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ACUTE HEADACHE: A CASE BASED DISCUSSION OF THE ANEURYSMAL BLEED - A POTENTIALLY LIFE THREATENING STROKE

T Adlan, S Chhatani, H Nizami, P Sankaye

Acute Headache: A case based discussion of the aneurysmal bleed - A potentially life threatening stroke.
Patient Management

Abstract

Acute headache is a common presentation to the emergency department. The aetiology of acute headache is wide and varied which can pose a challenge to establish clinical diagnosis and plan further management. Subarachnoid haemorrhage (SAH) is one of the important causes of acute headache that could be life threatening.

The cause of SAH is a ruptured aneurysm in 85% of cases (1), non-aneurysmal perimesencephalic haemorrhage in 10%, and a variety of rare conditions in 5%. Recognising the presentation of SAH and prompt imaging helps in establishing the diagnosis and subsequent management. In this case based article we will discuss the clinical presentation, imaging findings and management of aneurysmal bleed, the most common cause of SAH.

Case History

A 61-year-old lady presents with sudden onset headache and vomiting. She had a similar, but mild headache about 4 weeks prior to this. She has a background medical history of hypertension and smoking 15 cigarettes a day for a total of 30 years. She takes oral Amlodipine 10 mgs once a day (OD).

On examination she is slightly drowsy and nauseous. Her blood pressure is 170/95, heart rate is 48 per minute, respiratory rate is 18 per minute and oxygen saturation is 93% on room air. No focal neurological deficit is found on neurological assessment. Cardiopulmonary examination is largely unremarkable apart from sinus bradycardia.

What is your differential diagnosis?

Patients presenting with acute headache should be considered to have subarachnoid haemorrhage till proven otherwise (2). Other causes include meningococcal septicaemia and migraine.

Clinical features can be of paramount help in working out the differences between the various presentations. The presence of infective symptoms such as fever, rigors and skin rash could be in favour of the diagnosis of meningococcal septicaemia. Even in patients with migraine, we should try and exclude subarachnoid haemorrhage when patients present with sudden onset headache (2).

What is your first line of investigation?

Non-contrast CT scan of the head should be first line of investigation.

What are the points that should be taken into account when requesting and evaluating CT scan of the brain for patients with subarachnoid haemorrhage?

CT scans can be normal in up to 5% of patients with subarachnoid haemorrhage and further evaluation with lumbar puncture is therefore recommended in patients with negative CT scans of the brain(3). Lumbar puncture is carried out in patients with negative CT scans of the brain to look for xanthochromia to support a diagnosis of subarachnoid haemorrhage.

The patient then went on to have an urgent CT scan of the brain (Figure 1).

Figure 1A: Axial CT scan image of the brain showing high attenuation within the subarachnoid space (long arrows in Figure 1A). Note this is occupying the space, which is normally occupied by the CSF. Also make note of maximum attenuation seen near the short arrow in Figure 1A, as this may be the initial origin of the bleed.

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Figure 1B: (White Arrow) is demonstrating dilatation of the temporal horns of the lateral ventricles, a sign of early hydrocephalus.

Describe the findings on the CT scan in Figure 1?

There are areas of high attenuation within the subarachnoid space, consistent with an acute subarachnoid haemorrhage. There is also generalised sulcal effacement.

Describe one of the complications of subarachnoid haemorrhage that is demonstrated on the above scan?

In addition to the documented subarachnoid haemorrhage the scan demonstrates dilatation of the temporal horns of the lateral ventricles consistent with acute hydrocephalus. Another complication that could potentially develop in this context is ischaemia secondary to vasospasm caused by the presence of blood in the subarachnoid space.

A diagnosis of subarachnoid haemorrhage is made. On review of the history the patient reported a mild headache that preceded the acute presentation with subarachnoid haemorrhage. Is this relevant to the case?

Yes. If yes, what is this phenomenon called?

This phenomenon is called sentinel headache (4), which happens in some patients with subarachnoid haemorrhage. Some authors hypothesise that this phenomenon is caused by some minor leakage from the vessel, which precedes the event of SAH. There is debate about the true nature of sentinel headache and whether it is due to minor leakage or recall bias, although there is evidence to support that the described phenomenon is real rather than being entirely explained by recall bias.

What other signs on ophthalmological examination could potentially be demonstrated in patients with subarachnoid haemorrhage?

Subhyaloid / vitreous haemorrhage (Terson syndrome). The presence of subhyaloid / vitreous haemorrhage is often underestimated. It is likely to occur in patients with severe subarachnoid haemorrhage (5). Terson syndrome appears to have been documented with more frequency in prospective rather than retrospective studies suggesting that it is probably not very well documented (6).

What is the most common cause of spontaneous subarachnoid haemorrhage?

Rupture of an intracranial aneurysm is considered to be the most common cause of spontaneous subarachnoid haemorrhage.

CT cranial angiogram is the next best investigation to ascertain the cause of bleeding. Now study the CT angiogram images 2A, 2B and 2C.

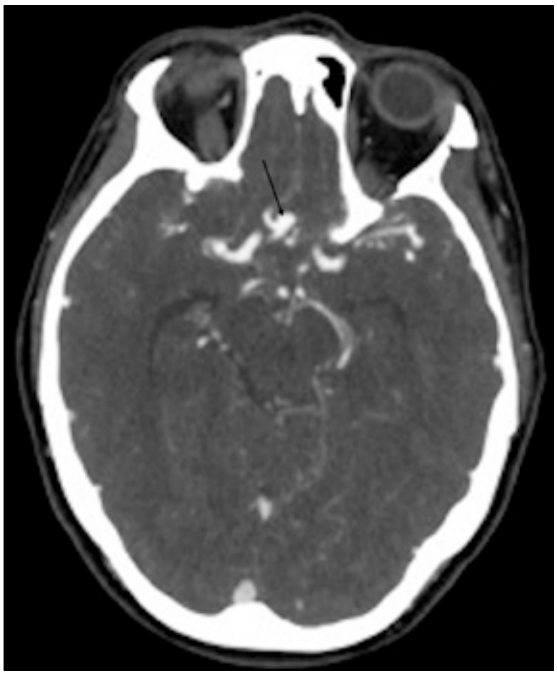

Figure 2A (Above), 2B (See page 8) and 2C (See page 8): The above CT cranial angiograms Figures 2A,2B and 2C demonstrate an anterior communicating artery (ACom) aneurysm. The raw CTA images in Figure 2A are suspicious of an ACom aneurysm.

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T Adlan, S Chhatani, H Nizami, P Sankaye

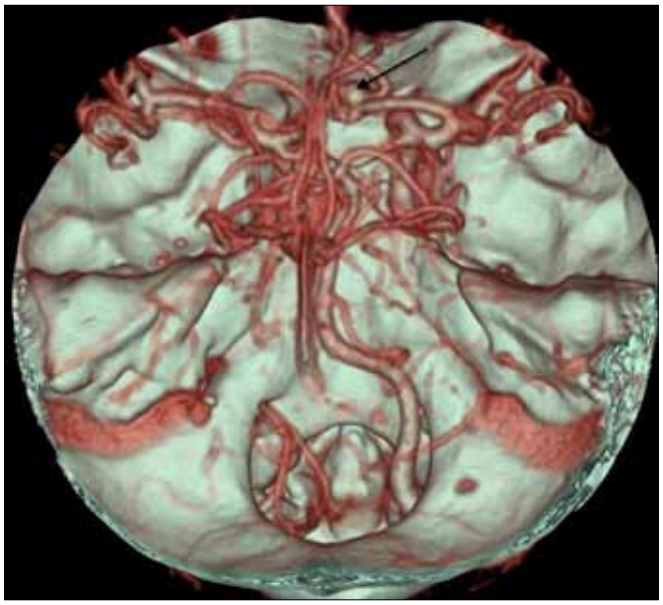

Figure 2B

Acute Headache: A case based discussion of the aneurysmal bleed - A potentially life threatening stroke.
Patient Management

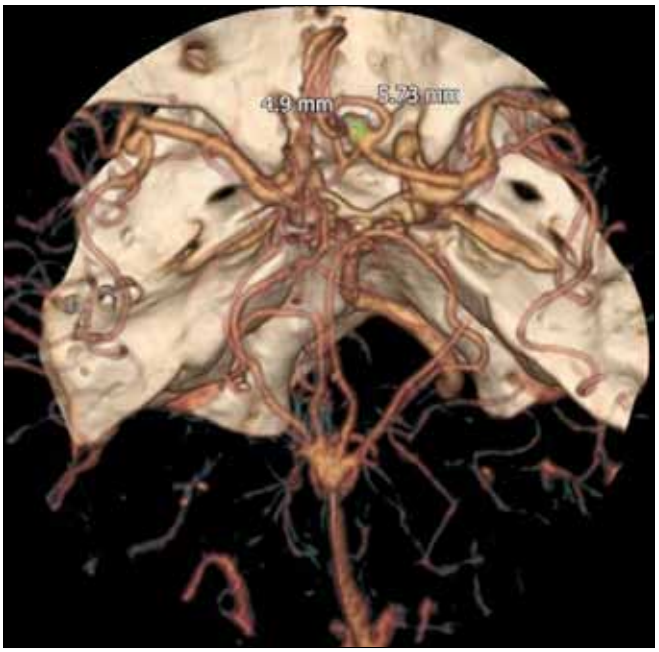

Figure 2C

Further 3D reconstructed CT scan images Figures 2B and 2C confirm a 5.7mm X 4.9mm ACom aneurysm. Note this was the site of maximum attenuation on the Figure 1 (short arrow). This sign often indicates possible site of bleeding.

ACUTE HEADACHE: A CASE BASED DISCUSSION OF THE ANEURYSMAL BLEED - A POTENTIALLY LIFE THREATENING STROKE

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What is the initial management of these patients?

The patient was admitted to the neurological high dependency unit and started on Nimodipine. Administration of Nimodipine is important in reducing vasospasm and development of cerebral ischaemia and consequent venous infarction (7).

What is the definitive management in this patient's case?

The patient subsequently went on to have the definitive treatment. On the same day patient underwent coiling of the aneurysm achieving greater than 95% of angiographic occlusion of the aneurysm. After 2 weeks of hospital recovery, as patient was medically stable, transferred to the community care for further rehabilitation and care.

Quiz

1. What are the modifiable risk factors for development of subarachnoid haemorrhage?

a) Excessive alcohol intake
b) Smoking
c) Hypertension
d) All of the above

2. What is the prevalence of intracranial aneurysms in asymptomatic patients with subarachnoid haemorrhage?

a) 0.5%
b) 2%
c) 10%
d) 5%

Answers

Answer 1:

Correct answer is d. It has been found that smoking, hypertension and excessive alcohol intake are significantly associated with increased risk of subarachnoid haemorrhage (8). These are modifiable risk factors and should be addressed in patient's management plan.

Answer 2:

Correct answer is b. A systematic review performed by Rinkel et al (9) showed the prevalence of asymptomatic intracranial aneurysms to be 2% with an annual risk of bleeding of 0.7%.

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ULTRASOUND GUIDED CHEST DRAIN INSERTION

L MacDonald, H-U Laasch

Ultrasound guided chest drain insertion
Practical Procedures

Abstract

A National Patient Safety Agency Rapid Response in 2008 highlighted ongoing morbidity and mortality associated with chest drain insertion (1). In response the British Thoracic Society (BTS) published new guidelines on pleural procedures in 2010 (2). In this article we describe how these guidelines are implemented in a supra-regional cancer centre.

Patient Presentation

A 70 year old woman with a history of lung cancer presents with increasing shortness of breath. On examination there is stony-dull percussion note and reduced breath sounds in the lower left thorax, associated with tachypnoea and tachycardia. A chest radiograph (Figure 1) demonstrates new opacification in the left mid and lower zones with a fluid meniscus laterally in keeping with a large pleural effusion. In view of the symptoms the patient is referred for chest drain insertion.

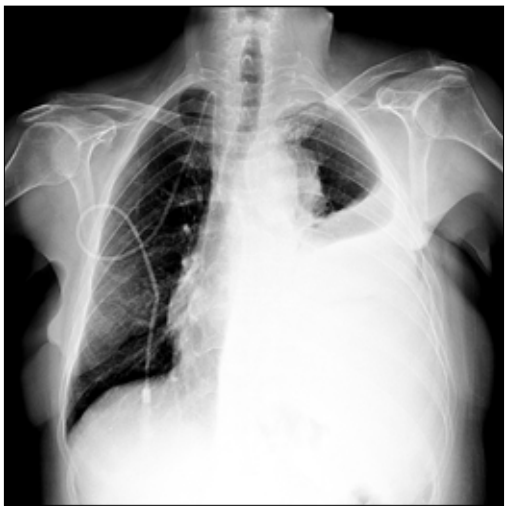


Figure 1: PA Chest radiograph demonstrating large left pleural effusion.

Indications

Indications for chest drainage are summarised in figure 2. Ideally drains should be inserted during "office hours" when there is appropriately trained staff available. However, if there are signs of respiratory compromise the procedure should be performed as soon as a suitably skilled operator is available.

Indications for chest drain Insertion

Pneumothorax
Malignant pleural effusion
Empyema and complicated parapneumonic effusion
Traumatic haemopneumothorax
Post surgical

Figure 2: British Thoracic Society Indications for chest drain insertion.

Contraindications

The main contraindication is coagulopathy. For non-emergency procedures the patient should have an INR ≤1.4 and platelets ≥50x10^9/l. Haemoglobin should ideally be ≥10g/dl, as the ability to compensate for haemorrhage is reduced if the patient is anaemic. If drainage is urgent and the parameters outside these limits, liaise with the haematology department regarding the use of fresh frozen plasma, platelets, blood or other clotting products.

Patient Preparation

Consent

Written consent should be obtained by a person competent in the procedure (3). The steps of the procedure and alternatives need to be discussed. The aim of chest drainage is symptom relief. Simple aspiration of a limited volume of fluid is not as successful and doing nothing is usually associated with symptom progression. Whilst neither are satisfactory alternatives, they should be discussed with the patient as part of the consent process.

ULTRASOUND GUIDED CHEST DRAIN INSERTION

L MacDonald, H-U Laasch

Complications

Pain can occur during insertion and whilst the drain is in situ. All procedures are carried out with local anaesthesia. Conscious sedation may be used if the patient is very anxious or had a previous bad experience.

Drain dislodgement and blockage can occur. Infection, either in the chest wall or within the pleural space, is uncommon but can lead to significant morbidity and further procedures. Visceral injury is the most severe complication, the use of ultrasound reduces this risk. Failure to insert the drain is uncommon, particularly with real-time ultrasound guidance.

Technique

Patient Position

Drains are best inserted with the patient sitting forward, leaning their arms on a support, such as a chair or table (Figure 3). Alternatives include lying semi-recumbent with their hand behind their head or lying on their side with their arms in front.

Figure 3: Patient sitting away from the operator with their arms crossed in front of them over a pillow for comfort.

Insertion site

The patient is placed in a comfortable position and ultrasound of the chest performed in the intercostal plane to confirm the presence and assess the depth of the chest wall and the effusion (Figure 4). Note must be taken of any loculations and pleural thickening or masses. Scanning in the longitudinal (coronal) plane helps identify the diaphragm and liver/spleen. The insertion point is marked with indelible pen in an intercostal space just above the rib. Ideally puncture is performed in the "safe-triangle" between the lateral borders of pectoralis major and latissmus dorsi and at or above the fifth intercostal space and where fluid is seen in the intercostal space above and below. However the best puncture site is often dictated by the easiest access to the effusion and the lowest risk of visceral injury. Posterior sites are to be avoided, as they hurt the patient lying down and may kink the drain.

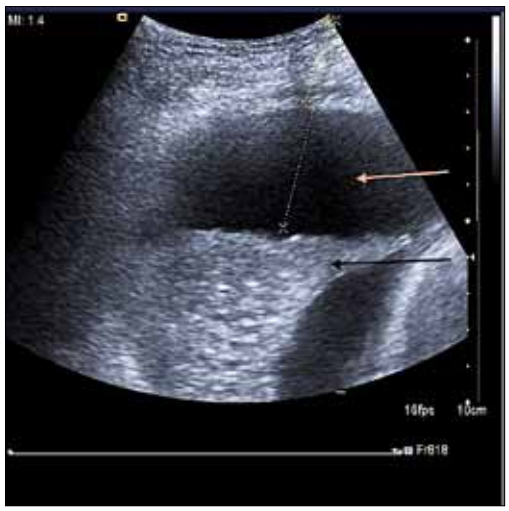


Figure 4: Ultrasound image taken in the intercostal plane showing a large uncomplicated pleural effusion (red arrow) with underlying atelectatic lung (black arrow).

Equipment

The equipment required is summarised in figure 5. A variety of drains are being marketed as suitable for chest drainage. Straight 12Fr surgical drains, adapted for wire-guidance and branded as "Seldinger drains" have become a favourite with many chest physicians. However these require the use of a rigid dilator and are usually bundled with a relatively soft guide wire, which is not stiff enough to guide the dilator around the lung. This unfortunate combination has become the basis for the NPSA alert.

Equipment required for chest drain insertion

Ultrasound machine +/- probe cover
Sterile Gown and gloves
Alcohol prep
Sterile drape
10ml 1%lidocaine
Drawing up needle
25G orange needle
21G green needle
Scalpel
2x10ml syringe
16G grey cannula or three part puncture needle
0.035" wire
8Fr locking pigtail drain.
Three-way tap
Drain dressing
Connecting tubing
Sterile water
Underwater drainage bottle or drainage bag with non-return valve

Figure 5: Equipment required for chest drain insertion.

ULTRASOUND GUIDED CHEST DRAIN INSERTION

L MacDonald, H-U Laasch

Radiologists will invariably insert smaller "pigtail" drains, which are designed for wire guidance and carry a much lesser risk of lung injury when inserted over a wire. Even 6 Fr drains will allow drainage rates of over 8l/24 hours as seen in daycase paracentesis. However these sizes are prone to blocking and kinking and we favour thin-walled nitinol re-enforced 8Fr locking pigtail drains (Navarre, Bard, Crawley, UK) (Figure 6). These are particularly kink-resistant and have a greater lumen for the nominal outer size, with increased flow rates than standard polyurethane catheters (4). For most effusions this provides adequate drainage while causing much less pain than straight 12Fr. drains. Drains of this size do not require the use of dilators, which has been identified by the NPSA as one of the main factors for morbidity and mortality associated with the procedure.

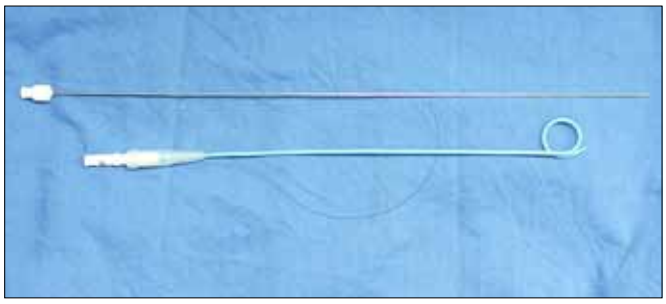


Figure 6A: 8Fr locking pigtail drain.

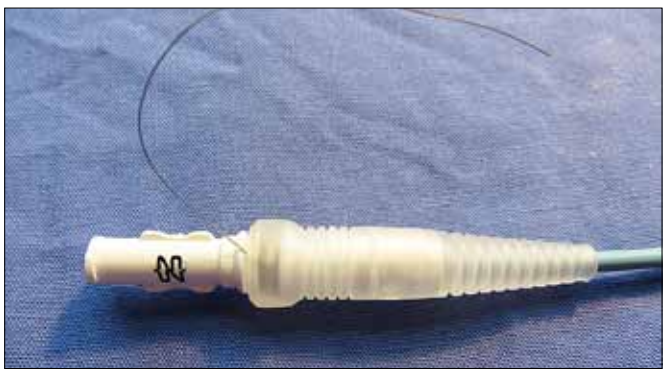


Figure 6B: Close up of the hub of the drain, once the drain is locked the sleeve is pulled over the thread to minimise any air leak from this site.

An alternative to using a Seldinger technique is to use a catheter with a safety trocar (e.g. SafeTcentesis, UK Medical, Sheffield, UK). The device has a spring-loaded trocar, which is pushed into the sharp needle tip by the pressure of advancing it through the tissues of the chest wall. Once the pleura is breached, the trocar advances beyond the needle tip, protecting the lung from injury. This changes the colour of an indicator at the end of the catheter (Figure 7). Fluid can also be aspirated from the trocar. At this point the catheter is advanced over the trocar like a large intravenous cannula. The drain is then secured as described below, taking into account that there is no internal locking mechanism.

Figure 7: The indicator within the hub of the SafeTcentesis (UK Medical, Sheffield, UK) turns from red to white when the pleura is breeched.

ULTRASOUND GUIDED CHEST DRAIN INSERTION

L MacDonald, H-U Laasch

Insertion of the drain

The operator should scrub and wear sterile gloves and gown. Clean the skin and attach a sterile drape to the patient, creating a large, comfortable working area. The skin and the pleura are the two sensitive layers and both must be infiltrated adequately with local anaesthetic. The skin is anaesthetised by raising a bleb with a 25G (orange) needle (Figure 8), followed by a 21G (green) needle to infiltrate the chest wall, the depth of which was measured on ultrasound. The needle is advanced under suction until pleural fluid is aspirated, then withdrawn slightly until aspiration stops and at least 5mls of local anaesthetic infiltrated onto the pleura. At this point the drainage equipment is unpacked and assembled, giving the local anaesthetic 3-4min to work. Pigtail drains come bundled with a metal stiffener and a trocar. The drain is mounted on the stiffener, but the trocar discarded.

Figure 8: Local anaesthetic is infiltrated into the skin. A bleb needs to raised to ensure anaesthesia of the dermis.

A tiny stab incision is made in the skin. One of the best needles to gain access to the pleural space is a grey intravenous cannula, mounted on a 10ml syringe. It is 45mm long and may not always be long enough to reach the pleura, in which case a more specialised puncture needle is required. Under constant suction the needle is advanced until pleural fluid is aspirated, at which point the needle is fixed and the cannula advanced into the pleural space.

The needle is removed from the cannula, and a 0.035" wire inserted. The cannula is removed and the drain mounted on the stiffener is inserted over the wire. As soon as the drain has entered the pleural space it is disconnected from the metal stiffener and advanced over the wire. Guidewire and stiffener are removed and the pigtail locked. A three-way tap is connected to the drain and this to an underwater drainage bottle or a drainage bag with a non-return valve. During these steps it is important to ensure no air is sucked into the pleura.

Securing the drain

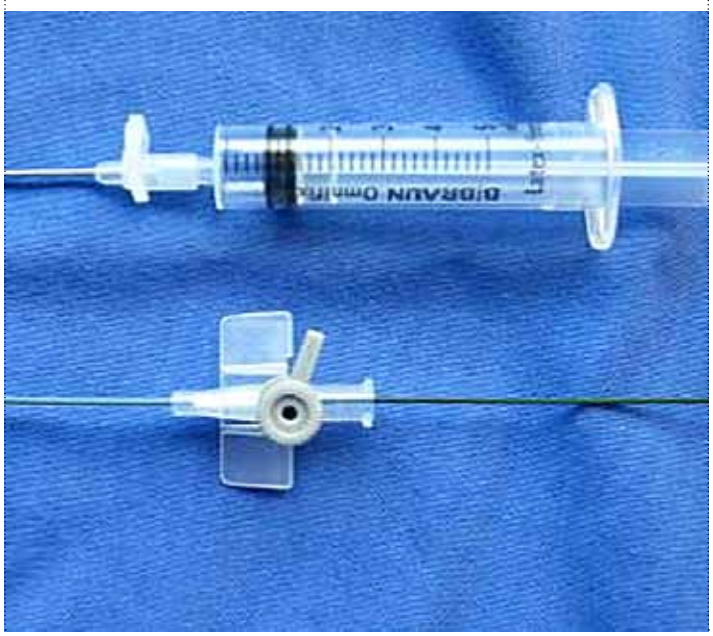
The drain is attached with a dedicated fixation plaster, routed in a straight line and the catheter hub and a loop of the extension tubing secured to the skin with adhesive plaster, ensuring the three-way tap is accessible. Excessive use of tape may reduce excursion of the chest wall and prevent adequate ventilation. All sharps must be disposed of safely.

Post-procedure care

To ensure successful drainage a clear protocol and regular review by staff experienced in the management are essential. Regular observations, initially every 15minutes extending to four-hourly must be performed whilst the drain is in situ, or more frequently if the clinical condition dictates.

No more that 1500ml should be drained in the first hour after insertion to avoid re-inflation pulmonary oedema. Further drainage should be performed slowly not exceeding 1500ml/day in 4-6 increments. Once drainage ceases or the rate drops to less than 200ml/day perform a chest radiograph to confirm resolution.

To remove the drain the pigtail needs to be unlocked to allow unravelling and the drain removed smoothly. If there is any difficultly removing the drain contact the inserting team for further advice. Drains up to 8Fr do not require any measures to occlude the track other than application of a waterproof dressing.



ULTRASOUND GUIDED CHEST DRAIN INSERTION

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Trouble shooting

The drain isn't draining.
Exclude kinks in the tubing and confirm the drain is still in correct position either with chest radiograph or ultrasound. If the drain is blocked or the fluid is too viscous, the drain can be upgraded over a guide wire. The use of fibrinolytics should also be considered especially if loculations were seen on the initial ultrasound.

The patient becomes short of breath.
An ABC assessment should be undertaken, including immediate oxygen administration. Complications to exclude are haemorrhage and pneumothorax, but don't forget other causes of breathlessness. Check for fresh blood in the drain and request a chest radiograph to exclude a pneumothorax. If the patient becomes haemodynamically unstable seek senior advice and contact radiology to assess drain position and exclude visceral injury.

Development of pneumothorax.
• *Check all connections.*
• *Pleural metastases may prevent the lung expanding, resulting in air being sucked in around the drain. Termed "trapped lung" this requires specialist management either with indwelling drains or thorascopic pleurectomy.*

The drain has fallen out.
The puncture site should be covered with a dressing and a chest radiograph performed to assess for residual effusion and presence of a pneumothorax.

The effusion reoccurs quickly.
If this happens repeat drainage with pleurodesis, surgical pleurectomy or insertion of a long-term indwelling drain should be discussed in the multi-disciplinary team.

Conclusion

Insertion of a chest drain usually gives rapid and excellent symptom relief for patients with pleural effusions. Ultrasound localisation is mandatory and reduces complications. If there are any concerns, seek advice from the team who inserted the drain as soon as possible.

Multiple Choice Questions

1. A patient has a large malignant pleural effusion and the blood tests reveal an INR 2.9. The patient is hypoxic and tachypnoeic thought to be due to the effusion. After you have instigated initial resuscitation of the patient what is the correct next step?

a) Arrange for the patient to have a chest drain inserted as soon as possible as they have respiratory compromise the INR can be ignored.

b) The INR is too high, correct with vitamin K and re-check the INR the next day.

c) Arrange for the patient to have a chest drain inserted and urgently liaise with the haematology department as to the best way to correct the high INR.

d) Hand the case over to the on call team.

e) A chest drain isn't appropriate as the INR is too high.

ULTRASOUND GUIDED CHEST DRAIN INSERTION

L MacDonald, H-U Laasch

2. How often should observations be performed following a chest drain insertion?

a) This isn't required.

b) Every 15 minutes whilst the drain is in situ.

c) Every hour for the first four hours, they can then be stopped.

d) Every 15 minutes for 1 hour, and then hourly whilst the drain is in situ or more frequently if the clinical situation requires.

e) Every 15 minutes for the first hour, every 30 minutes for the next two hours and then four hourly after that or more frequently if the clinical condition requires.

Answers

1. c.

In any medical emergency it is important to follow an ABC approach and instigate initial resuscitation of the patient. Once this has been done further more definitive management needs to be instigated. This patient needs an urgent chest drain as they have signs of respiratory compromise. However the INR is too high and needs to be corrected, the safest way to do this is to seek advice from the haematology department and they can guide you on the best product to use.

2. e.

Serious complications including visceral injury often manifest themselves soon after or during the procedure, which is why observations should be performed every 15minutes in the first hour. The probability that a serious complication has occurred decreases with time, hence why the frequency of observations can decrease. As with any patient if the patient's clinical condition changes the frequency of observations should be guided by their clinical condition.

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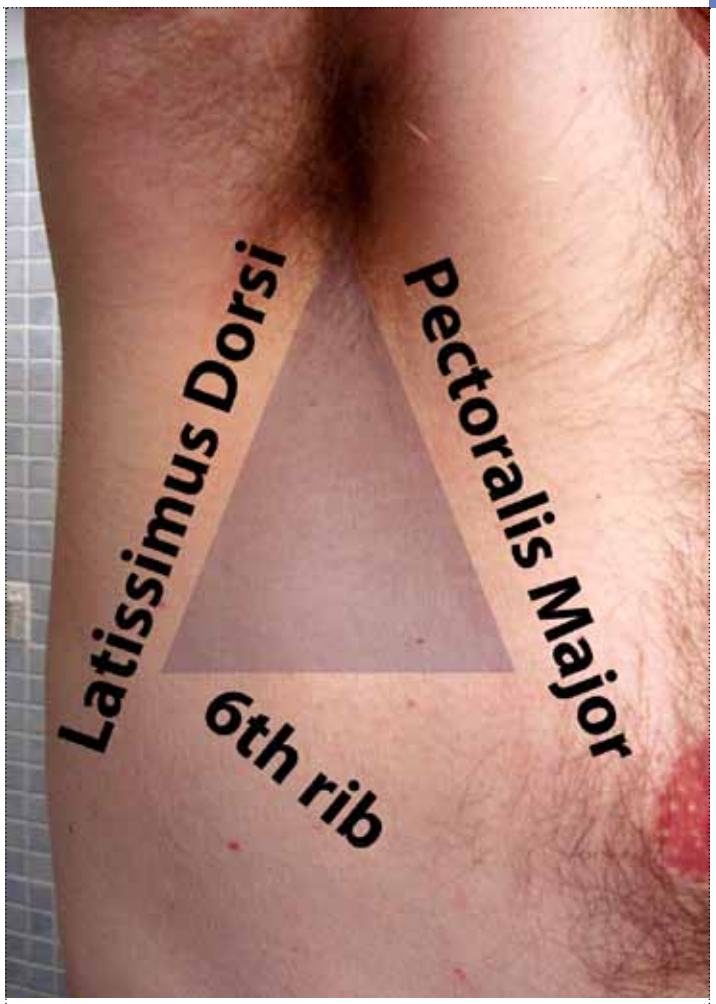

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CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Abstract

Arthritis is a pathophysiologic process affecting the joints and can present with various symptoms and signs. Often plain radiograph is the first investigation of choice and it can help in early diagnosis and management. Though each disease has it's own hallmarks, sometimes there can be more than one process involved making the diagnosis difficult. Also, to the untrained eyes, all arthritic radiographs may look the same and are often confusing. This review article, with case based discussion, will provide you with stimulating knowledge of the most common arthritis that will help you identify them and give you the ability to narrow down the differential diagnosis in degenerative or inflammatory disease to begin with.

Introduction

The easiest way to define arthritis is to understand that it is a pathophysiologic process affecting the bones on both the sides of the joint, which results in joint space narrowing and various complications if left untreated. About 22% of U.S. adults, or 50 million people aged 18 years or older in the civilian, non-institutionalized population, have self-reported doctor-diagnosed arthritis. (1) When patient presents to you, you need to start with a working diagnosis so as to request appropriate further investigations. Depending on the patient's history and examination, patient could be categorised in one of the following broad categories (see table 1). Further investigations would help to narrow down the diagnosis.

Clearing arthritis conundrum: a review article based on common cases of arthritis
Patient Management

Bone & Cartilage Disorders
- Osteoarthritis
- Osteonecrosis
- Metabolic Bone Diseases

Systemic Inflammatory Diseases
- Rheumatoid arthritis
- Systemic Lupus Erythematosus
- Scleroderma

Seronegative Spondyloarthropathy
- Ankylosing Spondylitis (AS)
- Psoriatic Arthritis (PsA)
- Reactive Arthritis
- Enteropathic Arthritis
- Undifferentiated Spondyloarthropathy

Arthritis Associated With Metabolic, Endocrine, Hematologic Diseases
- Gout
- Calcium pyrophosphate dehydrate deposition (CPPD or also known as Pseudogout)
- Diabetes
- Hypothyroidism
- Acromegaly
- Hyperparathyroidism
- Haemochromatosis

Non articular and Soft Tissue Rheumatism
- Fibromyalgia
- Bursitis
- Tendinitis or Tenosynovitis

Neoplasms and Tumour like Lesions
- Pigmented villonodular synovitis (PVNS)
- Malignancy

Congenital & Inheritable Disorders
- Bone and joint Dysplasia
- Storage and deposition Disorders

Table 1: American Rheumatism Association Categories of Arthritis (Modified from source: 2).

Now we will discuss few representative cases of arthritis.

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Case 1

A 35-year-old woman presents with recurrent episodes of painful swelling and stiffness of both hands. Radiographs of both hands and feet were obtained during her assessment. Now study the following images.

Figure 1: Rheumatoid arthritis. PA radiographs of both hands show extensive but almost symmetrical joint space narrowing (black arrows), marginal bone erosions (white arrows) and osteopenia of the metacarpophalangeal, distal radioulnar, radiocarpal and midcarpal joints (blue arrows); with erosions and loss of normal bony architecture in the wrist joint and the ulnar styloid process. (yellow arrow).

