Emergency medicine often brings together critically ill patients with inexperienced junior doctors – a dangerous combination with potentially serious consequences. The huge volume of information necessary to manage these patients adequately is overwhelming, as virtually any condition can present itself. The difficulties are compounded because radiographs are requested for many patients. These radiographs may be interpreted by relatively inexperienced, and often tired, personnel who have little training in how to evaluate them.

### Radiographic Projections

<table>
<thead>
<tr>
<th>Site</th>
<th>View</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger</td>
<td>Anteroposterior and lateral</td>
<td></td>
</tr>
<tr>
<td>Hand</td>
<td>Anteroposterior and oblique</td>
<td>Four views for suspected scaphoid fractures</td>
</tr>
<tr>
<td>Wrist</td>
<td>Anteroposterior and lateral</td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td>Anteroposterior and lateral</td>
<td>Additional views if fat pad present</td>
</tr>
<tr>
<td>Shoulder</td>
<td>Anteroposterior and Y view</td>
<td></td>
</tr>
<tr>
<td>Pelvis and sacrum</td>
<td>Anteroposterior only</td>
<td>Coccyx views rarely indicated</td>
</tr>
<tr>
<td>Hip</td>
<td>Anteroposterior and oblique</td>
<td>Anteroposterior of both hips and oblique or lateral of injured hip</td>
</tr>
<tr>
<td>Knee</td>
<td>Anteroposterior and lateral</td>
<td>Lateral is done with a horizontal beam</td>
</tr>
<tr>
<td>Ankle</td>
<td>Anteroposterior and lateral</td>
<td>Anteroposterior mortise view for trauma</td>
</tr>
<tr>
<td>Feet and toes</td>
<td>Anteroposterior and oblique</td>
<td></td>
</tr>
<tr>
<td>Cervical spine</td>
<td>Anteroposterior, lateral, and peg</td>
<td>Lateral must show C7/T1 (otherwise computed tomography)</td>
</tr>
<tr>
<td>Thoracic spine and lumbar spine</td>
<td>Anteroposterior and lateral</td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>Posteroanterior erect or anteroposterior</td>
<td>Also anteroposterior supine (trauma)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Anteroposterior supine</td>
<td>Erect anteroposterior chest radiograph helpful</td>
</tr>
<tr>
<td>Head</td>
<td>Computed tomography scan</td>
<td>Plain skull radiographs rarely indicated</td>
</tr>
<tr>
<td>Face</td>
<td>Occipitomental and occipitomental 30°</td>
<td>Posteroanterior or posteroanterior 20°</td>
</tr>
<tr>
<td>Mandible</td>
<td>Anteroposterior view and orthopantomograph</td>
<td>Oblique view if orthopantomograph not available</td>
</tr>
<tr>
<td>Foreign bodies</td>
<td>Anteroposterior and lateral or tangential</td>
<td>Metal marker at entry site. Consider ultrasound first or computed tomography</td>
</tr>
</tbody>
</table>

### Rules of Two

The rules of two are a simple set of guidelines. Most rules should be obvious and some relate to specific problems, but they are useful general principles that help to avoid errors in interpretation of radiographs and management of patients.
1 Two views
Preferably, the two views should be perpendicular to each other. This rule applies to virtually all radiographs obtained, except for those of the chest, abdomen, and pelvis. Rarely, the abnormality is not visible at all or is subtle on the first view.

2 Two joints
Image the joint above and below a long bone. This particularly relates to mid-shaft injuries of the forearm (radius and ulna) and lower leg (tibia and fibula). Sometimes subtle injuries may be present in the joint above or below the obvious fracture.

3 Two sides
Rarely, the abnormality may be difficult to detect, and comparison with the other side can be helpful, especially in children. Always get a second opinion before requesting another radiograph because it means exposing the patient to additional radiation (an especially important consideration with children).

Rule 1 Anteroposterior (left) and lateral view of right ankle (right). The anteroposterior view was considered normal. The lateral view shows a displaced oblique fibula fracture (arrows).

