Sudan University of Science and Technology

College of Graduate Studies

كلية الدراسات العليا

Determination and Analysis of Radiology Film Images

تحديد وتحليـــل أسباب رفض صور أفلام الاشعة

A thesis submitted for partial fulfillment of the requirements of Master degree in Medical Physics

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الآيــة

قَالَ تَعَالَىٰ:

(وَنُنَزِّلُ مِنَ الْقُرْآنِ مَا هُوَ شِفَاءٌ وَرَحْمَةٌ لِلْمُؤْمِنِينَ وَلَا يَزِيدُ الظَّالِمِينَ إِلَّا خَسَارًا)

صدق الله العظيم

سورة الإســـراء الآية (82)

Dedication

I dedicate this thesis to my mother, father, lovely sisters and brother that were always encourage and supported me to go forward.

Acknowledgements

My blessed to Allah, because he was make my road easy to complete this work.

All the thankful to **Sudan University of Science and Technology**, and to all hospitals and centers that give me all the data and information that I was needed to complete this work.

Great thankful to my secret friend he was always give me all the help I was needed.

Researcher …

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List of Abbreviations

Abbreviation	Item
ALARA	As Low As Reasonably Achievable
CR	Computed Radiography
DR	Digital Radiography
CRCPD	Conference of Radiation Control Programme Directors
CT	Computed Tomography
PSL	Photostimulable luminescence
IP	Image Plate
PSP	Photostimulable Phosphor
OSL	Optically Stimulated luminescence
QA	Quality Assurance
QAC	Quality Assurance Comity
MP	Medical Physicist
QC	Quality Control
Pos	Positioning
Art	Image Artifact
Cut-off	Anatomical Cut-off
PM	Patient Motion
UE	Under Exposure
WHO	World Health Organization
SI	International System of Unit
IAEA	International Atomic Energy Agency
RFA	Reject Film Analysis

Abstract

The study was conducted at a two Hospitals and two Centers in a radiology department and used five X-ray machines. Data were collected by standardized checklist as recommended by the Conference of Radiation Control Programme Directors (CRCPD) and International Atomic Energy Agency (IAEA).

The main objective of this study to determine and analysis of films (images) reject. The results of this study showed that the causes of reject film were anatomical cut-off(22.9%), over exposure and under exposure, patient motion, bad position of patients, improper collimator, artifact and finally others causes like patients cloth, no exposure, double exposures , incorrect patient ID all with (35.5%). The total reject rate for all hospitals and centers was (14.6%), which is not complies with the international standard as IAEA and CRCPD (5-10%).

The study recommended that: staff continuously attend refresher training courses to be aware about the common faults which lead rejects of film, continues of making rejection analysis that is the important evidence of image quality, necessity to a medical physicist to stay on the hospitals and centers to make periodic maintenance to machines and finally we need to make periodic quality control to machines.

المستخـــــــلص

أجريت هذه الدراسة في مستشفيين و مركزين ، و قد أُستخدمت خمس ماكينات أشعة سينية و جمعت البيانات بواسطة قائمة موصى بها من قبل وكالة الطاقة الذرية الدولية و مؤتمرمديـــــري برامج التحكم في الإشعاع .

الهدف الرئيسي من هذه الدراسة لمعرفة و تحليل أسبـــاب إعادة الصورة في أقســـام الأشعة. و أوضحت الدراسة أن أسباب رفض و إعادة الفليم او(الصورة) هي : قطع جزء تشريحي المطلوب (22.9%) ، زيادة في التعرض ، نقصان في التعرض ، حركة المريض ، خطـــأ في وضع المريض و محدد الأشعة ، التشوه وأسباب أخرى مثل إثيـــاب المريض ، عدم إطلاق إشعاع ، تكرار التعريض للصورة الواحدة ، رقم تعريفي غير صحيح للمريض و عدم ظهور صورة كل هذه الأسباب بنسبة (35.5%). أيضا معدل الإعـــــادة العـــام لكل المستشفيات و المراكز هو (14.6%) ، و هذه النتائج لا تتطابق مع المقاييس العالمية مثل وكالة الطاقة الذرية الدولية و مؤتمر مديري برامج التحكم في الإشعاع و الذي تنص نسبة الإعـــــادة المقبولة (5-10%).

