Procedures in Diagnostic Radiology

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Preface

This book is intended to be a reference work for radiology trainees learning to do practical procedures for the first time and also for practitioners called upon to perform such procedures when they may be outside their usual range of experience.

The authors are all working radiologists with a collectively wide experience in diagnostic and interventional studies. The book therefore has a heavily practical emphasis, considering not only the standard ways of performing the procedures but also how to overcome the problems and difficulties likely to be encountered.

Dunedin, New Zealand T.D.

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Introduction

ASSESSMENT OF PATIENTS

Before any patient is 'imaged', in an ideal situation they should be assessed by a member of the radiology department who is able to make decisions relating to the timing and type of procedure required to make the diagnosis with the least risk, at the least cost to the patient and to the community.

For instance it is not cost-effective to subject a patient with suspected acromegaly to a battery of radiological investigations from heel pad thickness to computed tomography to simply confirm the diagnosis if it has been made by growth hormone assay.

If a female of child-bearing age thinks there is a possibility that she may be pregnant then any examination involving ionizing radiation exposure to the pelvis should be postponed until her menstrual period starts unless there is a pressing medical indication for the examination.

A history of exposure to hepatitis 'B' is very important particularly if arteriography or other invasive examinations are planned. In cases of doubt the patient should be screened for antigens and the examination postponed until results are available. If antigens are present then special protective measures will be undertaken during the examination.

Patients with severe heart, renal or liver disease may be unable to survive invasive examinations unless they are modified to accommodate the limitations imposed by their disease. In particular patients with myeloma undergoing contrast examinations should not be dehydrated because of the risk of acute renal failure. The rigorous bowel preparation performed in preparation for a double contrast barium enema may be dangerous in a patient with ulcerative colitis.

In actual practice referring physicians may not commonly accept kindly the opinion of a radiologist regarding the timing of, or the need for, investigation of their patient. Radiological examinations are in most centres still 'ordered' rather than 'requested'. The clinical information provided is often inadequate.

Because of the rapid increase in imaging technology the radiologist is often the only person who is in a position to provide a logical and cost-

effective plan of investigation. This can be done by ensuring that all imaging 'request forms' are approved by the radiologist in charge of the area in which the investigation will be performed. If it is to be done properly the previous imaging examinations and often the case record notes must be perused. This is the practice in the Royal Melbourne only for selected examinations which are 'high cost' such as computed tomography or 'high risk' such as interventional angiography.

Simple examinations of the chest or limbs are of sufficiently high volume to render any pre-examination vetting impractical and sometimes the films are not seen by a radiologist before the patient departs.

The films from each examination should be viewed by a radiologist, and compared with previous examinations if possible, as they emerge from the film processor.

Contraindications to imaging procedures depends largely on the patients and their disease. Uterine angiography for instance is not recommended in early pregnancy but other decisions are less easy to make. Is carotid arteriography to confirm satisfactory clipping of a cerebral aneurysm necessary? If the result of the imaging examination will not influence the treatment or course of a disease process is the examination justified?

Absolute contraindications for examinations without the risk of ionizing radiation or the risk of contrast media are few. A history of severe reaction to contrast or the combination of dehydration and myeloma are relative contraindications to vascular contrast media. In most cases the examination can be modified or the patient's circumstances be changed by treatment to allow the disease process to be imaged adequately.

The particular indications and contraindications for each procedure are listed in the text.

SEDATION FOR DIAGNOSTIC PROCEDURES

If the procedure is not painful and the radiologist or X-ray technician explains what is required then sedation is not indicated or desirable. The worst part of most radiology procedures is the uninformed imagination of an anxious patient. Since patients are grouped by unit the chances are that the patient in the next bed can provide a horrific description of the procedure and its complications.

The anxious patient is conveniently premedicated with oral diazepam 10 mg 2 hours prior to the procedure. The diazepam appears to give the patient a shortened perception of the passage of time in addition to reducing anxiety.

It is not sensible to place a nervous patient outside an examination room from which are emanating a series of shrieks and moans from a patient in pain.

