UROradiology

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PREFACE

Medical books are now often written by committee. Knowledge is fattening, and one man can no longer hope to have the whole of his subject under his belt, let alone write about it. What reason then for this book? George Orwell (1947) gave plain answers to such pious questions in his essay 'Why I write'. Sheer egoism heads the list, trailing stuff like aesthetic enthusiasm (for medical writers, fun), historical impulse, and political purpose (medical intelligence). As regards medical intelligence, I wanted to give FRCR candidates and others a personal view of what is interesting and important about uroradiology. I have tried to prune or ignore everything else. The defects of the book are therefore entirely mine, but any merits rest on many shoulders. The book is mainly about what I learnt in my 10 years at the Institute of Urology and Royal Postgraduate Medical School. For this I am greatly indebted to many colleagues in clinical, pathological and radiological disciplines. Mr David Innes Williams taught me even more than anybody else. I thank them all very much.

I am especially grateful to my co-authors Alan Davidson and Lee Talner. Contributing to another's book is not particularly enticing. Both are old friends, and on this I traded shamelessly. The book now has at least three good chapters, and I thank them for their generous help.

The last part of my apologia concerns an obsession with the purpose of an investigative discipline in the closing decades of the century. What is scientific radiology about? One view is that the new imaging technology makes key contributions to amassing the evidence on which accurate diagnosis is based. Let us gather all the information we can about our patient, and evaluate the data. This is the apparatus of the diagnostic work-up, the impartial review of evidence leading from observation to conclusion. I think that the diagnostic work-up is unkind, uncritical and—much the worst indictment—deeply unscientific (Sherwood, 1978). Science works by trial-and-error, by generating ideas and testing them. On philosophical, humane and economic grounds, we are much better off if we start with an idea of what may be wrong with our patient, and then use radiological studies to test that hypothesis. In short, by building on the next likely diagnosis. This book therefore deals more with patients' presenting problems than with disease entities. I have not been able to carry this approach consistently through all parts of the book. The organizational muddle is mine, but it is an honest attempt to teach the sort of radiology apposite to our times.

The book has been written in the immediate sense, many times, by my secretary Mary Watts. It would not have come about without her. Peter Saugman commissioned the work, and I also thank David Manson and many other members of the Blackwell Scientific Publications staff.

Thomas Sherwood

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Sherwood T. (1978) Science in radiology. *Lancet* **i**, 594.

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PART I
Tools (X-ray and ultrasound)

These sections do not aim to provide a comprehensive manual of uroradiological techniques. Most readers will already have worked out their own approaches to common investigations like the IVU. A working knowledge of basic techniques will be taken for granted.

A. PLAIN FILM AND INTRAVENOUS UROGRAM (IVU)

Every radiological text hammers at the good plain film as an essential examination before starting out on contrast medium procedures. However tired, this message is absolutely sound and of pressing everyday importance. It has been said that the sharpest nightmares to haunt clinicians are made up of simple sins of omission or commission. Few patients come to harm for not having the latest laboratory test, but 'why didn't I do a rectal examination on Mr A, or look at the urine of Mrs B,' are the sort of questions that make for discomfiting sweats in the small hours. Inattention to the plain film is the exact counterpart of these sins in uroradiological practice, and many important mistakes still arise in this way.

The worth of the plain film is particularly dependent on good radiographic technique. 'Use a low enough kV and large enough contrast medium dose' is a simple maxim which can improve IVU practice overnight, much more decisively than installing tomographic equipment. Apart from using a low kV, the good radiographer is also keen to cover the whole of the urinary tract on plain films. The standard 35 × 43 cm film can only do this for perhaps half the usual size adults in this country, and many departments use a routine two-film survey to cope with this difficulty. The added radiation burden is a drawback, and a case can be made for an initial single 30 × 43 cm film, followed by a further bladder or kidney view if the first film is inadequate in either direction.

CONTRAST MEDIA

Current conventional urographic media are made up of a non-opaque cation (sodium and/or meglumine) and an opaque anion (diatrizoate, iothalamate or metrizoate). Nine combinations are therefore possible, and most are available commercially.

