Chapter-15

RADIATION EXPOSURE AND IMAGE QUALITY

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15.1. INTRODUCTION

Radiography stands as a cornerstone in diagnostic imaging, utilizing ionizing radiation to visualize internal anatomical structures with precision and clarity. Despite its clinical value, radiography involves the use of ionizing radiation, which carries inherent biological risks, making the optimization of radiation dose a fundamental goal in diagnostic radiology. The principle of ALARA (As Low As Reasonably Achievable) underpins modern radiographic practice, demanding that clinicians balance diagnostic yield against radiation exposure to patients. Central to this approach is a thorough understanding of the numerous factors—collectively termed radiation dose determinants—that influence the amount of radiation a patient receives during an examination. These determinants can be classified into technical, anatomical, procedural, and patient-specific categories. Technical factors include exposure parameters such as kilovoltage peak (kVp), milliampere-seconds (mAs), source-to-image distance (SID), and collimation. Each of these variables plays a direct role in modulating both image quality and radiation dose. For example, an increase in kVp enhances beam penetration and reduces patient dose per unit of exposure, but may decrease image contrast; conversely, higher mAs improves image density at the expense of greater dose. Therefore, radiologic technologists must judiciously select exposure settings based on patient size, the anatomical region being imaged, and the clinical question at hand. Patient anatomy and positioning also substantially influence dose requirements. Larger patients or denser anatomical areas necessitate higher exposure to achieve adequate image penetration, while improper positioning can lead to repeat exposures and cumulative dose increases [1].

The use of automatic exposure control (AEC) systems, when properly calibrated, helps maintain consistent image quality while adapting dose output based on patient thickness. Proper alignment of the X-ray beam with the region of interest minimizes the risk of retakes, thereby preserving both patient safety and diagnostic accuracy. Equipment performance and detector technology are equally critical. Advances in digital radiography, particularly direct digital detectors, have improved dose efficiency through enhanced sensitivity and noise reduction capabilities. Conversely, outdated or poorly maintained systems may produce suboptimal images at higher doses. Regular quality control testing, equipment calibration, and adherence to manufacturer specifications ensure that imaging devices function within safe operating parameters. Furthermore, beam restriction techniques, including collimation and filtration, serve as key strategies in dose reduction. Collimators restrict the X-ray field to the area of interest, decreasing exposure to surrounding tissues and reducing scatter radiation, which in turn improves image contrast. Filtration, typically using aluminum filters, removes low-energy photons from the beam, which contribute to skin dose but offer no diagnostic benefit. The use of radiographic grids also influences dose. Grids absorb scatter radiation and enhance image contrast, especially in thicker body parts; however, they also

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necessitate increased exposure due to absorption of part of the primary beam. Consequently, grids should be used selectively, taking into account patient size and clinical necessity. Shielding of radiosensitive organs, including thyroid, gonads, and breasts, remains an essential but evolving aspect of dose optimization, with current guidelines emphasizing context-specific application to prevent interference with AEC systems or image degradation. Beyond equipment and physical parameters, human expertise is a significant determinant of radiation dose [2]. The radiologic technologist's knowledge of exposure techniques, anatomy, and patient handling directly impacts both image quality and safety. Inadequate training or inattention can result in poor-quality images, unnecessary repeats, and elevated doses. Thus, ongoing professional development and adherence to standard protocols are indispensable. Regulatory standards and diagnostic reference levels (DRLs) serve as benchmarks for acceptable dose ranges, facilitating dose audits, quality assurance, and continual improvement. Alongside dose management, achieving high image quality is a central goal in radiographic practice. Image quality refers to the fidelity with which an image represents the anatomical structures of interest, and it is essential for accurate diagnosis and treatment planning [3]. It is shaped by a complex interplay of spatial resolution, contrast resolution, image noise, geometric accuracy, and artifact minimization.

Spatial resolution denotes the ability of the system to distinguish small structures that are close together, measured in line pairs per millimeter (lp/mm), and is influenced by factors such as focal spot size, detector element size, and geometric magnification. Small focal spots and increased source-to-image distances (SID) improve sharpness, while minimizing object-to-image distance (OID) reduces magnification and distortion. Contrast resolution, the ability to differentiate tissues of similar radiodensity, is governed by kVp, image receptor characteristics, scatter radiation, and post-processing. While lower kVp enhances subject contrast, it also increases patient dose, necessitating careful parameter selection based on clinical objectives. Image noise, comprising random signal variations that obscure fine details, is a critical limitation in low-dose imaging. Sources of noise include quantum mottle from insufficient photon counts and electronic interference in the detector system. Increasing exposure can reduce noise but must be balanced against radiation safety; alternatively, digital noise-reduction algorithms offer potential improvement, albeit sometimes at the cost of fine detail. Artifacts—unwanted visual features not present in the actual anatomy—arise from technical errors, patient movement, or digital processing flaws, and may lead to diagnostic misinterpretation. Strategies to minimize artifacts include proper patient instruction, equipment calibration, and real-time monitoring of image acquisition [4]. Geometric factors, including magnification, distortion, and blur, impact image fidelity. These effects are managed by optimizing patient positioning, beam alignment, and maintaining appropriate distances between the X-ray source, subject, and detector. In digital systems, post-processing techniques such as contrast enhancement, edge detection, and histogram normalization further refine image appearance, though these must be applied carefully to avoid loss of diagnostic content. Display monitor quality, ambient lighting, and observer experience also affect the perceived image quality [5]. Objective measures such as modulation transfer function (MTF), noise power spectrum (NPS), and detective quantum efficiency (DQE) provide standardized metrics for evaluating imaging system performance. Ultimately, the goal of radiographic imaging is to achieve diagnostic clarity with the least possible risk. This necessitates a synergy of optimized exposure protocols, high-performing equipment, skilled personnel, and continuous adherence to safety and quality assurance practices. As radiographic technology and clinical demands evolve, so too must our commitment to understanding and managing the intertwined dynamics of radiation dose and image quality in pursuit of excellence in patient care [6].

15.2. FACTORS AFFECTING X-RAY RADIATION DOSE

The amount of radiation dose, a patient receives during an X-ray examination is determined by a combination of technical settings, procedural choices, patient anatomy, and equipment design. A thorough understanding of these factors is essential for optimizing image quality while minimizing radiation exposure. Among these, technical exposure parameters such as tube voltage (kVp), tube current and exposure time (mAs), filtration, collimation, and source-to-image distance (SID) play a critical role in dose management.

A. **Tube voltage (kVp):** One of the most significant factors is the tube voltage, measured in kilovoltage peak (kVp). This controls the energy level of the X-ray photons produced. Higher kVp values result in more penetrating X-rays that can pass through dense anatomical structures like the pelvis or thorax more

efficiently. This means that fewer photons are absorbed superficially, which can reduce image noise and the likelihood of needing repeat exposures. However, increasing kVp also increases the total number of photons reaching the detector and the patient, thereby increasing the overall radiation dose if not managed correctly. Additionally, higher kVp tends to reduce image contrast, particularly in soft tissues, which can affect diagnostic accuracy. Therefore, the kVp must be carefully selected based on the region being imaged and the diagnostic requirement, maintaining a balance between sufficient penetration and optimal contrast.