A combination of opiate and atropine is used as a premedication but the patient is often nauseated by this combination and the addition of

metoclopramide (Maxolon) may be required. In our experience a nervous and uncooperative patient may become uncontrollable and move unpredictably when stimulated while heavily sedated.

When the procedure is painful at the point of insertion of a needle then a large volume of low strength local anaesthetic is often more effective than sedation. This works well in nephrostomies but is not suitable for external carotid embolization. If severe pain is to be expected or the procedure will be unbearably long then neuroleptanaesthesia, epidural anaesthesia or a general anaesthetic is indicated.

Post-procedural pain relief may be required after minor examinations and is always required after renal embolization due to the infarct produced. After-care of radiology procedures, particularly the invasive ones, is the radiologist's responsibility.

EMERGENCIES IN THE RADIOLOGY DEPARTMENT

Prophylaxis

Emergencies in the radiology department are usually medical. As some patients are more likely than others to cause an emergency then these 'high risk' patients should be under observation by a nurse, X-ray technician or doctor for the duration of their examination and they should be accompanied to and from the department if necessary with a cardiac monitor and by a person who is familiar with the patient's medical problem.

On arrival in the department the patient case record should be checked for a history of allergy, diseases such as phaeochromocytoma and myeloma, and if steroids have been given recently in significant doses.

If the examination is likely to precipitate an emergency then there should be resuscitation equipment in the room ready for immediate use. If the patient is in a parlous state the examination should be performed only if it is essential to the immediate management.

Although modern X-ray equipment is earthed and safe in an anaesthetic room, some older equipment cannot be made completely safe with respect to earth current leakage and is not suitable for use in the presence of an explosive anaesthetic gas. Such machines should be clearly labelled or preferably replaced.

Patients who have a documented history of a bronchospasm, circulatory collapse, or cardiac arryhthmia following contrast injection should be assessed by the radiologist and, if indicated, the examination postponed until pre-testing and prophylactic regime of corticosteriods undertaken. The non-ionic contrasts appear to offer much greater safety with regard to 'allergy' and are now indicated in all cases of previous reaction to contrast.

It is essential that all staff in the radiology department, including the non-medical personnel, are trained and practised in cardiopulmonary resuscitation and know where the emergency equipment is kept. As emergencies

are for the most part unexpected and infrequent, the staff may become complacent and unready. In The Royal Melbourne Hospital the Coronary Intensive Care Unit 'arrest team' attends all emergencies in the radiology department. This overcomes any inexperience through lack of practice on the part of the radiology staff and speeds the transfer of the patient to Intensive Care if required.

In cases of contrast 'allergy' there is now evidence that an intravenous challenge injection will be of prognostic value if a rigorous protocol is followed in which sufficient time is allowed after each test injection for a reaction to develop. If a severe reaction does occur after a test dose, the need for contrast examination should be carefully reassessed and non-ionic contrast (Iopamiro) or a corticosteroid premedication used.

Whenever contrast is given it is prudent to use a needle set which can be left in position until the end of the procedure in case a contrast reaction occurs. Onset of contrast reactions have been reported several hours after injection.

TREATMENT

Contrast media reactions

These are probably the most common emergencies in a radiology department and most occur in the urography area (Lalli 1980). If a contrast reaction should occur during an excretion urogram and the patient's condition permits, at least one roentgenogram should be made of the renal area as it may be diagnostic and it is likely that the examination will not be repeated.

Reactions are conveniently divided into three groups; minor, vaso-vagal and major.

Minor reactions

A minor reaction is usually evidenced by the presence of hives or an erythematous skin rash. The patient is often unaware of the rash and in such cases treatment is hardly necessary. If the patient complains of itching then intramuscular anti-histamines are given as a single dose.

Nausea and vomiting may occur after even a small amount of contrast and even if no treatment is given may not occur after much larger doses for a film run. If nausea is persistent then an anti-emetic (metoclopramide) is given intravenously. Vomiting after injections for urography is more common than with either injections for intravenous digital subtraction angiography or for arteriography. The reasons for this are not clear.

