

R E V I E W

Traumatic fractures in adults: missed diagnosis on plain radiographs in the Emergency Department

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Summary. Radiography remains the imaging standard for fracture detection after trauma. The radiographic diagnosis of most fractures and dislocations poses little difficulty to radiologists: however, occasionally these injuries are quite subtle or even impossible to detect on radiographs. Missed diagnoses of fracture potentially have important consequences for patients, clinicians, and radiologists. Radiologists play a pivot role in the diagnostic assessment of the trauma patients: emergency radiologists who are more practiced at seeking out and discerning traumatic fractures can provide an invaluable service to their clinical colleagues by ensuring that patients do not endure delayed diagnoses. This is a narrative review article aims to highlight the spectrum of fractures in adults potentially missed on plain radiographs, the causes of error in diagnosis of fractures in the emergency setting and the key elements to reduce misdiagnosis of fractures. (www.actabiomedica.it)

Key words: missed diagnosis, diagnostic error, fracture, emergency radiology, conventional radiography

Introduction

Diagnostic errors are important in all branches of medicine as they are an indication of inadequate patient care. Medically, the significance of a diagnostic error in an Emergency Department (ED) varies from minimal to potentially life threatening. In other patients a delay in diagnosis may negatively influence the long-term results, increase operative risks, and cause additional pain and suffering. However, all errors have implications for patient care (1-5).

Radiology is not immune to this phenomenon and presents an amount of distinctive features linked

to both the inherent characteristics of the discipline and its latest developments (6-10). In a recent review of closed malpractice claims in the United States, radiology was the sixth most frequent specialty despite making up less than 5% of United States physicians (11-15). Nearly 3 out of 4 claims against diagnostic radiologists cite errors in interpretation resulting in missed diagnoses (16-20).

The main cause of diagnostic error in the ED is the failure to correctly interpret radiographs: the majority of the diagnoses missed on radiography are fractures. Some of the fractures are subtle; however, the majority are obvious, which suggests inadequate train-

ing and/or poor technique in radiological interpretation. In other situations, the fractures are observed but misinterpreted as normal variants or old injuries. Misinterpretation of fractures may determine a delayed treatment and poor outcome for patients treated in the ED (21-25). It is also one of the most frequent factors leading to medical legal claims (26-30).

The present narrative review aims to highlight: the spectrum of fractures in adults potentially missed on plain radiographs, the causes of error in diagnosis of fractures in the emergency setting, and the key elements to reduce misdiagnosis of fractures.

Spectrum of fractures in adults potentially missed on plain radiographs

Cervical fractures

Standard radiographic evaluation of the cervical spine typically consists of cross-table lateral, anteroposterior, and open-mouth odontoid views, supplemented at some centers by oblique imaging. Several reports concluded that standard plain radiography is unreliable in detecting bony cervical spine injury and may miss > 50% of all cervical spine fractures (31-35). Moreover, false-negative interpretation of the cervical standard radiographs typically includes the following injuries:

- a non-displaced fracture of the transverse process of C1 with extension to a lateral mass;
- type III odontoid fracture of the axis;
- isolated non-displaced fracture of the transverse process and lamina of C7;
- fracture of the lamina of C6;
- isolated fracture of the anterior process of C1.

The quality of the plain radiographic study is of paramount importance to the identification of cervical spine injury. Prevention of artefact is of primary importance in detecting subtle, minimally displaced osseous injuries. Moreover, the lateral view is the most important radiograph to acquire. Because nearly half of all cervical spine injuries affect C6 and C7, the cervicothoracic junction must be seen, supplemented by additional views (swimmer's or oblique views) or by gently pulling down the shoulders (36-40).

The role of imaging in patients with suspected traumatic spinal injury has progressed significantly with the advent of increasingly sophisticated imaging hardware and techniques. The American College of Radiologists (ACR) appropriateness criteria for suspected spinal trauma in 2009 (41-45) recommends axial multidetector computed tomography (MDCT) with sagittal and coronal multiplanar reformations as the primary imaging modality of choice over radiography for patients in whom imaging is indicated based upon established clinical criteria [NEXUS] (46) or [Canadian Cervical Spine Rules] (47). It is well established that MDCT is more sensitive than radiography in diagnosis of cervical fractures. MDCT assesses the spine more quickly than obtaining multiple portable bedside radiographs, covers the entire spine, typically with adequate exposure (particularly compared with radiographs of the cervicothoracic junction) and permits reformation of data into 2D and 3D data sets that improve diagnosis and understanding of abnormal anatomy compared with the overlapping osseous structures displayed radiographically. Moreover, MDCT with intravenous contrast material allows assessment of the neck arterial vasculature concurrent with assessment of the cervical spine anatomy.

Thoraco-lumbar fractures

Thoracolumbar spine fractures occur in 4-18% of blunt trauma victims and are often associated with major concurrent injuries in the head, chest, abdomen, pelvis, and extremities (48-50). Conventional radiographs retain an important role as the initial imaging modality in exploring thoracolumbar spine trauma outside the context of polytrauma. They are inexpensive, readily available, and reproducible. Usually two views (anteroposterior and lateral) are performed in the decubitus position in order to minimize patient movement. Subtle injuries may be difficult to appreciate, however. Soft tissue injuries are inferred from disturbances in bone alignment rather than directly visualized (51-55).

Chest radiography for evaluation of the thoracic spine is fraught with difficulty (1, 13, 56-60).

The frequency of missed spine injuries seems to be highest among patients with concordant injuries to the

hollow viscus (61-65). Transverse process fractures, of which only 60% are identifiable with conventional radiography, may be associated with fractures of the vertebral body in approximately 10% of patients (66-70).

In one study (71), 12.7% of lumbar spine fractures were missed radiographically in multitrauma patients. The same study further revealed a miss rate of 23.2% of lumbar fractures relying solely on standard transaxial abdominopelvic CT images underscoring the importance of high-resolution images and multiplanar reformations.

Patients who sustain an acute vertebral fracture after a traumatic event experience damage to both bone and soft tissues. A positive radiograph will be followed by cross-sectional imaging with CT and likely MRI to assess the full extent of the injury. A negative radiograph will be viewed in the clinical context, and further imaging may be required depending on the clinical history, clinical examination, and assessment of the risk of injury.

Upper extremity fractures

The role of radiographs in the evaluation of patients with upper extremity trauma is well established, serving an important role alongside clinical history and physical examination.

Injuries to the sternoclavicular joint are a result of direct or indirect forces usually occurring in the setting of high-energy trauma (e.g., motor vehicle crash or falls from a height) and contact sports (e.g., rugby, wrestling, or football) (72). The medial aspect of the sternoclavicular joint is usually the target for injuries related to direct trauma, whereas forces along the anterolateral or anteromedial aspects of the shoulder can indirectly disrupt the joint. Because of the propensity of this type of injury to occur in high-energy trauma, sternoclavicular dislocations can be missed on radiographs for several reasons, including overlap of bones and soft tissues around the joints, while the other more apparent and possibly more serious injuries are treated (73-75).

Scapular fractures are often the result of high-energy trauma, where there is a direct force impacting the scapula (60, 76-80). Fractures of the scapula are rare injuries, accounting for less than 1% of all fractures and 5% of all shoulder fractures (74).

The combination of the complex geometry, obscuring adjacent structures, and the infrequency of fracture contribute to the difficulty in the recognition of a scapular fracture. To add to this challenge, there are significant anatomic variations that are confused easily with a scapula fracture, particularly in the young adult population most likely to suffer athletic or vehicular trauma. The key to this diagnosis is to systematically review the different parts of the scapula on each of the available radiographic views.