Rule 2 Anteroposterior view of right leg (left), lateral view of right knee (middle), and anteroposterior view of right knee (right). Shows a Salter-Harris type II injury – proximal tibial metaphysis is fractured, with separation and displacement of the epiphyseal growth plate and undisplaced fibula fracture (arrowhead).

Rule 3 Anteroposterior view of right elbow (left) and anteroposterior view of left elbow (right). The right elbow has a non-united, avulsed, right medial epicondyle (arrow). The injury is obvious when compared with the normal left elbow with fused epiphyses.
4 Two abnormalities
Do not stop looking after you find one abnormality. An underlying predisposing cause may be the reason for the fracture (pathological fracture), or an unrelated incidental finding (such as a “bone island”) might be present.

5 Two occasions
If old films are available, always take the opportunity to look at them. This is particularly relevant in chest radiographs, because previous films will tell you if the latest radiograph shows an old or new finding. Similarly, if there is a bony abnormality, in particular if osteomyelitis or a septic arthritis is suspected, old films are essential for early diagnosis.

6 Two visits
Always bring the patient back for a repeat set of radiographs after a procedure – especially after surgery, setting a fracture in plaster, reducing a dislocation, or removing a foreign body.

Sometimes the patient should come back for a repeat film after a set period of time to see whether the abnormality has resolved, got worse, or not changed. Classic scenarios in which this would be appropriate include a suspected scaphoid fracture or when abnormalities on chest radiographs are seen and an old film is not available for comparison.
7 Two opinions
Wherever possible, get a second opinion or show the radiograph to someone else. This is especially important if you are unsure about the radiograph. If the red dot system is used in your hospital, then this can be your first opinion.

The red dot system was introduced to help emergency department doctors. It is a voluntary system where the radiographer who took the radiograph gives his or her opinion as to whether the film is abnormal by placing a red dot next to the abnormality. It was initially, and in most hospitals still is, used for the peripheral skeleton only—that is, limb injuries. The red dot system helps to reduce errors and improve accuracy.

Radiographers are usually extremely experienced at taking films, looking at and interpreting them. Always ask the radiographer who took the film for their opinion first, especially if there is a red dot and you cannot find an abnormality.

8 Two records
Apart from recording the history and results of the examination, always record the findings of the radiograph. It is easy to look at the film and to forget to write down the findings. Films get lost, and your written record may be the only record.

9 Two specialists
All films should be seen and reported formally by a radiologist. This is particularly important for films that are at first thought to be normal because the patient is usually discharged and may not be seen by anyone else.

10 Two examinations
Sometimes, if the plain radiograph is normal, the symptoms may warrant further investigation. Studies have shown that if a scaphoid fracture is suspected and the scaphoid series of films are normal, the patient should have a magnetic resonance image scan when possible, rather than putting the patient in a splint or plaster and waiting 10–14 days before taking another set of films, which is “accepted normal management.”

In addition, several abnormalities detected on plain radiographs warrant further imaging. If a fracture extends to the major joints (for example, acetabular and tibial plateau fractures), a computed tomography scan of the joint should be done routinely to evaluate the extent of joint involvement and to exclude loose fragments.
Ten commandments

Touquet’s ten commandments are a simple set of guidelines to protect staff and hospitals from the inevitable mistakes that inexperienced doctors will make. Unfortunately, the commandments are often ignored. Many of the ten commandments are incorporated in the rules of two.

Command 1: treat the patient not the radiograph

Certain conditions or injuries should be treated on the basis of the clinical findings initially, especially if the injury is life threatening (such as a tension pneumothorax). With other injuries, delaying initial treatment to obtain a radiograph is unnecessary (for example, a dislocated ankle). The delay may be either life threatening, or have long term sequelae. In addition, a finding on the radiograph may be an incidental finding (the fourth rule in the rules of two).

Command 1

Left tension haemopneumothorax. The patient should have been treated with a chest drain insertion before the chest radiograph was taken.

