RADIOLOGICAL ASSESSMENT—II

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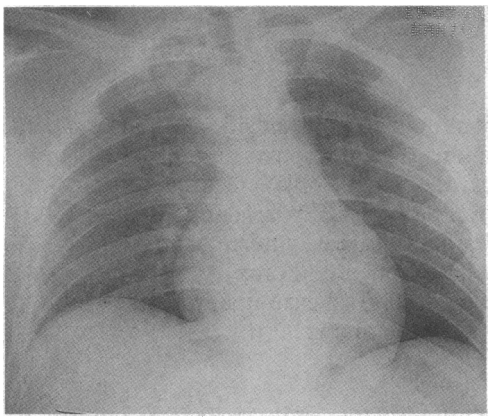
Chest injuries



Typical anteroposterior supine chest radiograph. There is poor inspiration and the upper lobe vasculature is prominent. The heart size is magnified.

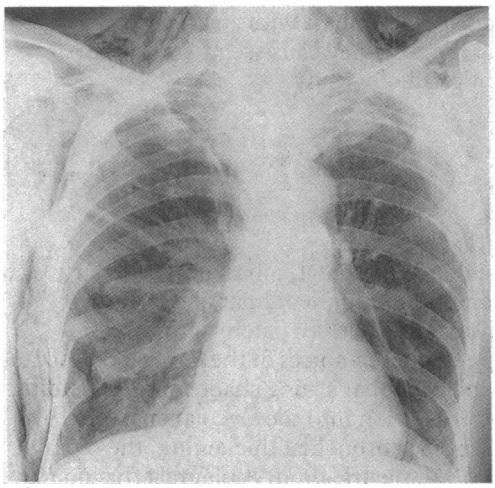
About 25% of deaths caused by major trauma are due to thoracic damage. The most useful radiograph in patients with thoracic trauma is the erect posteroanterior view. In the resuscitation room, however, the standard radiograph is often the supine anteroposterior view, which has the disadvantage of causing apparent enlargement of heart and mediastinal shadows, distending the upper lobe vessels, and making inspiration less efficient. In the supine position pleural air collects anteroinferiorly, outlining the diaphragm and heart, while pleural fluid layers posteriorly give ill defined opacification of the hemithorax.

Features shown in the initial chest radiograph

- Check for adequacy of inspiration, rotation of the patient, and artefacts of resuscitation
- Ensure that the density of each hemithorax is equal
- Localised opacities may be pulmonary, pleural, artefactual, or on the chest wall
- Look for rib fractures. How many ribs are fractured and how many fractures per rib?
- Check the mediastinum for contour, width, and presence of gas
- Check the aortic knuckle for contour and definition
- Look out for abnormal gas in the pleural, mediastinal, subcutaneous, and subphrenic spaces

Poor inspiration as well as rotation of the patient with relation to the radiographic beam may result in artefactually abnormal appearances. Ideally, five anterior ribs and 10 posterior ribs should be counted above the level of the hemidiaphragm. The medial ends of the clavicles should be equidistant from the vertebral spinous processes.

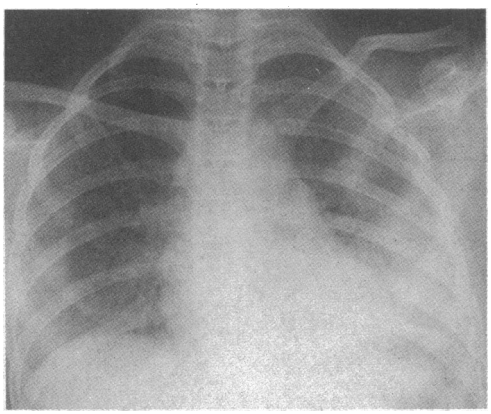
The basic rules for assessment of the chest radiograph are that the transverse diameter of the heart should not be greater than half the transverse diameter of the thorax and that two thirds of the heart should lie to the left of the midline. Vascular distribution should be symmetrical on each side, and each hemithorax should have equal translucency. The hilar shadows should be clearly defined, with the left hilum being about 1-2 cm higher than the right. Cardiac, mediastinal, and diaphragmatic contours should be clearly outlined.



