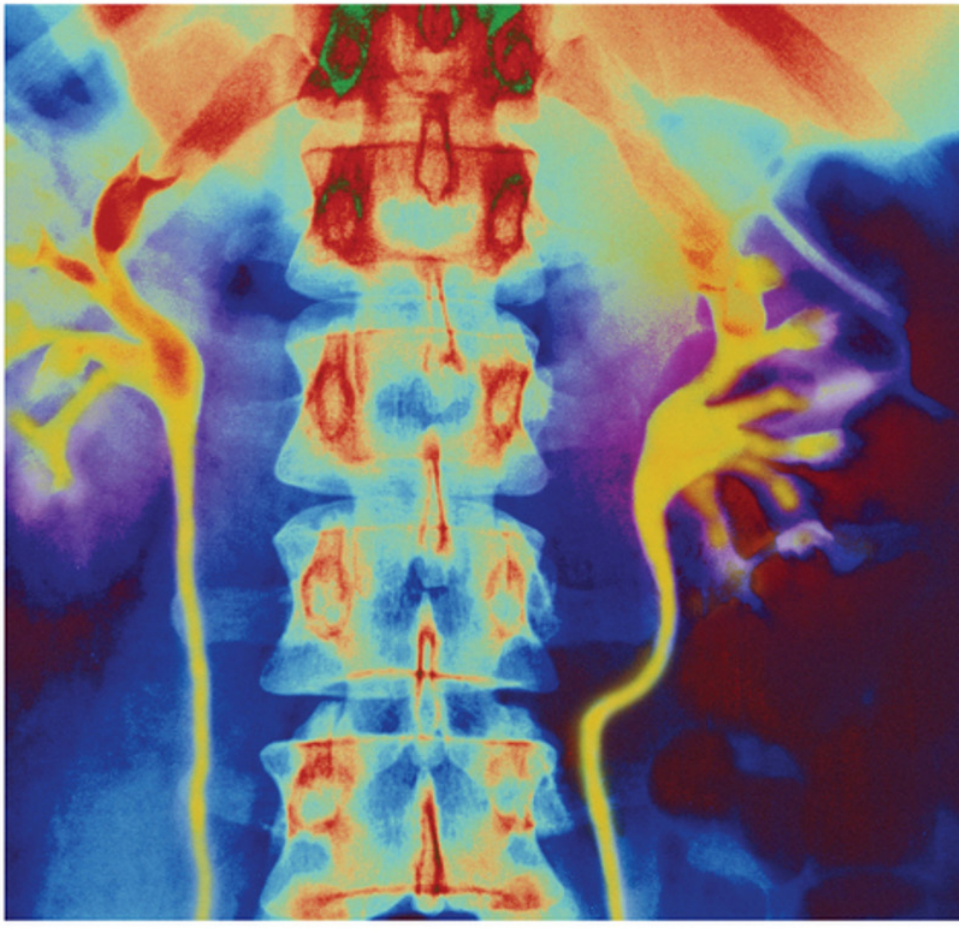
LECTURE NOTES

Urology

JOHN BLANDY
AMIR KAISARY

6th edition



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Lecture Notes: Urology

Lecture Notes

Urology

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Contents

Preface

More than 30 years ago, this book started as a set of brief notes mimeographed for medical students on the urology firm at The London Hospital. I hoped that students might find them helpful in understanding the patients and operations they saw on the wards and in the operating theatre. I believed that to understand the pathology of a condition was the key to understanding symptoms, signs and everything else. I also believed that pretty well every pathological process could be explained simply, that long-winded jargon was almost never needed, and in learning surgery as in most things, a spoonful of sugar helps the medicine go down.

Over 30 years, urology has seen extraordinary changes. New methods of imaging have transformed the precision of diagnosis. New techniques, especially laparoscopic surgery and the introduction of new lasers, have transformed operative surgery.My friend Amir Kaisary has worked hard to bring these notes up to date, without losing sight of their original intention, which was that students would find the subject interesting and yet has still managed to keep it clear and above all, we both hope, fun to read.

John Blandy

Acknowledgements

During preparation of this new edition we were both helped immensely by advice and contributions from many colleagues, for which we register our thanks. Special thanks also go to the Medical Illustration department at the Royal Free NHS Trust Hospital and Joint Royal Free and UCLH Medical School for the new artwork.

Anne and Karen, our wives, deserve a medal each for putting up with our moods during preparation of this book!

Further reading

It is now acknowledged that electronic communications ensure immediate access to sources of information without delay. You will note that there are no references listed at the end of chapters in this book. It is estimated that few months elapse between providing the text to publishers/printers and by the time the book is available on the market, few months have passed. This would inevitably make the material read not truly up to date. Continuous medical education (CME) would thus need the readers to get access to sources of education available electronically to keep you up to date. Useful sources are plentiful and here are some examples:

1 http://www.emedicine.com

This is an American-based website which is now internationally used. As a student you can register with this website for free. This will enable you to browse the information without having to pay for a subscription. This website gives an overview of the pathophysiology, epidemiology, clinical and radiographic findings and management options for most conditions.

2 www.pubmed.com or http://www.ncbi.nlm.nih.gov/sites/entrez/

PubMed is a service of the U.S. National Library of Medicine that includes over 18 million citations from MEDLINE and other life science journals for biomedical articles back to the 1950s. PubMed includes links to full text articles and other related resources. It is a useful tool where MEDLINE is not available to you or where you have not quite grasped how to use MEDLINE yet. It is user-friendly and provides links to articles that are relevant to your search. However, you will need an Athens password (and therefore subscription) to access most e-journals and articles.

3 http://wok.mimas.ac.uk/

Sign into the Web of Knowledge website in order to get to Web of Science. Again, you will need an Athens subscription of Web of Knowledge subscription. *Web of Science*® consists of seven databases containing information gathered from thousands of scholarly journals, books, book series, reports and more.

The three citation databases contain the references cited by authors of the articles. You can use these references to do cite reference searching. This type of search allows you to find articles that cite a previously published work.

Google scholar (http://scholar.google.co.uk) is a handy search tool because it will often return articles *and* books that have been published on the topic you are searching. It is deemed less academic compared to PubMed and is less useful if you are looking for recently published articles. However, with the power of Google as a search tool it will often find you active links to articles that can be accessed without a subscription.

Other valuable sites are UroSource Newsletters from European Association of Urology (EAU), Timely topics in Urology and web casts (info@ttmed.com and www.ttmed.com/urology), PeerView Press (webmaster@peerviewpress.com) and many more to find if you search.

This book gives you a lot and the initiative you take will give you more.

Amir V. Kaisary
John Blandy

Chapter 1

History and examination

Begin at the beginning: how old is your patient and what is his or her occupation? Do they smoke? Do they drink alcohol? Have they travelled in Africa or Indochina? Ask retired people about their previous occupation especially if there was any exposure to rubber, chemicals or plastics. Is there a family history of cancer? Women should be asked how many and how old are their children, and whether there was any complication during pregnancy or delivery that may have required catheterisation, which might have introduced infection.

What brings the patient to you? What were the first symptoms? When did they begin and how did they change as time went by? Let the patient do the talking – listening is the key to taking a history. Try to get a clear picture of the way the illness has developed over the years, and make sure you really understand just what is really bothering him or her right now. Never end your enquiry without asking whether the patient has noticed blood in the urine: haematuria is the single-most important symptom in the whole of urology, particularly if it is painless.

Your notes should be brief, but sufficiently clear that if you drop dead, another doctor can take up management of the case. No note is of any use if it cannot be read. If your handwriting is really bad, teach yourself to use a word processor. Put the date and name of the patient on every page. Always bear in mind that your notes are now available to the patient and may at any time be used as evidence in a court of law, so be polite about your patient and never be tempted to make a disparaging criticism of a professional colleague.

A drawing can save many words, so a sketch noting where the pain starts from and radiates to can be useful, together with a word or two to specify the type of pain, e.g. sharp, colicky or dull (Fig. 1.1). Avoid pretentious Greek or Latin terms unless they are clear and unambiguous. Dysuria can mean pain or difficulty or both: which do you really mean? Frequency is most simply expressed by writing down how often your patient voids by day and by night, e.g. D 6×, N 3×. Enuresis can be

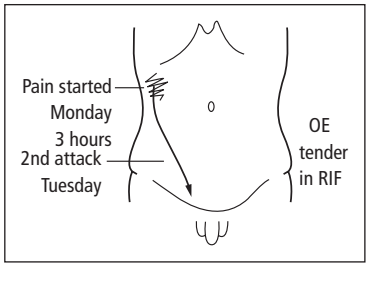

Figure 1.1 A sketch showing the main features in a patient with right ureteric colic.

