



The Critical Role of X-ray Imaging in Emergency Departments for Rapid Diagnosis of Injuries, Fractures, and Trauma Cases

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Abstract

Acute orthopedic injuries and limb trauma remain a prime cause for patients to visit emergency medical facilities worldwide. The acute limb injury remains a leading cause of disability, hospitalization, and use of emergency services. Derangements and significant deviations in joint anatomy are preferentially located at the articular surface, and as such, are often addressed through operative or interventional treatment strategies. Opportunity for orthopedic surgery often exists when a patient presents to an emergency department with acute pain secondary to an acute traumatic injury. Direct radiography is the cornerstone for initial workup. Information gathered from direct radiography greatly guides decision-making for surgical intervention. Detailed staging through focused magnetic resonance imaging continues to provide the gold standard for diagnosis and treatment planning in non-acute musculoskeletal cases. Where immediate treatment intervention is planned, staged imaging techniques including magnetic resonance imaging are often reserved for the latter stages of care. Rapid, accurate diagnosis remains essential, and the advantages and limitations of primary support imaging with direct radiography, CT, and MRI are discussed. (Ali & Waseem, 2023)



Keywords-x-ray imaging; rapid diagnosis; emergency departments; injuries, fractures; trauma; hospital efficiency; optimized patient flows; X-ray system; single-focus spot; medical care concept; injured patients; muscle or bone disorders; wireless communication; ER teams; transport process; medical grade standards; requirements; wireless interfaces; wireless access points; wireless accessories; wireless data transfer; special pendants; cable free accessories; X-ray room; X-ray examination; wireless weight scales; performance; clinical diagnosis; PA; lateral and oblique imaging.

1. Introduction

Acute or chronic pain or other health complications due to recent injuries and fractures cannot wait for more than a few hours for diagnosis. The role of medical imaging is critical in obtaining rapid diagnoses of various types of injuries and fractures and also in deciding upon the further course of action. The emergency department has been designed to cater to such critical cases, such as major accidents, falls, burns, infarctions, sudden severe symptoms, as well as chronic patients with long waiting times and chronic pain. Since the frequency of such cases requiring special attention is very high, the emergency department has radiological units in-house to provide immediate or on-demand medical imaging such as X-ray, computed tomography, magnetic resonance imaging, and ultrasound. It is known that X-ray and computed tomography are the most frequently used techniques in these situations. As not all radiological modalities are available within the emergency department, only the most serious cases undergo other studies inside the emergency department environment, while the remaining cases are generally referred to interoperable hospitals for such studies. (Hussain et al.2022)

2. Understanding X-ray Imaging

When patients go for an X-ray, they enter a room with a smart bed and a high-tech machine that looks a bit like a robotic drum set. Given the size of the bed and having to lie on it without moving a muscle, it can feel like being perched on a tightrope, and there can be knee-knocking nerves about what to expect. Most patients have had some experience with X-ray imaging for things like teeth. Regular body X-rays capture a broad view, and bone X-rays are used for falls and injuries. While the requirements are basically the same, the procedure is certainly more advanced. Thanks to medical imaging technology like X-rays, doctors can get an inside look at anything that might be wrong and work out what to do to fix it. When X-rays do their thing, they let patients portray their still images to help diagnose a problem and hypothesize what might be happening once patients are under the real-life gaze of a doctor. (Lftta et al.2024)

Back in the day when our collective grandparents were nursing aches and fractures, if they needed to have their bones seen to, that was typically a "no candy" drill. X-ray imaging was a



static affair affording a single bidimensional view when what they really wanted was an animated solution. Modern X-rays, both 2D and 3D devices fitted with accurate sensors that harness beam throttling and automatic dose adjustment, consistently enhance the patient experience. These next-gen devices can capture numerous constrained angle views, thus allowing a better look at the internal anatomy. In these performant X-rays, electronic breath holding helps the patient assume the required position. Sometimes the 2D impression doesn't tell the full story, and if needed, the operating clinician can order 3D imaging to get the utmost accuracy. Regardless of the nature of the patient's injury, these are some of the many ways technologically superior X-rays can ensure patients get the attention they need. The best part? They can all be customized to the patient's age and condition. These X-ray iterations can also highlight the intensity of bone density, detect fractures, or determine the end result of a fracture by verifying how much the bone has overlapped from the previous standard position. (Ehlke, 2021)

