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REVIEW ARTICLE

Trauma in the elderly patient

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ABSTRACT

Major Trauma Centres and Emergency Departments are treating an increasing number of elderly trauma patients in the UK. Elderly patients, defined as those over the age of 65 years, are more susceptible to injury from lesser mechanisms of trauma than younger adults. The number of elderly trauma cases is rising yearly, accounting for >25% of all major trauma nationally. The elderly have different physiological reserves and a different response to trauma due to pre-morbid frailty, co-existing conditions and prescribed medication. These factors need to be appreciated in trauma triaging, radiological assessment and clinical management. A lower threshold for trauma-call activation is recommended, including a lower threshold for advanced imaging. We will review general principles of trauma in the elderly, outline injury patterns in this age group and illustrate the radiological features per anatomical site, from head to pelvis and the extremities. We advocate using contrast-enhanced computed tomography as the primary diagnostic imaging modality as concern about intravenous contrast agent-induced nephropathy is relatively minor. Prompt investigation and diagnosis leads to timely appropriate treatment, therefore the radiologist can discerningly improve morbidity and mortality in this vulnerable group.

INTRODUCTION

Elderly patients differ significantly from the younger trauma patient in physiology, shock response, mechanisms and types of injury. An appreciation of these differences reduces the risk of under-triaging, so avoiding delay in investigation and diagnosis and decreasing morbidity and mortality.

We will review general principles of trauma in the elderly, outline injury patterns in this age group and illustrate the radiological features by anatomical region.

TRAUMA IN ELDERLY PATIENTS: WHY IS AGE A FACTOR?

Across the Western world, the population is ageing. In the UK, 18% of the population is now aged 65 and over (up from 16% 10 years ago), while 2.4% are aged 85 and over.¹ More than a quarter of trauma patients are over the age of 75, with obvious implications for national and local healthcare planning, particularly for Major Trauma Centres (MTCs) and Emergency Departments.²

The elderly are not only important demographically; advancing age is also associated with worse outcomes after trauma. Increasing age is an independent predictor of poor outcome following trauma, with a 2.4–5.6 greater risk of death.^{3–6} Age over 65 years is an independent risk factor for increased mortality in trauma, controlled for the same Injury Severity Score (ISS).^{7,8} Hence, 65 years is commonly accepted as the definition of elderly for trauma purposes.^{7,8}

PHYSIOLOGICAL RESERVES IN THE ELDERLY TRAUMA PATIENTS AND RESPONSE TO SHOCK

Advancing age is associated with progressive physiological changes affecting multiple systems, summarised in [Table 1](#).⁹

Impaired physiological responses or system failure(s) may also mask injuries and their severity, making clinical assessment and treatment more difficult. For example, haemorrhage and/or hypoperfusion can be missed because basal vital signs do not reflect shock response. Medication such

Table 1. Physiological changes with ageing

Cardiovascular system

1. Stiffening of the aorta and peripheral arteries
2. Increased peripheral vascular resistance
3. Increase in left ventricular thickness
4. Decreased cardiac output
5. Conduction abnormalities
6. Less ability to increase heart rate

Respiratory system

1. Decrease in surfactant
2. Diminished ciliary clearance
3. Less effective cough
4. Increased work of breathing
5. Chest wall stiffness/reduced elasticity
6. Atrophy of respiratory muscles
7. Diminished response to chemoreceptors
8. Decreased FEV^a
9. Decreased number of alveoli
10. V/Q^b mismatch

Neurological system

1. Decrease in brain size
2. Reduction in functioning neurons

Renal system

1. Decreased glomerular filtration rate
2. Decreased drug clearance time
3. Diminished control of acid-base balance
4. Inefficient concentrating and diluting
5. Poor renin-angiotensin response

Gastrointestinal (GI) system

1. Reduction in gut mobility
2. Decreased bowel absorption
3. Poor nutritional status
4. Decreased body mass

Immune system

1. Decreased humoral and cellular immunity

Musculoskeletal system

1. Decrease in bone mass and density
2. Stiffening of ligaments and joints
3. Joint degeneration and cartilage thinning
4. Loss of muscle bulk and sarcopenia
5. Disc degeneration

^aFEV: forced expiratory volume, the volume of air expelled during a forced breath

^bV/Q, ventilation (V)-perfusion(Q) ratio

as beta-blockers, anticoagulants and steroids further hide the normal shock response.⁹

Co-morbid factors such as renal and hepatic impairment, chronic steroid use or previous malignancy, further increase the mortality risk in the elderly trauma patients, by up to five times.¹⁰

CLINICAL EVALUATION AND TRIAGING

Triage can be more challenging in elderly trauma if there are barriers to communication, such as deafness or dementia, which can result in the severity of injury being under-appreciated.

Lower threshold for trauma protocol activation is recommended, because if an elderly trauma patient is under-triaged at presentation, their discharge disability and mortality rate are significantly increased (up to four times greater than younger adult patients).¹¹ Additionally, patients who are under-triaged away from higher dependency units (HDU) to a general ward have a fourfold increase in mortality rate and discharge disability compared to younger patients.⁵ As for other trauma patients, outcomes in elderly trauma are better for patients treated at MTCs.¹²

Elderly trauma patients in shock should be treated promptly and aggressively. Early admission of the appropriate patients to HDU and use of invasive monitoring reduces morbidity and mortality.¹³ Early involvement of geriatric physicians improves advanced care planning and multidisciplinary care makes discharge more speedy and, importantly, more successful.¹⁴ The radiologist can help clinicians with early, accurate diagnosis, enabling timely intervention.