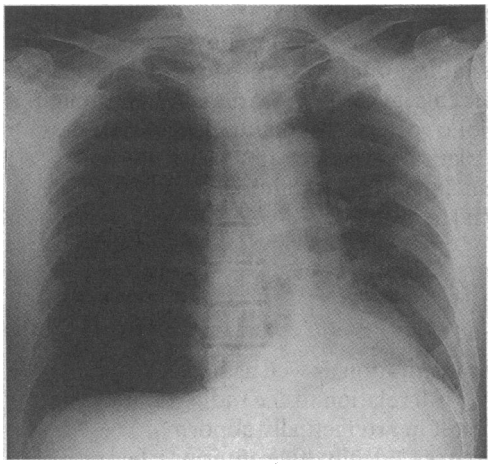
Extreme surgical emphysema and pneumomediastinum caused by multiple rib fractures. There is outlining of the pectoral muscle fibres on the right side.

Chest wall injuries

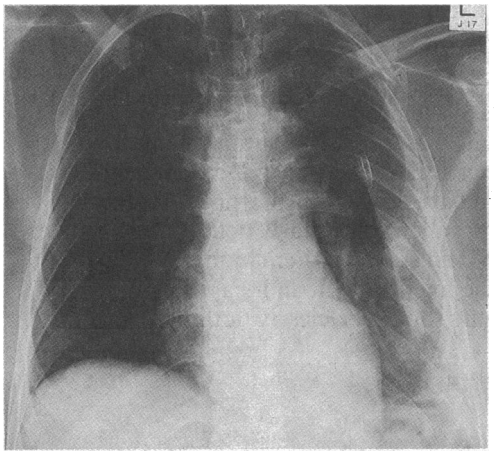
Injuries of the chest wall frequently accompany pelvic trauma. The fifth to ninth ribs are most commonly injured. Lower rib fractures may be associated with splenic, hepatic, or renal damage, while fractures of the first two ribs imply that the patient has sustained a considerable force and is likely to have associated cranial, cervical, or intrathoracic injury. A fracture of the first rib with displaced fragments carries a 60% risk of underlying major vascular damage. The presence of surgical emphysema in the neck or mediastinum in addition highlights the severity of the injury.



Left sided pulmonary contusion. There is ill defined opacification over the left mid-zone and base. Although the left clavicle is fractured, no obvious rib fracture is shown.



Right sided tension pneumothorax. The right hemithorax is very translucent with absent lung markings. There is flattening of the right dome of the diaphragm and considerable shift of the heart and mediastinum to the left.



Flail chest caused by at least six fractured ribs both in the posterior axillary line as well as anteriorly.

Radiological signs of major thoracic trauma

- Mediastinal widening
- Mediastinal shift
- Mediastinal emphysema
- Multiple rib fractures
- Fractured first or second ribs
- Pleural fluid
- Loss of aortic definition

Flail chest occurs when multiple and adjacent rib fractures allow an area of the chest wall to move paradoxically with respiration. Sternal fractures are best shown in the lateral radiograph and may cause underlying pulmonary or cardiac injury. Posterior sternoclavicular joint dislocation can be identified by obvious asymmetry at the manubrium, and there is associated risk of brachiocephalic vein disruption. Complications caused by rib fractures include pneumothorax, haemothorax, and pulmonary contusion or laceration.

Diaphragmatic injury

Rupture of the diaphragm is commoner on the left side and can be caused by either blunt or penetrating trauma. Haemothorax, pulmonary collapse due to compression, rib fractures, and hepatic or splenic injuries may coexist. Ruptures due to blunt trauma are usually larger and more immediately apparent. The appearances are easily misinterpreted as a subpulmonic effusion, loculated haemopneumothorax, or just a high hemidiaphragm of unknown cause. A contrast examination may be necessary to show bowel loops within the thorax.

Major vascular and cardiac injuries

Major vascular and cardiac injuries may be found in association with sternal or first rib fractures and in patients with injuries caused by deceleration forces. Patients with aortic rupture may well survive to reach the resuscitation room. Vital features include mediastinal widening, loss of definition of the aortic knuckle, deviation to the right of the trachea, and thickening of the apical pleura on the left side (see previous article in this series on thoracic trauma).

Cardiac and pericardial trauma may cause haemopericardium with the risk of tamponade. The heart size will be increased, but classically described features of a globular appearance and notable clarity of cardiac outline due to reduced motion are unreliable.

Mediastinal injuries

Penetrating injuries may result in mediastinal or pericardial emphysema. This is apparent in the radiograph as a white line that parallels the mediastinal border, particularly on the left side. Free mediastinal air may extend to the neck, where streaky air lucencies are readily visible in the soft tissue planes. The tracheobronchial tree and oesophagus may be injured in patients with blunt, penetrating, or deceleration trauma. Oesophageal rupture typically causes mediastinal emphysema with an accompanying left sided pleural effusion. Bronchial fracture may cause segmental or lobar collapse but can also be very subtle radiologically.