3. Importance of X-ray Imaging in Emergency Departments

The presentation will underscore the importance of X-ray imaging techniques such as digital radiography, which play a critical role in underpinning the work of emergency departments in hospitals. This type of high-quality X-ray imaging is a critical diagnostic technology for use in emergency departments. When arriving at the emergency department for any kind of accident or injury—including car accidents, sports-related injuries, physical abuse, and gunshot or knife wounds—patients must receive a rapid diagnosis for immediate treatment. X-ray imaging is a critical tool for this initial examination. Digital radiography, in which X-ray images are obtained digitally, is an indispensable tool for making a rapid diagnosis of the patient's condition so that an appropriate treatment plan can be put into place. Since many people are brought to the emergency department with accidents or injuries, hospital environments must be prepared to quickly and accurately diagnose a broad range of symptoms, from minor problems to serious conditions. Emergency departments must be equipped with an imaging modality that can rapidly perform detailed examinations of the patient's condition during leisure activities and work time. Diagnostic X-ray imaging that generates high-quality X-ray images on the spot is ideally suited to meet this expectation. The expected role of diagnostic X-ray imaging that combines an intrinsically simple examination method with high diagnostic accuracy is increasing due to its rapid, undelayed function that is required for these unique needs. The development of digital radiography is making it possible to deliver rapid, high-quality examinations. Moreover, this imaging modality does not require X-ray imaging facilities to be affiliated with a radiology department and is, therefore, used in non-radiology department medical institutions. These advantages have led to rapid ongoing expansion. (Irede et al.2024)



3.1. Quick and Accurate Diagnosis

One of the most important roles in the field of diagnostic radiology is probably the examination of patients referred to emergency services due to injuries and trauma from trauma cases by the attending physician. Organs and systems related to many specialties, such as thoracic systems, abdominal systems, and nervous systems, can be affected in emergency cases, while serious conditions may occur that could compromise life or cause permanent damage. Being the first step of treatment, a quick and accurate diagnosis will direct the remaining evaluation, type of intervention, and the final outcome of the patient. Although various imaging methods can be used in emergencies, the most commonly used method is undoubtedly X-ray imaging. Emergency departments are the most frequent imaging area we encounter in physical diagnosis and therapeutic applications. (Qudair et al.2022)

Modern digital X-ray systems utilized in health institutions perform this traditional diagnosis and control process for emergency cases. In these systems, several low-dose X-rays are generated and projected on the patient's area of interest, and therefore radiographs are produced. Thanks to the digital properties of these systems, they visually display radiographic images, and theoretically, images are seen by medical doctors in a fast and more accurate fashion. Additionally, in digital systems, various computer applications are performed, such as the use of exposure techniques to reduce patient exposure and image-based diagnosis or data storage. With these functionalities, the ease of use of the systems can be effectively increased. However, as in all radiological examinations, the primary ethical requirement is to minimize the potential risk factors that the patient is exposed to as much as possible and not to exceed the quality of the image sufficient for the diagnosis; that is, the patient should be examined with the lowest reasonable dose. (Hussain et al.2022)

3.2. Assessment of Fractures and Injuries

X-ray is frequently used to detect fractures or dislocations in trauma cases. To safely rule out the possibility of a fracture in the injured extremity of an adult patient, two radiographic views are most commonly used for the wrist, elbow, knee, and ankle. When evaluating knees, three views are preferred. Additionally, in some trauma cases, the comparison view of the unharmed extremity can make the diagnostic task more specific. For an injured child in whom growth plates are still present, a comparison view of the uninjured hand is one of the important fast-anatomic search techniques utilized to differentiate between fractures and growth plate injury. (Regnard et al.2022)

X-ray is frequently used to detect fractures or dislocations in trauma cases. 2D images that can be quickly obtained have many advantages and can also serve as a rapid bone survey. Both fractures and dislocations render important organs highly vulnerable to injury.