Posterior shoulder dislocations are much less common than anterior dislocations (1.1 vs 23.9 cases/100,000 population per year) but are much more frequently misdiagnosed at initial presentation (up to 79% of the time) (81). Delay in the diagnosis of posterior dislocation can result in persistent pain, decreased function, and glenohumeral osteoarthritis (82-84). An axillary view or trans-scapular Y view is mandatory to evaluate the joint and rule out malalignment.

The diagnosis of a greater tuberosity fracture is difficult on the basis of clinical grounds only. The imaging evaluation of the patient with shoulder trauma typically consists of anteroposterior internal and external views, scapular Y, and axillary view of the injured extremity. Careful evaluation of the greater tuberosity on anteroposterior external radiographs is the key to this diagnosis, especially if the fracture is not displaced or only minimally displaced. The profile view of the tuberosity will give the radiologist the best opportunity to evaluate the tuberosity cortex and to accurately assess the degree of displacement. Despite being a well-recognized clinical entity, isolated greater tuberosity fractures are missed commonly. Ogawa and colleagues (85) reported a series in which 58 of 99 shoulders (59%) with confirmed isolated fracture of the greater tuberosity had been overlooked initially.

The majority of elbow fractures in the adult patient are radial head and neck fractures, comprising approximately 33% to 50% of elbow fractures, about one-half of which are nondisplaced (86). As a result, they are easily missed, which can lead to increased patient morbidity. A recent study evaluating the value of CT in the detection of occult elbow fractures showed that 12.8% of patients with positive elbow extension test and normal plain radiograph had fractures on CT. Because AP and flexed lateral radiographs alone have

a high rate of missed elbow fracture in acute trauma, obtaining additional views has been emphasized, including internal and external obliques as well as the radial head-capitellum view (87).

Fractures of the distal radius are the most common fracture of the skeleton and account for an estimated 1 of every 6 acute fractures in the emergency setting (88).

In the setting of acute trauma, a routine wrist radiographic series includes posteroanterior (PA), lateral, and pronated oblique views. Although the majority of distal radius fractures are not challenging in terms of identification, nondisplaced fractures, particularly of the radial styloid, are occasionally the exception.

Wrist fractures are common injuries of the skeletal system and may be diagnostic challenges in emergency rooms. Conventional radiography is the first method of choice in diagnosing these traumatic lesions. Eight different shaped bones and a complex three-dimensional relationship with each other in the wrist region may be cloud to detect some occult fractures by using conventional radiography. Superposition of anatomical structures, suboptimal positioning and technique, and absent and/or suboptimal patient cooperation in emergency settings are factors that may also limit plain radiography (89, 90).

Scaphoid fracture is typically seen in younger active patients and results from a combination of axial and hyperextension forces on the wrist. The location of the fracture and degree of displacement play a major role in patient treatment and outcome. With up to 20% of scaphoid fractures occult radiographically, the diagnosis is often delayed, leading to an increased incidence of avascular necrosis (AVN), mal-union, and non-union (91, 92). It is important to evaluate the scaphoid on all radiographic views. An additional scaphoid view is indicated if the level of suspicion is high but the initial radiographs are negative. For patients with negative radiographs but a high index of suspicion, follow-up radiographs in 7-10 days are recommended, because the fracture line would be made more obvious secondary to the healing response. Because of the repercussions of a missed fracture, the use of MRI should be strongly considered if a radiographically occult scaphoid fracture is suspected (74).

A fractured hook of the hamate occurs after direct impact or avulsion at the transcarpal ligament in-

sertion. Imaging plays a crucial role in this scenario, typically beginning with posteroanterior, oblique, and lateral views of the wrist. The hook may be difficult to visualize on these views because of the overlap by the surrounding bones. Standard radiographs often fail to diagnose hamate fractures (93). If there is persistent suspicion for a fracture in this location and negative radiographs, CT should be the next imaging modality selected because it should reveal the fracture and any associated displacement.

Pelvic ring and lower extremity fractures

The pelvis is a ringlike structure with three components: the paired innominate bones and the sacrum. The integrity of the bony ring is preserved by ligaments, whose appreciation is essential to the understanding of patterns of injury and the assessment of stability of the affected hemipelvis (94-97).

Trauma imaging of the pelvis usually begins with a bedside anteroposterior (AP) radiograph, taken in the emergency department (98). AP radiograph is a rapid method to determine the need for immediate interventions and allowing early planning before computed tomography (CT) examination. In the acute situation, AP radiograph can identify most injuries and is usually sufficient to determine the presence or absence of pelvic ring instability, although the assessment of posterior ring injuries, such as sacral fractures, can be difficult and often requires further imaging evaluation. CT imaging with three-dimensional volume-rendered reconstructions is the modality of choice for accurately depicting pelvic ring fractures, and it has essentially eliminated the requirement for inlet and outlet views (99, 100).

The hip joint is frequently injured in trauma. Dislocations are relatively common in high-energy trauma and tend to occur in younger people. Evaluation of the hip joint starts with adequate radiographs that include an anteroposterior (AP) pelvic radiograph with accompanying AP and frog leg views of the hip. Even with careful inspection, the incidence of radiographically occult hip fractures ranges from 4% to 9% in patients presenting with pain after trauma (101, 102). Fractures may be missed due to factors like perception errors, the experience level of the readers, patient age,

or image interpretation under stressful conditions in the emergency room or by an on-call radiologist after office hours. The fracture may, however, simply be impossible to detect with radiography and in 2-9% radiography has been reported to have missed fractures or be suspect for fracture (103, 104). For evaluation of a suspected missed hip fracture, secondary imaging with Magnetic Resonance Imaging (105) or Computed Tomography (106) is usually performed.

Fractures of the femoral neck are generally a condition of elderly people (107). Subcapital fractures are most common, but these may be difficult to detect when the femur is externally rotated or there is significant osteophyte formation from arthritis. Obesity and osteopenia may further compromise an already challenging hip radiograph, so meticulous inspection is required.

Many fractures of the knee are caused by high-energy trauma. Avulsion and impaction fractures may imply the presence of an underlying ligament abnormality (108, 109). As many of these fractures are subtle, accurate detection of these fractures depends on knowledge of the anatomic high-risk areas as well as careful inspection of the radiographs.

Ankle injuries are extremely common. Most of these injuries affect the lateral ankle ligament complex resulting in the commonly diagnosed entity of "ankle sprain," which usually has an excellent response to conservative treatment. One cause for an apparently sprained ankle to have disproportionately severe or prolonged symptoms is a missed fracture. The most commonly missed fractures associated with inversion sprains are osteochondral fractures of the talar dome. Lateral dome lesions most commonly occur at its middle third, present as tenderness anterior to the lateral malleolus, and they may be visible on the mortise view of the plain radiograph. Other injuries easily missed during the initial radiographic assessment of acute ankle trauma include: lateral process of talus, posterior process of talus, anterior process of calcaneus, proximal fifth metatarsal and os peroneum fractures (110).

A fracture of the lateral process of the talus is either caused by ankle eversion with dorsiflexion so that the superolateral surface of the calcaneus strikes against the inferior margin of the lateral talus process or occasionally by ankle inversion. The fracture is ap-

parent only on frontal views of the ankle, and a tip-off is that the epicenter of the soft tissue swelling is distal to the lateral malleolus (107).

Diagnosis of Lisfranc fractures and Lisfranc injuries is challenging. Radiographic evaluation of the tarsometatarsal joint is difficult due to osseous overlap.

Although Lisfranc fracture dislocations account for 0.2% of all fractures, the diagnosis is initially missed in approximately 20% of the cases (111). Initial radiographs may appear normal, but weight-bearing views may show subluxation or dislocation. After midtarsal trauma, initial films are non-weightbearing AP, lateral and internal oblique views (30 degrees). It is important to keep in mind that subtle diastasis can be missed in up to 50% of cases on non-weightbearing radiographs. If there is a strong clinical suspicion, weightbearing films of both feet are required for comparison with the uninjured contralateral foot to rule out subtle diastasis or small displaced injuries. CT is an important preoperative tool for the evaluation of fracture pattern and surgical planning in patients after high energy trauma when complex fractures are suspected. CT permits detection of 50% more metatarsal and tarsal fractures compared with radiographs (112).