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ambiguous: if you mean the patient wets the bed, why not say so?

An exception is the term *haematuria*. It matters not whether the blood has been seen by the patient or found in a dipstick test, nor whether it is well mixed or appears at the beginning or the end of the stream: any kind of blood in the urine demands thorough investigation. Blood trickling from the urethra between acts of urination is probably coming from the urethra, but it still needs investigation.

Previous history

Ask about rheumatism and arthritis for which analgesics may have been taken: analgesic nephropathy is surprisingly common and seldom suspected unless you ask about the consumption of painkilling tablets.

Students often feel awkward when asking about venereal disease. In times past, men were usually secretly flattered at the suggestion that they might have been a Don Juan when young: today, one must be aware of the possibility of acquired immune deficiency syndrome (AIDS).

Do not waste time. As you listen to the patient it may be obvious that certain investigations are going to be needed. Unobtrusively filling in the relevant forms will not stop you from listening politely but will save time, and more importantly, may prevent you from writing down too much. Listening is far more important than writing.

Physical examination

Physical examination begins as the patient comes into the room. Does the patient look ill? Has the patient obviously lost weight? Does the gait suggest pain, Parkinsonism or ankylosing spondylitis? Is there that faint whiff of urine that suggests uraemia, or the ammoniacal reek of wet trousers?

To rise to shake your patient's hand is not mere politeness: it gives useful information. Whatever your specialty, never forget that you are a doctor first and your concern is for the patient as a whole. In an ideal world, where no doctor was ever pushed for time and no patient ever in a hurry to get back to work or children, you could spend all day over one case, getting to know your patient in depth and making a thorough examination of every system. Something approaching such a thorough clerking may indeed be necessary when admitting a patient to the ward, but in the outpatient clinic it would be cruelly slow and unfair to the others who are waiting.

In most patients who attend the urological clinic, you are looking for enlargement of a kidney or bladder, disorders in the inguinal region or genitalia, hypertension and signs in the pelvis that might be detected by vaginal or rectal examination.

Abdominal examination

Kidney

The traditional physical signs of an enlarged kidney (Fig. 1.2) are:

- a rounded lump in the loin, bimanually palpable, moving on respiration;
- you can get your hand between the lump and the edge of the costal margin; and
- there is said to be a band of resonance in front of the kidney due to gas in the colon (Fig. 1.3).

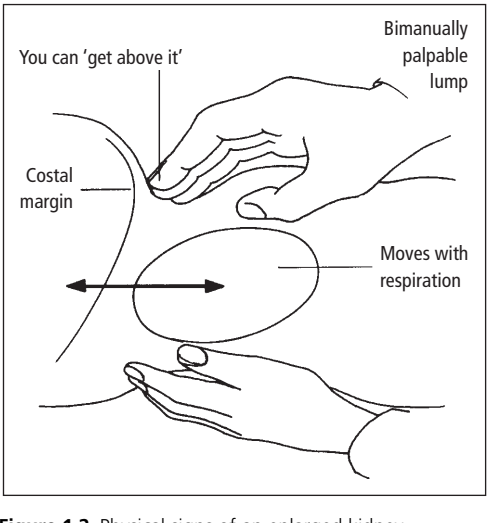

Figure 1.2 Physical signs of an enlarged kidney.

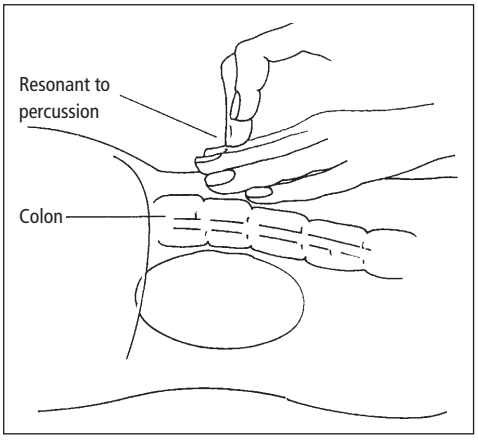

Figure 1.3 There is often a band of resonance in front of the kidney from gas in the colon.

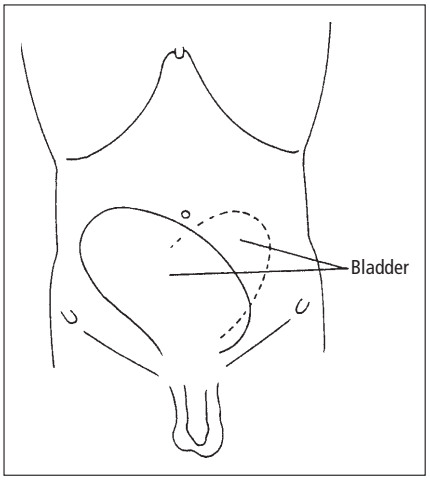

Figure 1.5 An enlarged bladder may go to one or other side.

None of these physical signs is trustworthy: on the right side the supposed 'kidney' may turn out to be the gall bladder or liver, and on the left it may prove to be the spleen, even though you think you can slide your hand between the lump and the costal margin. A large mass may arise from or displace the colon.

Bladder

An enlarged bladder (Figs. 1.4 and 1.5) may be equally misleading. One expects to find:

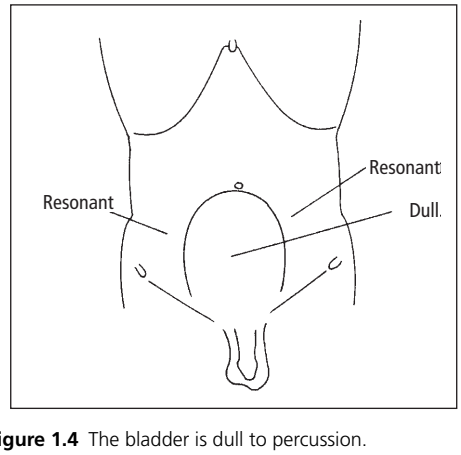

Figure 1.4 The bladder is dull to percussion.

- a rounded swelling arising out of the pelvis; and
- dull to percussion.

In practice, a floppy, over-distended bladder may be so soft that it is difficult to feel, and the bladder does not always rise up in the midline as expected, but is often more to one side than the other. The infallible sign is that the swelling goes away if you let the urine out with a catheter. Do not forget that an enlarged uterus arising from the pelvis could mimic a full, tense bladder.

Groin

Examination of the inguinal regions is concerned with three hernial orifices on each side (Fig. 1.6). Each must be felt with the patient standing up, lying down and coughing.

- An indirect inguinal hernia emerges lateral to the inferior epigastric vessels and slides down the inguinal canal to the scrotum.
- A direct inguinal hernia emerges medial to the inferior epigastric vessels, and seldom enters the scrotum.

Remember that direct and indirect inguinal herniae may be present in the same patient, with the two sacs emerging like a pair of trousers on either side of the inferior epigastric vessels (Fig. 1.7).

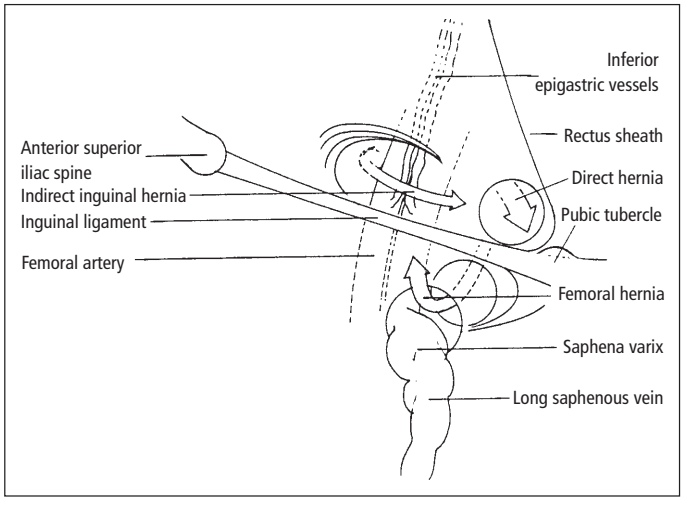

Figure 1.6 Landmarks for groin hernias.

• A femoral hernia pushes out below the inguinal ligament, medial to the femoral vein and then bulges up and out through the gap in the deep fascia where the saphenous vein joins the femoral vein. The sac has a narrow neck, and is always surrounded by a layer upon layer of fat like an onion, so that a cough impulse can be difficult to feel. A femoral hernia is mimicked by a saphena varix, the dilated upper end of the saphenous vein, but this has a cough thrill which runs down the saphenous vein, and the lump disappears when the patient lies down. If you help the patient to assume the sartorius position (hip flexion and lateral rotation), assessment of a possible femoral hernia can be made easier.