Vaso-vagal reactions

A feeling of impending doom accompanied by pallor and slow pulse indicate

a vaso-vagal reaction which is likely to be due to fear or the radiologist's attitude. Patient anxiety is thought by some to be the sole cause of 'contrast reactions' (Shehadi & Toniolo 1980) and if the patient is nervous then premedication with diazepam, a narcotic, and atropine is likely to produce a smooth examination. Many of the 'contrast reactions' in the patient history appear on close examination to be vaso-vagal in nature.

Major reactions

Major reactions are those in which the patient experiences bronchospasm, circulatory collapse or loss of consciousness. The treatment of such conditions is the intravenous injection of 1:10 000 adrenaline in 1 ml aliquots as required, and supportive methods aimed at maintaining an adequate airway and cardiac output. Cardiopulmonary resuscitation may be necessary.

Corticosteroids are usually administered but the rationale for this in the acute situation is unclear as their effects are not active immediately. Antihistamines are also usually given but after adrenaline the sense of this could also be questioned. Epsilon-amino-caproic acid may also have a protective effect. The patient is then transferred to the intensive care area for the next 24 hours as a further delayed reaction may occur.

Other medical emergencies

In a hospital environment there is always the possibility that a patient will suffer a cardiac arrest, pulmonary embolus, stroke or other event which is unrelated to the examination.

The first person on the scene should call for help, (preferably by way of a 'cardiac arrest alarm button') and immediately ensure that the airway is clear. If the patient has stopped breathing begin mouth to mouth respiration as an annoxic arrested heart will often resume beating normally when ventilation is adequate. (The chance of contracting AIDS or other infectious diseases this way is very slight.) If the airway cannot be cleared from above a 'tracheostomy' can be performed by passage of a large bore needle directly into the trachea below the cricoid.

Next evaluate the cardiac status. If in doubt start cardiac compression by alternating three or four compressions for each ventilation. If a second person has arrived one should ventilate while the other performs cardiac compression. A compression rate of about 60 per minute is sufficient. A higher rate is very tiring.

The arrival of the 'arrest team' will provide a defibrillator, ECG, and the drugs necessary to treat any arryhthmia and electrolyte imbalance. An endotracheal tube should be inserted and artificial ventilation with oxygen started if the patient is still not breathing spontaneously.

Access to the circulation may be obtained via the arm veins or by the femoral veins. There is usually insufficient time for a cut-down and small

veins are not likely to provide good central access for drugs, especially if the vein is distal and the cardiac output is poor.

If a satisfactory heart rate and blood pressure are maintained then the ventilation should be continued. If after 10 minutes or so, with adequate ventilation and cardiac compression, the patient is still non-responsive without heart beat, blood pressure or respiration then the resuscitation attempt should be abandoned. It is often harder to stop resuscitation than to start it.

REFERENCES

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Urinary tract

INTRAVENOUS PYELOGRAPHY

Indications

1. The basic method for displaying the anatomy of the kidneys, upper urinary tract and bladder.
2. Used to detect functional abnormalities, e.g. resulting from ureteric obstruction, or associated with renal artery stenosis.

Equipment

The intravenous injection

1. Butterfly needle, gauge 19 or 21.
2. Contrast medium. Water soluble ionic or non-ionic medium according to patients' risk category. (See 'Difficulties and complications'.) Approximately 20 g of iodine for adults. With ionic media meglumine salts are preferred because of lower toxicity even though sodium salts have been shown to give slightly higher iodine concentration in urine.
3. Resuscitation equipment for severe contrast reactions. In particular, an airway, a means of administering air or oxygen, a knowledge of cardiac massage and drugs including adrenaline 1 : 10 000.

Radiographic equipment

1. Tomographic facility an essential requirement.
2. Low kV techniques (i.e. 60 kV or less) required to enhance contrast. High mA necessary to keep exposure times as short as possible.
3. Abdominal compression belt (separate from ureteric compression) attached to table to steady patient and reduce abdominal thickness to shorten exposure times (Fig. 2.1).
4. Inflatable ureteric compression belt, attached to patient, but not to table, with quick release mechanism. Preferably separate balloons for each ureter (Fig. 2.1).
5. Bucky, screen–film–cassette combination.

