An Introduction to the Intravenous Urogram for student radiographers

The Intravenous Urogram:

This is the basic examination of the whole of the urinary tract:

Basic Anatomy:

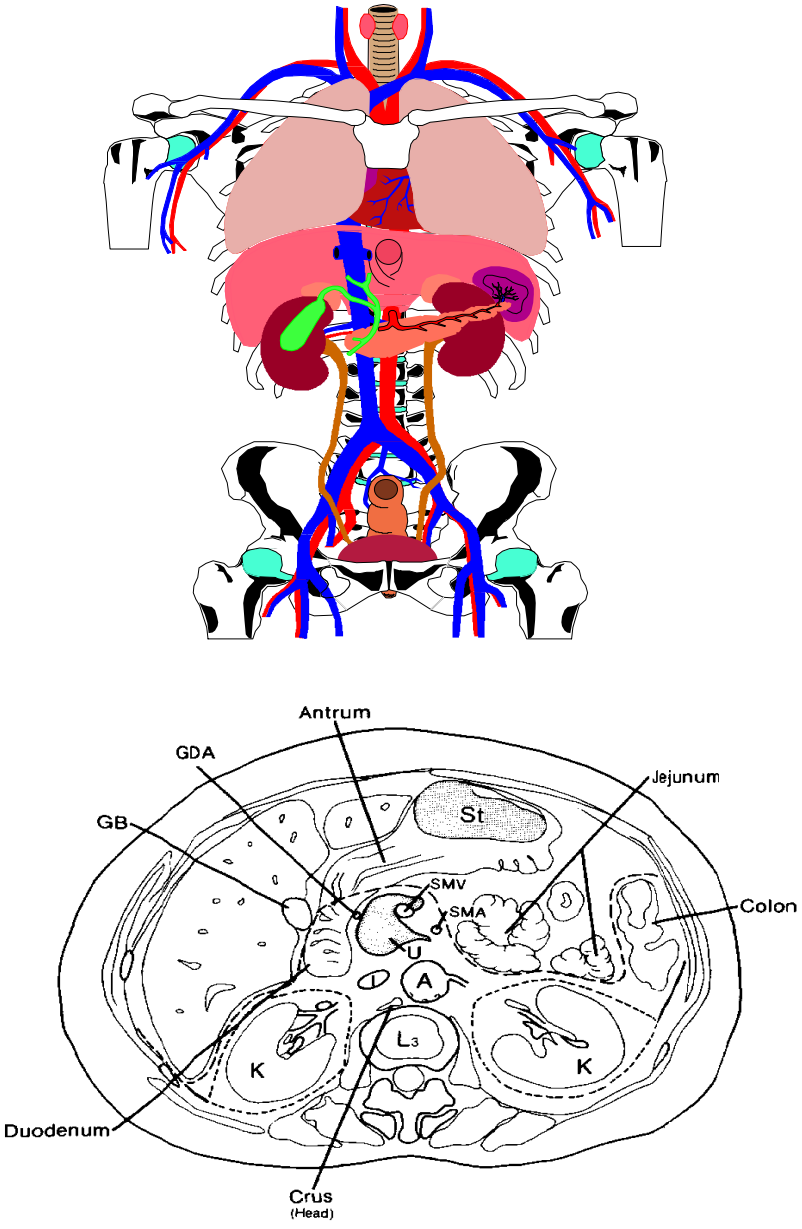


Fig 1 & 1a, Diagrams to demonstrate Position of Renal Tract and Transverse section at L3

Kidneys,

The two kidneys lie on the posterior abdominal wall on either side of the vertebral column. Their hila lie at about the level of the transpyloric plane. Each is about 10 cm long, 5 cm wide, 3 cm thick and weigh about 100 g.

Each consists of upper and lower poles anterior and posterior surfaces a convex lateral border and a concave medial border with the central portion of this concave wall being made of the hilus.

Each is set obliquely so that it's upper pole is nearest the mid-line, the right kidney is slightly lower than the left because of the bulk of the liver on the right side. The kidneys are embedded in a mass of renal fat which is enclosed by part of the perirenal fascia. Superiorly the kidneys are separated from the super renal glands by this fascia.

Relations:

Anteriorly, a portion of the liver, duodenum and right colonic flexure lie in front of the right kidney. A portion of the pancreas touches the mid anterior surface of the left kidney, and then the left part of the transverse colon, the left colic flexure, and upper part of the descending colon lie in front of the rest of the left kidney.

Posteriorly, the psoas muscles lie behind each kidney. The upper part of each kidney lies on the inner surface of the respective twelfth rib.