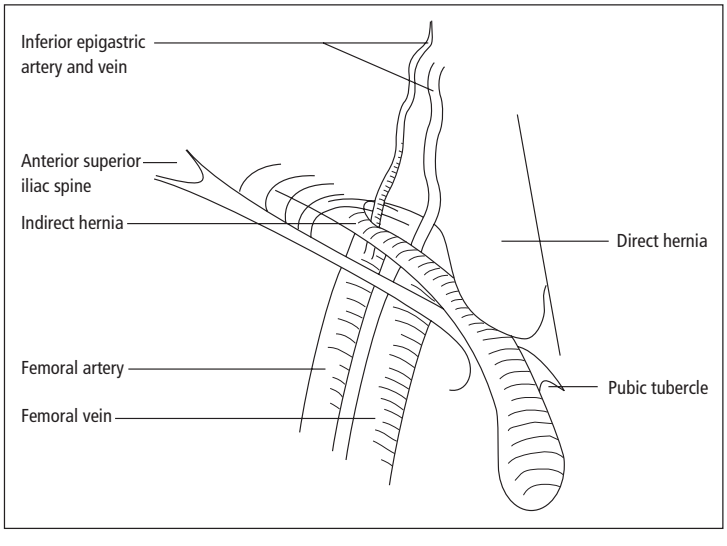

Figure 1.7 Pantaloon hernia.

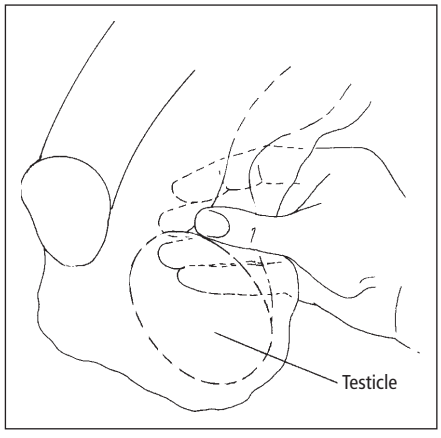

Figure 1.8 Lump in the scrotum: can you get above it?

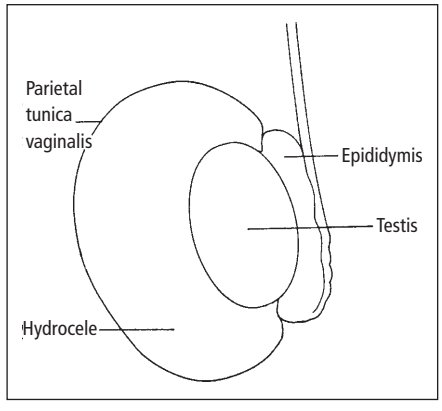

Figure 1.10 Hydroceles lie in front of the testis and tend to surround it.

The scrotum and its contents

The term 'testicle' includes testis and epididymis. When examining the scrotum, carry out the following simple steps:

- Can you 'get above' the swelling? If you can, it must be scrotal (Fig. 1.8).
- Is the lump fluctuant? Verify this by testing in two planes (Fig. 1.9). If it is fluctuant, then:
  - If it is in front or around the testis, it is likely to be a hydrocele – fluid in the sac of the tunica vaginalis (Fig. 1.10); and
  - If it is separate or behind the testis, it is likely to be a collection of cysts of the epididymis (Fig. 1.11).
- Can you shine a light through it? (An empty cylinder makes it easier to be sure of this in a well-lit room (Fig. 1.12).) If light does not shine through the swelling, either the wall of the swelling is thickened, or it contains not innocent clear fluid, but pus, blood or cancer.
- If the lump is not fluctuant, i.e. is solid, decide whether it is arising from the testis or the epididymis. A solid lump arising from the testis is cancer until proved otherwise (Fig. 1.13). A solid lump arising from the epididymis is usually benign, but calls for further investigation (Fig. 1.14).

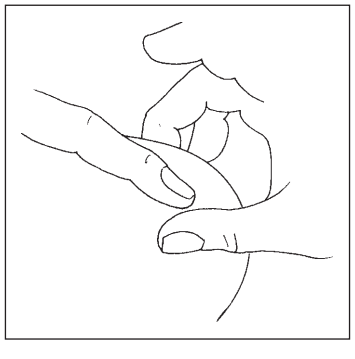

Figure 1.9 Lump in the scrotum: check whether it is solid or fluctuant. Determine fluctuation in two planes.

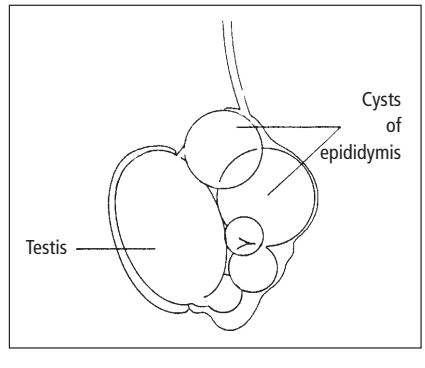

Figure 1.11 Cystic swellings behind the testis are cysts of the epididymis.

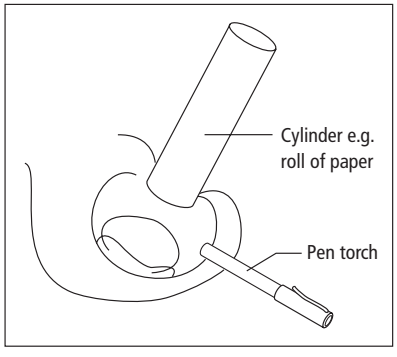

Figure 1.12 To see if light shines through a swelling, it helps to use a cylinder, e.g. one made from a rolled-up paper.

The spermatic cord

- *Varicocele:* The veins draining the testicle may become varicose and distended, feeling like a 'bag of worms', and there is a cough impulse (Fig. 1.15). (Like you, neither of us has ever actually felt a bag of worms, but we both know what it would feel like.)
- *Vas deferens:* The vas deferens lies posterior to the spermatic cord. If the vas is inflamed or has been operated on, e.g. by vasectomy, one may feel nodules along its course. Multiple knotty swellings are typical of tuberculosis (Fig. 1.16) and inflammatory swellings in the cord are seen in the tropical conditions of schistosomiasis and filariasis.

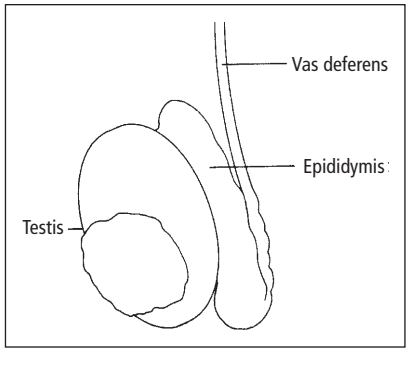

Figure 1.13 A solid swelling in the testis is a cancer until proved otherwise.

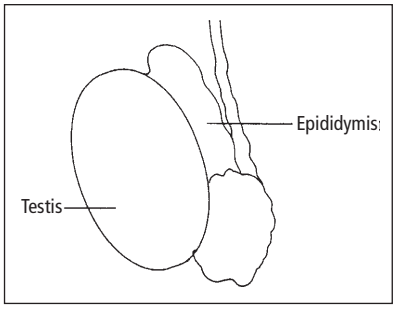

Figure 1.14 Solid swellings in the epididymis are usually inflammatory.

- *Encysted hydrocele of the cord:* When the testis descent in the scrotum is complete, the processus vaginalis closes completely forming a fibrous strand. If the closure happens proximally and distally only, this leaves a cystic structure within the spermatic cord which is mobile with it.

Rectal examination

One may perform a rectal examination in either sex in the supine, knee–elbow or left lateral position. Explain to your patient, what you are going

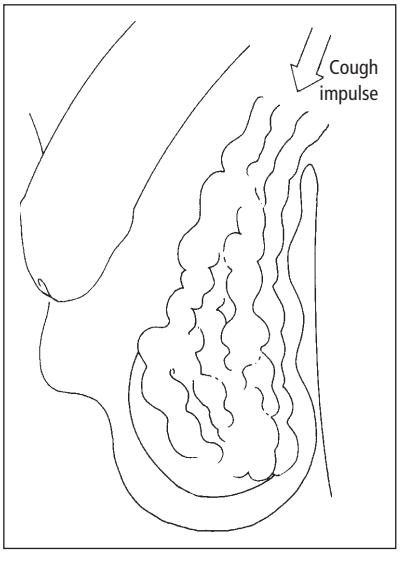

Figure 1.15 Varicocele: enlarged testicular veins. There is a cough impulse and the swelling disappears when the patient lies down.

