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X-Ray Machines Available in Najaf Hospitals, Iraq: Review

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Abstract **Review Article**

A myriad of X-ray machines have completely revolutionized the realm of medical imaging offered healthcare professionals an array of invaluable tools for accurate diagnosis and due to the importance of this matter and a comprehensive review was conducted of the X-ray machines available in Najaf hospitals and became clear that all possible types are available (conventional radiography (CR) machines, digital radiography (DR) machines, computed tomography (CT) scanners, fluoroscopy machines, C-arm machines, cone beam computed tomography (CBCT) scanners, mobile X-ray machines, positron emission tomography/ computed tomography (PET/CT) scanners, dual-energy X-ray absorptiometry (DXA) scanners, mammography (MG) scanners) for diagnosing various medical conditions, ranging from bone imaging to cross-sectional scanning, each machine avail a pivotal role in unveiling the mysteries of human health.

Keywords: X-ray, CR, DR, CT, Fluoroscopy, C-Arm, CBCT, Mobile X-ray, PET/CT, DXA, MG.

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1. INTRODUCTION

X-ray machines function as vital medical imaging tools that enable professionals in healthcare to view inner structures and diagnose medical cases through non-invasive procedures. The years of technological advancement have produced multiple X-ray machine types that serve different imaging requirements [1-3]. This review will discuss the types of X-ray machines that are available in Najaf hospitals, Iraq, in March 2024.

2. X-RAY MACHINES COMPONENTS

2.1 X-ray Tube

An X-ray tube creates the perfect environment for generating both braking rays and distinctive characteristic X-rays. It is composed of six vital components: “cathode, anode, glass or metal envelope, tube port, tube housing, and cable sockets”. Enveloped in a glass casing that’s been stripped of air, this tube holds two key components within its hermetically sealed realm: the cathode and the anode. At one end is the cathode, a negative electrode featuring a tungsten filament, when cranked up with heat, releases a shower of electrons through “a process known as thermionic emission”, and at the other end is the anode, a robust copper rod with a tiny target of tungsten. When an impressive voltage is unleashed between these two poles, electrons burst forth from the cathode and are catapulted at astonishing speeds toward the anode, ready to collide. These high-velocity electrons crash into the tungsten nucleus, and a spark of energy is unleashed, resulting in the creation of X-rays. This energetic beam then finds its way out through a slender glass window nestled within the casing of the tube. In certain models, the window is crafted from thin sheets of beryllium or aluminum, acting as filters to refine the emitted X-rays, ensuring that only the best make their way through [4-7].

2.2 Operating Console

The operating console gives radiologic technologists the power to adjust the X-ray tube's current and voltage, ensuring that their X-ray beam is adequate in quantity and quality. Radiation quantity describes the X-ray beam intensity with the number of X-rays present, the measurement unit for radiation quantity is “milligray (mGy)” or “milligray/milliampere-second (mGy/mAs)”. Radiation quality describes how well X-ray beams penetrate through materials and it is measured by "kilovolt peak (kVp)" or "half-value layer (HVL)". Users can adjust line compensation together with kVp and mA and exposure time through the operating console. The system includes meters which display kVp and mA and exposure time values. Some consoles display a mAs measurement through their metering system. The systems' automatic exposure control (AEC) needs separate mAs settings. The electric circuits between operating console meters and controls operate at low voltage to prevent hazardous shock risks. Operating consoles rely on computer technology. The system features digital controls and meters which allow users to select techniques through a touch screen interface. The selection of numeric techniques now uses body parts and size and shape icons instead of numeric values. Most x-ray imaging systems require 220 V power for operation but they can also run on 110 V or 440 V [8-10].

2.3 High-Frequency Generator

The X-ray generator circuit operates with different designs which include single-phase and three-phase, as well as constant voltage generators and high-frequency transformers. The device operates under the name that describes its purpose by employing "a high-frequency alternating waveform at 50,000 Hz" to perform efficient low-to-high voltage conversion through a step-up transformer. The output voltage becomes nearly constant through rectification and voltage smoothing processes. The generator operates at different frequencies which depend on exposure parameters (kV, mA, time) and X-ray tube high-voltage capacitor charge/discharge behavior and transformer frequency-to-voltage response [11,12].

