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Ceiling-mounted radiographic equipment for trauma management in the emergency room

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Use of ceiling-mounted radiographic equipment in an emergency room for management of the multiply injured patient is described. The protocol of the Advanced Trauma and Life Support manual is followed and three plain radiographs (lateral cervical spine, anteroposterior views of the chest and pelvis) are obtained by the radiographers, who are members of the trauma team. Abnormalities were diagnosed on 7 per cent of the cervical radiographs, 31 per cent of the chest and 28 per cent of the pelvis in 108 patients during the first year of use. With full integration of the radiographers into the trauma team these three initial films are obtained within 10 min. Subsequent films can be taken of skeletal injuries found clinically or incidentally on the first three plain radiographs. It is recommended that all emergency rooms should have a ceiling-mounted radiographic unit with an automatic daylight processor to provide the best service for patients with major trauma.

As part of the development of the Helicopter Emergency Medical Service and trauma unit at the Royal London Hospital a new resuscitation room was built incorporating ceiling-mounted radiographic equipment. Experience of the first year of operation of the Helicopter Emergency Medical Service and its background have already been described[1].

Patients and methods

Equipment

When the new emergency room was planned the need for a new approach to radiography was emphasized as a key factor in obtaining quick and reliable images. A ceiling-mounted overhead radiographic unit (Siemen's Mobilette XT; Siemens, Erlangen, Germany) that operates from a standard 110/120-V outlet was chosen. The ceiling support consists of a carriage (housing both generator and power unit) with a 2·6-m articulated arm system on longitudinal rails. The unit has an output equivalent to a high-powered mobile unit (450 mA at 40 kV, 30 kW peak output and 20 kW at 100 kV).

Only four bays in a row are serviced by the gantry equipment; the fifth is used for patients who do not require radiography (*Fig. 1*). An essential complementary facility is a daylight automatic film processor, allowing efficient use of equipment by a single radiographer. The resuscitation trolleys are made from radiolucent materials with a built-in compartment beneath the trolley top for loading and positioning the radiography cassette. A standard conventional mobile unit is made available in the resuscitation area if the ceiling-mounted machine is not in action.

Personnel

The trauma team usually includes two radiographers and a radiological senior registrar. One radiographer, without interrupting the resuscitation team, makes the three standard exposures and the second unloads the cassettes into the daylight processor. The radiologist then gives an immediate report on the films.

Organization

The choice of three initial radiographs, namely cervical spine, chest and pelvis, follows the American Advanced Trauma Life Support system[2]. The radiographer is called at the same time as the trauma team and during the 5 min available before the patient arrives the machine can be placed in position on the left side of the trolley for taking the cervical spine radiograph first.

The first radiograph carried out using the horizontal beam is a lateral view of the cervical spine with spinal stabilization (radiolucent cervical collar) in place and downward traction on both upper limbs in an attempt to visualize C7 and T1. Anteroposterior views of the chest and pelvis are then obtained.

While the radiographer waits for the chest and pelvis radiographs to be processed, the cervical spine film is assessed for completeness: C1–C7 and preferably T1 must be adequately visualized. If the lateral cervical spine is technically complete, the radiographer proceeds to other appropriate films, usually long bone, as designated by the team leader on the basis of findings from the surgical registrar and with advice from the radiologist. If the cervical spine film is incomplete a repeat lateral view, trauma obliques, or a swimmer's view is taken. The last requires a change in patient position and is contraindicated where there is a high suspicion of cervicothoracic junction injury[3]. Additional views, including anteroposterior of the lower cervical spine and the odontoid, may be necessary, but if they cannot be obtained then an immediate computed tomogram of the cervical vertebrae is obtained. This decision may be influenced by the presence of other injuries that require computed tomography (CT) for assessment.

Safety

Permanent protective walls are required as the overhead unit comprises fixed radiographic equipment. Shielding between adjacent bays is provided by mobile screens with 1·32-mm lead equivalent and 1·5-mm lead equivalent glass. All members of the trauma team wear lead aprons and any personnel who attend trauma calls frequently wear a radiation-monitoring badge.