RADIOLOGICAL ASSESSMENT

Prompt whole body computed tomography (CT) is the gold standard in elderly trauma imaging, as for younger patients. This decreases the duration of hospital stay, intensive therapy unit (ITU) admission rates, morbidity and mortality, even if the patient has a high ISS.¹⁵

Our institution applies a standard imaging protocol to all patients over the age of 18 years presenting with traumatic injury. In cases of blunt trauma, patients undergo a “Combiscan”, which involves biphasic contrast administration to allow simultaneous arterial and portal venous enhancement followed by a single volumetric multidetector CT acquisition.¹⁶ In penetrating trauma, separate arterial phase and portal venous phase scans are obtained to differentiate between arterial and venous bleeding; this better detect targets for interventional radiological or surgical response.¹⁶

Intravenous contrast is used as part of the standard protocol unless there is documented evidence of a contrast allergy (as set out in the Royal College of Radiologists Guidelines¹⁷). There is a higher prevalence of background renal impairment in older patients, but there is no evidence that age is an independent risk factor for contrast-induced nephropathy.¹¹ In our opinion, the diagnostic yield of a contrast-enhanced study outweighs the risk of contrast-induced nephropathy which can be managed medically; especially in view of the potential consequences of under-triage.

Causes of trauma

The elderly are susceptible to more serious injury from lesser/minor trauma when compared to younger adults. Unlike the young, only 25% of trauma in the elderly is due to road traffic collisions (—driver or pedestrian). Falls are the main cause of trauma in the elderly, accounting for 75% of cases, and are often low-level from standing or sitting height.^{10,11,15,18–20} These may be mechanical or due to a variety of medical causes.²¹ Injuries due to such low-level falls in the elderly should not be presumed

Figure 1. A 90-year-old female patient with loss of consciousness after a fall from a height of less than 2 m. Axial unenhanced CT image shows a large right convexity subdural haematoma and a small volume of subarachnoid blood, with moderate midline shift to the left and effacement of the lateral ventricles.

to be insignificant and can carry serious consequences. Falls are the fifth leading cause of death in adults over 65 years old.²²

PATTERNS OF INJURY BY ANATOMICAL REGION

Head Trauma

Head trauma in the elderly carries a greater risk of intracranial injury irrespective of ISS, as well as increased mortality and morbidity (2x and 4x respectively), when compared to the younger trauma patient group.^{11,23,24} This is due to the increased risk of haemorrhage in all the intracranial compartments, but particularly the subdural compartment. As the brain atrophies, the subdural compartment widens, stretching the bridging cortical veins which are then more susceptible to shearing injury.^{10,11} In addition, increasing fragility of vessels, hypertension, amyloid angiopathy, haematological conditions, alcohol and anticoagulant use increase the risk of bleeding in all compartments of the brain.^{11,20} Patients on anticoagulation have a 4–5 times increased risk of mortality from intracranial haemorrhage and are more likely to require intervention or experience complications (Figure 1).²⁵

It is estimated that around 3% of elderly patients will have intracranial injury without clinical indicators such as history of loss of consciousness, focal neurology or change in GCS.²⁶ This may be partly explained by the age-related increase in space between the brain and the skull which allows expansion of the intracranial contents with less symptoms.²⁰ Although National Institute

of Clinical Excellence criteria for performing CT Head examinations in the elderly are the same as for younger adults (GCS < 13 or GCS < 15 two hours after injury), it may be wise to perform these studies in all elderly trauma patients, other than in minimal to mild trauma. Early detection and treatment of traumatic abnormalities significantly improves overall clinical outcome and increases the chance of returning to normal independent living.^{24,26}

If a patient on anticoagulation has a positive scan for haemorrhage, this should be reversed. If the scan is negative, a protocol of twenty four hours of observation followed by repeat CT will identify most occurrences of delayed bleeding.²⁷

Spinal trauma

The elderly are at greater risk of having a spinal injury, mainly due to poorer osseous mineralisation, osteoporosis, and increased spinal rigidity. Spinal injuries tend to occur with seemingly minor trauma and are not infrequently multilevel.^{11,28–30} Since these may be clinically unstable and at risk of neurological decline, prompt imaging is required.¹¹

Cervical spine

Cervical spine trauma is an important source of morbidity and mortality in elderly patients who often sustain fractures after relatively low energy injuries. There are three recognised patterns of falls: fall from standing, fall from a height and falling down stairs. The latter results in a hyperextension injury, which may be associated with loss of consciousness and upper cervical injury.^{28,29} Hyperextension injuries also occur in patients with direct anterior craniofacial (“faceplant”) injury.²⁸

Conditions such as senescent spondylosis deformans, ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis and ossification of the posterior longitudinal ligament may result in increased rigidity of the mid and lower cervical spine, with relatively increased mobility of the superior cervical spine (C1 and C2) and craniocervical junction.^{28,29} As a result, up to 60% of fractures in the elderly involve the C1 ring and C2 dens.²⁹ If a fracture is detected, further assessment for possible contiguous and non-contiguous spinal fractures is required, as 30–40% of patients sustain multilevel cervical spinal injuries (Figure 2a–c).²⁹

Spondylosis also results in an increased incidence of spinal canal stenosis. This increases the risk of spinal cord injury, with or without bony injury, especially if the paraspinal ligaments and the ligamentum flavum are disrupted.¹¹ In hyperextension injuries, the bulging ligamentum flavum may compress the spinal cord resulting in a central cord syndrome (Figure 2a–c).

