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Radiology during the Evaluation of Earthquake Survivors

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Abstract

Earthquakes are one of the most devastating natural disasters, which may cause an unprecedented hazard to public health and the health system, depending on their intensity. Radiology has a central role in diagnosing and treating survivors who may have significant disorders directly related to the earthquake or its consequences. The trauma related to the earthquake may cause many disorders such as bone fractures, soft tissue and organ injuries, and both together. Moreover, infections are common in earthquake survivors who are mandated to live in non-optimal conditions. Hence, radiologists should be familiar with these complications and required imaging techniques. Digital radiography and computed tomography are the methods of choice to detect most earthquake-related disorders. In addition, ultrasonography also has its merits due to its diagnostic capability in soft tissue injuries and detection of pleural, pericardial, or intraperitoneal effusion. Besides, it is high reproducibility, feasibility, and availability rates. This review aimed to underline the radiological features of the most common complications in earthquake survivors.

Keywords: Imaging, earthquake, trauma

Introduction

Earthquakes are unpredicted natural catastrophes that may cause significant impacts on public health, mostly due to direct trauma on the human body depending on the intensity and location of both the earthquake and residential area.[1,2] The vast majority of traumas in survivors of the earthquake (e.g., falling objects, falling from a high area, and trapping under heavy objects) result in soft tissue injuries and bone fractures.[3,4] The most feasible and available radiological imaging modalities during the initial diagnostic workup are digital radiography (DR), computed tomography (CT), and ultrasonography which are also helpful for assessing therapeutic interventions. Therefore, the radiologist should be familiar with imaging findings and clues that lead to a final diagnosis and therapeutic guidance.[5,6]

Earthquake-Related Disorders

Often victims are evacuated after the earthquake, and radiologists at hospitals away from the earthquake zone have to be familiar with earthquake-related disorder imaging features. There are also post-earthquake conditions that are non-trauma type that must be considered, such as conditions brought on after being evacuated from the earthquake zone.[7]

Imaging Features

Bone Fracture, Soft Tissue, and Organ Injuries

Although inspection and physical examination are highly diagnostic for mechanical trauma, patients evacuated under the debris may be in shock or unconscious and therefore not able to describe their medical situation. Radiological imaging is particularly valuable in those patients. It has been demonstrated that most patients who survived the earthquake and were transferred to a hospital at its epicenter have multiple injuries. Bone fractures are the most common finding in earthquake survivors, which may be seen in up to 50% of all injuries.[3] The majority of bone fractures are detectable with DR. However, in patients with multiple trauma, due to inadequate patient positioning, pain, and soft tissue swelling, DR may be less useful and CT imaging is more valuable, particularly in those with subtle cortical bone injury.[8]

Among survivors of the earthquake, injuries are most commonly detected in extremities ranging from 37.2% to 72.4%.[9-11] It has been thought that, among patients with crush injury, extremity injuries are likely and hence should be investigated properly[12] (Figure 1). Due to its high frequency and high rates of complications, Crush syndrome is a significant problem in rescued patients. In patients with multiple injuries involving the extremities, Crush syndrome should be suspected in the presence of marked swelling and pain accompanied by neurological findings and circulatory deterioration. Since these patients either develop or are at high risk of acute renal failure, contrast administration for imaging should be avoided.

Due to high-force impacts, pelvic crush fractures are one of the most common injuries detected in earthquake survivors, which are prone to occur in bilateral direction and multiple fractures. Radiologists should assess the structures by comparing the contralateral side. Since pelvic fractures are frequently observed among patients rescued under the rubble, the possibility of sacrum fractures and acetabular ring fractures should be kept in mind.[13] Young classification system for pelvic ring fractures is a feasible and widely used system; hence, to ensure homogeneity among doctors, it should be used.[14] Computed tomography is crucial in evaluating complex acetabular and pelvic ring fractures (Figures 2 and 3). In addition to bone fractures, pelvic fractures carry a substantial risk of systemic deterioration due to uncontrolled bleeding. Bleeding due to vascular injuries may be pelvic, thigh, or retroperitoneal bleeding, all of which have hazardous consequences.