Results

Patients

In the first year of the helicopter operations 135 patients were admitted as a primary rescue. The Injury Severity Score ranged from 0 to 57 (median 20); major trauma is any score of 16 or more. Of 108 patients in the present study, 99 had blunt trauma and nine penetrating injuries. The predominant single system injury was to the head (54 cases) but multi-

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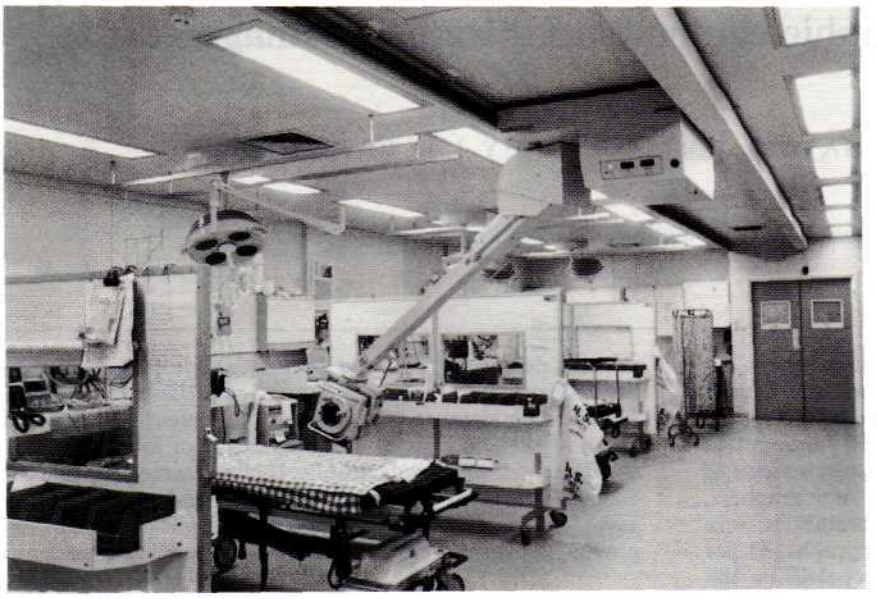

Fig. 1 Resuscitation room (part of the Helicopter Emergency Medical Service and Trauma Unit) in the Royal London Hospital with ceiling-mounted radiographic machine and individual resuscitation bays

Table 1 Emergency radiology for trauma

Potential assets	Mobile unit in resuscitation room	Conventional radiography room with static equipment	Ceiling-mounted radiographic unit
Ease of access to patient	Floor-standing mobile unit limits space around patient	Patient must be transferred to separate radiography room where there is usually inadequate space for trauma personnel and lack of access to patient	Good because ceiling-mounted unit does not occupy floor space
Rapidity of movement between bays	Mobile unit takes longer to move between bays	Only one patient at a time in radiography room	Ceiling track allows rapid movement between bays, with cables concealed and not trailing on the floor
Operating control	Hand-held switch on mobile unit	Fixed control panel	Hand-held remote control unit
Film processing	Inherent delay in remote dark-room processing facilities	Processing may not be immediately adjacent	On-site automatic daylight processor enables film processing in resuscitation room
Availability of system in an emergency	Mobile machine may not be immediately available	Radiography room may already be in use	Permanent dedicated system always available when required
Resuscitation facilities	Immediately available	Not available in conventional radiography room	Immediately available

regional trauma occurred in 61 cases. Twenty-five patients subsequently died.

Films of 108 patients were reassessed for abnormalities and adequacy; 27 patients had no radiographs because either none was taken (e.g. inappropriate in stabbing) or films were lost in a hospital to which they were subsequently transferred.

Cervical spine radiography

Abnormalities were identified on cervical spine radiographs ($n = 104$) in seven patients (7 per cent). Four had subluxation diagnosed, one of whom died with severe craniocerebral injury and another had a normal computed tomogram. Two patients had a body compression fracture, one of which was confirmed by CT, but the other patient died from severe craniocerebral injury before a computed tomogram could be obtained. One had possible air in the spinal canal, but a fracture of the base and vault of the skull with an intact cervical spine was diagnosed using CT.

Chest radiography

Thirty-three abnormalities (31 per cent), including six taken after a pleural drain had been inserted at the scene of the accident, were identified on 105 chest radiographs. Ten patients had a pneumothorax, three a haemothorax, two a haemothorax–pneumothorax, 18 lung contusion and 19 single or multiple rib fractures. Other skeletal fractures seen on the chest film were clavicle (five), scapula (two), acromioclavicular (one) and humerus (one).