Cases of missed diagnosis of fractures on plan radiographs are illustrated in Figures 1, 2 and 3.

Causes of error in diagnosis of fractures in the emergency setting

An error represents a deviation from the ordinary norm, regardless of whether it results in any damage. Diagnostic error has been defined as a diagnosis that is missed, wrong, or delayed as discovered by later conclusive test or finding (113-118). Errors may be categorized according to different approaches and we have systems to facilitate their identification so that steps can be used to decrease their incidence. Usually, there are four leading causes why radiologists are litigated: observer errors, errors in interpretation, failure to suggest the next appropriate procedure, and failure to communicate in a timely and clinically appropriate manner (117).

Kundel et al. (119) reported the following three varieties of observer error: scanning error, recognition

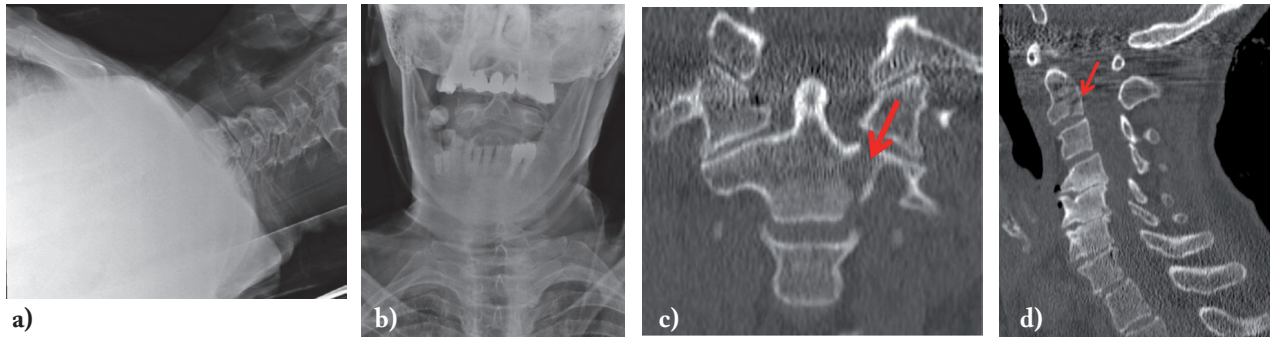


Figure 1. Cross-table lateral (a) and open-mouth odontoid (b) radiographs of the cervical spine. Missed diagnosis of fracture of the C2 vertebral body revealed by the subsequent MDCT examination (c, coronal reconstruction, red arrow; d, sagittal reconstruction, red arrow)

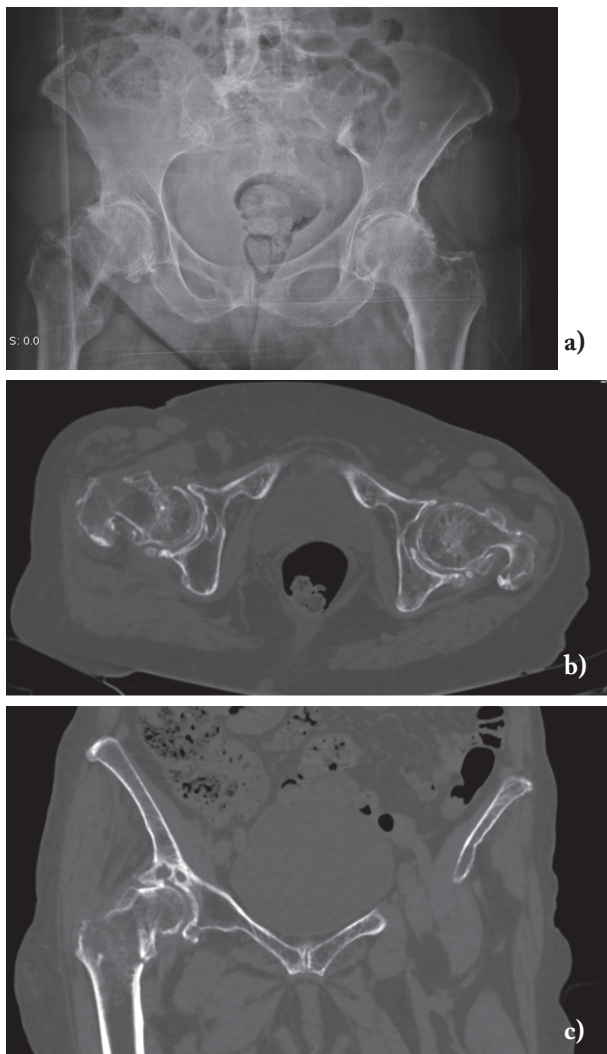


Figure 2. Anteroposterior radiograph of the pelvis in elderly patient. The radiologist reported absence of fracture, recommending the need of a CT examination. Subsequent CT showed a right femoral neck fracture

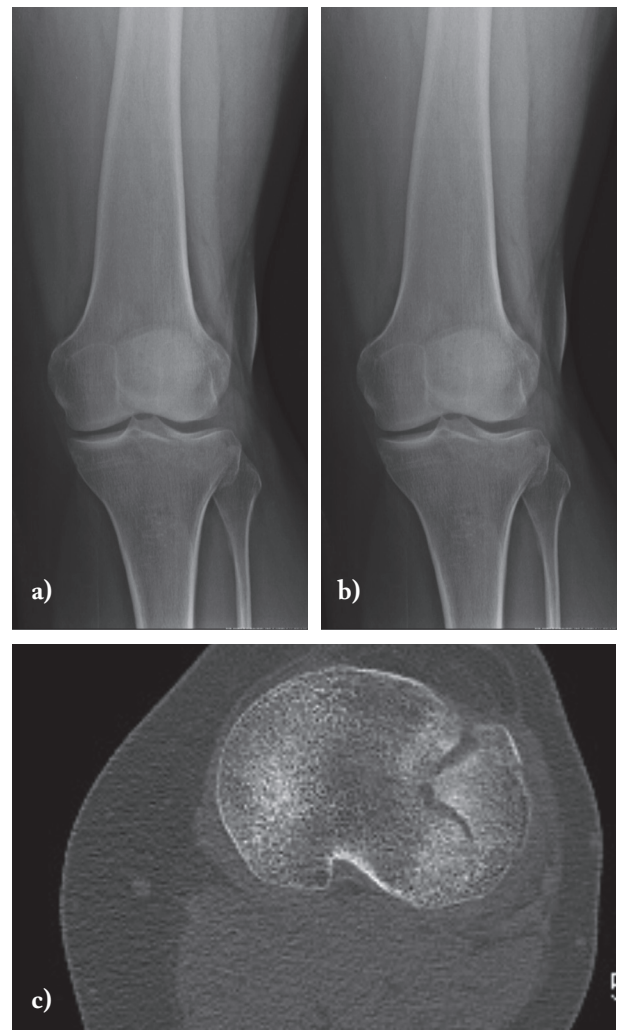


Figure 3. Missed diagnosis of fracture of the lateral plateau of the knee on radiographs (a and b). Subsequent CT (c) showed the presence of the fracture

error and decision-making error. Failure of the radiologist to fixate on the region of the lesion is a scanning error. Recognition error includes fixating on the area of the lesion yet failing to detect the lesion. Decision-making error is the inappropriate interpretation of a lesion as a normal finding.