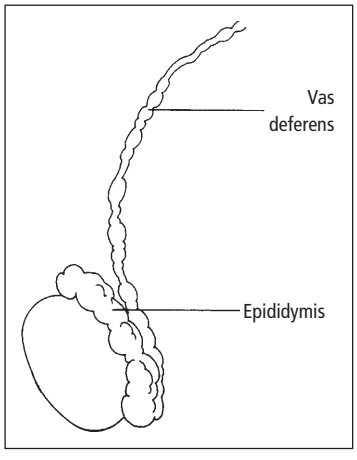

Figure 1.16 Multiple knotty swellings in the epididymis and a 'beaded' are highly suggestive of tuberculosis.

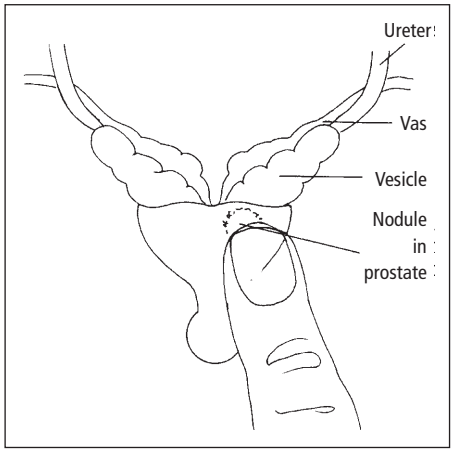

Figure 1.17 Anatomical landmarks that may be felt per rectum.

to do and ask his or her permission to do so. Always introduce your finger slowly and gently to allow the sphincter to relax (everyone knows the need to pass a constipated stool slowly). Once inside the rectum:

- Feel the wall of the rectum carefully – you will sometimes detect an entirely unexpected cancer of the rectum.
- Feel the prostate carefully for hardness or nodules which may mean cancer (Fig. 1.17). Even if it feels normal, try to estimate its diameters. If the prostate is tender on light palpation, it may be the site of inflammation.

Mistakes are easy to make when performing a rectal examination, but the worst mistake is not to do one at all.

Chapter 2

Investigations

Testing the urine

For centuries the doctor has learnt much from the urine: in times past, the doctor would look at it, measure it, smell it and even taste it. Today, he or she need not taste it. Infected urine usually stinks, and is always cloudy. Crystal clear urine is never infected. On many occasions a diagnosis may be made by having the patient simply record the time and volume of urine passed during 24 hours – the voiding diary or urine output chart (Fig. 2.1).

Office tests of the urine

pH

Indicator dyes impregnated on a paper strip measure pH sufficiently accurately for most purposes. Very acid urine should make you suspect uric acid stones. Very alkaline urine suggests infection with a microorganism that splits urea, e.g. *Proteus mirabilis*.

Protein

- Paper strips impregnated with tetrabromophenol normally turn blue in the pH range found in normal urine. Protein makes the colour yellowish. The dye is an indicator, and is therefore not reliable when the urine is very acid or very alkaline.
- A more reliable test for protein is to add a drop of 25% salicylsulphonic acid: this precipitates protein as a cloud unless the urine is exceptionally dilute.
- Boiling the urine precipitates a cloud, which persists when you add a drop of a dilute acid. If the cloud disappears, it was due to phosphates.
- When it is essential to know whether the quantity of protein in the urine is significant, collect the urine over 24 hours and have the protein measured quantitatively in the laboratory: more than 150 mg protein per 24 hours is abnormal and requires further investigation.

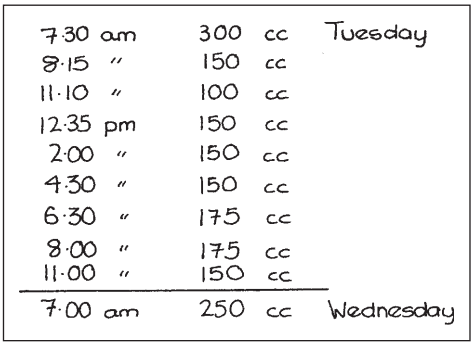

Figure 2.1 Voiding diary or fluid output chart.

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Glucose

- Paper strips are impregnated with potassium iodide and two enzymes: glucose oxidase converts glucose to gluconic acid and hydrogen peroxide; peroxidase then catalyses a reaction between hydrogen peroxide and potassium iodide to give a green–brown colour.
- If paper strips are unavailable, boil the urine with Fehling's or Benedict's solution. Glucose and other reducing substances throw down an orange precipitate of copper.

Blood in the urine

- Commercial stick tests for haematuria rely on the oxidation of tetramethylbenzidine by cumene peroxidase, which is catalysed by haemoglobin to give a green–blue colour, i.e. you are detecting free haemoglobin.
- If the test is positive, examine the urine under a microscope to confirm that red cells are present (see below).

The sensitivity of these stick tests is adjusted by the manufacturers to show a positive result when the amount of haemoglobin corresponds to about 10 red cells per high power field –twice the number found in normal urine – so a positive stick test always demands a thorough investigation. Remember that false-positive tests may occur if the glass container has been contaminated with povidone-iodine or has been cleaned with a bleaching agent such as hypochlorite.

Infection

Two stick tests for infection are available:

- based on bacterial conversion of nitrate to nitrite; and
- detection of leucocytes by leucocyte esterase activity.

In practice they are of limited use.

Bladder tumour antigen

The Bard bladder tumour antigen (BTA) test is based on the fact that bladder tumours break down the basement membrane, and liberate a protein – BTA – that can be detected by latex particles coated with human immunoglobulin G. The test strip produces a yellow band if positive, green if negative.

Microscopic examination of the urine

Blood

Put a drop of urine on a slide and cover with a cover slip. To find more than five red cells per high power field is abnormal.

Pus

A similar drop of urine will show more than five white cells per high power field if there is infection. When the pus cells come from the kidney, they have a characteristic glittering appearance. A Gram stain of the centrifuged deposit may identify which bacteria are present.

Casts

Casts are the squeezed-out contents of the collecting tubules of the kidney. When they are made of protein they are clear (hyaline): when made of red or white cells they are granular (Fig. 2.2).

Crystals

In cool urine there are always some crystals of triple phosphate and calcium oxalate. The hexagonal plates of cystine give away the diagnosis of cystinuria. Uric acid crystals are especially common in acid urine (Fig. 2.3).

Mycobacterium tuberculosis

The centrifuged urine is stained with auramine and examined under ultraviolet light: the mycobacteria shine as bright yellow dots.

Cancer cells

The urine is fixed with a roughly equal volume of 10% formalin and sent to the laboratory. There it

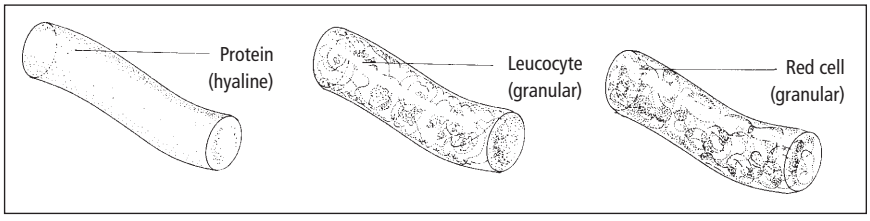


Figure 2.2 Casts in the urine.

is centrifuged: the deposit is made into a smear and stained with methylene blue (Papanicolaou's method; Fig. 2.4). Anaplastic tumour cells are larger and have bigger nuclei than normal urothelium. Note common sources of error:

- False-negatives may occur if the tumour is well differentiated when the shed cells are hardly different from normal urothelium.
- False-positives occur if part of the urothelium is undergoing mitosis in course of healing after some recent injury, e.g. from the passage of a stone.

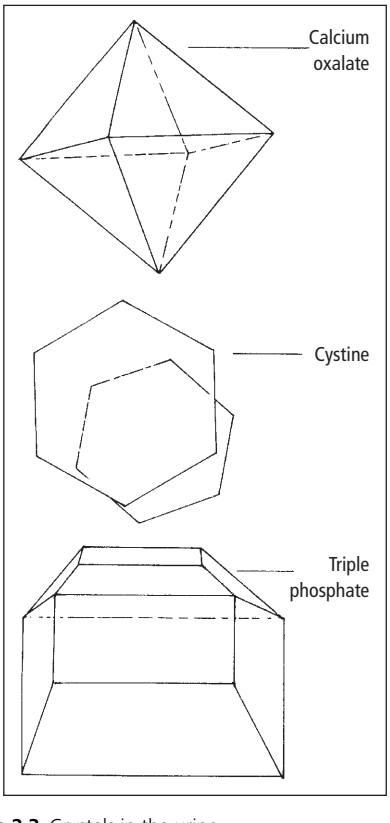


Figure 2.3 Crystals in the urine.