الدراسة توصي بعمل دورات تدريبية للعاملين بضرورة معرفة أسباب إعادة الصور ، و إستمرار عمل تحليل للأفلام المعـــــادة لأن ذلك يقلل من الإعـــــادة و يحســـن من جودة الصورة ، ضرورة وجود فيزيـــــائي طبي في المستشفى أو المركـــز لعمل ضبط جودة الماكنــــات .

CHAPTER ONE

Introduction

1.1 Introduction

The important source of ionizing radiation used in medicine for diagnostic or therapeutic, this can cause injury to human and environment. The primary goals in radiography to produce diagnostic image or make image quality to get diagnosis and take in to account radiation dose in line with ALARA principle (As Low as Reasonably Achievable). (WHO, 2004)

The annual dose from medical application of ionizing radiation 3.2 mSv this a current acceptable dose, put in to account the exposure of some people will be zero and in others it may be high in medical radiation, so it necessary to be concerned about radiation control and safety in medical imaging. (Bushong, 2001)

The use of X-ray was increased in diagnostic imaging through over the last decay that need more careful. (IAEA, 2001)

The main goals of any radiology facility to minimize patient exposure, that can fulfilling by minimizing the number of repeated exposures, so repeat films means those radiographs that are not diagnostically acceptable and require an addition exposure of the patient for the same view, that can act as a means of improving patient care, decreasing exposure and save the time consuming. (AAPM, 2002)

The computed radiography (CR) is the wide range now a days despite the fact that the image quality of CR is poorer than digital radiography (DR) that it requires a longer exposure to produce acceptable images so the optimizations is unimplemented that can lead to the stochastic risk of radiation . (Benza, 2018)(IAEA, 2014)

The reject film analysis (RFA) is a method of quality assurance in radiology that can reduce exposure to the patients, radiographers and personnel, overall can reduce the cost to the department and save time it will consume consequence of repeated examinations. (Benza, 2018)

The causes of film (image) reject take from Conference of Radiation Control Programme Directors (CRCPD) were positioning, patient motion, incorrect patient ID, under exposure, over exposure, double exposure and clear film. (CRCPD, 2001)

After performing the repeat analysis the result must need to comparable with the nation or international recommendations. So according to the recommendation of Conference of Radiation Control Programme Directors recommended (CRCPD, 2009) the repeat of medical images should not be <5% or greater than 10%. (Arbese et al, 2018)(Emmanuel, 2019)(CRCPD, 2001)

1.2 Problem of study

Still patient expose to unnecessary radiation dose and more time due to repeated examination after using modern X-ray machines.

1.3 Objective of research

1.3.1 General Objective

Determination and analysis of film (image) reject.

1.3.2 Specific Objective

* To set up remedial action based on results of analysis.

* To achieve quality of image.

* To ensure that not arrive unnecessary dose to the patient.

* To achieve not consuming time on repeated examination.

1.5 Thesis layout

This thesis composed of five chapters: Chapter one consist of: the introduction, problem of study, objectives and thesis layout. Chapter two consist of: literature review. Chapter three consist of: materials and methods. Chapter four consist of: results. Chapter five consist of: discussion, conclusion and recommendations.

CHAPTER TWO

Literature Review

2.1Theoretical background

2.1.1 Radiation

Radiation is the emission or transmission of energy in the form of waves or particles through space or medium. Radiation divided to:

* Particle radiation such as alpha, beta and neutron radiation.
* Acoustic radiation such as ultrasound, sound and seismic waves.
* Gravitational radiation. (Wikipedia, 2020)

Types of radiation depending on the energy of the radiated particles were: Ionizing radiation and non-ionizing radiation.

