REVIEW ARTICLE

CONVENTIONAL RADIOGRAPHY- A COMPARISON WITH COMPUTED RADIOGRAPHY (CR)

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Abstract- The discovery of radiography was a major event that immediately revolutionized the realms of physics and medicine. It is a method of achieving 2D images of a patient's anatomical structures, using radiographic film as a receptor. Conventional or screen-film radiography is a traditional method or we can say the first imaging method used in radiology. An x-ray beam is produced inside the x-ray tube for conventional or screen-film radiography and is delivered through the object to receptor or radiation detector to produce an image. Depending on the density, thickness, and atomic number (Z) of the tissue, different soft tissues, and anatomical structures attenuate x-ray photons in different ways. In this review, we have tried to describe important components of screen-film radiography and their use in radiography.

Index Terms- Conventional radiography, screen-film radiography, darkroom processes, cassette, x-ray film, x-ray source, DR, PSP

I. Introduction

II. Radiography is an imaging technique in diagnostic radiology in which x-ray photons (X-ray) is used to produce a shadow (Picture) of a patient. On November 8, 1895, Wilhelm Conrad Rontgen made the discovery of x-rays. The x-discovery rays were a significant development that immediately altered physics and medicine[1]. It is a method that employs x-ray film as a detector to produce two-dimensional images of a patient's anatomical structures (Receptor). Conventional or screen-film radiography is a traditional method or we can say the first imaging method used in radiology. In traditional or screen-film radiography, an image is created by passing an x-ray beam through a patient and onto film or a radiation detector. Depending on the density, thickness, and atomic number (Z) of the tissue, different soft tissues, and anatomical structures attenuate x-ray photons in different ways.[2]

X-RAY SOURCE:

Both x-ray machines use the same x-ray source. The x-ray beam is produced by an X-ray tube is characterized by energy dispersion. Bremsstrahlung and distinctive emissions from X-ray tube targets largely determine the energy distribution or radiation spectrum. The target (anode) material, exposure parameters (Kvp, mAs), and filtering all have an impact on these emissions.

When a fast-moving stream of electrons is rapidly accelerated from the cathode by providing a voltage and striking the target anode of an x-ray tube, X-rays are created through energy conversion between the anode (positive) and cathode (negative). The x-ray tube is a vacuum containing two electrodes enclosed with a special type of glass known as –Pyrex glass. The two electrodes are made such that electrons can be generated at the cathode end (negative terminal) and accelerated by a large potential difference (voltage) in the direction of the anode (positive terminal)[5]. The heated tungsten filament emits electrons that are driven along the tube until they strike the target made of tungsten, where they collide to create x-rays.

Image acquisition

Screen-film radiography

Ionizing radiation is used to create a latent picture (invisible image) on an x-ray film that is housed inside a cassette (X-ray). Then the x-ray film is chemically processed in the darkroom to turn the undetectable picture into a visible image. This system ordinarily requires somewhere in the range of 2 -5 minutes with an ordinary mechanized processor and manual tape reloading in the processing room, contingent upon the processor. The last picture can't be changed and is irreversible.

X-RAY FILM:

A key element of screen-film radiography is the presentation of the radiographic image (Picture) on X-ray film. A silver halide emulsion used to make X-ray film produces an electron and a silver ion (Ag+) when it is subjected to light. The electrons that are attracted to the sensitivity particles pull the silver ion toward them. The silver ions then combine to produce metallic silver clusters (black)[13,14].X-ray film is an emulsion-coated clear plastic sheet that serves as the photographic receptor for an X-ray image. When subjected to any of these two forms of radiation, which this emulsion is susceptible to, it turns black. The emulsion is sensitive, therefore damage from inappropriate handling is readily possible. A radiographic film that hasn't been exposed to light or X-rays will be clean and transparent after processing; there won't be any haze or areas of grey-black color. In addition to helping to preserve the intricacies of the tissues and objects that the x-ray beam passes through, radiographic film is also used to produce x-ray pictures.

