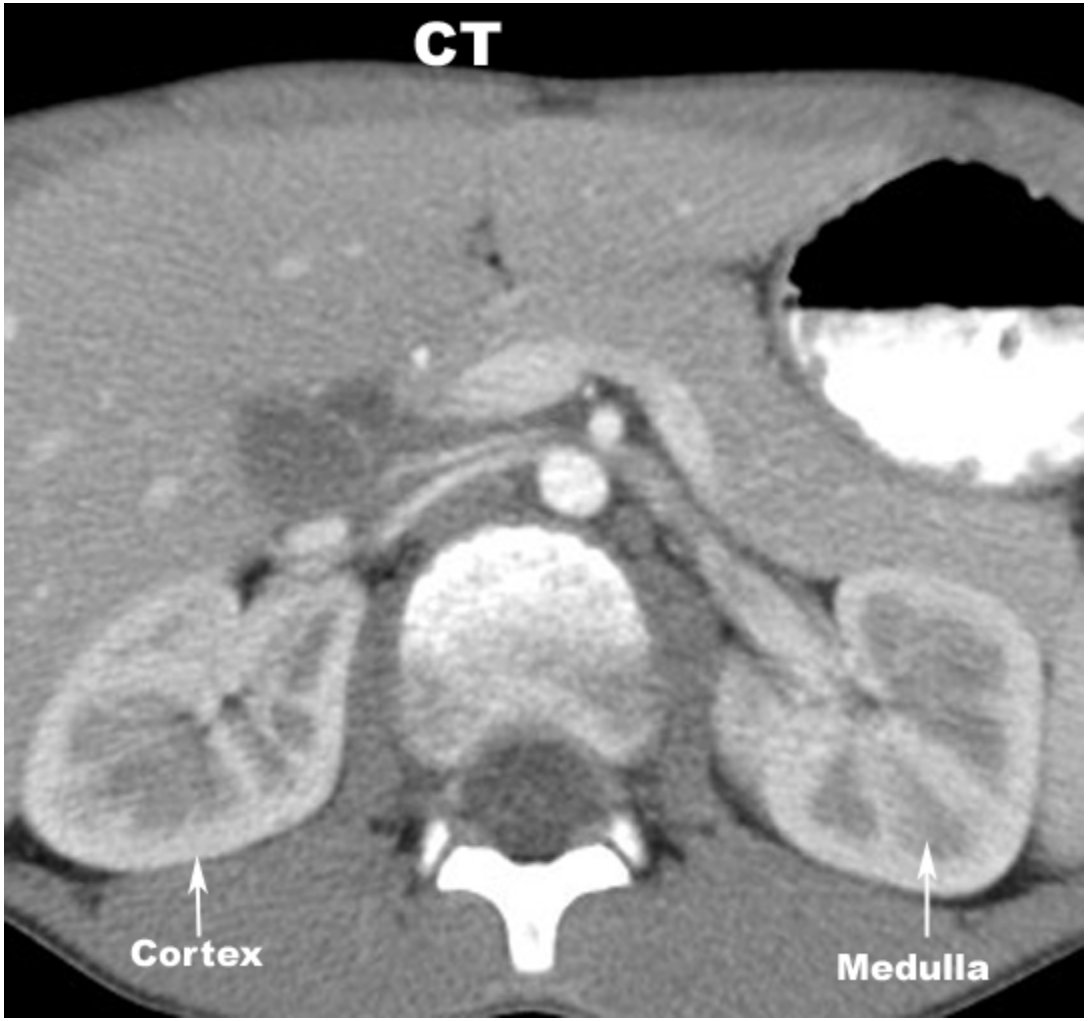
Renal Structure

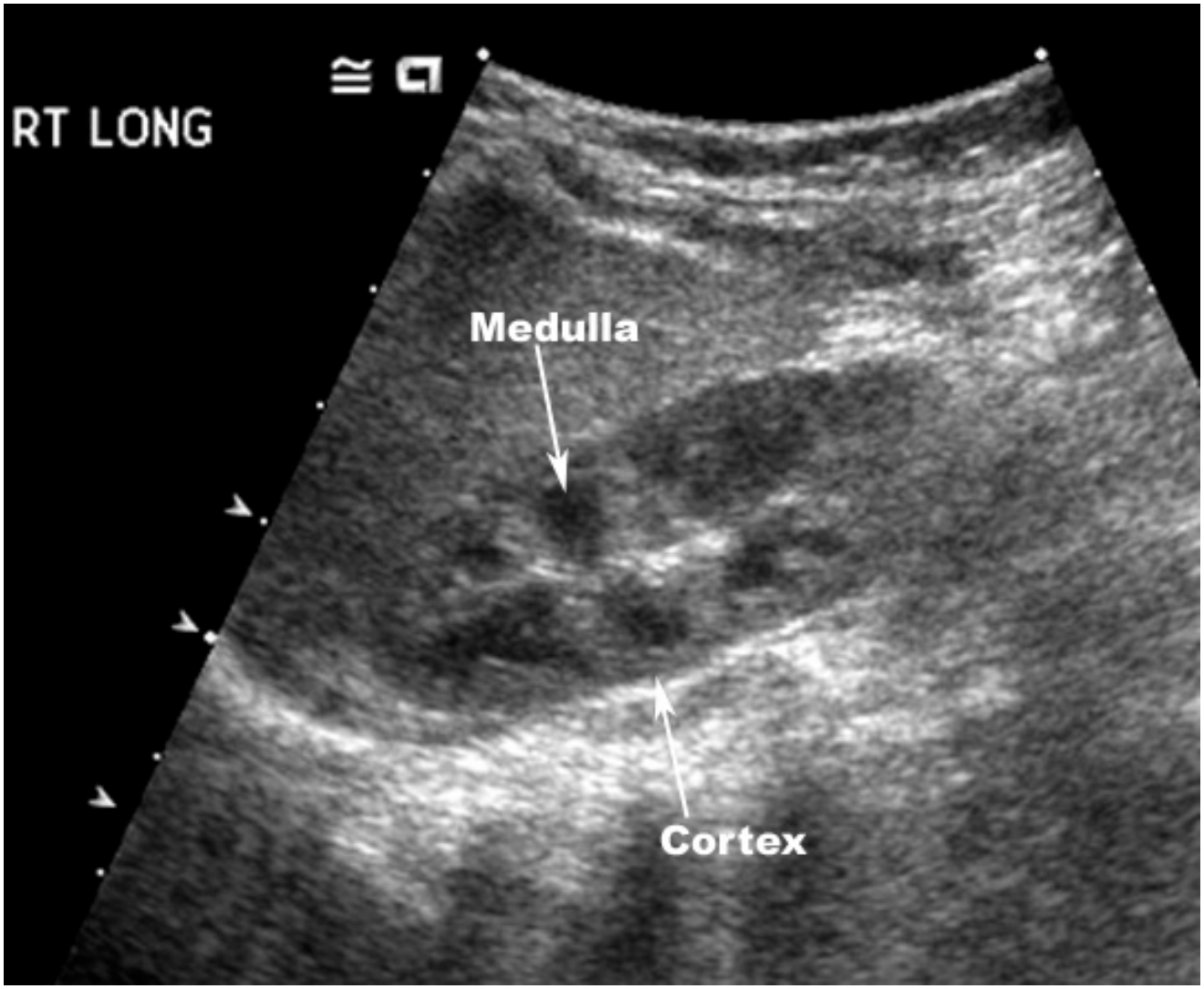
Cortex

- Renal cortex consists of glomeruli and renal tubules
- Normal thickness is 2.5 cm