The diagnostic value of radiographic assessment is limited by reduced bone density and spondylotic changes, therefore injuries may be missed in up to 40% of adult and 80% of elderly trauma patients.²⁸ Hyperextension injuries, for example, may be very subtle or occult on radiography with only slight widening of an intervertebral disc space or a soft tissue haematoma.²⁸ There should be a low threshold for imaging with CT (±MRI), given the complications that may arise from a missed cervical spinal

Figure 2. A 70-year-old male patient after fall from a height of less than 2 m. (a) Sagittal CT image on bone windows demonstrates widening at C6-C7 vertebral bodies (arrow) likely secondary to a hyperextension injury. (b) T2-weighted sagittal MRI performed the same day. There is constitutional narrowing of the mid-cervical canal. This sequence demonstrates a shallow pre-vertebral haematoma (arrow 1), cord contusion and haemorrhage from C4 to T2 (arrow 2), and ligamentum flavum interruption (arrows 3). Anterior and posterior longitudinal ligament interruption (arrow 4) and disc extrusion was also present (not shown). "Minor" trauma can have devastating consequences in the elderly. (c) A 90-year-old male patient with a fall from a height of less than 2m. Sagittal CT image on bone windows demonstrates diffuse moderate osteopenia. There is a mildly displaced fracture through the base of the odontoid peg (arrow 1), a fracture of the anterior inferior corner of C4 (arrow 2) and fractures of spinous processes of C3 and C4 (arrows 3 and 4). The pattern of fractures suggests a hyperextension injury. C2 fractures are common in the elderly, as are multiple associated fractures.

Figure 3. A 70-year-old male with right upper limb weakness following a fall from height of less than 2 m. No fracture or dislocation is demonstrated on the sagittal CT image on bone windows (a), but there is mild diffuse osteopenia. A sagittal T2 weighted MRI (b) obtained within 24 h demonstrates oedema in the spinal cord from C2 to C5 without ligamentous disruption, on a background of constitutional narrowing of the mid cervical vertebral canal and ligamentum flavum hypertrophy. This constitutes spinal cord injury without radiological (CT) evidence of trauma (SCIWORET).

fracture and the risk of spinal cord injury without radiological evidence of trauma (SCIWORET) (Figure 3).

Since patients with an apparently isolated head injury have a 5% risk of additional spinal injury, we suggest that cervical spine CT is added to all CT head studies in the elderly.³⁰

Cervical trauma is also associated with blunt cerebrovascular injury.³¹ Factors associated with increased incidence of vascular injury include neurological deficits, GCS < 6, petrous bone fracture, foramen transversaria fracture, diffuse axonal injury and a Le Fort II or III fracture (41% risk of blunt cerebrovascular injury). In these patients, CT angiography is helpful in detecting any cerebrovascular injury (Figure 4).

Thoracolumbar spine

Osteoporosis is a major risk factor for vertebral compression fractures particularly in the thoracolumbar spine. As well as being common in post-menopausal women, osteoporosis also affects a third of men over the age of 75 years.¹¹

Thoracolumbar spinal injuries, like cervical spinal injuries, can be difficult to detect radiographically.³² CT offers better diagnostic

Figure 4. An 80-year-old male patient who fell from a height greater than 2 m. Unenhanced axial CT (a) shows moderate osteopenia with an acute unstable C6 vertebral body fracture involving both transverse foramina (thick arrows) and the spinous process. The coronally reformatted CT angiogram (b) demonstrates short segment occlusions of the vertebral arteries bilaterally at the level of the fracture (thin arrows).

value and assessment of vertebral body height reduction and spinal canal diameter in cases of burst fractures with retropulsion. It also permits assessment of underlying lesions in suspected pathological fractures. A CT examination of the whole spine is advised in patients with significant spinal trauma, as 40% of injuries involve multiple, non-contiguous segments.¹¹ MRI is useful in cases of equivocal CT findings, suspected ligamentous injury, spinal cord injury or occult fractures.³³

The most common site of injury is at the thoracolumbar junction (T12-L2), followed by the mid-thoracic spine. Mortality is related to the number of fractured vertebrae and has been shown to be as high as 20% for fractures in rigid spines; often as a result of pneumonia and respiratory failure.^{11,33–35}

While the evidence for vertebroplasty and kyphoplasty in decreasing pain and encouraging mobilisation is equivocal, the radiologist can help to triage vertebral fracture patients into those

who might be suitable for these procedures and those where it is contraindicated, such as for a burst fracture.³⁶

BLUNT THORACIC TRAUMA

Rib fractures are the most common manifestation of blunt thoracic trauma in the elderly. Age-related osseous demineralisation leads to increased risk of rib fractures even with low energy mechanisms. These need to be treated seriously as they have a higher mortality rate, which may be partially explained by diminished physiological reserve, respiratory compromise and increased susceptibility to infections. Higher ISS (>30) and multiple fractures are particularly concerning.³⁷