B. **Tube current (mA)** and **exposure time (s):** Collectively expressed as milliampere-seconds (mAs), directly influence the quantity of X-rays produced. Increasing either the current or the exposure duration raises the number of photons generated, which enhances the signal reaching the detector. This improves image quality, especially in areas with low subject contrast or in patients with larger body habitus. However, this also increases the patient's radiation dose proportionally. For instance, doubling the mAs results in approximately double the dose. Radiographers must therefore adjust mAs based on the clinical indication, patient size, and the imaging system's sensitivity, ensuring that the dose is as low as reasonably achievable (ALARA) without compromising image quality [7].

C. **Beam filtration:** Another important consideration is beam filtration. Modern X-ray machines include inherent and added filters—commonly made of aluminum—which are used to remove low-energy, non-diagnostic X-rays from the beam. These low-energy photons are largely absorbed by the patient's skin and superficial tissues, contributing to dose without enhancing the image. By filtering them out, the beam becomes "harder," meaning it is composed of more penetrating, higher-energy photons that are more likely to reach the detector and contribute meaningfully to image formation. Proper filtration is thus a vital component of patient dose reduction and is a regulatory requirement in most countries.

D. **Collimation**: It is another essential factor in dose optimization. It refers to the restriction of the X-ray beam to the region of interest using adjustable lead shutters. By limiting the beam size to the smallest field necessary for diagnosis, collimation reduces the volume of tissue irradiated, thereby decreasing patient dose. It also reduces the amount of scatter radiation produced, which not only protects nearby tissues but also improves image quality by reducing fog and enhancing contrast. Collimation should be used meticulously in all radiographic procedures, particularly in pediatric imaging where radiosensitive tissues are more vulnerable.

E. **Source-to-image distance (SID):** SID also plays a role in radiation dose distribution. According to the inverse square law, the intensity of radiation decreases proportionally to the square of the distance from the source. This means that increasing the SID reduces the radiation intensity at the patient's skin surface. While increasing SID can lower entrance skin dose, it may also require a corresponding increase in mAs to maintain sufficient exposure to the detector, depending on the system's sensitivity. In practice, optimal SID values are standardized for various procedures, but understanding the relationship between distance and dose helps in making informed adjustments when necessary.

15.2.1. Patient-Related Factors Affecting X-ray Dose

Beyond technical parameters, patient-related factors significantly influence the radiation dose delivered during an X-ray examination. Every patient is anatomically and physiologically unique, and these individual differences play a vital role in determining the required exposure settings for optimal image quality [8]. Understanding these factors allows radiologic professionals to tailor imaging protocols to each patient, helping to minimize radiation dose while achieving diagnostic accuracy.

A. **Body habitus and anatomical thickness**: One of the most critical patient-specific variables is body habitus and anatomical thickness. Patients with a larger body habitus or increased tissue thickness, such as in obese individuals or when imaging regions like the abdomen or pelvis, inherently require higher radiation exposures to ensure sufficient penetration of X-ray photons through the tissues. In such cases, radiographers often need to increase both kilovoltage (kVp) and milliampere-seconds (mAs) to obtain images with adequate contrast and low noise. However, this results in a corresponding increase in radiation dose. Conversely, imaging thinner or pediatric patients allows for significant dose reduction. This highlights the importance of size-specific protocol optimization and the use of pediatric or low-dose

protocols where applicable.

B. **Patient positioning**: Another important consideration is patient positioning. Accurate and consistent positioning ensures that the region of interest is centered within the X-ray beam and is captured entirely within the imaging field. Proper positioning minimizes the need for repeat exposures due to missed anatomy or inadequate views. For example, incorrect centering or rotation can obscure critical structures or introduce artifacts, compromising diagnostic value and necessitating a second exposure. Additionally, appropriate positioning helps limit the exposure of adjacent tissues and organs that are not clinically relevant to the study, thereby reducing overall radiation burden. Positioning also includes correct alignment with automatic exposure control (AEC) sensors, which, when misaligned, can cause over- or underexposure, further increasing dose due to retakes.

C. **Motion artefacts**: whether from voluntary or involuntary movement, also contribute to increased radiation dose. Patient motion during image acquisition can blur the image, reducing sharpness and potentially obscuring pathology. This is particularly problematic in paediatric or elderly patients, as well as in cases of pain, anxiety, or confusion, where patients may struggle to remain still. Such motion-induced artifacts often necessitate repeat exposures to obtain diagnostically acceptable images, thereby increasing the cumulative radiation dose. Strategies to mitigate motion artifacts include clear patient instructions, immobilization techniques, shorter exposure times, and sometimes sedation in paediatric or uncooperative patients.

15.2.2. Imaging Technique and Equipment-Related Factors

The choice of imaging technique and the design and performance of radiographic equipment play a critical role in determining patient radiation dose. Modern advancements in imaging technology have significantly contributed to dose optimization, yet careful selection and operation of equipment remain essential to ensure safe and effective imaging.

A. **Analog vs. Digital Imaging:** One of the most notable shifts in radiology has been the transition from analog (film-based) systems to digital imaging. Digital radiography (DR) and computed radiography (CR) systems offer considerable advantages in terms of radiation dose and image quality. Digital systems possess a wider dynamic range compared to film, allowing for accurate imaging across a broad spectrum of exposure values. This means that even slightly under- or over-exposed images can often be corrected using post-processing software, reducing the need for repeat exposures. Furthermore, digital detectors are generally more sensitive to X-rays, enabling high-quality images to be captured at lower exposure settings. As a result, digital imaging typically requires a lower radiation dose than traditional analog systems while providing superior image clarity and consistency.

B. **Automatic Exposure Control (AEC):** Another important technological advancement in dose management is the implementation of Automatic Exposure Control (AEC) systems. AEC technology automatically adjusts the exposure parameters based on the patient's size, tissue density, and the specific anatomical area being examined. It works by detecting when the correct amount of radiation has reached the image receptor and then automatically terminating the exposure. This not only ensures consistent image quality across a range of patient body types but also minimizes the risk of underexposure or overexposure, thereby enhancing patient safety. Proper positioning of the patient and alignment with the AEC detectors is crucial for the system to function accurately; misalignment can result in incorrect exposure, potentially leading to unnecessary dose or image retakes.

C. **Use of Grid:** The use of anti-scatter grids is another factor that influences patient radiation dose. Grids are placed between the patient and the image receptor to absorb scattered radiation before it reaches the detector, thereby improving image contrast and diagnostic accuracy. However, the presence of a grid also absorbs a portion of the primary X-ray beam, necessitating an increase in exposure settings (typically mAs) to compensate for this attenuation. As a result, grid use inevitably increases patient dose. While grids are beneficial in imaging thicker body parts or adult patients where scatter is more significant, their use in paediatric imaging or in thinner patients must be carefully justified. In such cases, grid removal or alternative techniques may be employed to keep the dose as low as reasonably achievable (ALARA).

D. **Detector Efficiency (DQE):** The efficiency of the digital detector, particularly its Detective Quantum

Efficiency (DQE), significantly impacts the amount of radiation required to produce a high-quality image. DQE is a measure of how effectively the detector converts incoming X-ray photons into a useful image signal. Detectors with a high DQE can achieve better image quality at lower radiation doses because they capture more information from the same number of photons. Modern digital detectors with high DQE values are especially beneficial in reducing patient dose in routine imaging as well as in high-volume departments where minimizing cumulative exposure is critical.