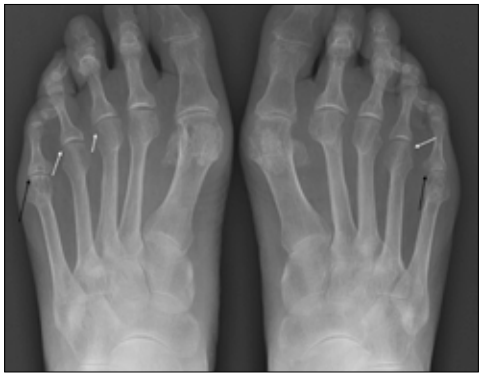

Figure 2: Rheumatoid arthritis. PA radiographs of both feet show near symmetrical joint space narrowing (black arrows) and bone erosions (white arrows) of both metatarsophalangeal joints and several interphalangeal joints. Note most extensive involvement of the fifth metatarsophalangeal and first interphalangeal joints.

What is Rheumatoid arthritis? Describe pathogenesis.

RA is the most common form of inflammatory arthritis. (3) RA is a chronic, multisystem autoimmune inflammatory disease of unknown aetiology, characterised by a symmetrical inflammatory polyarthropathy and extra-articular involvement. (2)

Rheumatoid Factor is positive in the majority of patients.

Pathogenesis: (4)

Immune complexes accumulate in the synovial joint and activate complement. Subsequently the synovial tissue is infiltrated with inflammatory cells. Localised hyperaemia causes periarticular osteoporosis.

Synovial inflammation and proliferation results into the synovial thickening (soft tissue swelling) and bony erosions in the bare areas of the joint region. This is the unprotected region that is not covered by the cartilage. Subsequent joint space narrowing and degeneration follow in untreated individuals.

It is confusing when you don't know the detailed joint anatomy, but have a look at this self-explanatory diagram.

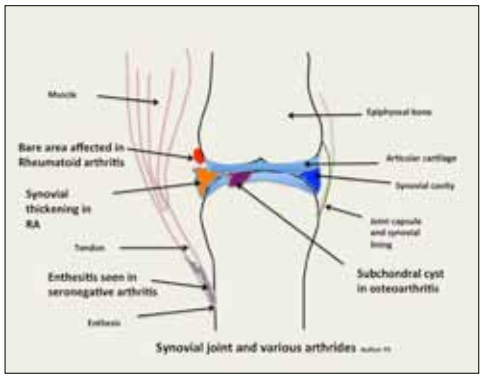

Illustration 1

Which are the common joints affected?

Predominant synovial inflammation (synovitis) means synovial joints will be affected (5) - Hands, feet, wrists, knees, ankles, elbows, shoulders, hips and the atlanto-axial joint in the neck are the commonly affected synovial joints.

Can you briefly describe imaging features? (5)

- *Symmetrical pattern of joint involvement.*
- *Soft tissue swelling.*
- *Joint space narrowing- uniform and symmetrical*
- *Peri-articular osteopaenia- result of increased blood flow*
- *Marginal erosions- at bare areas (the area which is not covered by the cartilage) where synovium lies in direct contact with the underlying bone*
- *Joint destruction – subluxation- due to ligamentous or capsular laxity and deformity*
- *Secondary degenerative arthritis*

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Clearing arthritis conundrum: a review article based on common cases of arthritis
Patient Management

Is plain radiography imaging enough? What if plain radiographs are normal? It is important to remember that RA is a clinical diagnosis. In early stages of the synovial disease plain films may be normal.

For the demonstration of early stage synovial thickening and hyperaemia ultrasound or MRI are more useful (6).

Ultrasound Doppler can identify synovial inflammation, joint effusion and bone erosions. It is extremely useful for diagnosing tenosynovitis and other tendon lesions.

MRI (6) is useful in early diagnosis with identification of hyperaemia in the soft tissue, synovitis, erosions, bone marrow oedema and tenosynovitis.

Early complications like tendon ruptures, avascular necrosis, and fractures can be diagnosed on the MR imaging. The disease severity can be graded, which is also useful in identifying if treatment is working.

Case 2

Middle aged male patient presents with bilateral joint pain and swelling. He also suffers from skin rashes. Following radiographs were obtained during his assessment.

Figure 3 and 4: Psoriatic arthritis. PA radiographs of both hands show extensive and asymmetrical narrowing of interphalangeal joints (black arrows) and interphalangeal joint fusion (white arrows). Note pencil-and-cup deformity (yellow arrows) caused by the combination of erosions and new bone formation (red arrows).

The wrists show irregular bone proliferation (blue arrows), erosion of the ulnar styloid processes, carpal erosion and near destruction with intercarpal bony fusion (ankylosis).

Figure 5 and 6: Psoriatic arthritis. PA radiographs of both feet show extensive, asymmetrical inflammatory and destructive changes of several metatarsophalangeal and interphalangeal joints (white arrows). Note pencil-and-cup deformity (black arrows) and interphalangeal joint fusion in the right foot (red arrows).

You may get confused, as many of arthritic radiographs look same. However each has it's own characteristics. Periarticular osteopenia is hallmark of RA, while new bone formation due to enthesopathy is seen in psoriatic arthritis.

The psoriatic arthropathy is part of a group known as seronegative arthropathy. What do you know about seronegative spondyloarthropathies? Describe pathogenesis.

Seronegative spondyloarthropathies are a group of related inflammatory diseases that share a number of common features and an association with the antigen HLA B27:

Ankylosing Spondylitis (AS)
Psoriatic Arthritis (PsA)
Reactive Arthritis
Enteropathic Arthritis
Undifferentiated Spondyloarthropathy

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Pathogenesis

The key pathological lesion in seronegative spondyloarthropathies is enthesitis. Enthesis is a region of bone where tendon, capsule or ligaments attach. The peripheral arthritis tends to be an asymmetrical oligoarthritis of the lower limbs. Spinal findings in seronegative arthropathy can be similar to Ankylosing spondylitis (described below).

How do you diagnose Psoriatic arthropathy?

Psoriatic arthritis affects 7% of patients with psoriasis particularly between the ages of 30-50 years. The finding of the psoriatic skin disease is critical in making correct diagnosis.

Can you briefly describe salient Radiological features (5,7) seen on the radiographs?

- *Bilateral but asymmetrical involvement of the joints*
- *Usually destructive in nature affecting distal interphalangeal joints: Pencil-in-cup deformity, acroosteolysis, bony ankylosis and arthritis mutilans deformities*
- *Bone density tends to be preserved*
- *Involvement of the synovial and cartilaginous joints and Enthesis: Soft tissue swelling causing sausage like digits, proliferative erosions, periostitis and heel spur with fuzzy margins*

Which are the common joints affected (5)?

MCP, MTP and IP joints of hands and feet; Spine and sacro-iliac joints.

Case 3

30-year-old male patient was involved in minor traffic collision and brought to emergency department with severe back pain and focal neurological signs in both legs. Urgent radiographs and CT scan were obtained. Please study the images.

Figure 7 and 8: Ankylosing spondylitis. Lateral and AP lumbar spine radiographs show anterior bridging syndesmophytes (white arrows) and facet joint fusion (black arrows). Also note AP radiograph shows bridging syndesmophytes (bamboo spine) (red arrows) and ossification of the interspinous ligament (dagger sign) (blue arrows).

Did you notice fracture dislocation at T12/L1 level? Now have a look at the reconstructed CT scan image of the same patient.

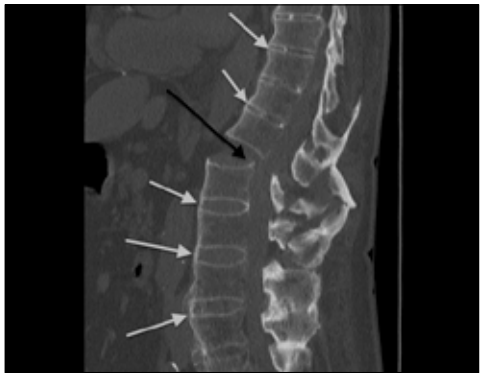

Figure 9: Ankylosing spondylitis with fracture dislocation at the T12/L1 level, Anderson lesion fracture (black arrow). Also note the anterior bridging syndesmophytes (white arrows).

Can you briefly discuss salient features of Ankylosing spondylitis?

Ankylosing spondylitis (5,8) (AS) is a chronic inflammatory disorder that predominantly affects the axial skeleton (sacroiliac joints and spine) with peak age of onset between 25 to 35 years and 10:1 male predominance.

To emphasise again the key pathological lesion in seronegative spondyloarthropathy is enthesitis. Subsequently varying degree of bony ankylosis, proliferative new bone formation, predominantly axial (spinal) involvement and syndesmophytes formation is seen. Syndesmophytes represent ossification of the outer lamellae of the annulus fibrosus and adjacent anterior longitudinal ligaments.

Spondylitis inflammation affects one or more of the vertebrae (100%) and sacroiliac joints (most). Peripheral joint involvement may occur (40%) and is typically oligoarticular, asymmetrical and tends to involve large rather than small joints.

Which are the common joints affected?

Sacroiliac joints and spine are most commonly affected. Hip, shoulder and knee joints are commonly involved. The small joints of the hands and feet are rarely involved.

Salient Radiological features seen on the radiographs are:

In Axial Skeleton (5,8)

- *Spine- Syndesmophytes eventually leading to bamboo spine*
- *Sacroiliac joints – Erosions and sclerosis eventually resulting into fusion*
- *Shiny or ivory corners due to anterior inflammation (Romanus lesions) and erosions of the central portion of the vertebral endplates that are not related to the anterior or posterior edge due to the spondylodiscitis (Anderson lesions)*

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Appendicular Skeleton is involved in up to 50% of cases

- *Most frequently affected joints are hip and shoulder with synovitis, sclerosis and often ankylosis*
- *Enthesitis - especially involving ischial tuberosity and greater trochanter of the femur*
- *Bone density tends to be preserved*

What is the role of other imaging modalities?

MRI and USS can be used to identifying active or inactive disease.

MR imaging (9) is better than plain radiography in its depiction of anterior spondylitis (Romanus lesions) and spondylodiscitis (Anderson lesions) since these oedematous changes in early disease cannot be seen on the radiograph.

Figure 10: Ankylosing spondylitis. AP pelvis radiograph shows bilateral symmetric bony erosions, sclerosis and widening of sacroiliac joints (arrows).

Remember sacroiliac (SI) joint involvement is typically bilateral and symmetric (10,11), and it usually precedes spinal involvement. Early erosions of the SI joints are often best seen in the inferior aspect of the joints.

Case 4

80-year-old male patient presents with knee pain to GP. GP had requested the plain radiographs. Can you identify the abnormality?

Figure 11

Figure 12

Figure 13

Figure 14

Figure 11 to 14: Osteoarthritis. AP and lateral knee radiographs show joint space narrowing, sclerosis and osteophyte formation (arrows) affecting all three compartments i.e. medial, lateral and patella-femoral. However note that predominately weight bearing medial compartment is involved.

What is Osteoarthritis?
Is it same as erosive osteoarthritis?

Intrinsic degeneration of the articular cartilage results in osteoarthritis (OA)

OA can be divided in 2 types (12).

It is important to remember here that some experts classify most common degenerative osteoarthritis as primary OA (11).

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Primary OA - *A familial arthritis which affects middle aged women and almost exclusively seen only in hands. It affects in symmetrical fashion in the distal and proximal interphalangeal joints and base of the thumb. Erosive osteoarthritis is a type of primary OA that is very painful and associated with severe osteoporosis and erosions in the hands.*

Secondary OA - *This is the most common variety which is usually referred to as osteoarthritis or degenerative joint disease. It can occur in any joints secondary to previous trauma but commonly seen in hands, knees, hips and spine on account of chronic micro trauma.*

Pathogenesis (5,12)

The sub articular plate in the weight-bearing joint is exposed due to degeneration or fibrillation of the cartilage resulting into the fragmentation of the subchondral plate. This results into the hypertrophic haphazard bone formation (osteophytes), bone remodelling, subchondral cysts and subchondral bony sclerosis.

Salient Radiological features seen on the radiographs are (5,12)

Asymmetric pattern, joint space narrowing, subchondral sclerosis, subchondral cysts, marginal osteophytes formation with lack of osteoporosis or bony erosions are common findings on the radiographs.

Common joints affected (5)

Weight-bearing joints like Knee and hip joints are commonly affected. Interphalangeal joints, MCP joints of the thumb and scaphotriquetral joints are affected in hand. Now have a look at this radiograph of a 46-year-old woman with painful hands.

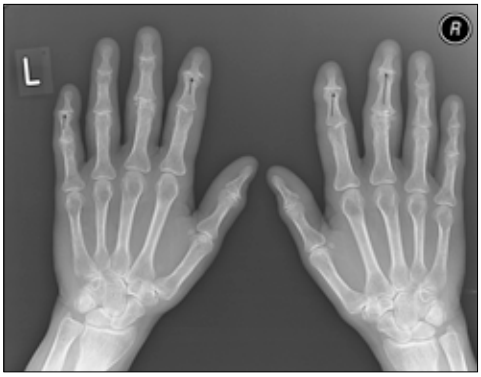

Figure 15: Inflammatory or erosive osteoarthritis. PA radiographs of hands show joint space narrowing, sclerosis and osteophyte formation at distal interphalangeal joints with prominent central erosions (arrows) giving appearance of 'Seagull sign' (arrow at left index finger).

Case 5

45-year male presents with repeated episodes of painful right great toe to GP. Plain radiograph was requested. Can you diagnose his problem?

Figure 16: Gout. AP foot radiograph shows well-defined punched-out juxta articular sclerotic erosion that looks like rat bite erosion (arrow). Note absence of periarticular osteopenia and preserved joint space.

Figure 17: Gout. AP foot radiographs shows well defined punched-out juxta articular sclerotic erosions (white arrows) and characteristic rat bite erosion (black arrow). Soft tissue swelling (red arrow) due to urate crystal deposition is also seen. Note absence of periarticular osteopenia and preserved joint space.

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

Clearing arthritis conundrum: a review article based on common cases of arthritis
Patient Management

Figure 18: Gout. AP hand radiographs shows well defined punched-out juxta articular sclerotic erosions (black arrows) with overhanging margins (red arrows). Soft tissue swelling (white arrows). Note once again, an absence of periarticular osteopenia and preserved joint space.

This patient was diagnosed with Gout, which is caused by monosodium urate crystals deposition near the joints, which display strong negative birefringence at polarized light examination. Most commonly affected site is the first MTP joint of the foot (11). Other joints, such as the interphalangeal joints are also affected. It will be helpful to remember, "When in doubt, think gout." As radiographic findings may at times be confusing and appear quite unusual. We have provided here three examples with repetitions of the text to emphasise the imaging features.

Summary

Above cases have given you overview of the most common arthritic conditions. When looking at radiographs if space narrowing is recognized, then you can look for erosions, which suggests an inflammatory arthritis; osteopenia would suggest rheumatoid arthritis, while osteophytes suggest osteoarthritis.

Below is a useful diagnostic algorithm to narrow down the differential diagnosis. (10,11,12)

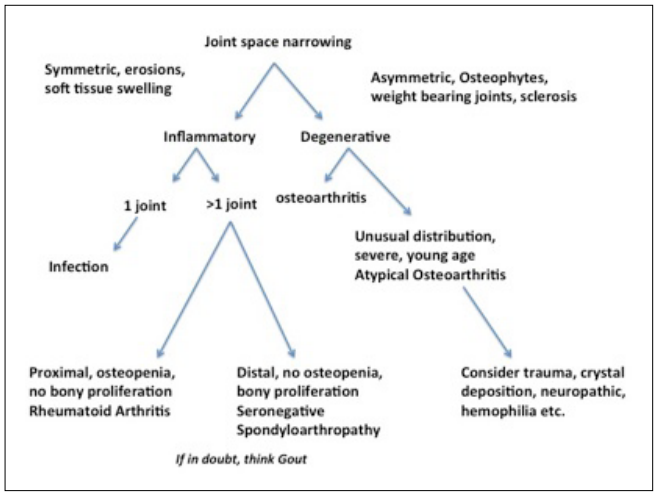

Illustration 2

EMQ's

1) 45-year woman presents with swelling of hand and wrist joints. Radiograph show erosive arthropathy. Which following other feature favour diagnosis of rheumatoid rather than psoriatic arthropathy.

a) Fluffy periosteal reaction

b) Joint fusion

c) Pencil in cup deformity

d) Periarticular osteopenia

e) New bone formation

CLEARING ARTHRITIS CONUNDRUM: A REVIEW ARTICLE BASED ON COMMON CASES OF ARTHRITIS

P Sankaye, S Chhatani, H Nizami, P Suresh

2) 46 year old male patient presents to ED with hyperuricaemia. He has swollen ankle. He is not known to have any diagnosed condition. A radiologist performs US guided aspirate, which shows strongly negative birefringent needle shaped crystals. What would be most likely finding on his foot radiograph?

a) Severe joint space narrowing

b) Central bony erosions

c) Juxta articular erosions with sclerotic margin

d) Juxta articular erosion with nonsclerotic margin

e) Soft tissue swelling giving sausage appearance to the toe

Answers:

1) Correct answer is D.

As periarticular osteopenia is important indicator of RA. It is seen secondary to the hyperaemia due to surrounding synovitis. Remember erosions are marginal in RA as cartilage would protect underlying bone in the centre.

2) Correct answer is C.

Plain radiograph often show well-defined punched-out juxta articular sclerotic erosion, which looks like a rat bite erosion. Absence of periarticular osteopenia and preserved joint space are hallmark of early Gout. a, b and e are often seen in inflammatory arthritis. d may be seen in gout but is not characteristic finding.

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PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

Pearls in Xray interpretation of 10 common adult fractures.
Patient Management

Introduction

So many fractures, so little time to study. Two radiologists have put together a short tour through 10 most commonly encountered in adults fractures. The cases have been chosen for their frequency, importance of prompt diagnosis and typical clinical presentations aiding pattern recognition. Salient features have been presented as bullet points for a quick reference. Common pitfalls to avoid have been stressed.

Case 1

26-year old man was assaulted at a pub. He presented to AED with right facial swelling. Facial bones Xray was performed (Fig 1A and 1B).

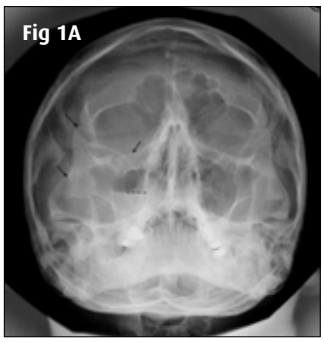

Fig 1A: Tripod fracture and suspicion of an orbital 'blow out' fracture. Caldwell projection. Fracture of right zygomatic arch, widening of right fronto-zygomatic suture and fracture of right inferior orbital rim (black arrows). Air/fluid level in right maxillary sinus (interrupted black line), potentially representing blood from fractured floor of the orbit. Superior aspect of the right maxillary sinus clear.

Fig 1B: Zygomatic arch fracture. Submentovertex (SMV) projection (so called jug handle view). Comminuted fracture on the right (white arrows) easily seen.

Diagnosis: Facial Bone Fractures

Pearls in Xray interpretation:

- *Zygomatic arch is best demonstrated on 'jug handle' view (submento-vertex =SMV).*
- *In fracture of the zygomatic arch examine ipsilateral inferior orbital rim and frontozygomatic suture to exclude a more complex tripod fracture.*
- *Air/fluid level in maxillary sinus, although seen in inflammatory sinus disease, in setting of trauma raises suspicion of orbital 'blow out' fracture.*
- *In orbital trauma look for tear-drop shaped opacification within the superior aspect of maxillary sinus representing inferiorly displaced orbital content.*

Discussion

Nasal bones and zygoma are the most commonly fractured facial bones, usually due to assault, sport injuries or road traffic accidents (RTA). Isolated fractures of the zygomatic arch are common but they often occur as part of a complex known as the tripod fracture. This involves:

1. Fracture through the zygomatic arch

2. Widening of the fronto-zygomatic suture

3. Fracture through the body of the zygoma which is seen as a cortical break in the inferior orbital rim.

Patients present with flattening of the malar eminence, facial asymmetry, trismus and altered sensation below the orbit if the infraorbital nerve gets trapped in the inferior orbital rim fracture.

The orbit is a conical structure, which on direct blow may be exposed to such increase in the intra orbital pressure that the walls of the cone fracture, leaving the rim as well as the globe intact ('blow out fracture'). The floor of the orbit is the commonest to be fractured in this protective decompression mechanism. Clinically the patients present with echymoses and swelling around the orbit and diplopia due to trapping of inferior rectus muscle in the fracture.

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

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Since the orbital 'blow out' fracture line cannot be readily demonstrated by an Xray, the following indirect signs should be sought on facial bones Xray (Table 1):

Fluid level in the maxillary sinus	May represent blood within the sinus from orbital floor fracture but nonspecific as seen in sinusitis
Soft tissue 'tear drop' opacity in the superior aspect of maxillary sinus	Represents herniated orbital content
Opacification of the ethmoidal air cells	Due to blood; nonspecific
'The black eyebrow sign'	Fracture of the floor of the orbit may extend to involve the walls of the maxillary or ethmoidal sinus. Air escapes from the affected sinus into the orbit and floats on top like a black eyebrow.

Table 1: Indirect signs of orbital 'blow out' fracture.

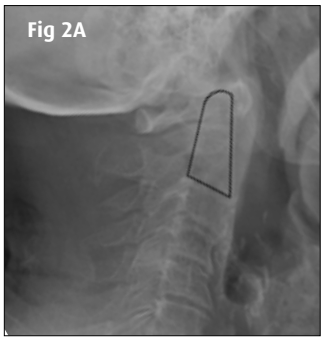
Undisplaced fractures are treated conservatively while surgical repair is carried out for displaced, comminuted fractures or patients presenting with trismus.

CT of the facial bones should be requested in all cases of significant facial trauma especially if the radiographic findings are equivocal.

The patient had CT examination in view of suspicion of orbital 'blow out' fracture, which was confirmed, although there was no displacement of orbital content as the fracture fragment rather unusually was directed upwards.

Case 2

An 82-year old female has been admitted following a fall out of bed in a nursing home, complaining of neck pain and holding her head in her hands. Initial Xray of cervical spine was normal, but in view of continuing symptoms CT of cervical spine was requested. However, she could not cooperate with CT examination and instead a repeat Xray of cervical spine was performed (Fig 2A and Fig 2B).



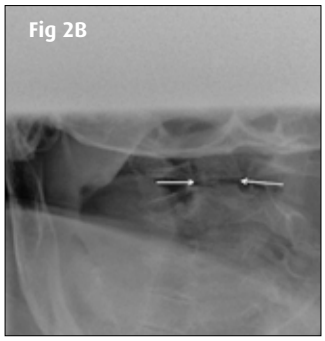


Fig 2A: Peg fracture. Lateral cervical spine Xray. Peg outlined (black line). No fracture or step visible.

Fig 2B: Peg fracture type 2. Peg view. Horizontal fracture line (white arrows) at the base of dens.

Diagnosis: Fracture of the odontoid process (peg = dens = C2)

Pearls in Xray interpretation:

- *Have high level of suspicion, scrutinizing Xray, requesting CT and questioning interpretation of imaging if peg fracture clinically likely.*
- *At least two views essential for peg assessment – lateral and peg view.*
- *False positive diagnosis of peg fracture possible: Mach artifact (spurious line across base); non-fused tip of the peg ossification centre.*
- *Beware of associated other cervical spine fractures.*

Discussion

Second cervical vertebra has a peg-like process, which commonly fractures, usually transversely, following even a minor fall onto head in an elderly or an RTA, often in association with other cervical injuries (e.g. anterior ring of C1 fracture, traumatic spondylolisthesis of C2=Hangman fracture). A non-traumatic fracture may occur through an underlying lytic malignant lesion.

Diagnosis of peg fracture is not uncommonly delayed as interpretation of Xrays may be difficult and horizontal orientation makes it less easily visible on CT. The patient may provide a clue by describing feeling of head being detached from neck. There are no neurological signs initially until complications occur.

The fracture is classified as type 1-3 depending at the involved level of the peg, moving from tip (type 1, rarest, stable with good prognosis) through base (type 2, commonest, unstable and most prone to non-union) to the body of C2 (type 3). A targeted radiograph performed through patient's open mouth shows peg and its distance from lateral masses of C1 vertebra on either side of peg, which should be equidistant. If the distance between peg and anterior arch of C1 on lateral radiograph exceeds 3 mms in adults or 5 mms in children, the transverse ligament behind the peg is disrupted. The fractured peg can be angulated either posteriorly (more common extension axial loading mechanism) or anteriorly (flexion axial loading). Displacement of the fracture leads to spinal cord compression, especially if there is disruption of transverse ligament. Treatment is with halo vest or surgical fixation.

Halo vest was applied but the patient succumbed to a hospital acquired pneumonia shortly afterwards.

Case 3

A 45 year old male pedestrian was involved in a collision with a car. Trauma series consisting of cervical spine, chest and pelvic Xrays was performed; only the CXR was abnormal (Fig 3A). The following day he became significantly more short of breath and a repeat CXR was done (Fig 3B).

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

Pearls in Xray interpretation of 10 common adult fractures
Patient Management

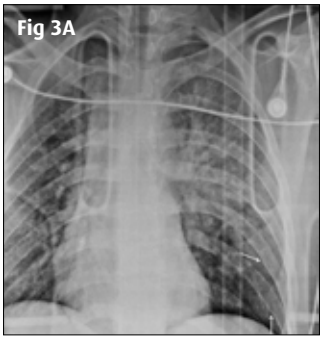


Fig 3A: 7th and 8th left posterior undisplaced rib fractures. Subtle fracture line visible (white arrows). Artefact from spinal board.

Fig 3B: Complication of rib fractures in a different patient. Known rib fractures not visible. Left pneumothorax (black arrowheads). Small subcutaneous emphysema (white arrow).

Diagnosis: Fracture Of Ribs With Subsequent Pneumothorax

Pearls in Xray interpretation

- *Rib fracture is a clinical diagnosis and may be invisible on initial CXR .*
- *Later CXR demonstrates callus formation making it more obvious.*
- *Oblique view Xray is more accurate but unnecessary for making diagnosis.*
- *Imaging with CT may be needed if damage to underlying organs or flail chest segment are suspected.*

Discussion

Common in all age groups, particularly in elderly, following RTA, other chest injury or fall. Typically multiple ribs are involved, in a linear fashion. Atraumatic rib fractures due to underlying malignant infiltration or hyperparathyroidism are possible. Damage to underlying lung resulting in pneumothorax and haemothorax is frequent. Other consequences depend on the location and number of fractures, with upper ones (1st-4th ribs) associated with heart and great vessels injuries, and lower ones (10-12th ribs) associated with abdominal organ injuries (spleen, liver, kidneys). Severe chest wall pain and difficulty in breathing are typical.

Imaging is not required to diagnose rib fracture and CXR is quite non-sensitive, especially in un-displaced fractures and early on. Complications of rib fracture, however, may require imaging. CXR will diagnose most pneumothoraces (with expiratory view increasing sensitivity in a small pneumothorax) and haemothoraces, as well as atelectasis or consolidation due to pain-restricted respiratory effort, possibly resulting in pneumonia. CT will show mediastinal , vascular and upper abdominal injuries. The configuration of multiple fractures may result in a flail, paradoxically moving chest segment, when at least two fractures are present in three or more of the adjacent ribs; this will also be better shown with CT. Ultrasound can be used to show a rib fracture.

Chest drain was inserted and the patient made an uneventful recovery.

Case 4

A 36 year old female presented to a walk-in centre after falling off a bike. Xray was performed (Fig 4A and 4B).

Fig 4A: Elbow effusion. Lateral elbow Xray. Posterior and anterior fat pad sign (interrupted black line. No fracture line visible. Normal radiocapitellar and anterior humeral lines (white lines).

Fig 4B: Radial head fracture. AP Xray. Subtle vertical fracture line visible (black arrow).

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

Diagnosis: Radial Head Fracture

Pearls in Xray interpretation

- *Obtain AP and a true lateral view of the elbow joint.*
- *A posterior fat pad is always indicative of a abnormality.*
- *Posterior fat pad may be absent in a fracture if there is joint capsule rupture or the fracture is extracapsular.*
- *Dedicated special views of radial head may be necessary to demonstrate undisplaced fracture.*

Discussion

The radial head is commonly fractured or dislocated due to indirect trauma, usually a fall on the outstretched hand with the elbow in various degrees of flexion. The patient presents with pain and/or swelling around the elbow joint. Two standard views of the elbow joint should be obtained- an AP and a true lateral view. Four types have been described, with treatment depending on the type: type 1 undisplaced, type 2 with displacement, type 3 comminuted and type 4 with elbow joint dislocation. Frequently (type 1) there is no obvious fracture line visible on Xray and indirect signs of radial fracture have to be searched for (Table 2):

Radiocapitellar line	Can be traced on both AP and lateral view. Through the proximal radial shaft, passes through the capitellum. Affected by the positioning and can only be traced on a true lateral view
Anterior humeral line	Best traced on lateral view. Along the anterior humeral cortex, passes through the capitellum. At least 1/3rd of the capitellum should lie anterior to this line in a normal elbow.
Anterior fat pad	Normal triangular shaped low density fat pad lying anterior to the elbow joint, best appreciated on the lateral view. It becomes displaced anteriorly due to a joint effusion (sail sign) in the setting of a radial head fracture.
Posterior fat pad	Always abnormal. May,however, be absent in the presence of a fracture if the joint capsule ruptures and the haemarthrosis drains away from the joint, or the fracture is extracapsular .

Table 2: Indirect signs of radial head fracture.

If the fat pads are abnormal but no obvious fracture is seen around the elbow joint, the patient must be managed as if a fracture is present and their arm should be placed in a collar and cuff.

The patient's type 1 undisplaced radial head fracture healed well after a short period of immobilisation.

Case 5

17 year old schoolgirl fell on outstretched hand when playing netball. She was taken to AED complaining of pain in anatomical snuff box. Her Xray is shown in Fig 5A. Her 49 year old father had a similar injury around the time she was born but did not seek medical attention. Since he suffered with chronic wrist pain, Xray was performed and is shown in Fig 5B.

Fig 5A: Scaphoid fracture. Dedicated scaphoid views. Subtle fracture line visible on 2 views (black arrows). Do not mistake scaphoid tubercle (bump on the radial aspect of scaphoid) for a fracture.

Fig 5B: Scaphoid proximal pole avascular necrosis secondary to fracture. Several months after injury nonunited scaphoid fracture line still visible and proximal pole of high density.

Diagnosis: Scaphoid fracture

Pearls in Xray interpretation

- *Fall on outstretched hand produces different fractures in different age groups, with 17-40 years old suffering scaphoid fracture.*
- *Four views essential for assessment of scaphoid bone.*
- *Follow up negative first Xray with the second one in 7-10 days, and cross-sectional imaging if necessary.*
- *Suspect ligamentous injury/carpal dislocation if there is marked displacement of scaphoid fracture fragments.*

Discussion

Scaphoid is the most frequently fractured wrist bone. It is the largest bone of the proximal carpal row, articulating with radius. It fractures after a fall onto an outstretched hand in a young adult. Fracture is usually minimally displaced, often making it invisible on Xray taken at the time of injury. Pain in the anatomical snuff box (hollow between tendons on the lateral aspect of the base of the thumb) occurs but is not specific, with thumb and radius fracture being another possible explanation.

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

The fracture line most frequently traverses its midportion (waist) and may or may not compromise the blood supply to proximal pole, which enters via the waist. Proximal pole fracture is second commonest and most prone to non-union due to always compromising blood supply, whilst distal pole fracture, not affecting the blood supply, is the least common and heals well. Standard frontal (PA) and lateral radiographs of the wrist do not provide sufficient detail, and two additional views centered on scaphoid bone should be obtained: PA with ulnar deviation, and oblique. It is mandatory to obtain further Xrays 7-10 days after injury in high likelihood cases. Even then the fracture may not be visible, and options include MR, isotope bone scan or CT imaging depending on the local protocol. Treatment consists of immobilization in a cast or surgical fixation of displaced fractures. Delayed diagnosis may result in avascular necrosis manifesting itself as sclerosis +/- bone segmentation.

The daughter's wrist had been put in a cast and she made a good recovery.

Case 6

A 62 year old female smoker slipped on ice and fell onto the right hip. She could not weight bear and the right leg was held in internal rotation. Xray of the pelvis is shown in Fig. 6.

Fig 6: Subcapital fracture hip. Pelvic Xray, well centered. Discontinuity of right lateral margin of femoral neck when compared with left. Disruption of trabeculae in right femoral neck . Subtle fracture line visible (black arrow). Double sterilisation clips bilaterally and left common iliac artery stent.

Diagnosis: Subcapital hip fracture

Pearls in Xray interpretation

- *Look for discontinuity of cortical outline of the femoral neck.*
- *Ring of osteophytes may mimic cortical discontinuity.*
- *White band of increased bone density due to impacted bone and discontinuity of bone trabeculations are helpful signs.*
- *Have low threshold for using additional imaging if clinically hip fracture likely.*

Discussion

Femoral neck fractures are usually sustained by elderly patients following a fall, but may also occur as insufficiency fractures or due to an underlying pathological lesion. Patients cannot weight bear and complain of groin or thigh pain, holding the lower leg in internal rotation. Pelvic Xray should be obtained. Its interpretation may be difficult due to suboptimal patient's positioning or presence of underlying osteoarthritis. Lateral hip Xray has traditionally been recommended, but it is of limited usefulness. CT, MR or bone scan may be used instead in indeterminate cases, especially if clinically suspicion is high.

The fracture may be intracapsular (subcapital-commonest, transcervical, basicervical) or extracapsular (intertrochanteric, subtrochanteric). Initially the hip fracture may be incomplete. The treatment of intracapsular fractures is with prosthesis, whilst extracapsular fractures are treated with a fixation by a screw, nail or plate.

The patient received an emergency right hip replacement with good effect.