Rib fractures are also often a sentinel injury associated with a higher ISS and more severe trauma, such as cardiac and great vessel injuries, pneumothoraces, pulmonary contusions, as well as liver and splenic trauma. Similarly, clavicular fractures are sentinel injuries for severe thoracic and brain injuries and are associated with a higher mortality rate in the elderly (Figure 5).^{5,11,37,38}

Mortality is directly proportional to the number of ribs fractured: if more than 6 ribs are fractured, the mortality rate is 33%. If there are more than 3 rib fractures, outcomes are better if the patient is treated aggressively with HDU admission and adequate analgesia to reduce the infection rate and need for mechanical ventilation. Adequate analgesia may be achieved with nerve blocks and epidural anaesthesia.^{11,37,38}

Flail segments are increasingly treated with open reduction and internal fixation at many MTCs. This has been shown to reduce the need for ventilatory support, shorten the intensive care and overall hospital stay, reduce the incidence of pneumonia and septicæmia, reduce the risk of chest deformity and reduce the mortality rate (Figure 6).^{38–41}

The radiologist can proactively identify patients with significant rib injuries and flail segments that may benefit from the above interventions. This will enable patients to mobilise

Figure 5. A 70-year-old driver who was ejected from the car in a road traffic accident. Axial contrast-enhanced CT of the thorax demonstrates displaced right rib fractures on the bone window image (a). The soft tissue window (b) shows an underlying right pneumothorax (arrow 1), haemorrhagic pulmonary contusions in the right lower lobe (arrow 2), right haemothorax (arrow 3), right soft tissue injury and subcutaneous emphysema (arrow 4). There is also a fracture of the right transverse process of the thoracic vertebra at this level (arrow 5). There is a partially imaged right pleural drain anteriorly (thin arrow).

Figure 6. An 80-year-old female patient who had an unwitnessed fall down multiple stairs. There are multiple displaced fractures of the first 5 right ribs demonstrated on the volumetric 3D CT reconstructions (arrows in a). The subsequent radiograph (b) shows open reduction and internal fixation of the right rib and right clavicle fractures. The patient has developed right lower lobe collapse and consolidation and a right pleural effusion in the interim. There is an endotracheal tube *in situ*, a right pleural drain and previous bilateral breast augmentations.

and commence physiotherapy earlier, decreasing the risk of secondary chest infections and their consequences.^{40,41}

Traumatic vascular injuries are uncommon in the elderly population, occurring in approximately 1% of cases. They are associated with a fourfold increase in adjusted mortality and early intervention should be considered.^{42,43} Injury is usually secondary to blunt trauma, most commonly in motor vehicle crashes, due to deceleration injury.⁴³ Atherosclerosis may contribute to increased risk of injury.⁴⁴ Patients with vascular injuries tend to have a higher ISS and the thoracic aorta is the most frequently involved vessel (Figure 7).⁴³

BLUNT ABDOMINAL TRAUMA

Blunt abdominal injury occurs following high-energy trauma and is no more common in elderly patients than in younger patients. However when abdominal trauma does occur, there is up to a fivefold increase in the mortality rate when compared to younger patients.¹¹ Clinical assessment is more challenging in geriatric patients, yet failure to intervene promptly results in a higher morbidity and mortality.¹⁸ Therefore, there should be a

Figure 7. An 80-year-old male patient who made an emergency stop. The patient had chest pain and marked bruising on examination of his chest. Sagittal and axial images from a contrast-enhanced CT of the thorax demonstrate an acute Type B aortic dissection, associated with aneurysmal dilatation of the proximal descending aorta (arrows in a and b). Right lung consolidation and haemothorax noted. The bony windows confirm the presence of a sternal fracture (arrows in c and d). It was presumed that this dissection was traumatic, although the converse is also possible and the emergency stop was due to the dissection.

Figure 8. A 70-year-old male driver who was involved in a head on crash and ejected from the car. Coronal image from an arterially enhanced CT of the abdomen demonstrates a grade 4 left renal laceration with a large subcapsular haematoma (arrow 1), a small subcapsular haematoma surrounding the right kidney (arrow 2) and retroperitoneal haematoma (thin arrows). In addition, there is a perisplenic haematoma (arrow 3) from a low grade laceration (not shown).

lower threshold for early imaging with contrast-enhanced CT to enable surgical and radiological intervention (Figure 8).