Another type of observer error that may contribute to lesions being overlooked is satisfaction of search (SOS) error (120). An SOS error is the consequence of the radiologist's attention being diverted from a tumour by an eye-catching but unrelated finding.

Causes of error in evaluation of clinically suspected fractures on radiographs in the emergency setting are multifactorial and frequently joined (53, 67, 121-128). Radiography remains the initial modality to detect or exclude the presence of a fracture. Failure to diagnose is the most common error alleged in medical malpractice suits against radiologists, and extremity fractures are the second most frequently missed diagnosis after breast cancer (11). Although some missed fractures may be related to perceptual errors that appear to be avoidable in retrospect, others are related to anatomic, technical, and physiologic factors that are out of the interpreting radiologist's control (63, 68, 116, 129-135). Many fractures are visible on only a single view. If that view is not obtained, then the examination will be interpreted as falsely negative. Most radiology departments follow protocols that call for orthogonal views in frontal (anteroposterior or posteroanterior) and lateral projections for the long bones. Technical factors such as the quality of the images and the views obtained are important in order to correctly diagnose the presence of skeletal fractures: with digital radiography insufficient tube current (milliamperes) will result in an underexposed radiograph that will have less information than a properly exposed radiograph (136, 137). However, because the display settings may present the image with the expected gray scale, contrast, and brightness, the radiograph may appear to be properly exposed. Even with properly positioned and technically excellent radiographs, some fractures are undetectable on radiographs because they are nondisplaced. These fractures are symptomatic and have the appropriate clinical findings and mechanism of injury, but they are not evident on radiographs. In essence, the radiograph findings are falsely negative, because the

method itself is insufficient to reveal the fracture and with a high clinical index of suspicion, further evaluation with additional imaging is typically required, particularly if the results of this imaging will affect clinical management (138-140). Moreover, quantity of clinical information, absence of previous imaging studies, the reading room atmosphere, the level of alertness of the interpreter, error of speed, failure of perception, lack of knowledge, error in interpretation, satisfaction of search, error due to multitasking, increased workload, rising quality expectations, misjudgement and poorly understood factors seemingly inherent to "human nature" may all play an important role (141-145).

Radiologists must warrant that their suggestions or recommendations for any additional radiological procedures are appropriate and will add significant information to explain, confirm, or exclude the initial impression (146). Mainly in the emergency setting, a radiologist may recommend supplementary imaging procedures (especially CT) that disclose injuries not evident on the conventional radiographic examination. Radiologists more completely understand the limitations of radiography for certain diagnoses and can best indicate the need for more advanced imaging, such as CT, for a correct diagnosis in an appropriate time frame.

Key elements to reduce misdiagnosis of fractures

The problem of misdiagnosis cannot be solved without education, but it also cannot be solved with education alone.

In the emergency setting, errors in the diagnosis of fractures can be reduced by increases both in knowledge and in systems. Key elements are communication of the patient's clinical history, comparison of the current imaging procedure with the previous radiological investigation, and correct selection of the initial and subsequent radiological procedure (143). Risks for medico legal litigation can be largely prevented by giving adequate information to patients and offering adequate follow up.

Better system organization arises from improvements in working conditions and in the time available for reporting, equipment changes to prevent accidental

error and good communication between clinicians and radiologists (147).

Learning from errors requires a critical appraisal of our own practice and the implementation of change to enhance performance levels. Peer review is crucial: peer review acts as an essential tool to assess radiologists' performance and to improve diagnostic accuracy.

Conclusions

In the Emergency Department a patient with polytrauma is a catalyst for multiple errors as well as serious complications for various reasons: inadequate history, quick life-saving decisions, severity and complexity of the injuries or due to the patient's pre-existing medical conditions, multiple concurrent tasks, and multidisciplinary approach.

Radiographs remain the mainstay for fracture assessment; their assessment remains challenging. A fracture may be missed because it is radiologically invisible or equivocal: in fact, some non-displaced and subtle fractures may be radiographically occult. Thus, in presence of negative plain radiographs and high clinical suspicion of occult fracture, failure of diagnosis may occur if the radiologist does not indicate in the report the need of additional, more appropriate examinations.

Radiologists play a pivot role in the diagnostic assessment of the trauma patients: key elements to reduce errors in the diagnosis of fractures on plain radiographs are knowledge, experience, and correct application of imaging protocols.

References

- Miele V, Galluzzo M, Trinci M, Missed fractures in the emergency department, *Errors in Radiology*, Springer-Verlag Milan 2012, pp. 39-50.
- Barile A, Arrigoni F, Bruno F, Guglielmi G, Zappia M, Reginelli A, Ruscitti P, Cipriani P, Giacomelli R, Brunese L, Masciocchi C. Computed Tomography and MR Imaging in Rheumatoid Arthritis. *Radiol Clin North Am* 2017; 55: 997-1007.
- Zappia M, Castagna A, Barile A, Chianca V, Brunese L, Pouliart N. Imaging of the coracoglenoid ligament: a third ligament in the rotator interval of the shoulder. *Skelet Radiol* 2017; 46: 1101-1111.
- Barile A, Bruno F, Arrigoni F, Splendiani A, Di Cesare E, Zappia M, Guglielmi G, Masciocchi C. Emergency and Trauma of the Ankle. *Semin Musculoskelet Radio*. 2017; 21: 282-289.
- Reginelli A, Zappia M, Barile A, Brunese L. Strategies of imaging after orthopedic surgery. *Musculoskeletal Surg* 2017; 101:
- Busardo FP, Frati P, Santurro A, Zaami S, Fineschi V. Errors and malpractice lawsuits in radiology: what the radiologist needs to know. *Radiol Med* 2015; 120: 779-84.
- Di Pietto F, Chianca V, de Ritis R, Cesarano E, Reginelli A, Barile A, Zappia M, Ginolfi L. Postoperative imaging in arthroscopic hip surgery. *Musculoskeletal Surg* 2017; 101: 43-49.
- Splendiani A, D'Orazio F, Patriarca L, Arrigoni F, Caranci F, Fonio P, Brunese L, Barile A, Di Cesare E, Masciocchi C. Imaging of post-operative spine in intervertebral disc pathology. *Musculoskeletal Surg* 2017; 101: 75-84.
- Barile A, Bruno F, Mariani S, Arrigoni F, Reginelli A, De Filippo M, Zappia M, Splendiani A, Di Cesare E, Masciocchi C. What can be seen after rotator cuff repair: a brief review of diagnostic imaging findings. *Musculoskeletal Surg* 2017; 101: 3-14.
- Barile A, Bruno F, Mariani S, Arrigoni F, Brunese L, Zappia M, Splendiani A, Di Cesare E, Masciocchi C. Follow-up of surgical and minimally invasive treatment of Achilles tendon pathology: a brief diagnostic imaging review. *Musculoskeletal Surg* 2017; 101: 51-61.
- Whang JS, Baker SR, Patel R, Luk L, Castro A, 3rd. The causes of medical malpractice suits against radiologists in the United States. *Radiology* 2013; 266: 548-54.
- De Filippo M, Pesce A, Barile A, Borgia D, Zappia M, Romano A, Pogliacomì F, Verdano M, Pellegrini A, Johnson K. Imaging of postoperative shoulder instability. *Musculoskeletal Surg* 2017; 101: 15-22.
- Splendiani A, Bruno F, Patriarca L, Barile A, Di Cesare E, Masciocchi C, Gallucci M. Thoracic spine trauma: advanced imaging modality. *Radiol Med* 2016; 121: 780-792.
- de Filippo M, Azzali E, Pesce A, Saba L, Mostardi M, Borgia D, Barile A, Capasso R, de Palmi F, Caravaggio F. CT arthrography for evaluation of autologous chondrocyte and chondral-inductor scaffold implantation in the osteochondral lesions of the talus. *Acta Biomedica* 2016; 87: 51-56.
- Splendiani A, Perri M, Grattacaso G, Di Tunno V, Marsecano C, Panebianco L, Gennarelli A, Felli V, Varrassi M, Barile A, Di Cesare E, Masciocchi C, Gallucci M. Magnetic resonance imaging (MRI) of the lumbar spine with dedicated G-scan machine in the upright position: a retrospective study and our experience in 10 years with 4305 patients. *Radiol Med* 2016; 121: 38-44.
- Berlin L, Berlin JW. Malpractice and radiologists in Cook County, IL: trends in 20 years of litigation. *AJR Am J Roentgenol* 1995; 165: 781-8.
- Patriarca L, Letteriello M, Di Cesare E, Barile A, Gallucci M, Splendiani A. Does evaluator experience have an impact on the diagnosis of lumbar spine instability in dynamic