Other findings

Sequelae of thoracic trauma include segmental, lobar, or pulmonary collapse. Features of opacification and alteration of hilar and fissure positions must be sought. Fluid aspiration causes patchy air space consolidation, typically in the upper lobes or apices of the lower lobe. Acute pulmonary oedema may appear solely as "bat's wing shadowing" extending from the hila resulting from fluid exudation into the alveolar spaces. Interstitial oedema is hallmarked by peribronchial thickening, the septal lines of interlobular fluid, and, indeed, pleural fluid. A pleural effusion may also indicate an abdominal injury such as splenic or hepatic laceration, and signs of subdiaphragmatic air from a visceral perforation should be sought in the chest radiograph.

Pelvic injuries

"Open book" pelvic fracture showing wide separation of the pubic symphysis and diastasis (widening) of the right sacroiliac joint.

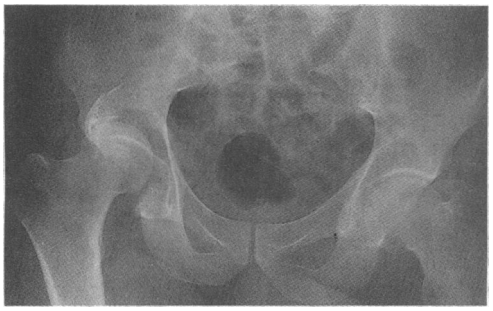
The plain supine anteroposterior radiograph of the pelvis may be supplemented by radiographs of the inlet or outlet to show further detail of fractures or displacement. Judet views—acetabular views at 45°—may also be helpful.

General principles of symmetry and cortical and trabecular integrity apply to pelvic radiographs. Intrapelvic fat and soft tissue planes should be closely observed. Their displacement may be caused by large haematomas, which are common in patients with pelvic fractures owing to proximity of major vessels, venous plexuses, and considerable skeletal vascularity.

A single fracture in a bony ring with ligamentous support such as the pelvis should initiate the search for either a second fracture or a joint diastasis. Individual fractures may occur in the pubic rami, iliac wing, or sacrum.

Bilateral pubic ramus fractures with separation (the straddle injury). Catheterisation for cystography has been performed. There is also an undisplaced left iliac wing fracture.

Fractures of the major pelvic ring are caused by different types of forces. Lateral compression may result in inward rotation of a hemipelvis with disruption of the sacroiliac joint. The pubic rami are usually fractured and sometimes the sacrum is also. Anteroposterior forces tend to drive the iliac wings apart and disrupt the symphysis (the open book fracture). Pubic ramus fractures may also be present. The straddle injury of bilateral pubic ramus fractures may be associated with urethral damage. Vertical shear forces tend to displace the hemipelvis upwards in relation to the sacrum, with high risk of vascular injury. Additional pelvic fractures will usually be present.

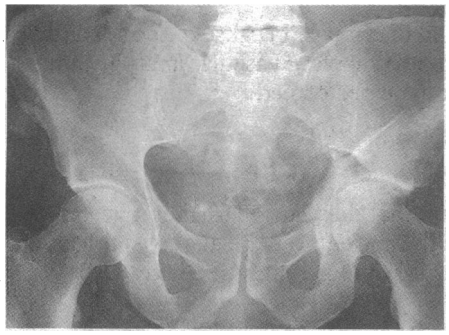


Acetabular fracture with posterior dislocation of the right femoral head. The acetabular fragment shows as a white line above the hip joint. The hip joint space is considerably widened medially and inferiorly.

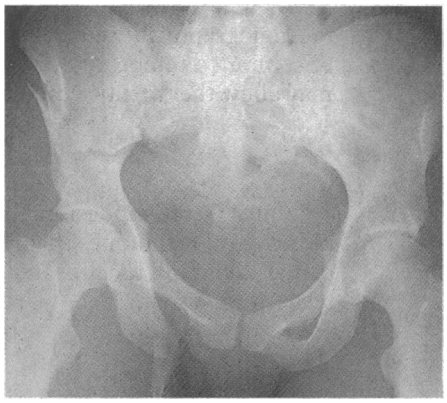
The commonest type of acetabular fracture occurs in the posterior wall and is associated with posterior hip dislocation in a patient who has sustained a strong anterior force while in a sitting position. A lateral force may result in a central hip dislocation with associated acetabular fracture, but relocation either spontaneously or by manipulation may leave only subtle soft tissue changes. Anterior acetabular fractures are the least common.