CATION (radiolucent)	*ANION* (radiopaque)
sodium	diatrizoate
meglumine	iothalamate
sodium/meglumine	metrizoate

Sodium agents are preferable for the IVU, since meglumine leads to a more intense diuresis, diluting the pyelogram (Benness, 1970; Dacie & Fry, 1972). Meglumine agents have advantages for angiography, though these do not necessarily apply to the kidney (Talner & Saltzstein, 1975). There is little to

choose between the opaque anions: cost per gram of iodine is one good criterion (Saxton, 1969—a key paper).

A jungle of trade names obscures these simple facts. Radiologists are guilty of falling in with the practice of referring to these compounds, some of the main tools of their work, by uninformative and even obscurantist names. Any single manufacturer's trade name for a range of contrast media ('Urografin', 'Conray' or whatever) usually refers to the same anion, but includes different combinations of cations.

Dose

A similar sloppiness extends to the contrast doses used for the IVU, and is taken up by clinical request forms asking for 'high dose urograms'. It is best to state clearly on each X-ray report exactly what and how much contrast medium was given. Most centres now use a minimum dose of 300 mg iodine per kg body weight for the standard adult with normal renal function. In renal failure this dose must be doubled (see Division 1 section B).

Excretion

Glomerular filtration is the only important route of renal excretion (Saxton, 1969). From the point of view of the kidney this is of course a cold, inactive process, the energy being supplied by the heart. The higher the plasma level of contrast medium, the more will be filtered. Plasma level in turn is dependent on the contrast dose and, to a smaller extent, on the speed of injection. The filtered contrast medium produces the *nephrogram*, diffuse opacification of the whole kidney.

The *IVU nephrogram* is therefore an upper nephron event, and can be regarded as a functional window for looking in on the upper nephron. It is dependent only on plasma contrast level, glomerular filtration and the obligatory sodium and water reabsorption occurring in the proximal convoluted tubule. It is *not* affected by the patient's state of hydration, which influences the the pyelogram through distal tubular water reabsorption. The very early nephrogram seen during the IVU is also made up of a vascular component (contrast medium in renal vascular spaces), but its importance is short-lived, lasting seconds rather than minutes.

Extrarenal excretion

In the normal state, renal excretion of contrast medium is dominant, and the existing hepatic and intestinal pathways unimportant. These are of interest, however, in renal failure states. This is not because they are able to take over efficient elimination of the contrast medium—if required, dialysis must be used to this end. The interest lies in explaining otherwise puzzling findings: opacification of the gall-bladder (Fig. I.1) and gut (Fig. I.2). The hepatic route is the most important of the extrarenal excretory pathways, and can lead to an opaque