15.3. TECHNIQUES FOR DOSE REDUCTION IN DIAGNOSTIC RADIOLOGY

Radiation dose reduction is a central tenet of radiologic practice, especially given the widespread use of diagnostic imaging across all patient populations. While radiological procedures have transformed the landscape of modern medicine with their unparalleled ability to visualize internal structures, the use of ionizing radiation must always be justified and optimized to mitigate associated risks. It is essential to remember that dose reduction should never compromise diagnostic efficacy. High-quality imaging must remain the goal, but this should be achieved with the lowest reasonable exposure to radiation—a principle that forms the foundation of radiation protection. This section outlines a variety of techniques, strategies, and technologies that are employed to reduce patient radiation dose while maintaining diagnostic image quality [9].

A. Optimization of Exposure Parameters

The optimization of exposure parameters is one of the most effective and controllable strategies for dose reduction. The main parameters that directly affect radiation dose are kilovoltage peak (kVp), tube current-time product (mAs), and exposure time. These must be fine-tuned based on the body part being imaged, patient size, and clinical indication. A key concept is the use of the lowest possible mAs and kVp settings that still provide acceptable image quality. Lower mAs results in fewer X-ray photons, thereby reducing dose. However, this must be balanced against the potential increase in quantum mottle (image noise). Similarly, while lower kVp reduces dose, it also lowers photon penetration, which could compromise image quality in denser anatomical areas. Therefore, protocols must be tailored to ensure a balance between dose and image clarity. In certain cases, high kVp and low mAs techniques are preferred. For example, chest radiography typically benefits from a high kVp (e.g., 110–130 kVp), which allows better penetration of the thoracic cavity and reduces the radiation absorbed by superficial tissues such as the skin and breast tissue, effectively lowering the entrance skin dose. Additionally, the use of Automatic Exposure Control (AEC) systems can assist in optimizing exposure settings by terminating the exposure once sufficient radiation has reached the detector, thereby avoiding overexposure. Another critical aspect is the adoption of size-specific exposure protocols, especially for paediatric patients. Children's smaller body size and higher radiosensitivity necessitate custom protocols with substantially lower exposure parameters. Software that automatically adjusts parameters based on patient age, weight, or cross-sectional dimensions has proven highly effective in paediatric dose optimization [10].

B. Patient Shielding

The use of radiation shielding remains a widely recognized method for protecting sensitive organs from unnecessary exposure. Although modern digital imaging systems and better collimation have reduced the need for extensive shielding, it still plays an important role in specific clinical contexts. Lead aprons and thyroid shields are commonly used to protect radiosensitive organs located near the imaging field. For example, during dental or cervical spine radiographs, the thyroid gland is at risk of unnecessary exposure and should be shielded with a properly fitted thyroid collar. Similarly, lead aprons help shield abdominal organs and the gonads, especially during extremity imaging where scatter radiation might otherwise reach these areas. Gonadal shielding, once routinely applied, has become a subject of debate in recent years. Several radiological societies, including the American Association of Physicists in Medicine (AAPM), now recommend a more selective approach, as shielding can obscure anatomy, interfere with automatic exposure control, and sometimes lead to repeat exposures. Nonetheless, in certain contexts—particularly when imaging young patients or when reproductive

organs lie close to the primary beam—gonadal shielding may still be appropriate. Breast shielding may be beneficial during scoliosis series or thoracic imaging in adolescent females, as breast tissue is highly radiosensitive. However, such decisions should be guided by patient age, the imaging field, and institutional protocols, with the aim of reducing unnecessary exposure while ensuring no compromise to diagnostic value.

C. Proper Positioning and Immobilization

Proper patient positioning is crucial not only for diagnostic accuracy but also for minimizing radiation dose. When a patient is positioned correctly, the anatomical region of interest is adequately centered and aligned with the imaging beam, reducing the risk of partial imaging or obscured pathology that might necessitate repeat exposures. Moreover, correct positioning helps ensure that automatic exposure control sensors function properly, leading to optimal image acquisition and avoiding over- or underexposure. For instance, misalignment in chest radiography can result in unnecessary exposure of non-target tissues or poor image quality due to improper AEC triggering. Immobilization is particularly important in paediatric imaging or with uncooperative or cognitively impaired patients. Movement during exposure leads to motion blur, reducing image clarity and potentially requiring repeat imaging. Using immobilization devices such as sandbags, Velcro straps, foam wedges, or dedicated paediatric restraint systems can greatly enhance image sharpness and reduce the number of exposures needed. In addition to physical aids, effective communication with the patient plays a vital role. Explaining the procedure clearly and ensuring patient comfort can significantly reduce anxiety-induced motion, particularly in paediatric, geriatric, or trauma patients.

D. Use of Collimation and Filtration

Beam collimation and filtration are two of the most fundamental yet often underutilized tools in dose optimization. Collimation involves narrowing the X-ray beam to match the area of clinical interest, thereby reducing the volume of tissue irradiated. This not only minimizes patient exposure but also enhances image contrast by reducing scatter radiation. Overexposed fields due to improper collimation increase radiation dose without contributing useful diagnostic information. For instance, in extremity imaging, careful collimation to the region of interest—such as the hand or ankle—can significantly reduce exposure to adjacent structures like the abdomen or chest. Filtration, on the other hand, involves the addition of materials—typically aluminum or copper—in the X-ray beam path to remove low-energy, non-penetrating photons. These photons are absorbed by superficial tissues and do not contribute to image formation. Removing them helps reduce surface dose and skin erythema risk. In paediatric imaging, additional filtration is especially important due to the higher radiosensitivity of growing tissues and organs. Modern X-ray systems are equipped with both inherent filtration (e.g., from the X-ray tube and housing) and added filtration that can be customized based on the examination protocol. Some systems also feature automated beam shaping filters that dynamically adjust beam properties based on the selected exam and patient anatomy.

E. Technological Advances

Rapid technological evolution in medical imaging has significantly enhanced the ability to perform diagnostic radiology at reduced radiation doses. A major breakthrough has been the widespread implementation of Digital Radiography (DR), which offers vastly improved detector sensitivity and image processing capabilities compared to traditional film-based systems. DR systems provide high-quality images at lower radiation doses due to their high Detective Quantum Efficiency (DQE). DQE measures how efficiently an imaging system converts incoming X-ray photons into a usable image. A higher DQE indicates better performance at lower doses, which is particularly beneficial in paediatric, neonatal, and high-throughput imaging settings.

NOTE: The use of Dose Tracking Software is another key advancement. These systems automatically record and monitor radiation doses delivered to each patient, providing technologists and radiologists with valuable feedback. Over time, this data helps identify areas where doses can be further optimized. Dose tracking also facilitates compliance with regulatory requirements and supports institutional quality assurance programs. Pulsed

fluoroscopy is an important technique in reducing dose during dynamic imaging procedures such as barium studies, interventional radiology, or catheter placements. Unlike continuous fluoroscopy, pulsed fluoroscopy emits radiation in short bursts (pulses), significantly decreasing cumulative dose while maintaining sufficient temporal resolution for clinical needs. Coupled with features such as last-image hold, digital zoom, and real-time collimation, pulsed fluoroscopy offers a powerful tool for dose reduction. Other technological enhancements include automatic beam modulation, noise reduction algorithms, and iterative reconstruction techniques (more common in CT but emerging in digital radiography), all of which contribute to better image quality at lower exposure levels.