Superiorly, the adrenal glands are sited on the superior surface of each kidney.

Inferiorly. Coils of small bowel supported on their mesentery lie below each kidney.

Medially, The vertebral column lies between the two kidneys. Immediately in front of it are the great vessels, the aorta on the right and the inferior vena cava on the left and their associated renal blood supply and drainage.

Blood Supply:

Right and left renal arteries respectively, branches of the abdominal aorta.

Venous drainage:

Right and left renal veins respectively, branches of the inferior vena cava.

Lymph drainage:

To the para aortic nodes situated around the trunk of the renal arteries.

Nerve supply:

Motor neurones from the autonomic nervous system.

Function:
To produce urine from the filtration of blood.
Regulate water balance.
pH balance of blood.
Elimination of urea, urates, creatanine and uric acid from protein metabolism.
Excretion of the end products of drugs and toxins.
Maintenance of blood pressure control.

Blood pressure and the kidneys

When the blood pressure within the kidneys falls below a certain point, the kidneys secrete an enzyme called rennin, which activates angiotensin in the blood which causes a constriction of the arterial muscle walls which raises the blood pressure. Angiotensin also increases the output of aldesterone, from the adrenal cortex, which in turn increases re-absorption of salt from the nephrons which increases the osmotic pressure excerpted by the blood and tissue fluid enters the circulatory system increasing it's volume and the blood pressure.

Ureters:

These are two long tubes leading from the pelvis of each kidney to the bladder, descending on either side of the vertebral column and passing forward over the pelvic brim, to enter obliquely into the posterior base of the bladder. The ureters are constructed so that urine passes along them by peristaltic action. There is an inner lining of mucous membrane supported on a submucosal layer, then a layer of plain circular involuntary muscle, and an outer layer of white fibrous tissue. The ureters have a length of approximately 20 cm and an internal diameter up to 3 mm.

Blood supply:
Ureteric arteries from the aorta.

Venous drainage:
Ureteric veins from the Inferior vena cava.

Nerve supply:
Grey motor neurones from the autonomic nervous system supply the muscle layer.

Bladder:

The bladder acts as a reservoir for urine from the kidneys and subsequently expels it via the external urethra. It is a hollow muscular organ lying in the anterior part of the pelvis outside the peritoneum. When empty it is pyramidal in shape and presents an apex behind the smphysis pubis, a base anteriorly and a superior and two inferolateral surfaces.
The ureters enter the postero lateral angles of the base and the urethra leaves inferiorly at the narrow neck.
In the male the bladder is supported by it's continuity with the prostate and in the female it is supported by the pelvic facia in contact with the cervix and anterior vaginal fornix. The interior of the balder is covered with mucous membrane which thrown into folds, except in the trigone between the ureteric orifices, in the contracted state and stretched more smooth when the bladder is distended.

Relations:
The infero lateral surfaces are separated from the pubic bones and the levator ani muscles by the fat filled retropubic space.
The superior surface is in contact with the coils of intestines and in the female the uterus.

The base lies in front of the rectum separated by the vagina in the female and the seminal ducts and the seminal vesicles in the male.
Inferiorly the neck overlies the urogenital diaphragm in the female and the prostate in the male.

Blood supply:
Vesical branches of the internal arteries.

Venous drainage:
Internal Iliac veins.

Lymph drainage:
Internal and external iliac nodes.

Nerve supply:
Sympathetic fibres from 1st and 2nd lumbar segments.
Parasympathetic fibres from the 2nd, 3rd and 4th sacral segments.

Prostate: (male)

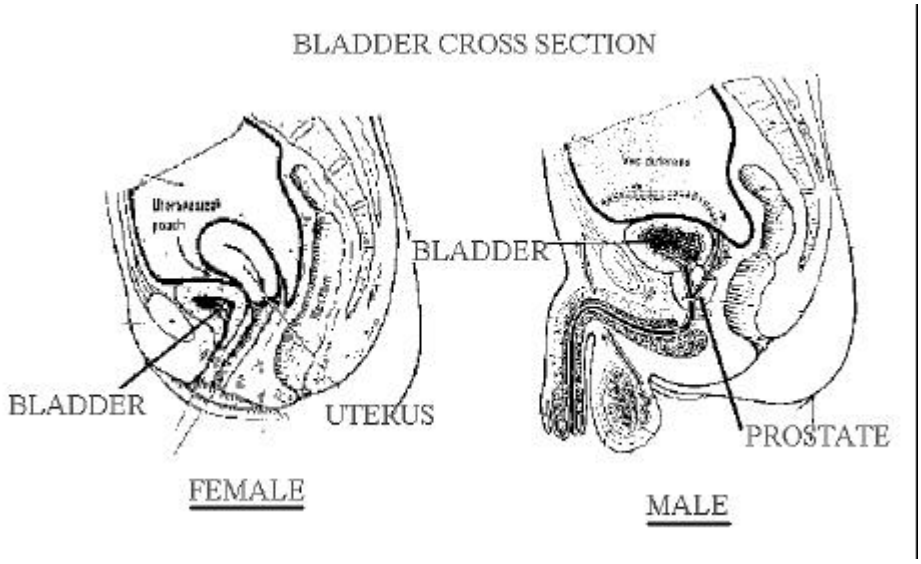
This is a fibromuscular organ lying between the neck of the bladder and the urogenital diaphragm. It is short and conical in shape about 3 cm in diameter. It is traverses by the urethra and the ejaculatory ducts.