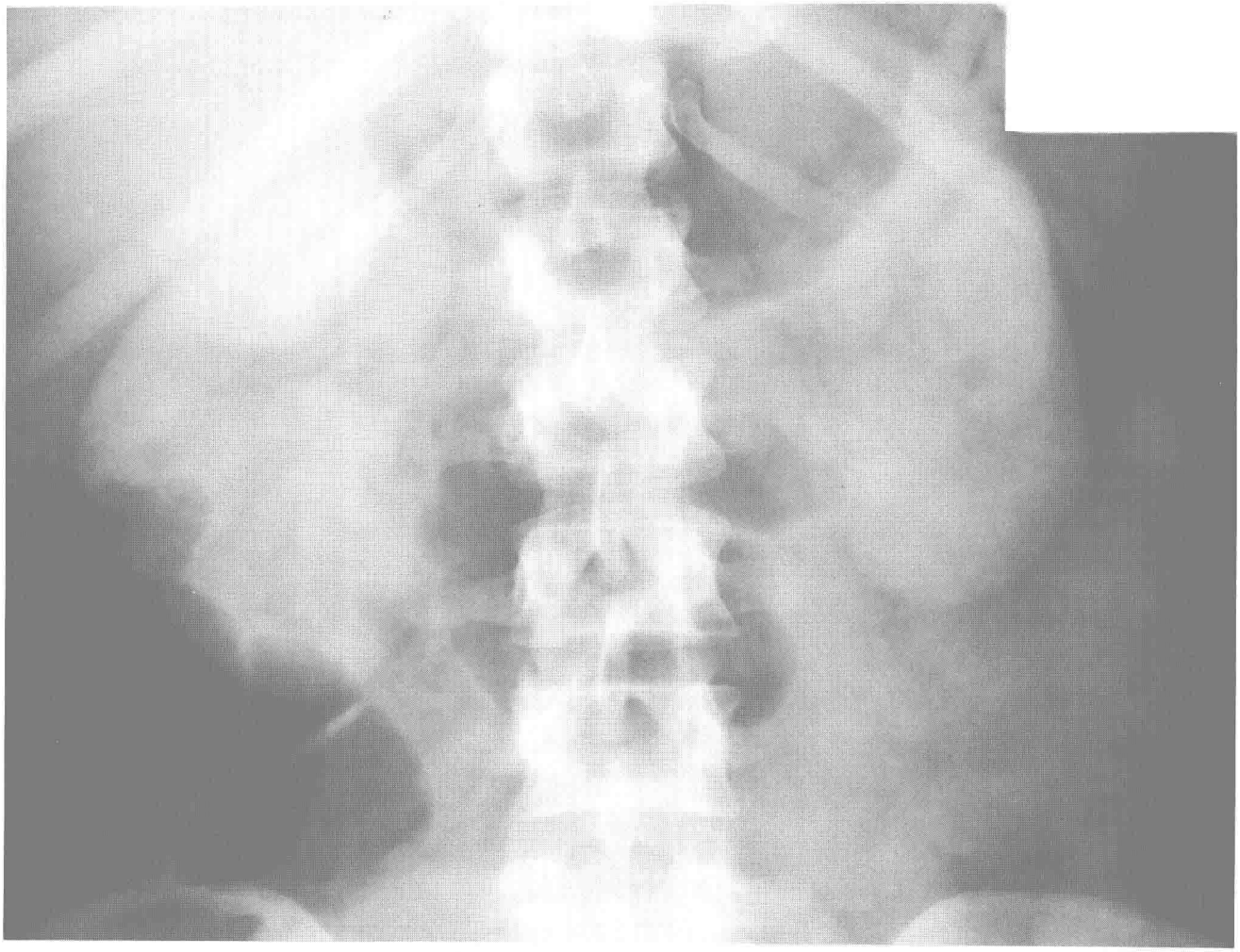

Fig. I.1 Eighteen hours after the start of the IVU in this young woman with acute renal failure, both kidneys are still densely opacified—the long-lasting nephrogram characteristic of acute tubular necrosis. Note that the gallbladder is also opacified.

gall-bladder even in the presence of normal renal function. This is seen particularly when one kidney is suddenly obstructed, e.g. in ureteric colic, and Sokoloff and Talner (1973) have elegantly shown that unusually prolonged, high plasma contrast levels are the explanation. There is an impression that this finding is more common when metrizoate is the medium used.

Free iodide—salivary gland enlargement

The iodine in standard contrast media is bound into the organic benzoic acid ring, but a small fraction of free, inorganic iodide is also present (Coel *et al,* 1975). Once injected, there is *in vivo* splitting off of further iodide, and this is