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

Case 7

78 year old female with osteoporosis presented to AED with painful deformity of left thigh following tripping over a curb. Xray is shown in Fig 7A. 2 years earlier she suffered a right femoral fracture after she was hit with a toy by her grandchild (Fig 7B). On both occasions she remembered having some vague thigh pain for months prior to the fracture. She was on long term treatment with biphosphonates, which continued after the first femoral fracture.

Fig 7A: Atypical femoral fracture secondary to long term biphosphonate use. AP Xray left femur. Horizontal fracture through thick cortex following minimal trauma.

Fig 7B: Atypical femoral fracture secondary to long term biphosphonate use. AP Xray right femur 2 years earlier. Horizontal fracture through thick cortex (black arrowheads) and a beak-like medial fracture fragment (black arrow), again following minimal trauma. Biphosphonates were continued after the right femoral fracture occurred.

Diagnosis: Atypical Femoral Fracture Due To Biphosphonate Treatment

Pearls in Xray interpretation

- *Note presence of large bone (femoral) fracture despite a trivial injury.*
- *Typical morphology, different from high impact spiral fracture, is invariably present: a transverse component through thickened cortex and a medial unicortical beak.*

Discussion

Atypical femoral fractures have emerged as a complication of long term biphosphonate treatment, resulting in depressed bone turn-over making it prone to fracture. They usually occur in the proximal third of the femoral shaft just distal to the lesser trochanter. By definition there is minimal or no trauma. Characteristically patients report prodromal symptoms of deep thigh or groin pain.

The fracture may be complete or incomplete, with complete fractures usually transverse with a characteristic medial unicortical beak. They are associated with a periosteal stress reaction, seen as thickening of the lateral cortex at the fracture site. Biphosphonate "holiday" after 5 years of treatment is recommended, especially to prevent subsequent femoral fracture after the first one has occurred.

The patient recovered well after internal fixation of each of the fractures. After the second fracture her biphosphonate treatment was stopped.

Case 8

A 78 year old female was brought into AED after collapsing in a street. She recovered quickly but was complaining of knee pain. Her knee Xray is shown in Fig 8A and 8B.

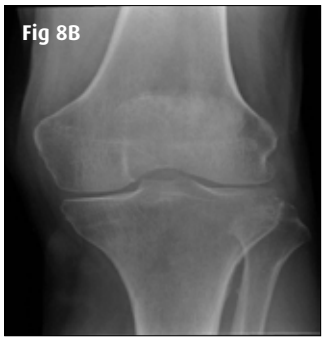


Fig 8A: Lipohemarthrosis. Horizontal beam (cross table) lateral XRay left knee. Fat/fluid level in suprapatellar fossa (interrupted white line).

Fig 8B: Occult medial tibial plateau fracture. AP view. No definite fracture line. Undisplaced fracture of medial tibial plateau was subsequently demonstrated on CT (not shown).

Diagnosis: Medial Tibial Plateau Fracture With Lipohemarthrosis

Pearls in Xray interpretation

- *Fat/fluid level on the lateral view obtained in horizontal position (lipohemarthorosis) indicates presence of intraarticular fracture.*
- *Fracture may be subtle or very obvious.*
- *CT is necessary prior to treatment to demonstrate degree of depression of fragments.*

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

Discussion

Tibial plateau fractures result from valgus stress, axial load or direct blow. Either of the two tibial plateau may be involved, in isolation or jointly. Medial plateau is stronger and significantly less frequently fractures. In osteoporosis a compression tibial plateau fracture may occur with relatively minor injury. Associated ligamentous and meniscal injuries occur not infrequently, most commonly injured being medial collateral and anterior cruciate ligaments, and lateral meniscus.

The degree of fragmentation and fracture fragment depression determines decision about surgical treatment, with depression of >3mms the usual indication. It is best demonstrated by CT.

Since no depression of the medial tibial plateau was present, the patient was fitted with a hinged knee brace.

Case 9

34-year old male presented with marked swelling and pain of midfoot following falling out of a bunk bed. His Xray is shown in Fig 9A and 9B.

Fig 9A: Lisfranc dislocation. AP view left foot. Discontinuity of lines running along medial 2nd metatarsal and medial aspect of intermediate cuneiform bone (black lines). No fracture line visible.

Fig 9B: Lisfranc dislocation. Discontinuity of lines running along medial 3rd metatarsal and medial aspect of lateral cuneiform bone (black lines). No fracture line visible.

Diagnosis: Lisfranc Fracture Dislocation

Pearls in Xray interpretation

- *Trace the alignment of the 2nd and 3rd metatarsals with intermediate and lateral cuneiform on AP and oblique views of the foot respectively.*
- *Request weight bearing views and consider additional imaging with MRI if no obvious abnormality detected on radiography when high index of suspicion for a Lisfranc injury.*

Discussion

The articulation of the tarsus with the metatarsal heads is known as the Lisfranc joint, comprising the first three metatarsals articulation with the three cuneiforms, and the 4th and 5th metatarsals articulation with the cuboid. The Lisfranc ligament attaches the 2nd metatarsal to the medial cuneiform and is fundamental to the stability of the midfoot.

Lisfranc injuries encompass a spectrum of injuries from mild sprain to fracture/dislocations at the tarsometatarsal joints. They occur either as a result of direct crush injury or axial loading on a plantar flexed foot. The swelling around tarsometatarsal joints is usually out of proportion to the radiographic findings and most patients have echymoses around the mid foot. AP and oblique non weight bearing views of the foot should be initially obtained and the alignment of the metatarsals with the bones of proximal tarsal row should be meticulously traced (Table 3).

AP view	Medial margin of the base of the 2nd metatarsal	Medial margin of the intermediate cuneiform
Oblique view	Medial margin of the 3rd metatarsal	Medial margin of the lateral cuneiform

Table 3: Normal alignment at Lisfranc joint.

Supplemental weight bearing views may be requested if no obvious abnormality is detected on the initial views. Up to 15% of radiographs can be normal in patients who have Lisfranc injuries and in these patients additional imaging such as an MRI should be requested to avoid delayed diagnosis resulting in long term disability.

PEARLS IN XRAY INTERPRETATION OF 10 COMMON ADULT FRACTURES

N Jabbar, J Makowska-Webb

There are two types of fracture dislocations:

- Homolateral - more common, all metarsals get displaced in the same direction (laterally);

-Divergent - the 1st metatarsal is medially displaced and the 2nd - 5th metatarsals are laterally displaced.

There may be accompanying fractures of the base of the 2nd metatarsal or the cuboid.

Simple sprains are treated conservatively while those with severe injuries have open reduction and internal fixation.

The patient had undisplaced fractures of 2nd-5th metatarsals on MR in addition to dislocation, and was treated operatively.

Case 10

A 73-year old female presented with ankle pain after falling down a couple of steps. Her Xray is shown in Fig 10.

Fig 10: 5th metatarsal base fracture. Oblique view foot. Horizontal fracture line through base of 5th metatarsal (white arrow).

Diagnosis: Fracture of the base of the 5th metatarsal

Pearls in Xray interpreatation:

- *Image the foot rather than the ankle if base of 5th metatarsal fracture suspected .*

- *Always examine base of 5th metatarsal on ankle Xrays.*

- *An unfused apophysis gives a vertical line, whereas a fracture line is horizontal.*

Discussion

A fracture of the base of the 5th metatarsal can present a diagnostic challenge as the usual symptom is pain around the ankle joint; less commonly there is pain and swelling in the forefoot. Therefore one needs to have a high index of suspicion so as to ask for the foot to be imaged rather than the ankle joint, to avoid patient mismanagement.

Fracture of the base of the 5th metatarsal is usually due to a plantar flexion inversion injury and is due to avulsion of the tendon of peroneus brevis which inserts at its base. AP and oblique views of the foot should be obtained. A fracture line is usually visible as a horizontal lucent line across the base of the 5th metatarsal which may or may not extend to the articular surface.

A common pitfall in diagnosing this fracture is the presence of an unfused apophysis, which results in a vertical lucent line parallel to the 5th metatarsal, whereas a fracture line is nearly always horizontally orientated. These fractures are treated conservatively unless there is an intra articular extension which requires fixation.

The patient did well with conservative treatment.

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RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

Radiological evaluation
of thoracic malignancy
Good Clinical Care

Introduction

Lung cancer is estimated to account for around 15% of all cancers and is a leading cause of death. Over the last 20 years there has been rapid progress in the management of thoracic cancers based upon advances in imaging technology, surgical techniques and chemo/ radiotherapeutic regimes. This has been aided by better staging of disease and assessment of operability. The mainstay of treatment for non small cell lung cancer remains surgery, and the strongest prognostic indicator for survival is whether complete resection of tumour is achieved.

Imaging plays a major role in the initial diagnosis and evaluation of thoracic lesions. It is generally non-invasive and provides vital anatomical and physiological information. Imaging is further employed to guide targeted biopsy and treatment including radiotherapy and radiofrequency ablation. The philosophy of thoracic cancer management is changing to a more proactive approach of identifying and screening high-risk groups for lung cancer.

This article reviews the radiological presentation and evaluation of thoracic cancer. It will concentrate on lung cancer, which is the most common thoracic malignancy, but it will also include pulmonary metastases, mesothelioma and incidentally found pulmonary nodules. The role and limitations of various imaging modalities, and the clinical implications of imaging findings on the prognosis and management of patients are discussed.

Lung Cancer

Lung cancer is unique amongst major cancers in that it has a single dominant and modifiable risk factor with up to 90% (1) of the incidence attributable to smoking. Although the risk declines with smoking cessation the long term risk is still associated with overall exposure and includes age of starting smoking, duration, number of cigarettes. Other risk factors include occupational exposure to asbestos, pulmonary fibrosis secondary to other lung pathologies, and genetic predisposition (2).

The peak incidence of lung cancer is between ages 50 and 60, with men having a slightly higher risk than women. The presentation may be an incidental finding on a chest radiograph (CXR) or CT study as approximately 25% of patients are asymptomatic at the time of diagnosis. More commonly, a patient will present with symptoms which vary according to the site and extent of the disease. Cough, wheezing, haemoptysis, symptoms of pneumonia and paraneoplastic syndromes (inappropriate secretion of antidiuretic hormone and peripheral neuropathy) can occur in patients who may still be curable. By the time there are symptoms suggestive of local disease spread with hoarseness, chest pain, Horner's syndrome, superior vena caval obstruction (SVCO), and dysphagia the prognosis is normally poor.

Some symptoms and signs warrant extremely urgent investigation. These include features suggesting metastatic spinal cord compression and SVCO. The latter can present with dyspneoa, headache, facial oedema and upper limb swelling. The compression of the SVC is well demonstrated by CT (Fig 1) and endovascular stenting should be considered to relieve symptoms.

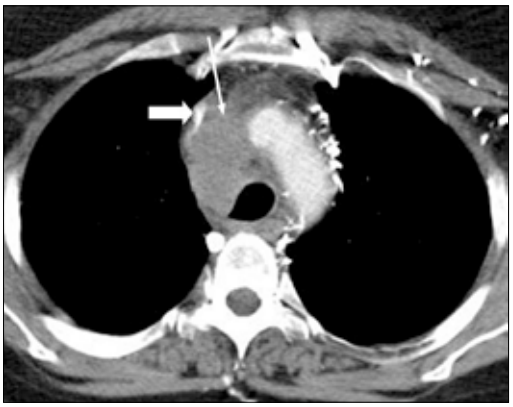


Fig 1: CT shows a mediastinal mass (thin arrow), compressing the superior vena cava (thick arrow).

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

Bronchial carcinoma is usually classified into squamous cell (30-50%), adenocarcinoma (30-50%), small cell carcinoma (20-30%) and large cell anaplastic carcinoma (10-15%). The incidence varies slightly according to different series which have been published. They are also divided into Non Small Cell lung cancer (NSCLC) and Small Cell (SCLC). This is useful due to the markedly different prognoses and treatment regimens between the two groups. Tumours are characterised by histology. They have different behavioural patterns shown on cross sectional imaging which can be correlated with clinical history and presentation (Table 1). Illustrations are given (Figs 2-5).

Tumour	Characteristics
Non-small cell carcinoma	
Squamous Cell Carcinoma	**Radiological features:-** Arises centrally can involve central (main, lobar and segmental) airways, often presents with hilar mass. Cavitation relatively common *(Fig 2a and 2b)* Metastasis often late **Clinical correlate:-** Strong smoking association
Adenocarcinoma	**Radiological feature:-** Usually presents as a peripheral lung nodule Frequently spiculated *(Fig 3a and 3b)* Common in the upper lobes. **Clinical correlate:-** Weak smoking association Associated with lung fibrosis
Bronchoalveolar carcinoma	**Radiological features:-** Subtype of adenocarcinoma, non invasive, growing along the alveolar or bronchiolar walls. Solitary nodule, usually ill-defined with ground glass opacity and air bronchograms (60%) (good prognosis) Diffuse patchy consolidation or nodules *(Fig 4)* (40%) (poor prognosis) **Clinical correlate:-** Weak smoking association Mucinous type have productive cough with mucoid expectoration
Large Cell Carcinoma	**Radiological feature** Usually presents as a large peripheral mass (>4cm) Early metastases with poor prognosis. **Clinical correlate:-** Strong smoking association
Small cell Carcinoma	**Radiological feature** Tends to be central presenting with multiple mediastinal lymph nodes *(Fig 5)* **Clinical correlate:-** Strong smoking association Neuroendocrine effects e.g. Cushings, SIADH Associated with paraneoplastic syndromes

Table 1: Radiological, pathological and clinical correlates of various cancers.

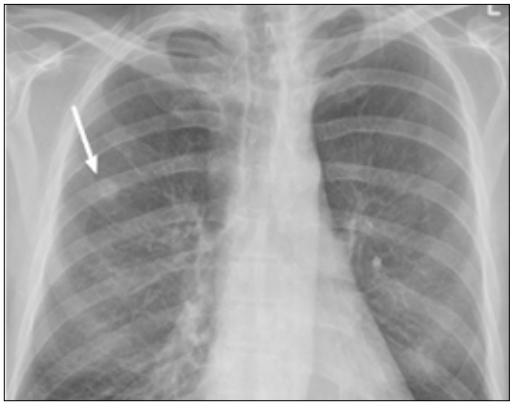


Fig 2A: CXR with a cavitating nodule in the right mid zone (arrow).

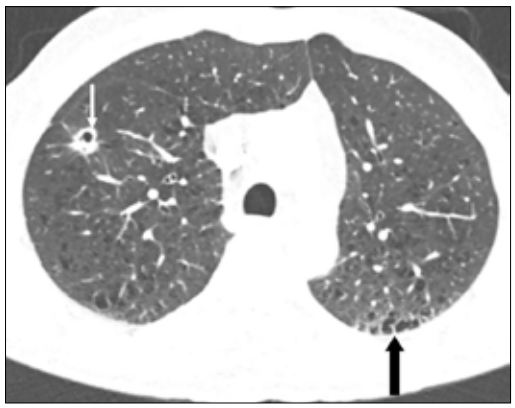


Fig 2B: CT shows the 1cm cavitating nodule (thin arrow). This appearance is typical for squamous cell carcinoma. Moderate emphysematous changes are present (thick arrow).

Fig 3A: CT shows a peripheral, irregular mass (thin arrow) with ipsilateral mediastinal nodal disease (thick arrow)

Fig 3B: CT shows the peripheral lesion to be spiculated (arrow). This was biopsied and found to be an adenocarcinoma

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

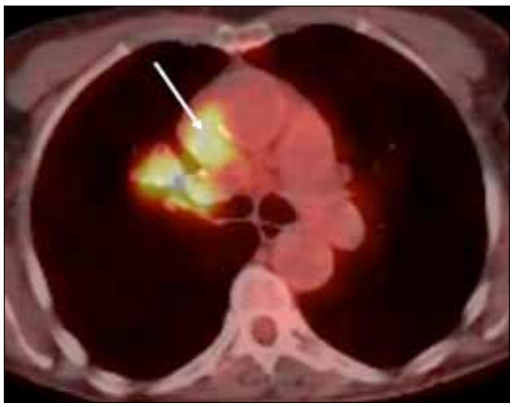


Fig 3C: PET/CT of the same patient shows tracer uptake in the involved nodes (arrow).

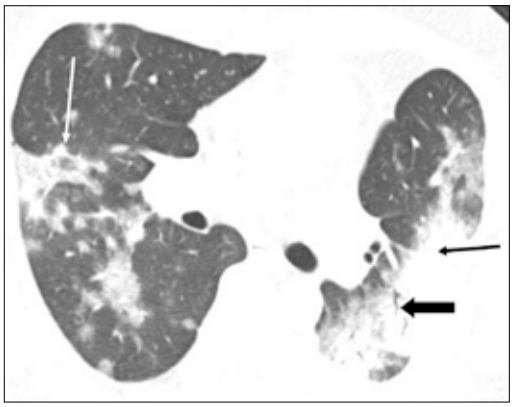


Fig 4: CT demonstrates patchy consolidation (thin arrows) with an air bronchogram (thick arrow). This was bronchoalveolar carcinoma.

Radiological evaluation of thoracic malignancy
Good Clinical Care

Fig 5: CT shows mediastinal nodes (small arrow) compressing the superior vena cava (thick arrow). This was small cell carcinoma.

1.1 Imaging and Staging

All patients with suspected lung cancer should be referred to a Rapid Access Lung Cancer Service and then discussed at an expert Multidisciplinary Team (MDT) meeting where core personnel can make decisions about further investigations and also treatment. Radiology plays an essential role in the pathway, and imaging is important for the detection, diagnosis, staging and post-treatment monitoring of lung cancer.

The overall 5 year survival rate in lung cancer is extremely poor at 15%. Surgery offers the best chance of improved survival for early stage (Stage I and II) tumours. The International Early Lung Cancer Action Program (3) reported a survival rate of 92% for Stage I cancers following surgical resection. Staging is therefore geared towards assessment for radical treatment.

Lung cancer is staged using the TNM classification, the most current being TNM7. T represents the location and morphologic characteristics of the primary tumour, N the presence or absence of hilar, mediastinal or other lymphadenopathy and M the presence or absence of distant metastases (4). (Table 2 a,b,c,d shows the revised TNM7 staging)

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

T1 T1a T1b	≤2cm ≥2cm but ≤3cm	No invasion proximal to lobar bronchus	No local invasion	
T2 T2a T2b	≥3cm but ≤5cm ≥5cm but ≤7cm	Main Bronchus (≥2cm distal to the carina)	Invasion of the visceral pleura	Atelectasis extends to the hila but does not involve whole lung
T3	>7cm	Main Bronchus (≤2cm distal to the carina)	Invasion of chest wall/diaphragm/mediastinal pleura/parietal pericardium	Atelectasis of entire lung, separate tumour in ipsilateral primary tumour lobe
T4	Any	-	Invasion of the mediastinum, trachea, heart, greater vessels/ esophagus, carina	Separate tumour nodule within the ipsilateral lung but different lobe as the primary mass

Table 2A: Primary Tumour (T) Staging.

Stage	Lymph node (N)
N0	None
N1	Ipsilateral hilar or peribronchial, no mediastinal nodes
N2	Subcarinal node +/- ipsilateral nodes
N3	Contralateral hilar or mediastinal nodes

Table 2B: Nodal involvement (N) Staging.

Stage	Spread
M1a	Local intrathoracic spread - malignant pleural/pericardial effusion - separate tumour nodules in contralateral lung
M1b	Disseminated (extrathoracic) disease Liver, bone, brain, adrenal gland etc.

Table 2C: Distant Metastasis (M) Staging.

T and M	N0	N1	N2	N3
T1a	Ia	IIa	IIIa	IIIb
T1b	Ia	IIa	IIIa	IIIb
T2a	Ib	IIa	IIIa	IIIb
T2b	IIa	IIb	IIIa	IIIb
T3	IIb	IIIa	IIIa	IIIb
T4	IIIa	IIIa	IIIb	IIIb
M1a	IV	IV	IV	IV
M1b	IV	IV	IV	IV

Table 2D: Final Stage.

Generally, tumours are considered unresectable if they are classified as either T4, N3 or M1. In resectable tumours, the best prognosis is obtained by a complete resection. The current practice for pulmonary resection is lobectomy or pneumonectomy. Studies have demonstrated a survival advantage of lobectomy over less extensive sub-lobar resection (wedge resection and segmentectomy) for stage I tumours (5).

Small cell carcinoma has been traditionally considered as unresectable, but recent data suggests that localised tumour with no evidence of disease spread should be considered for surgical resection with intent to cure (6). SCLC is therefore staged using the same TNM classification as NSCLC.

In unresectable SCLCs imaging is used to determine whether the lesion can be covered by a radical radiotherapy portal, in addition to giving chemotherapy. The terms limited and extensive stage disease are still often used (Table 3). SCLC patients not suitable for surgery are offered multi-drug platinum based chemotherapy. Patients with limited stage SCLC may benefit from thoracic irradiation in addition to chemotherapy

Limited stage disease	Extensive stage disease
Tumour can all be included within a "tolerable" radiotherapy port. e.g. disease confined to one hemithorax and ipsilateral hilar nodes.	Tumour has spread to sites beyond the definition of limited disease. e.g. metastases in contralateral lung, distant metastatic involvement (brain, bone, liver or adrenals)

Table 3: Staging of small cell tumour divided into limited and extensive disease.

1.2 Imaging Modalities & Their Role

1.2.1 Chest radiograph (CXR)

The CXR is relatively insensitive for the detection of lung cancer. A size of >1cm is the accepted threshold for detection by plain film. The average size of lesions detected by CXR is 2.4cm (7). A review of the literature suggests the proportion of missed lung cancers varies between 25% and 90%. Peripheral lesions are much easier to detect than central lesions and retrospective identification of lung cancer on plain film is 90% for peripheral masses and 75% for central masses.

The CXR is a two dimensional representation of three dimensional structures composed of 4 densities; namely air, fat, soft tissue and bone. The silhouette sign refers to the fact that two soft tissue densities, when in contact, cannot be visualised separately. This concept is important for the localisation of an identified mass. For example, non-visualisation of the aortic knuckle implies a left upper lobe mass abutting it (Fig 6), and a collapsed right upper lobe with poorly visualised right hilum implies a central obstructing lesion.

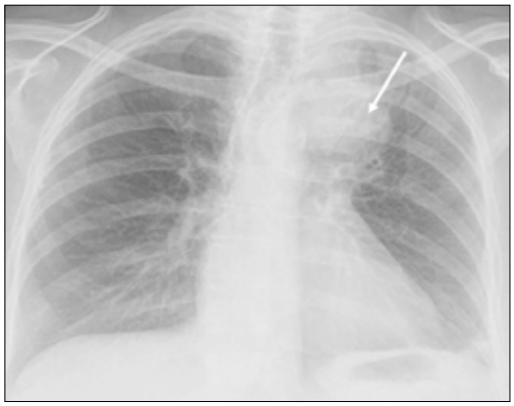
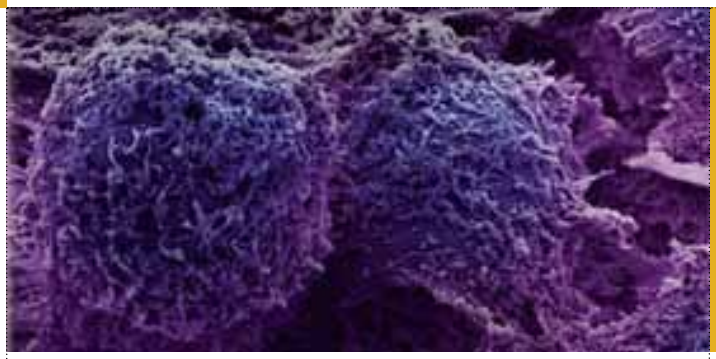


Fig 6A: The aortic knuckle is not clearly seen (arrow). There is a mediastinal mass obliterating the outline (silhouette sign).

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker



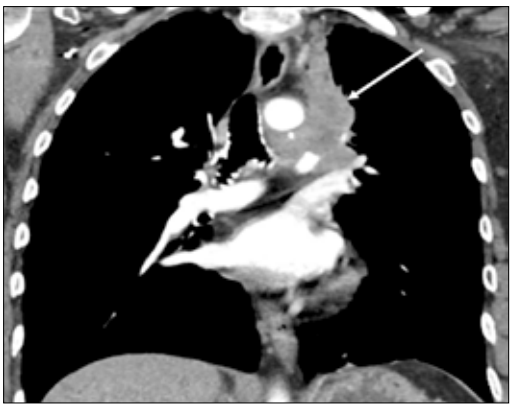


Fig 6B: Coronal reconstruction demonstrates the left upper lobe mass invading the mediastinum (arrow).

Peripheral cancers commonly present as spherical or oval lesions. They can be lobulated and may contain calcification (e.g. in patients with old TB) or cavitation (e.g. Squamous cell cancers). If tumours invade the chest wall there may be bony destruction and pain. An apical (Pancoast) tumour may look like apical pleural thickening. It can extend to involve the brachial plexus, see description later. Patients with central lesions may show several findings, including hilar enlargement (Fig 7), increased hilar density and hilar lobulation. Central lesions can obstruct a large bronchus and cause collapse and consolidation of the lung distal to the tumour.

Fig 7A: A bulky right hilum is seen on CXR. There is background emphysema.

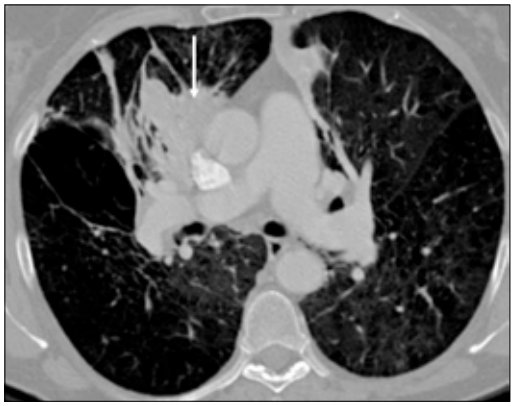


Fig 7B: There is a right hilar mass extending to the right middle lobe (arrow). Background emphysematous changes are seen.

Blind spots on a CXR are sites where lesions are commonly missed due to overlying structures. They constitute important review areas and include the diaphragm, retrocardiac area, breast, bones and lung apices (Fig 8), the last of which is notorious for missed lesions. This is due to significant "anatomical noise" from the costochondral junction, clavicle and the brachiocephalic artery such that the radiologist either risks overcalling or undercalling pathology.

Fig 8A: CXR shows right apical soft tissue (arrow).

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

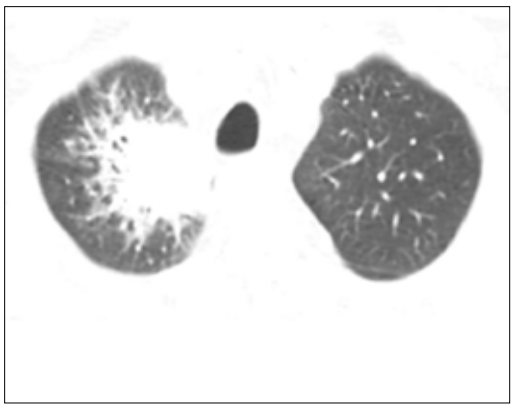


Fig 8B: CT of the same patient demonstrates a mass in the right apex.

1.2.2 CT

The size threshold for the detection of lesions by CT is about 3mm, although 48% of tumours less than 3mm can be detected (3). Frequently overlooked tumours on CT include endobronchial lesions, lower lobe nodules, focal peripheral air space opacities and pleural based thickening.

CT provides morphological information about the tumour including location, extent, and the invasion or involvement of adjacent structures. In some cases CT enables the identification of characteristic benign features such as fat in a hamartoma (Fig 9).

Fig 9A: CXR shows a 1.5cm rounded lesion in the left lower zone (arrow).

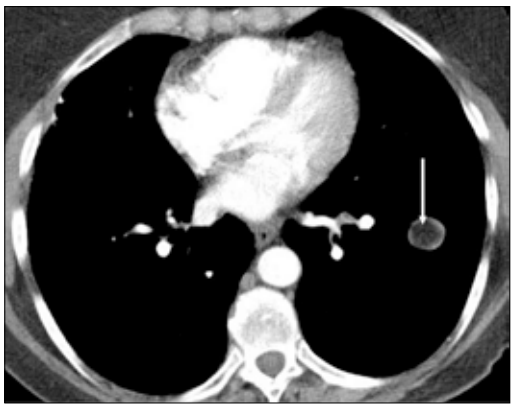


Fig 9B: CT is diagnostic of a benign hamartoma with intralesional fat (hypodense area indicated by thin arrow).

The role of CT is to stage the tumour according to the TNM guidelines. A staging CT is routinely performed of the chest and upper abdomen (including the liver and adrenals), following intravenous contrast medium, in order to evaluate the common metastatic sites of lung cancer, i.e. the lung, bones, kidneys, liver and adrenals, and to assess for nodal spread. The pelvis is not routinely included.

Screening for lung cancer is likely to be integrated into NHS practice in the future. Low dose CT screening has been associated with a 20% reduction in lung cancer mortality in the National Lung Screening Trial (NLST) in a high risk population in the United States (9). A UK Lung Screening programme is underway. One disadvantage of lung cancer screening is the incidentally discovered lung nodules which generate a tremendous amount of additional follow-up CT scans to determine if they are stable. Computer assisted detection software packages are being designed to flag up suspicious lesions on screening CT, but their impact has not yet been evaluated in routine clinical practice.

1.2.3 MRI

The role of magnetic resonance imaging (MRI) is limited in the aerated lung, but it is useful in evaluating superior sulcus tumours (Pancoast tumours Fig 10). These tumours in the apex of the lung can invade the pleura, spine, chest wall, and the brachial plexus resulting in arm pain and paraesthesia. MRI is particularly good at evaluating chest wall invasion, having superior soft tissue resolution.

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

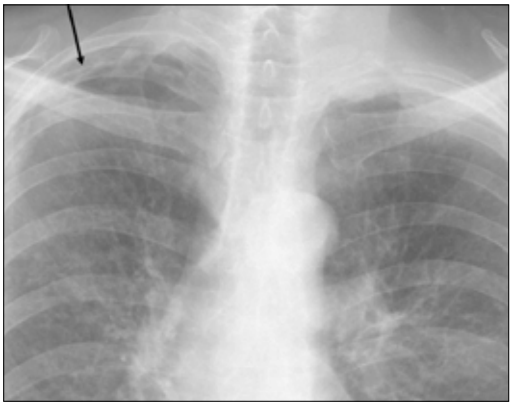


Fig 10A: CXR shows subtle rib destruction at the right lung apex.

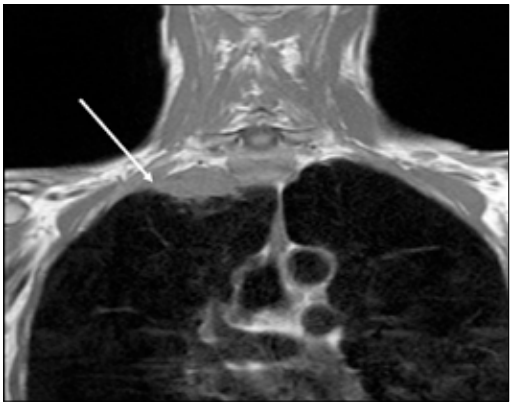


Fig 10B: MR Coronal T1 shows soft tissue at the right lung apex.

MRI is also used to further characterise distant lesions to help decide whether they are metastatic from the primary thoracic tumour. The most commonly encountered use is in the evaluation of lesions in solid organs, particularly the liver in which multiphase-gadolinium-enhanced imaging characterises the dynamic contrast features of parenchymal lesions and also in the adrenals where the identification of cellular fat suggests a benign adenoma.

1.2.4 Ultrasound

The capability of ultrasound (US) is limited in an aerated lung. In the clinical setting there are several uses of ultrasound (Table 4). An example is the assessment of neck nodes (Fig11) where fine needle aspiration (FNA) biopsy can be performed.

a. *Evaluation of solid abdominal organs*
Assessment of the liver, spleen, kidneys and adrenals for focal lesions suspicious of metastases (useful in patients allergic allergic to intravenous contrast medium). These may need further assessed with CT/MR unless there are characteristic benign features. US-guided biopsy of lesions.
b. *Assessment of nodes in the head and neck.*
Morphological features of nodes can be assessed on ultrasound. There are characteristic sonographic benign and malignant features (*Fig 11*), US may be further used to guide fine needle aspiration of the node.
c. *Assessment of peripheral lung lesion.*
Lesions abutting the pleura or involving the chest wall may be suitable for US-guided biopsy.
d. *Assessment of pleural effusion.*
US guided pleural aspirate for the detection of tumor cells. This suggests pleural spread and may upstage the disease.

Table 4: Common uses of US in lung cancer assessment.

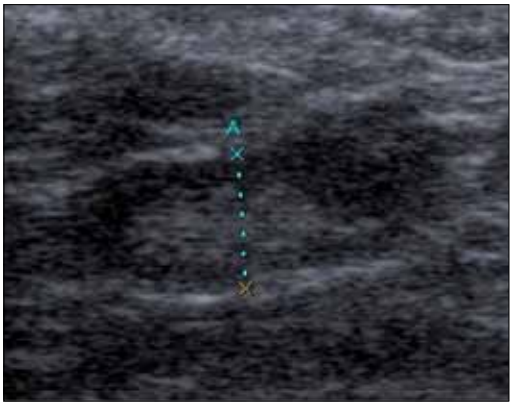


Fig 11. Ultrasound demonstrates a cervical node measuring 1cm. It has a fatty hilum and is likely to be benign.