Ionizing radiation are ability to excite and ionize atoms of matter with which they interact this include X-rays, fast electron (alpha and beta) radiation, heavy charged particles (proton, deuteron, triton, alpha particle and pions) also include neutrons. ***(***ATTIX, 1986)

Non ionizing radiation such as radio waves, microwaves, infrared and visible light. (Wikipedia, 2020)

2.1.2 Biologic effect of ionizing radiation

Some biological changes can occurs when the x-ray pass through the body, and there are two types of damages can occur stochastic effect and deterministic effect produce in the absence of adequate repair. (Linet, 2012)(WHO, 2004)

2.1.2.1Stochastic effect

The stochastic means the changes induce result of the low of probability and

it's not depending of radiation dose .These can cause cancer or affected on gen-material and influence on future generation by means (hereditary effect) ‘’ a very small x-ray dose cause a base change on DNA (Linet,2012) ‘’ . (Linet, 2012)(WHO, 2004)

2.1.2.2Deterministic effect

Deterministic or non-stochastic means the changes will always occur after exposure is more than the threshold, and the severity increase more than threshold value increase. (Linet, 2012)(WHO, 2004)

2.1.3 X-rays

2.1.3.1 General types of x-ray examinations

Radiography, fluoroscopy, and computed tomography CT.

Radiography uses film or a solid-state image receptor and usually an x-ray tube mounted from the ceiling on a track that allows the tube to be moved in any direction. Such examinations provide the radiologist with fixed images. Bushong, 2013)

Figure (2-1) shows the x-ray imaging system(Bushong, 2013)

2.1.3.2 Discovered of X-ray

X-rays was discovered by Wilhelm Rontgen in the 1895, within a very short time X-rays became useful tools in the practice of medicine, within about a month of his discovery and physicians on both sides of the Atlantic were routinely using x-rays in diagnostic radiography within a year, thus setting some kind of record for the rapid adoption of a new technology in practical applications. ***(***ATTIX, 1986)

2.1.3.3 X-rays production

The electron projected from the cathode hits the target of the anode producing x-rays. Some x-rays interact with tissue and other x-rays interact with the image receptor forming an image. (Bushong, 2017)

Remaining electrons giving continues x-ray spectrum after interact with target, electrons penetrate the anode and induced change in velocity after it pass nearly to the nuclei and lose energy in the shape of Bremsstrahlung. (Dowsett, 2006)

2.1.3.4 X-ray interaction with matter

Five mechanism for x-ray interaction are: coherent scattering, Compton scattering, photoelectric effect, pair production and photodisintegration.

2.1.3.4.1 Coherent scattering

This scattering for energies below 10 Kev. That the incident x-ray interacts with a target atom and become excited and release this excess energy as scattered x-ray with same wavelength on forward direction. The change of direction is the result of cohort scattering and no energy transfer and no ionization. (Bushong, 2017)

2.1.3.4.2Compton effect

X-rays interactions with outer-shell that not only scatters the x-ray but reduce energy and ionizes the atom. the x-ray continuous in different direction with less energy , and the Compton scattered energy equal to the different between the incident and ejected electron , the energy is divided between the scattered x-ray and Compton this may have sufficient energy to undergo additional ionizing interaction before lose all their energy . Compton-scattered x-ray deflected in any direction. The x-ray scattered back into direction of incident x-ray beam. (Bushong, 2017)

2.1.3.4.3 Photoelectric effect

X-ray is not scattered when interaction with inner-shell electrons that named photoelectric effect, the electron removed is called photoelectron and the energy equal to the different between the incident x-ray and binding energy of the electron, so the photoelectron is released with kinetic energy nearly equal to the energy of the incident x-ray. Characteristic x-rays are produced after a photoelectric interaction. The vacancy in K-shell results in a vacancy in the k-shell and that corrected by drop L-shell into the vacancy, the characteristic x-ray consist of secondary radiation and have sufficiently low energy and do not penetrate into image receptor. (Bushong, 2017)