15.3.1. Justification and Clinical Audit

Perhaps the most foundational technique in radiation dose reduction is the justification of every examination. According to international radiation protection guidelines, no imaging study involving ionizing radiation should be performed unless the expected diagnostic benefit clearly outweighs the potential radiation risks. Justification is particularly important in young patients, pregnant women, and individuals requiring multiple imaging studies. Radiologists, referring physicians, and radiologic technologists must collaborate to ensure that each imaging request is appropriate. Decision support tools, such as clinical imaging referral guidelines and computerized order-entry systems, can aid in this process by offering evidence-based recommendations for the best imaging modality based on clinical presentation. Equally important is the conduct of clinical audits, which involve systematic evaluation of radiological practices against established standards. Audits assess the appropriateness of imaging requests, adherence to exposure protocols, and effectiveness of dose reduction strategies. By identifying deviations and opportunities for improvement, audits play a crucial role in enhancing patient safety and promoting a culture of continuous quality improvement. Clinical audits also serve as an educational tool, allowing staff to stay informed about evolving best practices in radiation protection. Feedback from audits can be used to update institutional protocols, refine imaging techniques, and promote training initiatives focused on dose optimization.

15.3.2. Special Considerations in Paediatric Imaging

Paediatric imaging demands special attention in the field of radiology due to the unique anatomical, physiological, and developmental characteristics of children. One of the most significant concerns is that children are considerably more radiosensitive than adults, meaning that the same amount of radiation can have a more profound biological effect. This heightened sensitivity arises from the fact that rapidly dividing cells, which are more abundant in growing bodies, are more vulnerable to radiation-induced damage. Additionally, children have a longer expected lifespan, increasing the window of time during which radiation-induced stochastic effects, such as cancer, could manifest. These factors make it imperative to adopt stringent dose-reduction strategies tailored specifically for paediatric populations. A primary method for reducing radiation exposure in children is the use of pediatric-specific imaging protocols. These protocols are designed with lower kilovoltage peak (kVp) and milliampere-seconds (mAs) settings compared to those used for adults. Lowering these parameters reduces the intensity and number of X-ray photons used, thereby minimizing dose while still producing images of acceptable diagnostic quality. Because children's bodies are smaller and less dense, lower exposure levels are often sufficient to achieve clear imaging results. Another key consideration is the avoidance of unnecessary use of anti-scatter grids. While grids enhance image contrast by absorbing scatter radiation, they also require higher exposure levels to maintain image quality. In paediatric imaging—especially for small body parts—scatter is inherently low, making grids often unnecessary. Omitting them can significantly reduce the patient dose without compromising image clarity, provided proper collimation and positioning are maintained.

Utilization of dedicated paediatric imaging equipment is also critical. Equipment designed for children typically includes adjustable settings that allow for fine-tuned control over exposure parameters. In addition, facilities that routinely image paediatric patients should employ personnel trained in paediatric radiology, as these professionals understand the specific challenges and techniques associated with safely imaging younger individuals. Minimizing radiation dose in paediatric imaging also relies heavily on effective communication and patient management. Clear instructions to both children and their caregivers help reduce movement during imaging,

which in turn lowers the likelihood of repeat exposures. The use of gentle immobilization devices such as papoose boards or foam supports can assist in maintaining correct positioning for children who may not be able to stay still on their own. Furthermore, limiting the number of views and repeat exposures is a practical step in reducing cumulative radiation exposure. Each image should be clinically justified and performed with precision to avoid redundancy. In summary, paediatric imaging requires a cautious, customized approach that prioritizes radiation protection without compromising diagnostic outcomes. Incorporating size-appropriate protocols, avoiding unnecessary equipment, using trained personnel, and fostering patient cooperation are all essential elements in achieving safe and effective paediatric radiology.

15.3.3. Regulatory and Safety Guidelines

The field of diagnostic radiology is governed by a robust framework of international and national safety standards, all of which aim to ensure that the use of ionizing radiation in medicine is both justified and optimized. Central to these regulatory guidelines is the overarching principle of radiation protection, which emphasizes minimizing patient and occupational exposure without diminishing the diagnostic benefits of radiographic procedures. A foundational tenet in radiation safety is the ALARA Principle—"As Low As Reasonably Achievable." This principle mandates that every effort be made to reduce exposure to ionizing radiation through thoughtful planning, appropriate use of technology, and continuous quality improvement. The goal is to maintain radiation doses at levels that are as low as possible while still achieving the desired clinical outcome. ALARA is not just a technical guideline but a philosophical approach to radiological practice, encouraging healthcare professionals to weigh the risks and benefits of each imaging procedure and to continuously seek opportunities for dose optimization.

Another important concept is the establishment and use of Diagnostic Reference Levels (DRLs). DRLs serve as benchmark values for typical radiation doses in standard imaging procedures. They are not strict dose limits but rather indicators that help identify outliers in clinical practice. When doses consistently exceed DRLs, it prompts a review of imaging protocols and practices to determine whether optimization is needed. DRLs are typically set at the 75th percentile of dose distributions collected from multiple institutions, providing a practical and evidence-based standard for dose assessment. Several international organizations have played key roles in developing and disseminating radiation safety guidelines. The World Health Organization (WHO) promotes global health initiatives and supports the development of safe imaging practices through research, policy development, and education. The International Commission on Radiological Protection (ICRP) is a leading authority that provides recommendations on all aspects of radiation protection, including dose limits, risk assessment, and ethical considerations. The ICRP's publications serve as foundational references for radiation protection standards worldwide. Similarly, the International Atomic Energy Agency (IAEA) supports the safe and peaceful use of nuclear technologies, including medical imaging. The IAEA offers training, publishes technical documents, and conducts audits to ensure compliance with radiation safety standards in healthcare facilities around the globe. The National Council on Radiation Protection and Measurements (NCRP), based in the United States, also contributes significantly to the scientific basis of radiation protection policies. The NCRP provides guidance documents, conducts research, and advises federal and state agencies on issues related to radiation exposure in medicine and other fields. In many countries, these international guidelines are adapted into national regulations through organizations like the Atomic Energy Regulatory Board (AERB) in India or the Nuclear Regulatory Commission (NRC) in the United States. These national bodies are responsible for licensing, monitoring, and enforcing radiation safety practices across medical institutions. They may also mandate periodic quality assurance programs, clinical audits, and continuing education for radiology professionals to maintain compliance with evolving safety standards.