PELVIC TRAUMA

Pelvic trauma in the elderly may be caused by low- or high-energy trauma: including motor vehicle accidents and falls.^{11,45,46} Lateral compression fractures are five times more common than antero-posterior compression fractures in the elderly population, a reversal of the normal pattern observed in younger patients. Osteoporosis may also account for the susceptibility of older patients to fractures from low energy mechanisms that would not normally produce fractures in younger patients.^{11,46}

Elderly patients who sustain pelvic trauma have a fourfold increase in mortality rate (up to 20%) when compared to younger patients. They also suffer greater morbidity and have a longer length of hospital stay despite aggressive treatment. Mortality is most often a result of multiorgan failure; however, haemorrhage remains a major concern. Age over 60 years has been shown to be a significant risk factor for active bleeding, with the elderly having an eightfold risk of significant pelvic bleeding compared with younger adults, which may require early intervention.^{11,20,46,47}

Haemorrhage in lateral compression fractures does not often respond to external fixation or fracture stabilisation. Occult

Figure 9. A 70-year-old male patient who fell down two steps. (a) Plain radiograph demonstrates undisplaced fractures of the left superior and inferior pubic rami. (b) Coronal CT images confirm extraluminal blush of contrast (fat arrow) from the right pelvic side wall with bilateral retroperitoneal haematoma, larger on the right (thin arrows). This area of active haemorrhage was subsequently successfully embolised. Apparently “minor” pelvic fractures may be associated with significant active bleeding.

cardiovascular dysfunction is common; as many as two thirds of patients over the age of 60 years with a bleeding complication on CT were asymptomatic. Early invasive monitoring and intervention with angiography has been shown to improve outcomes and although there are no universally agreed guidelines, many centres recommend a low threshold for repeat CT imaging or angiography with embolisation (Figure 9).^{11,45,47}

EXTREMITY FRACTURES

Extremity fractures in the elderly may be sustained following high-energy trauma in relatively normal bone or minor trauma or insufficiency fractures in osteopenic bone (including in patients on bisphosphonate therapy). Additionally, fractures may be pathological or peri-prosthetic.¹¹

All extremity fractures in the elderly are associated with increased mortality with increasing age. A typical femoral neck fracture for example, is associated with increased mortality (up to 20% 1-year mortality risk) and morbidity (one third of patients do not return to independent living).¹¹

Proximal femoral fractures are the most commonly sustained extremity osteoporotic injury, followed by fractures of the pelvis, femoral shaft, proximal humerus, distal femur and distal radius respectively.⁴⁸ Fracture severity is increased in patients with osteoporosis, mimicking injuries seen in younger patients after high-energy trauma, and there is greater need for surgical fixation.⁴⁹

All patients with suspected extremity fractures should initially be assessed by radiography. There should be a low threshold for continuing to CT or MRI if the initial radiograph is normal; retrospectively reviewed radiographs only detect as little as 15% of MRI-apparent insufficiency fractures of the proximal femur or pelvis.⁵⁰ There is particularly poor sensitivity for sacral and acetabular fractures.⁵⁰ CT identifies 69% of insufficiency fractures whereas MRI identifies 99% of insufficiency fractures of the pelvis and proximal femur. MRI will often reveal

Figure 10. An 80-year-old male patient with a fall from a height of less than 2 m. Oblique coronal image (bone window) from a contrast-enhanced CT of the abdomen and pelvis demonstrates an acute fracture of the L2 vertebral body on the right (arrow 1) and a comminuted, moderately displaced left intertrochanteric fracture (arrow 2).

additional, unsuspected concomitant fractures at other sites in the pelvis (Figure 10).^{50–52}

Periprosthetic fractures are more common in patients over the age of 70 years, female patients and in those who have had previous revisions.⁵³ These fractures are best imaged with CT which allows simultaneous evaluation of bone stock.⁵⁴

Fracture complications are commoner in the elderly, especially in cases of poor mobility or prolonged bed rest. These include skin

sores (related to casts, skin traction or pressure/“bed-sores”), infection and delayed bone healing, wound healing or haematoma resolution. The incidence of venous thromboembolism is also greater in older patients, with age over 40 years an independent risk factor.^{55,56}

ELDERLY ABUSE OR NEGLECT

Physical abuse is an important consideration in elderly patients presenting with trauma. The true prevalence of elder abuse is difficult to determine but is estimated at up to 10%.⁵⁷ It often overlaps with the presentation of accidental trauma and only a small fraction of cases are correctly identified in the Emergency Department. Therefore, a high level of vigilance for elder abuse is required, just as for non-accidental injury in children.

The most common injuries in physical abuse are: upper extremities (44%), maxillofacial, dental and neck (23%), skull and brain (12%), lower extremity (11%) and torso (10%). This distribution of injuries cannot be confidently distinguished from accidental trauma but some patterns are extremely suggestive, for example injuries to the axilla, posterior torso and lower extremity, inner thigh and the dorsal or plantar aspects of the foot.^{58,59}

Victims of abuse resulting in trauma have more severe injuries are more likely to be admitted to an intensive care unit and have a higher risk of death when compared to accidental trauma patients.^{60,61} Prompt diagnosis of elder abuse is important but remains complex. Radiologists play an important role in highlighting unusual patterns of injury.

CONCLUSION

The elderly are a unique patient group and need to be treated as such. They are more susceptible to injury from lesser trauma than younger adult patients. Additionally, they may be frail, have decreased physiological reserves, co-morbid conditions, and be on medication with significant effects in trauma. Although clinical and radiological diagnosis in the elderly is more challenging, prompt investigation, diagnosis and treatment will improve morbidity and mortality. Radiologists can have a positive impact on the care and wellbeing of these more vulnerable patients.