Schistosoma ova

The centrifuged deposit of urine may show the characteristic ova of Schistosoma. The different species have ova of characteristic shape (Fig. 2.5).

Culture of urine

Urine is an excellent culture medium and is easily contaminated from the wall of the urethra, prepuce or vulva, or by air-borne dust. At room temperature contaminants grow rapidly so that urine must either be plated out at once, or put in a refrigerator. A mistaken diagnosis of infection may be made if the urine is allowed to stand around at room temperature for a few hours before reaching the laboratory. The urine is obtained in three ways:

- By needle aspiration of the bladder. Any organisms found are abnormal.
- By catheterisation, but passing a catheter is uncomfortable and may introduce infection.
- By 'clean-catch' specimen or 'mid-stream urine'. Urine is mixed with a culture medium before incubation. Each organism gives rise to one colony, so a colony count shows how many bacteria were present in the urine. As a rule more than 50,000 (10^5) colonies/mL signifies infection, and anything less means contamination. Remember that these figures only apply to clean-voided urine. One easy way to make a colony-count is with a dip-slide (Fig. 2.6). Plastic slides coated with culture media are dipped in urine, drained off, placed in a sterile bottle and incubated. After 12 hours, a glance at

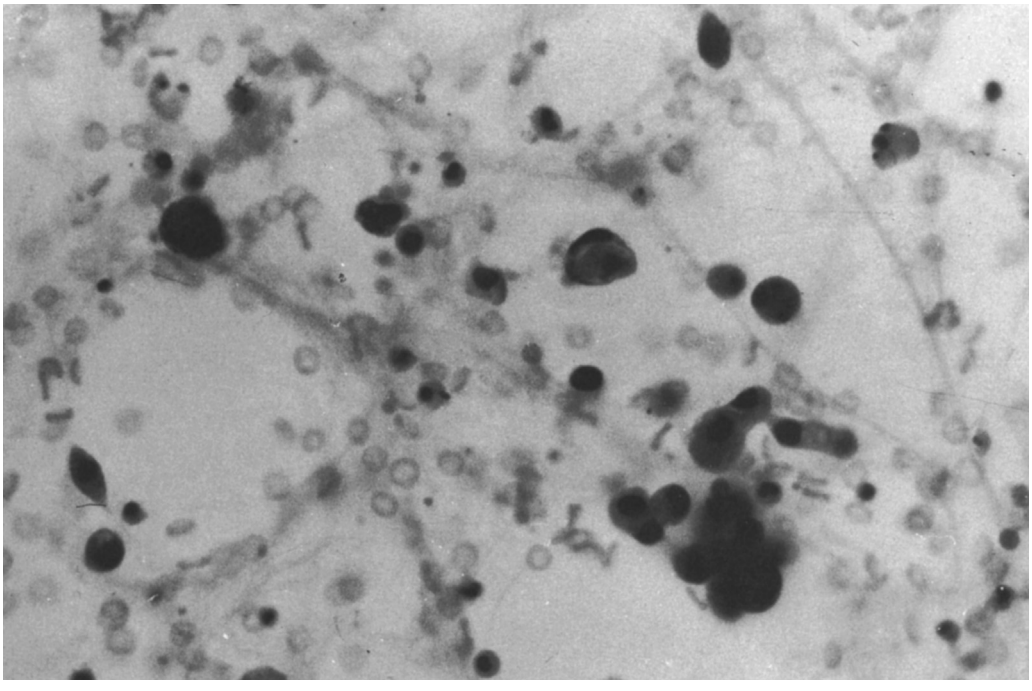


Figure 2.4 Centrifuged deposit from urine stained to show cancer cells.

the chart supplied with the slide shows whether there are more than 10^5 colonies or not.

Imaging the urinary tract

Plain abdominal radiograph ('scout film'; kidney, ureter and bladder (KUB) etc.)

Check adequacy of the film. It must include the bladder base and the prostate urethral region in order not to miss a urethral stone. Look at each film with four Ss in mind (Fig. 2.7):

- *Side:* Radiographers, being only human, sometimes put the wrong letter on the film. Always check that the soft tissue shadow of the liver is on the right side and the gastric air bubble on the left.
- *Skeleton:* Check the spine, ribs, hips and sacroiliac joints for bony metastases, the evidence of ankylosing spondylitis, or loss of joint space in the hips for which the patient might have taken

Figure 2.5 Ova of *Schistosoma haematobium.*

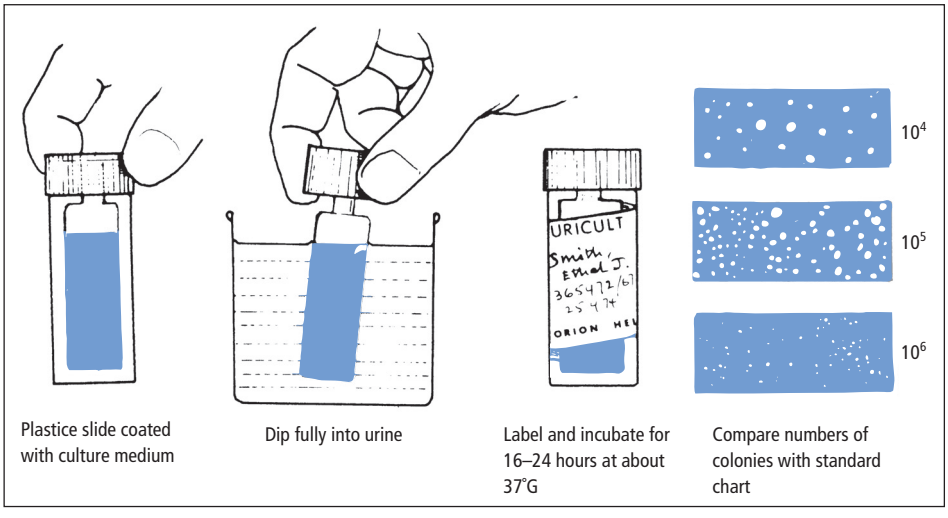


Figure 2.6 Dip-slide method of estimating colony count.

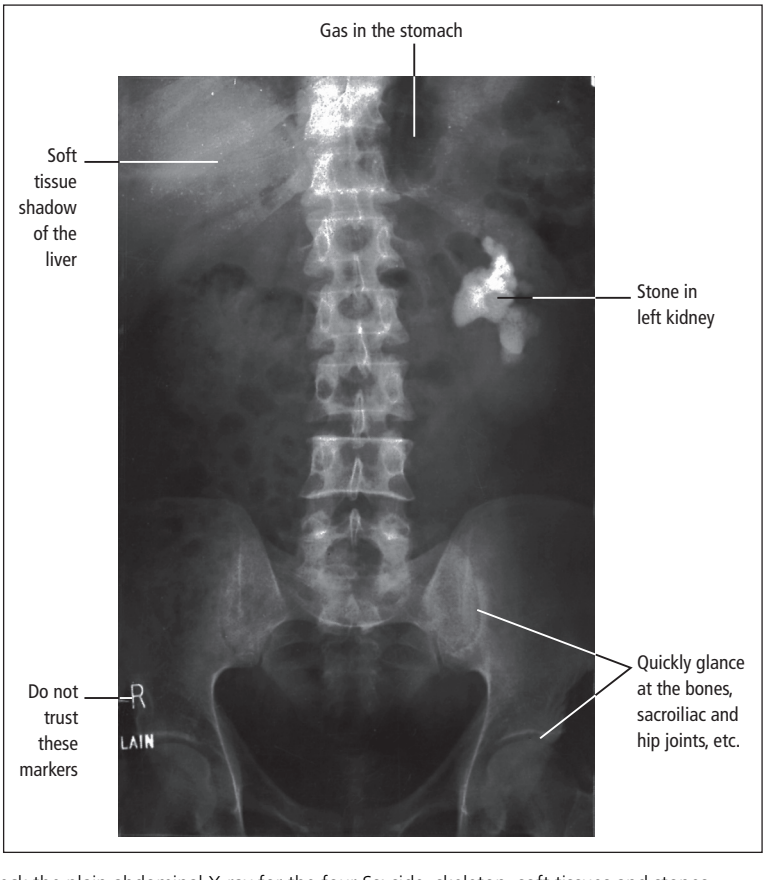


Figure 2.7 Check the plain abdominal X-ray for the four Ss: side, skeleton, soft tissues and stones.

analgesics and incurred the risk of analgesic nephropathy. In children with enuresis, careful examination of the lumbosacral spine is essential to exclude spina bifida defects.