Table: 15.1. Typical Radiation Dose in Radiological Procedures

Imaging Procedure	Effective Dose (mSv)	Comments
Chest X-ray (PA view)	0.02 – 0.1	Very low dose; often used as a reference point
Abdominal X-ray	0.5 – 0.7	Higher dose due to denser anatomy

Spine X-ray (Lumbar AP + Lat)	1.5 – 3.0	Involves multiple views and thicker body regions
Mammography (both breasts)	0.4 – 0.7	Low dose; uses low energy X-rays optimized for soft tissue
Dental X-ray (periapical)	0.005 – 0.01	Extremely low; modern digital systems reduce this further
Dental Panoramic X-ray (OPG)	0.02 – 0.03	Covers full jaw; still considered a very low dose
Head CT scan	1.5 – 2.0	Dose can be lower in pediatric scans or with dose modulation
Chest CT scan	5.0 – 7.0	Higher than chest X-ray but provides far more detailed cross-sectional data
Abdomen & Pelvis CT scan	8.0 – 10.0	Among the highest routine diagnostic exposures
CT Coronary Angiography	10.0 – 15.0	High dose due to long scan length and high resolution
CT Whole Body Trauma	20.0 – 25.0	Used in emergency settings; combines multiple regions in one scan
Bone Scan (Nuclear Medicine)	3.0 – 5.0	Involves radiotracer injection
PET-CT (FDG)	18.0 – 25.0	Combines CT with nuclear scan for metabolic imaging
Barium Swallow/Meal/Enema	3.0 – 8.0	Fluoroscopy procedures; dose depends on time and complexity
Fluoroscopy (e.g., GI series)	2.0 – 10.0+	Dose varies significantly with fluoroscopy time and technique
Interventional Cardiology (e.g., Angioplasty)	15.0 – 30.0	Among the highest due to prolonged fluoroscopic exposure

15.4. IMAGE QUALITY IN X-RAY (RADIOGRAPHY)

Image quality in radiography refers to the ability of an X-ray image to accurately represent anatomical structures and pathologies with sufficient clarity to allow for reliable diagnosis. The diagnostic value of a radiographic image depends on how well it displays contrast, brightness, spatial resolution, noise levels, and the absence of distortion. Achieving optimal image quality is not only crucial for accurate interpretation but also essential for minimizing repeat exposures and radiation dose to the patient. Multiple imaging parameters, equipment settings, and patient-related factors influence each of these components. The following sections explore each parameter in detail.

15.4.1. Contrast

Radiographic contrast is one of the fundamental determinants of image quality in X-ray imaging. It refers to the difference in density (in film-screen systems) or brightness (in digital systems) between adjacent areas on the radiograph. High-quality contrast ensures that different anatomical structures—such as bones, muscles, fat, and organs—can be visually distinguished from each other with clarity. Without adequate contrast, an image may appear uniformly gray or washed out, severely limiting its diagnostic value. Contrast in radiography is essential for identifying both normal anatomical detail and pathological changes. Its effectiveness depends on the ability to visualize differences in X-ray attenuation between tissues. For example, bones absorb more X-rays than soft tissues, resulting in a higher degree of contrast between them on the radiographic image. Several factors affect contrast, including exposure parameters, the physical properties of the tissues, and characteristics of the imaging system. Radiographic contrast can be categorized into two primary types: subject contrast and image receptor contrast. Both types contribute to the overall image contrast, but they originate from different sources and are influenced by different variables.

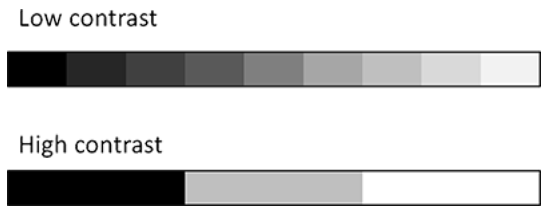

Fig: 15.1. Low and High Contrast

Subject Contrast: Subject contrast refers to the inherent differences in X-ray absorption among various tissues within the patient's body. It is primarily determined by the physical and chemical composition of the tissues being imaged. Mathematically, subject contrast is expressed as:

$$c \propto (\mu_1 - \mu_2) \times t$$

Where:

- c = subject contrast
- μ_1 and μ_2 = linear attenuation coefficients of two different tissues
- t = thickness of the tissue

This relationship indicates that greater differences in attenuation properties and increased tissue thickness enhance the resulting contrast in the image. Several factors influence subject contrast:

- Tissue Density and Atomic Number: Structures with higher atomic numbers (e.g., bone) absorb more X-ray photons via the photoelectric effect than structures with lower atomic numbers (e.g., soft tissue), leading to greater subject contrast.
- Thickness of the Tissue: Thicker anatomical areas absorb more radiation, further enhancing the contrast between thick and thin regions.
- Beam Energy (kVp): The kilovoltage peak (kVp) of the X-ray beam has a profound effect on subject contrast. Lower kVp settings produce low-energy X-rays that are more likely to undergo photoelectric absorption, resulting in high contrast (short gray scale) images. This is suitable for imaging areas such as extremities, where fine detail and sharp contrast are needed. Higher kVp increases beam penetration and leads to more Compton scatter, producing low contrast (long gray scale) images that are better suited for chest or abdominal imaging where differences between soft tissues must be captured over a broad dynamic range.

Image Contrast: Image contrast is the ability of the imaging system (film or digital detector) to capture and display the differences in X-ray intensity that reach the detector. This type of contrast is influenced by the following factors:

- Detector Type: Traditional film-screen systems have a fixed contrast response and limited dynamic range. In contrast, modern digital detectors (computed radiography [CR] and digital radiography [DR]) offer wide dynamic range and greater contrast resolution, enabling the detection of subtle tissue differences that may not be apparent on film.
- Detector Sensitivity and Processing: In digital systems, contrast can be adjusted using software-based post-processing tools. Parameters like window level and window width allow manipulation of image brightness and contrast after acquisition, offering flexibility without additional patient exposure.
- Characteristic Curve (Film Only): In film-screen radiography, the characteristic or Hurter-Driffield (H&D) curve describes the film's response to varying exposure levels. Films with steep slopes have higher contrast but a narrow exposure latitude, whereas films with flatter slopes have lower contrast but broader latitude.

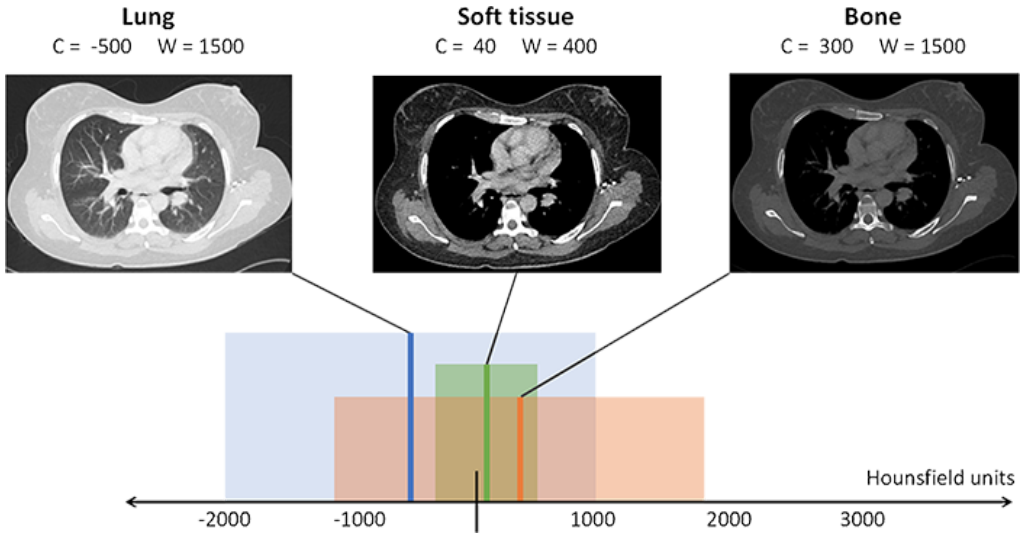

Fig: 15.2. Image Contrast

Apart from subject and receptor contrast, several additional technical factors influence the overall contrast of a radiographic image:

- Use of Grids: Grids are placed between the patient and the image receptor to absorb scattered radiation, which degrades image contrast. By reducing scatter, grids significantly improve contrast, especially in imaging thicker body parts.
- Beam Collimation: Collimation limits the X-ray beam to the area of interest, reducing scatter production and enhancing contrast.
- Patient Positioning: Proper alignment and positioning minimize the superimposition of structures, ensuring clearer visualization of anatomical detail and improving localized contrast.
- Filtration: Beam filtration removes low-energy X-rays that do not contribute to image formation and only increase patient dose. Proper filtration helps maintain contrast by shaping the X-ray beam's energy spectrum.