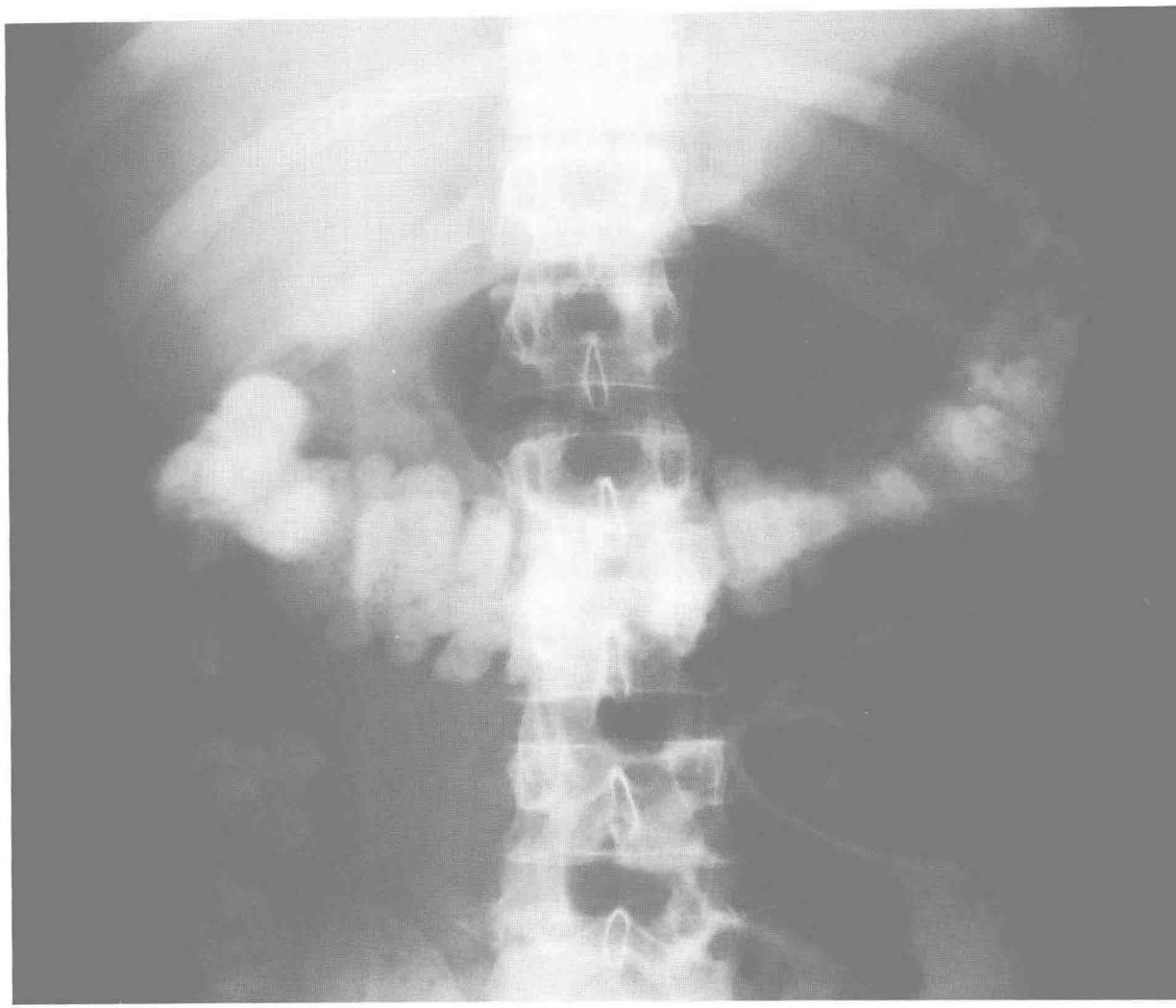

Fig. I.2 Chronic renal failure—6 days after the IVU the colon is seen.

more pronounced in the uraemic patient because contrast medium is retained longer. The salivary glands concentrate iodide, and also secrete the contrast medium intact (Talner *et al*, 1973). For these reasons transient enlargement of the salivary glands ('iodide mumps') may occasionally be seen in uraemic patients several days after the IVU.

Dehydration

By long tradition the patient having an IVU is first deprived of fluid for several hours. This was most necessary when small contrast doses of the order of 50 mg

iodine per kg were used: a good pyelogram was not seen without good urine concentration. Even so, overnight dehydration is not a reliable way of ensuring maximal urine concentration—it is a short period in the body's overall water household.

With current IVU techniques of using larger contrast-medium doses, dehydration has become much less important. Opinion is now divided whether it should remain part of the preparation for the standard IVU. Certainly there is no justification for turning down an urgent IVU request 'because the patient hasn't fasted'. This applies with particular force to ureteric colic (Casualty IVU, see Division 2 section B): the important information sought about ureteric obstruction will not be affected by the cups of tea the patient may or may not have had.