Pelvic radiography

Abnormalities were identified on pelvic films ($n = 92$) in 26 patients (28 per cent). Five patients had a type I fracture (individual bone without a break in the pelvic ring), ten a type II (a break in the continuity of the pelvic ring), 11 type III (a double break in the continuity of the pelvic ring) and nine type IV (acetabular fracture). Some patients had multiple fractures. Fractures of the proximal femur (six) and lumbar

vertebrae (two) were identified on the radiograph of the pelvis. Eleven patients had associated chest injuries

Computed tomography

Sixty-seven patients (62 per cent) had further imaging. CT of the head was performed in 24 patients (37 per cent) and of the head and cervical vertebrae in 28 (42 per cent). A further 11 patients (16 per cent) had a body scan (abdomen eight, pelvis two, chest one) with the head computed tomogram. One patient had a scan of the abdomen only and one a pelvic scan. Two patients had CT of the cervical spine alone.

Discussion

Plain radiography remains the most important single imaging technique for the initial evaluation and diagnosis of the multiply injured patient[4,5]. The advice contained in the North American *Advanced Trauma Life Support Student Manual*[2] to perform radiographs of the cervical spine, chest and pelvis is borne out by experience. The number of abnormalities detected depends on the injured population but in the present study 7 per cent were found on the cervical spine films, 31 per cent on those of the chest and 28 per cent on those of the pelvis. The lateral cervical spine radiograph was considered incomplete in 25 per cent of cases because it did not include the essential C7–T1 junction and had to be supplemented by subsequent repeat lateral films or a swimmer's view. This inability to decide whether or not there is a neck injury has led to the routine introduction of two oblique films of the cervical vertebrae. The results of this policy will be evaluated to determine whether the diagnostic process can be accelerated and made more accurate.

The seriously ill patient frequently arrives already intubated and with a pleural drain inserted to deal with a haemothorax or pneumothorax. When in doubt endotracheal intubation is the safest procedure with a patient who has compromised breathing but in those requiring positive-pressure ventilation the danger of tension pneumothorax is greatest. The purpose of the emergency chest radiograph is to diagnose lung contusion, assess the presence of a haemothorax or pneumothorax, enable the mediastinal shadow breadth to be measured and discover fractured ribs. It also establishes the correct position of the endotracheal tube and pleural drain. The pelvic radiograph is essential at this early stage; not only can injury to the pelvic ring and its individual bones be diagnosed but the head and upper end of the femur can be seen. Pelvic and chest wall trauma frequently occur together, and radiographs reveal fractures and displacements which, together with clinical impressions, predict the likelihood of associated damage to radiolucent structures. All three films are essential, as they provide rapidly vital diagnostic information in the multiply injured patient.

The order of the three films may be changed but this break in protocol must be audited. In a penetrating wound of the chest the chest radiograph may take precedence but in general terms the radiographers can perform the cervical spine lateral film so quickly that almost no time is lost before moving to the chest film. Repositioning the radiographic tube from the position prepared before the patient arrived wastes time. Knowledge that the cervical spine radiograph appears normal is essential before log rolling the patient at the end of the secondary survey to examine the back and perform a rectal examination. CT has become an important adjunctive procedure in the evaluation and diagnosis of trauma and should be available in the emergency department[6].

With few exceptions, notably head injuries, plain films remain the primary imaging technique. The purchase and placing of the ceiling-mounted unit provides an essential part of emergency room management. The advantages of the unit and the disadvantages of conventional radiographic facilities are summarized in *Table 1*. The majority of serious injuries can be diagnosed or suspected from the three essential radiographs. The routine addition of two cervical spine oblique films may make the diagnosis or exclusion of neck injury more accurate. Further radiographs are taken in the acute phase because abnormalities are suspected by localized pain in the conscious patient, or by deformity or external damage when the injured patient is unconscious. These additional radiographs are usually of the upper or lower limbs and the thoracic or lumbar vertebrae. The accuracy of fracture diagnosis in the emergency room should be greater than 90 per cent but there is no indication for routine additional films as the injuries are not usually life threatening.

References

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