15.4.2. Brightness (Optical Density)

Brightness, also referred to as optical density in film-screen radiography, is a key determinant of image quality and refers to the overall lightness or darkness of a radiographic image. It directly influences the visibility of anatomical details and is primarily controlled by the amount of radiation reaching the image receptor. In traditional film-screen systems, brightness is governed by optical density, which increases with higher radiation exposure—most commonly adjusted through changes in milliampere-seconds (mAs). A higher mAs results in the generation of more X-ray photons, leading to a darker radiographic image, while lower mAs yields a lighter image due to insufficient exposure. Proper development conditions and film sensitivity also play a role in determining the final image density. In digital radiography systems (such as CR and DR) allow for post-acquisition manipulation of brightness using image processing software. This flexibility enables radiologic technologists to adjust the luminance of the image displayed on the monitor without repeating the exposure. However, even in digital systems, correct exposure settings are crucial—underexposure may lead to quantum mottle or image noise, while overexposure can unnecessarily increase patient radiation dose and potentially obscure diagnostic detail. To ensure consistent and optimal brightness across varying patient sizes and anatomical regions, modern radiographic systems often employ automatic exposure control (AEC). AEC systems monitor the radiation reaching the detector in real time and automatically terminate the exposure when the required dose is achieved. This automation minimizes exposure errors and enhances image consistency. Despite the advantages of digital manipulation and

AEC, radiologic technologists must still select appropriate exposure parameters tailored to each clinical situation to ensure clear visualization of both high-density structures like bone and low-density tissues such as fat or air-filled organs. Ultimately, brightness must be optimized in conjunction with other image quality factors to achieve high diagnostic value while adhering to radiation safety principles.

15.4.3. Spatial Resolution

Spatial resolution is a critical component of image quality in radiography, defined as the imaging system's ability to distinguish and accurately depict small structures that are close together. It determines how sharply the edges of anatomical structures are rendered and how clearly fine internal details—such as trabecular bone patterns, microcalcifications, or subtle pulmonary markings—can be visualized. High spatial resolution is particularly vital in diagnostic tasks that involve detecting minute or early pathological changes, such as identifying hairline fractures in bone, early-stage lung nodules, or microcalcifications in breast tissue during mammography. The quality of spatial resolution is affected by several interrelated factors, both geometric and system-based. One of the primary geometric factors is focal spot size. A smaller focal spot results in reduced geometric unsharpness, yielding images with crisper detail. However, smaller focal spots also concentrate more heat in a limited area of the anode, restricting the amount of tube current (mA) that can be safely used, particularly in high-exposure examinations. Another influential factor is the source-to-image distance (SID). Increasing the SID decreases the divergence of the X-ray beam reaching the image receptor, thereby reducing magnification and enhancing spatial resolution. Conversely, the object-to-image distance (OID) should be kept as small as possible. A larger OID increases the size of the projected image on the receptor, leading to geometric magnification and image blur. Therefore, positioning the patient or the anatomical part of interest as close to the image receptor as practical is crucial for maintaining optimal resolution. Patient or equipment motion during exposure can introduce significant blur, commonly referred to as motion unsharpness. This is particularly problematic in long exposure times or when imaging pediatric or acutely ill patients who may not remain still. To reduce motion artifacts and preserve resolution, short exposure times and immobilization techniques (e.g., sandbags, positioning aids, or sedation when necessary) are recommended.

In digital radiographic systems, detector characteristics play a central role in determining spatial resolution. Key parameters include pixel size, pixel pitch, and matrix size. Smaller pixel sizes yield finer resolution because they can sample more detail per unit area of the image. For example, a digital detector with a 3000 × 3000 matrix over a 35 × 43 cm image plate provides greater spatial resolution than one with a 1500 × 1500 matrix covering the same area. However, increasing spatial resolution in digital detectors often comes with trade-offs, such as increased image file size, higher system noise, and sometimes a need for greater radiation exposure to maintain adequate signal-to-noise ratio (SNR). The concept of modulation transfer function (MTF) is often used to quantify how well an imaging system can reproduce varying levels of detail. A system with a higher MTF at high spatial frequencies is more capable of preserving fine image details. Other technological aspects that influence spatial resolution include the type of detector technology—such as indirect flat-panel detectors (which use a scintillator to convert X-rays to light) versus direct flat-panel detectors (which convert X-rays directly into electrical signals). Direct detectors generally provide better spatial resolution due to the absence of light scatter within the scintillator layer. Additionally, image processing algorithms, while primarily used for contrast enhancement or noise reduction, can also affect the perceived sharpness of digital images. However, they cannot compensate for poor resolution caused by inappropriate technique or system limitations. In clinical practice, optimizing spatial resolution involves a careful balance between technical factors, patient positioning, motion control, and appropriate system configuration. Overemphasizing spatial resolution at the expense of radiation dose or workflow efficiency can be counterproductive. Therefore, radiologic technologists must apply a comprehensive understanding of these parameters to tailor imaging protocols that preserve high spatial resolution while maintaining patient safety and operational effectiveness.

15.4.4. Image Noise

Noise in radiographic imaging refers to the presence of random, undesired fluctuations in the signal that can

obscure anatomical details and degrade the overall quality of the image. In digital radiography, noise manifests visually as a grainy or mottled texture, which becomes particularly problematic in regions of low subject contrast, such as soft tissues or areas containing subtle pathologies. The most prevalent type of noise in radiographic imaging is quantum mottle, which results from statistical variations in the number of X-ray photons reaching the detector. Quantum mottle is most commonly encountered when using low exposure settings—particularly low milliampere-seconds (mAs)—which produce fewer photons and, consequently, a lower signal. As the number of detected photons decreases, the relative fluctuation in signal becomes more pronounced, giving rise to a noisy image. While reducing exposure may be desirable from a radiation safety standpoint, doing so excessively increases quantum noise and may render the image non-diagnostic. In addition to quantum mottle, electronic noise from the digital detector's readout electronics can also contribute to image degradation. This type of noise originates from thermal or electronic variations within the imaging system's internal circuitry and may be especially evident in older or poorly maintained equipment. Another contributor to noise is scattered radiation, which arises primarily from X-ray interactions within the patient's body. Scatter introduces extraneous signals that are unrelated to the primary beam path and thus reduce both contrast and spatial clarity. Effective strategies to reduce image noise include using optimal exposure parameters that ensure adequate photon flux to the detector, typically by selecting appropriate mAs and kilovoltage peak (kVp) values tailored to the patient's size and the anatomical region being imaged. Anti-scatter grids are frequently used to absorb scattered photons before they reach the image receptor, thereby improving the signal-to-noise ratio (SNR) and enhancing image clarity.