- *Soft tissues:* In fat people the kidneys are surrounded by radiolucent fat which defines their outlines. A distended bladder or an enlarged uterus will fill the pelvis and displace the usual bowel gas shadows. In order to detect a large bladder residual volume, it is often helpful to obtain the film after voiding.
- *Stones:* Any radio-opaque shadow in the line of the urinary tract might be a stone. If it seems to be in the kidney, it should move up and down with the kidney during respiration. 'Stones' in the pelvis often turn out to be calcified fibroids or phleboliths. Only 60–70% of stones are dense enough to be visible on radiographs.

Intravenous urogram or pyelogram

This investigation allows good visualisation of the collecting systems and ureters. It is predominantly used to investigate haematuria and also to determine the ureteric anatomy. More recently its use in renal pain, ureteric colic and urinary stone disease has been replaced by computerised axial tomography/KUB (spiral CAT) studies.

Contrast media

Its high atomic number makes iodine relatively opaque to X-rays. Free ionic iodine is toxic, but when joined to benzoic acid it forms organic salts which can be given in large quantities, usually with safety. It does however have several drawbacks:

- *Chemical irritation:* Occasionally irritation of the vein results in flushing, nausea and vomiting, when the bolus of hypertonic contrast medium reaches the systemic circulation. These effects are not common and seldom serious. Chemical inflammation and necrosis of skin could result if the hypertonic solution is accidentally injected outside the vein. This is less of a concern now as the contrast media used are non-ionic and of low osmolarity.
- *Allergy:* True allergy to contrast medium is much more serious. It can range from a trivial urticarial rash which will vanish with an antihistamine, to life-threatening oedema of the glottis, trachea and bronchi, with widespread vasodilatation, hypotension and cardiac arrest. The allergen is the complete iodobenzoate molecule, not free iodine, so it is futile to perform skin tests with iodine. The reaction is not avoided by giving the first few millilitres of contrast slowly.

Millions of intravenous urograms (IVUs) are done every year, and fatal reactions occur only in 1:200,000. Patient anxiety increases the likelihood of a reaction thus quick reassurance to patients by the staff is helpful. Essential precautions are:

- Always enquire about even the most trivial previous reaction to contrast media.
- Be always ready for one. Never start to give intravenous contrast medium without first making sure for yourself that all the essentials for treating an allergic reaction are to hand and within reach of the X-ray table. There must be:
  - adrenaline;
  - hydrocortisone;
  - oxygen, with face-mask and airway;
  - a 'minitracheostomy' kit; and
  - a 'panic button' that will summon the cardiac arrest team.

Contrast medium in the kidney

Nephrogram

It takes 15–20 seconds for the contrast medium to reach the kidney. Contrast medium should be injected rapidly in order to ensure the bolus reaches the kidneys quickly. A film taken in the first 30 seconds will catch the contrast as it lies in the glomeruli and proximal tubules where water is being reabsorbed, so this, the 'immediate' or 'nephrogram' film, gives an image of the renal parenchyma (Fig. 2.8). Note that:

- When it is particularly important to obtain a good picture of the renal outline, e.g. when scarring or a tumour is suspected, then tomograms are taken during the nephrogram phase to eliminate unwanted shadows from gas in the bowel.

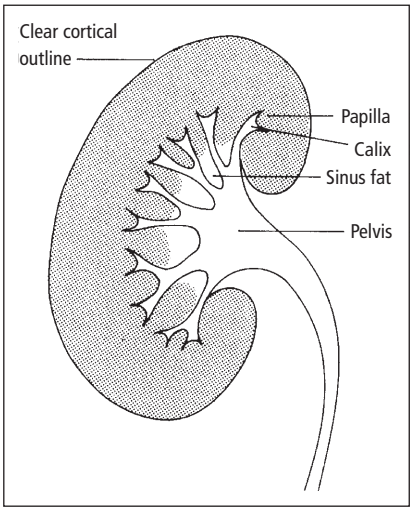


Figure 2.8 Nephrogram phase of IVU.

• In obstruction the filtrate cannot escape down the tubule, and so the nephrogram is denser and lasts longer. (With a stone blocking the ureter it is quite common to see the nephrogram persist for 24 hours or more.)

Pyelogram

In a normal patient the glomerular filtrate containing the contrast medium quickly reaches the calices and pelvis to give the pyelogram (Fig. 2.9). A film taken at 5 minutes will therefore show the relationships of the calices to the renal contour and many centres obtain this 'pyelogram' film in place of the 1-minute film in order to limit radiation exposure dose. The calices can be filled out by compressing the abdomen with a tight band to squeeze the ureters for the first 10–15 minutes. This compression is only applied if there are more of the following: evidence of obstruction, in children, and history of trauma, aneurism or recent abdominal surgery.

• A film taken just after releasing the band will then show the whole length of the ureter. If a portion of the ureter is shown poorly, obtaining oblique views often results in better visualisation.

• Later films are taken to show the contrast in the bladder (Fig. 2.10).

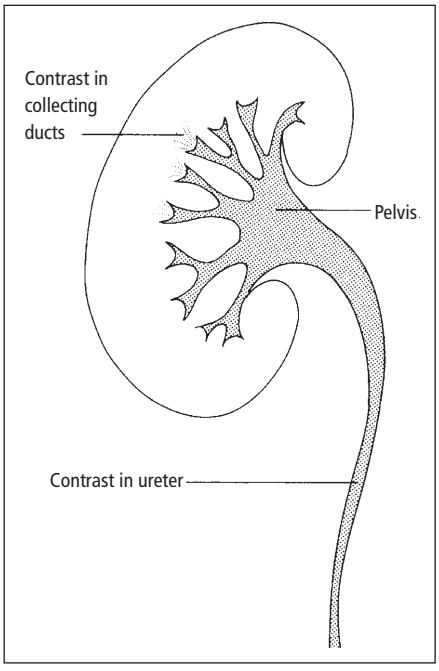


Figure 2.9 Pyelogram phase of IVU.

• The patient then empties the bladder, and if there is any question about the urethra, oblique films are taken during micturition to give a descending urethrogram. Afterwards a post-micturition film is taken which gives a rough idea of the volume of residual urine.

If one kidney is very small or scarred, most of the solute load has to be eliminated by the other one. In the small kidney the filtrate flows only slowly down the tubules, and in doing so becomes sufficiently concentrated to give a misleadingly clear image: never mistake a good image for good function.

Preparation for IVU studies

The obsolete practice still lingers of preparing patients for an IVU by depriving them of fluid for 6 hours or longer. This may give a slight increase in the concentration of contrast in the filtrate, and perhaps a marginal improvement in the image, but in a normal patient given the usual amount of contrast the improvement does not justify the

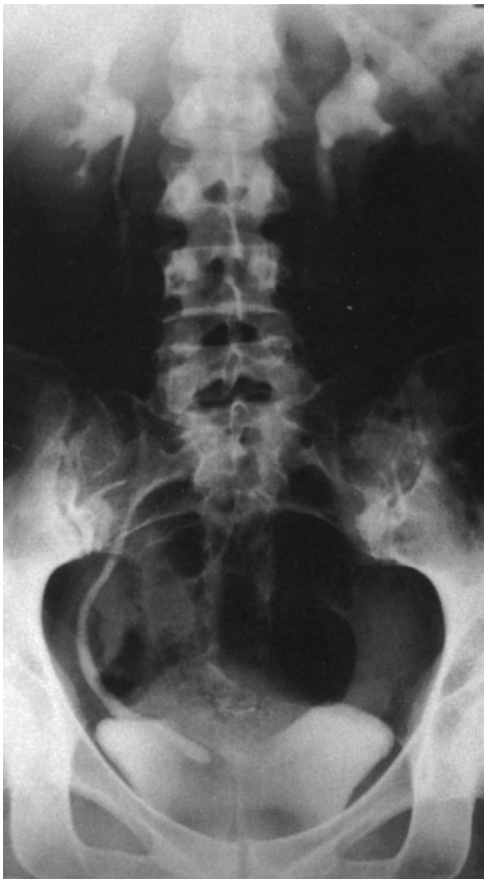


Figure 2.10 The upper tracts and bladder are shown in the 20-minute film of the IVU.

discomfort to the patient. Not only is the practice usually futile, it can be dangerous:

- the period of starvation can be dangerous in diabetes; and
- in myeloma it may lead to anuria from protein blocking the tubules.