REFERENCES

- Office of National Statistics. Article: Overview of the UK population: July 2017. 2017. Available from: <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/july2017>.
- Kehoe A, Smith JE, Edwards A, Yates D, Lecky F. The changing face of major trauma in the UK. *Emerg Med J* 2015; **32**: 911–5. doi: <https://doi.org/10.1136/emmermed-2015-205265>
- Grossman MD, Miller D, Scaff DW, Arcona S. When is an elder old? Effect of pre-existing conditions on mortality in geriatric trauma. *J Trauma* 2002; **52**: 242–6.
- Gubler KD, Davis R, Koepsell T, Soderberg R, Maier RV, Rivara FP, et al. Long-term survival of elderly trauma patients. *Arch Surg* 1997; **132**: 1010–4. doi: <https://doi.org/10.1001/archsurg.1997.01430330076013>
- Keller JM, Sciadini MF, Sinclair E, O'Toole RV. Geriatric trauma: demographics, injuries, and mortality. *J Orthop Trauma* 2012; **26**: e161–e165. doi: <https://doi.org/10.1097/BOT.0b013e3182324460>
- Jacobs DG. Special considerations in geriatric injury. *Curr Opin Crit Care* 2003; **9**: 535–9. doi: <https://doi.org/10.1097/00075198-200312000-00012>
- Jacobs DG, Plaisier BR, Barie PS, Hammond JS, Holevar MR, Sinclair KE, et al. Practice management guidelines for geriatric trauma: the EAST Practice Management Guidelines Work Group. *J Trauma* 2003; **54**:

- 391–416. doi: <https://doi.org/10.1097/01.TA.0000042015.54022.BE>
8. Caterino JM, Valasek T, Werman HA. Identification of an age cutoff for increased mortality in patients with elderly trauma. *Am J Emerg Med* 2010; ; **28**: 151–8210. doi: <https://doi.org/10.1016/j.ajem.2008.10.027>
9. Gillies D. Elderly trauma: they are different. *Aust Crit Care* 1999; **12**: 24–30. doi: [https://doi.org/10.1016/S1036-7314\(99\)70509-6](https://doi.org/10.1016/S1036-7314(99)70509-6)
10. Grossman MD, Miller D, Scaff DW, Arcona S. When is an elder old? Effect of preexisting conditions on mortality in geriatric trauma. *J Trauma* 2002; **52**: 242–6.
11. Sadro CT, Sandstrom CK, Verma N, Gunn ML. Geriatric trauma: a radiologist's guide. *Radiographics* 2015; ; **35**: 1263–85Jul-Aug.
12. Goodmanson NW, Rosengart MR, Barnato AE, Sperry JL, Peitzman AB, Marshall GT. Defining geriatric trauma: when does age make a difference? *Surgery* 2012; **152**: 668–75. doi: <https://doi.org/10.1016/j.surg.2012.08.017>
13. Scalea TM, Simon HM, Duncan AO, Atweh NA, Sclafani SJ, Phillips TF, et al. Geriatric blunt multiple trauma: improved survival with early invasive monitoring. *J Trauma* 1990; ; **30**: 129–34Feb.
14. Olufajo OA, Tulebaev S, Javedan H, Gates J, Wang J, Duarte M, et al. Integrating geriatric consults into routine care of older trauma patients: one-year experience of a level I trauma center. *J Am Coll Surg* 2016; **222**: 1029–35. doi: <https://doi.org/10.1016/j.jamcollsurg.2015.12.058>
15. Dwyer CR, Scifres AM, Stahlfeld KR, Corcos AC, Ziembicki JA, Summers JJ, et al. Radiographic assessment of ground-level falls in elderly patients: Is the "PAN-SCAN" overdoing it? *Surgery* 2013; **154**: 816–22. doi: <https://doi.org/10.1016/j.surg.2013.07.015>
16. Hakim W, Kamanahalli R, Dick E, Bharwani N, Fetherston S, Kashef E. Trauma whole-body MDCT: an assessment of image quality in conventional dual-phase and modified biphasic injection. *Br J Radiol* 2016; **89**: 20160160. doi: <https://doi.org/10.1259/bjr.20160160>
17. Royal College of Radiologists. Publication 2011: Standards of practice and guidance for trauma radiology in severely injured patients. 2011. Available from: <https://www.rcr.ac.uk/clinical-radiology/publications-and-standards>.
18. Finelli FC, Jonsson J, Champion HR, Morelli S, Fouty WJ. A case control study for major trauma in geriatric patients. *J Trauma* 1989; **29**: 541–8. doi: <https://doi.org/10.1097/00005373-198905000-00001>
19. Mosenthal AC, Livingston DH, Elcavage J, Merritt S, Stucker S. Falls: epidemiology and strategies for prevention. *J Trauma* 1995; **38**: 753–6.
20. Samaras N, Chevalley T, Samaras D, Gold G. Older patients in the emergency department: a review. *Ann Emerg Med* 2010; **56**: 261–9. doi: <https://doi.org/10.1016/j.annemergmed.2010.04.015>
21. Sterling DA, O'Connor JA, Bonadies J. Geriatric falls: injury severity is high and disproportionate to mechanism. *J Trauma* 2001; **50**: 116–9. doi: <https://doi.org/10.1097/00005373-200101000-00021>
22. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. *Maturitas* 2013; **75**: 51–61. doi: <https://doi.org/10.1016/j.maturitas.2013.02.009>
23. Gutman MB, Moulton RJ, Sullivan I, Hotz G, Tucker WS, Muller PJ. Risk factors predicting operable intracranial hematomas in head injury. *J Neurosurg* 1992; **77**: 9–14. doi: <https://doi.org/10.3171/jns.1992.77.1.0009>
24. Rathlev NK, Medzon R, Lowery D, Pollack C, Bracken M, Barest G, et al. Intracranial pathology in elders with blunt head trauma. *Acad Emerg Med* 2006; **13**: 302–7. doi: <https://doi.org/10.1111/j.1553-2712.2006.tb01697.x>
25. Mina AA, Knipfer JE, Park DY, Bair HA, Howells GA, Bendick PJ. Intracranial complications of preinjury anticoagulation in trauma patients with head injury. *J Trauma* 2002; **53**: 668–72. doi: <https://doi.org/10.1097/00005373-200210000-00008>
26. Mack LR, Chan SB, Silva JC, Hogan TM. The use of head computed tomography in elderly patients sustaining minor head trauma. *J Emerg Med* 2003; **24**: 157–62. doi: [https://doi.org/10.1016/S0736-4679\(02\)00714-X](https://doi.org/10.1016/S0736-4679(02)00714-X)
27. Menditto VG, Lucci M, Polonara S, Pomponio G, Gabrielli A. Management of minor head injury in patients receiving oral anticoagulant therapy: a prospective study of a 24-hour observation protocol. *Ann Emerg Med* 2012; **59**: 451–5. doi: <https://doi.org/10.1016/j.annemergmed.2011.12.003>
28. Ehara S, Shimamura T. Cervical spine injury in the elderly: imaging features. *Skeletal Radiol* 2001; **30**: 1–7. doi: <https://doi.org/10.1007/s002560000300>
29. Lomoschitz FM, Blackmore CC, Mirza SK, Mann FA. Cervical spine injuries in patients 65 years old and older: epidemiologic analysis regarding the effects of age and injury mechanism on distribution, type, and stability of injuries. *AJR Am J Roentgenol* 2002; **178**: 573–7. doi: <https://doi.org/10.2214/ajr.178.3.1780573>
30. Bub LD, Blackmore CC, Mann FA, Lomoschitz FM. Cervical spine fractures in patients 65 years and older: a clinical prediction rule for blunt trauma. *Radiology* 2005; **234**: 143–9. doi: <https://doi.org/10.1148/radiol.2341031692>
31. Bromberg WJ, Collier BC, Diebel LN, Dwyer KM, Holevar MR, Jacobs DG, et al. Blunt cerebrovascular injury. *J Trauma* 2010; **68**: 471–7.
32. Parizel PM, van der Zijden T, Gaudino S, Spaepen M, Voormolen MH, Venstermans C, et al. Trauma of the spine and spinal cord: imaging strategies. *Eur Spine J* 2010; **19**(Suppl 1): 8–17. doi: <https://doi.org/10.1007/s00586-009-1123-5>
33. Bernstein M. Easily missed thoracolumbar spine fractures. *Eur J Radiol* 2010; **74**: 6–15. doi: <https://doi.org/10.1016/j.ejrad.2009.06.021>
34. Wood KB, Li W, Lebl DR, Lebl DS, Ploumis A. Management of thoracolumbar spine fractures. *Spine J* 2014; **14**: 145–64. doi: <https://doi.org/10.1016/j.spinee.2012.10.041>
35. Westerveld LA, Verlaan JJ, Oner FC. Spinal fractures in patients with ankylosing spinal disorders: a systematic review of the literature on treatment, neurological status and complications. *Eur Spine J* 2009; **18**: 145–56. doi: <https://doi.org/10.1007/s00586-008-0764-0>
36. Robinson Y, Heyde CE, Försth P, Olerud C. Kyphoplasty in osteoporotic vertebral compression fractures - Guidelines and technical considerations. *J Orthop Surg Res* 2011; **6**: 43. doi: <https://doi.org/10.1186/1749-799X-6-43>
37. Bergeron E, Lavoie A, Clas D, Moore L, Ratte S, Tetreault S, et al. Elderly trauma patients with rib fractures are at greater risk of death and pneumonia. *J Trauma* 2003; **54**: 478–85. doi: <https://doi.org/10.1097/01.TA.0000037095.83469.4C>
38. Schulte K, Whitaker D, Attia R. In patients with acute flail chest does surgical rib fixation improve outcomes in terms of morbidity and mortality? *Interact Cardiovasc Thorac Surg* 2016; **23**: 314–9. doi: <https://doi.org/10.1093/icvts/ivw092>
39. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. *J Trauma* 2000; **48**: 1040–7. doi: <https://doi.org/10.1097/00005373-200006000-00007>
40. Unsworth A, Curtis K, Asha SE. Treatments for blunt chest trauma and their impact on patient outcomes and health service delivery. *Scand J Trauma Resusc Emerg Med* 2015; **23**: 17. doi: <https://doi.org/10.1186/s13049-015-0091-5>
41. Wu JJ, Lollo L, Grabinsky A. Regional anesthesia in trauma medicine. *Anesthesiol Res Pract* 2011; **7132812011**: 713281. doi: <https://doi.org/10.1155/2011/713281>