Therefore, missed or misdiagnosed fractures or dislocations may lead to dangerous sequelae. Additionally, postoperative images can determine the positioning and the location of the hardware, as well as other abnormalities in fractures after reduction or operation. (Regnard et al.2022)

3.3. Detection of Internal Injuries

Internal injuries are injuries inside the body that do not show obvious signs of trauma, and some can be very serious. For a rapid diagnosis and timely treatment of internal injuries, computed tomography scans make it possible to detect internal injuries. Nevertheless, ED CT is often overused, and the majority of ED CT scans are associated with meaningfully greater cancer risks and more significant costs to society. A triage decision-making process based on shielding is beneficial for utilizing CT scans only when they are necessary. A rapid triage process for improved CT imaging should be performed. The application of these and similar diagnostic processes, as well as combinations of multiple imaging modalities, will enhance patient care and benefit society. (Wijetunga et al.2020)

4. Technology and Equipment Used in X-ray Imaging

X-ray technology has become more advanced than we think. X-rays are becoming digital, and they are being directly transferred to the computer screen from the X-ray radiography. Computer images obtained with X-ray technology are clearer, and any kind of deformation can be seen by magnifying. The claustrophobia problem, one of the important issues of old X-ray radiography systems, has been eliminated with paneled X-ray systems. Any angle can be X-rayed easily, and long-term scanning processes are disappearing with increased speed. Higher quality images can be recorded easily thanks to high-resolution photographs obtained with digital port plates. Besides, the radiation dose that must be taken during data collection has been decreased by up to 40%. For smaller patients, those who will be X-rayed for any reason multiple times, and especially those being scanned molecularly, who receive more radiation than an X-ray, these radiographies provide faster results and a low radiation dose, making them an important solution for patient protection. Furthermore, once obtained, images can be used by physicians on every platform. They can be sent to other physicians for their views and can be kept on any platform for years. (Mettler et al.2020)

When it is necessary to protect other body parts from radiation effects, these areas can be covered with a special coated stainless material that is resistant to radiation. The scattering of the areas covered with this material is minimized, affecting less the person standing close, and they can be radiographed in a healthier manner. Direct digital user panels that can be controlled easily can shorten diagnosis times immediately. The attending nurse or doctor in the emergency room can retake the X-ray image and can see on screen if necessary, allowing them to get results rapidly without waiting for the radiologist's expertise. In case the patient



moves, makes a different movement, or if problems due to technical inadequacy are experienced, this issue will be noticed in a very short time, and necessary operations will be expected to be solved. Energy conservation is another advantage. The long waiting periods of classic radiography systems consume electricity, creating a disadvantage for institutions. In the new glossy systems, as well as the absence of any waiting period, the electricity savings due to the work done in a short duration also provide an economic advantage to the user. The system costs less than the classic radiography systems. Besides the perfect image and the exposure at low radiation, it decreases the working times. These studies are very important for the patient because they reduce the normal operation times in the emergency section and shorten the healthcare process, as well as the presence of the patient in the hospital. (Skjøt-Arkil et al.2021)