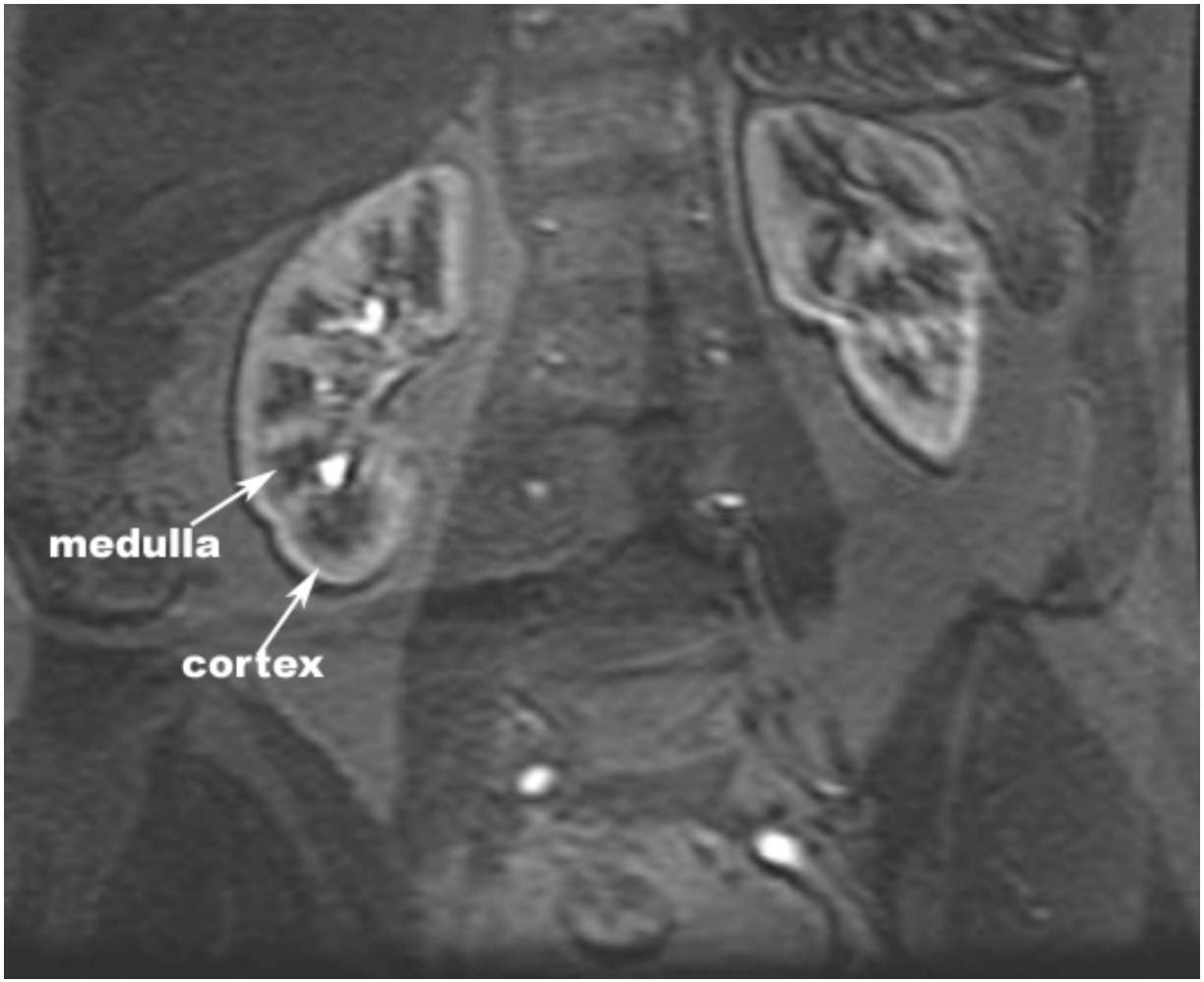
Medulla

- Consists of multiple renal pyramids

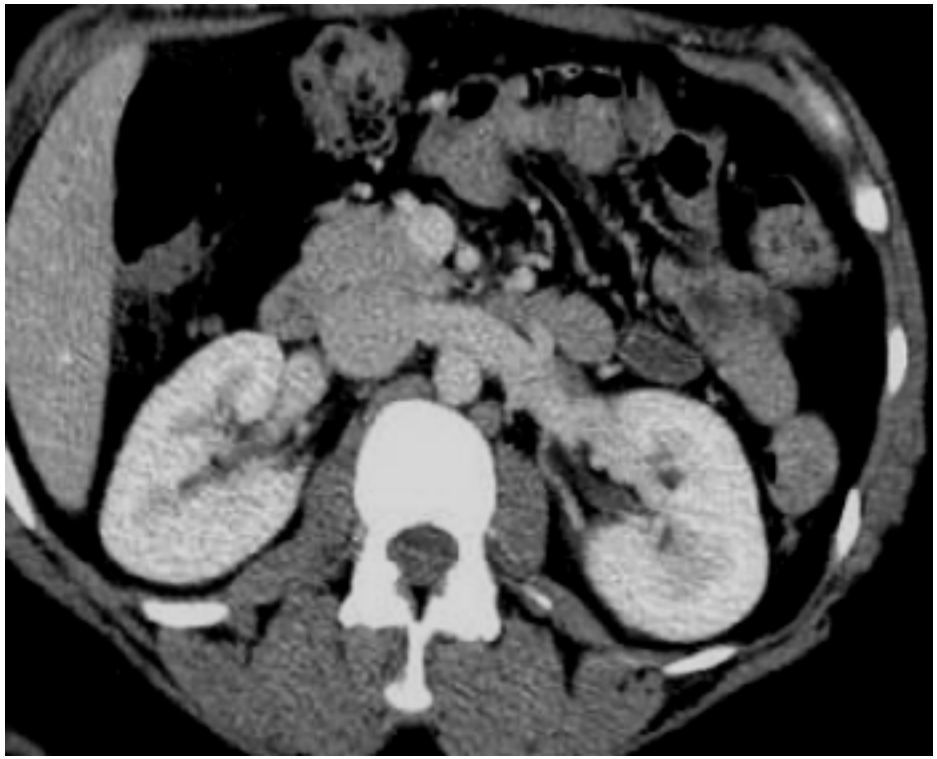

CT
Cortex
Medulla



Ultrasound of Right Kidney

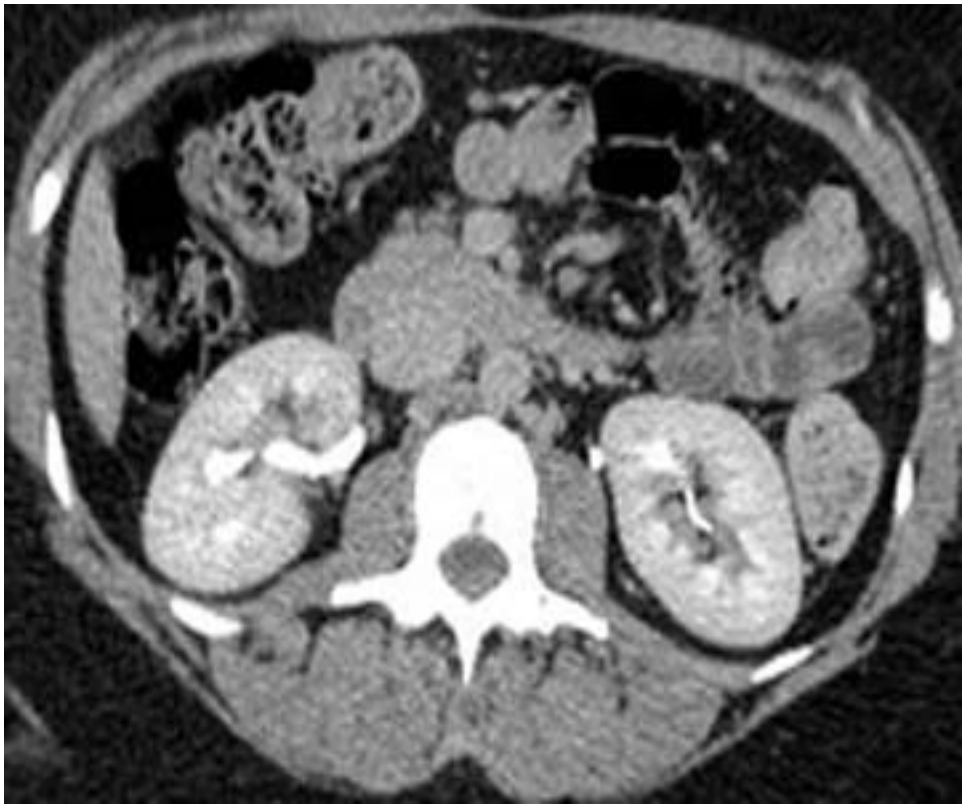


MRI of Kidneys



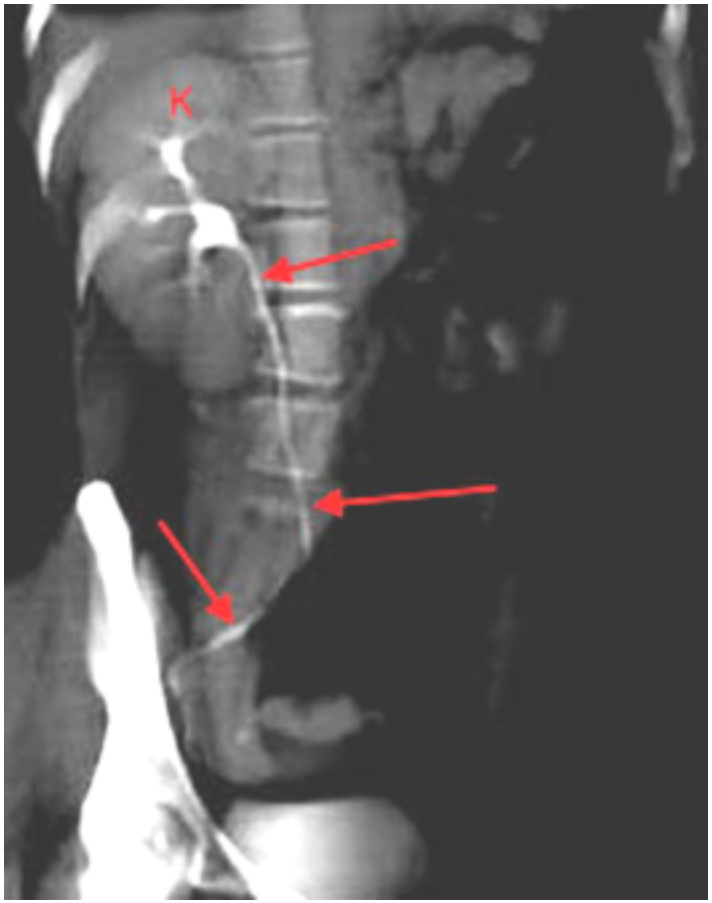
Contrast enhanced CT scan through the kidneys in nephrogram phase (showing corticomedullary differentiation)

This is approximately 100 seconds following contrast administration and would show renal lesions well



Contrast enhanced CT scan through the kidneys in *pyelogram phase* (showing excretion of contrast into the collecting system)

This is approximately 8 minutes following contrast administration and would show *urothelial lesions* well, such as transitional cell carcinoma, stones, blood clots



3D reconstructed image from CT scan of the abdomen and pelvis known as **CT urography**

Nowadays, this exam is quickly replacing the conventional IVU

3D reconstruction is performed through the right kidney (K) and follows the normal ureter (arrows) all the way to the ureter's insertion into the bladder

Renal Collecting System

Calyces

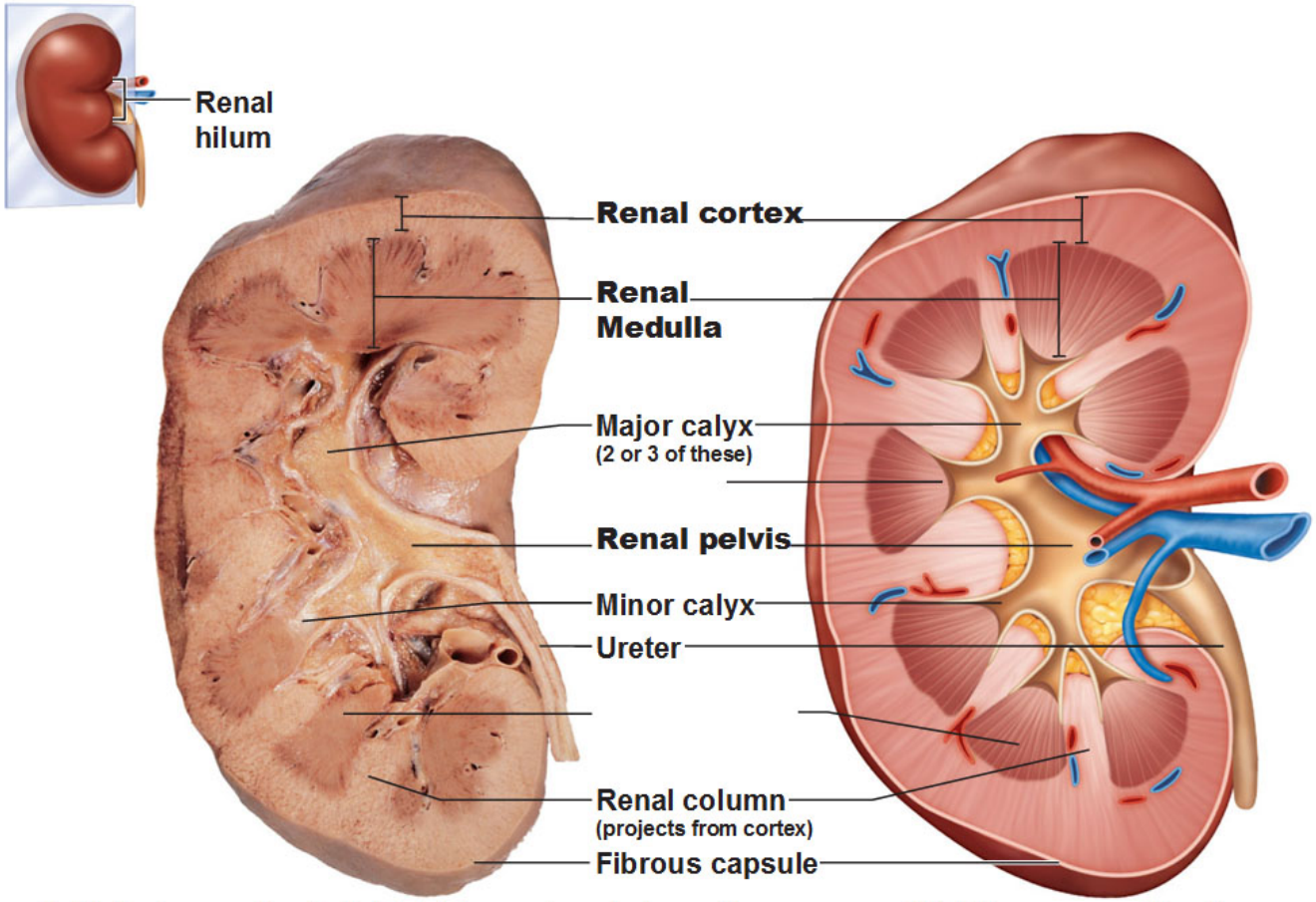
- Medulla sits in the fornix of the minor calyx
- Papillae drain into minor calyces
- Minor calyces coalesce to form 3 or 4 major calyces
- Major calyces combine to form the pelvis