- MRI? Interobserver agreement study. *Neuroradiol J* 2015; 28: 341-346.
18. Mariani S, La Marra A, Arrigoni F, Necozone S, Splendiani A, Di Cesare E, Barile A, Masciocchi C. Dynamic measurement of patello-femoral joint alignment using weight-bearing magnetic resonance imaging (WB-MRI). *Eur J Radiol* 2015; 84: 2571-2578.
 19. Masciocchi C, Arrigoni F, Barile A, Role of conventional RX, CT, and MRI in the evaluation of prosthetic joints, *Imaging of Prosthetic Joints: A Combined Radiological and Clinical Perspective*, Springer-Verlag Milan 2014, pp. 63-69.
 20. Masciocchi C, Conchiglia A, Conti L, Barile A, *Imaging of insufficiency fractures, Geriatric Imaging*, Springer-Verlag Berlin Heidelberg 2013, pp. 83-91.
 21. Guly HR, Grant IC. Patients who attend two accident and emergency departments. *J Accid Emerg Med* 1994; 11: 231-3.
 22. Barile A, Conti L, Lanni G, Calvisi V, Masciocchi C. Evaluation of medial meniscus tears and meniscal stability: Weight-bearing MRI vs arthroscopy. *Eur J Radiol* 2013; 82: 633-639.
 23. Barile A, Lanni G, Conti L, Mariani S, Calvisi V, Castagna A, Rossi F, Masciocchi C. Lesions of the biceps pulley as cause of anterosuperior impingement of the shoulder in the athlete: Potentials and limits of MR arthrography compared with arthroscopy. *Radiol Med* 2013; 118: 112-122.
 24. Masciocchi C, Conti L, D'Orazio F, Conchiglia A, Lanni G, Barile A, *Errors in musculoskeletal MRI, Errors in Radiology*, Springer-Verlag Milan 2012, pp. 209-217.
 25. Limbucci N, Rossi F, Salvati F, Pistoia LM, Barile A, Masciocchi C. Bilateral Suprascapular nerve entrapment by glenoid labral cysts associated with rotator cuff damage and posterior instability in an amateur weightlifter. *J Sports Med Phys Fitness* 2010; 50: 64-67.
 26. Berlin L. Defending the "missed" radiographic diagnosis. *AJR Am J Roentgenol* 2001; 176: 317-22.
 27. Barile A, Limbucci N, Splendiani A, Gallucci M, Masciocchi C. Spinal injury in sport. *Eur J Radiol* 2007; 62: 68-78.
 28. Masciocchi C, Barile A, Lelli S, Calvisi V. Magnetic resonance imaging (MRI) and arthro-MRI in the evaluation of the chondral pathology of the knee joint. *Radiol Med* 2004; 108: 149-58.
 29. Camperchioli A, Mariani M, Bartollino S, Petrella L, Persico M, Orteca N, Scambia G, Shahabi S, Ferlini C, Fattorusso C. Investigation of the Bcl-2 multimerisation process: structural and functional implications. *Biochim Biophys Acta* 2011; 1813: 850-7.
 30. Mangano K, Veralgato F, Mammana S, Mariano A, De Pasquale R, Meloscia A, Bartollino S, Guerra G, Nicoletti F, Di Marco R. Evaluation of hyaluronic acid-P40 conjugated cream in a mouse model of dermatitis induced by oxazolone. *Exp Ther Med* 2017; 14: 2439-2444.
 31. Woodring JH, Lee C. The role and limitations of computed tomographic scanning in the evaluation of cervical trauma. *J Trauma* 1992; 33: 698-708.
 32. Davis JW, Phreaner DL, Hoyt DB, Mackersie RC. The etiology of missed cervical spine injuries. *J Trauma* 1993; 34: 342-6.
 33. Pierot L, Söderman M, Bendszus M, White P, Muto M, Turjman F, Mangiafico S, Gralla J, Fiehler J, Szikora I, Cognard C. Statement of ESMINT and ESNR regarding recent trials evaluating the endovascular treatment at the acute stage of ischemic stroke. *Neuroradiology* 2013; 55: 1313-1318.
 34. Izzo R, Guarnieri G, Guglielmi G, Muto M. Biomechanics of the spine. Part I: Spinal stability. *Eur J Radiol* 2013; 82: 118-126.
 35. Masala S, Nano G, Marcia S, Muto M, Fucci FPM, Simonetti G. Osteoporotic vertebral compression fracture augmentation by injectable partly resorbable ceramic bone substitute (Cerament™|SPINESUPPORT): A prospective nonrandomized study. *Neuroradiology* 2012; 54: 1245-1251.
 36. Berritto D, Pinto A, Michelin P, Demondion X, Badr S. Trauma Imaging of the Acute Cervical Spine. *Semin Musculoskelet Radiol* 2017; 21: 184-198.
 37. Guarnieri G, Vassallo P, Pezzullo MG, Laghi F, Zeccolini F, Ambrosanio G, Galasso R, Muto M, Izzo R. A comparison of minimally invasive techniques in percutaneous treatment of lumbar herniated discs a review. *Neuroradiol J* 2009; 22: 108-121.
 38. Briganti F, Tortora F, Elefante A, Volpe A, Bruno MC, Pagniotopoulos K. An unusual case of vertebral arteriovenous fistula treated with electrodetachable coil embolization. *Minimally Invasive Neurosurgery* 2004; 47 (6): 386-388.
 39. Caranci F, Tedeschi E, Leone G, Reginelli A, Gatta G, Pinto A, Squillaci E, Briganti F, Brunese L. Errors in neuroradiology. *Radiol Med* 2015; 120: 795-801.
 40. Muccio CF, Di Blasi A, Esposito G, Brunese L, D'Arco F, Caranci F. Perfusion and spectroscopy magnetic resonance imaging in a case of lymphocytic vasculitis mimicking brain tumor. *Pol J Radiol* 2013; 78: 66-69.
 41. Daffner RH, Wippold FJ, Bennett DL, ACR appropriateness criteria suspected spine trauma, 2009.
 42. Briganti F, Delehay L, Leone G, Sicignano C, Buono G, Marseglia M, Caranci F, Tortora F, Maiuri F. Flow diverter device for the treatment of small middle cerebral artery aneurysms. *J Neurointervent Surg* 2016; 8: 287-294.
 43. Muccio CF, Caranci F, D'Arco F, Cerase A, De Lipsis L, Esposito G, Tedeschi E, Andreula C. Magnetic resonance features of pyogenic brain abscesses and differential diagnosis using morphological and functional imaging studies: A pictorial essay. *J Neuroradiol* 2014; 41: 153-167.
 44. Caranci F, Briganti F, La Porta M, Antinolfi G, Cesarano E, Fonio P, Brunese L, Coppolino F. Magnetic resonance imaging in brachial plexus injury. *Musculoskeletal Surg* 2013; 97: S181-S190.
 45. Briganti F, Tedeschi E, Leone G, Marseglia M, Cicala D, Giamundo M, Napoli M, Caranci F. Endovascular treatment of vertebro-vertebral arteriovenous fistula. A report of three cases and literature review. *Neuroradiol J* 2013; 26: 339-46.
 46. Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker

- MI. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. *N Engl J Med* 2000; 343: 94-9.
47. Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, De Maio VJ, Laupacis A, Schull M, McKnight RD, Verbeek R, Brison R, Cass D, Dreyer J, Eisenhauer MA, Greenberg GH, MacPhail I, Morrison L, Reardon M, Worthington J. The Canadian C-spine rule for radiography in alert and stable trauma patients. *JAMA* 2001; 286: 1841-8.
 48. Howes MC, Pearce AP. State of play: clearing the thoracolumbar spine in blunt trauma victims. *Emerg Med Australas* 2006; 18: 471-7.
 49. Cappabianca S, Scutto A, Iaselli F, Pignatelli di Spinazzola N, Urraro F, Sarti G, Montemarano M, Grassi R, Rotondo A. Computed tomography and magnetic resonance angiography in the evaluation of aberrant origin of the external carotid artery branches. *Surg Radiol Anat* 2012; 34: 393-9.
 50. Cappabianca S, Colella G, Russo A, Pezzullo M, Reginelli A, Iaselli F, Rotondo A. Maxillofacial fibrous dysplasia: personal experience with gadolinium-enhanced magnetic resonance imaging. *Radiol Med* 2008; 113: 1198-210.
 51. Moutinho R, Tyrrell P, Cassar-Pullicino VN. Emergency and Trauma Imaging of the Thoracolumbar Spine. *Semin Musculoskelet Radiol* 2017; 21: 199-209.
 52. Cappabianca S, Colella G, Pezzullo MG, Russo A, Iaselli F, Brunese L, Rotondo A. Lipomatous lesions of the head and neck region: Imaging findings in comparison with histological type. *Radiol Med* 2008; 113: 758-770.
 53. Caranci F, Cicala D, Cappabianca S, Briganti F, Brunese L, Fonio P. Orbital Fractures: Role of Imaging. *Semin. Ultrasound CT MRI* 2012; 33: 385-391.
 54. Cappabianca S, Iaselli F, Negro A, Basile A, Reginelli A, Grassi R, Rotondo A. Magnetic resonance imaging in the evaluation of anatomical risk factors for pediatric obstructive sleep apnoea-hypopnoea: a pilot study. *Int J Pediatr Otorhinolaryngol* 2013; 77: 69-75.
 55. Romeo A, Pinto A, Cappabianca S, Scaglione M, Brunese L. Role of Multidetector Row Computed Tomography in the Management of Mandible Traumatic Lesions. *Semin. Ultrasound CT MRI* 2009; 30: 174-180.
 56. Bernstein M. Easily missed thoracolumbar spine fractures. *Eur J Radiol* 2010; 74: 6-15.
 57. Piccolo CL, Ianniello S, Trinci M, Galluzzo M, Tonerini M, Zeccolini M, Guglielmi G, Miele V. Diagnostic Imaging in pediatric thoracic trauma. *Radiol Med* 2017;
 58. Miele V, Buquicchio GL, Piccolo CL, Stasolla A, Ianniello S, Brunese L. Injuries of the pleural spaces, *Medical Radiology*, Springer Verlag, 2017.
 59. Miele V, Buquicchio GL, Piccolo CL, Stasolla A, Galluzzo M, Lung injury, *Medical Radiology*, Springer Verlag, 2017.
 60. Miele V, Di Giampietro I. Diagnostic imaging in emergency. *Salute Soc* 2014; 127-141.
 61. Beaunoyer M, St-Vil D, Lallier M, Blanchard H. Abdominal injuries associated with thoraco-lumbar fractures after motor vehicle collision. *J Pediatr Surg* 2001; 36: 760-2.
 62. Muto M, Perrotta V, Guarnieri G, Lavanga A, Vassallo P, Reginelli R, Rotondo A. Vertebroplasty and kyphoplasty: Friends or foes? *Radiol Med* 2008; 113: 1171-1184.
 63. Caranci F, Brunese L, Reginelli A, Napoli M, Fonio P, Briganti F. Neck Neoplastic Conditions in the Emergency Setting: Role of Multidetector Computed Tomography. *Semin. Ultrasound CT MRI* 2012; 33: 443-448.
 64. Grassi R, Lombardi G, Reginelli A, Capasso F, Romano F, Floriani I, Colacurci N. Coccygeal movement: assessment with dynamic MRI. *Eur J Radiol* 2007; 61: 473-9.
 65. Dialetto G, Reginelli A, Cerrato M, Rossi G, Covino FE, Manduca S, Lassandro F. Endovascular stent-graft treatment of thoracic aortic syndromes: a 7-year experience. *Eur J Radiol* 2007; 64: 65-72.
 66. Krueger MA, Green DA, Hoyt D, Garfin SR. Overlooked spine injuries associated with lumbar transverse process fractures. *Clin Orthop Relat Res* 1996; 191-5.
 67. Reginelli A, Pinto A, Russo A, Fontanella G, Rossi C, Del Prete A, Zappia M, D'Andrea A, Guglielmi G, Brunese L. Sharp penetrating wounds: spectrum of imaging findings and legal aspects in the emergency setting. *Radiol Med* 2015; 120: 856-865.
 68. Pinto A, Reginelli A, Pinto F, Lo Re G, Midiri F, Muzj C, Romano L, Brunese L. Errors in imaging patients in the emergency setting. *Br J Radiol* 2016; 89:
 69. Zappia M, Carfora M, Romano AM, Reginelli A, Brunese L, Rotondo A, Castagna A. Sonography of chondral print on humeral head. *Skelet Radiol* 2016; 45: 35-40.
 70. Zappia M, Di Pietto F, Aliprandi A, Pozza S, De Petro P, Muda A, Sconfienza LM. Multi-modal imaging of adhesive capsulitis of the shoulder. *Insights Imaging* 2016; 7: 365-71.
 71. Rhee PM, Bridgeman A, Acosta JA, Kennedy S, Wang DS, Sarveswaran J, Rhea JT. Lumbar fractures in adult blunt trauma: axial and single-slice helical abdominal and pelvic computed tomographic scans versus portable plain films. *J Trauma* 2002; 53: 663-7; discussion 667.
 72. Martetschlager F, Warth RJ, Millett PJ. Instability and degenerative arthritis of the sternoclavicular joint: a current concepts review. *Am J Sports Med* 2014; 42: 999-1007.
 73. Chaudhry FA, Killampalli VV, Chowdhry M, Holland P, Knebel RW. Posterior dislocation of the sternoclavicular joint in a young rugby player. *Acta Orthop Traumatol Turc* 2011; 45: 376-8.
 74. Gyftopoulos S, Chitkara M, Bencardino JT. Misses and errors in upper extremity trauma radiographs. *AJR Am J Roentgenol* 2014; 203: 477-91.
 75. Zappia M, Reginelli A, Russo A, D'Agosto GF, Di Pietto F, Genovese EA, Coppolino F, Brunese L. Long head of the biceps tendon and rotator interval. *Musculoskeletal Surg* 2013; 97: S99-S108.
 76. Goss TP. Scapular Fractures and Dislocations: Diagnosis and Treatment. *J Am Acad Orthop Surg* 1995; 3: 22-33.
 77. De Filippo M, Bertellini A, Sverzellati N, Pogliacomi F, Costantino C, Vitale M, Zappia M, Corradi D, Garlaschi G, Zompatori M. Multidetector computed tomography ar-