2.1.3.4.4 Pair production

The interaction between the nucleus of the atom and the electron comes from interaction of incident x-ray with it, that causes x-ray to disappear and two electrons appear, one with positive charge and other with negative this called pair production. Incident x-ray photon have 1.02 MeV energy and distributed equally between two electrons, when the losing energy through excitation and ionization and fills vacancy, the positron with a free electron converted to energy as annihilation radiation. (Bushong, 2017)

2.1.3.4.5 Photodisintegration

X-ray with energy above 10 MeV escape interaction with electron and absorbed by the nucleus. The nucleus is raised to excited state and emits Nucleon or other. (Bushong, 2017).

2.1.3.5 X-ray imaging system

Types of x-ray are identified according to the energy of the x-ray produce or the purpose for intended x-rays. They are operated at 25 to 150 kilo voltage and 100 to 1200 mill ampere .The fluoroscopic x-ray tube is located under the examining table. The table of examination flat or curved but uniform in thickness. (Bushong, 2001)

X-ray imaging system has three principal part

X-ray tube, operating console and the high voltage generator. (Bushong, 2001)

2.1.3.5.1 X-ray tube

The x-ray tube located in the room of examinations. The external structure of x-ray tube consist of: support structure, protective housing, and the glass .The internal structure include anode and cathode electrodes. (Bushong, 2001)

2.1.3.5.2 Operating console

The operating console is located in an adjoining room with a protective barrier from the examinations room, this also must have a window to viewing the patient during examination. The operating console allows the radiologic technologist to control the current and voltage of x-ray tube. Modern operating console are based on recent computer technology, controls and mAs are digital and the technique is selected by touching screen, many of the features are automatic but technologist must know purpose and use. (Bushong, 2001)

2.1.3.5.3 High voltage generator

The high voltage generator housed in an equipment cabinet against wall and it's close to X-ray tube .The high voltage generator responsible for converting the low voltage into a kilo voltage and this contain three part: high voltage transformer, filament transformer and rectifiers. (Bushong, 2001)

2.1.4 Radiographic film

Image forming from X-ray exit the patient to expose radiographic intensifying screens placed in a cassette, these intensifying screens emit light which expose the radiographic film placed between two screens and the thickness of film is 150 to 300 µm. (Bushong, 2001)

The manufacture of radiographic film is precise and manufacturing facilities are clean so bit of dirt can make contamination and limit the ability of film to produce the information of X-ray beam.

Radiographic film has two parts: the base and emulsion .The emulsion covering by gelatin to protective them from pressure, scratches and contamination.

The adhesive layer is thin coating of material based between base and emulsion, this allows to emulsion and base to maintain proper contact and integrity. (Bushong, 2001)

2.1.4.1 Base

The base is the ground of film and provide rigid structure on to emulsion coated, its flexible and resistant to allow easy handling **.**The base of radiographic film keep its size and shape so it does not contribute to image deformation, dye is added to the base during manufacturing to colorful the film blue, so if film is utinted this coloring results in less eyestrain for the radiologist and conductive to efficient and accurate diagnosis. The standard base is cellulose nitrate or substitute material but it’s a glass plate in original. (Bushong, 2001)

Early the polyester is the popular one that the cellulose nitrate and cellulose triacetate because the last one is danger that can flammable, but polyester is more resistant to warping from age and easier transport through automatic processors and thinner. (Bushong, 2001) .

2.1.4.2 Emulsion

The heart of radiographic film is emulsion that contain the latent image before it process, that transfer information when photons light was interact from radiographic intensifying screen. The emulsion consist of gelatin and silver halide crystals , gelatin is clear so transit light and the silver halide is active ingredient of the emulsion and the 98% of silver halide is silver bromide and the remain is silver iodide . Among radiographic films the different in speed, contrast and resolution affected by silver halide crystals and the gelatin. (Bushong, 2001)

2.1.5 Types of film

Medical imaging is technical and improved especially radiologic imaging that appear in the number and variety of film that produced more than 25 different films.