Layers

Base: It is a transparent supporting material. Polyester polyethylene as a film base offers the advantage of improved dimensional stability. Triacetate and polyester bases are clear and colorless. In 1933 first blue tint was added to X-Ray film to make it more convenient to visualize against the sky. The thickness of the base layer is about 0.18 mm.

Film emulsion

The emulsion of the x-ray film is made up of a combination of gelatin and tiny silver halide crystals (grains).

Adhesive layer

An adhesive layer is also called a subbing layer or substratum layer. It is made of a gelatin solution and solvent of the film base. It keeps emulsion layers and bases adhered to each other during the coating stage and processing. It offers a consistent surface on which the emulsion can be evenly covered.

Protective layer

To protect the emulsion, which would be easily stretched and damaged by normal handling, a very thin outer layer is applied. The unexposed radiographic film is rendered sturdy by the gelatin-based protective layer. It is anti-static and lessens bending, pressure, or contamination during handling, processing, and storage.

Computed radiography

The registered radiography approach, in like manner, utilizes tapes, yet the idle picture is recorded on a PSP inside the tape as opposed to x-beam film. A laser plate peruser situated inside a PC workstation changes the gathered picture into noticeable light, transforming it into a picture that should be visible. Notwithstanding a X-beam machine, the CR framework incorporates imaging plates of different sizes, a peruser, a PC, and a printer. The computer provides the ability to process, store, and display images. Instead of a screen-film cassette, the imaging plate is utilized. By deleting outdated image data, it may be utilized repeatedly. Then, using a processing method, this comparable information is converted to digital form. Depending on the body location being examined, the manufacturer has already pre-set the algorithm[6].

IMAGINGG PLATE

The adaptable screen can be produced using phosphor, which is encased in a strong tape and is known as an imaging plate (0.5 mm). The imaging plate or PSP tape was first introduced by Fuji, Japan, in 1983 and is like that of a regular tape. The cross-part of the imaging plate. In the imaging plate, the PSP particles are haphazardly present all through the fastener, and it tends to be dealt with in basically the same manner as that of a screen-film tape.

CLINICAL APPLICATIONS AND DIAGNOSTIC ROLE

X-ray imaging is the first line of imaging for diagnosing many clinical problems since it is widely and easily available, inexpensive, non-invasive, well-known among medical professionals, relatively innocuous compared to other imaging modalities, and has a quick turnaround time. It is easy to fathom the essential capability that radiographs play in the clinical screening process when you consolidate this with an extraordinary goal and difference. Although customary or screen-film radiography actually has a bigger client base than computerized radiography, this benefit is rapidly dissolving. The set dose scope, fixed non-direct dim scale reaction, and restricted capacity for patient portion decrease are the reasons for the falling ubiquity of conventional radiography. All of these restrictions restrict the amount of data that may be recorded on film. Once the photos have been processed, the contrast cannot be adjusted. In addition, the film is expensive, labor-intensive, processed with dangerous elements, and retrieving and storing it over an extended period is challenging. PACS and conventional radiography are incompatible.

Digital radiography has continued to develop and take on new forms. Instead of the traditional film screen, a photostimulable phosphor plate is utilized in computed radiography (CR) to detect x-rays. A photomultiplier tube gathers the light that a helium-neon laser produces as it navigates the uncovered plate, changing it into a simple electrical circuit prior to being digitalized. Direct radiography is one more sort of DR that gets rid of the inert endlessly picture plate peruser by straightforwardly changing x-beam radiation into electrical transmissions utilizing a semiconductor-based sensor. Shapeless silica switches X-beam photons over completely to light, which is hence transformed into electrons by scintillators such as strong state identifiers (selenium drums) and level board locators (selenium and cesium iodide). A computerized sensor associated with video screens considers continuous picture escalation, which is exceptionally useful for screening during radiological, vascular, and muscular medicine. It can increase brilliance by up to multiple times without expanding the radiation dose.