To postpone an IVU merely because the patient 'is not prepared' should not be accepted as an excuse. Always obtain a control film.

Retrograde urogram

A fine ureteric catheter is passed up the ureteric orifice through a cystoscope and contrast medium is injected to outline the ureter, pelvis and calices

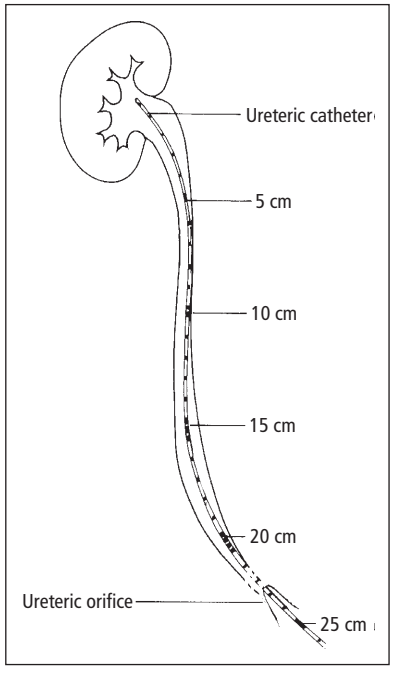


Figure 2.11 Retrograde pyelogram with a ureteric catheter.

(Fig. 2.11). A bulb-ended catheter jammed in the ureteric orifice allows dye injection up the whole length of the ureter (the ureterogram; Fig. 2.12) without possible leak back in the bladder. These retrograde studies are performed under X-ray control.

Antegrade or descending urogram

A fine needle is passed into the renal pelvis under X-ray or ultrasound control. A flexible guidewire is passed through the needle into the pelvis, the needle is withdrawn, and a cannula slipped over the guidewire into the pelvis to perform a percutaneous nephrostomy (Fig. 2.13). This is the first step in a whole range of percutaneous operations on the kidney. Contrast medium injected through the cannula will delineate the renal pelvis and ureter. The pressure inside the cannula can be measured at the same time in the course of investigating obstruction.

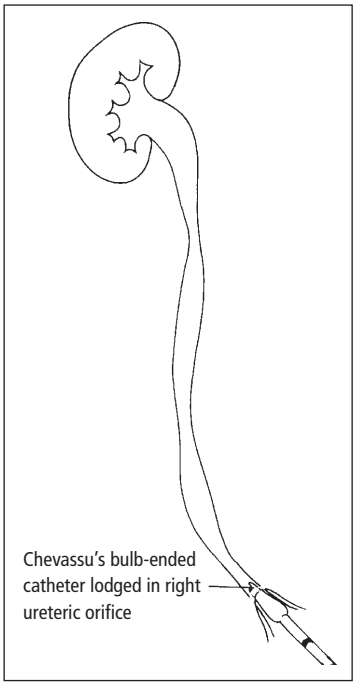


Figure 2.12 Retrograde ureteropyelogram using a bulb-ended catheter.

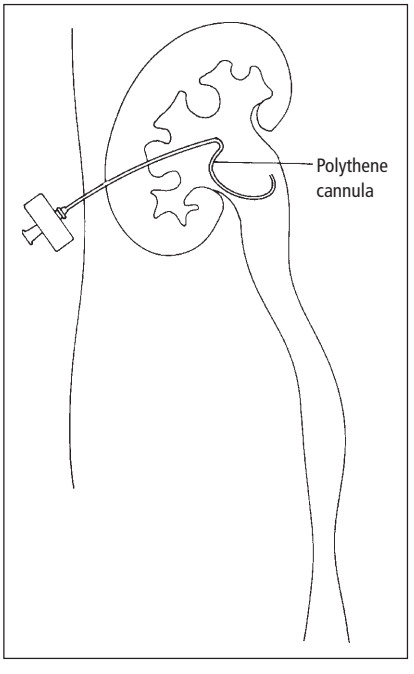


Figure 2.13 Percutaneous nephrostomy to obtain descending or antegrade pyelogram.

Cystogram

The image of the bladder in the standard IVU will usually show diverticula or large tumours of the bladder (Fig. 2.14). If the picture is not clear, or when it is necessary to rule out reflux from the bladder up the ureters, or in order to investigate incontinence, then the bladder is filled with contrast and screened while the patient passes urine. This is often combined with measurements of the pressure inside the bladder and the urine flow rate in a micturating cystometrogram.

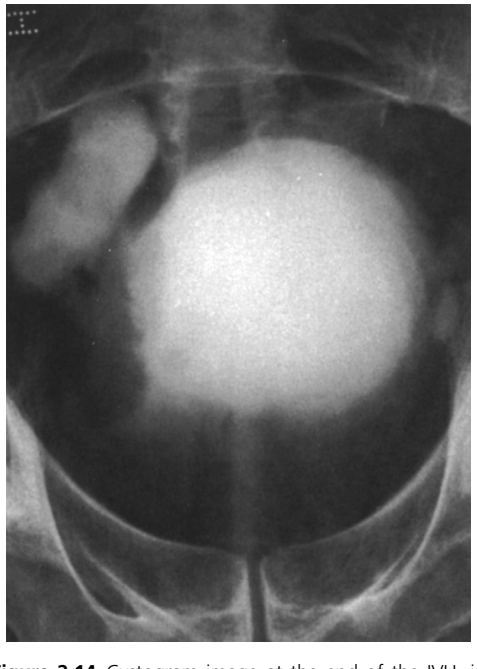


Figure 2.14 Cystogram image at the end of the IVU, in this case showing a diverticulum on the right side of the bladder.

Urethrography

In investigating strictures and other disorders of the urethra an ascending urethrogram is made by injecting contrast medium into the urethra with a small catheter. As opacification of the female urethra is technically difficult, this study is predominantly performed in men.

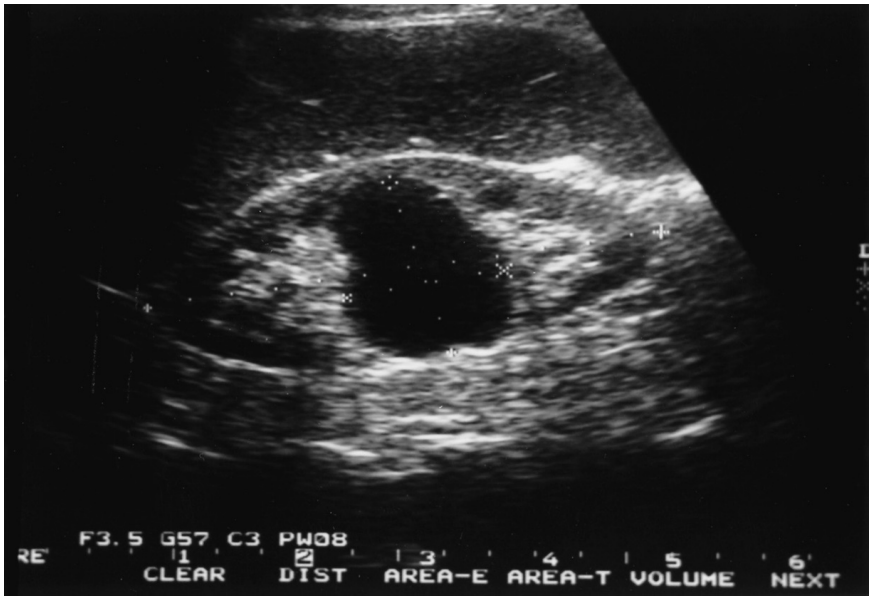


Figure 2.15 Ultrasound image of kidney containing a cyst.

Ultrasound

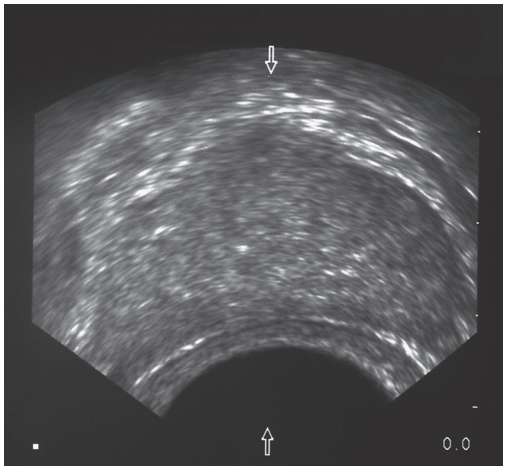
Ultrasonography is cheap, painless and uses no dangerous radiation. An AC current is applied to a piezoelectric crystal which then pulsates and produces a sound wave. The resulting wave penetrates soft tissues and is reflected by interfaces between tissues of different density, e.g. renal calices and parenchyma, or a renal cyst and parenchyma (Fig. 2.15). The returning echoes are received by the crystal which reverses the process. The sound is converted into an electrical impulse which is processed by a computer to give an image. Ultrasound images are more meaningful if you see them moving on a screen yourself. As images are obtained in a real-time mode, it is an excellent guide to interventional procedures, e.g. nephrostomy. It is the method of choice in paediatrics.