In middle age their is often hypertrophy of the glandular tissue which enlarges and pushes into the bladder and so interfering with micturition. cancer of the prostate may produce similar symptoms but can usually be distinguished by a hard irregular surface palpable on rectal examination.

Urethra:

This tube conducts urine from the bladder to the exterior, in the female it is around 4cm long and in the male around 18cm long.

Fig 2. Bladder Saggital Sections, Male/female



Intravenous Urogram:

Indications: (See Royal College of Radiologist's guidelines 1993)
Suspected urinary tract pathology.
Repeated infections ? focus, damage, (when linked with other symptoms.)
Heamaturia.
Investigation of hypertension not controlled by medication in young adults.
Renal colic.
Trauma.

Contra Indications:
General contra indications to water soluble contrast agents.
Hepato renal syndrome,
Thyrotoxicosis,
Pregnancy, (Allow 28 days from childbirth)
Blood urea raised above 12 mmol./L. urography unlikely to be successful.

Patients Preparation:
Basic abdominal preparation, aperients taken for 24 hours previous, to clear faecal residue.
Nil by mouth for 4-6 hours before the examination.
Patient to remain ambulant as long as possible to reduce air swallowing.
Adaptations to patient preparation will be required for certain groups of patients e.g. children, diabetics and patients with other predisposing medical conditions, in line with current department practice.

Basic psychological preparation with reassurance and explanation of technique.
Patient wears only a starch free white examination gown.
Bladder emptied immediately before examination.

Normal patient examination interview plus:
? Previous I.V.U.
? Previous experience of iodinated contrast media.
? Abdominal surgery.
? Asthma / Allergies. (Hypersensitivity's.)
? Current drug therapy (? thyroid function tests)
? Breast feeding in appropriate females.
? Blood urea levels (normal approx. 2.5-6.5 mmol./L.)

Equipment:
Medium powered X-Ray generator set-up, typical 40-60 kW.
Basic tomography equipment.
Abdominal compression equipment.
Medium / Regular film screen combination in a variety of sizes.
Pads and immobilisation aids.

Intravenous administration equipment:
50 ml syringe, filling needle, skin prep, sticky tape,
Selection of needles, straight/'Butterfly' 16, 19, 21,23 gauge.
Tourniquet or blood pressure cuff.

Emergency drugs and equipment, checked and to hand.

Contrast agents and drugs:

Typical examples for a 70 kg adult with normal blood urea values (2.5 - 7.5mmol/L.)
Contrast media must be warmed to body temperature before injection.

Product	Main constituent	Iodine mg./ml	Dose	Route
Niopam 300	Iopamidol	300	50ml.	I.V.
Omnipaque 350	Iohexhol	350	50ml.	I.V.
Urograffin 370	Diatrozates	370	50ml.	I.V.

Typical Exposure Values: (*Dose = Typical Dose from N.R.P.B.)

Projection	Kv	mAS	F.F.D.	Focus	Grid	Film/Screen
AP Abdomen	65-75	50-70	100cm	Broad	Yes	Regular
Tomogram 20° @ 9cm	60-75	70-120	100cm	Broad	Yes	Regular

Technique:

The median cubital vein is punctured with a 19 gauge needle and the warmed (40°C) contrast agent is injected rapidly. Films are then taken at intervals to demonstrate the whole of the renal tract.

Film Sequence:

Preliminary film, (35 x 43cm) supine full A.P. abdomen to include lower border of symphysis pubis and diaphragm, to check, abdominal preparation, exposure values and for any calcifications overlying the renal tract areas.
Supplementary films to determine position of any opacities.
35° posterior oblique of the renal areas.
Tomogram of the renal areas at 8-11 cm

Immediate film, (24 x 30cm) A.P. of the renal areas to show the nephrogram, i.e. the renal parenchyma opacified by the contrast medium in the renal tubules.