2.4 Collimator

The X-ray field which exits from the tube port gets its dimensions and form through collimators. A swivel joint connects the collimator assembly to the tube housing which houses the tube port. Two parallel-opposed pairs of lead amenable shutters determine a field of rectangular X-ray. A low X-ray attenuation mirror inside the collimator housing reflects light which duplicates the X-ray beam. "The positive beam limitation (PBL)" collimator system restricts the field dimensions to the detector's functional area. The film cassette holder contains mechanical sensors which detect both the size and position of the cassette to enable automatic blade adjustments for matching the X-ray field to the cassette dimensions. The PBL circuit needs to be disabled to increase the field area but the field area reduction requires only an adjustment [13,14].

3. X-RAY MACHINES USED IN NAJAF HOSPITALS

3.1 Conventional Radiography Machines

Conventional radiography (CR) machines is best for getting stationary two-dimensional images and is therefore best for imaging bones, joints and the chest. The diagnostic tool serves to detect fractures and dislocations and lung infections and evaluate bone health. Where this X-ray equipment includes an X-ray tube together with a flat detector or film cassette [1-3,15]. Hospitals and medical facilities use CR machines or stationary X-ray machines as their most common X-ray machine type as is the case with the use of one of them in Al-Najaf Teaching Hospital, shown in Figure 1.

Figure 1: CR Machine in Al-Najaf Teaching Hospital.

3.2 Digital Radiography Machines

Digital radiography (DR) machines now operate as replacements for CR film-based machines through their use of digital detectors. The detectors use X-ray images to create digital pictures which displayed on computer screens. The DR machines provide three main benefits through their quick image capture and reduced radiation exposure and image adjustment capabilities that enhance diagnostic precision [16,17]. Medical imaging departments use these devices for general radiography procedures as is the case with the use of one of them in Al-Najaf Teaching Hospital, shown in Figure 2.

Figure 2: DR Machine in Al-Najaf Teaching Hospital.

3.3 Computed Tomography Scanners

"Computed tomography (CT) scanners" produce detailed images by rotating an X-ray tube with a detector array. CT scans produce detailed images that show bones and soft tissues and organs at high resolution. CT scans serve as essential tools for detecting complex medical conditions including tumors and vascular diseases and traumatic injuries and for surgical planning precision [18,19]. CT scanners are advanced X-ray machines that produce three-dimensional (3D) cross-sectional images of the body as is the case with the use of one of them in Al-Najaf Teaching Hospital, shown in Figure 3.

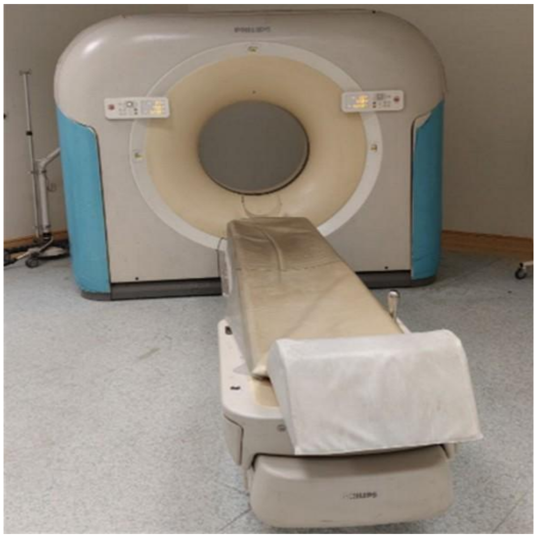

Figure 3: CT Scanner in Al-Najaf Teaching Hospital.

3.4 Fluoroscopy Machines

Fluoroscopy machines display "X-ray images in real-time on a monitor" through a fluoroscopic screen or digital detector. Fluoroscopy serves as a guidance tool for interventional procedures that include catheter insertions and joint injections and gastrointestinal studies. The medical procedure helps surgeons navigate during surgical operations through real-time visualization [17,20]. These machines are X-ray imaging in real-time systems which allows continued imaging of inner structures as is the case with the use of one of them in Al-Najaf Teaching Hospital, shown in Figure 4.

Figure 4: Fluoroscopy Machine in Al-Najaf Teaching Hospital.

3.5 C-Arm Machines

C-arm machines are expert fluoroscopy imaging systems that have a C-shaped arm that can be maneuvered into different positions. Their mobility and versatility make them suitable for real-time imaging during orthopedic surgeries, vascular systems, and pain management interventions [21,22]. C-arm machines are commonly used in surgical settings and interventional procedures as is the case with the use of one of them in Al-Batoul Private Hospital, shown in Figure 5.