Transluminal ultrasound

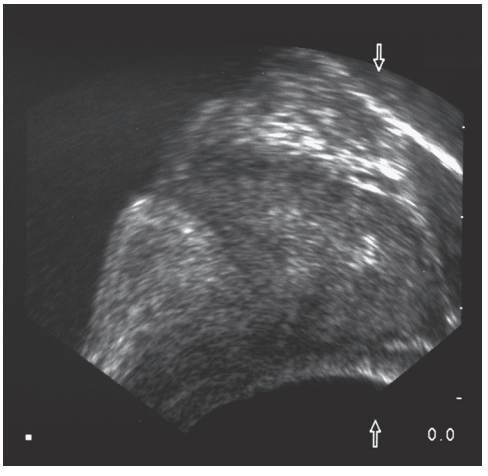
By inserting a special probe into the rectum (transrectal ultrasound; TRUS), high-resolution images can be obtained of the prostate (Fig. 2.16). This allows geographically mapped guided prostate biopsies. Transvaginal ultrasound has been particularly valuable in the detection of urethral diverticula.

Angiography

A flexible guidewire is passed through a needle in the femoral artery over which a flexible cannula with a curved tip is slipped, and guided under X-ray control into the opening of the renal artery. Contrast is then injected into the renal artery or its branches to give an arteriogram (Fig. 2.17). This investigation can be of value in the diagnosis of trauma, stenosis of the renal artery and where the cause of haematuria proves to be particularly hard to discover. Similar studies are made when it is suspected that there may be extension of tumour into the vena cava (cavography; Fig. 2.18). The image of smaller vessels in the angiogram can be improved if overlying shadows of bone and bowel gas are removed: this can be done with a computer (Fig. 2.19) to give a digital subtraction angiogram. Renal venography has been largely replaced by ultrasonography or contrast-enhanced CAT or MRI. One remaining indication is the cannulation of



(a)



(b)

Figure 2.16 Transrectal ultrasound (TRUS) examination of the prostate: (a) transverse and (b) longitudinal.

the gonadal veins with a view to embolisation in cases of scrotal varicocoeles.

Computed tomography

The CAT image is obtained by the computerised calculation of X-ray absorption after thousands of pencil thin beams of X-rays are transmitted through a patient as a rotating source whilst the patient moves through the source on a table (hence producing a 'spiral' data set. This technique provides exquisitely good spatial resolution but does involve a high radiation dose. It is the test of choice in urolithiasis, staging of renal cell carcinoma and the evaluation of renal tract

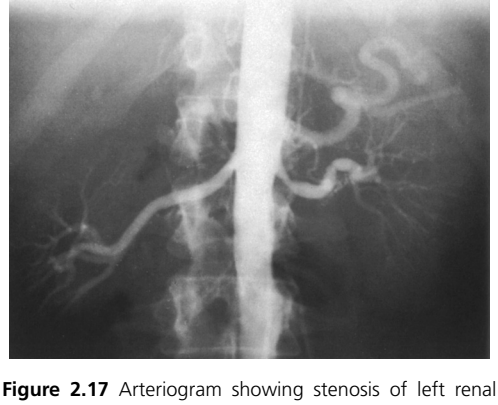


Figure 2.17 Arteriogram showing stenosis of left renal artery.

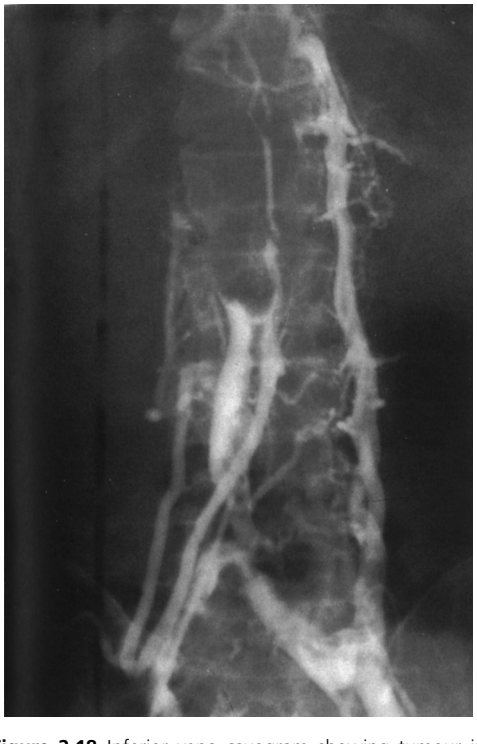


Figure 2.18 Inferior vena cavogram showing tumour in the vena cava.

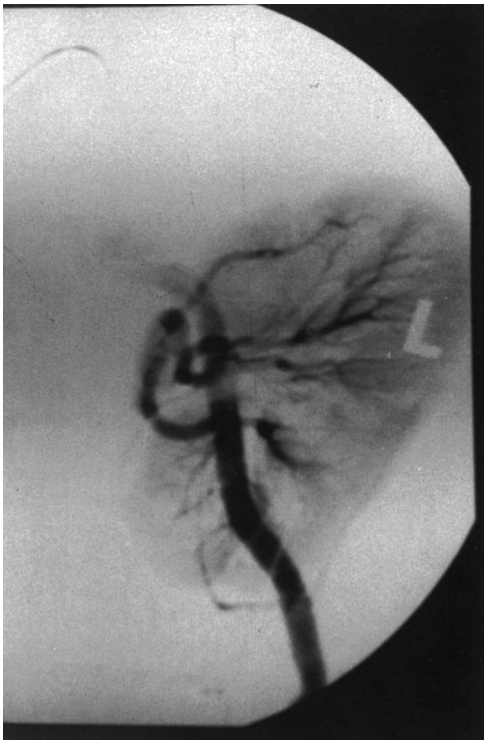


Figure 2.19 Subtraction angiogram of a renal transplant in the left iliac fossa.

trauma (dynamic CT scanning). It can be supplemented with contrast, e.g. intravenous dye injections (CAT/IVU combination) (see Fig. 2.20).

Magnetic resonance imaging

Atoms behave like gyroscopes whose axes are tilted by a strong magnetic field. When the field is turned off the gyroscopes whip back to their original position, and as they do so, give off a pulse of electromagnetic energy – magnetic resonance – which can be detected by a set of electronic sensors, mounted in a hoop and processed by computer to give an image (Fig. 2.21). This technique is becoming increasingly available and has the advantage of not involving irradiation or iodide contrast medium. Current indications for urological MRI include the local staging of pelvic urological cancers, assessing the degree of venous involvement of a renal cell cancer and the detection of renal artery stenosis. Some centres use MRI routinely in patients with impaired renal function in whom the use of nephrotoxic contrast medium is inadvisable. Patients who have pacemakers and metal surgical devices are not suitable for this type of investigation.

Radio-isotope studies

Radionuclides are tagged on to various pharmaceuticals (often with very long names!) to create radiopharmaceuticals. These are administered to the patient to provide functional imaging, and in some cases quantification, of various bodily processes. The radionuclide decays, and as it does so, emits small packets of energy (usually gamma photons) which interact with the detector crystal on a gamma camera, to cause a small flash of light to be emitted. This flash of light is then converted into an electrical current and amplified by an array of photomultiplier tubes on the back of the crystal. The resulting current is then put through a range of electronic wizardry and a digital image is produced. The more radiopharmaceutical materials are taken up, the brighter the image.

Four radiopharmaceuticals are most commonly used in renal imaging:

1 ^{99m}*Tc benzoylmercaptoacetyltriglycerine* (more conveniently known as MAG3) is secreted by the proximal tubules into the tubular lumen.

2 ^{99m}*Tc diethylenetriamine pentaacetic acid* (DTPA) is excreted predominantly by glomerular filtration. Both of these agents are used for dynamic renography, which allows time activity curves to be produced (Fig. 2.22) that show how the kidneys handle the tracer and give a good idea of how well each kidney is functioning. The images also give valuable information about the anatomical appearance of the kidneys although in less detail than ultrasound or CAT. Better results in patients with poorer renal function are obtained from MAG3 than DTPA.

3 ^{99m}*Tc 2,3 dimercaptosuccinic acid* (DMSA) is taken up and 'fixed' by the tissues of the proximal convoluted tubules. This radiopharmaceutical is not