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

1.2.5 Endobronchial ultrasound

Endobronchial Ultrasound (EBUS) with Transbronchial Biopsy/Fine Needle Aspirate (TBNA) is now an accepted practice for the mediastinal staging of lung cancer and it has been shown in numerous studies to be at least as good as mediastinoscopy (done under general anaesthetic), traditionally considered the gold standard. EBUS employs either a rotating radial or convex ultrasound probe mounted on the end of a bronchoscope, which allows real time visualisation and transbronchial biopsy of mediastinal nodes (Fig 12) including paratracheal and hilar nodes, up to the lobar and interlobar nodal stations. Paraoesophageal nodes and pulmonary ligament nodes may also be accessible via Endoscopic US (EUS) needle aspiration.

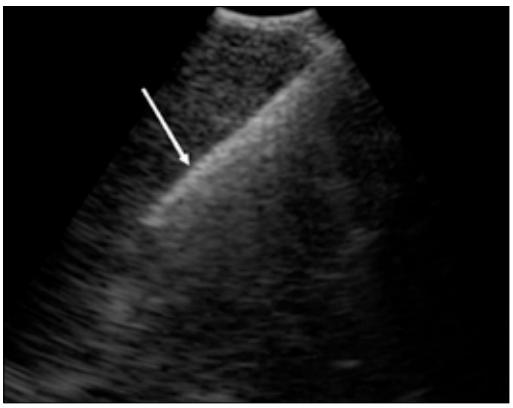


Fig 12: EBUS TBNA, echogenic linear structure represents the needle (arrow).

Current evidence suggests that for NSCLC staging, EBUS guided biopsy has a sensitivity of 93% and specificity of 100% (10) with higher sensitivity for lesions evaluated as suspicious by Positron Emission Tomography (PET) or CT. This is higher than the sensitivity (88%) and specificity (78%) (11) of standard flexible bronchoscopy for the diagnosis of central bronchogenic carcinoma. Compared to mediastinoscopy, the overall diagnostic yield for all lymph nodes was significantly higher with EBUS-TBNA (98% vs 78%) in particular for the diagnosis of subcarinal nodes which are difficult to evaluate with mediastinoscopy (12).

Potentially operable patients with lung cancer and evidence of nodal disease on CT or PET should be considered for EBUS-TBNA to obtain tissue. In addition, tumours with high pretest probability of nodal involvement e.g. small cell carcinoma should be considered for EBUS, even if the nodes are insignificant by size criteria (<1cm) on CT.

1.2.6. Nuclear Medicine

Nuclear imaging has progressed from two dimensional planar imaging to 3 dimensional hybrid imaging using Positron Emission Tomography (PET) and Single-Photon emission Computed Tomography (SPECT). These correlate precise anatomical detail from the CT with static or dynamic physiological detail from the nuclear medicine study.

A PET study employs 18-Fluorodeoxyglucose as a radiotracer. This is taken up by metabolically active lesions (Fig 13, 14). A SPECT study employs a radiotracer (e.g. technetium) which is chemically bound to a molecule targeted at a receptor of interest. PET localizes metabolic activity but SPECT localizes receptor avidity. An example is a lung carcinoid, which is a slow growing tumour with somatostatin receptors. This may be "cold" on PET but "hot" on an octreotide (somatostatin analogue)-SPECT. There are a number of roles for PET studies (Table 5).

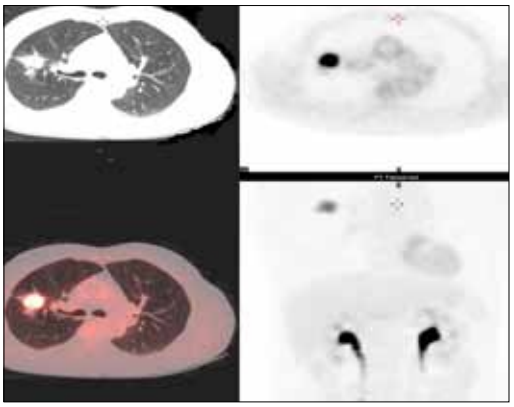


Fig 13: PET shows a solitary right upper lobe lesion which is FDG avid and likely to be malignant.

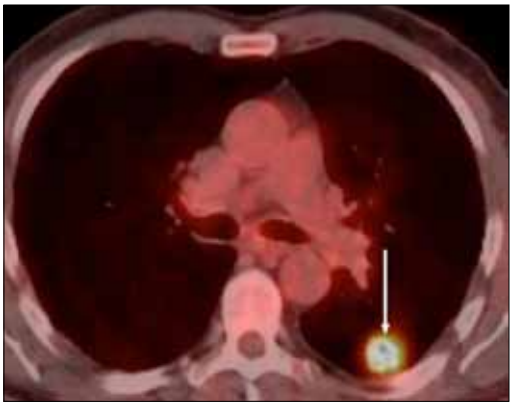


Fig 14A: PET image shows a 2cm mass (arrow) in the apical segment of the left lower lobe.

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

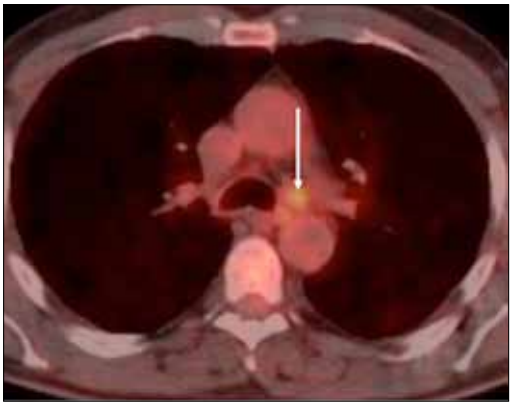


Fig 14B: PET in the same patient shows a normal size node in the aortopulmonary window (arrow) with a high SUV. This is likely to be involved and should be biopsied.

a. *Distinguishing a malignant from a benign lesion*[19]
High FDG avidity is suggestive of malignancy (*Fig 13*) and merit a CT guided biopsy. Low FDG avidity allows follow up by sequential imaging.
b. *Assessing locoregional lymph nodes*[20]. (*Fig 14a and b*)
Typically an SUV value of >2.5 is suspicious upstaging the nodal status of the lesion. Further investigation can be performed with EBUS or mediastinoscopy for biopsy.
c. *Detecting metastatic disease*
The whole body can be imaged without additional radiation exposure.
d. *Monitoring of response to therapy and detection of recurrence.*
Normalisation of FDG uptake after treatment appears to be an indicator of good prognosis.[21]

Table 5: Role of PET in assessment of thoracic cancer.

SPECT imaging is useful in the detection of bony metastases. It overcomes the limitations of a traditional bone scan by allowing correlation of the site of a "hot" lesion with concomitant CT anatomical and morphological detail such as bone sclerosis/lysis, cortical destruction, periosteal reaction, soft tissue component and invasion of surrounding structures. This can allow differentiation between a bony metastasis and degenerative change, which can both look similar on a bone scan.

1.2.7 Lung Biopsy

In patients with suspected lung cancer being considered for radical treatment it is important to obtain tissue for histological evaluation to confirm the diagnosis. A tissue diagnosis is also helpful in evaluating indeterminate nodules in patients at low clinical risk of having lung cancer, lesions which may be metastases from other primary tumors, and in the evaluation of persistent consolidation. This can be done in a number of different ways and options are discussed in an MDT meeting with radiologists, chest physicians and surgeons present. The choice of technique is determined mainly by the location of the lesion. Options include image-guided percutaneous biopsy, bronchoscopy, EBUS with TBNA and surgical techniques such as video assisted thoracic surgery (VATS), mediastinoscopy and open surgery.

Peripheral lesions are generally more amenable to CT guided percutaneous biopsy which is able to obtain cores of the lesion. This gives more information to help the pathologist in the interpretation of the lesion than a fine needle aspiration (FNA), which only provides cytology. The main risks are pneumothorax 5-20% (Fig 15) (commoner in emphysematous lungs) and haemoptysis 5.3% (Fig 16). A CXR is performed two to three hours after the procedure to evaluate for pneumothorax before the patient goes home. Other complications are relatively rare and include tumour seeding, cardiac tamponade, and conversion of chest infection to an empyema. Relative contraindications given by the British Thoracic Society include: International Normalized Ratio (INR) >1.4, Forced Expiratory Volume (FEV) < 35%, platelets <100,000 and pulmonary hypertension (13).

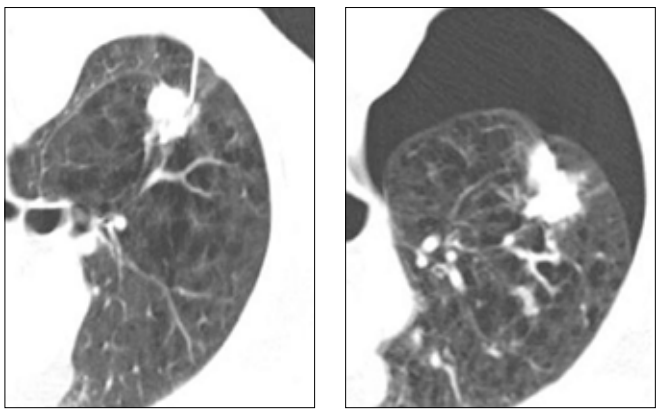


Fig 15A: Lung biopsy performed on a right upper lobe nodule, there is background emphysema. Fig 15B: Post biopsy in the same patient, showing a moderate right pneumothorax.

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

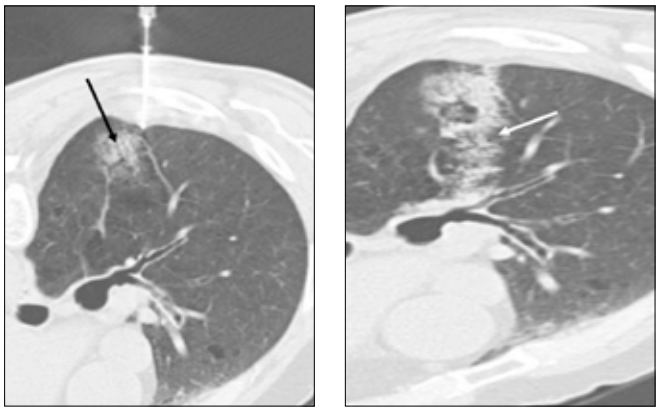


Fig 16A: CT guided biopsy of a ill defined nodule (arrow) in the left upper lobe. Fig 16B: Post biopsy, there is some haemorrhage (arrow) into the lung.

2. Pulmonary Metastases

The radiological manifestation of metastases depends chiefly on their site e.g. to lung parenchyma, lymphatic system, blood vessels and the airways.

Parenchymal metastases are the most common and manifest as nodules of varying size with tendency for a basal distribution. The most frequent sources of parenchymal metastases are tumours of the lung, breast, kidneys, bones, thyroid cancers and also melanoma. Unlike primary tumours, metastases are usually sharply marginated and lobulated (Fig 17). Multiple nodules (Fig 18) are common and reflect recurrent embolic episodes and different growth rates. Solitary metastases may be seen in 5-10%. Cavitation is rare, 5% of cases. Calcification in metastases occurs most commonly with osteogenic sarcoma, chondrosarcoma, synovial sarcoma and mucinous adenocarcinoma.

Fig 17A: Plain radiograph shows a 2cm lesion (arrow) in the left midd zone. Fig 17B: A solitary 2 cm soft tissue lesion (arrow) in the left lower lobe. This has a smooth, rounded contour typical of a metastasis.

Fig 18: CT shows multiple soft tissue densities in the lungs bilaterally (thin arrows) which are metastases from the primary tumour (thick arrow).

Lymphangitic spread of metastasis results in lymphatic obstruction and is most commonly seen in patients with carcinoma of the breast, lung, stomach, pancreas, prostate, cervix or thyroid. Patients present with increasing shortness of breath. Lymphangitis carcinomatosis is seen on a CXR as reticulonodular opacities and Kerley B lines, and on CT as septal thickening with associated micronodules. Unilateral interstitial thickening in the absence of pulmonary plethora on a CXR of a patient with known malignancy should raise suspicion of lymphatic invasion.

Airway metastases usually develop from local spread from mediastinal structures e.g. oesophagus and lung and present with airway obstruction and pulmonary atelectasis.

Vascular metastases may be caused by renal cell carcinoma, hepatoma, right atrial myxoma and angiosarcoma, and manifest with pulmonary embolism and pulmonary infarction. Mediastinal spread is relatively uncommon for extrathoracic tumours but can occur in head and neck and genitourinary tumours. Pleural metastases may manifest with pleural effusion or pleural thickening and occasionally with spontaneous pneumothorax which is most typical of metastatic sarcoma.

3. Incidentally Detected Nodules

Modern CT scanners have increased the detection of small lesions measuring 5mm and below, raising the dilemma of what to do with them. Radiological features of pulmonary nodules that raise suspicion of malignancy are listed in Table 6.

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

Radiographic characteristics of lung cancer presenting as solitary tumours
Diameter > 2cm
Ill defined, irregular or spiculated margin.
Lobulated, irregular outline,
Cavitation with thick (15mm) and nodular wall
Atypical or dystrophic calcification
Enhancement >15HU
Lack of satellite nodule
Feeding vessel,
Rapid doubling time of 30-200 days. (though BAC may be slow growing)

Table 6: Malignant features of incidentally detected nodules.

In practice, lesions lacking specific benign features (decrease in size on successive scans or presence of intralesional fat) are treated with suspicion and biopsied when possible.

The situation becomes more difficult with nodules smaller than 1cm, as they are difficult to biopsy and up to 35% may turn out to be malignant. Traditional considerations relating to the shape and edge of such nodules are difficult to evaluate due to the small size, and need to be modified. The only reliable marker of malignancy is tumour growth between successive scans. The widely employed guidelines on the frequency of follow up scans come from the recommendations of the Fleishner Society and American College of Chest Physicians (14). These guidelines stratify patients into low and high risk groups with different follow-up intervals based on the lesion size. Follow up is normally for 12 or 24 months and radiologists will often suggest when the next CT should be performed in the radiology report to help planning

4. Mesothelioma

Mesothelioma is a highly malignant lesion with very poor prognosis. Although uncommon amongst thoracic cancers, it occurs in up to 5% of asbestos-exposed patients and typically manifests 20-40 years post exposure. It arises in relation to the parietal pleura and typically presents with a pleural effusion and pleural mass or thickening. Features of malignant pleural thickening are shown in Table 7. See Fig 19.

Radiological features of malignant pleural thickening.
a. Nodular thickening. (Fig 19a and b)
b. Concentric thickening
c. Extension to the mediastinal surface (Fig 19b)
d. Mediastinal and pericardial invasion (Fig 19c)
e. Thickness >1cm
f. Chest wall invasion
g. Fissural involvement
h. Non-expanding lung on full inspiration

Table 7: Features of malignant pleural thickening.

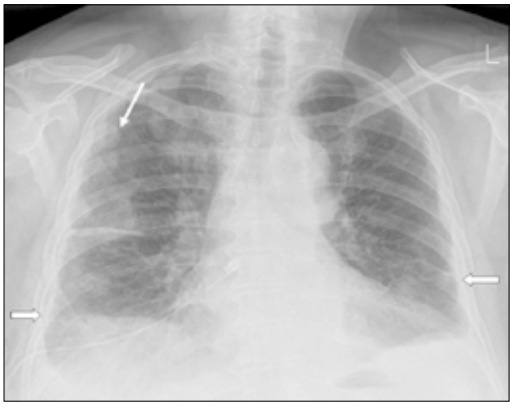


Fig 19A: Plain radiograph shows multiple pleural nodules masses (arrows).

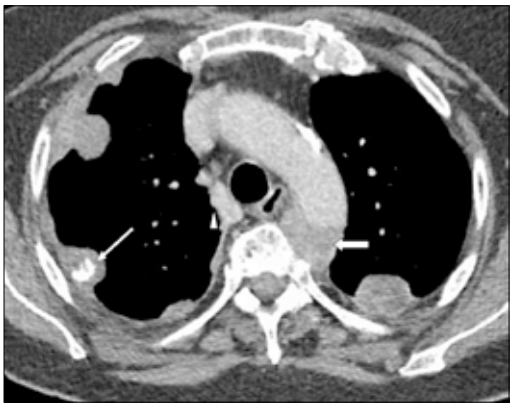


Fig 19B: Multiple pleural nodular lesions some with calcification (thin arrow), with mediastinal pleural involvement(arrow head). There is mediastinal invasion on the left (thick arrow).

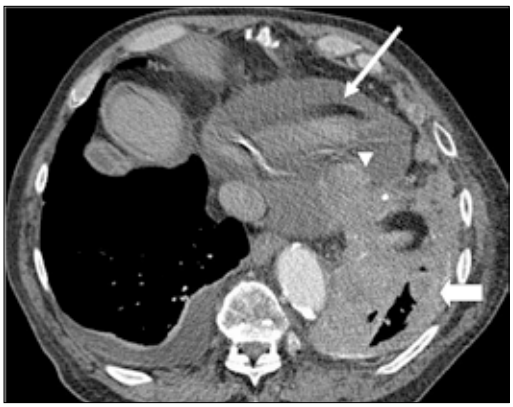


Fig 19C: CT shows a mesothelioma with nodular thickening of the pleura (thick arrow) and invasion of the pericardium (arrow head) and pericardial effusion (thin arrow)

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

The main differential is metastatic adenocarcinoma which may metastasise to the pleura. Calcified plaques are stigmata of previous asbestos exposure and make the diagnosis of mesothelioma more likely but their absence does not imply non-exposure. Biopsy should be employed to reliably diagnose the tumour. CT guided biopsy has been shown to be more sensitive than "blind" Abram's needle biopsy.

5. Future Directions

Rapid advances in all imaging modalities are likely to have an impact on the investigation and management of thoracic cancers. Dual-energy subtraction chest radiographs is a new technique which has improved the detection of hilar and mediastinal masses as well as peripheral lesions obscured by bones (15). In the field of MRI diffusion weighted imaging is being used to evaluate response to therapy (16). Contrast enhanced ultrasound has been explored as a means of distinguishing malignant from benign thoracic lesions . On the interventional front, percutaneous ablation for lung cancer has demonstrated satisfactory survival benefits in stage I and II NSCLC (17). It is very likely that in half a decade from now, the current guidelines and accepted management pathways will be superseded.

Questions

1. Regarding lung cancer, which statement is false?

a. Surgical resection offers the best prognosis for stage I tumours.

b. Adenocarcinoma tends to present as a small central tumour with multiple lymph nodes.

c. Squamous cell carcinoma may show cavitation.

d. Small cell carcinoma can be staged as limited or extensive disease, according to whether it has spread below the diaphragm.

e. Disease with contralateral mediastinal nodal involvement (N3) is regarded as non-resectable.

2. Regarding the use of imaging modalities in the assessment of lung cancer, which statement is correct?

a. Central lesions are easier to miss than peripheral lesions on a CXR.

b. The presence of fat in a lesion on CT is a malignant feature and warrants biopsy.

c. A 2cm lesion in the anterior segment of the right lower lobe without pleural invasion is best assessed with magnetic resonance imaging.

d. A patient with pleural metastatic adenocarcinoma has become more unwell and you are concerned about a pneumothorax, You should request a portable US rather than a CXR for evaluation.

e. SPECT can be used for assessment of mediastinal lymph nodes.

3. Regarding metastases, which statement is correct?

a. A patient with breast cancer presenting with unilateral septal thickening with micronodules may have metastases to the small segmental pulmonary vessels.

b. Multiple nodules are common, reflecting recurrent embolic episodes, hence all metastases are generally a similar size.

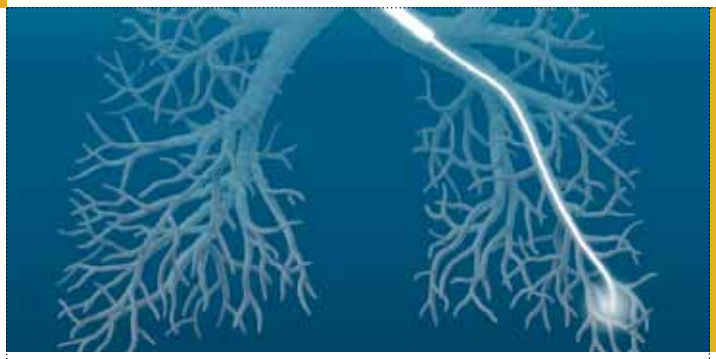
c. Irregular pleural thickening in a patient with rectal adenocarcinoma may indicate metastatic disease.

d. Airway metastases usually arise from distant spread of a tumour.

e. A spiculated nodule with a vessel running through the lesion and multiple mediastinal lymph nodes is more in keeping with metastases than a primary tumour.

RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker



4. Regarding mesothelioma which statement is false?

a. A patient presenting 30 years after asbestos exposure cannot have mesothelioma.

b. Pleural plaques suggest previous exposure to asbestos but are not always present in a patient with mesothelioma..

c. Mediastinal pleural involvement is a feature of malignancy.

d. Prognosis is generally poor in patients with mesothelioma.

e. Mesothelioma is an uncommon thoracic malignancy which has a strong association with asbestos exposure.

Answers

1. Answer: a

(a). is correct, because it is easy to miss central lesions due to overlying mediastinal structures. Intralesional fat (b) is a benign feature and suggests the diagnosis of a pulmonary hamartoma. MRI (c) is poor at assessing lesions surrounded by aerated lung , but good at assessing lesions with pleural/chest wall invasion. US (d) is not routinely used to assess a pneumothorax. PET (not SPECT) should be used to assess the metabolic activity of mediastinal lymph nodes.

2. Answer: c

Adenocarcinoma may metastasise to the pleura and cause irregular pleural thickening. Smooth pleural thickening is more likely to be benign, e.g. chronic effusion/ empyema. (a) describes lymphangitis carcinomatosis and indicates metastases to the lymphatic (not vascular) system. Airway metastases (d) usually arise from local spread from adjacent mediastinal structures i.e. esophagus and lung. Metatases are often multiple (b) but generally have different sizes reflecting different embolic episodes and different growth rates. (e) is a typical description of a primary lung tumour.

3. Answer:b

Adenocarcinoma tends to present as a peripheral, solitary lesion, hence b is false. Surgical resection offers the best chance of cure and recent data suggests that isolated small cell carcinoma with no evidence of nodal disease or metastases should be staged as per TNM and considered for surgery. Disease with N3 or M1 spread is generally not resectable.

4. Answer: a

Mesothelioma is an uncommon thoracic malignancy but up to 5% of asbestos exposed patients may be affected. The absence of pleural plaques does not exclude mesothelioma. Patients may present 40 years after exposure. Prognosis is generally poor. Mediastinal pleural involvement is a feature suggestive of malignancy, as is nodular thickening, and thickening greater than 1cm.

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RADIOLOGICAL EVALUATION OF THORACIC MALIGNANCY

KE Low, AD Tasker

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PLAIN FILM INTERPRETATION OF TRAUMATIC ELBOW INJURIES IN CHILDREN

J Tuckett, A Karsandas, E Fatone, R Sinha, IG Hide

Abstract

Elbow fractures are common injuries in children, however evaluating radiographs of the paediatric elbow can be challenging. Difficulties in analysis result from both the complex nature of changing anatomy in the developing child and the subtle radiographic findings associated with serious fractures. Elbow radiographs can be safely interpreted by evaluating four specific areas:

- *Assessing for the presence of an effusion by evaluating the fat pads.*
- *Evaluating the alignment with the anterior humeral and radiocapitellar lines.*
- *Identifying the expected ossification centres in their normal location.*
- *Looking carefully at the common fracture sites.*

Presentation & Initial Investigations

Patients usually present following a fall onto an outstretched arm. Less commonly, fractures can follow direct trauma to the elbow. Younger children will show reluctance to move the affected limb, especially at the elbow. Older children complain of pain around the elbow and upper arm. Clinical examination can reveal a deformity in severe cases, or swelling and bony tenderness. However, in younger children, examination may be difficult.

Plain film interpretation of traumatic elbow injuries in children
Good Clinical Care

Radiographs are used to look for a fracture and associated joint effusion. An understanding of the normal radiographic anatomy is essential to correctly interpret elbow radiographs in children. The normal radiographic appearances and a system for interpreting radiographs will be outlined in this article. If uncertain, the opinion of a senior colleague or radiologist should be sought. Further radiological investigation is rarely indicated. Ultrasound may be used to assess soft tissue structures. Computed tomography (CT) is used infrequently due to the ionising radiation involved and the potential consequences in this age group.

Routine Projections & Normal Anatomy

Two views are routinely obtained to assess the elbow in the context of trauma, an anteroposterior (AP) (figure 1a) and a lateral (figure 2a) projection. The AP projection is taken with the elbow fully extended. The lateral is taken with the elbow flexed to 90°.

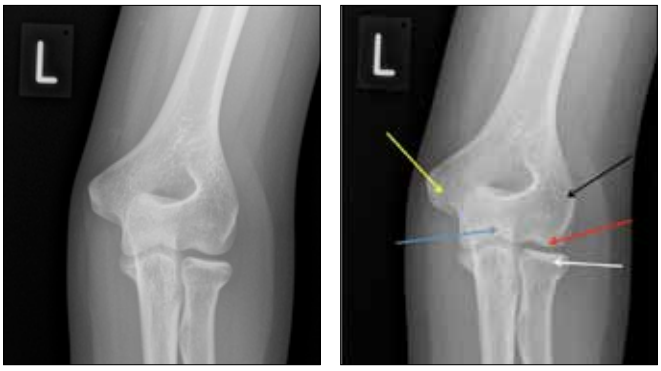

Figure 1: Normal AP radiograph of the left elbow of a 14 year old patient, taken in full extension (figure 1a) with bony anatomy outlined in figure 1b. The distal humerus flares out at its distal end with medial epicondyle (yellow arrow in figure 1b) and lateral epicondyle (black arrow) just proximal to the articular surfaces of the pulley like trochlea (blue arrow) and the rounded capitulum (red arrow). The radial head (white arrow) articulates with the capitulum.

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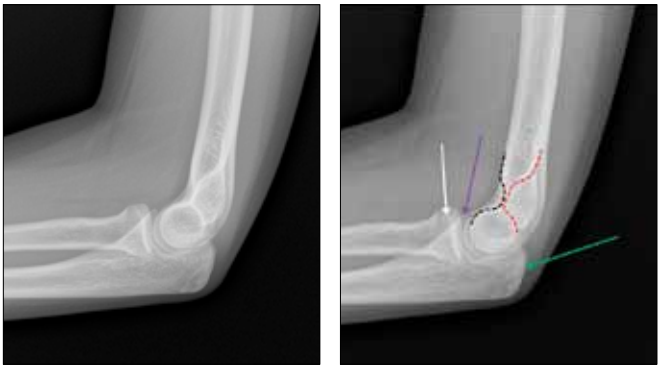

Figure 2: Normal lateral radiograph of the left elbow of a 14 year-old patient, taken in approximately 90° flexion, (figure 2a) with bony anatomy outlined in figure 2b. The proximal ulna hooks around the trochlea with the olecranon proximally (green arrow) and the coronoid process distally (purple arrow). The radial head (white arrow) is well seen articulating with the capitulum. The shallow depressions of the radial and coronoid fossae are superimposed on the anterior aspect of the distal humerus (black dashed line). On the posterior aspect, the deeper olecranon fossa is seen (red dashed line).

The distal humerus flares out at its distal end and has two articular surfaces, the rounded capitulum and the more pulley-like trochlea. Adjacent to each of these are two bony protuberances, the lateral and medial epicondyles (figure 1b). These protuberances serve for attachment of the extensor and flexor muscles of the forearm respectively. The proximal end of the radius, the radial head, articulates with the capitulum. The proximal ulna hooks around the pulley-like trochlea with the olecranon proximally and the coronoid process distally (figure 2b). The powerful triceps muscle which extends the elbow inserts onto the olecranon. There are three shallow depressions on the distal humerus, the radial and coronoid fossae on the anterior aspect and the olecranon fossa on the posterior aspect. These fossae contain fat pads. As the anterior fossae are shallower than the posterior olecranon fossa, the anterior fat pads are usually visible as a thin low attenuation (dark) line paralleling the distal humerus on the lateral radiograph. In contrast, the posterior fat pad is not normally visible on a lateral projection.

Interpreting elbow radiographs in children

Evaluating paediatric elbow radiographs is challenging, especially if the radiographs appear normal initially. Certain features should be assessed routinely in all cases.

1. Assessment for the presence of a joint effusion

Distension of the synovial cavity with fluid floats the fat pads out from their normal location. The anterior fat pad no longer parallels the distal humerus and the posterior fat pad becomes visible as a dark line (figure 3); these are known as the anterior fat pad or sail sign and the posterior fat pad sign. If identified on radiographs performed in the context of trauma, the effusion is most likely to be a haemarthrosis indicating an intra-articular fracture. The radiographs should be closely inspected to look for an accompanying fracture, and even if one is not identified, the elbow should be immobilised and the patient referred to fracture clinic. A fracture will be identified on future imaging in 75% of such cases.

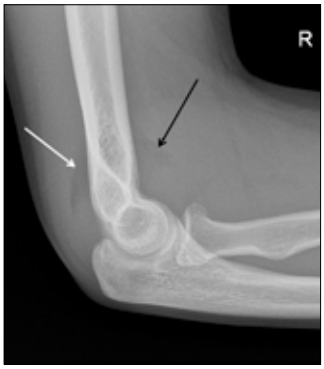

Figure 3: Lateral radiograph of an elbow demonstrating a joint effusion. The anterior fat pad is elevated more than normal, giving the so-called "sail sign" (black arrow). The posterior fat pad becomes visible (white arrow) as a dark line adjacent to the posterior aspect of the distal humerus.

It is important to remember that there are other causes of a joint effusion besides a haemarthrosis secondary to an intra-articular fracture, thus making elevated fat pads a non-specific finding. Septic arthritis and inflammatory arthritis are both causes of a joint effusion, while in patients with haemophilia, a haemarthrosis may form spontaneously without an underlying fracture.

Other potential pitfalls exist with this radiological sign. One is seen in cases where the lateral radiograph has not been well-positioned. If the lateral projection is taken with the elbow extended, the olecranon pushes fat out of the posterior fossa making it visible. Massive soft tissue swelling can tamponade the fat pads in place preventing an effusion from giving raised fat pads. Similarly rupture of the joint capsule is another cause of a false negative as the fluid released from an intra-articular fracture leaks into the adjacent soft tissues, rather than building up as an effusion.

2. Evaluation of alignment

The examiner should mentally draw two lines on all trauma elbow radiographs. The first is the anterior humeral line, drawn on the lateral projection along the anterior border of the distal humerus (figure 4). This should continue to pass through the middle third of the capitulum. This is often abnormal in supracondylar fractures (figure 5), the commonest fracture of the elbow in children under ten. It follows a fall onto an outstretched hand. In this fracture, the anterior humeral line passes through the anterior third, or even in front of the capitulum (figure 6). The anterior humeral line is of crucial importance as the actual fracture line may be difficult to see with only a subtle lucent line seen on the AP view or a defect in anterior cortex of distal humerus on the lateral projection. Supracondylar fractures are important to recognise as there is a high risk of associated nerve and vascular injury, as well as malunion and resultant elbow deformity.

PLAIN FILM INTERPRETATION OF TRAUMATIC ELBOW INJURIES IN CHILDREN

J Tuckett, A Karsandas, E Fatone, R Sinha, IG Hide

Figure 4: Lateral radiograph of a normal elbow demonstrating the anterior humeral line. A line drawn along the anterior aspect of the distal humerus (red dashed line) should pass through the middle third of the capitulum (black circle).

Figure 5: Lateral radiograph in a patient with a supracondylar fracture. Note that a joint effusion is also present, as evidenced by the posterior fat pad being visible.

Plain film interpretation of traumatic elbow injuries in children
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Figure 6: Lateral radiograph of the same patient in Figure 5. The anterior humeral line (red dashed line) does not pass through the middle third of the capitulum, instead it passes anterior to it, indicating a displaced supracondylar fracture.

The second line is the radiocapitellar line. This is drawn along the proximal part of the radius, and should pass through the centre of the capitulum (figure 7). This can be affected by positioning of the radiograph and is only reliable in a well-positioned lateral radiograph. If the line does not pass through the capitulum, it implies dislocation of the radial head (figure 8). As the bones of the forearm form a ring of bone that cannot be broken in one place, dislocation of the radial head is usually seen in association with other injuries, such as dislocation of the ulna at the elbow or fracture of the ulna. The ulna fracture may be in the forearm and not visible on the elbow radiographs, so forearm views should be obtained if an isolated radial head dislocation is seen. The combination of dislocation of the radial head and fracture of the ulna is known as a Monteggia fracture dislocation (figure 9).

PLAIN FILM INTERPRETATION OF TRAUMATIC ELBOW INJURIES IN CHILDREN

J Tuckett, A Karsandas, E Fatone, R Sinha, IG Hide

Figure 7: Lateral radiograph of a normal elbow demonstrating the radiocapitellar line. A line drawn along the middle of the proximal radius (red dashed line) should pass through the middle of the capitulum (black circle).

Figure 8: Lateral radiograph in a patient with a radial head dislocation. The radiocapitellar line drawn along the middle of the proximal radius (red dashed line) passes superior to the capitulum.

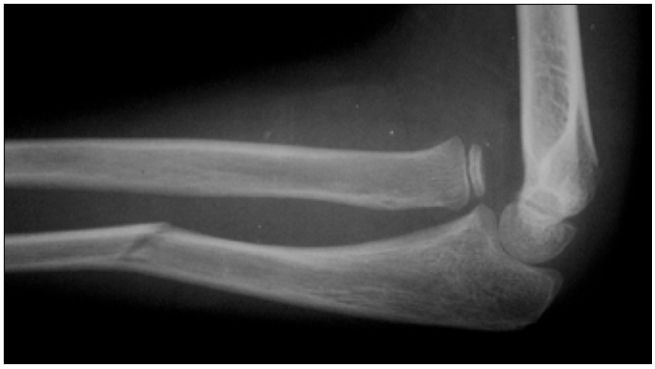

Figure 9: Lateral radiograph of the elbow and forearm in the same patient as seen in figure 8. A displaced fracture of the diaphysis of the ulna is demonstrated. The combination of a dislocation of the radial head and a fracture of the ulna is known as a Monteggia fracture-dislocation.