COSTS

Conventional

X-ray Cassettes, radiographic films, darkroom chemicals, and automatic processors have relatively low upfront expenses, but they have greater ongoing expenditures than digital systems (mostly because of films and chemicals, which also include the safe disposal of discarded materials). The time needed for equipment upkeep, and picture acquisition, including repeated exposures from non-diagnostic radiographs, and image retrieval from the archive, can result in indirect expenditures.[7]

Digital

Costs may be much higher depending on the technology utilized and the requirements of each practice, however digital radiography systems and computed radiography systems may be acquired for around 1 million and 1.5 million, respectively. Although a CR system has lower start-up expenses than a DR system, the phosphor plates have a limited lifespan and often need to be replaced sooner. However, if both digital systems adopt filmless operations, long-term savings may be substantial. Although laser film may be used to print digital photographs, this type of film is relatively costly, takes a long time to produce, and has to be stored.[8]

RADIOGRAPHIC IMAGING EQUIPMENT

- To correctly provide the desired voltage(kVp), current (mA), and exposure duration(S), the x-ray apparatus must be calibrated. In order to guarantee the proper radiation dose, this needs to be monitored periodically. The film is composed of:

- The super coat- gelatin;
- Emulsion-radiosensitive silver halide
- Adhesive layer- a mixture of gelatin solution and solvent of the film bas
- Film base- Polyester polyethylene

The sensitivity of the film is directly inversely correlated with the amount of silver bromide.

The radiographic film serves as the acquisition, display, and storage medium for images in traditional radiography. However, the creation of a picture in CR can be divided into four very major categories, Image acquisition, processing, storage and display. The performance of all these four distinct processes may be independently tuned for optimal effectiveness. Instead of the silver halide plates used in conventional radiography, which have a thin coating of fine-grained divalent Europium (Eu+) crystals doped with barium fluoro halide, CR employs phosphor plates[9]. The phosphor crystals absorb incident x-ray photons, creating high-energy photoelectrons. To create F centers, the electrons are captured at halide vacancies (color centers). The plate is scanned by a 633 nm laser beam made of helium-neon. Which releases the energy in the form of light photons, the color centers absorb energy, causing electrons to decay to a low energy level. A high-sensitivity photomultiplier tube transforms these photons into electric current. The picture is then created by digitizing the analog electrical signal and may either be printed using a laser printer or seen on a high-resolution display in greyscale. Images can be easily accessed at a later time if needed after being placed on PACS. Multiple users and any terminal can access the images.

VIEWING RADIOGRAPHS

Screen-film radiographs

The viewing of conventional radiographic film requires a light box.

Computed radiography

These radiographs can be imprinted on film or seen on a screen. Computerized pictures might be modified in different ways on the screen, including zooming, difference and scope changes, flipping and revolution, and greyscale reversal. Estimations and points can be taken, recorded, and shown regardless of these remarks on the image. While dissecting countless radiographs, the powerlessness to move between pictures as quickly as certified films because of the screen's size is a huge disadvantage.

IMAGE QUALITY

Conventional

The visual contrast between a traditional scan and a digital radiograph might be jarring. The actual diagnostic quality of the produced pictures isn't much that diverse between good, well-maintained conventional systems and computed radiography, though. Good screen-film systems have a little higher spatial resolution. In actuality, operator error is a common reason why conventional radiography have poor picture quality (such as excess or underexposure). Another relative shortcoming of traditional film is that contrast and latitude are inversely connected, meaning that a high contrast image will always be paired with a low grey scale. The contrast and latitude of a photograph are influenced by the type of film, processing, and exposure factors; high KV settings result in a relatively weak contrast, whereas low KV settings result in a stronger contrast, which is a technique used in thoracic and abdominal radiography to improve images. Finally, the dynamic range of vintage movies is quite low. Exposure factors must be carefully adjusted to the region of interest and its thickness to prevent overexposure or underexposure.