In digital systems, image processing algorithms can also play a role in noise management. Advanced noise reduction techniques, including frequency-based filtering and edge-preserving smoothing algorithms, are commonly employed during post-processing to suppress background noise while retaining diagnostic detail. However, overuse or improper tuning of these algorithms can blur fine structures, so they must be applied judiciously. Regular maintenance and calibration of equipment, including detector gain correction and flat-fielding procedures, are essential to prevent artifacts and suppress system-based noise. The SNR is a critical quantitative measure used to evaluate image quality, representing the ratio of the meaningful diagnostic signal to the background noise. A higher SNR implies a cleaner, more detailed image with reduced visual interference. Maintaining a high SNR is especially important in clinical scenarios requiring high diagnostic sensitivity, such as the detection of early-stage disease, subtle fractures, or small pulmonary nodules. Thus, controlling noise is not only a technical concern but a key factor in maintaining diagnostic accuracy and patient safety.

15.4.5. Geometric Unsharpness in Radiographic Image Quality

Geometric unsharpness, also known as penumbra, refers to the loss of image sharpness or edge detail that results from the geometric setup of the X-ray imaging system. It is a crucial factor affecting the spatial resolution of radiographic images and is primarily influenced by the size of the X-ray focal spot, the distance between the source and the object (SOD), and the distance between the object and the image receptor (OID).

Following are the key factors affecting geometric unsharpness:

1. Focal Spot Size (F): A larger focal spot produces more divergence in the X-ray beam, which increases the blur around the edges of the image. Conversely, a smaller focal spot results in a sharper image with reduced unsharpness.
2. Object-to-Image Distance (OID): As the distance between the object and the image receptor increases, geometric unsharpness also increases because the X-ray shadows cast by the object become more spread out. Minimizing OID reduces blurring.
3. Source-to-Object Distance (SOD): Increasing the distance between the X-ray source and the object reduces geometric unsharpness. A longer SOD allows the X-rays to travel in straighter paths, creating sharper image edges. Geometric unsharpness (Ug) can be estimated using the formula:

$$Ug = (F \times OID) / SOD$$

Where:

Ug = geometric unsharpness

F = effective focal spot size
OID = object-to-image distance
SOD = source-to-object distance

Minimizing geometric unsharpness is essential for improving diagnostic accuracy, especially in imaging small structures such as fractures or microcalcifications. To achieve optimal image sharpness, radiographers should use the smallest focal spot size suitable for the examination, reduce OID as much as possible, and use the greatest feasible SOD within the equipment's constraints.

15.4.6. Magnification in Radiographic Imaging

Magnification refers to the enlargement of the radiographic image of an object compared to its actual size. It occurs due to the divergence of the X-ray beam as it travels from the source to the image receptor.

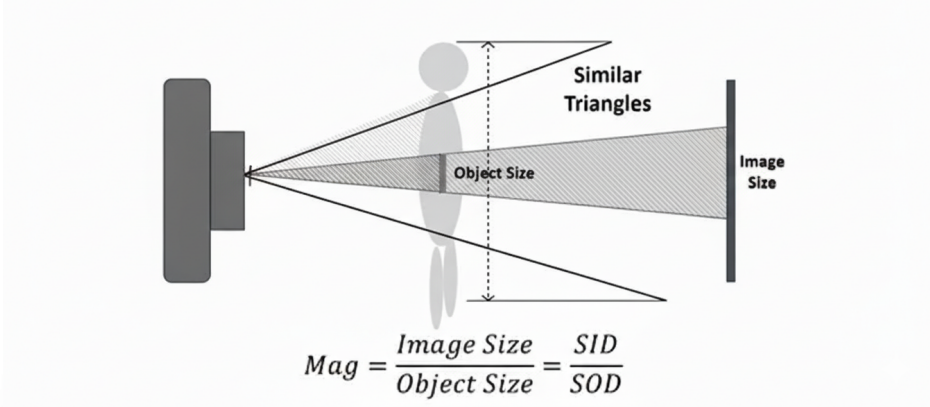

Fig: 15.3. Image Magnification

While some magnification is inevitable in radiographic imaging, excessive or uncontrolled magnification can distort anatomical structures and lead to misinterpretation. Factors Influencing Magnification are:

1. Object-to-Image Distance (OID): The greater the distance between the object and the image receptor, the more the X-ray beam diverges, increasing magnification. Minimizing OID helps reduce magnification.
2. Source-to-Image Distance (SID): A longer SID decreases the divergence of the X-ray beam at the object, thus reducing magnification. Increasing SID is a common strategy to minimize size distortion. The magnification factor (MF) can be calculated using the following formula:

MF = SID / SOD

Where:
MF = magnification factor
SID = source-to-image distance
SOD = source-to-obiect distance

Alternatively, the image size (I) and object size (O) relationship is, MF = Image Size / Object Size

Understanding magnification is vital when accurate measurement of anatomical structures is required, such as in orthopaedic imaging for prosthesis sizing or in assessing tumour dimensions. To minimize magnification artefacts, radiographers aim for a short OID and a long SID wherever possible.

15.4.7. Distortion and Magnification

Distortion in radiographic imaging refers to the alteration or misrepresentation of the true shape, size, or position of anatomical structures captured on the image. Distortion can compromise diagnostic accuracy by creating

images that do not accurately reflect the true anatomical features. There are two primary types of distortion: shape distortion and size distortion (magnification). Shape distortion occurs when the image of the object is altered in terms of its proportions or alignment, and it includes phenomena such as elongation and foreshortening. These types of distortion arise when the X-ray beam, anatomical structure, or image receptor are not properly aligned. For example, elongation typically results when the X-ray tube is positioned at an angle to the object, while foreshortening occurs when the object is not parallel to the image receptor. Accurate patient positioning and precise centering of the anatomical region of interest to the central ray are critical to minimizing shape distortion and ensuring that the image accurately represents the structure.

15.5. ARTIFACTS IN RADIOGRAPHY

Artifacts in radiographic imaging refer to unwanted or extraneous elements that distort the true representation of the anatomical structures being imaged. These anomalies can arise from a variety of sources, including issues with the radiographic equipment, patient-related factors, or processing errors. Artifacts can compromise the diagnostic value of radiographs, leading to misinterpretations or the masking of pathological conditions. Identifying and understanding the types of artifacts is crucial in ensuring high-quality images, as it allows for appropriate corrective measures to be taken. Artifacts in radiography can be broadly categorized into technical artifacts, patient-related artifacts, and processing artifacts, with each type having specific causes and manifestations.