3. Assessment of the ossification centres

There are multiple ossification centres at the elbow and the pattern of ossification here is complex (figure 10). Knowledge of this pattern is helpful in the analysis of paediatric elbow radiographs. The mnemonic CRITOE is useful to remember the order in which the centres begin to ossify. This stands for:

Ossification centre	Approximate age of normal ossification
Capitulum	1yr
Radial head	3yr
Internal (medial) epicondyle	5yr
Trochlea	7yr
Olecranon	9yr
External (lateral) epicondyle	11yr

Table

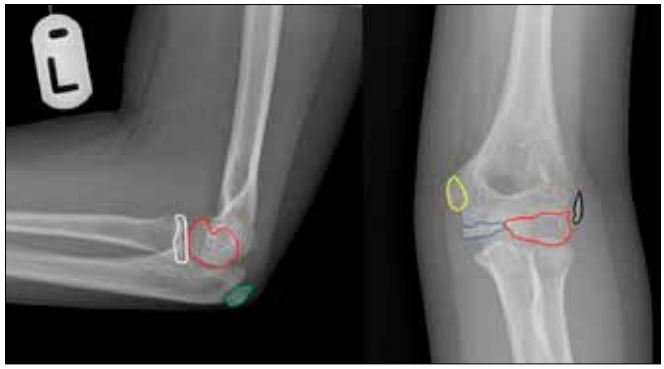

Figure 10: Normal lateral (left) and AP (right) radiographs of a 12 year-old patient demonstrating all the ossification centres. The capitulum (outlined in red) is the first to appear, followed by the radial head (white) and then the internal or medial epicondyle (yellow). The internal epicondyle always appears before the trochlea (blue), with the olecranon (green) appearing next before the external or lateral epicondyle (black), which is last to ossify.

The precise ages of ossification can be variable, but the order in which they appear is extremely important. While there can be minor variation in this order, crucially the internal (medial) epicondyle always begins to ossify before the trochlea. Therefore, if an ossified trochlea can be identified on radiographs but the internal (medial) epicondyle cannot be visualised in its normal location, it is likely to have been pulled away from its normal location by the powerful forearm flexors which attach to it.

PLAIN FILM INTERPRETATION OF TRAUMATIC ELBOW INJURIES IN CHILDREN

J Tuckett, A Karsandas, E Fatone, R Sinha, IG Hide

Avulsion of the medial epicondyle is a common paediatric injury, classically seen in adolescents who participate in throwing sports or have been arm-wrestling (figure 11). It is difficult to recognise as the misplaced internal (medial) epicondyle is often interpreted as the trochlea ossification centre. The epicondyle may avulse into the joint and urgent surgery is required to restore normal elbow and forearm function, making this an important diagnosis not to miss.

Figure 11: AP radiograph of a 16 year-old patient demonstrating avulsion of the internal (medial) epicondyle from its normal location closely apposed to the medial condyle. This is an unstable injury requiring surgical fixation.

Note that the trochlea ossification centre can have multiple separate foci of ossification giving it a fragmented appearance. On the lateral projection this can give the appearance of multiple loose bodies in the joint, but this is a normal finding.

4. Common fractures to look for if the radiographs look normal

The identification of the commonest paediatric elbow fractures, the supracondylar fracture, has been discussed above, as well as the Monteggia fracture dislocation and avulsion of the medial epicondyle. Other common fractures in paediatric patients include lateral condyle fractures and radial head and neck fractures.

Fractures of the lateral condyle (figure 12) are the second commonest paediatric elbow fractures, often seen following a blow to lateral elbow or due to a varus stress. As the fracture can mostly involve the cartilaginous structures, with only minimal bony involvement, it can be subtle on plain film radiographs. However, there is a high risk of displacement due to the powerful pull of the attaching forearm extensors. As these fractures are intra-articular, synovial fluid can flow into the fracture with a high risk of non-union. Therefore open reduction and internal fixation is often required.

Figure 12: AP radiograph of a 4 year-old. A fracture line (white arrows) is seen across the lateral condyle extending from the articular surface to the superolateral aspect of the distal metaphysis. These fractures may be very subtle and difficult to spot.

Proximal radial fractures are seen commonly following a fall onto an outstretched hand (figure 13). The radial neck is constantly remodelling as the bone grows, therefore this area of bone is particularly weak and tends to fracture in children. By contrast, in older adolescents and adults, the radial head is the commonest site for fracture, and this area should be examined carefully as fractures here can be very subtle. This is particularly the case when a joint effusion is present (see above) but a fracture has not been identified.

Figure 13: AP radiograph of a 15 year old patient, demonstrating a fracture of the radial neck (white arrow), which extends across the radial head to the articular surface. The radial neck is the commoner site of fracture in children, as this represents the area of fastest bone turnover. However, fractures at this site can be very subtle.

PLAIN FILM INTERPRETATION OF TRAUMATIC ELBOW INJURIES IN CHILDREN

J Tuckett, A Karsandas, E Fatone, R Sinha, IG Hide

Further Reading

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Multiple Choice Questions:

1. Regarding radiographs of the elbow:
a.) Both AP and lateral projections are taken in full extension
b.) Both AP and lateral projections are taken with the elbow in 90° flexion
c.) Only one view is required for trauma assessment
d.) The AP projection is taken in 90° flexion and the lateral view is taken in full extension
e.) The AP projection is taken in full extension and the lateral view is taken in 90° flexion

2. Which of the following describe the correct point of insertion or origin of the stated muscle?
a.) Triceps muscle inserts onto the coronoid process
b.) Forearm flexors arise from the lateral epicondyle
c.) Forearm extensors arise from the medial epicondyle
d.) Forearm flexors arise from the medial epicondyle
e.) Biceps brachii muscle inserts onto the radial head

3. In elbow radiographs, the posterior fat pad:
a.) if visible as a dense (white) line at the posterior aspect of the distal humerus
b.) may indicate a haemarthrosis following trauma
c.) is a normal finding
d.) is a specific sign of a haemarthrosis
e.) is caused by the appearance of fat normally found in the coronoid fossa

4. Supracondylar fractures:
a.) usually follow a fall onto an outstretched hand
b.) can be recognised through disruption of the radiocapitellar line
c.) are never associated with a joint effusion
d.) are trivial injuries that usually heal with little medical input
e.) usually involve the anterior humeral line passing through the posterior third of the capitulum

5. Which of the following statements regarding ossification centres of the elbow is correct?
a.) The radial head is the first to ossify
b.) The order of appearance of the ossification centres is the exactly the same in all children
c.) The olecranon is commonly seen as a multiple fragments of ossification
d.) The internal epicondyle always begins to ossify before the trochlea
e.) All the ossification centres should have appeared by age 8.

Answers

1.) e.
Two views should routinely be obtained in the context of trauma, an AP projection with the elbow fully extended and a lateral projection with the elbow flexed to 90°.

2.) d.
The forearm flexors arise from the medial (internal) epicondyle and the forearm extensors arise from the lateral (external) epicondyle.

3.) b.
The posterior fat pad becomes visible as a dark line posterior to the humerus and is always abnormal. In the context or trauma, this is most likely to be due to a haemarthrosis indicating an intra-articular fracture, though other causes of an effusion are possible.

4.) a.
Supracondylar fractures result in the anterior humeral line passing through the anterior third, or even in front of the capitulum.

5.) d.
The mnemonic CRITOE is useful to remember the order in which the centres begin to ossify, though the order can be variable. However, the internal (medial) epicondyle always appears before the trochlea. The trochlea ossification centre can have multiple separate foci of ossification giving it a fragmented appearance.

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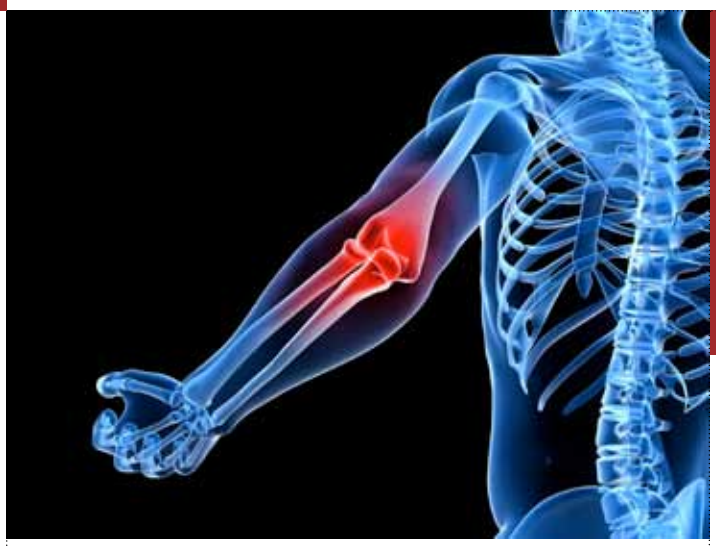
RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh



Recognising bone tumours on Imaging: A review article based on common cases of benign & malignant bone lesions.
Patient Management

Abstract

Bone tumour often presents with non specific symptoms and is frequently discovered on imaging as an incidental finding. As there are bewildering number of benign and malignant bone tumours, brief knowledge of various radiological signs which differentiate aggressive and non-aggressive bony lesions would help to narrow the differential diagnosis to help early diagnosis. This can improve the patient outcome dramatically.

Patient age remains one of the most important clinical factors in the diagnosis of bone tumours, because certain tumours have predilection for specific age groups. The approach to the radiographic diagnosis of bone tumours should start in a systematic way with attention to the specific radiographic features of tumour location, margin, zone of transition, periosteal reaction, mineralisation, size and number of lesions and presence of a soft-tissue component. We aim to provide brief overview of some of the commonly occurring benign and malignant bone lesions in this case based discussion.

Introduction

Bone tumours can be a great diagnostic challenge given their vast variety and variable presentation. Imaging plays a major role in the work up of a bone tumour. Despite the availability of multiplanar imaging, standard radiographs are still the mainstay in detection and characterisation of bone tumours and histology is still the gold standard for definitive characterisation of a bone tumour. However, the combination of age, location, multiplicity and features on standard radiographs can narrow the differential diagnosis and improve the patient management.

Bone tumours can be classified into primary and secondary lesions. Primary lesions can be further sub-classified into benign and malignant lesions. There is a long list of bone tumours which one can classify into different categories for ease of remembering.

Few common tumours are identified in the following table.

Classification of Primary Tumours of bone (1)

Histologic Type	Benign	Malignant
Haematopoietic		Myeloma
		Lymphoma
Chondrogenic	Osteochondroma	Primary Chondrosarcoma
	Chondroma	Secondary chondrosarcoma
	Chondroblastoma	Dedifferentiated chondrosarcoma
	Chondromyxoid fibroma	
		Mesenchymal chondrosarcoma
		Clear cell chondrosarcoma
Osteogenic	Osteoid Osteoma	Osteosarcoma
	Osteoblastoma	Parosteal osteosarcoma
		Perisoteal osteosarcoma
Unkown origin	Giant cell tumour	Ewing's tumour
		Malignant giant cell tumour
		Adamantinoma
Fibrogenic	Fibroma	Fibrosarcoma
	Desmoplastic fibroma	Malignant fibrous histiocytoma

Most common malignant bone tumour encountered in clinical practice is likely to be a metastatic bone lesion like a metastatic carcinoma, myeloma or metastatic non-Hodgkin's lymphoma rather than a primary bone tumour especially in an adult over 40 years old.

Around 600 cases of primary bone cancer are diagnosed each year in the United Kingdom.(2) Multiple myeloma, osteosarcoma, Ewing's sarcoma and chondrosarcoma are the four most common primary bone tumours. (3)

We present a case based discussion focused on radiological features of some of the most common bone tumours. To start with, we would like you to understand how to differentiate an aggressive from a nonaggressive bone lesion. However, there are certain bone lesions which can mimic both. In such cases it is important to understand that the aggressive bone lesion does not necessarily mean it is a malignant lesion, but rather indicates the characteristics of the lesion.

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

Following table is useful to start with:

	Aggressive bone lesion	Nonaggressive bone lesion
Type of bone destruction	Permeative or Moth-eaten	Geographic pattern
Margin	Indistinct, cortical breakthrough possible	Well defined, sclerotic margin, intact cortex
Zone of transition	Wide	Narrow
Periosteal reaction	Laminated or spiculated Disorganised Codman's triangle may be seen	No periosteal reaction or thin, solid nonaggressive periosteal reaction
Soft tissue mass	Often present	Absent

Table 1: (4)

Now Study the following cases making note of the different characteristics used to describe these lesions in Table 1.

Case 1

Tom is a 26 year old teacher who presents to emergency department (ED) with acute pain around his right knee following a fall from standing. He is unable to weight bear but is otherwise known to be fit and well, although he mentions that of late he has had nagging discomfort in his right thigh, which was partly relieved with anti inflammatory medication.

What could be the possible cause for his pain?

- *Ruptured quadriceps tendon*
- *Patella fracture*
- *Osteoarthritis of the knee*
- *Pathological fracture femur*

You would be correct if you were thinking on these lines, but surely not osteoarthritis as it is seen in the older age group!

Take a look at his radiographs

Figure 1 A and 1B

How would you describe your findings?

AP and Lateral radiographs of femur in a patient show a large ill-defined lytic lesion in meta-diaphyseal region (arrow). There is a wide zone of transition, indistinct margin, periosteal interruption and a pathological fracture through the lesion.

How is the history helpful in this patient?

There is a clue in the history stating fall from standing. A significant force is required to fracture the normal femur.

Now look at the distal femur. Apart from the break in the cortex does it appear normal otherwise?

There is a geographical area of mixed lytic/sclerotic morphology with a wide zone of transition through which the femur has fractured.

What is your most likely diagnosis? Would you consider metastases in the differential?

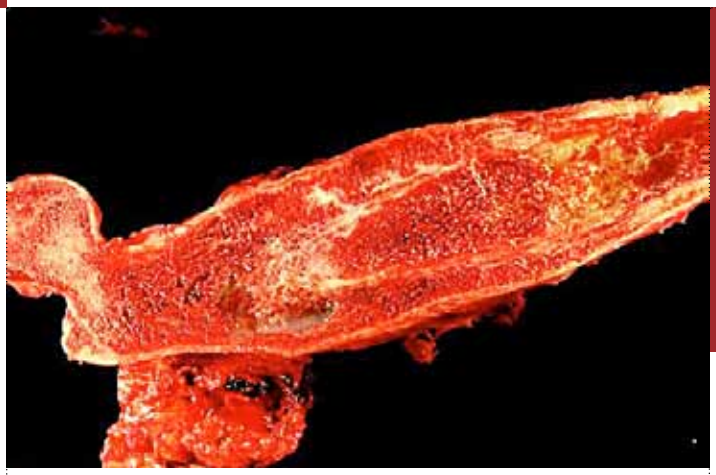
Given the radiological features of the lesion combined with patient's age, the differentials are a primary bone tumour i.e. osteosarcoma, and in the presence of raised inflammatory markers and fever, osteomyelitis. It is uncommon to see metastatic bone disease in people less than 40 years of age. (5)

Given the aggressive nature of this lesion patient is referred to regional bone centre for further management. Subsequently this patient is diagnosed to have osteosarcoma on histology.

Osteosarcoma is a common malignant primary bone tumour with a bimodal age distribution being frequent under the age of 30 and then again around 60-70 years. Secondary osteosarcoma is more common in the latter age group.

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

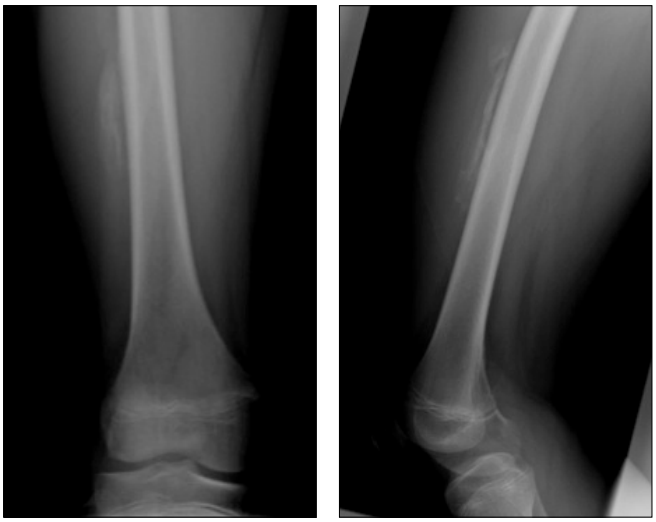
P Sankaye, H Nizami, S Chhatani, P Suresh



Case 2

Jack, a 15 year old keen cyclist, presented to his GP complaining of a dull ache around his knee and thigh which started a couple of months after he came off his bicycle preparing for a cycling tournament. No other significant history of note. He had plain radiographs of his knee and femur which are shown below.

Can you recognise the abnormality?



Figures 2A and 2B show soft tissue ossification that is not attached to the bone, with distinct peripheral margin of mature ossification which is characteristic of myositis ossificans.

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Patient Management

Is there any differential you will consider and if yes, how will you rule that out?

Myositis ossificans can be very easily confused with parosteal osteosarcoma. In myositis ossificans, there is likely to be a past history of trauma or repeated trauma. Radiologically, it typically has circumferential calcification(6) with a lucent centre due to formation of peripheral well organised mature lamellar bone and central immature non-ossified cellular region; whereas parosteal osteosarcoma has an ill defined peripheral calcification with a calcified center due to outer fast growing tumor cells yet to be ossified.

These are best demonstrated on the CT scan.

A helpful way of narrowing down the differential diagnoses is the location of the bone lesion as some have characteristic predilections as shown by the following:

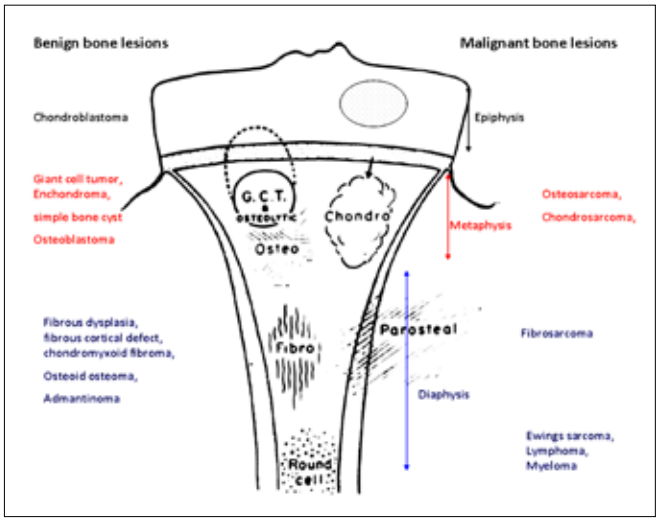

Illustration 1: (7,8) Common bone lesions with predilection for specific locations.

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

What other features can help differentiate a benign from an aggressive bone lesion? (see table 1).

When we describe any bone lesion we need to evaluate site, size, number of lesions but more importantly we also need to describe the margin, zone of transition, periosteal involvement and presence or absence of cortical breach. Hence pattern recognition is important.

The zone of transition is the single most reliable indicator of an aggressive bone lesion. A narrow zone can be described as a thin boundry between normal and abnormal bone. A lesion with a sclerotic margin is likely to be benign. In theory we should be able to draw around a benign lesion. In contrast, a wide zone of transition suggests an aggressive lesion where growth is rapid. But all lesions with aggressive features are not necessarily malignant for eg. bone infection and eosinophilic granulomas do demonstrate wide zone of transition and can mimic a malignant lesion.

Case 3

Mark, a 17 year old student, came to ED with a painful elbow following a direct blow to it while doing martial arts. He was noted to have an incidental finding on his radiographs.

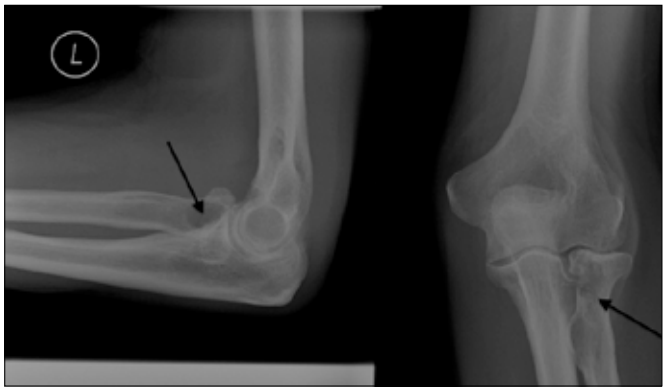

Figure 3A

How do you describe the lesion?

Lateral and AP radiographs of elbow (Figure 3A) show a central, well marginated radiolucent defect (arrow on the lateral view) in the metaphysis with no bony loculations, narrow zone of transition. There is no associated soft tissue mass. Note an arrow on the AP radiograph is pointing to the fracture through the cyst.

What modality is the image below and how does it help in the diagnosis?

Figure 3B

This is a multiplanar reconstructed CT scan image (Figure 3B) which shows a central, well marginated radiolucent defect (red arrow) in the metaphysis with no bony loculations. Note fracture through the cyst (blue arrow). This helps to confirm the characterisation of the lesion in detail and thus diagnose it.

What is the diagnosis?

We can see a well defined lucent lesion within the proximal radius with a narrow zone of transition, sclerotic rim and no periosteal reaction, all features of a benign bone lesion. (9,10) This is a simple bone cyst. In an older patient we should have a subchondral cyst (part of degenerative change) on the differential list.

Case 4

Rachel, a 55 year old with Paget's disease, undergoes a pelvic radiograph for hip pain. Take a look at her pelvic radiograph.

Figure 4

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

Recognising bone tumours on Imaging: A review article based on common cases of benign & malignant bone lesions.
Patient Management

Paget's disease is characterised by coarse trabeculations, thickened sclerotic cortex and a flame shaped medullary cavity. Above radiograph is a known case of Paget's disease demonstrating coarse trabeculations and thickened sclerotic cortex (long arrow). Note the disruption in the cortex around the greater trochanter (short arrow) and wide zone of transition. This is a marker of aggressive bone disease.

What other important radiological feature you should look for in a patient with Pagetic bone changes?

A well recognised complication of Paget's disease is secondary osteosarcoma and should always be ruled out. As there are features of aggressive bone disease .i.e. disruption of cortex around the greater trochanter (short arrow) with wide zone of transition, this is likely to be an osteosarcoma with Paget's disease.

Periosteal reaction is another indicator of bone abnormality because it can be used as an ancilliary sign in deciding if a lesion is benign or malignant(9). Various periosteal reactions are described (11);

Nonaggressive: Thin, solid, thick irregular, septated

Aggressive: Laminated (onion skin), spiculate (hair on end or sunburst), disorganised and Codman's triangle.

We can think of these on a spectrum of benign to malignant with a solid reaction likely to be benign.

Cortical destruction is perhaps the easiest to pick up but does not always help as this is also demonstrated in benign lesions like osteomyelitis and eosinophilic granuloma. On their own each of these features may not indicate one or the other but none the less are very helpful if they are looked at in union.

Case 5

Rob, a 14 year old boy, presented to his GP along with his mum complaining of pain in his right thigh and groin which has been ongoing for a couple of months. His mother tells the GP he has been febrile intermittently. Clinically the groin feels warm to touch. Review his radiographs and describe what you see, is it a benign or malignant lesion?

Figure 5

There is a predominantly lytic expansile lesion in the right superior pubic ramus with a wide zone of transition and sunray periosteal reaction (arrow). A differential for this would include Ewing's sarcoma, osteomyelitis, metastatic carcinoma or lymphoma but considering the age of the patient, Ewing's sarcoma is most likely.

This patient underwent CT scan for further assessment.

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

Figure 6: CT scan image shows a large ill-defined lytic soft tissue density lesion in the right superior pubic ramus (arrow). There is a wide zone of transition, indistinct margin, periosteal interruption and large soft tissue component.

Ewing's Sarcoma (9,11): *Primarily affects young adults and children. Commonly involves the diaphysis of long bones but is also known to occur in flat bones, pelvis, shoulder girdle and ribs. Radiographically it presents as a permeative lesion with onion skin/sunray/Codman's periosteal reaction.*

The clinical presentation of Ewing's sarcoma includes pain and swelling of weeks or months duration. The affected site may have erythema with local rise in temperature. Blood tests may show leucocytosis, anaemia and an increased ESR.

What is the next step in the management of this patient?

A CT scan and MRI are essential to delineate bone and soft tissue involvement respectively.

Case 6

Miller, a 33 year old male, builder by profession, presents with a long standing swelling in his right middle finger. Although there is no other significant history of note, but he informs you that his fingers have been swollen for a while, which he attributes to his profession as a builder. You request plain radiograph of his hand.

What do you see?

Figure 7

There are well defined multiple lytic lesions noted in the metacarpals and phalanges with no periosteal reaction or associated soft tissue mass. The lesions show narrow zone of transition. There are no aggressive radiological signs. These are benign bone lesions i.e. enchondromas. This is a case of multiple enchondromatosis. They tend to occur in the bone formed from cartilage and often contain punctate chondroid calcifications, although here they are seen as cystic lesions with no calcification. A common site would be the wrist / phalanges. These lesions remain painless unless they are fractured. The pain in the abscence of a fracture, should raise the concern of chondrosarcoma. Multiple enchondromas are termed Ollier's disease and when associated with soft tissue haemangiomas, known as Maffucci's syndrome.(9)

Case 7

Ms Brooks, a 43 year old lawyer, presents with a few months history of right hip pain and feeling fatigued. You request a pelvis radiograph.

Figure 8

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

Recognising bone tumours on Imaging: A review article based on common cases of benign & malignant bone lesions.
Patient Management

How do you describe the above radiograph?

There is a lucent lesion within the proximal femur (arrow) demonstrating an ill defined lesion with a wide zone of transition but there is no periosteal reaction or soft tissue swelling. With lytic lesions one should always think about myeloma, lymphoma or metastases in the differential. Further investigation with bone scan is necessary to look for other deposits to rule out metastases. A skeletal survey is necessary for myeloma screen.

In the older age group a differential of metastases is warranted as they may mimic any bone lesion.(8,9) It would be worthwhile to note that prostatic and breast metastases tend to be sclerotic where as renal and thyroid metastases generally are lytic and expansile.

Myeloma: *Occurs in the adults over 40 years of age and tends to affect the calvaria, presenting as a diffuse permeative 'moth eaten' lesion.(8) Diffuse skeletal involvement usually demonstrates multiple osteolytic lesions of uniform size which are well defined with a narrow zone of transition. But as seen above, it can be a great mimic on the radiograph. So it is better to first differentiate between aggressive and nonaggressive lesions and then investigate further.*

Case 8

Now look at this radiograph of Janet, a 65 yr old patient with left hip pain, who is otherwise well. Describe what you see.

Figure 9A

In the radiograph above we see an ill defined lucent lesion within the left ischial tuberosity (arrow). It has a wide zone of transition. This is an aggressive lesion and as mentioned before considering patient age and above features of the lesion, we need to consider lytic metastases as the first possibility, renal cell carcinoma and thyroid metastases as likely source.

What are the next investigations?

This should prompt immediate further investigations in the form of bone scan and/or CT scan to look for primary.

Figure 9B: Bone scan depicts increased uptake of the isoptope in the left ischial bone (arrow). Also note multiple further vertebral body deposits. These are thought to be metastatic bone lesions which prompted whole body CT scan to look for primary malignancy.

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

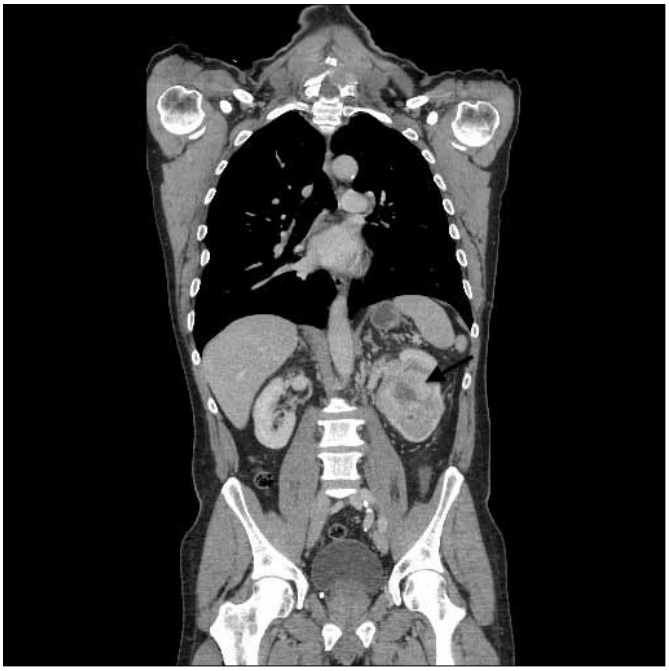

Figure 9C: The multiplanar reconstructed CT image shows left renal cell carcinoma as the primary source of malignancy.

Now study the following list of common benign bone lesions which can look aggressive on the plain radiographs. You should be aware of these lesions.

Osteomyelitis: *Osteomyelitis is a bony inflammation that is almost always due to infection, typically bacterial but mycobacterial, fungal infections are also seen. It can present as an acute or chronic osteomyelitis. Osteomyelitis can occur at any age, but extremes of age remain at risk. In those without specific risk factors it is particularly common between the ages of 2-12 years of age and is more common in males (M:F of 3:1). (12)*

The bone itself may remain normal in appearance for 10-14 days. Following changes can be seen with varying degree. (13)

1. Regional osteopaenia

2. Periosteal reaction - variable, and may appear aggressive including formation of a Codman's triangle (14)

3. Eventual peripheral sclerosis

4. In chronic or untreated cases, eventual formation of a sequestrum, involucrum or cloaca may be seen.

Figure 10: Above radiograph shows an aggressive bone lesion within the femoral meta-diaphysis with an ill defined margin, wide zone of transition and thickened periosteum. This is a chronic osteomyelitis showing involucrum (white arrow) and cloaca (black arrow).

Often MRI changes precede the radiographic changes, which may not be evident if treated early.

Eosinophilic Granuloma (EG): *This entity generally affects patients under the age of 30. (8,9) Their radiological features depend on location but they may appear lytic or sclerotic and if they have a periosteal reaction, it tends to be solid. EG can mimic Ewing's sarcoma. This makes radiological diagnosis very challenging.*

Figure 11A and 11B: The arrows show an osteolytic lesion within the humeral diaphysis with a wide zone of transition, ill defined margin and thick periosteal reaction, thus making it an aggressive looking bone lesion in a young child.

RECOGNISING BONE TUMOURS ON IMAGING: A REVIEW ARTICLE BASED ON COMMON CASES OF BENIGN & MALIGNANT BONE LESIONS

P Sankaye, H Nizami, S Chhatani, P Suresh

This turned out to be an Eosinophilic granuloma, a benign but aggressive looking bone lesion.

Summary

As a junior doctor on the ward, you are likely to request plain radiographs and view them before anyone else. Plain radiographs still remain the mainstay of bone tumour diagnosis despite the availability of advanced imaging methods such as CT and MR imaging. Systematic analysis of any bone lesion can help you initially determine if the lesion is radiologically aggressive or nonaggressive. The next step would be to pay attention to the age of the patient, the location of the lesion, and the radiographic features of the lesion, so that you would be able to narrow down the differentials. Make sure you know the desciptors used in table 1. This can go a long way in the early diagnosis and proper management of the patient.

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Patient Management

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CASE-BASED DISCUSSION: DIAGNOSIS & MANAGEMENT OF STROKES IN TEENAGERS & YOUNG ADULTS

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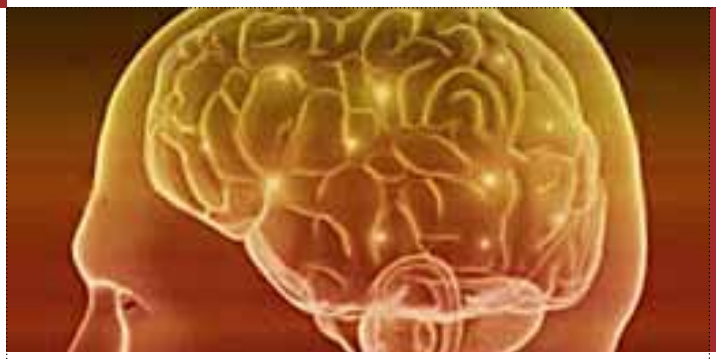

Case-Based Discussion: Diagnosis & management of strokes in teenagers & young adults
Patient Management

Abstract

Although much more common in older adults, stroke should also be included in the differential diagnosis of acute focal neurological deficit presentations in young adults, teenagers and children, although it remains a rare presentation, with an incidence of ~1:20.000. In older adults atherosclerosis is the most common cause but in younger patients this aetiology is uncommon and other causes have to be considered. This case-based discussion will focus on patient presentation and physical examination findings, with guidance into appropriate management and radiological imaging. The classic findings in different imaging modalities will be briefly explained.

Case History

A 21-year-old female presents to the emergency department with sudden onset, at rest, of difficulty pronouncing words associated with right arm and leg weakness. This was preceded by a one-week history of nausea, vomiting and low-grade fever. She was brought in by ambulance, with her neurological deficits occurring 30 minutes prior to arrival.

She denies any previous similar episodes. The past medical history is significant for symptomatic mitral valve prolapse, status post-annuloplasty ring repair 8 months before, followed by a completed period of oral anticoagulation. Currently she is not taking any medications. There is no history of smoking, drug abuse or alcohol abuse. She denies any family history of neurological disease.