English Unit (in)	SI Unit (cm)
7 × 7	18×18
8 × 10	20 × 25
10 × 12	24 × 30
14 × 14	35 × 35
14 × 17	35 × 43

Table (2-1) Standard Film Sizes on English and SI Units (Bushong, 2017)

There are two kinds of films

2.1.5.1 Screen-film

The most used image receptor in radiology is Screen-film. It has many characteristic:

Speed, contrast, crossover, spectral matching, safelight and ferocity law .Screen-film is available in multi latitude and sensitivities. (Bushong, 2001)

2.1.5.2 Direct-exposure film

Direct-exposure film sometimes called non screen film and its especial application such as that film used in mammography, video recording, cineradiography and dental radiology (Bushong, 2017).

The film is more blurred when used and exposure film without screens , now the extremity examination use fine grain , high details screen and double-emulsion film than in the past , that the Direct-exposure film is thicker than of the screen film and higher concentration of silver halide to improve the interaction of the x-ray .(Bushong ,2017)

2.1.6 Computed radiography image receptor

The Computed radiography (CR) is a shape of digital radiography (DR), that many sameness between CR imaging and screen film imaging use as image receptor, also can produce latent image in a different form after processing. Enclosed electrons can see in a higher energy metastable state when its response to x-ray interaction in CR. (Bushong, 2017)

2.1.6.1 Photostimulable luminescence

Light emit when some material as barium fluorohalide with europium (BaFBr:Eu or BaFI :Eu) exposed to different source of light that process named photostimulable luminescence (PSL) . The (Eu) is act as activator and responsible for the storage property of PSL and without it there is no latent image .The photostimulable phosphor(PSP) , barium flourohalide is fashioned of screen that the latent image was occurred , so this screen called storage phosphor screen (PSP) shows in fig15-4(Bushong ,2017)

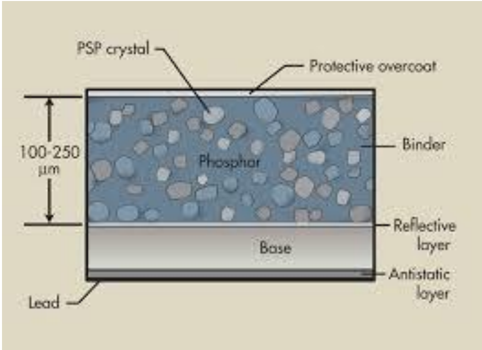

Figure (2.2) shows the PSP screen (Bushong, 2017)

The PSP are positioned random through a binder. PSPs are stable and optimize the stimulated light, also can enhance the X-ray absorption when incorporate phosphors and limit the spread of emission. (Bushong, 2017)

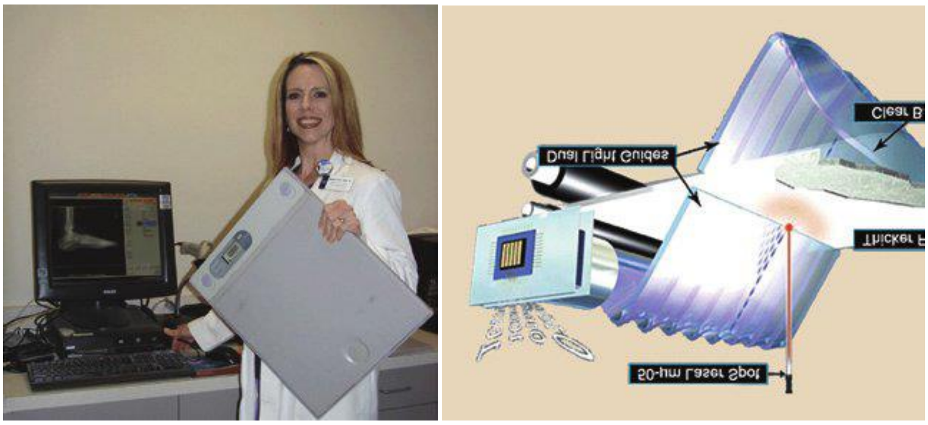

Figure (2.3) shows the computed radiography imaging plate prepared or insertion into electronic reader. (Bushong, 2017)