5 Minute film, (24 x 30cm) A.P. of the renal areas to determine if excretion is symmetrical or if uptake is poor and a further dose of contrast agent is required.
Compression may be applied in some centres at this point to distend the pelvicalyceal systems to demonstrate any filling defects and a film taken at 10 minutes of the renal areas. Compression should not be used in cases of suspected renal colic, renal trauma or after recent abdominal surgery.

15 Minute film (35 x 43cm) (On release if compression has been applied) to demonstrate the pelvicalyceal systems and the ureters.

25 Minute film (24 x 30cm) 15° caudal angulation centred 5 cm above the upper border of the symphysis pubis to demonstrate the distended bladder.

Post Micturition film (24 x 30cm) 15° caudal angulation centred 5 cm above the upper border of the symphysis pubis to demonstrate the bladder emptying success, and the return of the previously distended lower ends of ureters to normal.

Additional Projections:

Inspiratory, expiratory and oblique projections may be required to demonstrate the relationship of opacities and filling defects to the renal tract.

Tomography, may be required to accurately demonstrate the renal outlines and overcome shadowing from the gastro intestinal tract.

Prone films may be required to investigate pelvi ureteric and ureteric obstruction as the heavy contrast laden urine will more readily gravitate to the site of the obstruction.

Rapid sequence films may be taken in cases of suspected renal hypertension to evaluate differential rates of contrast excretion.

Delayed films may be taken for up to 24 hours in order to demonstrate the actual site of ureteric obstruction.

Radiographic appearances during Intravenous Urography:

Immediate post-injection radiograph:

A film taken immediately after injection of contrast should demonstrate the kidneys increased in density because of the contrast within the nephrons. If either kidney is not seen in the normal place and has not be visualised on the control film a full abdomen film will demonstrate an ectopic kidney, common sites are low in the pelvis or low down on the same side as one visualised in a cross duplex situation.

Different density nephrograms may indicate renal artery stenosis, if this is suspected a series of films at 1 min. 2min, 3min after injection may aid more accurate visualisation.

The kidney outlines should be smooth, any irregularity may indicate a scar or a mass, a mass or bulge in the outline which does not concentrate contrast is likely to be cystic whilst one concentrating the medium will more likely be a tumour.

Five / Ten minute film:

At this stage the calyces, renal pelvis and part of the ureters will be visible. There is considerable anatomical variation in the number and pattern of the renal calyces but they are normally reasonably symmetrical. The nephrogram will be reduced but both kidneys should have the same density.

If one or both kidneys appear to have two separate groups of calyces then there may well be duplex collecting systems and ureters.

When one kidney is denser than the other, this is due to persistence of the contrast media within the kidney (persistent nephrogram) and suggests ureteric obstruction.

The pelvi-caylceal system is not filled or apparent a delayed film of that side should be taken 45 -60 minutes after injection or later if required, to determine the site of obstruction.

Horseshoe kidney.

The two kidneys may be joined together across the midline nearly always by the low poles. The calyces are then pointing medially or backwards and the ureters emerge laterally rather than medially.

Variations in calyceal patterns.

There are normally three major calyces with two minor calyces at the end. However they may only

two major calyces and the pelvis may even be divided into two. All the calyces should be smooth and cupped at the ends. If the calyces appear blunted the it may

be because the kidney is rotated and an oblique projection will bring them into the 'normal' plane.
Hydronephrosis is bilateral is usually due to bladder outflow obstruction e.g., stricture or enlarged prostate,
If the renal contour curves inwards this is likely to be from scarring of the parenchyma from old infection, trauma, surgery or infarct
If there is a localised outward bulge with distorted calyces this is most likely a cyst or tumour or from a haematoma following trauma.

Causes of a large kidney.

Hydronephrosis and hydroureter due to obstruction of the ureter, if bilateral are usually caused by bladder outlet obstruction e.g. enlarged prostate, urethral valves or stricture, however the ureters may be obstructed by an abdominal mass.
Renal tissue will usually be reduced when there is long standing hydronephrosis. A large renal pelvis should not be mistaken for hydronephrosis.
A normally large pelvi-ureteric enlargement may persist for up to 3 month after giving birth.

A renal mass causes localised enlargement, there may be a cyst or a tumour. If a cyst there is no increase in density during the early post injection phase, whereas the rest of the kidney will increase in density following injection of contrast media. A tumour will have the same density as the rest of the kidney at the immediately post injection film. Either a tumour or cyst may displace the calyces as well as distorting the renal outline.
When one kidney is absent, ceases to function, or functions poorly, the other will eventually enlarge, this is known as compensatory hyperplasia.