Computed Radiography

One of its main advantages is that digital radiography requires a little less maintenance and exposure adjustment. This is mostly due to the increased dynamic range, which allows for a larger variety of exposure settings. Poor exposure selection can significantly reduce the number of radiographs that need to be retaken. Severe overexposure or underexposure, on the other hand, cannot be fixed and lead to the production of artifacts. While it occasionally has poorer spatial resolution than traditional films, digital radiography has the advantage of a more independent connection between contrast and latitude, which leads to greater contrast resolution.

Radiation safety

Conventional

Poor exposure selection and underdevelopment, as was previously mentioned, can lead to a disproportionately increase the repeated radiographs. However, this can be reduced using effective radiography methods. The primary beam must be collimated to the film for an exposed rim to be visible on all four edges. This is a crucial step in ensuring radiation safety.

Computed Radiography

Radiation levels could be reduced by digital radiography by possibly lowering the number of repeat radiographs. Overexposure is mostly automatically corrected, albeit the operator might not be aware of this if it happens. As a result, it's possible to regularly employ exposure factors that are higher than necessary. Raising the total radiation dose may exceed the benefits of fewer retakes. Exposure factors should be frequently tracked and evaluated to prevent personnel from receiving undue radiation exposure. Although accurate beam collimation is as crucial in digital systems, picture processing frequently results in the loss of the primary beam's edges.

SPECIAL TECHNICAL FACILITIES

To detect modest discoveries without adding artifacts, the detector/receptor/PSP in computed imaging should ideally be able to detect even small amounts of incoming quanta. The proportion of photons from the subject that result in a picture is known as the detector efficiency. Film screens are two to four times slower than phosphor plates. A higher efficiency suggests less x-ray exposure. The pixel size, pixel depth, signal-to-noise ratio, and dynamic range are additional factors that affect image quality in a digital system in addition to the x-ray machine's quality and the dose used. The Shannon Theorem asserts that there won't be any information loss if the pixel size is less than the smallest detail that must be seen.

Archiving

Conventional

To detect modest discoveries without adding artifacts, the detector/receptor/PSP in computed imaging should ideally be able to detect even small amounts of incoming quanta. The proportion of photons coming from the subject that results in the detector's Film archiving takes a fair amount of time and storage space. Films may be lost, misplaced, or misfiled, which may be quite upsetting and worrying as they serve as legal papers.

Computed Radiography

The storage space reductions from electronic archiving systems can be substantial, particularly in settings with heavy demand. Additionally, if a sufficient network and monitors are available, a single radiograph can be seen simultaneously in many places. In an emergency, radiographs can be rapidly delivered through email for a second opinion. Another benefit is that there won't be any time wasted looking for missing or lost radiographs.

LIMITATIONS

There is some storage, financial, and film distribution restrictions with the conventional x-ray technology. It was previously believed that a lack of spatial resolution was to blame for the deficiencies in computed radiography pictures. Numerous studies have compared the spatial resolution of computed radiography to screen film radiography. Computed radiography was determined to have at least as excellent resolution as screen film radiography in a direct comparison on hand imaging[10]. Another research of 122 radiographs of the musculoskeletal system read by four readers discovered that a resolution of 2048 X 61680 X 12 bits, or 2.5 lines per millimetre, was sufficient to identify minor findings[11]. The diagnostic yield of digital and conventional radiographs is equal at this resolution. Computed radiography magnification methods may be used to overcome the limitations brought on by a poor spatial resolution12. The resolution for skeletal images using screen film radiography is typically 8 lines per millimeter. Another characteristic is that the size shown in the photographs could not accurately reflect anatomical proportions. The pictures are so challenging to template for preoperative surgical planning. For example, the templates for hip replacement surgery are frequently 15% to 20% larger than the original size, which corresponds to screen film radiography. A digital image with a range of magnification cannot be templated since the image will not fit any conventional template. Some implant manufacturers are creating digital templating alternatives to overcome this issue.

III. CONCLUSION

Computer-aided X-ray is a useful and affordable imaging technique that has some advantages over screen-film X-ray if the radiographer is aware of its limitations. To fully utilize computer-assisted radiography, clinicians must be aware of the imaging technology, the basics of image processing, and the artefacts that often occur.

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