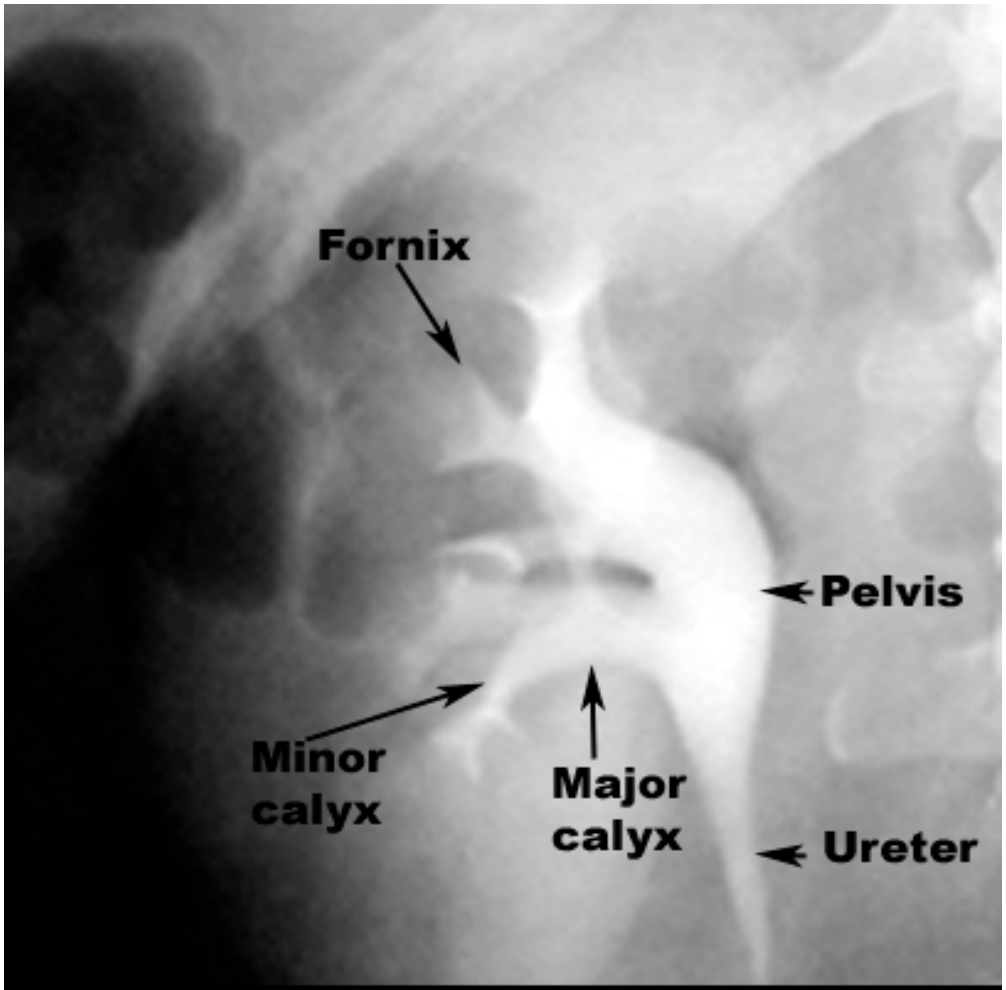
Renal Collecting System

Pelvis

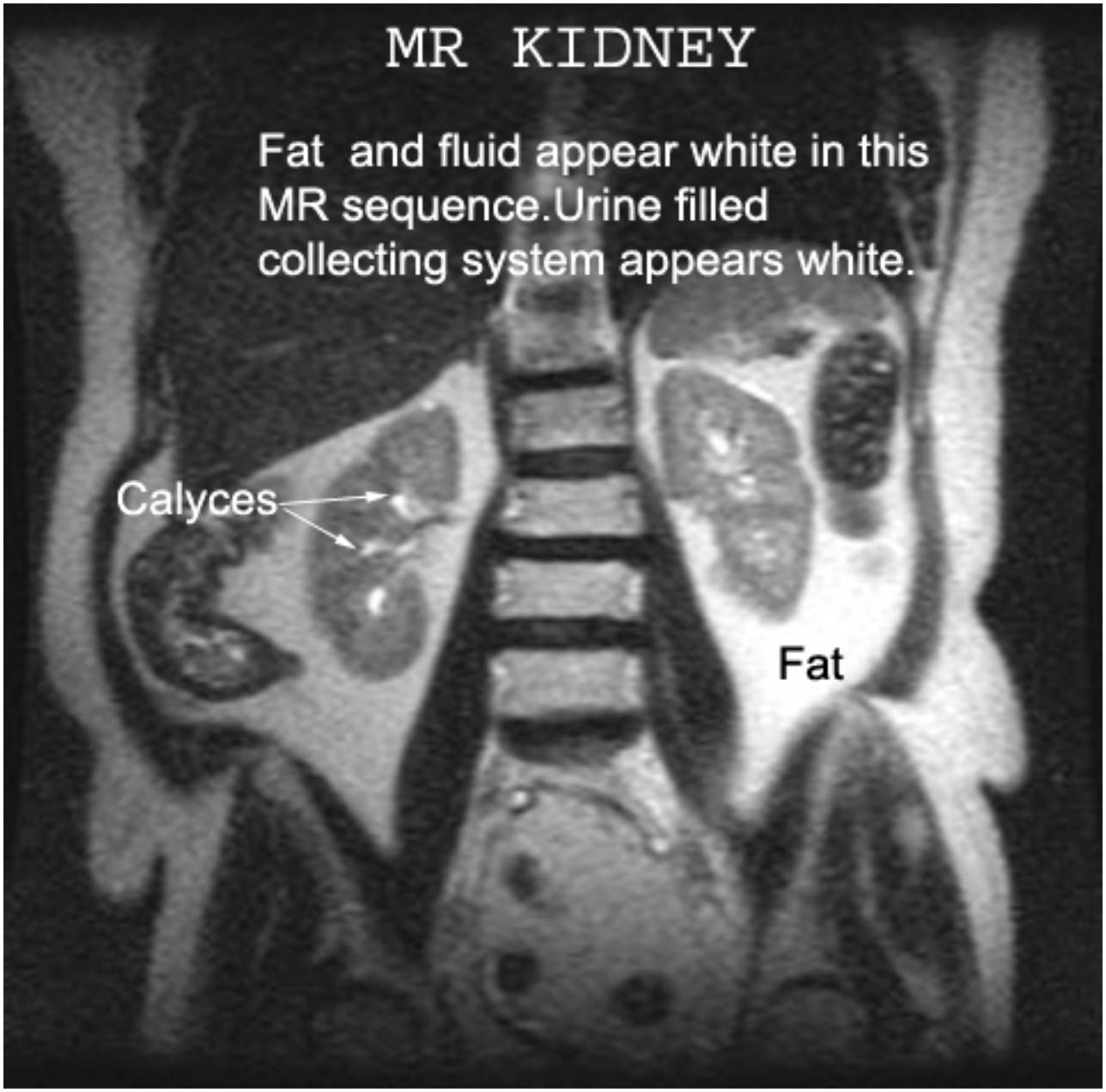
- broad dilated part of the urine collecting system, located in the hilum
- renal pelvis drains into the ureter

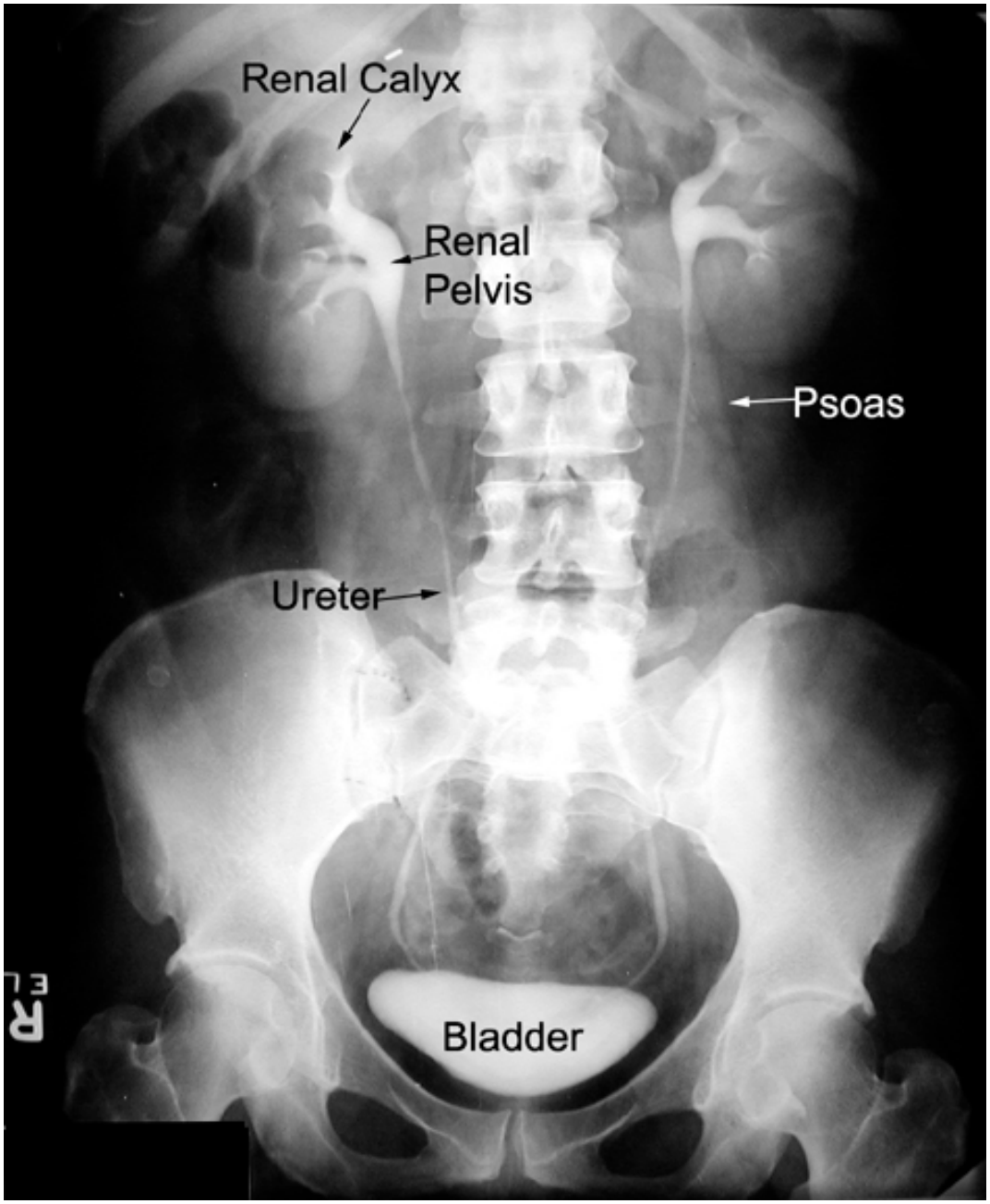
Internal Gross Anatomy of the Kidneys





Pappilae positioned in the apex of pyramids drain into the fornix of the minor calyces. They join to form 3 or 4 major calyces,which join to form the renal pelvis. The renal pelvis drains into a muscular tube called the ureter.


MR KIDNEY
Fat and fluid appear white in this MR sequence.Urine filled collecting system appears white.
Calyces
Fat


Renal Calyx
Renal Pelvis
Psoas
Ureter
Bladder

Ureters

Ureters

25-30 cm in length and 3 mm diameter

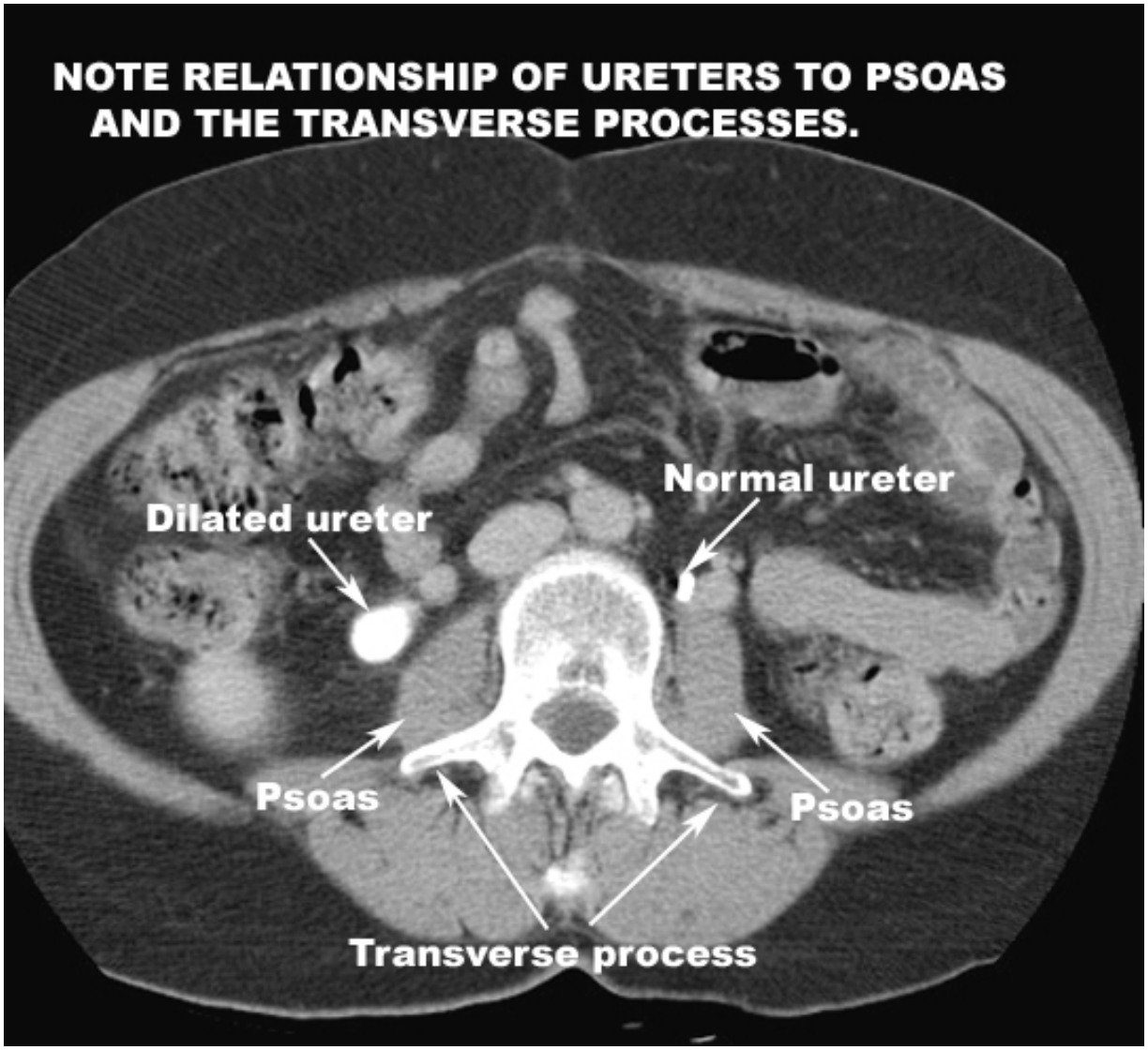
Areas of Narrowing

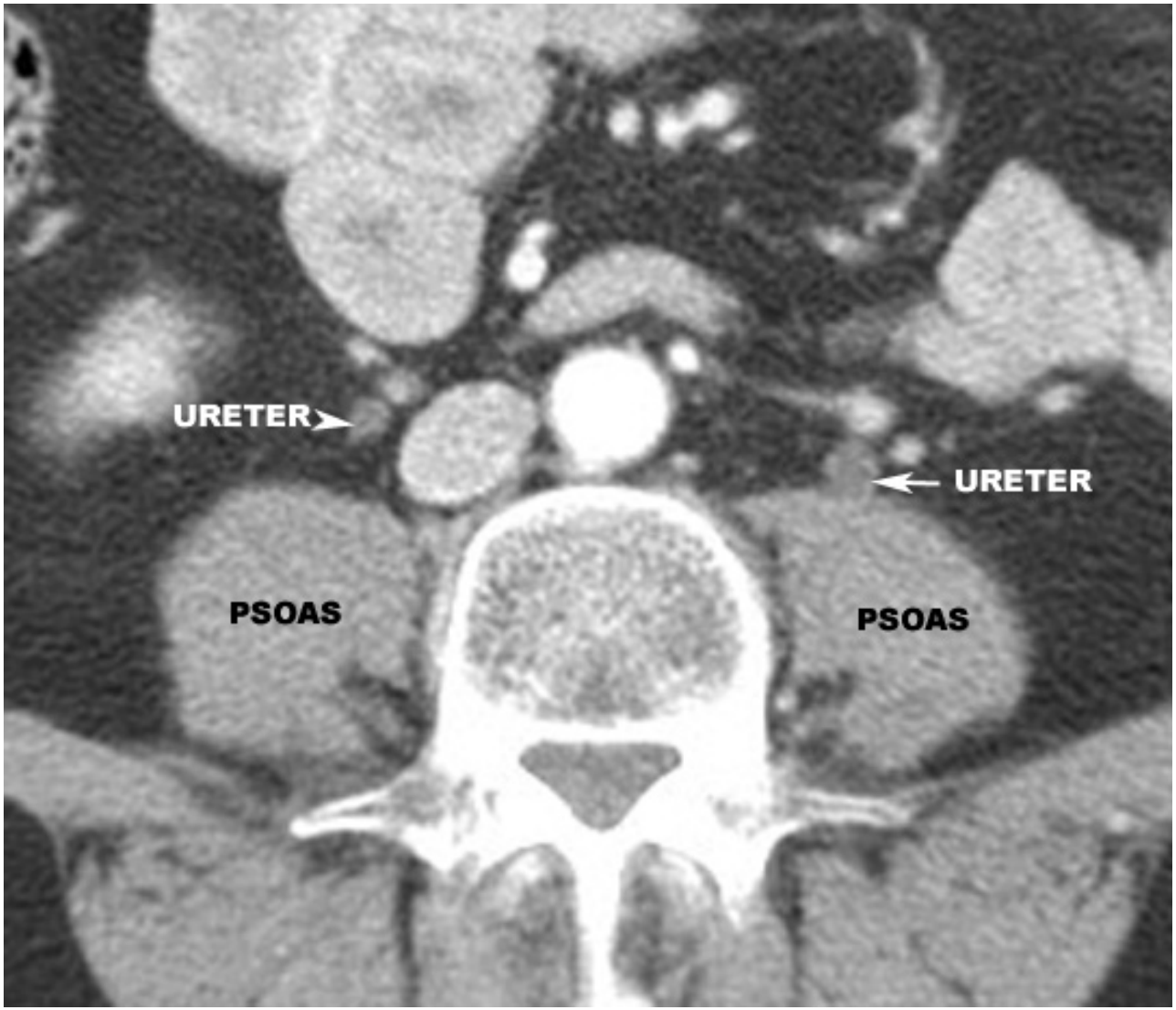
Three areas of normal narrowing:

Ureteropelvic Junction

Bifurcation of the iliac vessels

Ureterovesical Junction


NOTE RELATIONSHIP OF URETERS TO PSOAS
AND THE TRANSVERSE PROCESSES.
Dilated ureter
Normal ureter
Psoas
Psoas
Transverse process


URETER
URETER
PSOAS
PSOAS

Urinary Bladder

Urinary Bladder

Size and shape vary considerably

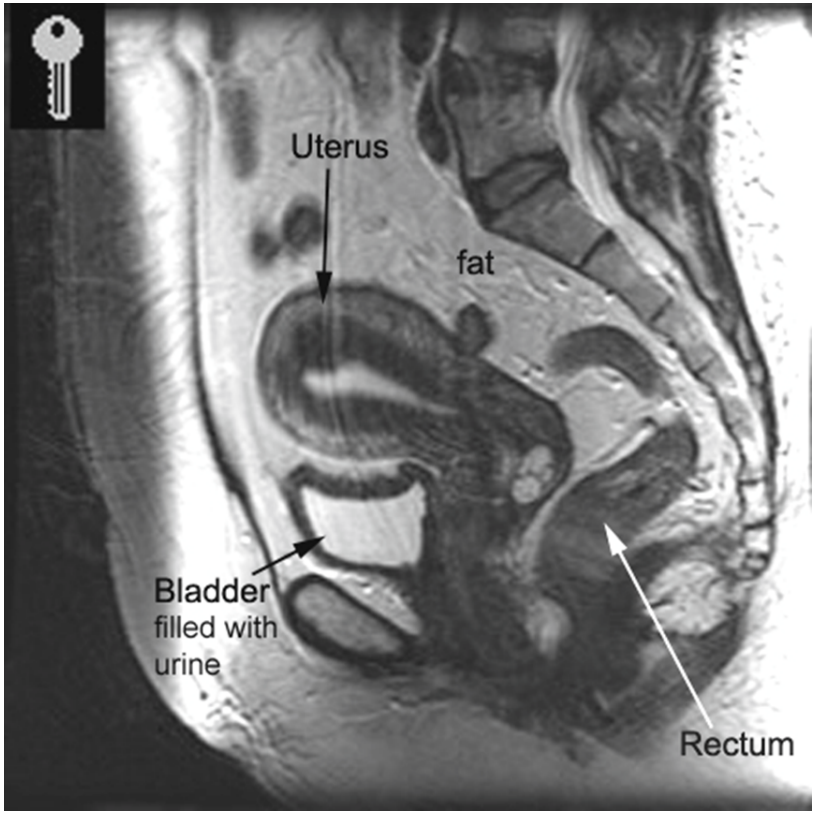
When empty, it is completely within the pelvis

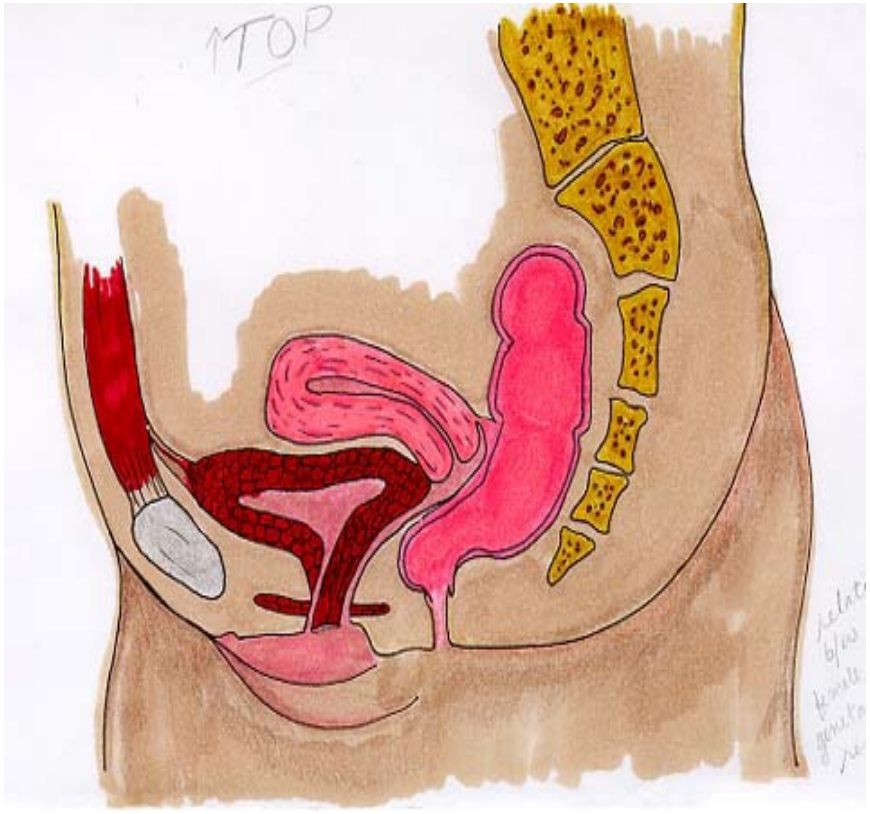
Dome is rounded in male and flat or slightly concave in female

Urinary Bladder

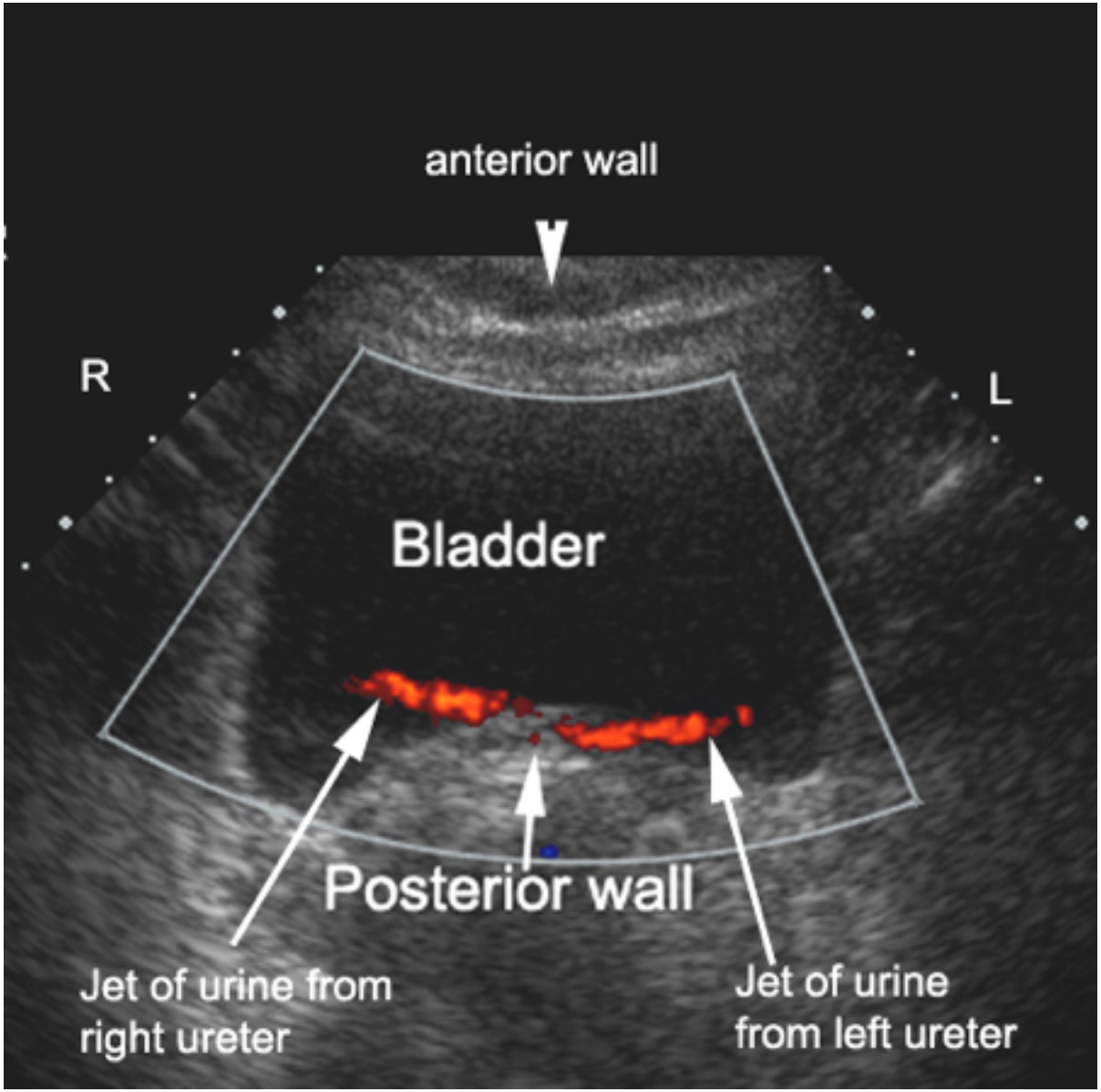
Bladder is relatively free to move except at the neck which is fixed by the puboprostatic ligaments (males) and pubovesicle ligaments (females)

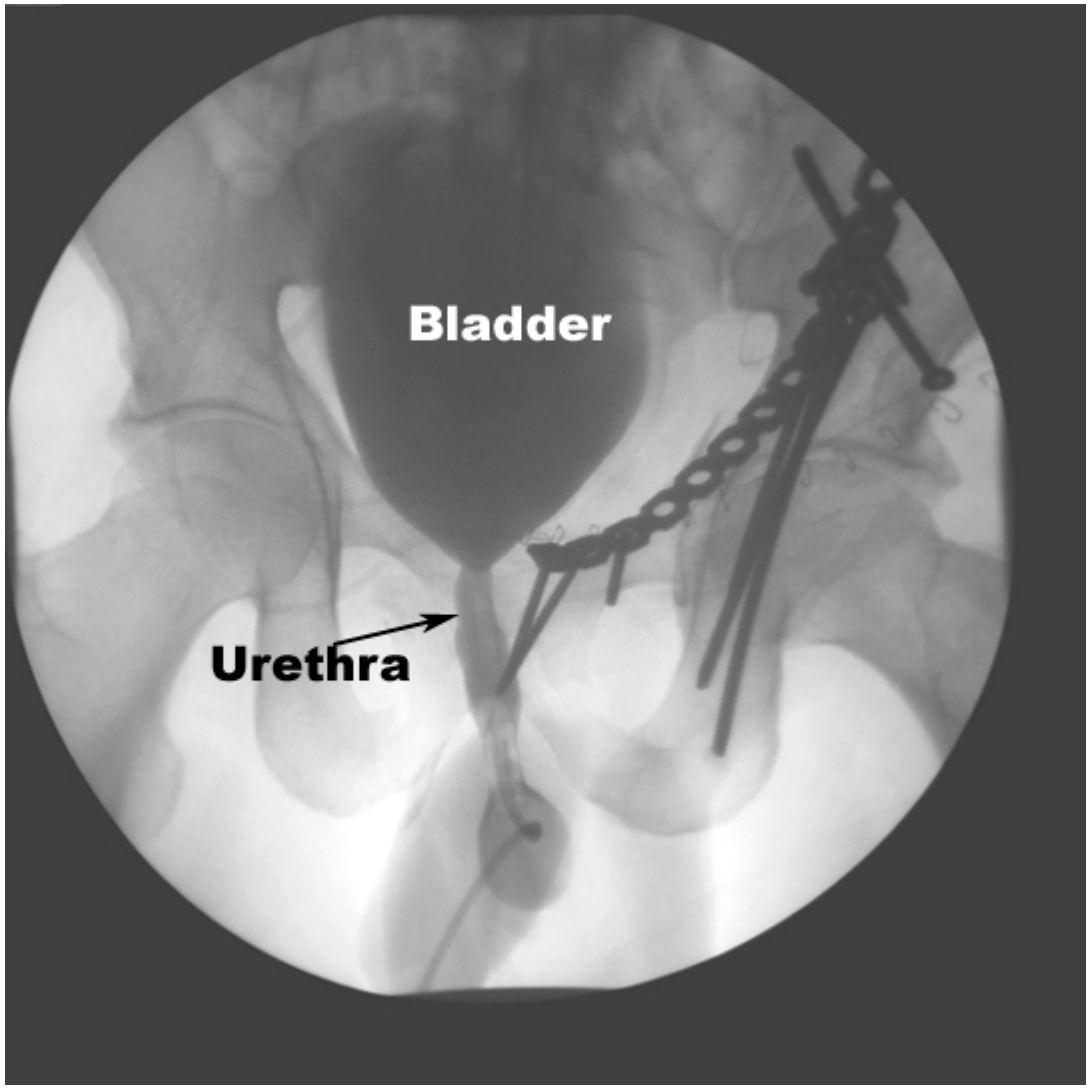
Peritoneal reflection - Rectovesicle pouch in males and vesicouterine and rectouterine pouch in females