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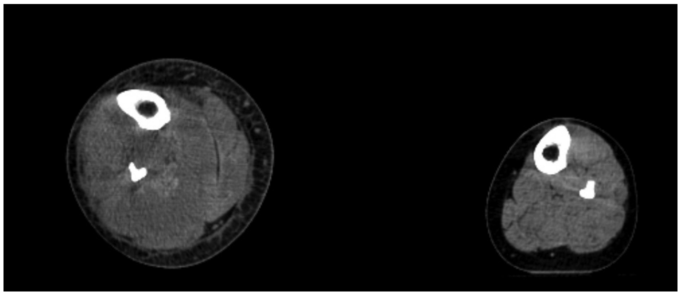

Figure 1. Image of a 16-year-old woman who was rescued under the wreckage. Axial unenhanced CT showing swelling of the muscles of the right lower leg. CT, computed tomography.

On the other hand, patients who suffered cranial, thoracic, and abdominal blunt trauma are under high risk of mortality.[15,16] The head is more prone to injuries caused by falling objects due to its position located at the top of the body in patients who are in an upright position. Head injury is the leading cause of earthquake-related death, responsible for 30% of all earthquake victims.[11] The most common types of head injury are laceration or contusion in 59.2%, skull fracture in 32.3%, and intracranial hemorrhage in 22.1% among survivors. Intracranial hemorrhage includes epidural hematoma which is the most common, intracerebral hemorrhage, and subdural hematoma.[17] Since the major cause of epidural hematomas is the injury of the surrounding vascular structures of the bones, the radiologist should be aware of the possibility of epidural hematoma adjacent to the fractured bones in patients with head trauma.[18] Epidural hematomas are restricted by the cranial sutures and not limited by the dura hence can be seen across the tentorium. In contrast, subdural hematomas can be seen on both sides of the trauma but tend to be contralateral side to the trauma (contre-coup), unilateral and restricted to the hemispheres. The underlying cause is the tear at the bridging veins. During the acute phase (first week), subdural hematomas appear hyperdense in CT imaging. Due to active bleeding areas, thrombus formation, and cerebrospinal fluid leakage, there are also hypodense areas within the hematoma. Contrast-enhanced CT demonstrates focal contrast extravasations indicating the bleeding areas (spot sign).[19,20] During the subacute phase (second and third week), hyperdense areas become isodense and challenge the discrimination between hematoma and normal parenchyma. In the chronic phase, hematoma becomes hypodense.

Prior studies have shown that even without mentioning direct compression, counter coup compression, shearing force, and lacerations caused by broken ribs, which are all blunt trauma related, persistent and heavy crushing will result in tonicity of the lungs leading to alveoli injury and hemorrhaging of the interstitium resulting in pulmonary contusion[12] (Figure 4). Alveolar hemorrhage and parenchymal injury expand during the first day of the injury and afterward tend to be stable. They are prone to disappear quickly within 7 days of the impact. Pneumothorax and pleural effusion are frequently observed concomitantly with these injuries. Thorax CT is superior to chest x-ray for the detection of lung contusions. Also, earthquake-related life-threatening ruptures within the cardiovascular system can be detected using multi-detector CT angiography.[21,22]

Abdominal solid organ injuries associated with the earthquake are frequently due to the direct impact of the trauma. In addition, it is also associated with the compression, tension, or the tearing effects of the trauma. Solid organs tend to bleed, whereas organs with cavities are at risk of perforation and bleeding, hence peritoneal contamination may be observed. Hemoperitoneum might occur due to trauma-related liver, spleen, and mesenteric lacerations. Morison pouch, right paracolic sulcus, and Douglas pouch are the most common locations of hematoma following trauma-related bleeding. Hematoma due to acute bleeding appears anechoic with ultrasonography. Over time, increased echogeneity and septations may be seen within the hematoma.[23]