2.1.6.2 Image plate (IP)

The PSP screen is housed in a cassette shows in figure (2.3. The PSP screen film cassette is called imaging plate , and can storage as a screen film cassette , CR used with any X-ray imaging system and the PSP screen is handled in manner of a screen film daylight loader , so no need for use a dark room . IP improve resolution and contrast of IR consequence of reduction of backscatter of the x-ray beam, because IP has lead backing (Bushong, 2017).

2.1.6.3 Light stimulation – emission, latent image and imaging process

The PSL is same to optically stimulated luminescence (OSL) that emitted light when crystal of an OSL is illuminated. The electrons are transfer to metastable state when PSP exposes to x-ray beam results of examination, some of that electrons also back to ground state resulting in prompt emission of light and this causes latent image and IP must be read after exposure, and the beam of light directed to the PSP, as laser beam intensity increases this show spatial resolution of the CR imaging system. Laser is penetrate and spreads depending in the sickness of the PSP, so light being in the visible spectrum and the latent image made visible during this process. The electrons does not travel completely to ground state after the last stage of PSL stimulation cycles, some of this electrons are remaining. (Bushong, 2017)

2.1.6.4 Computed radiography reader

Mechanical, optics and computer modules typifies the CR reader.

2.1.6.4 .A Mechanical features

The drive mechanism moves the IP fixedly when it's the cassette inserted into the CR reader, so motor drive is constant to prevent artifacts, so laser is scanned during retrace and error is fraction of pixel. The IP leaves cassette and scan always at right angles to the direction of any grid lines. (Bushong, 2017)

2.1.6.4. B Optical feature

Component of the optical features subsystem consist of:

Laser, beam shaping, light collection optics, optical filters and photo detector.

The beam shaping optics save the size, shape, speed and intensity when the laser beam defected along the IP, and it's corrected the beam after enter go slowly along the wall, light also directed to photo detector and filtered to improve the signal-to-noise ratio

Before arrive to the photo detector. (Bushong, 2017)

2.1.6.4. C Computer control

Analog signal transmitted to a computer after coming from the photo diode, and this signal was processed to digitized signal before the final image. Finally the completed image was stored before used. (Bushong, 2017)

The most important of radiographic image quality are spatial resolution, contrast resolution and noise.

2.1.7 Resolution

Resolution definition as an ability to image two separate objects and visually distinguish

One from the other.

Spatial resolution refers to the ability to image small objects that have high subject contrast, such as a bone–soft tissue.

Contrast resolution is the ability to distinguish anatomical structures of similar subject contrast such as liver–spleen. (Bushong, 2017)

2.1.8 Noise

Noise is a term that is borrowed from electrical engineering .The utter, hum, and whistle heard from an audio system constitute audio noise that is inherent in the design of the system. A number of factors contribute to radiographic noise including some that are under the control of radiologic technologists. Lower noise results in a better radiographic image because it improves contrast resolution. (Bushong, 2017)

2.1.9 Quality assurance QA

The overall management program, put in place to ensure that a comprehensive range of quality control activities work effectively. A Quality Assurance Program should be comprehensive, looking at all aspects of the work involved in producing high quality radiographs. This program should be cost effective and achieve its aims .The ultimate responsibility for setting up, running, evaluating and taking remedial action lies with the head of department, although appropriate delegation maybe necessary. It is important that someone accepts that responsibility and ensures that the program happens effectively. (WHO, 2001)

2.1.9.1 Quality assurance program includes

Periodic QC test, preventive maintenance procedures, administrative method and training also continuous assessment of the efficiency of the imaging service.

The main goals of QA to ensure the fixed item of prompt and accurate diagnosis of patients. (Chaloner, 1996)

2.1.9.2 Radiology department QA committee

In a hospital or center must need a Quality assurance committee (QAC) to plan and evaluate the program and resolve QA problems. And this have strategy and formulate the standards for image quality. (Chaloner, 1996).