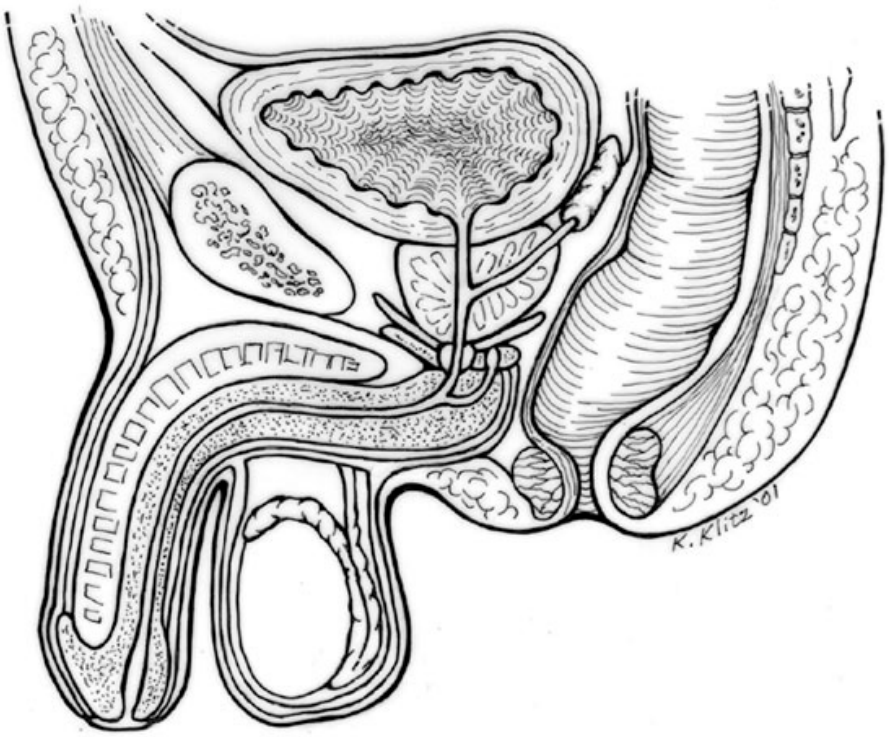




Anatomy of Female Pelvis showing the Urinary Bladder

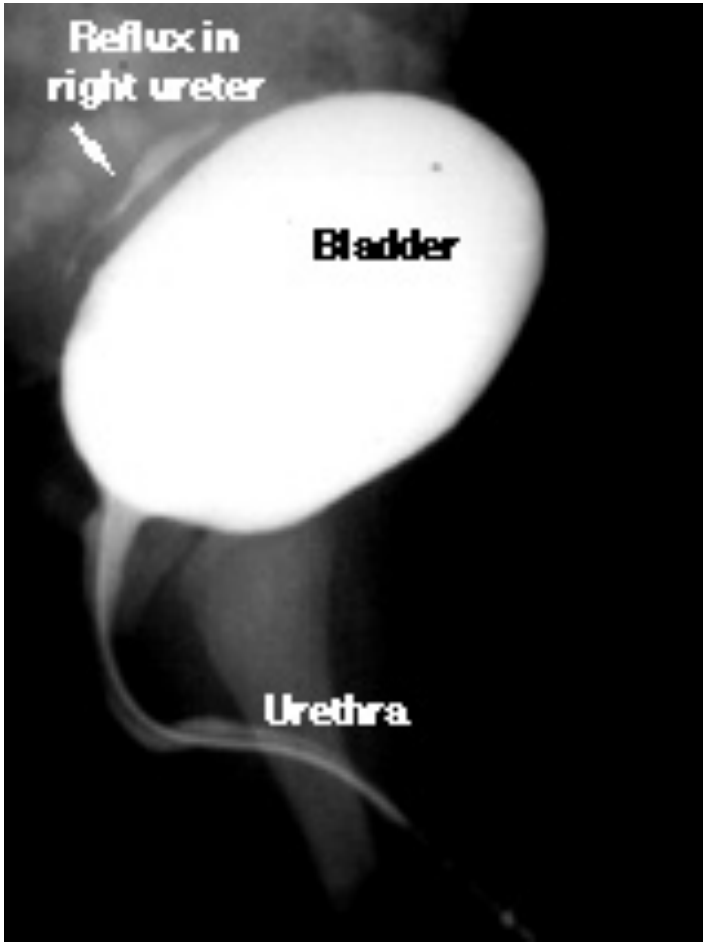

anterior wall
R
L
Bladder
Posterior wall
Jet of urine from
right ureter
Jet of urine
from left ureter


Bladder
Urethra

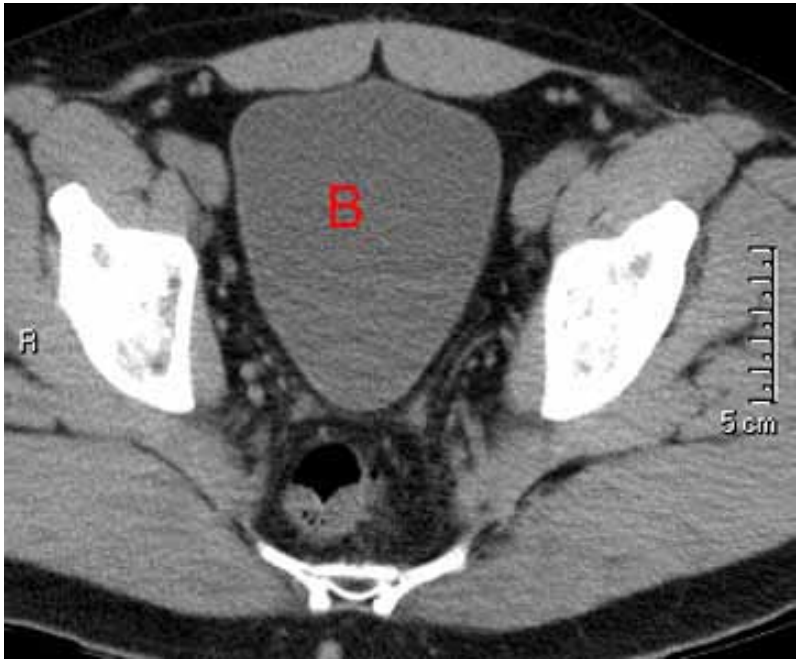


Anatomy of Male Pelvis showing the Urinary Bladder

Voiding Cystourethrogram

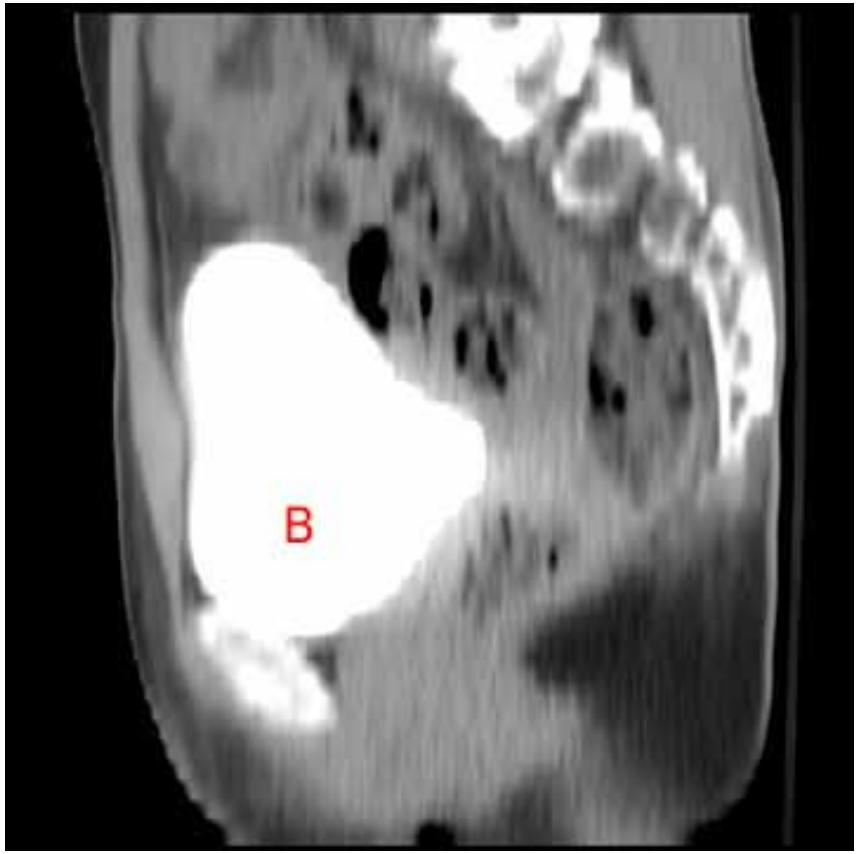


Urinary Bladder



Unenhanced CT scan through a normal bladder (B) shows a normal fluid density structure (less than 10 Hounsfield units on CT density scale)

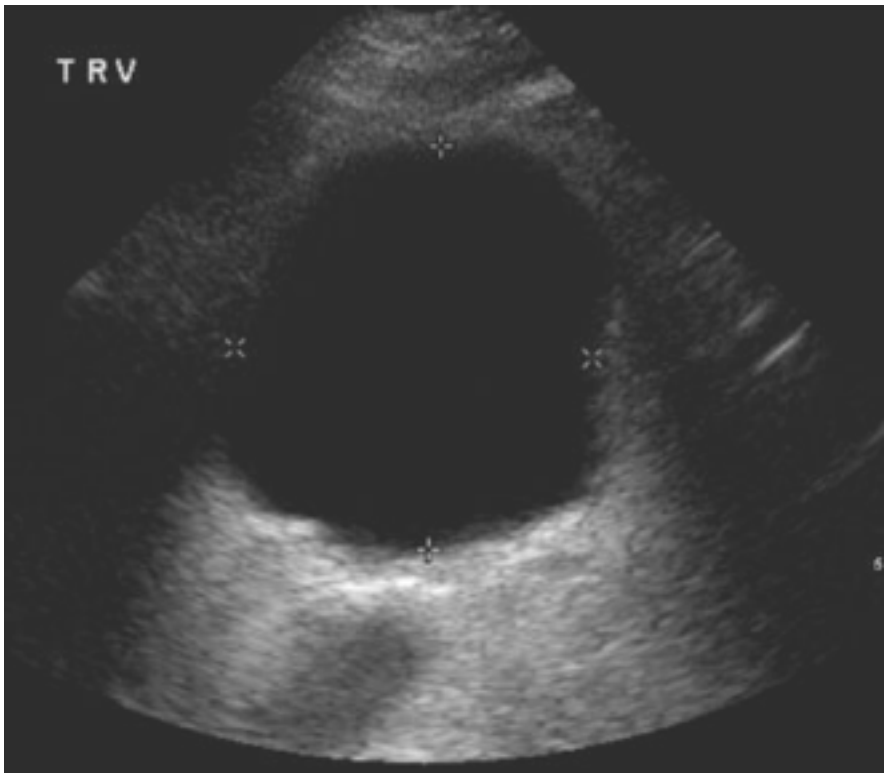
Urinary Bladder



3D reconstructed image of a normal bladder in the sagittal plane following CT urography

This is delayed image 10 minutes following IV contrast administration, excreted contrast fills an otherwise normal bladder (B)

Urinary Bladder



Transverse image through a normal urinary bladder (calipers "x" and "+" outline the bladder wall) using ultrasound shows normal anechoic structure (anechoic = no echoes = black)