Her vital signs include a temperature of 37.3 C, blood pressure of 110/75 mm Hg, heart rate of 80 bpm, respiratory rate of 16 cpm, and oxygen saturation of 98% on room air. The patient remains alert and oriented to self, time and space. While attempting to communicate, she exhibits a significant expressive dysphasia. Physical examination is negative for vascular bruits. Neurological examination reveals severe right hemiparesis, specifically paresis of the right hand and arm, and less markedly of the right leg. There is decreased sensation to pinprick and light touch in the same areas.

Discussion

An appropriate history is crucial, both in terms of determining the clinical diagnosis, its differential aetiology and management. Besides ischaemia, we should exclude from the history a recent seizure (resulting in Todd's paralysis), migraine, hypoglycaemia, intoxication, hypoxaemia and recent trauma. The important features of the history that were and should be addressed at presentation include:

- **Demographics (age and race are factors associated with potentially different aetiologies)**
- **Time of onset of symptoms - this is important to consider with regards to the time scale for the administration of "clot-busting" medication**
- **Alertness**
- **Blood pressure levels**
- **Accompanying symptoms**
- **Motor and sensory deficit distribution and type of aphasia.**
- **Past medical history**
- **Social history to include smoking and IV drug use history**

In our presented case, the signs and symptoms are classical for a clinical diagnosis of stroke in the left middle cerebral artery territory. The middle cerebral artery supplies the lateral aspect of the cerebral hemisphere – primarily the frontal, parietal and upper half of the temporal lobes. Contralateral face/arm weakness and hypoesthesia, more severe than the leg, are the result. Usually, when the patient is right-handed, Broca's area is located on the left cerebral hemisphere, and thus, with left middle cerebral artery strokes, Broca's area is involved, resulting in an expressive dysphasia (motor region controlling the vocal mechanism). If the infarction extends into the superior temporal lobe, a fluent dysphasia may be the result (Wernicke's area).

CASE-BASED DISCUSSION: DIAGNOSIS & MANAGEMENT OF STROKES IN TEENAGERS & YOUNG ADULTS

SJ Karia, AK Banerjee

After clinically diagnosing a left middle cerebral artery stroke, there are a number of steps that should be followed. The National Institutes of Health (NIH) stroke scale should be assessed; it is a commonly used scale to evaluate and quantify stroke severity based on examination, with the scale ranging from 0 (normal neurological examination) to 42. It correlates with stroke outcome. This patient's NIH score was assessed to be 15 (moderate severity).

Following that, obtaining a non-contrast head computerised tomography (CT) is the appropriate next step. The management of ischaemic stroke is based on giving intravenous tissue plasminogen activator (IV TPA) if the appropriate window time of 4.5 hours and an appropriate NIH score are present. Cerebral haemorrhage must be excluded before administration of this drug, and this is investigated with a head CT scan without contrast (similarly to acute haemorrhage, contrast appears white and may confound findings). Aspirin, clopidogrel and heparin should not be given prior to ruling out intracranial haemorrhage.

Magnetic resonance imaging (MRI) often demonstrates changes of ischaemic stroke earlier than CT. MRI includes different sequences related to magnetic physics of particles. One such sequence is the diffusion weighted imaging (DWI), which is extremely useful in stroke. DWI imaging is remarkably able to show ischaemic changes within minutes of stroke onset. However, the time required to scan the patient is usually unacceptably lengthy. The window time for intervention is narrow and the goal is to quickly select patients that can be treated with IV TPA, mainly by excluding haemorrhage. DWI does not help us in achieving this goal. Newer MRI protocols can be performed with acquisition times of five minutes or less (compared to standard 20 minutes), but the utility of these newer methods has not yet been studied. Currently there also is no data to show that MRI is superior to CT in selecting patients who could be treated with IV TPA. It can be used at a later stage depending on the patient's clinical requirements.

Figure 1 is an axial image through the brain of our patient's non-contrasted head CT. There is a major finding. It constitutes one of the early signs of stroke and is called the dense middle cerebral artery (MCA) sign. It represents a clot in the middle cerebral artery. It is not always present, but it remains a very sensitive sign, although very non-specific. Figures 2 and 3 are axial images of a CT of a normal brain, without and with contrast in the arteries (it is an arterial phase scan), to illustrate various arterial branches of the circle of Willis, so that you can better understand the major finding on Figure 1. Other signs that may be seen on CT and described on the radiologist's report include loss of gray-white matter differentiation (particularly in the insular cortex – "insular ribbon sign") and blurring of the lentiform nucleus. Stroke itself appears as a dark area in the cerebral cortex.

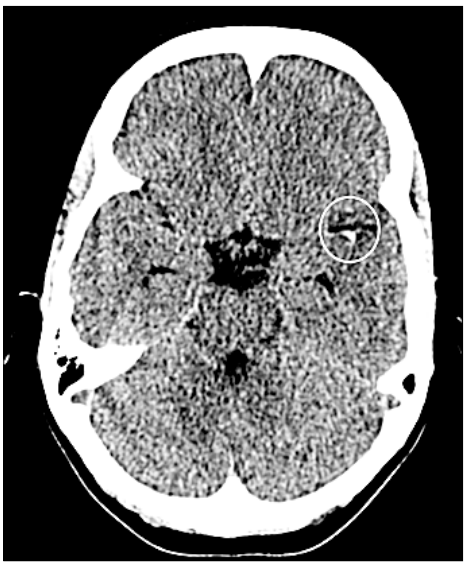

Figure 1: Uncontrasted head CT on our patient who presented with signs of a left MCA stroke.

Figure 2: Normal uncontrasted head CT, with no abnormal findings. Slice through the circle of Willis.

CASE-BASED DISCUSSION: DIAGNOSIS & MANAGEMENT OF STROKES IN TEENAGERS & YOUNG ADULTS

SJ Karia, AK Banerjee

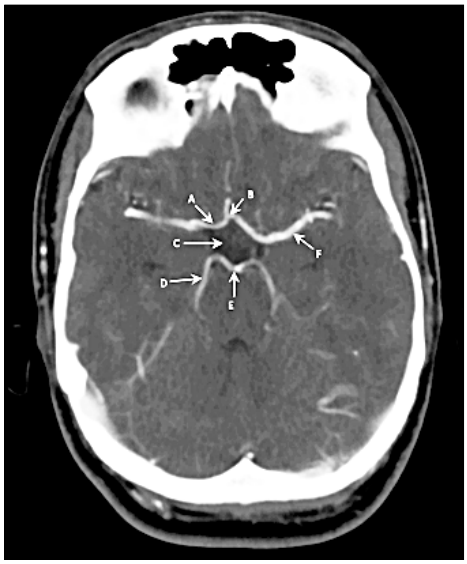

Figure 3: Normal head CT with arterial contrast. Slice through the circle of Willis. A-Right anterior cerebral artery, B-Anterior communicating artery, C-Suprasellar cistern, D-Right posterior cerebral artery, E-Basilar artery, F-Left middle cerebral artery.

Importantly, the non-contrast head CT ruled out an intracerebral haemorrhage, and given the time of onset, the most appropriate next step is to administer IV TPA to the patient and admit her to the stroke unit. Intra-arterial TPA (injection through a catheter in the artery just proximal to the thrombus) or mechanical removal are other good interventional options for large vessel thrombosis such as seen in this case, however IV TPA should still promptly be administered. Following that, these options may be considered depending on the outcome.

Case-Based Discussion: Diagnosis & management of strokes in teenagers & young adults
Patient Management

Clinically, we were already suspecting there to be a large vessel thrombosis, in the left middle cerebral artery. Had the dense MCA sign not been evident on the non-contrast head CT, we would have needed to obtain a cerebral angiogram to confirm a thrombus. If present, its management potentially includes either of the above mentioned interventional options. The angiogram is typically performed using CT, although traditionally it was done with direct cerebral angiography in the catheter lab.

This patient was administered IV-TPA, which immediately resulted in improvement of her speech. Some mild right arm weakness and subtle aphasia for complex words remained. A follow-up scan needs to be performed within 24 hours, mostly to rule out complications, either using CT or MRI.

An MRI was performed shortly after the administration of IV-TPA and it ruled out free blood products in the brain. The DWI sequence (figure 4) was included and illustrates the difference in contrast between normal brain tissue and early infarcted tissue (appearing white). As you can see, differences are dramatic on MRI, while CT may fail to show any changes at all in the parenchyma.

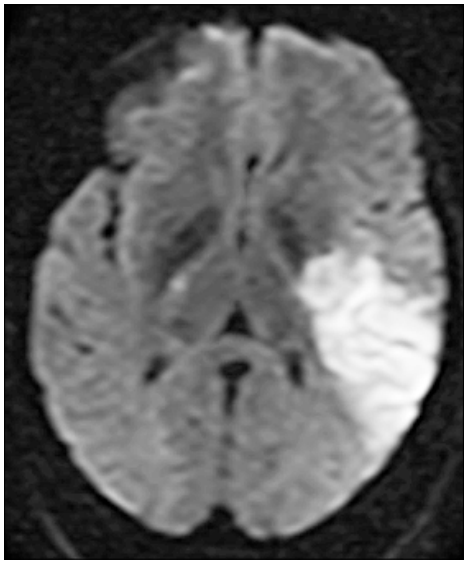

Figure 4: Axial image through the brain using diffusion weighted imaging on our patient.

CASE-BASED DISCUSSION: DIAGNOSIS & MANAGEMENT OF STROKES IN TEENAGERS & YOUNG ADULTS

SJ Karia, AK Banerjee

As the patient achieves recovery, we need to remind ourselves about the patient's demographics and recall that even though stroke is possible in young patients, it still remains rare and its aetiology must be further worked up, for secondary prevention of repeat ischaemic strokes.

She had a history of mitral valve prolapse, which was repaired a few months before with an annuloplasty. Even without this history, an echocardiogram would be indicated to evaluate for intracardiac thrombi as a potential cause for the cerebral emboli - in this patient we had an added significant risk factor. The transthoracic echocardiogram showed a small mobile echodense lesion attached to the posterior mitral valve annular ring. A transoesophageal echocardiogram allows better evaluation of the valve leaflets, and would be adequate to further characterize this lesion (a vegetation as blood cultures were positive for Enterococcus faecalis).

What is very important to note is the physical examination at presentation: it should have included cardiac auscultation to evaluate for murmurs, and the skin should have been examined to look for signs of endocarditis - an important lesson! Skin manifestations of endocarditis include the presence of petechiae beneath the fingernails, tender violaceous papules in the fingers or toes (Osler nodes) and painless erythematous lesions in the palms or soles (Janeway lesions).

Focusing on possible differential diagnoses for strokes in teenagers and young adults, risk factors include pregnancy, auto-immune processes causing vasculitis, hypercoagulability, illicit drug use and cardiac valve disease/ congenital heart disease. Atherosclerosis as a cause is rather uncommon, although premature atherosclerosis does exist in young adults.

In children, sickle cell disease is the most common cause of stroke. A particular chronic syndrome named Moyamoya affects children and adults, but has a higher incidence in the far-east Asian paediatric population. It uniquely affects the internal carotid arteries causing them to stenose. Collateral vessels are formed, exhibiting a classic appearance on angiography that gives origin to its name (Japanese for puff of smoke).

History of trauma should not be dismissed in the thinking process in the workup. Dissection of the vertebral artery, i.e., damage to the vessel, remains an important cause in both groups and can be caused by trauma including road traffic accidents (the vertebral artery is a branch of the subclavian artery and joins its contralateral branch to form the basilar artery, which contributes to the posterior blood supply of the brain). Connective tissue disorders such as Marfan's and Ehlers-Danlos further predispose to dissection, highlighting the importance of a detailed family history.

Key points

• Stroke also occurs in children, teenagers and young adults, and has a significant morbidity and mortality - but it is rare, with an incidence of ~5:100.000.

• The causes for stroke are different and encompass hypercoagulability (cerebral venous thrombosis), vasculitis, illicit drug use (as a cause of endocarditis) and congenital heart disease, amongst others.

• Dissection of the vertebral artery can be caused by trauma; connective tissue disorders such as Marfan's and Ehlers-Danlos are added risk factors for dissection.

• Sickle cell disease is the most common cause of stroke in children.

• A specific syndrome named Moyamoya (Japanese for puff of smoke) affects the internal carotid arteries, causing them to stenose.

• Head CT is the preferred imaging modality in presentation of acute stroke, because it is readily available, is fast and easily allows for the detection of intracranial haemorrhage.

• Early signs of acute ischaemic stroke that may be present on CT include a hyperdense vessel, the insular ribbon sign and blurring of the lentiform nucleus. Infarcted tissue appears as hypodense (ie, darker).

• MRI, with DWI sequences, is able to detect hyperacute ischaemia and haemorrhage, but is not always available and its acquisition time often unacceptably delays treatment.

• Treatment using IV-TPA is the mainstem of treatment, regardless of the age, for eligible patients. It should be followed with imaging within 24 hours to exclude iatrogenic cerebral haemorrhage.

CASE-BASED DISCUSSION: DIAGNOSIS & MANAGEMENT OF STROKES IN TEENAGERS & YOUNG ADULTS

SJ Karia, AK Banerjee

Multiple choice questions

1. A 22 year-old teacher presented to the emergency department with a 3 day history of left-sided nystagmus, dysmetria and vertigo. The head CT revealed hypodensity in the superior part of the cerebellum, left vermis and left tectal plate. Which side and vascular territory is involved?

a. Right superior cerebellar artery

b. Left anterior-inferior cerebellar artery

c. Right posterior-inferior cerebellar artery

d. Left superior cerebellar artery

e. Right vertebral artery

Case-Based Discussion: Diagnosis & management of strokes in teenagers & young adults
Patient Management

2. A 13 year-old asian girl developed right sided hemiplegia. An MRI revealed a left middle cerebral artery infarct and multiple small vessels in the base of the brain. The left internal carotid at this point was narrowed. What is the diagnosis?

a. Dissection of the left internal carotid

b. Sarcoidosis

c. Polyarteritis nodosa

d. Kawasaki disease

e. Moyamoya disease

Answers

1. Correct answer – D

Cerebellar symptoms are caused by ipsilateral lesions in the cerebellum, as opposed to what happens in the brain. The affected area is supplied by the left superior cerebellar artery. The hypodensity in the cerebellar parenchyma seen on CT represents ischaemic changes representative of a stroke.

2. Correct answer – E

Moyamoya disease, which is relatively more frequent in the paediatric Asian population, is the diagnosis. It is characterized by narrowing of the supraclinoid internal carotid artery and development of significant collateral circulation (the small vessels described). The middle cerebral artery arises from the internal carotid artery, which due its narrowing, resulted in an infarct.

CASE-BASED DISCUSSION: DIAGNOSIS & MANAGEMENT OF STROKES IN TEENAGERS & YOUNG ADULTS

SJ Karia, AK Banerjee

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Case-Based Discussion: Diagnosis & management of strokes in teenagers & young adults
Patient Management

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THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

The Acute Abdomen – Common Imaging Features On CT Good Clinical Care

Introduction

Acute abdominal pain accounts for 5-10% of visits to the emergency department, and imaging plays an important role in the management of these patients, especially as clinical evaluation results can be inaccurate. CT can provide accurate and reproducible diagnosis.

Imaging has been shown to have a positive effect on the accuracy of the clinical diagnosis (1,2) to lead to changes in management decisions (3,4) and to increase the level of diagnostic certainty in patients with acute abdominal pains (5,6).

It is with this in mind that we would like to illustrate the important imaging characteristics, on CT, of common acute abdominal conditions presenting to the Emergency Department.

The acute abdominal conditions covered are:

'Appendicitis', 'diverticulitis', 'cholecystitis', 'pancreatitis', 'colitis', 'perforation', 'renal colic', 'small bowel obstruction', 'large bowel obstruction' and 'ruptured abdominal aortic aneurysm'.

Appendicitis

Clinical features:

- One of the commonest causes of 'acute abdomen' and appendicectomy is the commonest emergency surgical operation performed worldwide.
- Diverse clinical presentation due to variable anatomical location, with atypical presentations in up to 30%.
- Usual presentation is of colicky central abdominal pain, radiating to the right iliac fossa, associated with nausea, vomiting, fever and raised inflammatory markers.
- Inflammation is usually caused by luminal obstruction secondary to lymphoid hyperplasia or a faecolith.
- Imaging has a role in improving clinical outcome by increasing the accuracy of diagnosis.

CT Imaging findings:

- Not the first choice investigation due to patient radiation dose, but is increasingly used to exclude other causes of abdominal pain.

Early findings:

- Dilated, thickened (> 6mm transverse diameter), blind ending fluid filled loop of bowel originating from caecal pole. (Fig.1).
- May demonstrate circumferential enhancement.
- Appendicolith seen in 20 to 40% (7) (Fig.2).
- Peri-appendiceal and peri-caecal inflammatory fat stranding (8).

Fig.1: Acute Appendicitis. Dilated tubular appendix (arrow), containing an appendicolith, with surrounding inflammatory stranding.

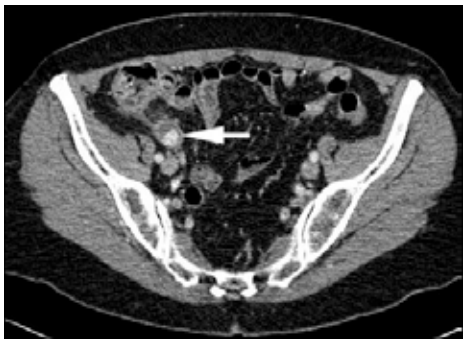

Fig.2: Acute Appendicitis. Appendicolith (arrow) in a dilated appendix.

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Late/Advanced findings:

- Appendix mass - inflamed appendix +/- adherent omentum +/- small bowel.
- Progress to peri-appendiceal collections and abscess formation.
- Perforation.

Diverticulitis

Clinical features:

- Diverticulosis is a common condition in Western society, affecting 5%–10% of the population over 45 years of age and approximately 80% of those over 85 years of age (9).
- Diverticulae can occur anywhere in the colon but most commonly in the sigmoid colon.
- Diverticulitis is caused by occlusion of a diverticulum by stool, inflammation or food particles resulting in microperforation of the diverticulum and inflammation of surrounding soft tissues.
- Presents with abdominal pain usually in the left iliac fossa, fever and raised inflammatory markers. In chronic diverticular disease patients can present with altered bowel habit, large bowel obstruction and blood/mucus per rectum.
- Complications include perforation, abscess formation (Fig.3) and fistulation to adjacent structures such as bladder or uterus.

Fig.3: Diverticulitis. Multiple sigmoid diverticula (arrows), with surrounding inflammatory 'streaking', and secondary diverticular perforation; note the large extra-colonic gas collection (asterix).

CT Imaging findings:

- CT is highly sensitive as it can accurately demonstrate the bowel wall as well as pericolic soft tissues. Diverticula are seen as gas or faeces containing out-pouchings from the colonic wall (Fig.4).
- Bowel wall thickening.
- Bowel wall hyperaemia/enhancement.
- Pericolic fat stranding. (Fig.5).
- Presence of diverticulae in the affected segment confirms the diagnosis.
- When diverticulitis involves the right colon, it may mimic other conditions such as appendicitis.

Fig.4: Diverticulosis. Multiple sigmoid diverticula (arrowheads).

Fig.5: Diverticulitis. Inflammatory pericolonic stranding (arrow) in the proximal sigmoid colon. Subtle diverticula are evident posteriorly (arrow heads).

Cholecystitis

Clinical features:

- Gallbladder Inflammation secondary to gallstone obstruction (90-95% cases) in the gallbladder neck or cystic duct.
- Acalculous cholecystitis occurs in seriously ill patients and may be caused by decreased flow in the cystic artery.
- Presents with right upper quadrant (RUQ) abdominal pain radiating to right shoulder, with associated nausea, vomiting, fever and raised inflammatory markers.
- Complications include gallbladder necrosis, perforation, pericholecystic abscess and local fistulation.

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VS Gada, RR Misra

The Acute Abdomen – Common Imaging Features On CT Good Clinical Care

CT Imaging findings:

- Abdominal ultrasound is the imaging investigation of choice in patients with suspected acute gallbladder disease.
- CT is often used to monitor secondary complications of acute cholecystitis and also to rule out other causes of RUQ pain.
- CT has a relatively high negative predictive value (89%) (10), and acute cholecystitis is unlikely in the setting of a negative CT.
- Gallbladder wall thickening.
- Peri-gallbladder stranding.
- Peri-gallbladder collections (Fig.6).
- Biliary calculi may be visualized (Fig.6).
- Locules of free gas adjacent to gallbladder in cases of perforation.

Fig.6: Cholecystitis. Mild gallbladder wall thickening, gallstones and peri-cholecystic fluid (arrow).

Pancreatitis

Clinical features:

- Classified as acute and chronic.
- Alcohol and cholelithiasis (gallstones) account for 60-70% cases.
- Other causes include metabolic disorders, multiple myeloma, amyloidosis, sarcoidosis, trauma, surgery, viral infections and drugs. Hereditary pancreatitis is an autosomal dominant disorder.
- Acute pancreatitis presents with epigastric abdominal pain radiating to the back, associated with nausea and vomiting. Severe acute pancreatitis can present with shock and Adult Respiratory Distress Syndrome (ARDS).
- Chronic pancreatitis presents with chronic intermittent abdominal pain and signs and symptoms of pancreatic insufficiency, including diabetes mellitus and malabsorption.
- Complications include acute peri-pancreatic fluid collections , pseudocyst formation, pancreatic necrosis and pancreatic abscess.

CT Imaging findings:

- Triple phase scan – an unenhanced scan, to show pancreatic calcification, supplemented by arterial and venous phase scans.
- Acute pancreatitis is a clinical diagnosis. However CT has a role in assessing the presence and severity of pancreatitis and in the evaluation of complications. May demonstrate:
- An enlarged indistinct, but normally enhancing pancreas. Surrounding peripancreatic inflammatory 'streakiness' and peripancreatic free fluid (Fig.7).
- Hyperdense intrapancreatic areas may represent haemorrhagic pancreatitis
- Non-enhancing areas indicate pancreatic necrosis (associated with poor prognosis) (Fig. 8). CT is 100% specific for necrosis if more than 30% of the gland is non-enhancing (11) (Fig.9).
- Chronic pancreatitis.
  - Coarse or spiculated pancreatic calcification (Fig.10).
  - Dilated pancreatic duct (> 5mm in the head and > 2mm in the body of pancreas).

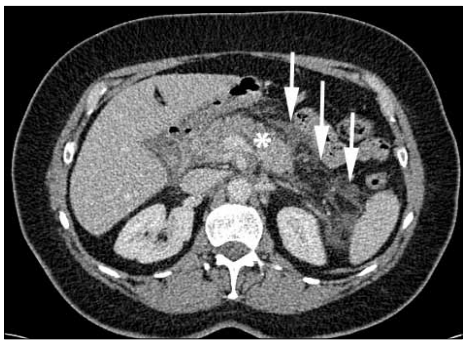

Fig.7: Acute pancreatitis. Normal enhancing pancreas (asterix) with surrounding peripancreatic inflammatory stranding and peripancreatic free fluid (arrows).

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

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Fig.8: Necrotising pancreatitis. Non-enhancing pancreatic head (arrow). Body of pancreas enhances normally (asterix). Peri-pancreatic fluid collection (arrowhead).

Fig.9: Necrotising Pancreatitis. Indistinct, non-enhancing, oedematous pancreas with peripancreatic fluid (arrows).

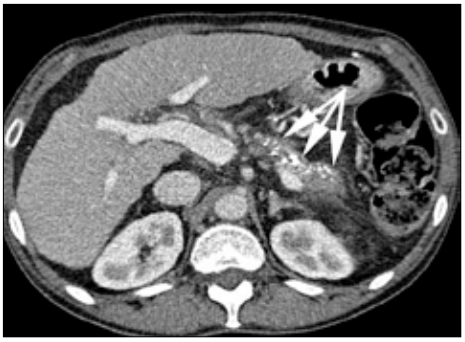

Fig.10: Chronic Pancreatitis. Multifocal coarse pancreatic calcification (arrows).

Colitis

Clinical features:

· Group of conditions linked by inflammation of the colon; includes inflammatory bowel disease (ulcerative colitis and Crohn's disease), ischemic, infective and radiation induced colitides.

Ulcerative colitis is an idiopathic inflammatory bowel disease that typically affects the left sided colon, but may also cause diffuse colitis.

· Rectum is involved in 95% of untreated patients.
· Circumferential contiguous proximal colonic ulceration.
· Skip lesions are not a feature. Backwash ileitis can occur.

• Extracolonic manifestations are common:

· Ankylosing Spondylitis.
· Erythema Nodosum.
· Iritis.
· Chronic Active Hepatitis.
· Primary Sclerosing Cholangitis.
· Peripheral Arthritis.

· Presents with abdominal pain and bloody diarrhoea. May be accompanied by electrolyte imbalance and fevers.

· Complications include toxic megacolon with risk of perforation, stricture formation and increased risk of colon cancer.

Crohn's disease causes transmural inflammation affecting any part of gastrointestinal tract from mouth to anus.

· Most commonly involves terminal ileum; skip lesions may be present.
· Presents with crampy right iliac fossa pain and non-bloody diarrhoea.
· Complications include malabsorption, fistula formation and inflammatory adhesions.

Ischemic colitis is caused by insufficient blood supply to segments of the colon secondary to thrombosis, bowel obstruction or trauma.

· Most commonly affects the descending colon and arterial watershed at the splenic flexure.
· Presents with acute abdominal pain, out of proportion to the clinical signs.
· Complications include stricture formation and colonic infarction in severe cases.

Pseudomembranous colitis is caused by Clostridium difficile infection.

· Predisposing factors include antibiotic exposure, chronic illness, proximal large bowel obstruction, intestinal ischemia, impaired immunity and HIV infection.
· Presents with profuse watery diarrhoea, abdominal pain and tenderness.
· Complications include toxic megacolon and perforation.

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

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Radiation colitis is a late complication of radiation.

- Radiation causes occlusive endarteritis.
- Most commonly occurs in rectum following treatment for gynaecological malignancies.
- May present with rectal bleeding and diarrhoea.

CT Imaging findings:

- CT features help narrow the differential diagnosis. Final diagnosis is with clinical correlation, endoscopy and biopsy.

Ulcerative colitis

- Circumferential, symmetrical and diffuse bowel wall thickening (Fig.11).
- Halo sign - a low attenuation ring in the submucosal layer secondary to fat deposition.

Fig.11: Ulcerative Colitis. Long segment of circumferential colonic wall thickening (arrowheads) due to ulcerative colitis.

Crohn's disease

- Typical eccenteric and segmental bowel wall thickening (Fig.12,13).
- Pericolic fat proliferation resulting in bowel loop separation.
- Collections, abscesses and fistulation to adjacent organs may be seen.

Fig.12: Crohn's disease. Terminal ileum thickening (arrow) and thickening of caecal pole.

Fig.13: Crohn's disease. Long segment of terminal ileal thickening (arrow).

Ischemic colitis

- Arterial phase CT demonstrates filling defects in the splanchnic vessels.
- Venous thrombosis is better assessed during portal phase scanning.
- Circumferential and symmetrical bowel wall thickening.
- Low attenuation may be seen in the bowel wall due to oedema, or high attenuation due to mural haemorrhage.
- Mural gas and gas in the portal vein may be seen in severe cases.

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

Pseudomembranous colitis

- Marked eccentric or circumferential bowel wall thickening.
- Ascites has been reported in 35% of the cases (13).
- When haustral folds are significantly thickened, they can appear as broad transverse bands that may trap oral contrast. This appearance is known as the accordion sign.
- The accordion sign is very suggestive of pseudomembranous colitis but typically occurs only in severe cases and is therefore a poorly sensitive indicator.

Radiation colitis

- Luminal narrowing and homogeneous colonic wall thickening.
- There may be thickening of pararectal fascia with fibrosis.

Perforation

Clinical features:

- The aetiology of a pneumoperitoneum is perforation of a hollow viscus, with escape of free air and/or fluid into the peritoneal cavity.
- Common causes include perforated duodenal ulcers, sigmoid diverticular disease, acute appendicitis, toxic megacolon, trauma or iatrogenic intervention.
- Post-operative gas takes a variable time to disappear, usually 2-5 days, sometimes longer.
- Presents with abdominal pain, which may be initially localised, but gradually becomes generalised secondary to peritonitis.
- Clinical correlation and additional CT findings help with the diagnosis.

CT Imaging findings:

- Very sensitive in detecting free gas, but plain x-rays (CXR +/- AXR) remain the first line imaging modality due to the high radiation dose incurred by CT.
- Look for the presence of extraluminal contrast or air.
- Free gas may be seen around liver and deep to the abdominal wall. (Fig.14).
- Locules of free gas may be seen adjacent to a suspected viscus (Fig. 3).
- Locules of free gas may be seen within the free fluid or, in cases of a sealed perforation, within contained fluid.
- Retroperitoneal gas is associated with perforation of 2nd, 3rd and 4th parts of the duodenum, ascending and descending colon and rectum.
- Other signs include discontinuity of the bowel wall, on an enhanced scan, and focal bowel wall thickening adjacent to locules of free air, with mesenteric fat infiltration (14).

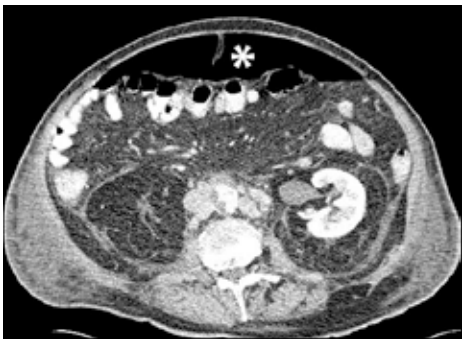


Fig.14: Perforation. Free gas seen under the anterior abdominal wall (asterix).

Renal Colic

Clinical features:

- Calculous disease of renal tract may affect kidney, ureter or bladder.
- Risk factors include chronic dehydration, urinary tract infections, urinary stagnation and abnormal oxalate, cysteine, urate and xanthine metabolism.
- Four main types of calculi.
- calcium (75%).
- struvite (15%).
- uric acid (6%).
- cysteine (1%).
- Indinavir stones (15) (associated with anti-retroviral drug use) and pure matrix stones are radiolucent and not detected on CT.
- Obstruction results in severe colicky renal angle pain radiating from loin to the groin, associated with nausea and vomiting.

Three common sites of urinary tract obstruction:

- pelviureteric junction (PUJ).
- pelvic brim.
- vesico-ureteric junction (VUJ).

CT Imaging findings:

- Calculi are easily identified as high-density foci (Fig.15a). Knowledge of the ureteric course will help distinguish renal calculi from calcification within adjacent structures eg: arterial, venous (phlebolith), nodal and prostatic calcification.

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

The Acute Abdomen – Common Imaging Features On CT Good Clinical Care

Fig.15a: Renal tract obstruction. Obstructing left upper ureteric calculus (arrow). Note the subtle perinephric stranding (arrowhead).

Two helpful signs in distinguishing ureteric calculi from phlebolith:

- Comet-tail sign (tail of non-calcified vein extending from calcification) – favours a phlebolith.
- Soft tissue rim sign (a 'cuff' of soft tissue is seen around the calcification) – favours a ureteric calculus.

Secondary signs of obstruction/infection include:-

- Dilated pelvi-calyceal system (Fig.15b) and dilated ureter.
- Enlarged kidney, which may be of reduced attenuation, due to odema.
- Perinephric and periureteric 'streakiness' secondary to oedema.
- Gas within the collecting system is suggestive of pyonephrosis; this is a urological emergency that requires urgent drainage.

Fig.15b: Renal tract obstruction (Same patient). Left kidney is hydronephrotic (asterix).

Bowel Obstruction - Small Bowel Obstruction

Clinical features:

- Small bowel obstruction (SBO) and large bowel obstruction (LBO) share similar clinical features of abdominal distension, colicky pain, vomiting and constipation. Their aetiology and management are usually different.
- SBO – the small bowel proximal to the obstruction dilates with gas and fluid, resulting in a fluid shift, hypovolaemia, tachycardia and electrolyte imbalances. The small bowel distal to the obstruction collapses.
- If untreated SBO can lead to strangulated obstruction and risk of perforation and peritonitis.
- Causes of SBO.
- Intraluminal – foreign body, food bolus, gallstones and bezoar.
- Mural – tumour, intussception, inflammation, stricture and haematoma.
- Extraluminal – adhesions, hernia, volvulus and congenital bands.
- Commonest cause of SBO is adhesions and hernias (16).

CT Imaging findings:

- A small bowel diameter > 2.5 cm on CT is abnormal (Fig.16).
- The 'transition point' is a change in calibre from dilated to collapsed bowel, and indicates the level of obstruction.
- Small bowel faeces sign – presence of particulate matter in the lumen of the dilated small bowel, usually at transition point.
- Adhesions are not visible on CT (Fig.16), and diagnosis is inferred in absence of a demonstrable cause.
- Strangulated bowel – shows circumferential bowel wall thickening due to oedema from venous congestion.
- In severe cases, gas may be seen in the bowel wall and portal venous system due to necrosis and portal pyaemia.
- Review of hernial orifices is important (Fig.17a, 17b).

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

Fig.16: Small bowel obstruction. Multiple dilated loops of fluid filled small bowel (asterix) due to adhesions (not seen on CT).

Fig.17a: Small bowel obstruction. Multiple dilated fluid filled loops of small bowel (asterix) in the pelvis due to an obstructed right obturator hernia.