Infection

Although infections of the soft tissues due to injuries may be observed in earthquake survivors, generally, infection diseases are not directly related to the earthquake. Still, most of the infections are related to bad hygiene among the earthquake survivors who are mandated to live in non-optimal conditions. Survivors with or without injuries live in crowded places that do not have

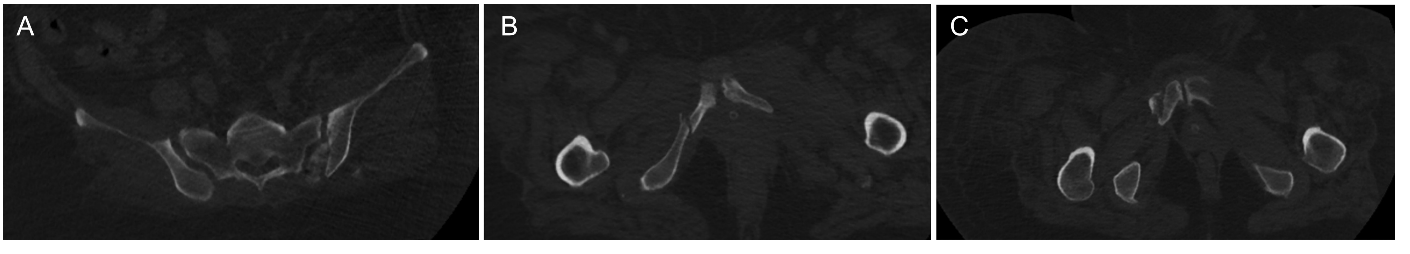

Figure 2. Image of a 61-year-old woman. Axial CT shows crescent fracture of the pelvis (A), the fractures of the right inferior pubic ramus (B, C). CT, computed tomography.

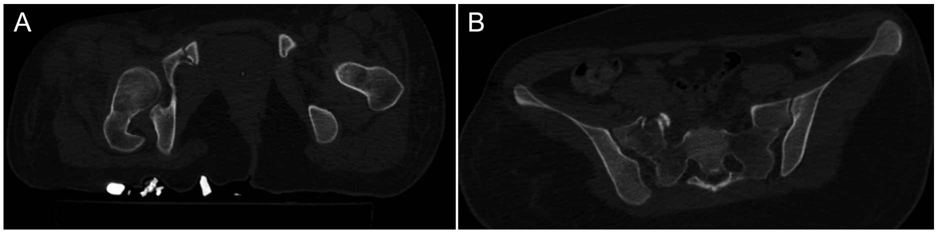

Figure 3. Image of the pelvis of a 23-year-old woman. Axial CT shows the fracture of right superior pubic ramus (A) and sacral fracture (B). CT, computed tomography.

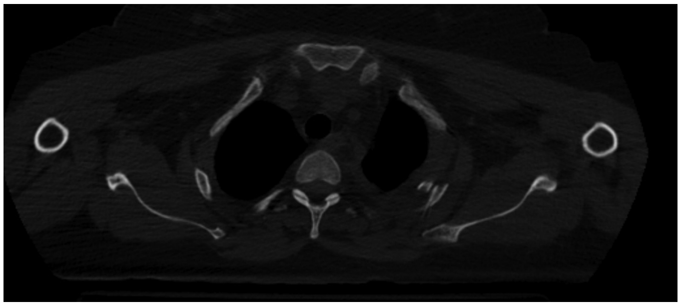

Figure 4. Axial unenhanced chest CT demonstrates fracture of a significantly displaced left second rib. CT, computed tomography.

proper sanitation systems. Hence, contagious infective diseases are a problem for the public health system following days after the mainshock. These infections are observed mainly in the respiratory system and gastrointestinal tract.[24]

Conclusion

Radiological imaging is key during the initial workup and guiding the therapy in earthquake survivors. Although DR is a diagnostic imaging method in most patients with bone fractures, CT imaging is required in patients with multiple injuries due to its higher diagnostic ability. Although it is widely available in most centers worldwide, centers with this equipment may be damaged and re-initialization takes days. Sonography is also helpful when assessing soft tissue injuries and effusions and should be available where the healthcare system is provided.

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