5. Challenges and Limitations

Most EDs face the problem of dealing with large numbers of patients, yet not having the modern facilities of a radiology department. Funding fixed X-ray facilities and human resource capabilities are significant barriers. X-ray resources may not be available at all or sometimes not for 24-hour service. Despite efforts to centralize radiology services to make them more efficient and cost-effective, for many reasons, access to these centralized radiology facilities can be inconvenient and sometimes time-consuming for the assessment of injured patients in an ED setting. Overall, the resources for radiography in many EDs are not optimally planned or resourced. If available, the radiography machines are not adequate to manage the workload and may be of old or suboptimal configurations and settings. Staff and more experienced facility technology is irregular, and thus its performance can also be variable. Advanced and dedicated facilities are very expensive, often needing an annual service fee even if maintained in a standby state. Staffing is another significant issue. Limited hours of service remain a significant issue in some sites. In some environments, tele-radiography has been of growing assistance in dealing with these significant resource problems. Analysis of high-quality X-rays or the potential need to obtain advanced imaging in a trauma center can be a significant restriction to timely and best-practice care onsite. Moreover, population growth and the pressure to increase acute care beds have resulted in emergency departments being upgraded significantly; however, generally, this upgrade does not include a coinciding upgrade in radiological equipment within the ED department. Thus, the need for a 'first shot' image of an injury justified for patient care is not usually in the planning documentation. (Ramazan et al., 2022)

6. Future Developments and Innovations

In conclusion, X-ray imaging plays a critical role in the prompt and effective diagnosis of many types of traumatic injuries. Advances related to the use of knowledge-guided artificial intelligence to process X-ray images will result in optimization and quality improvements. It



can help expedite diagnosis, streamline referrals to medical specialists and surgeons, and accelerate intervention. It can also assist in the rapid and effective management of injuries, fractures, and trauma cases, particularly in terms of handling underlying conditions by providing fast responses, which is an important factor in enhancing patient outcomes. Artificial intelligence can substantially affect clinical workflows in emergency departments with regard to the processing and management of X-ray images, as AI can be utilized to develop faster, more objective assessments and to promptly and informatively guide patient handovers between imaging teams, referring clinicians, and relevant medical specialists. Furthermore, future innovations in CT technologies through the use of knowledge-guided AI will potentially result in faster scanning times and the utilization of a smaller X-ray radiation dose to create optimized images, all of which can ultimately help to enhance patient safety, comfort levels, and outcomes. Other innovations in imaging protocols and streamlined work processes can help resolve any potential challenges related to the optimization of diagnosis. (Galvez et al.2020)

7. Conclusion

The use of x-ray imaging is predominant in emergency departments for a broad range of acute cases, including skin, soft tissues, and bone injuries. The critical role of x-ray imaging is to enable immediate diagnosis without the need of transporting patients across the hospital or between locations of different health care setups. X-rays work with minimal discomfort to injured patients, and so this imaging procedure is safe and rapid. It facilitates the assessment of the nature of injury by health departments working at the emergency departments, enabling them to promptly establish a suitable treatment plan. X-ray is the best imaging method for acute traumas of patients who are in a shocked state or at an unstable condition. In cases of trauma, medical doctors in emergency departments evaluate the patient and results of x-ray images simultaneously to rapidly take appropriate decisions. (Ippolito et al.2020)

The macro number of x-ray images requested in emergency departments causes a rapid workload. Technological advances including digital images, self-developing plates, dose reduction software, and the ease of saving, printing, and sharing digital images are useful to meet these high daily demands. These technical facilities raise their routine use and minimum waiting time levels for patients, prohibiting the outcome of fatal or near-fatal traumas that become immediately clear following the patient's admission to the emergency department. In order to properly employ the capacity offered by this imaging procedure, a qualified radiologic technician must be available round the clock. The insufficiency of technicians during off hours leads to a further increase in the workload that the technician has to carry out. Radiologic technicians employed in emergency department units should be experienced and skilled in taking x-ray images with the patient in their condition and injury. It must be taken into account that there are special shooting requirements in cases of trauma involving



multiple injuries. Radiologic technicians must be sufficiently experienced and skilled in these types of special situations. (Rachh et al.2021)

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