The supporters of routine fluid deprivation make several points. On average, somewhat better pyelograms will be seen. No complex, fallible instructions need be given to the patient about keeping to a moderate fluid intake or avoiding diuretics like coffee. If the contrast medium induces nausea, retching on an empty stomach is much safer than vomiting in the supine position

Against this can be ranged serious arguments on the dangers of fluid deprivation. The dehydrated patient with renal impairment (or multiple myeloma) stands to be harmed by the investigation. Most instances of renal failure precipitated or worsened by an IVU can be put down to inappropriate dehydration. Unless there is very close clinical liaison, the radiologist may not always know at the outset of an IVU that his patient does not suffer from renal impairment. Why run these risks when fluid deprivation has only a small influence on IVU quality, is the argument of this school.

The reader of this book will wish to choose his own path between these voices. If he/she works in a unit with excellent clinical rapport, there is still something to be said for fluid deprivation of the patient with assuredly normal renal function. There is no disagreement whatever that dehydration is to be avoided at all costs in three groups of patients who may be *harmed* by it:

1. Renal impairment. For practical purposes this means a raised blood urea or creatinine. Patients in renal failure cannot concentrate their urine, so the attempt at making them do so is silly as well as dangerous.

2. Infants.

3. Myeloma. Diabetes may come to be added to this list.

Newer contrast media

The high osmolality of the conventional urographic media has drawbacks, though distension of the urinary tract by the ensuing osmotic diuresis is helpful. Dimer contrast media, linking together two opaque anions, have been developed, e.g. sodium iocarmate. They have particular advantages in sites where high osmolality is undesirable, e.g. in the subarachnoid space. Six iodine atoms

in a dimer molecule have an 'osmolality cost' of only three particles (dimer anion, two cations), as opposed to four particles in the monomer (two anions, two cations). A non-ionic contrast medium, metrizamide, has been developed, with only a third of the osmolality of the monomer per iodine mass.

The high cost of these media militates against their routine use. It might be thought from the armchair that they would have a special place in advanced renal failure, where the kidney is already subject to an osmotic diuresis and reduced glomerular filtration rate. This is not so in experimental practice (Webb *et al*, 1978), and for the IVU their place remains uncertain.

Reactions

Contrast medium reactions are probably the most feared complication in X-ray departments. This is because they occur unheralded, in previously fit patients, and may advance at a frightening pace to death within minutes. Perhaps most worrying of all is that there is as yet no hypothesis which can consistently explain these reactions, and make up a scaffolding for sensible action. Four mechanisms under study are mentioned by Lasser *et al* (1977):

1. An antigen–antibody reaction directed against the contrast medium, which functions as a haptene.

2. Activation of complement and of coagulation systems.

3. Release of histamine from mast cells and basophils.

4. Anxiety.

The unpredictable sequential pattern of contrast medium reactions within the same patient is a particular stumbling block. A patient may have a reaction at one IVU and not at another, using the same contrast compound. There is no crescendo effect of each reaction rather worse than the last, which might be expected on an immunological basis. Reactions are almost unknown under general anaesthesia. It might be argued that most uroradiological examinations under anaesthesia involve retrograde rather than parenteral injections, but contrast medium is in fact absorbed into the circulation in small amounts across the urothelium.

These puzzles lend particular support to the anxiety hypothesis. Thus Lalli (1975) had nine patients with previous life-threatening reactions who suffered no ill effects at their next examination, conducted with calm assurance. I do not think there is any difficulty about accepting that patients may 'die of fright', but I am not yet convinced that all the observed facts can be fitted into this hypothesis. There is no doubt that the personalities and approach of the medical staff are of major importance in this as in most other radiological fields. Reactions may arbitrarily be grouped into three classes of severity.

1. Minimal reactions. Most patients feel uncomfortably warm during the injection because of vasodilatation. Sensations of flushing in face and throat, or of

imminent incontinence are common. A few patients develop nausea and retching. These symptoms hardly deserve the title of reactions, and are to be managed with calm explanation.