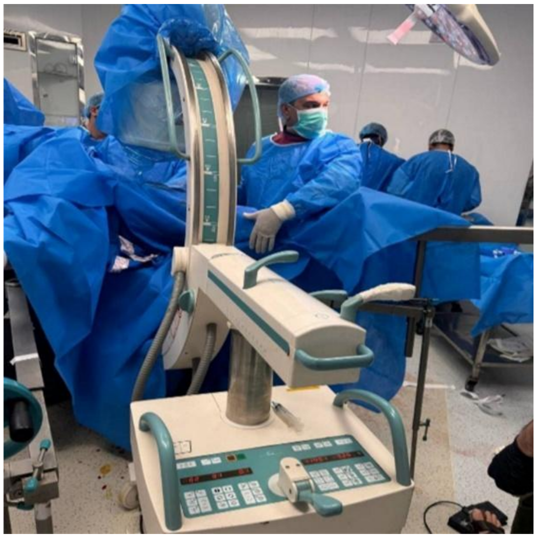

Figure 5: C-Arm Machine in Al-Batoul Private Hospital.

3.6 Cone Beam Computed Tomography Scanners

"Cone beam computed tomography (CBCT) scanners" are primarily used in dentistry and maxillofacial surgery. These scanners assist in assessing oral health, diagnosing complex dental issues (such as; deep cavities and root infections), and planning advanced dental treatments (such as; implants and orthodontics) [23-26]. They use cone beam (CB) X-rays to capture detailed 3D images of bones and hard tissues as is the case with the use of one of them in Al-Najaf Teaching Hospital, shown in Figure 6.

Figure 6: CBCT Scanner in Al-Najaf Teaching Hospital.

3.7 Mobile X-ray Machines

Mobile X-ray machines are small, “portable units that can be easily carried to a patient's bedside”, emergency rooms, or remote locations. They are handy for imaging critically ill or immobile patients who cannot be moved to conventional X-ray rooms [27,28]. Mobile X-ray machines are commonly used in nursing homes, home healthcare settings, and intensive care units (ICUs) as is the case with the use of one of them in Al-Najaf Teaching Hospital, shown in Figure 7.

Figure 7: Mobile X-ray Machine in Al-Najaf Teaching Hospital.

3.8 Positron Emission Tomography/ Computed Tomography Scanners

“Positron emission tomography/ computed tomography (PET/CT) scanners” are a hybrid tomography used to visualize the biodistribution of radioactive materials within tissues. These scanners rely on detecting annihilation photons resulting from the interaction between positrons emitted by radioisotopes injected into the body and electrons present in tissues [29-32]. PET/CT scanners are sensitive tools for detecting tumors, staging them, and monitoring the effects of various treatments as is the case with the use of one of them Amir Al-Momineen Specialized Hospital, as shown in Figure 8.

Figure 8: PET/CT Scanner in Ameer Al-Momineen Specialty Hospital.

3.9 Dual-energy X-ray Absorptiometry Scanners

"Dual-energy X-ray absorptiometry (DXA) is considered the standard for measuring bone mineral density (BMD)" with accurate and acceptable margins of error and good accuracy and repeatability. These examinations are the best densitometric technique for assessing BMD in postmenopausal women [33-36]. DXA scans allow accurate diagnosis of osteoporosis, estimation of fracture risk and monitoring of patients undergoing treatment as is the case with the use of one of them in Al-Sadr Teaching Hospital, shown in Figure 9.

Figure 9: DXA Scanner in Al-Sadr Teaching Hospital.

3.10 Mammography (MG) Scanners

Mammography (MG) scanners are recognized as the reference method for breast cancer screening and diagnosis, offering high-resolution imaging with acceptable accuracy and good precision. The MG scans are the most active radiologic technique for premature detection of breast cancer, particularly in women over 40. These scans enable the identification of suspicious lesions, microcalcifications, and abnormal tissue changes, aiding in early diagnosis and improved treatment outcomes [37-39]. MG scans produce high-quality imaging to help with better diagnosis as is the case with the use of one of them in German Oncology Center in Najaf, shown in Figure 10.

Figure 10: MG Scanner in German Oncology Center in Najaf.

4. SUMMARY

A review was conducted on the X-ray machines used in Najaf hospitals, where it became clear that all the different types of devices are available (CR machines, DR machines, CT scanners, Fluoroscopy machines, C-arm machines, CBCT scanners, Mobile X-ray machines, PET/CT scanners, DXA scanners, MG scanners) that enable diagnosis of various types of diseases, these health facilities in Najaf can diagnose and treat urgent cases such as fractures, tumors, etc. immediately, they also allow early screening for malignant tumors, including cancerous tumors, and conducting examinations during surgery, this all of that requires the presence of a cadre of radiology technicians capable of performing these examinations and a medical staff capable of interpreting the results of these examinations, and this is what Najaf currently possesses.

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