A. Technical Artifacts

Technical artifacts are related to the performance and functioning of the imaging equipment. These artifacts are often the result of mechanical, electrical, or calibration issues within the X-ray system. One of the most common technical artifacts is motion artifact, which occurs when there is any movement of the patient or the imaging system during the exposure. This can lead to blurring, streaking, or ghosting of the image, which reduces the clarity of anatomical details. Motion artifacts are particularly problematic when imaging pediatric or critically ill patients who may not be able to remain still. To minimize motion artifacts, short exposure times, immobilization aids, or sedation may be required. Another type of technical artifact is geometric distortion, which includes size distortion (magnification) and shape distortion (elongation or foreshortening). These artifacts occur when there is improper alignment between the X-ray tube, the patient, and the image receptor. For instance, when the patient is not positioned correctly relative to the image receptor, or if the source-to-image distance (SID) or object-to-image distance (OID) is not optimized, magnification or shape distortion can occur. These artifacts can lead to inaccurate representations of anatomical structures, affecting diagnostic accuracy.

B. Patient-Related Artefacts

Patient-related artefacts stem from the individual characteristics of the patient or external factors such as clothing or implanted medical devices. External objects, such as jewelry, clothing with metal fasteners, or hearing aids, can cause areas of increased density or shadowing on the image. For example, a metal button on a patient's clothing may create a high-density artefact, obscuring underlying tissues. To prevent this, radiologic technologists are trained to remove all metallic objects before performing the radiographic procedure. Another common source of patient-related artefacts is metallic implants or prostheses, such as hip replacements, dental fillings, or surgical pins. These materials can create significant attenuation of the X-ray beam, resulting in streaks, shadows, or areas of high-density on the image, which can obscure surrounding anatomical structures. These artefacts are particularly problematic in diagnostic imaging of areas close to the metal object, such as imaging of joints with prosthetics. Although it is often difficult to avoid these artefacts completely, techniques such as adjusting positioning, using alternative imaging modalities like MRI or CT, or using advanced imaging processing techniques can help mitigate their impact. Additionally, patient positioning errors can result in artefacts, such as superimposition of anatomical structures or misrepresentation of the area of interest. For example, if the patient is not correctly centered to the X-ray beam, the resulting image may show overlapping tissues or distorted structures, which can lead to incorrect diagnoses. Proper alignment and centering are essential to minimize patient-

related artefacts.

C. Processing Artefacts

Processing artefacts occur due to issues during the image acquisition or post-processing stages, often related to the radiographic system's software or hardware. In digital radiography, detector-related artefacts are common, such as dead pixels, which appear as blank or incorrectly rendered areas on the image. These artefacts are usually the result of faulty or non-functioning pixels in the imaging detector. Column dropout, where entire columns of pixels fail to record data, can also occur and produce linear patterns or dark stripes across the image. Regular calibration and maintenance of digital detectors are essential to identify and correct these issues. Aliasing is another common processing artefact in digital systems, which arises when the sampling frequency of the detector is too low. This results in the appearance of unwanted lines or patterns in the image, which do not correspond to real anatomical structures. To prevent aliasing, it is important to ensure that the digital system's sampling frequency meets the requirements of the imaging procedure. Compression artefacts can also occur in digital imaging when image files are excessively compressed to save storage space. This compression can result in a loss of image quality, including pixelation and the degradation of fine anatomical details. Compression artefacts are particularly problematic in high-resolution imaging applications, such as mammography, where fine detail is critical for diagnosis.

D. Environmental Artefacts

Environmental factors, although less common, can also introduce artefacts in radiographic images. Electrical interference from nearby equipment, such as MRI machines, can sometimes cause lines, shadows, or noise in the image, particularly in digital detectors. Additionally, static electricity can lead to digital artefacts, causing pixel noise or random black and white dots on the image.

15.5.1. Minimizing and Managing Artefacts

The presence of artefacts in radiographic images can significantly reduce their diagnostic value, but there are strategies to minimize and manage them. Proper patient positioning and alignment of the imaging system are the most effective ways to prevent shape distortion and superimposition artefacts. Careful selection of exposure parameters, including optimal mAs and kVp settings, can reduce the occurrence of quantum mottle and minimize electronic noise. Equipment maintenance and calibration, along with the use of advanced image processing algorithms, are essential in reducing detector-related and software-induced artefacts. Furthermore, radiologic technologists should always ensure that patients remove all metallic objects before imaging to prevent external artefacts. Regular quality control (QC) procedures are necessary to detect and correct any mechanical or digital system issues that may lead to artefacts. By understanding the various types of artefacts and implementing appropriate corrective measures, radiologic technologists can ensure that radiographs provide accurate, reliable, and diagnostically useful images.

15.5.2. Immobilizing Devices Used in Radiography

Immobilizing devices are essential tools in radiographic imaging to ensure that the patient or the body part being imaged remains motionless during exposure. Patient movement can lead to motion blur**,** significantly degrading image quality and potentially requiring repeat exposures, which increases radiation dose. These devices are especially important in paediatric imaging, trauma cases, and for patients with limited mobility or cooperation. Following are the common immobilizing devices used in radiography:

1. Positioning Sponges and Blocks: These foam or radiolucent materials help support and stabilize specific body parts during imaging, such as the head, limbs, or thorax. They assist in maintaining proper anatomical alignment and minimizing movement.
2. Sandbags: Radiolucent sandbags are used to add gentle weight and restrict motion, particularly for limbs. They are useful in trauma imaging to support injured extremities without applying pressure.

3. Velcro Straps and Compression Bands: These are used to secure a patient or a limb to the table or immobilizer to prevent involuntary movements. They help in maintaining consistent positioning throughout the procedure.
4. Head Clamps and Chin Straps: Used mainly in skull or cervical spine imaging, these devices stabilize the head to avoid rotation or tilting, ensuring reproducibility and accurate alignment.
5. Pigg-O-Stat: A specialized pediatric immobilization device used for infants and toddlers. It holds the child in an upright position with arms secured to prevent movement during chest or abdominal radiographs.
6. Radiolucent Immobilization Boards (e.g., Octostop): These boards allow infants to be secured in multiple positions (AP, lateral, oblique) without readjusting their body. They are designed to be X-ray transparent to avoid image artefacts.
7. Tape and Foam Padding: For short procedures, radiolucent medical tape and foam may be used to gently restrain small body parts like fingers or toes in a fixed position.
8. Cervical Collars and Splints (Trauma Cases): Often used in trauma settings, these devices immobilize injured areas (like the neck or limbs) while also maintaining patient safety. Care must be taken to minimize imaging artefacts they might cause.

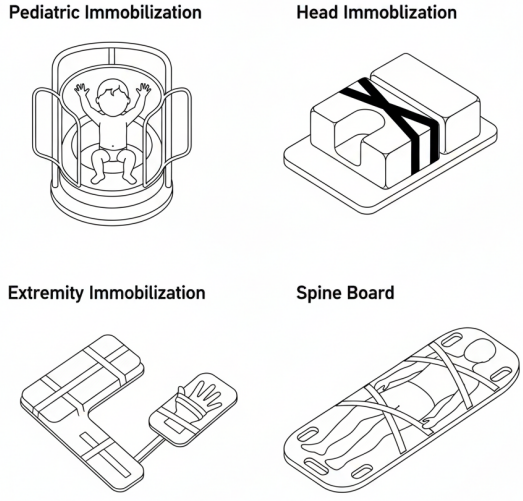

Fig: 15.4. Common Immobilizing Devices used in Radiography

End of Chapter

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