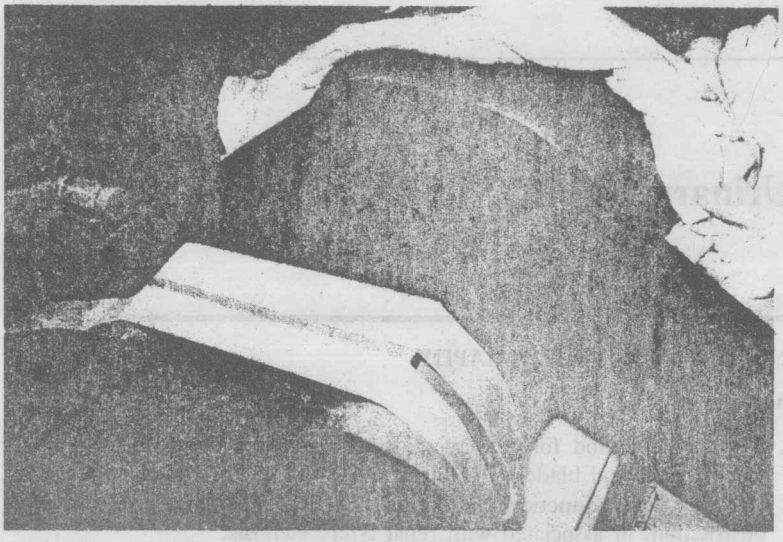

Fig. 2.1 Arrangement of compression bands during intravenous pyelography. The broad upper belt, fixed to the table, steadies the patient and reduces the thickness of the abdomen. The lower ureteric compression belt, attached to the patient only, has two separate inflatable bags to compress each ureter.

Patient preparation

1. No fluid or food restriction. The patient is advised to eat and drink normally. Fluid restriction increases the risk of renal impairment following contrast injection particularly in diabetics with chronic renal failure. Following examination the patient is encouraged to maintain a high fluid intake for 24 hours.
2. Mild laxative on evening before examination.
3. Question about previous contrast reactions and relevant history, e.g. analgesic intake, diabetes, etc. If a previous severe contrast reaction use non-ionic contrast medium.
4. Empty bladder. Immediately prior to examination. Use catheter if necessary.

Technique

1. To avoid missing small opaque calculi or calcified foci, it is essential that adequate plain radiographs are obtained prior to contrast injection. Oblique views, tomography, and views on inspiration and expiration may be required. Plain films must be carefully inspected before contrast injection and further views made if in doubt. Calculi are not infrequently overlooked.

2. Although some films in the series should include kidneys, ureter and bladder the majority of views should be coned to particular areas of interest for greater detail.
3. Injection of the contrast medium.
   (a) Although arguable a reasonable practice is to inject 5 ml of contrast and to wait a few minutes to see if a major reaction occurs. The time can be spent in questioning the patient concerning relevant matters such as analgesic intake, i.e. essential knowledge when interpreting abnormal pyelograms.
   (b) The remainder of contrast is injected rapidly as a bolus taking about one minute and a renal film, preferably a tomogram, is made immediately to show the nephrographic phase.
4. In all cases, except suspected reno-vascular hypertension (see p. 10), the usual procedure is to make coned renal films:
   (a) Five minutes from conclusion of injection without ureteric compression. Apply ureteric compression (Fig. 2.1).
   (b) A renal film at 10 minutes from injection with compression applied.
5. Urography requires continual supervision by the radiologist. Careful assessment at the 10 minute mark of the films obtained determines the programme of views to complete the examination. The series will usually include:
   (a) A full length film of the filled ureters immediately after release of compression.
   (b) Coned views of the filled bladder including obliques if pathology suspected.
   (c) A film immediately after micturition to include the entire tract.

The following comments may be helpful if elucidating particular problems.

Apparent unilateral non-function of the kidney

1. If a nephrogram was demonstrated but no outlining of the pelvicalyceal system, ureteric obstruction is likely, particularly if the kidney appears swollen. A further loading dose of contrast medium (equal to the original injection) and delayed filming after several hours or more may demonstrate the obstructed ureter.
2. Availability of ultrasound allows immediate detection of pelvicalyceal dilatation. If so, antegrade pyelography (see later) can be performed as an immediate follow-on procedure.