- thrography of the shoulder: diagnostic accuracy and indications. *Acta Radiol* 2008; 49: 540-9.
78. Cappabianca S, Porto A, Petrillo M, Greco B, Reginelli A, Ronza F, Setola F, Rossi G, Di Matteo A, Muto R, De Rimini ML, Piccolo S, Catalano M, Muto P, De Rosa N, Barra E, De Rosa I, Antinolfi F, Antinolfi G, Caputi M, Brunese L, Grassi R, Rotondo A. Preliminary study on the correlation between grading and histology of solitary pulmonary nodules and contrast enhancement and [18F] fluorodeoxyglucose standardised uptake value after evaluation by dynamic multiphase CT and PET/CT. *J. Clin Pathol* 2011; 64: 114-119.
 79. Scialpi M, Cappabianca S, Rotondo A, Scalera GB, Barberini F, Cagini L, Donato S, Brunese L, Pisciole I, Lupatelli L. Pulmonary congenital cystic disease in adults. Spiral computed tomography findings with pathologic correlation and management. *Radiol Med* 2010; 115: 539-550.
 80. Ingegnoli A, Corsi A, Verardo E, De Filippo M, Sverzellati N, Zompatori M. Uncommon causes of tracheobronchial stenosis and wall thickening: MDCT imaging. *Radiol Med* 2007; 112: 1132-41.
 81. Robinson CM, Seah M, Akhtar MA. The epidemiology, risk of recurrence, and functional outcome after an acute traumatic posterior dislocation of the shoulder. *J Bone Joint Surg Am* 2011; 93: 1605-13.
 82. Hawkins RJ, Neer CS, 2nd, Pianta RM, Mendoza FX. Locked posterior dislocation of the shoulder. *J Bone Joint Surg Am* 1987; 69: 9-18.
 83. Barile A, La Marra A, Arrigoni F, Mariani S, Zugaro L, Splendiani A, Di Cesare E, Reginelli A, Zappia M, Brunese L, Duka E, Carrafiello G, Masciocchi C. Anaesthetics, steroids and platelet-rich plasma (PRP) in ultrasound-guided musculoskeletal procedures. *Br J Radiol* 2016; 89:
 84. Perrotta FM, Astorri D, Zappia M, Reginelli A, Brunese L, Lubrano E. An ultrasonographic study of entheses in early psoriatic arthritis patients naive to traditional and biologic DMARDs treatment. *Rheumatol Int* 2016; 36: 1579-1583.
 85. Ogawa K, Yoshida A, Ikegami H. Isolated fractures of the greater tuberosity of the humerus: solutions to recognizing a frequently overlooked fracture. *J Trauma* 2003; 54: 713-7.
 86. Tyson S, Hatem SF. Easily Missed Fractures of the Upper Extremity. *Radiol Clin North Am* 2015; 53: 717-36, viii.
 87. McGinley JC, Roach N, Hopgood BC, Kozin SH. Nondisplaced elbow fractures: A commonly occurring and difficult diagnosis. *Am J Emerg Med* 2006; 24: 560-6.
 88. Owen RA, Melton LJ, 3rd, Johnson KA, Ilstrup DM, Riggs BL. Incidence of Colles' fracture in a North American community. *Am J Public Health* 1982; 72: 605-7.
 89. Kaewlai R, Avery LL, Asrani AV, Abujudeh HH, Sacknoff R, Novelline RA. Multidetector CT of carpal injuries: anatomy, fractures, and fracture-dislocations. *Radiographics* 2008; 28: 1771-84.
 90. Balci A, Basara I, Cekdemir EY, Tetik F, Aktas G, Acarer A, Ozaksoy D. Wrist fractures: sensitivity of radiography, prevalence, and patterns in MDCT. *Emerg Radiol* 2015; 22: 251-6.
 91. Ahn JM, El-Khoury GY. Occult fractures of extremities. *Radiol Clin North Am* 2007; 45: 561-79, ix.
 92. Gelberman RH, Wolock BS, Siegel DB. Fractures and non-unions of the carpal scaphoid. *J Bone Joint Surg Am* 1989; 71: 1560-5.
 93. Avery DM, 3rd, Rodner CM, Edgar CM. Sports-related wrist and hand injuries: a review. *J Orthop Surg Res* 2016; 11: 99.
 94. Leone A, Cassar-Pullicino VN, Perez MH, Guglielmi G. Emergency and Trauma of the Pelvic Ring. *Semin Musculoskelet Radiol* 2017; 21: 210-217.
 95. Russo A, Reginelli A, Zappia M, Rossi C, Fabozzi G, Cerrato M, Macarini L, Coppolino F. Ankle fracture: radiographic approach according to the Lauge-Hansen classification. *Musculoskelet Surg* 2013; 97 Suppl 2: S155-60.
 96. Zappia M, Cuomo G, Martino MT, Reginelli A, Brunese L. The effect of foot position on Power Doppler Ultrasound grading of Achilles enthesitis. *Rheumatol Int* 2016; 36: 871-874.
 97. Cuomo G, Zappia M, Iudici M, Abignano G, Rotondo A, Valentini G. The origin of tendon friction rubs in patients with systemic sclerosis: a sonographic explanation. *Arthritis Rheum* 2012; 64: 1291-3.
 98. Pinto A, Reginelli A, Pinto F, Sica G, Scaglione M, Berger FH, Romano L, Brunese L. Radiological and practical aspects of body packing. *Br J Radiol* 2014; 87:
 99. Pinto A, Niola R, Tortora G, Ponticello G, Russo G, Di Nuzzo L, Gagliardi N, Scaglione M, Merola S, Stavolo C, Maglione F, Romano L. Role of multidetector-row CT in assessing the source of arterial haemorrhage in patients with pelvic vascular trauma. Comparison with angiography. *Radiol Med* 2010; 115: 648-67.
 100. Russo A, Zappia M, Reginelli A, Carfora M, D'Agosto GF, La Porta M, Genovese EA, Fonio P. Ankle impingement: a review of multimodality imaging approach. *Musculoskelet Surg* 2013; 97 Suppl 2: S161-8.
 101. 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.
 102. Parker MJ. Missed hip fractures. *Arch Emerg Med* 1992; 9: 23-7.
 103. Oka M, Monu JU. Prevalence and patterns of occult hip fractures and mimics revealed by MRI. *AJR Am J Roentgenol* 2004; 182: 283-8.
 104. Zappia M, Capasso R, Berritto D, Maggialelli N, Varella C, D'Agosto G, Martino MT, Carbone M, Brunese L. Anterior cruciate ligament reconstruction: MR imaging findings. *Musculoskeletal Surg* 2017; 101: 23-35.
 105. Yu JS. Easily Missed Fractures in the Lower Extremity. *Radiol Clin North Am* 2015; 53: 737-55, viii.
 106. Dunker D, Collin D, Gothlin 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.