Prostate Gland

Prostate Gland

Largest accessory gland of male reproductive system

Lies around the first part of the urethra at the base of the bladder

(Tr) 4 cm x 3 cm (height) x 2 cm (AP) in size

Surrounded by dense fibrous capsule

Prostate Gland

Base – closely related to neck of bladder

Apex

Posterior surface

Anterior surface

Anterolateral surfaces

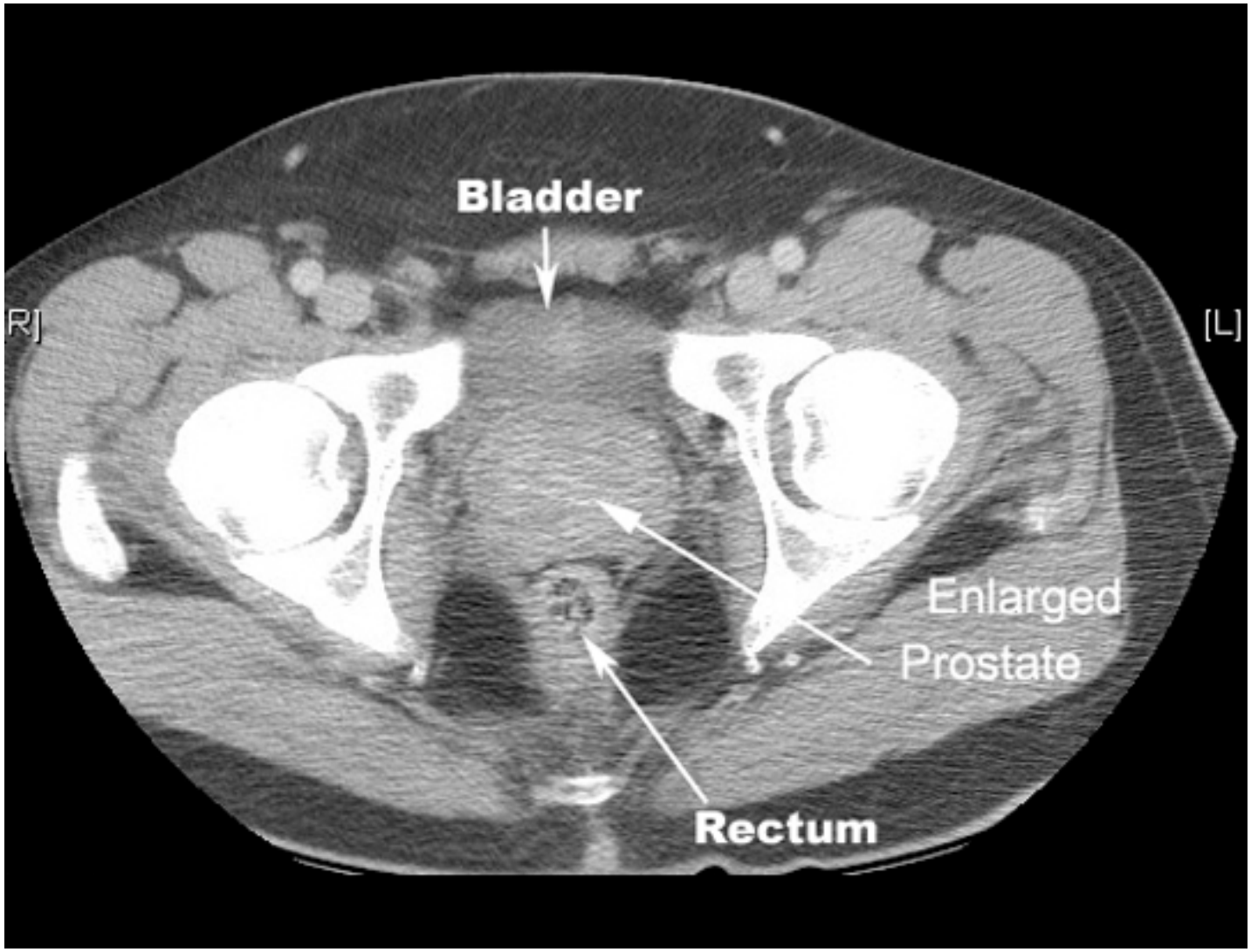
Prostate Gland

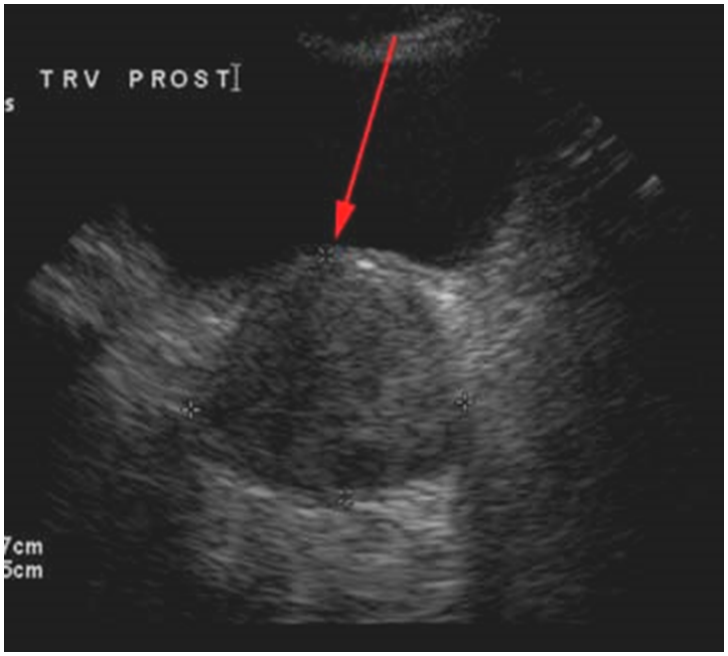
Prostate gland can be divided into

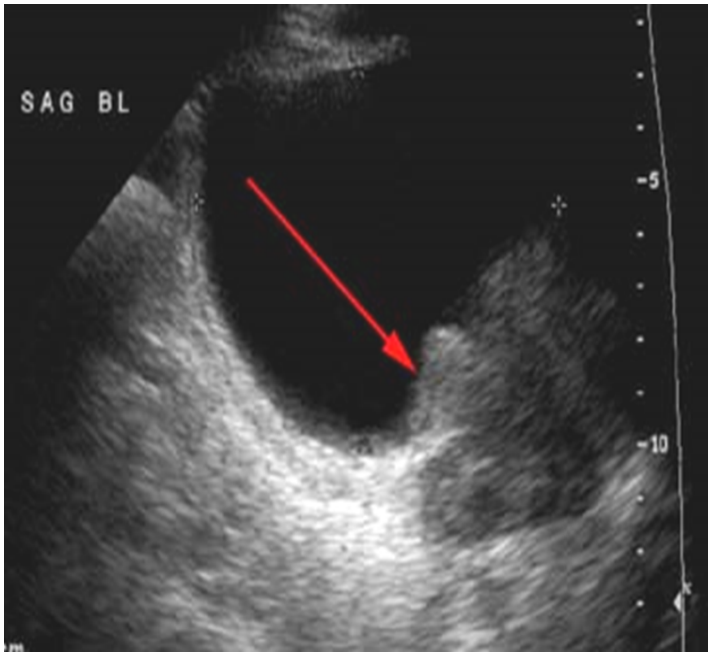
- An inner gland –transition zone
- An outer gland – central and peripheral zones

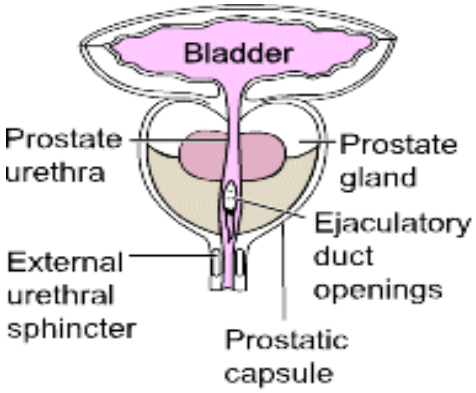
Transition zone which lies in periurethral location is the site of *benign* **prostate hypertrophy** which can occlude the urethra