2. Minor reactions. Patients develop urticaria, at times with very extensive, itchy weals, peri-orbital oedema and stuffy sinuses. These uncomfortable symptoms can be helped by antihistamines, or possibly steroids in severe cases.

3. Major reactions.
(a) *Laryngeal or bronchial obstruction.* Steroids are the traditional stand-by, but subcutaneous adrenaline probably still has a place, arguably more effective.
(b) *Hypotensive collapse or cardiac arrest.* Emergency treatment of these rare complications follows standard resuscitation lines. It is worth remembering to try to obtain a quick abdominal radiograph during the recovery phase: it is probably the only IVU ever advisable in that patient.

Prophylaxis

Various manoeuvres have been tried, often without success.

Pre-testing. This has involved applying contrast medium to various sites like the cornea, or injecting a small bolus intravenously. There is now general nihilism about the value of such testing. Certainly a negative result does not preclude a major reaction. However, those with a positive intravenous pre-test perhaps run a greater risk of serious reaction if the full dose is then given (Lasser *et al,* 1977). The rarity of a positive pre-test result makes this rather unimportant.

Change of contrast medium. There is no convincing evidence that this is an important consideration in dealing with the patient who has already suffered a reaction. Meglumine compounds appear more likely to be associated with bronchospasm (Ansell, 1976), so a change to a sodium compound might be sensible for a subsequent examination in a patient with such a reaction.

Pre-treatment. The place of intravenous steroids in the treatment of the acute incident is accepted rather uncritically. However, Lasser *et al* (1977), authoritative voices, support steroid pre-treatment of patients who have already had a reaction (or those 'thought specifically at risk') for two days before the new examination.

Summary comment

Any department carrying out IVUs must clearly be prepared to deal with contrast medium reactions. Because the life-threatening occasion is rare, arises unannounced and progresses quickly, the doctor first on the scene may never have met one before. He can guard against disasters by remaining easily within call of the IVU room for the first 10 minutes following injection—most reactions

arise early. There is everything to be said for having a wall chart or booklet on diagnosis and treatment of reactions in every IVU room (e.g. Ansell's *Notes on Radiological Emergencies,* Blackwell Scientific Publications).

The tentative evidence on the importance of anxiety in reactions is cheering: the kind, considerate radiologist can look forward to fewer reactions than his surly colleague.

TECHNIQUE POINTS

Compression

The best pyelograms for demonstrating caliceal detail will need compression. It is therefore a good manoeuvre, providing it is well done (Saxton & Strickland, 1972). Compression must be used with common sense and discretion, e.g. avoided in those with abdominal masses, tenderness, or urinary tract obstruction. Rarely, compression has led to renal rupture. Since acute ureteric obstruction alone can rupture a kidney (Fig. I.3), it is not sensible or necessary to add this insult to patients having an IVU for ureteric colic. For many patients having follow-up IVUs the questions posed do not bear on caliceal detail, but on ureteric drainage. Compression is then clearly inappropriate.

Effective compression is uncomfortable and tends to be remembered with particular aversion by many patients. There is no point in using it in any half-cocked way. There are also instances when it is best forgotten altogether, e.g. in frightened children.

Tomography

This is an essential technique for the renal failure IVU: the nephrogram which is the key to the investigation may not be seen properly without it. A control pre-injection tomogram should be done first, so that comparison is possible for the doubtful nephrogram. Many centres now use tomograms as part of their standard initial IVU. Providing this does not become a radiation extravaganza, the pay-off in avoiding ambiguous examinations is probably justified.

Follow-up IVUs

Most second or further IVUs can be severely curtailed. It should be a point of honour for the radiologist to use the bare minimum of films. The questions asked of the examination are usually sharply limited at this stage, and can often be answered by two radiographs, plain film and ten-minute full-length film.