2.1.9.3 Radiology department QA program

These include QC testing and administrative procedures by written plan of action outlining policies and procedures. The QAP evaluate itself by retake rate and causes, equipment repair and replacement …etc. (Chaloner, 1996)

2.1.9.4 QA personnel training

The QA program includes training to all personnel with QA responsibilities and especially those directly with QC testing that is necessary to keep personnel up-to-date. (Chaloner, 1996)

2.1.10 Quality Control (QC) Process

2.1.10.1 Equipment selection

The medical physicist need to have an educated in the administrative technical and clinical aspects of equipment performance to assess appropriateness of imaging equipment that mean ability to deliver the quality for a specific imaging at a cost to both patient and hospital that is suitable of dose , money and downtime .Before delivery to have any equipment the medical physicist (MP) show and tabulate the specification of the equipment that will ensure for them in acceptance test prior to the work . (AAPM, 2002)

2.1.10.2 Acceptance testing

After an appropriate system performed the (MP) responsibility to assure that the equipment function safety and decimation system performance and make maintained after any warranty period. (AAPM, 2002)

2.1.10.3 Quality control QC

The means by which each area of interest is monitored and evaluated (WHO, 2001).

Periodic monitoring and evaluation must needed after installing and acceptance test that performed in QC .QC procedure to discover changes in degration quality or increase in radiation exposure , if any error appear that testing frequently to determine any change in the unit . (AAPM, 2002)

2.1.10.3. A The repeatable of QC test depends on

* The inherent changeability of the equipment.

* Age of use of the equipment, frequency and reliability.

* The critically of the element in the imaging chain.

The older equipment is monitored more than newer .The new equipment make quality QC more frequent to collect more data and this can help to choice a suitable monitoring. (AAPM, 2002)

2.1.10.3. B Action considers prior QC frequency start

- Know the frequency of the QC in literature.

- Make the test frequency more than recommended.

- Back to frequency on literature after six month to one year.

- Monitor the results of QC and reassessment of test frequency.

2.1.10.4 Documentation

The results of test should be recorded and analysis and also comparable with another test in specific period or with another device.

The QC test should be performed by technologist daily, weekly and monthly and by MP periodically, also the choice of instrumentation to performed the QC test depending on type of equipment and the intended user can refer to AAPM report 60 to assist on selection of equipment .(AAPM, 2002)

2.1.11 Reject films

Reject-repeat film is image that are not diagnostically acceptable and need to expose same patient for the same view. (AAPM, 2002)

2.1.11.1 Factors that affected the facility repeat

1- Method of collecting data.

2- Experience of staff.

3- Time of day shift.

2.1.11.2 The categories for evaluation repeat films are

2.1.11.2.1 Positioning (Pos)

This factors result of the patient incorporation or mal positioning of the collimator also can make a default on the film. (Emmannuel, 2018)

2.1.11.2.2 Image Artifact (Art)

These can appear from the malfunction of the machine or failure on processing. (Dowestt, 2006)

2.1.11.2.3 Anatomical cut-off (cut-off)

This one of the image reject occurs consequence to wrong placing of markers at the region must need to being examined. (Emmannuel, 2018)

2.1.11.2.4 Patient motion (PM)

This is completely induced film default by moving of patient out of the place fixed on before make an examination.

2.1.11.2.5 Under Exposure (UE)

This also responsible of film default by selected factors smaller than the normal factor expected that lead to too light and drop out the details. (Emmannuel, 2018)

2.1.11.2.6 Others

These can drive from not main reason of reject such as (patients wearing something, not shooting, double print, incorrect patient ID).