Peripheral zone is the **primary tumor** site in 70% patients

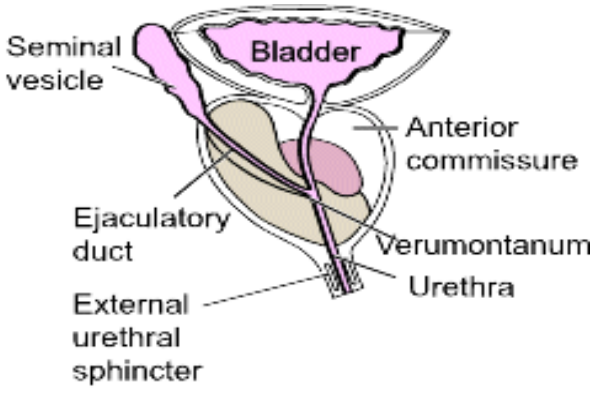

Bladder
R]
[L]
Enlarged
Prostate
Rectum





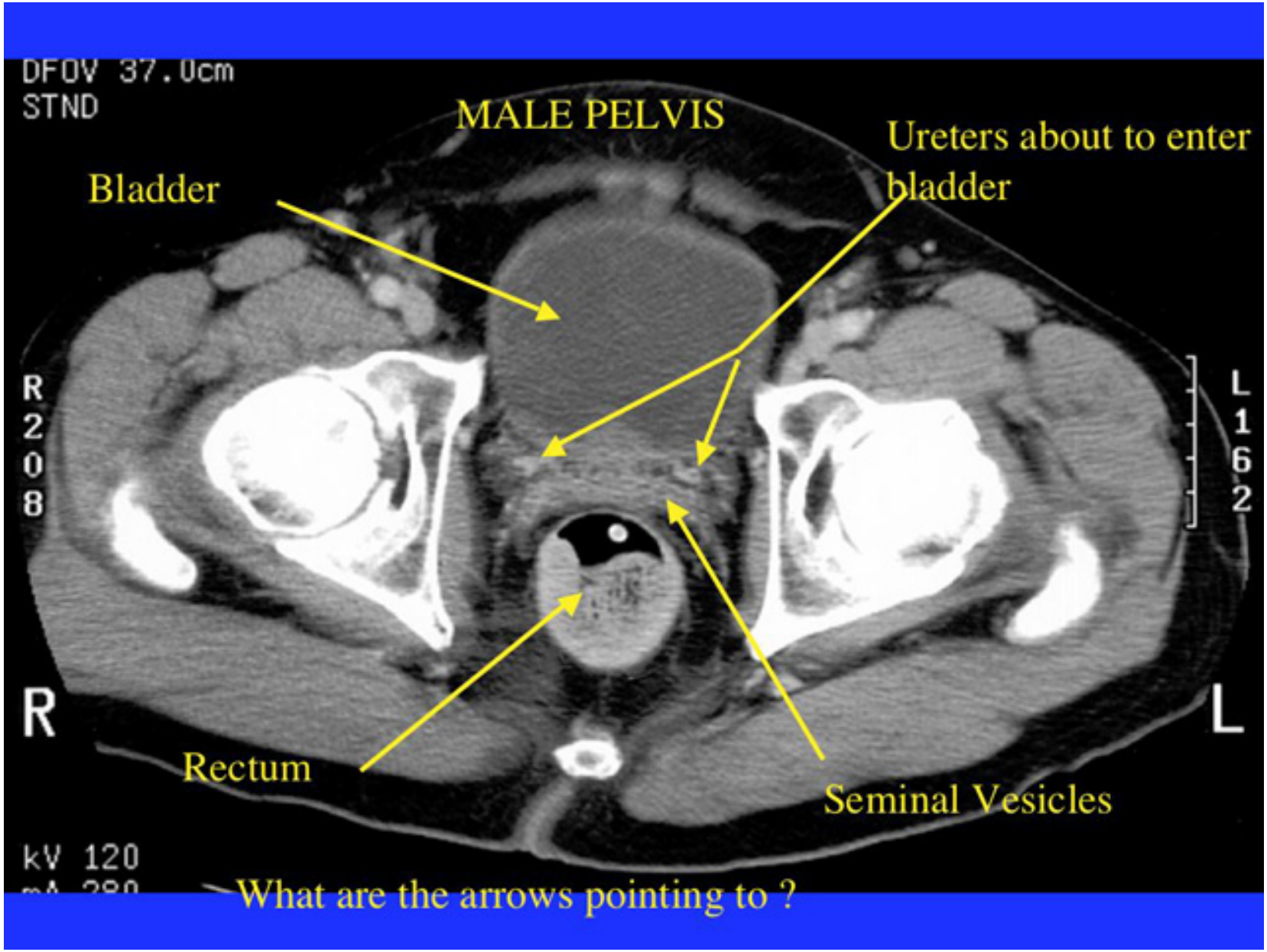


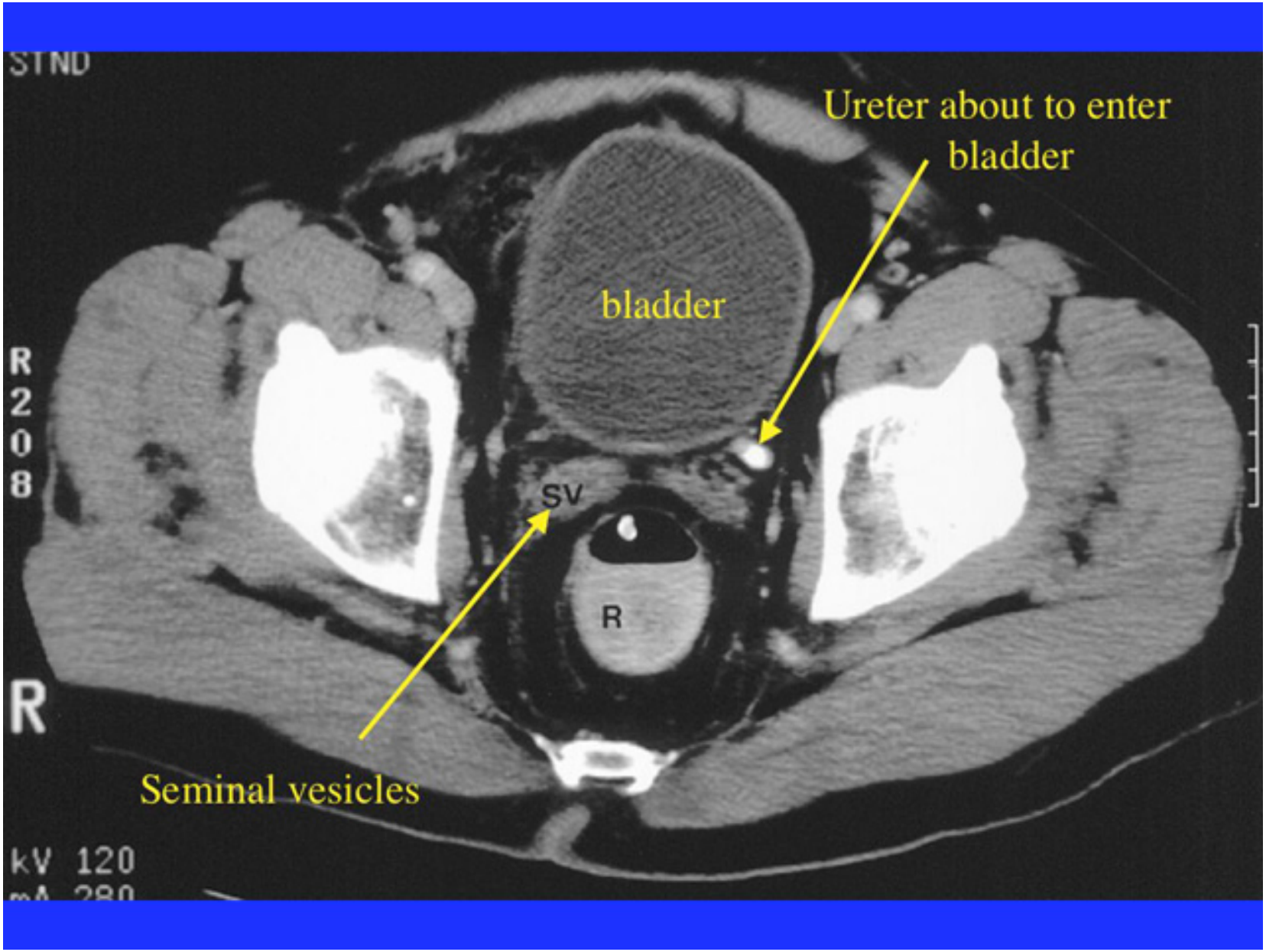
Frontal view of normal prostate

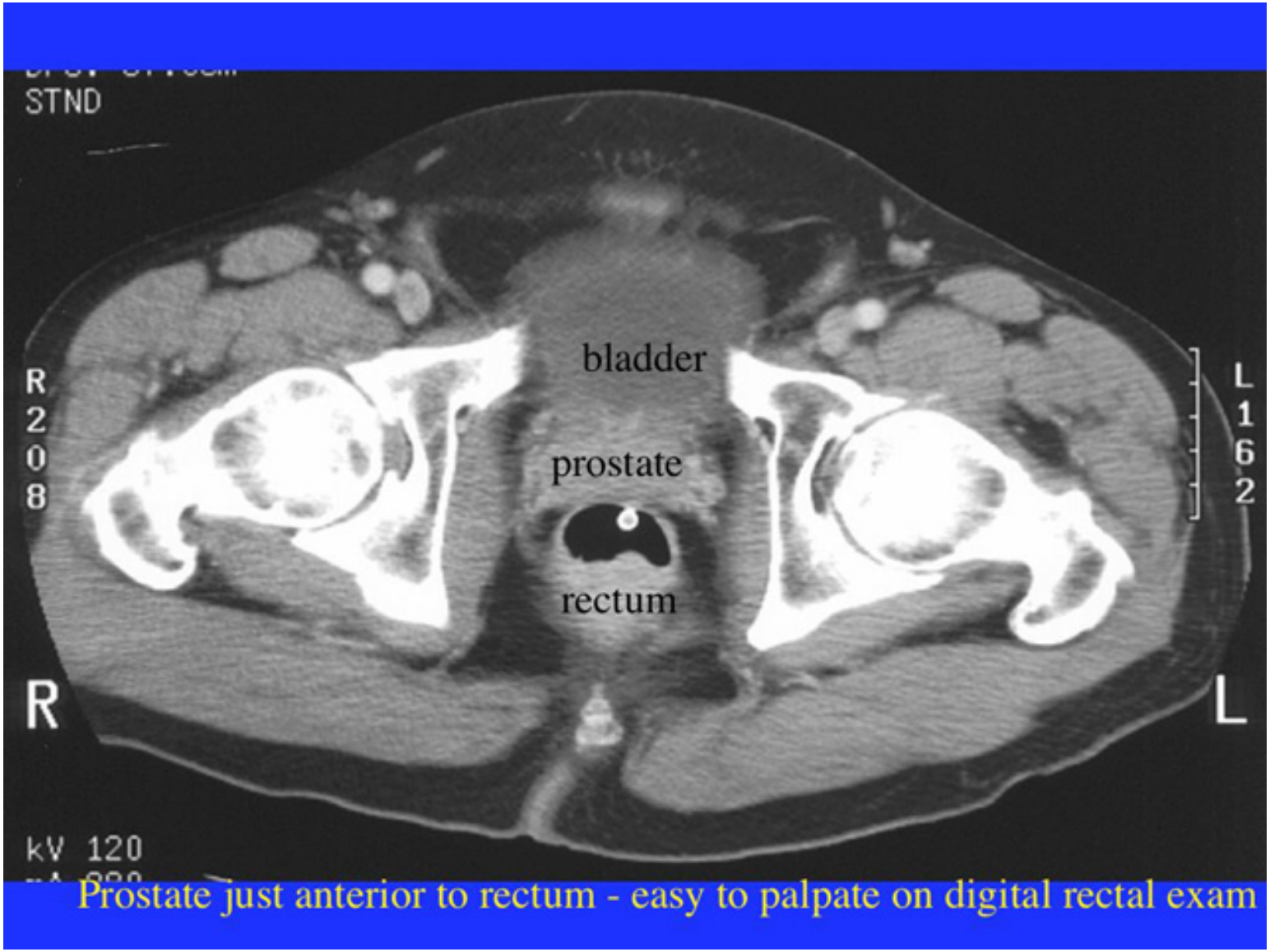


Saggital view of normal

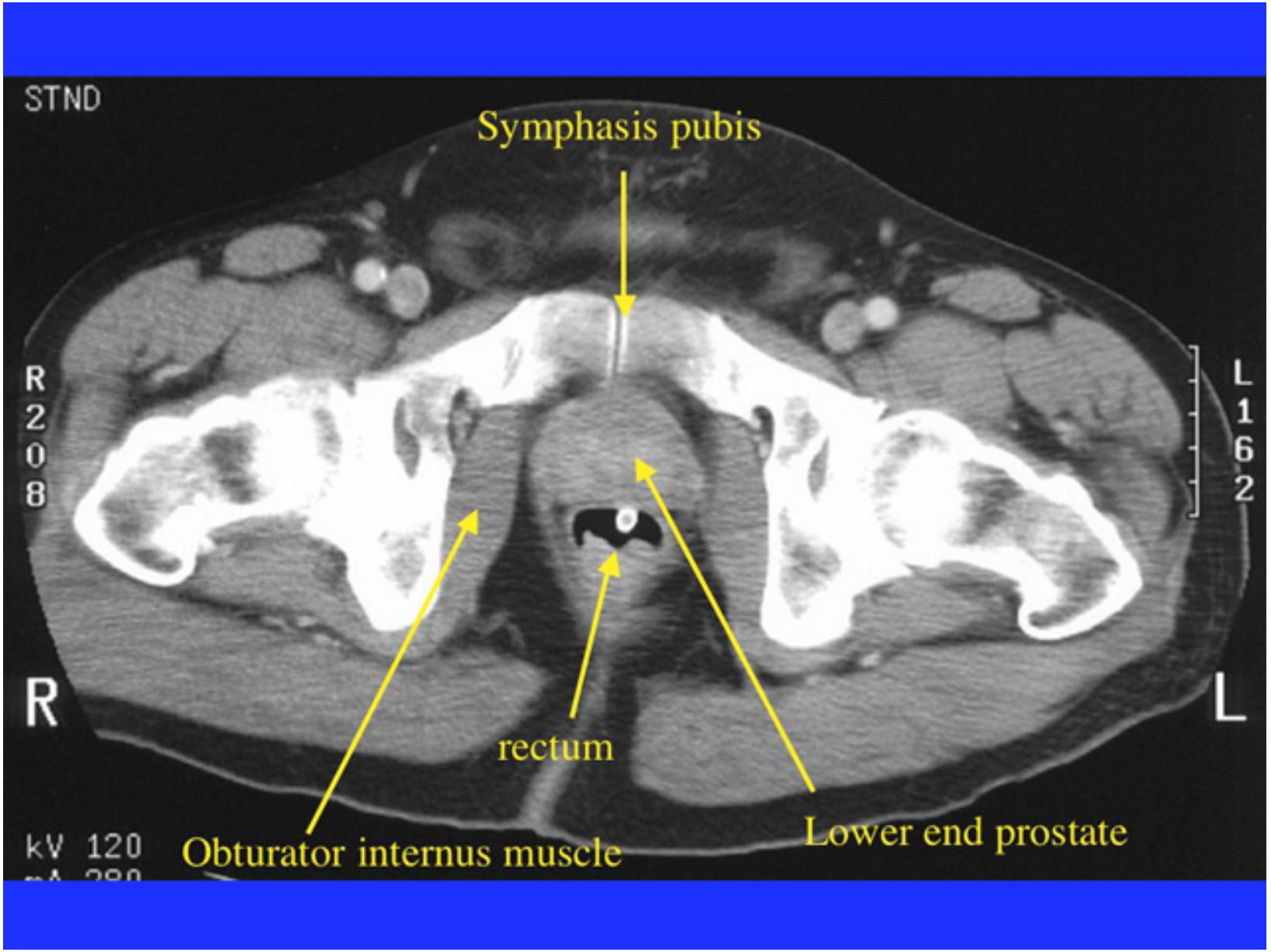
Peripheral zone Transition zone Central zone


DFOV 37.0cm
STND
MALE PELVIS
Bladder
Ureters about to enter bladder
R 208
L 162
R
L
Rectum
Seminal Vesicles
kV 120
What are the arrows pointing to ?

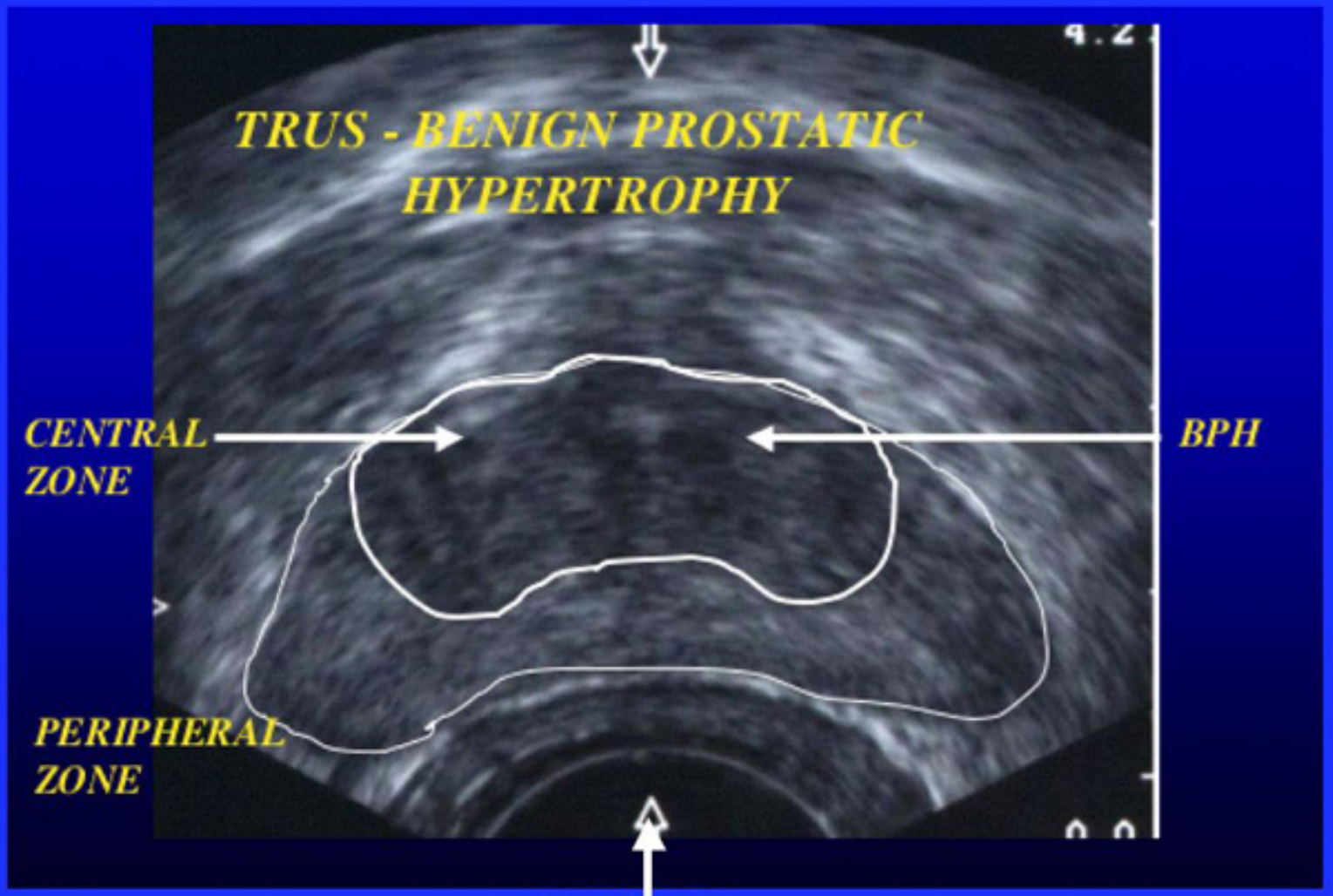

STND
Ureter about to enter bladder
bladder
R 2 0 8
SV
R
R
Seminal vesicles
kV 120