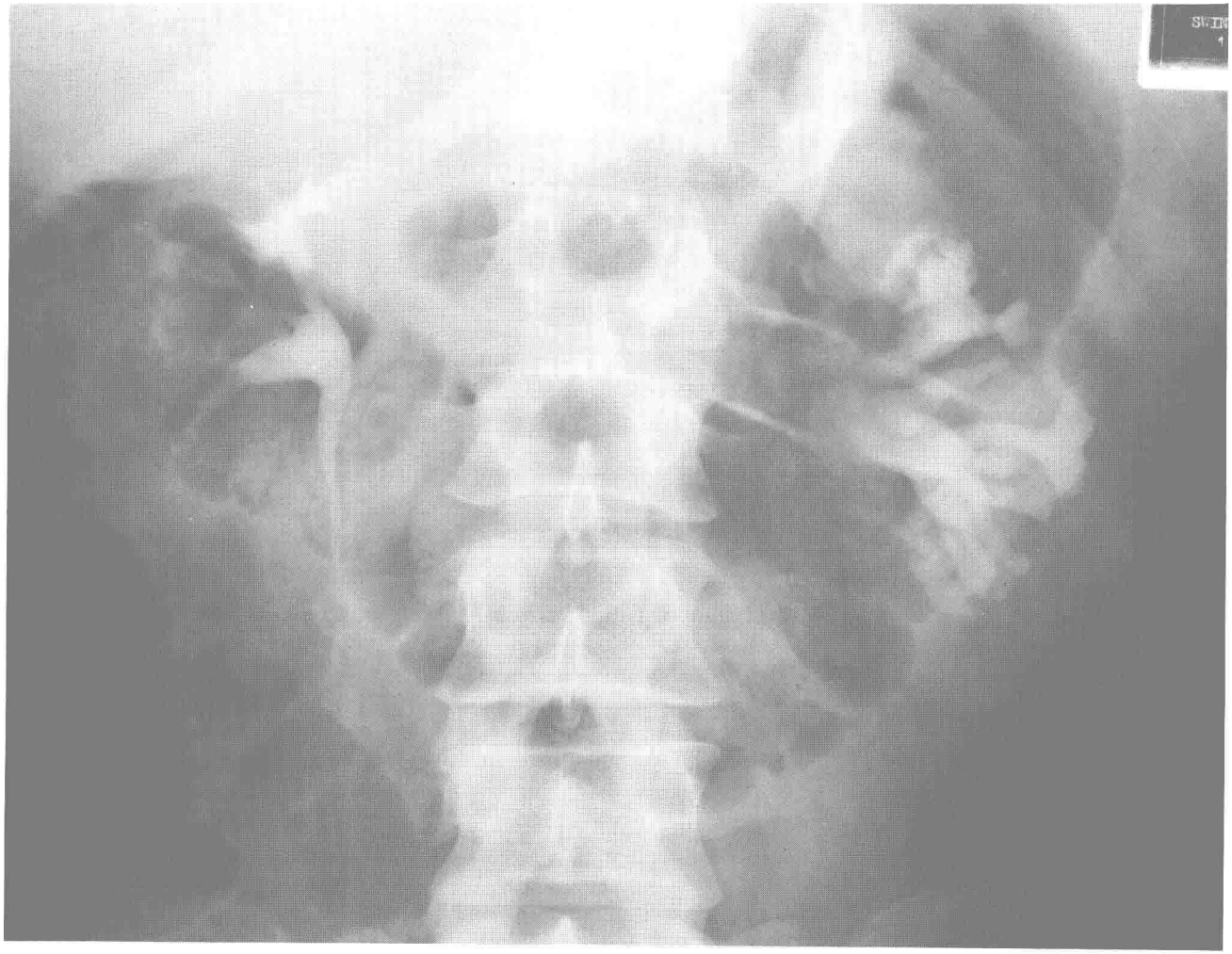

Fig. I.3 Left ureteric colic and stone causing renal rupture—note contrast medium in the left renal sinus.

Injection speed

Remember the worries about patients with known heart disease—see Division 1 section B under 'Contrast medium and dose'.

Children

Children are not small scale adults. Their IVU needs are different—see section J p. 36.