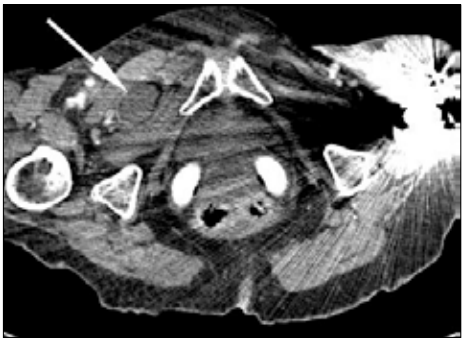


Fig.17b: Small bowel obstruction due to an obstructed right obturator hernia (arrow).

Tumour

Irregular bowel wall thickening at the transition point +/- lymphadenopathy. Intussusception – the target sign ('bowel in bowel' appearance containing mesenteric fat and vessels), when present, is pathognomonic of an intussusception (Fig.18).

Fig.18: Intussuception. 'Target sign' (arrows) - bowel in bowel appearance containing mesenteric fat and vessels.

Gallstone ileus

Gas in the biliary tree and dilated small bowel loops (Fig.19a) are suggestive of a cholecystoenteric fistula. The obstructing gallstone may be evident distally (Fig.19b).

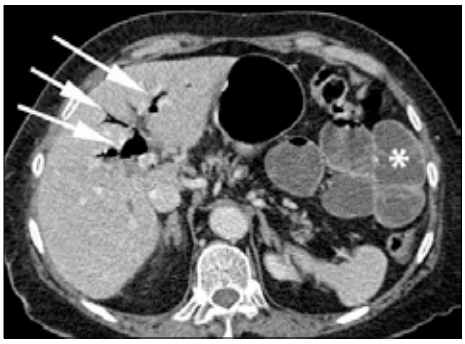
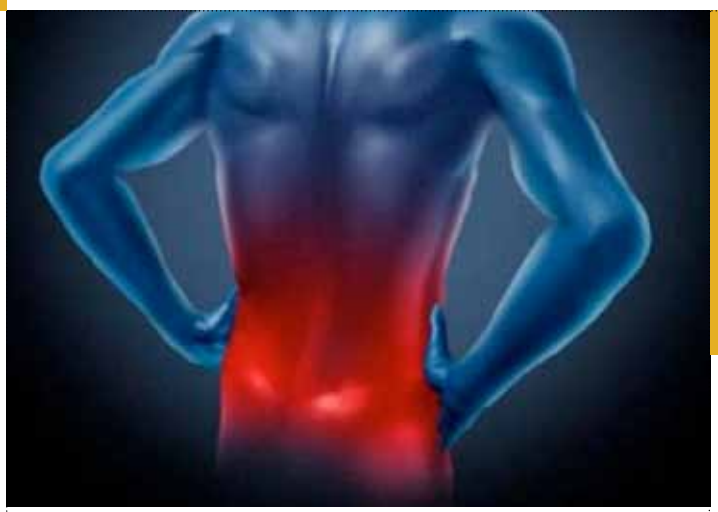


Fig.19a: Gallstone ileus. Air in the biliary tree (arrows) and obstructed fluid filled loops of small bowel. (asterix).

Fig.19b: Gallstone ileus. Obstructing laminated gallstone (arrow) in a small bowel loop.

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra



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Large Bowel Obstruction

Clinical features:

- Large bowel obstruction (LBO) with colicky abdominal pain and absolute constipation are features of complete obstruction. Abdominal distension predominates.
- Common Causes of LBO are carcinoma of colon, diverticulitis and volvulus.
- Clinical history is key to underlying diagnosis.
- Volvulus – abrupt onset of symptoms.
- Carcinoma – prolonged history of change in bowel habit and weight loss.
- Diverticulitis – chronic history of constipation.
- Right-sided colonic lesions present late as they can become quite large before obstruction develops. Sigmoid and rectal tumours tend to obstruct earlier due to narrower colonic calibre and the presence of more solid stool.

CT Imaging findings:

- Significant colonic dilatation (Fig.20a) (colonic diameter > 6cm; > 9cm in caecum).
- CT helps identify the transition point between dilated and normal calibre/ collapsed bowel (Fig.20b). This will often reveal the underlying cause (vide infra).
- Allows assessment of complications of LBO such as strangulation, intramural gas, perforation and abscess formation.

Fig.20a: Large bowel obstruction. Dilated large bowel (asterix).

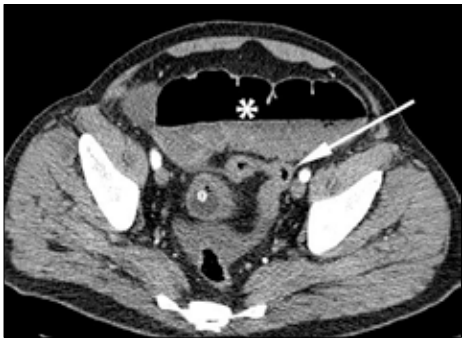

Fig.20b: Large bowel obstruction. Dilated large bowel (asterix) with a collapsed distal segment (arrow).

Carcinoma

- Focal irregular bowel wall thickening with proximal dilatation (Fig.21).
- Lymphadenopathy and distant metastases may be seen (Fig.21).

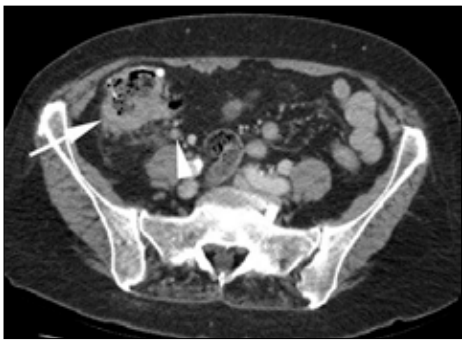

Fig.21: Caecal carcinoma. Irregular eccentric malignant caecal wall thickening (arrow) and adjacent local lymphadenopathy (arrowhead).

Diverticulitis – Recurrent diverticulitis can result in stricture formation and can cause LBO.

- Most commonly affects the sigmoid colon.
- Colonic diverticula are seen as gas filled out-pouchings arising from the colonic wall (Fig.4).
- Inflammatory 'streaking' seen in the surrounding soft tissues (Fig.5).
- Secondary complications, such as local perforation or abscess formation may be seen (Fig.3).

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

Volvulus

- Sigmoid colon and caecum are the commonest sites.
- Bowel 'twists' on its mesenteric axis.

Pseudo-obstruction – Most frequently occurs in elderly patients, with systemic medical conditions, due to autonomic imbalance.

- No cause for mechanical obstruction identified on CT i.e. there is no 'transition' point between dilated and normal calibre/collapsed bowel.

Ruptured Abdominal Aortic Aneurysm

Clinical features:

- An aneurysm is a localised dilatation of aorta caused by weakening of all 3 layers of the aortic wall.
- Abdominal aorta diameter > 3 cm is called an aneurysm (17).
- Found in 2-4% of the population over the age of 50 years (18).
- Atherosclerosis is the commonest cause, but may also be secondary to trauma, infection, vasculitis or connective tissue disorders.
- Often asymptomatic. May present with pulsatile mass, vessel rupture or embolic event.
- A ruptured aneurysm classically presents with hypovolemic shock, a pulsatile mass and back pain.

CT Imaging findings:

- A retroperitoneal haematoma adjacent to an abdominal aortic aneurysm (AAA) is the most common imaging finding of AAA rupture (19) (Fig.22).
- Active extravasation of contrast is frequently demonstrated (Fig.23).
- A well-defined peripheral crescent of increased attenuation within the thrombus of a large abdominal aortic aneurysm is a CT sign of acute or impending rupture (20).

Fig.22: Ruptured AAA. Ruptured aneurysm (asterix), with aortic wall discontinuity, and extensive retroperitoneal haematoma (arrows).

Fig.23: Ruptured AAA. Clear active extravasation of arterial contrast is seen, at the site of the aneurysm rupture (arrow).

Multiple Choice Questions

1. Colonic wall thickening may be seen in:

a) Ulcerative colitis.

b) Crohn's colitis.

c) Ischemic colitis.

d) Pseudomembranous colitis.

e) Radiation colitis.

2. How frequently is an appendicolith seen in cases of appendicitis?

a) 75% cases.

b) 50% cases.

c) <5% cases.

d) 20-40% cases.

e) 100% cases.

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

3. Following statements are TRUE or FALSE:

a) In acute appendicitis the diameter of the dilated appendix is > 6mm.

b) Diverticulosis is seen in 10% of cases over 85 years of age.

c) 90-95% of cases of cholecystitis are secondary to gallstones.

d) In ulcerative colitis, the rectum is involved in 95% of untreated cases.

e) Ascites is seen in 5% of cases of pseudomembranous colitis.

4. Free intra-peritoneal air may be associated with:

a) Perforated duodenal ulcer.

b) Ruptured aneurysm.

c) Acute appendicitis.

d) Abdominal trauma.

e) Ischaemic colitis.

The Acute Abdomen – Common Imaging Features On CT Good Clinical Care

5. Regarding renal calculi:

a) Commonest calculi are struvite stones.

b) 'Soft tissue rim sign' on CT favours a ureteric calculus over a phlebolith.

c) Gas within the collecting system is a urological emergency.

d) Indinavir stones are usually not detected on CT.

e) Calculi are seen as low density foci on CT.

Answers

Question 1:

a) True

b) True

c) True

d) True

e) True

Question 2:

a) False

b) False

c) False

d) True

e) False

THE ACUTE ABDOMEN – COMMON IMAGING FEATURES ON CT

VS Gada, RR Misra

Question 3:

a) True

b) False

c) True

d) True

e) False

Question 4:

a) True

b) False

c) True

d) True

e) True

Question 5:

a) False

b) True

c) True

d) True

e) False

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THE RADIOLOGY OF SHOULDER DISLOCATIONS

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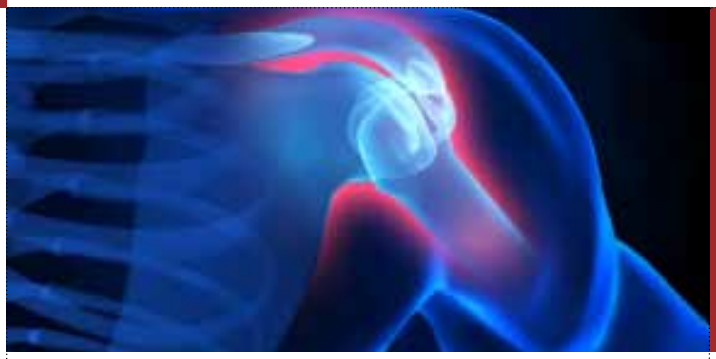

Abstract

The shoulder consists of two synovial joints, the glenohumeral and acromioclavicular joints. Both of these may dislocate secondary to trauma. Accurate diagnosis of injury requires a sound understanding of the radiographic anatomy as well as an understanding of the appearances of normal injury patterns and their complications.

A 23-year-old man presents to the Emergency Department with a severely painful right shoulder having fallen awkwardly during a judo match. Clinical examination reveals an obvious deformity to the right shoulder and an inability to move the right arm without precipitating severe pain. There is no evidence of neurovascular injury in the arm. A shoulder dislocation is suspected.

Shoulder Dislocations

Background and pathophysiology

The shoulder is comprised of two joints: the glenohumeral and acromioclavicular joints. The majority (85%) of dislocations in the shoulder region are of the glenohumeral joint and the term "shoulder dislocation" is generally used to refer to dislocations of the glenohumeral joint. However, dislocation of the acromioclavicular joint does also occur, accounting for 15% of dislocations in the shoulder region. Acute glenohumeral dislocation is an emergency, requiring prompt recognition of the diagnosis and early attempted reduction if appropriate. A delay in reduction of a glenohumeral dislocation past 24 hours vastly reduces the chances of a successful closed reduction as well as exposing neurovascular structures to potential injury.

The glenohumeral joint is the commonest joint to be dislocated. This usually follows a traumatic injury, but can be seen following a trivial injury in those with a particularly unstable joint.

Presentation

Patients usually present with a severely painful shoulder which they are unable to move. There is normally a history of trauma and patients often recall the exact moment they felt their shoulder 'pop out'.

Interpretation of initial investigations

Radiographs are used to diagnose a shoulder dislocation. A sound understanding of the normal appearances and the radiographic anatomy is essential to diagnose shoulder dislocation accurately.

As with all trauma radiographs, two views should be obtained, incorporating a frontal anteroposterior (AP) projection (figure 1a) and a second view, commonly an axial (axillary) view (figure 2a) or a scapular 'Y' view (figure 3a).

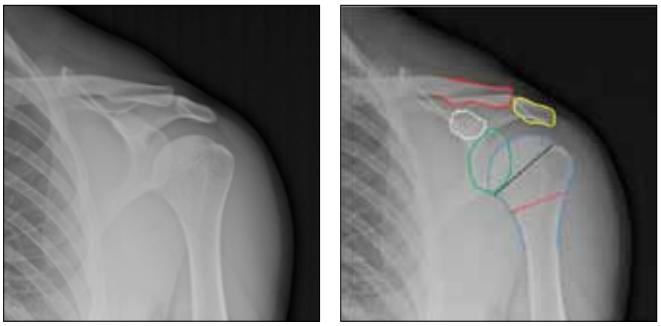

Figure 1: AP projection of the normal shoulder (figure 1a). Normal bony anatomy is outlined in figure 1b. The radiograph is taken with the arm by the patient's side and held in external rotation, which gives the medial border of the humeral head (blue line in figure 1b) a more rounded medial border than the straighter lateral border. The anatomical neck is between the articular surface and the tuberosities (black dashed line) and the surgical neck is more distal, below the tuberosities (red dashed line). The humeral head articulates with the glenoid (green oval) with a small crescent shaped area of overlapping bone. Above the head of the humerus the acromion (yellow) is seen, articulating with the lateral clavicle (red). Below the clavicle and superomedial to the glenoid the coracoid is seen (white dashed line).

The anatomy of the AP projection (figure 1b), axial projection (figure 2b) and scapula 'Y' view (figure 3b) are labelled to help identify the key landmarks in each projection.

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

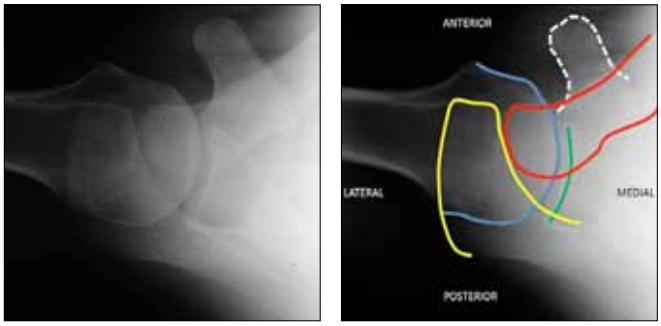

Figure 2: Axial projection of a normal adult shoulder (2a), taken with the arm in abduction and the x-ray cassette between the arm and the patient's torso in the axilla. Normal bony anatomy is outlined in figure 2b. Two bony prominences are seen to point anteriorly, the coracoid process medially (outlined with a white dashed line) and the acromion laterally (yellow). The lateral clavicle (red) passes over the coracoid to articulate with the acromion. The rounded head of humerus (blue) is seen articulating with the small saucer-like glenoid (green).

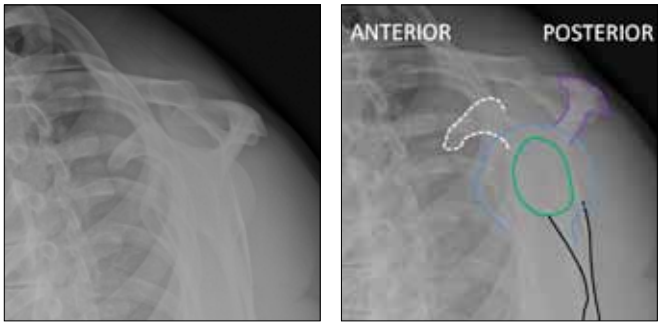

Figure 3: Scapular 'Y' view of a normal adult shoulder (figure 3a). Normal bony anatomy is outlined in figure 3b. The ribs are towards the anterior of the image. Two bony projections are identified from the superior aspect of the scapula, the coracoid process anteriorly (white dashed line in figure 3b) and the spine of the scapula (purple) which curves forwards as the acromion process. The spine of the scapula is seen extending inferiorly (black outline). These three structures join to form the letter Y and the glenoid (green) is situated at the confluence of these three structures. The humeral head (blue) should be centred on the glenoid, at the joining of the three limbs of the Y.

Radiology of glenohumeral dislocation

Dislocation of the glenohumeral joint can occur in three directions.

Anterior dislocation

Anterior dislocation is the commonest glenohumeral dislocation, responsible for 95% of all glenohumeral dislocations. This injury usually occurs following violent external rotation in abduction which results in the humeral head being levered anteriorly out of the glenoid socket.

Anterior dislocation is usually easily recognised on plain film radiographs. On the AP projection (figure 4), the head of the humerus is seen to be more inferomedial than normal, with the head lying inferior to the coracoid. On the axial view, the humeral head is anterior to the glenoid (figure 5), and on the scapular Y view, the humeral head is seen to be displaced anteriorly, no longer covering the glenoid at the junction of the limbs of the Y (figure 6).

Figure 4: AP radiograph of an adult shoulder demonstrating an anterior glenohumeral dislocation. The humeral head is displaced inferomedially, lying beneath the coracoid. A large proportion of the glenoid is overlain by the humeral head, in comparison to the small crescent of overlapping bone seen on the normal AP projection (see figure 1).

Figure 5: Axial projection of an adult shoulder demonstrating an anterior glenohumeral dislocation. The humeral head is displaced anteriorly such that is no longer articulates with the glenoid, lying anterior to this structure. The humeral head is also more medially located than normal.

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

Figure 6: Scapular 'Y' view of an adult shoulder demonstrating an anterior glenohumeral dislocation. The ribs are anterior to the scapula. The humeral head is displaced anteriorly from its normal location. It no longer lies over the glenoid, which is found where the three limbs of the 'Y' join.

Both before and after attempted reduction, the plain film radiographs should be closely inspected for associated fractures. Bone fragments may break from the anteroinferior aspect of the glenoid (figure 7), termed a bony Bankart lesion. A depressed fracture of the posterosuperior aspect of the humeral head may also be seen due to impaction of this area on the glenoid, which is termed a Hill-Sachs lesion (figure 7). Bone fragments within the joint can also prevent successful reduction.

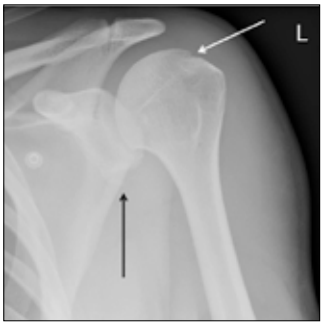

Figure 7: AP radiograph of an adult shoulder following attempted reduction of an anterior dislocation. Glenohumeral alignment is now normal. However, bony irregularity is seen at the posterosuperior aspect of the humeral head in keeping with a depression fracture at this site, known as a Hill-Sachs lesion (white arrow). A chip of bone in keeping with a fracture is also seen the anteroinferior aspect of the glenoid, in keeping with a bony Bankart lesion (black arrow).

Other significant associated injuries not seen on plain films include damage to the cartilaginous labrum (a Bankart lesion and its variants) and injury to the capsule of the joint.

Posterior dislocation

Posterior shoulder dislocations are much less common, responsible for approximately 4% of cases of glenohumeral joint dislocation. This injury is often seen following a fall onto a flexed elbow with a flexed shoulder, commonly encountered in rugby players. It may also be seen secondary to an epileptic fit, electrocution or lightning injury, when it may be bilateral. The abnormal muscular contractions seen in such injuries cause excessive internal rotation which forces the humeral head posteriorly. Posterior dislocation may also be a voluntary action in those with a congenital or developmental laxity of the posterior capsule of the joint; this is often seen in children who may continue to dislocate their shoulder as a party trick.

Posterior dislocations are more difficult than anterior dislocations to identify on radiographs and these injuries are often missed in the Emergency Department. On the AP view the only abnormality may be a loss of overlap of the humeral head and the glenoid rim (figure 8). The patient also will struggle to externally rotate the arm as is normal for an AP radiograph, giving the humeral head a more symmetrical appearance – this is said to appear like a light bulb.

Figure 8: AP radiograph of an adult shoulder demonstrating a posterior glenohumeral dislocation. The arm is held in internal rotation, giving the humeral head a more symmetrical appearance than normally seen (see figure 1), known as the 'light bulb' sign. There is also loss of the normal overlap between the humeral head and the glenoid.

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

On axial views the humeral head is seen to be posterior to the glenoid (figure 9). On the scapular Y view the humeral head is posterior to the junction of the three limbs of the Y (figure 10).

Figure 9: Axial projection of an adult shoulder demonstrating a posterior glenohumeral dislocation. The humeral head is displaced posteriorly with its articular surface posterior to the glenoid. In this instance an impaction fracture of the anteromedial humeral head is demonstrated (asterisk), known as the trough sign. If large, as in this instance, this may preclude successful reduction of the dislocation, known as a locked shoulder.

Figure 10: Scapular 'Y' view of an adult shoulder demonstrating a posterior glenohumeral dislocation. The ribs are anterior to the scapula. The humeral head is displaced posteriorly from its normal location and lies posterior to the glenoid, whish is situated where the limbs of the Y join.

Again, radiographs should be closely evaluated for associated fractures, including fractures to the posterior glenoid. An impaction fracture of the anteromedial humeral head may also be seen, analogous to the Hill-Sachs lesion, known as the trough sign (figure 9). Whilst not seen on plain film radiographs, damage to soft tissue components such as the cartilaginous labrum, the capsule of the joint and the rotator cuff tendons is also common following these injuries.

Luxatio erecta or inferior dislocation

Luxatio erecta or inferior dislocation is the rarest form of glenohumeral dislocation, responsible for around 1% of shoulder dislocations. It follows a forced hyper-abduction of the arm, with the humeral head forced inferiorly from the glenoid. The patient presents with the arm held fixed above the head. It is usually easily recognised on the AP projection (figure 11), with the humeral articular surface facing inferiorly, below the rim of the glenoid. It is associated with rotator cuff tendon tears, fractures of the acromion and injury to the axillary vessels and nerves of the arm.

Figure 11: AP radiograph of an adult shoulder following luxatio erecta glenohumeral dislocation. The humeral head has been forced inferiorly from the glenoid with its articular surface facing inferiorly below the inferior rim of the glenoid.

Acromioclavicular joint disruption

This joint is most commonly injured by a direct downward force onto the acromion at the lateral aspect of the shoulder. This injury is commonly seen in sports which involve tackles, for example rugby and ice hockey, or falling from a height onto the shoulder, such as mountain biking. AC joint injuries are assessed on the AP projection (figure 12), where the inferior border of the lateral clavicle should be on the same plane as the inferior border of the acromion. However, this can be variable, and if there is diagnostic uncertainty, comparison with a radiograph of the asymptomatic side may be required.

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

The gaps between the acromion and the clavicle (the AC joint space) and the coracoid and the clavicle are assessed (figure 12); the AC joint space should be less than 5mm and the interval between the coracoid and the clavicle should be less than 13mm. A number of classification systems exist for grading injuries to the acromioclavicular joint. The simplest is the Allman and Tossy classification, which describes three grades of injury.

Figure 12: AP radiograph of an adult shoulder demonstrating normal configuration of the acromioclavicular joint. The inferior border of the lateral clavicle and the inferior border of the acromion (red lines) should be on the same level. The AC joint space (white arrows) should measure less than 5mm, and the coracoclavicular distance (black arrows) should measure less than 13mm.

Grade I injury refers to a mild sprain of the acromioclavicular ligaments, and is characterised by normal radiographs or mild widening of the AC joint space, but with normal alignment of the inferior acromion and clavicle and normal coracoclavicular distance (figure 13). These injuries are treated conservatively with analgesia, activity modification and physiotherapy.

Figure 13: AP radiograph of an adult shoulder demonstrating a grade I injury of the acromioclavicular joint. The inferior borders of the acromion and the lateral clavicle are on the same plane, however, the AC joint space is widened, measuring approximately 7mm in this instance.

Grade II injuries involve a step at the AC joint, with the lateral clavicle elevated above the inferior border of the acromion, but not above the superior border of the acromion (figure 14). The coracoclavicular distance remains within normal limits (< 13mm). Grade II injuries are usually treated conservatively, but may occasionally require surgery.

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

Figure 14: AP radiograph of an adult shoulder demonstrating a grade II injury of the acromioclavicular joint. The inferior borders of the acromion and the lateral clavicle are no longer on the same plane, however, the coracoclavicular distance is not increased.

Grade III injuries involve a step at the AC joint and an increase in the coracoclavicular distance greater than 13mm (figure 15). These injuries involve rupture of the coracoclavicular ligaments and may require surgery. Multiple surgical strategies exist for these injuries, commonly employing a hook plate which passes through the AC joint.

Figure 15:AP radiograph of an adult shoulder demonstrating a grade III injury of the acromioclavicular joint. The coracoclavicular distance is widely increased, measuring 24mm in this case.

More complex grading systems exist, such as the Rockwood classification, which divides Grade III injuries into four further categories.

Initial Management

The initial aim is to provide patients with adequate analgesia. In cases of glenohumeral dislocation, once the radiographs confirm a dislocation, an attempt should be made to reduce this, which often requires sedation. A repeat radiograph is taken to confirm satisfactory reduction and to assess for associated fractures. AC joint disruptions are usually immobilised with a sling and referred for prompt orthopaedic follow-up in the fracture clinic.

Prognosis

Despite optimal management, many patients with glenohumeral joint dislocation go on to develop recurrent dislocation. Injuries to the anteroinferior labrum in the form of Bankart and bony Bankart lesions reduce the stability of the shoulder joint, predisposing to further dislocation. Studies have shown that the risk of recurrent dislocation is inversely proportional to the age at first dislocation. For patients aged 20-25, the risk is up to 75%. Patients with recurrent shoulder dislocation may be investigated arthroscopically. However, MRI arthography is increasingly being used to assess the glenoid labrum. In this procedure, dilute MRI contrast is injected into the joint prior to the patient undergoing an MRI scan. The contrast is seen to outline the glenoid labrum (figure 16).

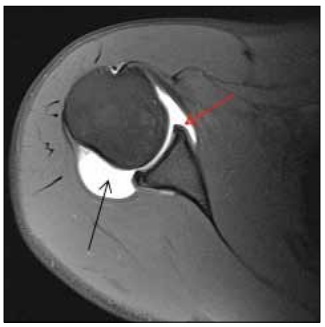

Figure 16: Axial fat-suppressed T1-weighted image from an arthrogram. A solution of gadolinium has been injected into the joint, seen as an area of high signal (black arrow). This is seen to outline the glenoid labrum, which is seen as a small triangle of low signal material at the periphery of the glenoid (red arrow). The anteroinferior labrum (the site of Bankart lesions) is normal in this example.

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

Grade I and II injuries of the AC joint tend to do well with conservative management. There is an increased risk of degenerative changes at the AC joint, which can cause irritation to the supraspinatus muscle and tendon as they move under the AC joint in abduction of the arm, giving the constellation of symptoms known as impingement. Long term data following surgical repair of grade III injuries is still relatively sparse. Similar to lesser injures, impingement may also be seen following grade III AC joint disruption, as well as symptoms of deformity, neck pain and neural brachial plexus symptoms.

Further Reading

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Multiple Choice Questions

1. The glenohumeral joint is best described as a:

a.) Synovial hinge joint

b.) Synovial ball and socket joint

c.) Fibrous hinge joint

d.) Fibrous ball and socket joint

e.) Cartilaginous ball and socket joint

2. What is the name given to a depression in the posterior aspect of the humeral head seen following anterior glenohumeral dislocation?

a.) Bankart lesion

b.) SLAP lesion

c.) Trough lesion

d.) Hill-Sachs lesion

e.) Bucket-Handle lesion

THE RADIOLOGY OF SHOULDER DISLOCATIONS

A Karsandas, J Tuckett, E Fatone, R Sinha, IG Hide

3. Grade III acromioclavicular joint injuries involve an increase in the coracoclavicular distance greater than:

a.) 5mm

b.) 7mm

c.) 13mm

d.) 20mm

e.) 25mm

4. What is the imaging technique of choice for suspected tears of the glenoid labrum?

a.) CT scan

b.) Plain x-ray

c.) Bone scan

d.) Ultrasound scan

e.) MRI arthogram

5. Which one of the following statements regarding posterior glenohumeral dislocation is correct?

a.) It is the commonest glenohumeral dislocation

b.) It gives rise to the 'light bulb' appearance of the humeral head

c.) The humeral head is seen to lie inferior to the coracoid process on the AP view

d.) It is associated with fractures of the antero-inferior aspect of the glenoid

e.) It occurs usually occurs following violent external rotation of the arm in abduction

Answers

1.) b
The rounded head of the humerus (ball) rests in the cup-like glenoid fossa (socket) of the scapula.

2.) d
A Bankart lesion is a fracture of the anteroinferior aspect of the glenoid, also associated with anterior glenohumeral dislocation.

3.) c
The normal acromioclavicular joint space should be less than 5mm.

4.) e
Dilute MRI contrast is injected into the joint prior to the patient undergoing an MRI scan to highlight certain structures within the joint more clearly.

5.) b
The patient struggles to externally rotate the arm giving the humeral head a more symmetrical 'light bulb' appearance.

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TUBES & LINES IN RADIOGRAPHS

LS Naidu, R Botchu

Abstract

Plain radiography is integral in the examination of ill patients particularly nursed in intensive care and high dependency units. Evaluation of placement of tubes and lines is critical to ensure patient safety before administration of treatment. Immediate help from radiologists will not be always be available, hence junior doctors should be competent to evaluate these radiographs for this crucial information.

The purpose of this pictorial review is to discuss the expected range of normal position of the commonly used devices and illustrate their abnormal placement.

For the purpose of simplicity, we will be discussing central venous catheters; endotracheal tube and nasogastric tube which constitute the most commonly placed tubes and lines in acute setting.

Other tubes like pulmonary artery (swan-ganz) catheters, intra-aortic balloon pumps, umbilical artery/vein lines, pacing wires will not be covered in this article.

Patient presentation

A 65 year old man came to casualty with shortness of breath, sweaty and generally feeling unwell .Whilst being examined by junior doctor, patient had a cardio-pulmonary arrest. Patient was resuscitated by arrest team and during this process; patient was intubated along with insertion of central catheter. A portable chest radiograph was requested. The arrest team was summoned elsewhere and junior doctor was asked to review the radiograph on PACS (picture archiving and communication system).

Central Venous Catheters (CVC)

These devices include short term central venous catheters, peripherally inserted central catheters (PICC lines), long term tunnelled catheters (e.g., Hickman, groshong lines), dialysis lines, implanted port systems (portacath) and midline catheters.

Routine central lines are typically placed via the internal jugular or subclavian vein, while PICCs (peripherally inserted central catheter) are placed via an arm vein, typically the basilic vein.

The indications of CVC are shown in the table 1:

1	For administration of chemotherapy, long term antibiotics, blood/blood products
2	For monitoring central venous pressure and SvO2
3	For parenteral nutrition
4	Long term hydration ,electrolyte maintenance, continuous renal replacement therapy (CRRT)
5	For administration of drugs which are harmful to peripheral veins i.e.; hyperosmolar drugs/fluids, irritants etc

The optimal position of the tip is in the distal SVC, at the junction of the SVC and the right atrium, or within the proximal portion of the atrium (Fig 1). It has to be noted that catheter tip can move several centimetres cephalad when patients move from supine position to sitting position.

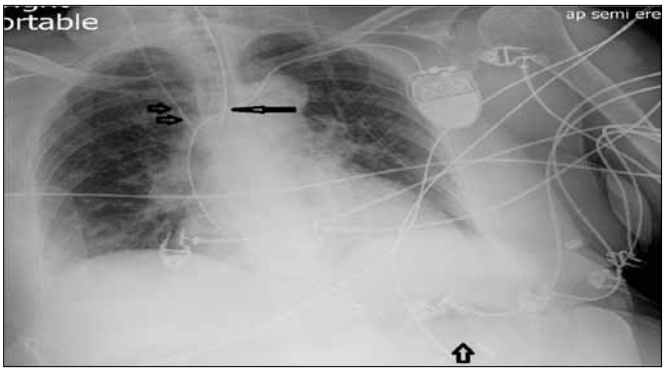

Figure 1: AP (anterio-posterior) semi-erect portable chest radiograph demonstrates the tip of the right internal jugular line in the superior vena cava (short open arrows). Endotracheal tube is 2cms above the carina (long arrow) and NG tube tip is below the diaphragm (wide open arrow).

Carina is an useful radiological landmark. When CVC lines are inserted on both sides, the tip of the left sided CVC should be at or just below the level of carina and right CVC line should be above the level of carina.

TUBES & LINES IN RADIOGRAPHS

LS Naidu, R Botchu

Complications

Immediate

Catheter malposition involves turning up into the neck or out into the axilla, across the brachiocephalic vein to the other side and into the azygous vein. (Fig 2). Rarely, the catheter may terminate in pericardiophrenic vein, left superior accessory vein or internal mammary vein. In a patient with variant anatomy, a catheter can be misplaced in left sided superior vena cava or coronary sinus. If the catheter is long, it can be curled in right atrium or even in inferior vena cava. Significant tubing within the right atrium should be avoided as these can induce arrhythmias. Malpositioning is more common in bedside peripherally inserted central catheter lines i.e.; PICC line can be malpositioned in the neck as shown in (Fig 3).