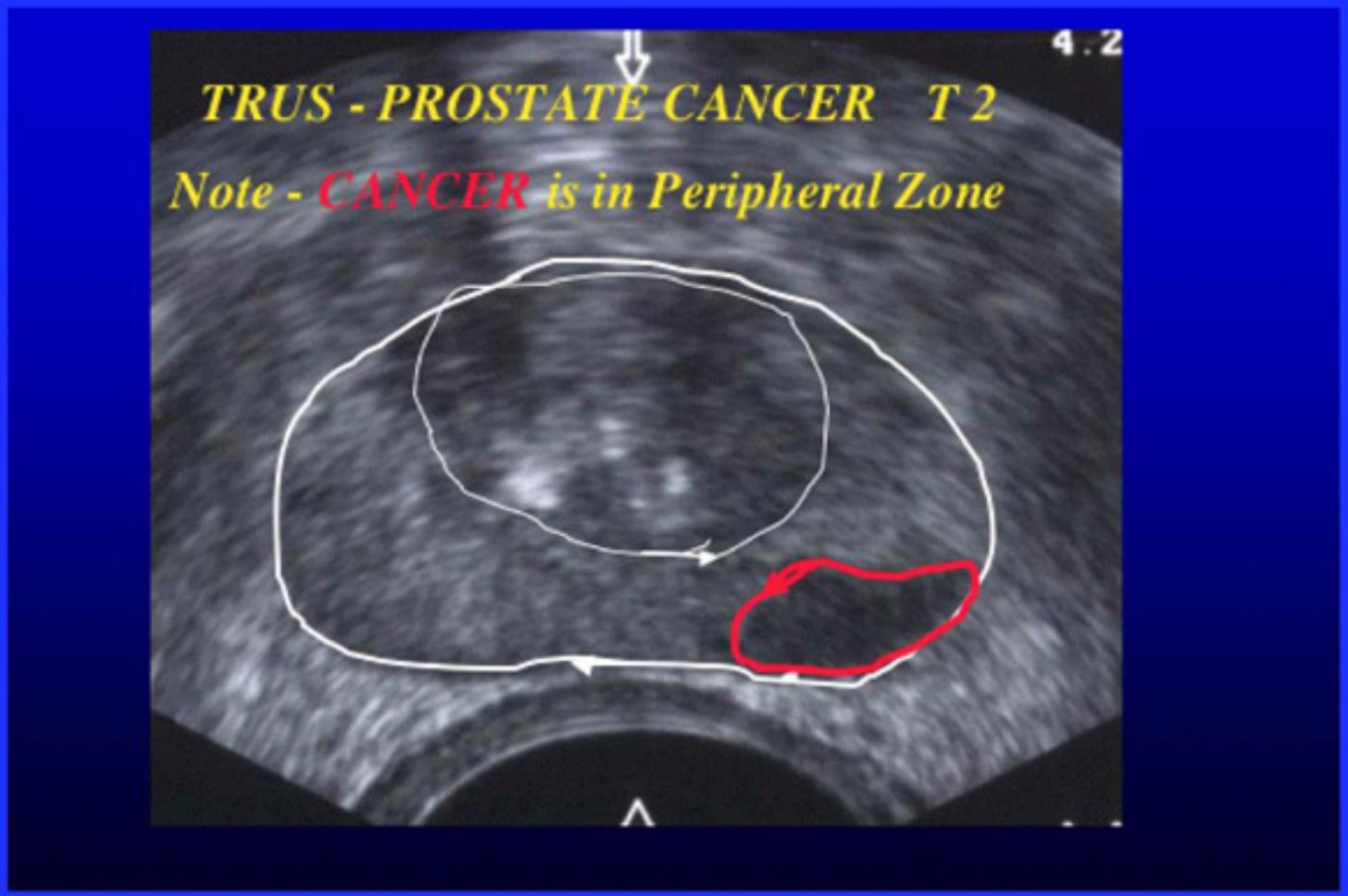


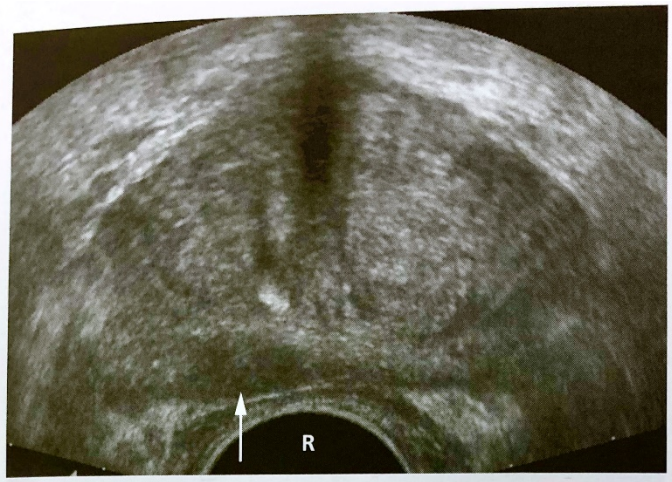
Prostate just anterior to rectum - easy to palpate on digital rectal exam


STND
Symphasis pubis
R
2
0
8
L
1
6
2
R
L
rectum
Obturator internus muscle
Lower end prostate
kV 120

TRANSRECTAL ULTRASOUND




4.2
TRUS - PROSTATE CANCER T 2
Note - CANCER is in Peripheral Zone



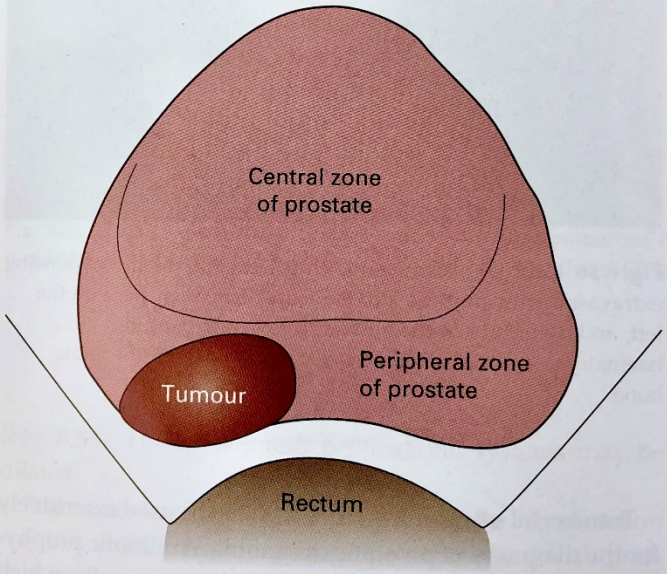
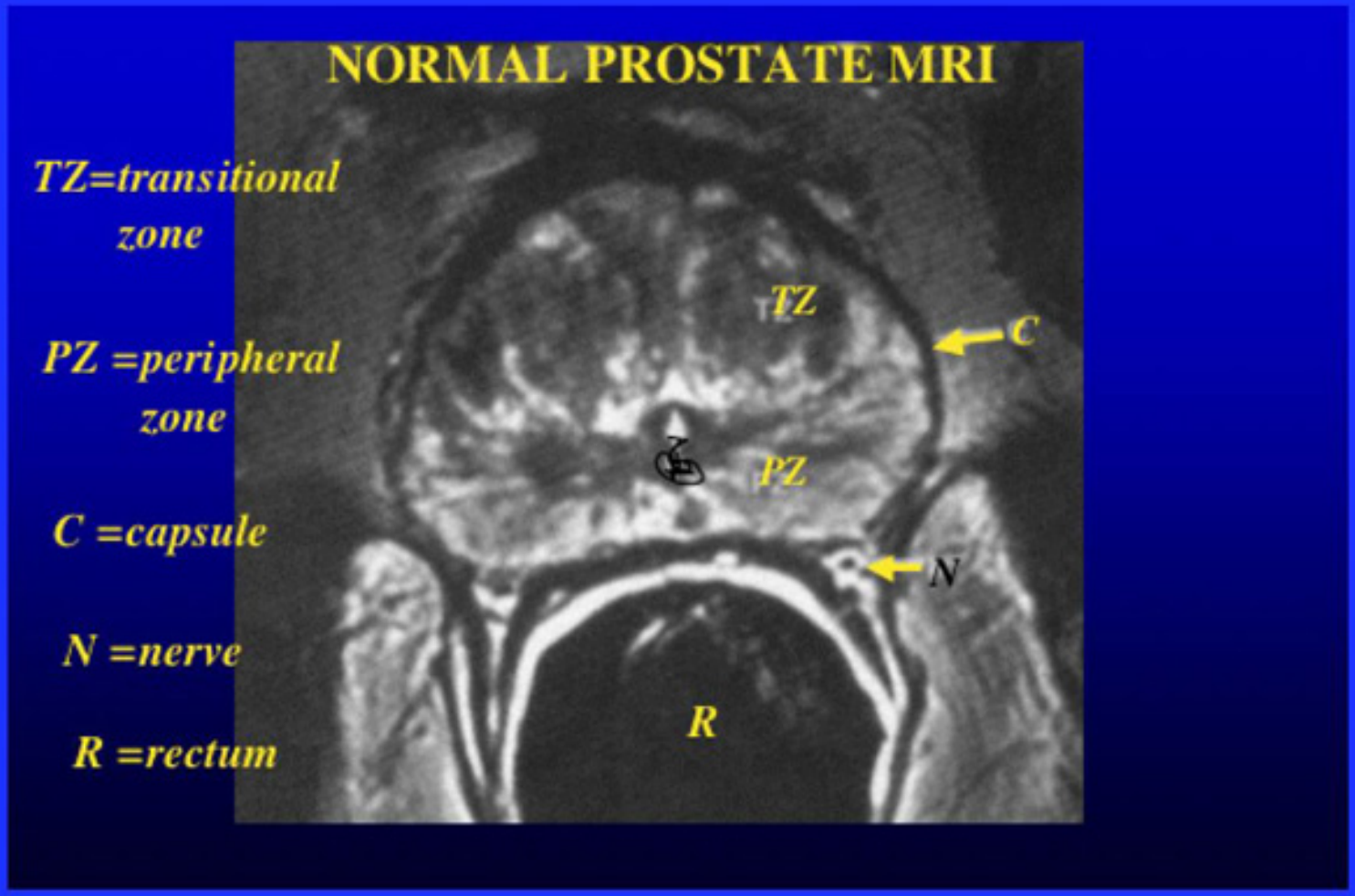
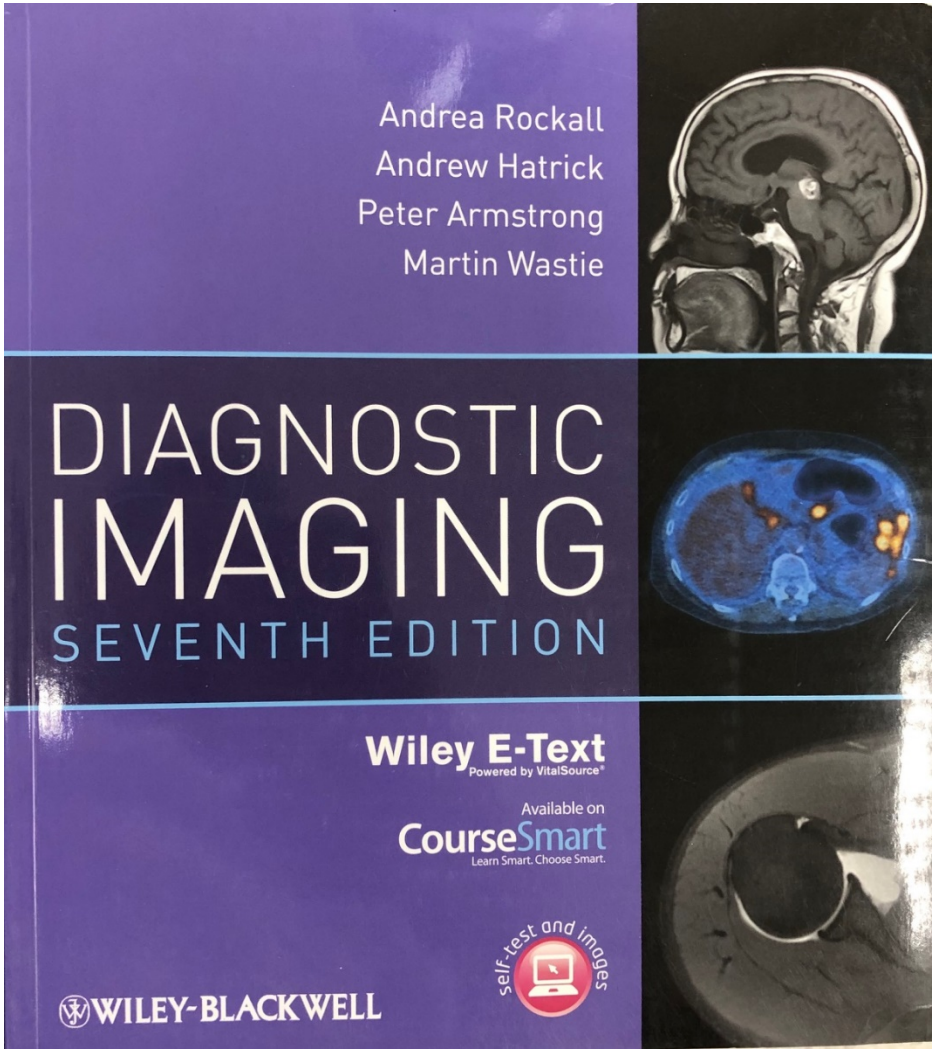


Fig. 8.57 Early prostate cancer. Prostate carcinoma shown by TRUS. The tumour (T) is seen as a low echogenic ovoid mass in the right peripheral zone (arrow). R, rectum.

NOTE; PROSTATE CAPSULE BETTER SEEN WITH MRI




Andrea Rockall
Andrew Hatrick
Peter Armstrong
Martin Wastie
DIAGNOSTIC
IMAGING
SEVENTH EDITION
Wiley E-Text
Powered by VitalSource®
Available on
CourseSmart
Learn Smart. Choose Smart.
self-test and images
WILEY-BLACKWELL


Thank You For Your Attention