42. Konstantinidis A, Inaba K, Dubose J, Barmparas G, Lam L, Plurad D, et al. Vascular trauma in geriatric patients: a national trauma databank review. *J Trauma* 2011; **71**: 909–16. doi: <https://doi.org/10.1097/TA.0b013e318204104e>
43. Steenburg SD, Ravenel JG, Ikonmidis JS, Schönholz C, Reeves S. Acute traumatic aortic injury: imaging evaluation and management. *Radiology* 2008; **248**: 748–62. doi: <https://doi.org/10.1148/radiol.2483071416>
44. Teixeira PG, Inaba K, Barmparas G, Georgiou C, Toms C, Noguchi TT, et al. Blunt thoracic aortic injuries: an autopsy study. *J Trauma* 2011; **70**: 197–202. doi: <https://doi.org/10.1097/TA.0b013e3181df68b3>
45. Dechert TA, Duane TM, Frykberg BP, Aboutanos MB, Malhotra AK, Ivatury RR. Elderly patients with pelvic fracture: interventions and outcomes. *Am Surg* 2009; **75**: 291–5.
46. Henry SM, Pollak AN, Jones AL, Boswell S, Scalea TM. Pelvic fracture in geriatric patients: a distinct clinical entity. *J Trauma* 2002; **53**: 15–20. doi: <https://doi.org/10.1097/00005373-200207000-00004>
47. Kimbrell BJ, Velmahos GC, Chan LS, Demetriades D. Angiographic embolization for pelvic fractures in older patients. *Arch Surg* 2004; **139**: 728–32. doi: <https://doi.org/10.1001/archsurg.139.7.728>
48. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury* 2006; **37**: 691–7. doi: <https://doi.org/10.1016/j.injury.2006.04.130>
49. Clayton RA, Gaston MS, Ralston SH, Court-Brown CM, McQueen MM. Association between decreased bone mineral density and severity of distal radial fractures. *J Bone Joint Surg Am* 2009; **91**: 613–9. doi: <https://doi.org/10.2106/JBJS.H.00486>
50. Cabarrus MC, Ambekar A, Lu Y, Link TM. MRI and CT of insufficiency fractures of the pelvis and the proximal femur. *AJR Am J Roentgenol* 2008; **191**: 995–1001. doi: <https://doi.org/10.2214/AJR.07.3714>
51. Dominguez S, Liu P, Roberts C, Mandell M, Richman PB. Prevalence of traumatic hip and pelvic fractures in patients with suspected hip fracture and negative initial standard radiographs—a study of emergency department patients. *Acad Emerg Med* 2005; **12**: 366–9. doi: <https://doi.org/10.1197/j.aem.2004.10.024>
52. Dunker D, Collin D, Göthlin JH, Geijer M. High clinical utility of computed tomography compared to radiography in elderly patients with occult hip fracture after low-energy trauma. *Emerg Radiol* 2012; **19**: 135–9. doi: <https://doi.org/10.1007/s10140-011-1009-9>
53. Meek RM, Norwood T, Smith R, Brenkel IJ, Howie CR. The risk of peri-prosthetic fracture after primary and revision total hip and knee replacement. *J Bone Joint Surg Br* 2011; **93**: 96–101. doi: <https://doi.org/10.1302/0301-620X.93B1.25087>
54. Brady OH, Garbuz DS, Masri BA, Duncan CP. The treatment of periprosthetic fractures of the femur using cortical onlay allograft struts. *Orthop Clin North Am* 1999; **30**: 249–57. doi: [https://doi.org/10.1016/S0030-5898\(05\)70079-1](https://doi.org/10.1016/S0030-5898(05)70079-1)
55. Selby R, Geerts W, Ofosu FA, Craven S, Dewar L, Phillips A, et al. Hypercoagulability after trauma: hemostatic changes and relationship to venous thromboembolism. *Thromb Res* 2009; **124**: 281–7. doi: <https://doi.org/10.1016/j.thromres.2008.10.002>
56. Knudson MM, Ikossi DG, Khaw L, Morabito D, Speetzen LS. Thromboembolism after trauma: an analysis of 1602 episodes from the American College of Surgeons National Trauma Data Bank. *Ann Surg* 2004; **240**: 490–6.
57. Baker PRA, Francis DP, Hairi NN, Othman S, Choo WY. Interventions for preventing abuse in the elderly (Review). *Cochrane Database of Systematic Reviews* 2016; CD010321.
58. Murphy K, Waa S, Jaffer H, Sauter A, Chan A. A literature review of findings in physical elder abuse. *Can Assoc Radiol J* 2013; **64**: 10–14. doi: <https://doi.org/10.1016/j.carj.2012.12.001>
59. Rosen T, Bloemen EM, LoFaso VM, Clark S, Flomenbaum NE, Lachs MS. Emergency department presentations for injuries in older adults independently known to be victims of elder abuse. *J Emerg Med* 2016; **50**: 518–26. doi: <https://doi.org/10.1016/j.jemermed.2015.10.037>
60. Friedman LS, Avila S, Shah M, Tanouye K, Joseph K. A description of cases of severe physical abuse in the elderly and 1-year mortality. *J Elder Abuse Negl* 2014; **26**: 1–11. doi: <https://doi.org/10.1080/08946566.2013.780944>
61. Lachs MS, Pillemer KA. Elder abuse. *N Engl J Med* 2015; **373**: 1947–56. doi: <https://doi.org/10.1056/NEJMra1404688>