Command 2: take a history and examine the patient before requesting a radiograph

A thorough clinical history and examination enables the mechanism of injury to be established, and the appropriate radiographs can then be requested. Knowledge of the mechanism of injury can often help to determine the likely pattern of injuries.

Command 2

Chest radiograph taken after a road crash (left) showing a widened mediastinum (arrow), and a haemothorax (arrowhead). A traumatic aortic injury was suspected and a computed tomogram was requested. The computed tomography image (right) confirms traumatic aortic injury (arrow) with associated mediastinal haematoma (arrowhead) and a large left haemothorax (H).

Touquet’s ten commandments of emergency radiology

- Command 1: treat the patient not the radiograph
- Command 2: take a history and examine the patient before requesting a radiograph
- Command 3: request a radiograph only when necessary
- Command 4: never look at the radiograph without seeing the patient and never see the patient without reviewing the radiograph
- Command 5: look at the radiograph, the whole radiograph and the radiograph as a whole in appropriate settings
- Command 6: re-examine the patient when incongruity exists between the radiograph and the expected findings
- Command 7: remember the rules of two
- Command 8: take radiographs before and after procedures
- Command 9: if a radiograph does not look quite right, ask and listen (the seventh rule of the rules of two)
- Command 10: ensure you are protected by failsafe mechanisms

Tension pneumothorax, dislocated joints (for example, hip or ankle), and a pulled elbow in a toddler are examples of conditions where treatment should be started on the basis of clinical findings.

Command 1

Dislocated left ankle. The ankle should have been reduced without the radiograph.

Command 2

Chest radiograph after a road crash showing a widened mediastinum (arrow), and a haemothorax (arrowhead). A traumatic aortic injury was suspected and a computed tomogram was requested. The computed tomography image confirms traumatic aortic injury (arrow) with associated mediastinal haematoma (arrowhead) and a large left haemothorax (H).
Command 3: request a radiograph only when necessary
Many requested investigations do not alter the patient’s management, and in some cases they may be misleading. In head injuries, there is virtually no indication for performing a skull radiograph. Most patients who have sustained a substantial head injury should have a computed tomography scan. A safe approach to head injuries is always to scan it.

Command 4: never look at the radiograph without seeing the patient and never see the patient without reviewing the radiograph
Look at the radiograph properly, not be biased, and use a systematic approach. Always get the clinical history before giving an opinion. Then you will often pick up abnormalities that you may otherwise have missed. Never rely on someone else’s opinion or report on radiographs if you have not seen the radiographs yourself. This is particularly relevant when patients are handed over at the end of a shift or when patients are transferred from elsewhere.

Command 5: look at the radiograph, the whole radiograph, and the radiograph as a whole in appropriate settings
In a pressured environment such as an emergency department, it is easy to rush and make mistakes. Interpreting radiographs too quickly inside a badly lit, noisy room with many distractions is a recipe for disaster. Interpretation of radiographs should be done in a calm manner in a quiet, well-lit room using a viewing box or monitor. A common problem is that the person assessing the radiograph will focus immediately on expected abnormalities. Even knowing the clinical history, try to ignore it at first and use a systematic approach. It is critical though that you always get the clinical history before giving your final opinion or report, because you must try to interpret the radiological findings in the context of the clinical presentation and answer the question.

Command 6: re-examine the patient when an incongruity exists between the radiograph and the expected findings
Review the radiographic findings in conjunction with the patient’s history and your clinical findings. If the radiograph does not fit, review the history and clinical findings or ask for help. Many cases require further imaging – for example, request a magnetic resonance scan or an isotope bone scan in an elderly patient with a suspected fracture of the neck of femur, even if the initial plain radiographs seem normal.

In review clinics, radiographs are often lost or not available, but you must review previous radiographs. As a minimum, get the radiologist’s report or repeat the films.

Trauma to the coccyx, most clinically obvious nose fractures, head injuries (request a computed tomography scan), and simple rib fractures are examples of when radiographs are not necessary.
Command 6: Anteroposterior view of right hip showing subtle fracture of neck of femur (arrow), which was missed initially (left) and later confirmed on isotope bone scan as a fracture (arrowhead).