If both kidneys are large, without hydronephrosis, there is probably polycystic disease, the renal outlines will probably be ill defined, irregular but smooth.

Causes of small kidney.

The kidney may never have developed completely, renal hypoplasia.
Scarring following infection.
Reduced renal blood supply.
Both kidneys may be small from the end stage of renal disease.

15 minute film, full length:

Causes of dilation of the ureters.

Obstruction at any level, if one ureter is obstructed this is probably due to a stone or a clot or occasionally due to a stricture or bladder tumour near the bladder ureteric orifice. If both ureters are dilated, the cause is more probably in the bladder or urethra.

Reflux due to malfunction of the ureterovesical junction, from any cause with or without infection.

Pregnancy at any time after the first three months both ureters undergo physiological dilatation, which may persist for up to three months after delivery.

Paralysed bladder after spinal injury.

Irregular dilatation, especially at the lower ends bilaterally is usually due to schistosomiasis, if unilateral, it may be attributable to tuberculosis or the passage of calculi.

The ureters may be pushed from their normal line by ovarian tumours, Burkitt's lymphoma in children, fibroids, abdominal aortic aneurysm, tumours or retroperitoneal fibrosis or haemorrhage.

Bladder Film:

The bladder may be large due to,
Prostatic enlargement,
Urethral obstruction,
Neurogenic bladder.

The bladder may be small due to,
Tuberculosis,
Schisotosomiasis,
Pelvic irradiation, surgery.

Irregular bladder outline,
Rough indistinct outline is commonly due to muscle wall hypertrophy with trabecualtion or to diverticula.
Chronic cystitis,
Neurogenic bladder.

Stones,
These are often large and single and may be calcified and laminated or radiolucent.

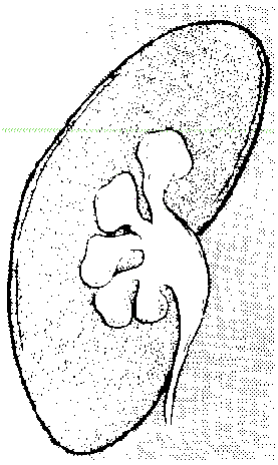
Calcification,
Schistosomiasis, calcifications in papillae or patchy in tuberculosis.

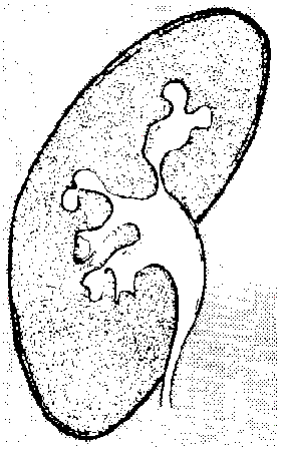
Local filling defects,
Usually from a tumour with an irregular outline more often adjacent to the ureteric junction.
Non radio opaque stones will produce a smooth rounded filling defect.
A crescent shaped filling defect at the base is usually due to prostatic enlargement, their may be prostatic calcifications.

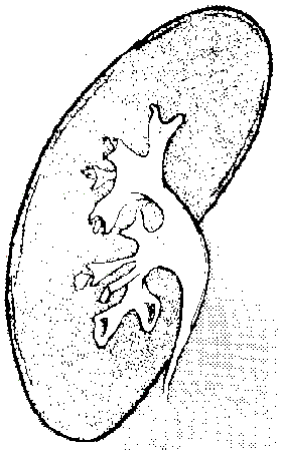
Gas in the bladder,
This is usually due to a fistula between the bladder and the bowel or vagina.

Variations in calyceal patterns.

1. Mild Hydronephrosis 2. Scarred upper/mid poles 3. Papillary necrosis







Radiation Protection:

In addition to all normal good techniques for radiation protection.
Direct lead rubber protection to abdomen when renal area films are taken.

Patient Aftercare:

General psychological reassurance.
Needle wound site dressed and checked for extravasation.
Check patient understands how to receive the results.
Ensure patient understands any preparation instructions are finished
Escort to changing rooms and bid good-bye.

Additional Imaging Techniques:

Radio nuclide imaging for renal function evaluation.
Radio nuclide imaging for renal transplant rejection assessment.
Ultrasound for bladder investigation as a first line of imaging.
Ultrasound for renal cyst imaging and drainage if required.
C.T. for investigation of trauma and renal masses.
Renal Angiography.
Retrograde pyelography,
Urethrography.
Magnetic resonance imaging.