Suspected calculi

1. Comprehensive plain films are essential particularly in all patients with pain.
2. When a filling defect in contrast films is detected due to a low density

calculus, blood clot, tumour or sloughed papilla, study the plain films of the site very carefully, and if unclear repeat the plain film on another occasion. A faint opacity, indicating a stone, may be detected in retrospect.

3. The after release film should clarify the position of small opacities in the line of the ureter. If not, the ureteric compression should be reapplied and a further contrast injection, if necessary, given. Further views, including obliques, after the second release of ureteric compression should clarify the situation. Only rarely should retrograde ureteric catheterization be needed to determine whether an opacity is in or outside a ureter. The radiologist should look on such a requirement as a failure of his IVP technique.

Prostatism

1. In frail, very elderly men the essential information from pyelography can be elicited with no special patient preparation and a minimum of effort.
2. Plain films of the urinary tract will exclude obvious calculi, and reveal prostatic bone metastases.
3. A full length view after contrast will show back pressure dilatation of the ureters, will provide some idea of renal size and function, and show trabeculation, diverticula and evidence of bladder tumour.
4. A view of the bladder base on a 25 × 20 cm film provides the best view for assessing the intravesical extension of the prostate. The centre ray is angled 12° cranially and is centred to the inferior margin of the symphysis pubis.
5. A full length film after micturition provides an assessment of residual urine.

Lasix washout test in suspected pelvi-ureteric junction (PUJ) obstruction

1. When an after micturition film on intravenous pyelography shows a degree of retention and distension suggesting PUJ obstruction, some assessment of the degree of obstruction can be made by repeating the contrast injection with 20 mg of Lasix.
2. Films made at 10-minute intervals allow comparison with the other kidney. The degree of additional distension after Lasix compared with the normal side, is an index of the degree of obstruction.

Suspected reno-vascular hypertension

The examination aims to show functional differences between the two kidneys. The ischaemic kidney is smaller and contrast appears later. Also, because the ischaemic kidney excretes a smaller urine volume and reabsorbs more sodium, the ischaemic pyelogram is denser.

1. After rapid bolus injection of contrast, films of the kidneys are made at 1, 2, 5 and 9 minutes without ureteric compression. This allows assessment of appearance time, and measurement of renal sizes.
2. Ureteric compression is applied and a further renal view is made at 15 minutes. This may show increased contrast density on the ischaemic side.
3. Further views if necessary are then prescribed depending on the appearances obtained. If the findings suggest unilateral ischaemia, a view 5 minutes after 20 mg Lasix may show delayed washout on the ischaemic side.

Remember if focal disease, e.g. scarring of reflux nephropathy is present, the assessment of renal ischaemia by IVP is unreliable, as it depends on the parenchyma of the normal and ischaemic kidney being morphologically normal.

Difficulties and complications of IVP

Contrast medium reactions

Over 20% of patients experience some reaction following the intravenous injection. The majority are trivial including nausea and minor urticaria. A few patients are more severely affected with hypotension and degrees of circulatory collapse or bronchospasm. A major collapse with asystole accounts for most of the reported mortality ranging from 1 : 40 000 to 1 : 117 000 IVP examinations (Ansell 1976). Such a reaction usually occurs in the five minutes following injection and 90% of severe reactions occur within 15 minutes. The patient must not be left unattended during this period.

A drill should be established and practised to deal with catastrophic circulatory collapse. If an adequate cardio-respiratory status can be maintained during the crucial period prior to admission to an intensive care facility the prognosis should be good.

For minor reactions intravenous antihistamine preparations are usually effective. Minor degrees of bronchospasm are overcome with subcutaneous adrenaline 1 : 10 000.

For a major collapse the team involved should take the following steps:

1. Insert an oral airway to immobilize the tongue.
2. Commence cardiac massage and continue uninterrupted.
3. Provide room air or oxygen under pressure using a face mask. The Oxyviva type apparatus is simple and effective (Fig. 2.2).
4. Intravenous adrenaline 1 : 10 000 may be given in doses of 1 ml/min up to a total of 5 ml. With the availability of intensive care facilities and ECG monitoring, additional steps may be taken including bicarbonate infusion, endotracheal airway, cardiac defibrillation and intravenous corticosteroids.