A compound pelvic fracture may occur either with breaching of the skin or if bone fragments perforate the vagina or bowel. Such complication may raise the associated mortality to as high as 50%. Patients with pelvic fracture may require contrast examinations—for example, intravenous urography, urethrography, or cystography. Major pelvic trauma is associated with rupture of the bladder in 10-15% of cases.

Provided that the patient is stable, computed tomography provides excellent definition of the position of fragments, the acetabular anatomy, and any fluid collections. Arteriography may be used diagnostically or for therapeutic embolisation of bleeding vessels.



Left sided acetabular fracture with central dislocation of the femoral head. There is narrowing of the medial aspect of the hip joint space and medial displacement of the femoral head. Note the thick white line of overlapping bone fragments.



Vertical shear fracture involving both right sided pubic rami and iliac wing with a small amount of superior displacement. A sacral fracture is also visible.

Contrast material within the bladder from an intravenous urogram shows bladder displacement by a large haematoma. The transverse sacral fracture can be clearly seen.

Skull injuries

Criteria for skull radiography

- Suspected penetration of the skull by a foreign body
- Cerebrospinal fluid or blood discharging from the nose or ear
- Loss of consciousness
- Altering consciousness during examination
- Focal neurological symptoms or signs
- Patient lives alone or is likely to be poorly supervised during the subsequent week
- Adequate clinical assessment is precluded by injury, intoxication, or a long standing clinical condition, such as stroke

Unnecessary importance is sometimes given to radiography of the skull. Criteria for its use have been proposed that essentially require that a neurological deficit of intracranial origin is present or that assessment of such a deficit is not possible. Some features to aid differentiation of fractures from other lucencies appearing in the skull radiograph are given in the table. Look carefully for the depressed fracture, which may be shown only by the white line of overlapping fragments.

Differentiation of lucencies in the skull

Feature	Artery	Vein	Suture	Fracture
Shape	Regular and roughly straight	Wandering	Tortuous but inner junction straight	Usually straight
Calibre	Even	Uneven	Even	Variable
Cortical margin	Present	Present	Present	Absent
Branching	Common, even	Common, irregular	Rare (for example, lambdoid suture)	May be stellate if depressed
Anatomical site	Fairly constant	Very variable	Constant	Anywhere

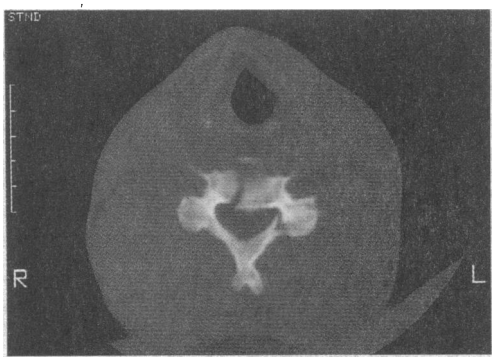
Other imaging techniques

Apparent crush fracture of C6 with flattening of the vertebral body and loss of alignment of the anterior marginal line. There is considerable prevertebral soft tissue swelling.

Ultrasonography, computed tomography, angiography, and embolisation do not have a place in the resuscitation room, but they may alter the pattern of immediate management once the patient is clinically stable.

Ultrasonography may be used to assess damage to soft tissues, particularly in the abdomen. It can be used frequently in monitoring as it does not expose the patient to ionising radiation, though bowel gas and tenderness may preclude optimal imaging.

Computed tomography requires time for transfer and preparation of the patient, but this is repaid because minimum manipulation of the patient is necessary during investigation. The data obtained provide accurate assessment of the degree of internal damage as well as localising bone fragments and locating abnormal collections of air and fluid. The technique helps in determining the extent of spinal injury and compromise of the cord.



Axial computed tomogram through the C6 level shows not only the extent of the fracture through its body with some posterior fragment displacement but also a fracture through the arch (not apparent in the plain radiograph).

Angiography is used less often than previously because of the advantages of computed tomography but is better at showing vascular anatomy and may allow therapeutic embolisation to be performed.

It must be re-emphasised, however, that these are all further investigative radiological techniques that require the patient to be relatively stable. The plain radiograph remains the primary imaging technique in the resuscitation room.

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The ABC of Major Trauma has been edited by Mr David Skinner, FRCS; Mr Peter Driscoll, FRCS; and Mr Richard Earlam, FRCS.