Command 7: remember the rules of two
The original commandments included two views, two joints, two sides, and two occasions only (see the first, second, third, and fifth of the rules of two).

Command 8: take radiographs before and after procedures
See the sixth of the rules of two.

Command 9: if a radiograph does not look quite right, ask and listen
See the seventh of the rules of two.

Command 10: ensure you are protected by failsafe mechanisms
See the eighth and ninth of the rules of two. Abnormalities will be missed by all grades of staff and in all specialties. A report from a radiologist as well as personnel from the emergency staff, however, will minimise the effect of these errors on the patient and in the eyes of the law. Reports should be timely and accurate, and these failsafe mechanisms should be audited regularly. To miss an injury radiologically may not be negligent, but not to have a system in place to provide for this eventuality is negligent.

**ABCs systematic assessment**

The rules of two and the ten commandments are helpful guidelines for who, what, how, and when to radiograph and how to minimise the chances and consequences of errors.

The ABCs systematic assessment shows how to interpret radiographs. It is particularly helpful for junior doctors who have had little or no training on how to look at radiographs. This approach will help to familiarise them with the normal radiographs and minimise interpretive errors.

The ABCs systematic assessment is different for each type of body system. The ABCs for the peripheral skeleton are the same, but it is worth changing the order slightly to look for specific signs, in particular a fat pad sign in the elbow or a fat-fluid level (lipohemarthrosis) in the knee. Both of these signs are easy to detect and should alert you immediately to the presence of a probable fracture. Hence in the elbow and knee start by looking at soft tissues.

**Peripheral and axial skeleton**
- Alignment
- Cartilage and joints
- Bones
- Soft tissues and foreign bodies

**Chest**
- Adequacy, all lines and tubes and airways – follow trachea and bronchi
- Breathing – Compare and contrast left and right lungs
- Circulation – Review heart, hila, and pulmonary vasculature
- Diaphragm
- Edges – Trace the pleura
- Skeleton – Edge the bones, review soft tissues, and seek foreign bodies

**Abdomen**
- Air – Search for free intraperitoneal air and abnormal air
- Bowel gas pattern
- Calcification
- Densities – For example, look for foreign bodies, or tablets
- Edges – For example, hernial orifices, or lung bases
- Fat planes – Relating to psoas, kidneys, and bladder
- Soft tissues and skeleton

**Head (computed tomography scan)**
- Air spaces
  - Eyes
  - Brain and bones
  - Cerebrospinal fluid spaces
- Dural spaces
- Face
  - Alignment – Trace McGregor's and Campbell's lines
  - Bones – Consider LeFort's classification
  - Cartilage – Delinate zygomaticofrontal suture and temporomandibular joints
  - Densities – Search for foreign bodies, glass, metal
  - Soft tissues and sinuses – For example, frontal, ethmoid, and maxillary

**Cervical spine (thoracic spine and lumbar spine)**
- Adequacy, all lines and tubes, and airway
- Alignment
- Bones
- Cartilage – Check disc spaces and joints
- Soft tissues (prevertebral, paravertebral, and psoas)
Lateral view of elbow – Look for fat pad sign first. An anterior (arrow) and posterior (arrowhead) fat pad sign indicate a probable fracture.

Horizonal beam lateral view of knee shows a lipohaemarthrosis (arrow). The fat (black) floats on the blood (white). This indicates a fracture (arrowhead), which in retrospect is visible.

**Further reading**

- American College of Surgeons, Committee on Trauma. *Advanced trauma life support for doctors (ATLS) instructors’ manual*. Chicago: American College of Surgeons, 2003
- Stern JE. *Trauma radiology companion*. Philadelphia: Lippincott, Williams and Wilkins, 1997

**KEY POINTS**

- Request the correct radiographic examination
- Knowledge of anatomy is essential for evaluation of a radiograph
- Fundamental principles help reduce errors
- Remember the rules of two and the ten commandments
- Use a systematic approach to evaluate radiographs (ABCs)