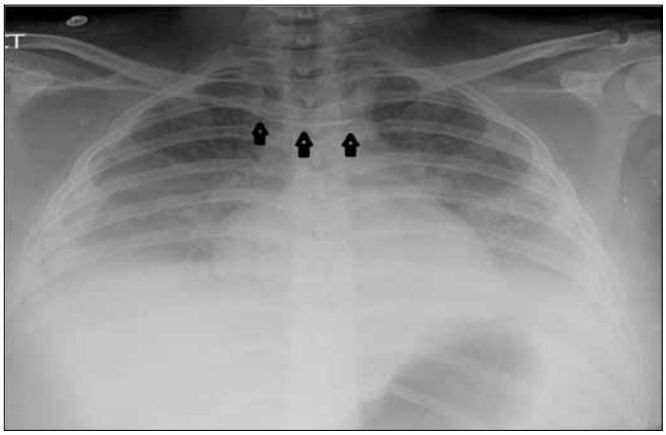

Figure 2: AP radiograph of the chest demonstrates right subclavian catheter across the left side and into the left brachiocephalic vein.

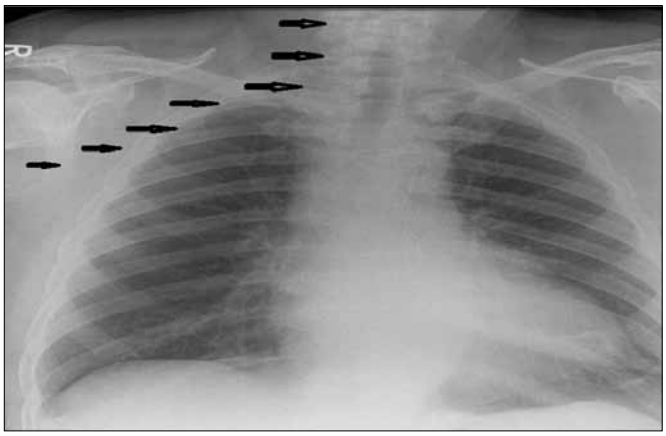

Figure 3: PA (posterior-anterior) chest radiograph demonstrates right PICC line inserted via basilic vein in the right internal jugular vein rather than in SVC.

Pneumothorax is more common if the line is not inserted under ultrasound or fluoroscopic guidance due to increased risk of pleural puncture. This is seen more commonly in subclavian vein puncture than puncture of internal jugular vein. Post insertion chest radiograph is mandatory for lines which have not been inserted without fluoroscopic guidance i.e. intensive care and high dependency units.

Air embolism can happen at any stage if air is allowed through the catheter but most likely during insertion or removal of catheter. This is predominantly seen with tunnelled catheters.

Great vessel or cardiac perforation is rare and results in haemothorax, medastinal haematoma or cardiac tamponade. This is more commonly seen in subclavian vein puncture. Cardiac arrhythmias can occur when the tip is deep in the right atrium. This is especially common with floppy tips of PICC lines than wide tip CVC lines.

Long term

Infection – central line associated blood stream infection (CLABS), fibrin sheath formation around the tip, venous thrombosis can happen due to clot formation at tip from mechanical or chemical irritation in incorrectly placed catheters or long term catheters and impairment of patency due to mechanical obstruction (catheter dislodgement) or build up of lipids from pareneteral nutrition or medication.

Endotracheal Tubes (ET)

These are inserted for ventilatory support in an acute setting. The main advantage of ET tube is that it provides an unobstructed passage of air to the lungs by reducing the anatomic dead space (larynx and trachea). It also protects the airway from aspiration, provides access to tracheo-bronchial tree for suction of secretions, access to aerosolised medications and enables positive pressure ventilation without gastric ventilation. The main disadvantage of ET is that it can be an irritant and can cause bronchial spasms and increased mucus secretions.

Indications for ET are as shown in table 2:

1	Reduced conscious level (GCS < 8, absent gag reflex)
2	Cardio-pulmonary arrest
3	Inadequate oxygenation which cannot be corrected by gas mask
4	Inadequate ventilation i.e.; shallow respiration
5	Before surgery for anaesthesia
6	Severe head and facial injuries
7	Imminent danger of upper airway obstruction

TUBES & LINES IN RADIOGRAPHS

LS Naidu, R Botchu

In radiographs, ET is identified by thin opaque line which runs along the line of the tube. When patient's head is in neutral position, the tip should be approximately 2-4 cms above the carina or at the level of aortic arch or at the level of clavicular heads. These radiology landmarks are clearly evident on a chest radiograph. Flexion and extension movements of the neck can move the tube up by 2cms. In adults, the tip of an ET tube should not be less than 2 cm above the carina and should not be above the thoracic inlet. (Figure 8)

Complications

(1) Trauma to teeth, vocal cords, larynx and related structures

(2) Tachycardia and high blood pressure can happen due to intense stimulation of intubation i.e.; transient cardiac arrhythmias due to vagal stimulation

(3) Placement of the tube too low may lead to bronchial intubation, more commonly right than left as right bronchus is more in line with the trachea which may lead to collapse of the non-intubated lung (Figure 4)

(4) High placement may lead to dislodgement. High ET may have its cuff at the level of the glottis. If this position is maintained for a considerable time it can be catastrophic for phonation. (Fig 5)

(5) Oesophageal intubation by the ET precludes not only adequate lung oxygenation but the tube often projects outside the tracheal air shadow on the AP chest x-ray, and the stomach is distended with gas.

(6) Damage to ET cuff can result in cuff leak and improper seal

(7) Overstimulation of larynx can result in laryngopasm

(8) Occasionally, baro-trauma from over ventilation can sometimes lead to pneumothorax

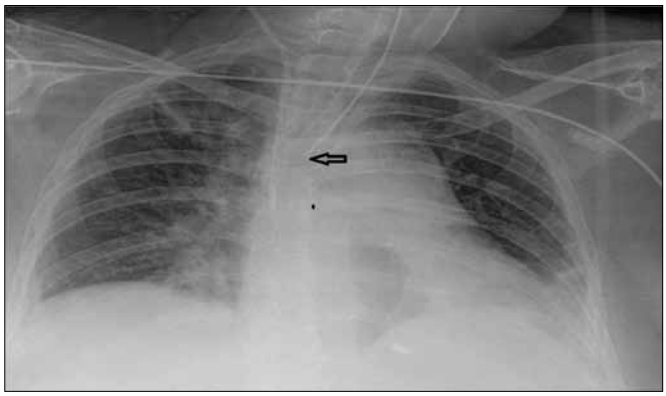

Figure 4: AP chest radiograph demonstrates the tip of the endotracheal tube at the carina and towards the right main bronchus.

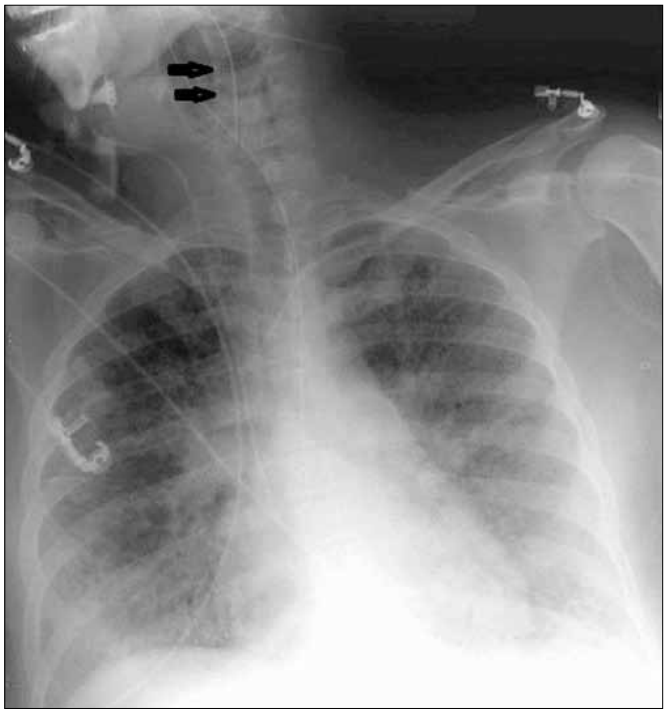

Figure 5: AP chest radiograph demonstrates the endotracheal tube high in the trachea.

TUBES & LINES IN RADIOGRAPHS

LS Naidu, R Botchu

Nasogastric (NG) Feeding & Draining Tubes

Nasogastric feeding is a common practice used in ill patients to provide nutrition, hydration and administration of medication. Draining tubes are used for aspiration of stomach contents i.e.; facilitate gastric motility in suspected ileus, to avoid aspiration and in suspected oral poisoning.

NPSA Alert 2005 (National patient safety agency) suggests that individual risk assessment should be carried out by a competent person. There are particular group of patients who are more at risk of placement error, tube migration or aspiration as shown in table 3.

1	reduced conscious level
2	dysfunctional swallowing mechanism
3	recurrent vomiting or retching
4	Ventilated or sedated patient

Specialist opinion should be sought in patients who has one of the conditions as shown in table 4.

1	Maxillofacial diseases, surgery and trauma
2	Oesophageal diseases like strictures
3	Oropharyngeal tumours or surgery
4	Radiotherapy to neck
5	Unstable cervical spine injuries
6	Head injury with skull fracture
7	Laryngeal surgery

The characteristic appearance of NG tubes on x-ray demonstrates a radio-opaque lining of the tube with bulky radio-opaque distal tip which should be in the stomach.

The drainage tubes tend to have radio-opaque bulky tip with non-radio-opaque lining. It has to be noted that the oesophago-gastric junction is below the curve of the diaphragm and on plain radiographs it is approximately 2-3 cm below the diaphragm (Figure 9).

There are various techniques to confirm the position like measuring pH of aspirate using pH indicator and by doing a radiograph. "Whoosh" test, blue litmus test for acidity/alkalinity and relief of respiratory distress as indicators are no longer recommended by NPSA for accurate positioning of naogastric tubes. Patients who are on antacid medications are likely to have gastric pH levels of 6 or above.

Radiograph should not be routinely used but is particularly indicated in patients in intensive care units and neonates.

Complications

(1) Misplacement of NG tube in the tracheobronchial tree does happen especially if there is impairment of patient's conscious level and it is vital to check this on radiograph before any fluid administration through the NG tube. (Fig 6).

(2) Sometimes NG tube can be curled up in the neck (Fig 7) or too high in the oesophagus (Fig 8)

(3) Perforation of the oesophagus and stomach is extremely rare due to soft nature of the tube and flexible stiffener.

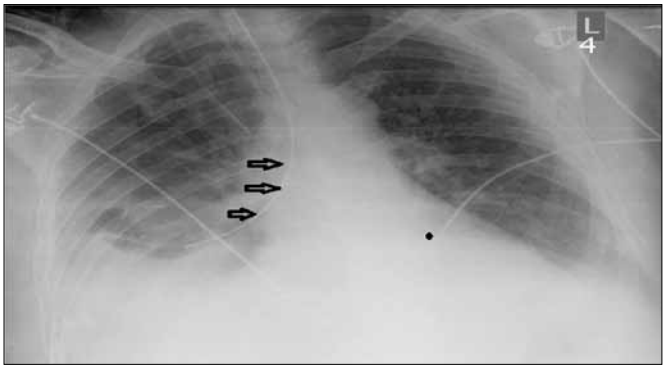

Figure 6: AP chest radiograph demonstrates the NG tube in the right main bronchus.

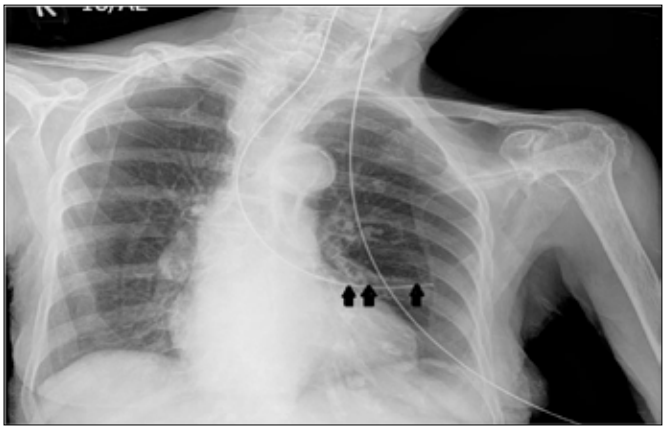

Figure 7: AP chest radiograph demonstrates the NG tube in the left main bronchus.

TUBES & LINES IN RADIOGRAPHS

LS Naidu, R Botchu

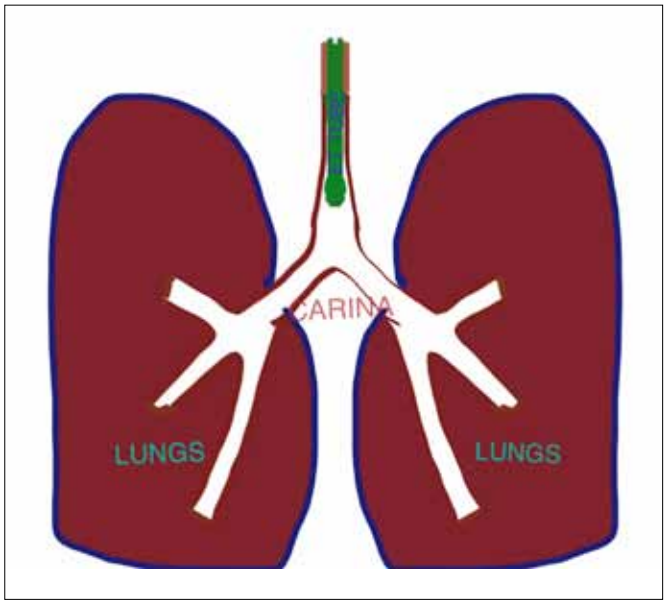

Figure 8: The sketch demonstrates the position of ETT relative to other mediastinal structures.

Tubes & Lines In Radiographs
Good Clinical Care

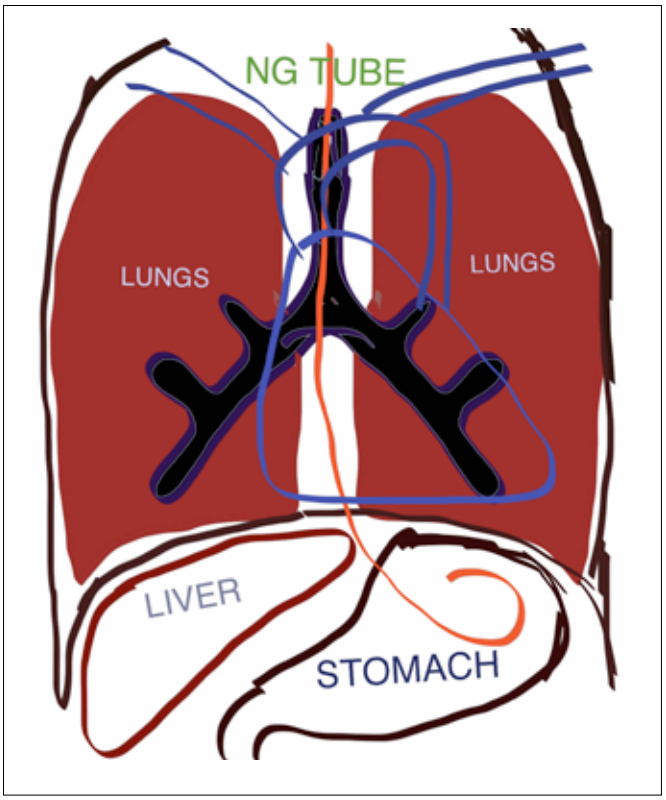

Figure 9: The sketch demonstrates the optimal position of Ng tube below the diaphragm.

TUBES & LINES IN RADIOGRAPHS

LS Naidu, R Botchu

Quiz Questions

1. The optimal position of the tip of CVC is:

a. right brachiocephalic vein

b. inferior vena cava

c. distal superior vena cava

d. proximal superior vena cava

e. left atrium

2. The following complication are more common with subclavian puncture than IJV puncture for CVC insertion (tick one or more answer):

a. pneumothorax

b. mediastinal haematoma

c. haemothorax

d. air embolism

e. none of the above

3. The optimal position of endotracheal tube is (tick one or more answer)

a. carina

b. level of aortic arch

c. first anterior rib

d. level of clavicular heads

e. larynx

4. The position of nasogastric tube can be confirmed with the following

a. pH indicator test

b. "whoosh test"

c. radiograph

d. blue litmus test for acidity/alkalinity

e. All of the above

Answers

1. (c) distal superior vena cava

2. (a),(b) and(c)

3. (b) and (d) level of aortic arch, level of clavicular heads or atleast 2 cms above the carina

4. (a) or (c)

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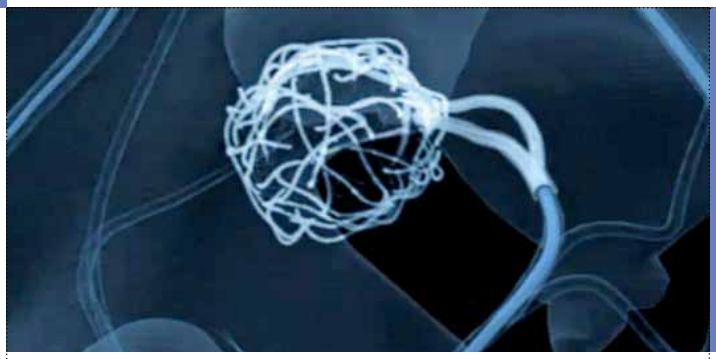
UTERINE ARTERY EMBOLISATION

D Maudgil



Uterine Artery Embolisation
Practical Procedures

Abstract

Uterine artery embolisation (UAE) is a technique that is increasingly being used both electively for uterine fibroids (more than 100,000 carried out worldwide to date) and in emergency situations for post partum haemorrhage.

Fibroids are non-cancerous growths that develop in the wall of the uterus. Some women with fibroids may not have any symptoms, while others may experience heavy bleeding, urinary incontinence, and pressure or pain in the abdomen. Fibroids can also sometimes make it difficult for a woman to conceive or carry a pregnancy to term.

Symptomatic fibroids are often treated with a hysterectomy, in which the whole uterus is removed, or with a myomectomy, in which just the fibroids are removed.

Uterine artery embolisation is a less invasive procedure and involves blocking the blood supply to the fibroids so that they shrink.

Procedure (For Elective Embolisation)

At least a few days before the procedure, the interventional radiologist meets with the patient (who is encouraged to bring along a partner or friend), for a consultation at which the benefits and risks of the procedure are discussed.

On the day of procedure the patient is admitted to a ward and comes down to the Interventional Radiology Department in a bed.

Pre-operative antibiotics are given and a PCA (patient controlled analgesia) pump is set up so that the patient can start using it as soon as the procedure is finished.

Under local anesthesia and using aseptic technique, a right common femoral artery puncture is performed. A catheter is navigated under xray control to each internal iliac artery (Figure 1), then each uterine artery in turn. Often it is not possible to access the ipsilateral uterine artery and therefore a left sided femoral puncture may also be required.

Figure 1: Angiogram showing catheter from right femoral artery with tip in left internal iliac artery. Contrast has been injected and is filling the anterior and posterior divisions (the uterine artery comes off the anterior division).

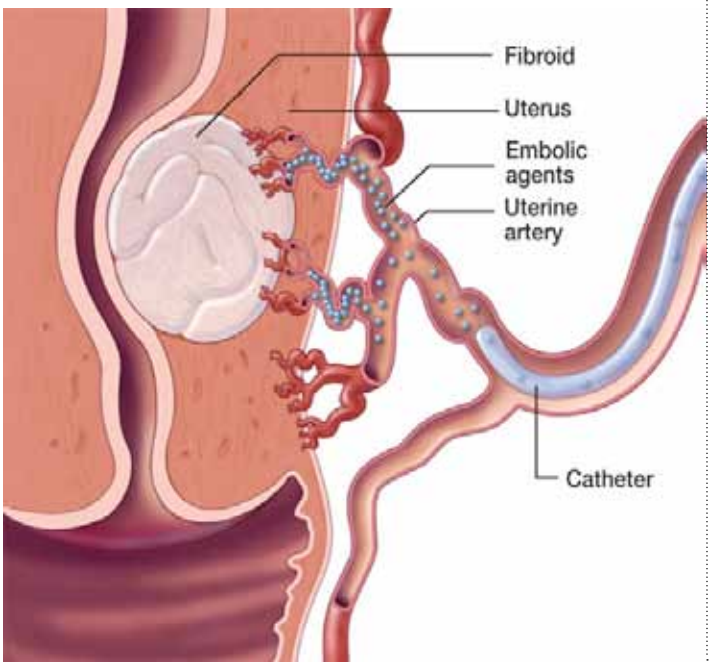
A satisfactory position in the uterine artery will be indicated when injection of contrast fills only the uterine fibroid circulation and not that of other "non-target" territories such as the vessels to the bladder, ovaries or vagina (Figure 2).

UTERINE ARTERY EMBOLISATION

D Maudgil

Figure 2: Angiogram showing catheter with tip in uterine artery. Contrast has been injected and is only filling the characteristic "corkscrew" vessels of the uterine fibroids.

The fibroids are embolised with PVA particles and sometimes an embolic coil is placed which occludes the vessel. Embolisation is performed until either all the small vessels fail to fill ("pruned tree", Figures 3 and 4) or until any contrast starts to come back around the catheter upon injection. Usually contrast will be static in the main vessel being embolised once a satisfactory result has been achieved.



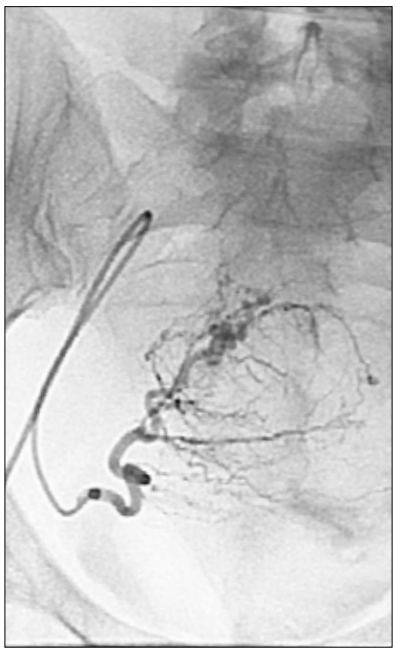


Figure 3: A catheter has been navigated from the right common femoral artery to the (ipsilateral) left uterine artery. Note the abundant "corkscrew" vessels of the fibroids.

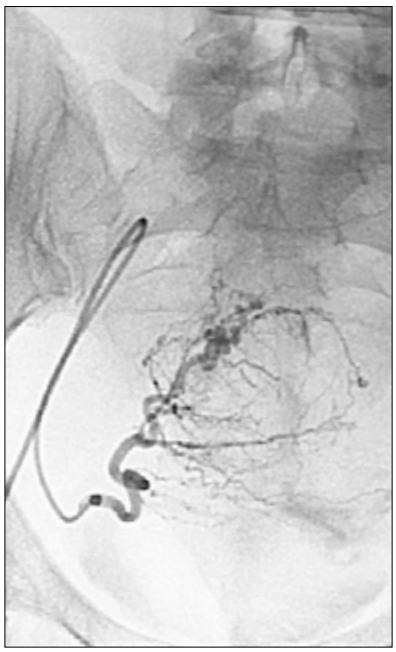


Figure 4: Embolisation has been performed and the corkscrew vessels have been occluded ("pruned tree"). If one looks carefully at the catheter, one can see that the column of contrast is now passing slightly along the distal tip of the catheter, suggesting early reflux.

UTERINE ARTERY EMBOLISATION

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Post Procedure Care

The most commonly reported side-effect after embolisation is severe pelvic pain, usually starting immediately following the embolisation and lasting for up to 12 hours. Moderate pain may continue for a few days.

For this reason an overnight stay with attention to pain relief is usually advised unless (as some centres do), a unilateral embolisation is performed, followed by the contralateral embolisation at an interval. Careful attention should be paid to analgesia requirements when the patient goes home. Ongoing severe pain should not be ignored as it may be a sign of sepsis (including endometritis or abscess formation), which may require urgent treatment.

Another important side effect to be aware of is post-embolisation syndrome, causing pain, fever, malaise and nausea for a few hours up to a few days. This is thought to be immune mediated and is reported in up to 50% of patients. It is treated with antipyretics and anti-inflammatories.

Large Scale Study Of Outcomes

Using the Fibroid Registry for Outcomes Data (FIBROID) (1), a multicentre, prospective, voluntary registry of patients undergoing uterine embolization for uterine fibroids, changes in symptom status, health-related quality of life, subsequent care, menstrual status, and satisfaction with outcome were studied.

Of 2,112 eligible patients, follow-up data were obtained on 1,797 (85.1%) at 6 months and 1,701 (80.5%) at 12 months. At 12 months, the mean symptom score had improved from 58.61 to 19.23 ($P < .001$), whereas 5.47% of patients had no improvement.

The mean health-related quality-of-life score improved from 46.95 to 86.68 ($P < .001$). Five percent did not improve.

In the first year after embolization, hysterectomy was performed in 2.9% of patients, with 3.6% requiring gynecologic interventions by 6 months. An additional 5.9% required intervention between 6 and 12 months.

Amenorrhea as a result of embolization occurred in 7.3% of patients. Of these, 86% were age 45 or older. Most patients were satisfied with their outcome (82% strongly agree or agree).

The need for hysterectomy and/or repeat UAE for treatment failure is around 10% at 1 year, rising to 20-25% after 5 years (2).

It should be noted that in comparison with hysterectomy and myomectomy, UAE is relatively safer: In the REST trial (157 women, UK multicentre) 12% of UAE patients experienced a major complication in the first year, compared to 20% of the surgically treated group (3).

In the HOPEFUL trial (972 UAE versus 762 hysterectomies), significantly fewer major complications were reported during the 2-6 year follow up for UAE (17.6%) v hysterectomy (26%) (4).

UTERINE ARTERY EMBOLISATION

D Maudgil

Cost Effectiveness

FEmISA (5) (The Fibroid embolisation information, support and advice centre) has recently compared the cost savings from performing UAE versus hysterectomy:

The NHS tariff for UAE is £202 cheaper than hysterectomy.

If 60% of the 40,000 hysterectomies per year currently performed in the UK were converted to UAE, there would be a cost saving of around £4.8 million. More importantly, because UAE only requires an overnight stay (versus hysterectomy which usually requires 4-5 days), there would be a saving of about 70,000 bed days.

Return to work and normal activities after UAE is normally after 1-2 weeks compared to hysterectomy, which takes about 3 months. This implies a potential saving to the UK economy of around £117 million.

Emergency Uterine Artery Embolisation

For several years there has been recognition of the important role of uterine artery embolisation in managing post partum haemorrhage to avoid the need for emergency hysterectomy.

The technique is identical to elective UAE except that instead of using permanent embolic agents, temporary embolic agents such as gelfoam (which are reabsorbed over several weeks) are used.

In cases where post partum haemorrhage is anticipated (e.g. in placenta accreta or percreta), balloon catheters can be placed in both internal iliacs or uterine arteries, allowing immediate inflation to stop blood flow to the uterus and arrest haemorrhage. Subsequent embolisation via the balloon catheter can then be performed if required.

Studies have shown that pre-operative placement of balloons in placenta percreta can reduce blood loss by 40-50%.

Conclusions

In summary UAE is a widely used, safe and well tolerated procedure, which can bring significant benefits to women in the elective and emergency situation.

In accordance with NICE guidelines UAE should be mentioned as a treatment option to women with heavy menstrual bleeding and fibroids (6).

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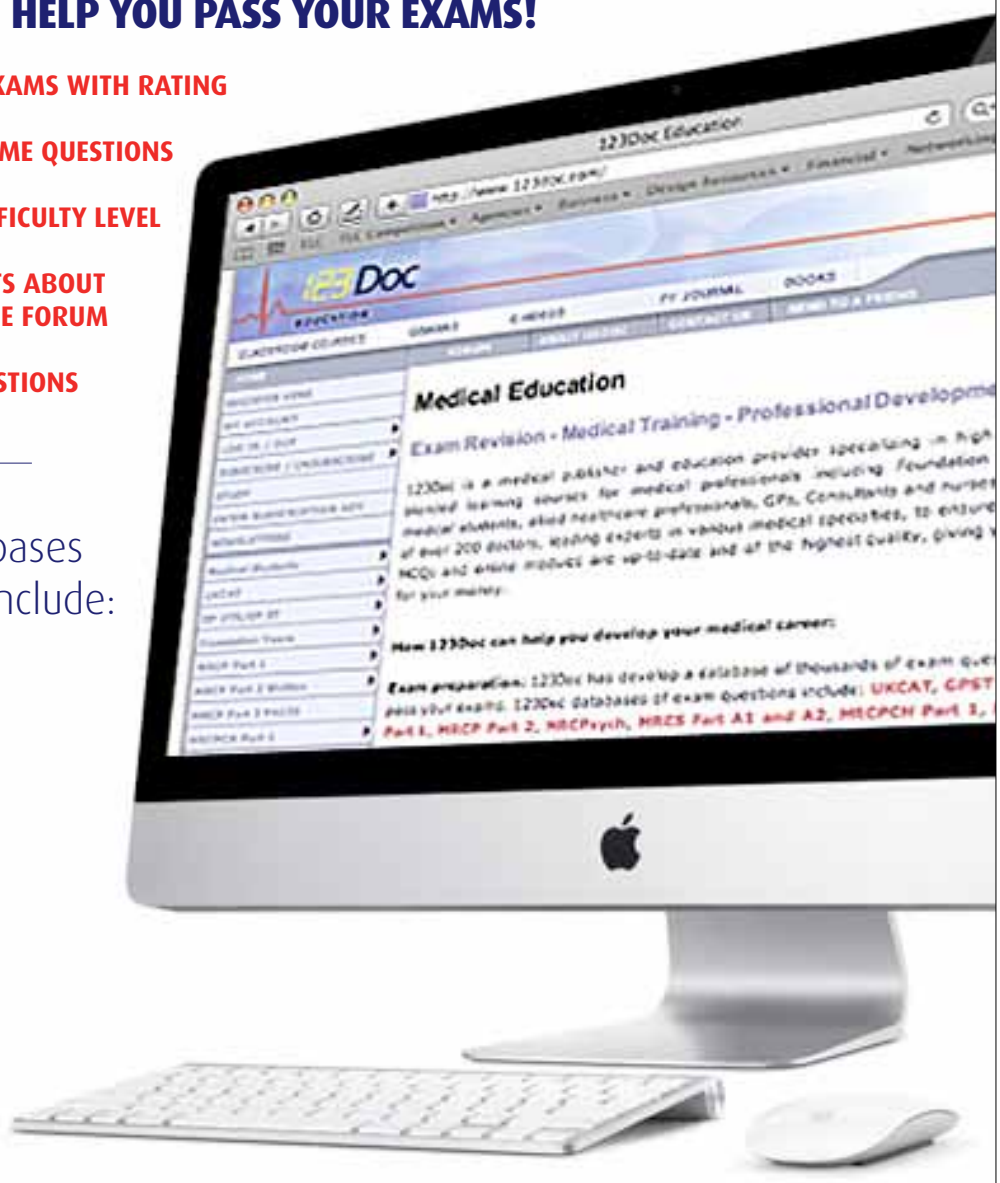

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Volume 8, Issue 1: **Radiology - Part 2**

2013 Past Issues

Volume 7, Issue 10: Vascular Disease - Part 2
Volume 7, Issue 9: Radiology Issue - Part 1
Volume 7, Issue 8: Environmental Medicine
Volume 7, Issue 7: Neurology - Part 1
Volume 7, Issue 6: Cardiology - Part 1
Volume 7, Issue 5: Vascular Disease - Part 1
Volume 7, Issue 4: ENT - Part 2
Volume 7, Issue 3: Ophthalmology - Part 2
Volume 7, Issue 2: Accident & Emergency
Volume 7, Issue 1: ENT

2012 Past Issues

Volume 6, Issue 10: Ophthalmology
Volume 6, Issue 9: Oncology
Volume 6, Issue 8: Anaesthesia Part 2
Volume 6, Issue 7: General Surgery Part 2
Volume 6, Issue 6: Psychiatry Part 2
Volume 6, Issue 5: Anaesthesia
Volume 6, Issue 4: General Surgery
Volume 6, Issue 3: Orthopaedics, Oral & Maxillofacial
Volume 6, Issue 2: Rheumatology
Volume 6, Issue 1: Geriatrics

2011 Past Issues

Volume 5, Issue 10: Psychiatry
Volume 5, Issue 9: Respiratory
Volume 5, Issue 8: Gastroenterology
Volume 5, Issue 7: Haematology Infectious Diseases
Volume 5, Issue 6: Cardiology General Practice
Volume 5, Issue 5: Gynaecology & Obstetrics
Volume 5, Issue 4: Neurology
Volume 5, Issue 3: Urology
Volume 5, Issue 2: Nephrology Immunology
Volume 5, Issue 1: Vascular Diseases

2010 Past Issues

Volume 4, Issue 10: Dermatology & Paediatrics
Volume 4, Issue 9: Diabetes & Endocrine
Volume 4, Issue 8: General Practice
Volume 4, Issue 7: ENT
Volume 4, Issue 6: Ophthalmology
Volume 4, Issue 5: Acute Medicine
Volume 4, Issue 4: Oncology
Volume 4, Issue 3: Neurology
Volume 4, Issue 2: Anaesthesia
Volume 4, Issue 1: Surgery

2009 Past Issues

Volume 3, Issue 10: A&E
Volume 3, Issue 9: Geriatric-Palliative Care
Volume 3, Issue 8: Orthopedics-Rheumatology
Volume 3, Issue 7: Psychiatry
Volume 3, Issue 6: Respiratory
Volume 3, Issue 5: Urology
Volume 3, Issue 4: Gastroenterology
Volume 3, Issue 3: Gynaecology & Obstetrics
Volume 3, Issue 2: General Practice, Cardiology
Volume 3, Issue 1: Infectious Disease, Immunology

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