107. Yu JS. Hip and femur trauma. *Semin Musculoskelet Radiol* 2000; 4: 205-20.
108. Gottsegen CJ, Eyer BA, White EA, Learch TJ, Forrester D. Avulsion fractures of the knee: imaging findings and clinical significance. *Radiographics* 2008; 28: 1755-70.
109. Nurzynska D, Di Meglio F, Castaldo C, Latino F, Romano V, Miraglia R, Guerra G, Brunese L, Montagnani S. Flat-foot in children: anatomy of decision making. *Ital J Anat Embryol* 2012; 117: 98-106.
110. Jibri Z, Mukherjee K, Kamath S, Mansour R. Frequently missed findings in acute ankle injury. *Semin Musculoskelet Radiol* 2013; 17: 416-28.
111. Gupta RT, Wadhwa RP, Learch TJ, Herwick SM. Lisfranc injury: imaging findings for this important but often-missed diagnosis. *Curr Probl Diagn Radiol* 2008; 37: 115-26.
112. Llopis E, Carrascoso J, Iriarte I, Serrano Mde P, Cerezal L. Lisfranc Injury Imaging and Surgical Management. *Semin Musculoskelet Radiol* 2016; 20: 139-53.
113. Graber M. Diagnostic errors in medicine: a case of neglect. *Jt Comm J Qual Patient Saf* 2005; 31: 106-13.
114. Pinto A, Brunese L, Pinto F, Reali R, Daniele S, Romano L. The Concept of Error and Malpractice in Radiology. *Semin. Ultrasound CT MRI* 2012; 33: 275-279.
115. Pinto A, Brunese L, Pinto F, Acampora C, Romano L. E-learning and education in radiology. *Eur J Radiol* 2011; 78: 368-371.
116. Pinto A, Pinto F, Faggian A, Rubini G, Caranci F, Macarini L, Genovese EA, Brunese L. Sources of error in emergency ultrasonography. *Crit Ultrasound J* 2013; 5: 1-5.
117. Pinto A, Brunese L. Spectrum of diagnostic errors in radiology. *World J Radiol* 2010; 2: 377-83.
118. Briganti F, Marseglia M, Leone G, Briganti G, Piccolo D, Napoli M, Caranci F. Endovascular treatment of a small aneurysm of the superior cerebellar artery with a flow-diverter device. *Neuroradiol* . 2013; 26 (3): 327-331.
119. Kundel HL, Nodine CF, Carmody D. Visual scanning, pattern recognition and decision-making in pulmonary nodule detection. *Invest Radiol* 1978; 13: 175-81.
120. Samuel S, Kundel HL, Nodine CF, Toto LC. Mechanism of satisfaction of search: eye position recordings in the reading of chest radiographs. *Radiology* 1995; 194: 895-902.
121. Briganti F, Leone G, Marseglia M, Cicala D, Caranci F, Maiuri F. P64 Flow Modulation Device in the treatment of intracranial aneurysms: initial experience and technical aspects. *J NeuroInterv Surg* 2016; 8 (2): 173-180.
122. West RW. Radiology malpractice in the emergency room setting. *Emergency Radiology* 2000; 7: 14-18.
123. Wei CJ, Tsai WC, Tiu CM, Wu HT, Chiou HJ, Chang CY. Systematic analysis of missed extremity fractures in emergency radiology. *Acta Radiol* 2006; 47: 710-7.
124. Fitzgerald R. Error in radiology. *Clin Radiol* 2001; 56: 938-46.
125. Scaglione M, Iaselli F, Sica G, Feragalli B, Nicola R. Errors in imaging of traumatic injuries. *Abdom Imaging* 2015; 40: 2091-8.
126. Stone PC, Hilton CF. Medicolegal aspects of emergency department radiology. *Radiol Clin North Am* 1992; 30: 495-501.
127. Sica G, Guida F, Bocchini G, Codella U, Mainenti PP, Tanga M, Scaglione M. Errors in imaging assessment of polytrauma patients. *Semin Ultrasound CT MR* 2012; 33: 337-46.
128. Mazzei MA, Volterrani L. Errors in multidetector row computed tomography. *Radiol Med* 2015; 120: 785-94.
129. Ha AS, Porrino JA, Chew FS. Radiographic pitfalls in lower extremity trauma. *AJR Am J Roentgenol* 2014; 203: 492-500.
130. Reginelli A, Mandato Y, Solazzo A, Berritto D, Iacobellis F, Grassi R. Errors in the radiological evaluation of the alimentary tract: part II. *Semin Ultrasound CT MR* 2012; 33: 308-17.
131. Salerno S, Tudisca C, Murmura E, Matranga D, La Tona G, Lo Re G, Lo Casto A. Umbilical venous catheters placement evaluation on frontal radiogram: application of a simplified flow-chart for radiology residents. *Radiol Med* 2017; 122: 386-391.
132. Lo Casto A, Priolo GD, Garufi A, Purpura P, Salerno S, La Tona G, Coppolino F. Imaging evaluation of facial complex strut fractures. *Semin Ultrasound CT MR* 2012; 33: 396-409.
133. Lo Re G, De Luca R, Muscarneri F, Dorangricchia P, Piccone D, Vernuccio F, Salerno S, La Tona G, Pinto A, Midiri M, Russo A, Lagalla R, Cicero G. Relationship between anxiety level and radiological investigation. Comparison among different diagnostic imaging exams in a prospective single-center study. *Radiol Med* 2016; 121: 763-8.
134. De Filippo M, Corsi A, Evaristi L, Bertoldi C, Sverzellati N, Averna R, Crotti P, Bini G, Tamburrini O, Zompatori M, Rossi C. Critical issues in radiology requests and reports. *Radiol Med* 2011; 116: 152-62.
135. De Filippo M, Rovani C, Sudberry JJ, Rossi F, Pogliacomini F, Zompatori M. Magnetic resonance imaging comparison of intra-articular cavernous synovial hemangioma and cystic synovial hyperplasia of the knee. *Acta Radiol* 2006; 47: 581-4.
136. Mandato Y, Reginelli A, Galasso R, Iacobellis F, Berritto D, Cappabianca S. Errors in the radiological evaluation of the alimentary tract: part I. *Semin Ultrasound CT MR* 2012; 33: 300-7.
137. De Filippo M, Ingegnoli A, Carloni A, Verardo E, Sverzellati N, Onniboni M, Corsi A, Tomassetti S, Mazzei M, Volterrani L, Poletti V, Zompatori M. Erdheim-Chester disease: clinical and radiological findings. *Radiol Med* 2009; 114: 1319-29.
138. Scaglione M, Pinto A, Pinto F, Romano L, Ragozzino A, Grassi R. Role of contrast-enhanced helical CT in the evaluation of acute thoracic aortic injuries after blunt chest trauma. *Eur Radiol* 2001; 11: 2444-8.
139. Ierardi AM, Floridi C, Fontana F, Duka E, Pinto A,

- Petrillo M, Kehagias E, Tsetis D, Brunese L, Carrafiello G. Transcatheter embolisation of iatrogenic renal vascular injuries. *Radiol Med* 2014; 119: 261-268.
140. Schueller G, Scaglione M, Linsenmaier U, Schueller-Weidkamm C, Andreoli C, De Vargas Macciucca M, Gualdi G. The key role of the radiologist in the management of polytrauma patients: indications for MDCT imaging in emergency radiology. *Radiol Med* 2015; 120: 641-54.
141. Robinson PJ. Radiology's Achilles' heel: error and variation in the interpretation of the Rontgen image. *Br J Radiol* 1997; 70: 1085-98.
142. Pinto A, Acampora C, Pinto F, Kourdioukova E, Romano L, Verstraete K. Learning from diagnostic errors: a good way to improve education in radiology. *Eur J Radiol* 2011; 78: 372-6.
143. Goddard P, Leslie A, Jones A, Wakeley C, Kabala J. Error in radiology. *Br J Radiol* 2001; 74: 949-51.
144. Leslie A, Jones AJ, Goddard PR. The influence of clinical information on the reporting of CT by radiologists. *Br J Radiol* 2000; 73: 1052-5.
145. Ierardi AM, Fontana F, Giorlando F, De Marchi G, Pinto A, Radaelli A, Schampaert S, Tonolini M, Novario R, Carrafiello G. Evaluation of tablet ultrasound for routine abdominal interventional procedures. *Radiol Med* 2016; 121: 675-80.
146. Berlin L. Errors of omission. *AJR Am J Roentgenol* 2005; 185: 1416-21.
147. Lee CS, Nagy PG, Weaver SJ, Newman-Toker DE. Cognitive and system factors contributing to diagnostic errors in radiology. *AJR Am J Roentgenol* 2013; 201: 611-7.

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