2.2 Previous Study

There are many authors considerable under this study in the scope about information can support this study, for example

Chaloner P and Periard MA , 1996 , Diagnostic X-ray Imaging Quality Assurance . Study of Chaloner aimed and overviewed essential aspects of a quality assurance program and is intended to encourage the review of a moderate size hospitals Xx-ray imaging quality .(Chaloner ,1996)

Teferi S et al, 2010, X-ray Film Reject Rate at Eight Selected Government hospitals in Addis Ababa, Ethiopia. The aim of research to identify the main causes of film faults as well as the pattern and magnitude of film rejection. The study was performed on the adult and pediatric radiographs used 12165 x-ray exposure , 374(3.1) were rejected and the result of study showed that one hospital was not on an acceptable range according to. The main cause causes of rejected film were poor technical judgment, patient motion and poor supervision of staff. (Teferi, 2010)

Yousif M , Ahmed H , Edward C et al ,2013, Film Reject Analysis for Conventional Radiography In Khartoum hospitals . Study aimed to explore causes of reject and repeat of x-ray examination and to obtain information for further recommendation in Khartoum state hospitals. study of Yousif used 7 x-rays and the result showed that under exposure (26.8%) was a main cause of reject or repeat image and the over exposure (19.2%) was a second one, also position (23.8%) the bigger contributor of reject images. (Yousif, 2013)

Miftaudeen M.N et al, 2017, X-ray Film Reject Analysis as a Quality Indicator in a Tertiary Health Center in Northern Nigeria. The aim of study to assess the rate of rejects in routine radiography as a quality control measure, this obtained from two conventional diagnostic rooms of the radiology department at Usmanu Denfodiyo university teaching hospital, Sokoto. The overall results reject rate was found to be 16.4%, and the major cause of reject was inappropriate collimation (18.1%), all the result was above of the recommended level given by World Health Organization (WHO). (Abubaker, 2017)

Benza Ch , Daniels E et al , 2018 , The Causes of Reject images in Radiology Department at a State Hospitals in Windhoek , Namiba . The study aimed to identify the causes of reject images and to calculate the rejection rates at state radiology department in Windhoek, Namiba. The study used CR techniques. The results of study were 2258 images reviewed and 181 were rejected. Overall positioning (63%) and exposure (24%) were the common contributor for reject images. The skull and chest radiographs had the highest reject rates of 9.9% and 48.1%respectively, all the result within an acceptable range according to the IAEA 5-10% recommended range. (Benza, 2018)

Emmanuel MW, 2019, Radiographic Reject Film Analysis in Radiology Department of a Teaching Hospital in Jos, plateau State, Nigeria. Study aimed to evaluating the rate at which radiographic films used for diagnoses rejected; assess the reasons for rejection and to obtain information for further image quality at the teaching hospitals. The study conduct in Nigeria. 5761 radiographs were studied and 476 were rejected and analyzed, appear that the bigger contributor of images rejection were overexposure (28.39%). (Emmanuel, 2019)

CHAPTER THREE

Material and Method

3.1 Material

3.1.1 X-ray Machine

I used five X-ray machines in four hospitals and centers in Khartoum state. The table below explain the type and characteristic of X-ray machines used.

Hospital/center	Type	Manufacture	Model	Serial Number
A	Table / Stand	Fuji	E7242	13F666
	Table / Stand	Shimadzu	R-20J	66B-55051-34
B	Table / Stand	Shimadzu	R-20J	3Z7B50C1301E
C	Table / Stand	Shimadzu Jap	R-20J	LZ7B52A57018
D	Table / Stand	Neusoft china	--------	-----------

Table (3.1.A) Shows specification of X-ray machines for all hospitals and centers

Hospital/center	Installation	Calibration	Max KVp	Total Filtration
A	2013	15/9/2019	140	Al 1 mm
	30/5/2017	30/7/2019	140	Al 1 mm
B	2013	Sep2019	150	Al 1 mm
C	2012	Jul 2019	150	Al 1 mm
D	2016	2018	150	Al 1 mm

Table (3.1.B) Shows specification of X-ray machines for all hospitals and centers

3.1.2 X-ray Films

Different size of films were used. The table below explain the size of X-ray Films used.

Hospital/center	Film size		
A	14*17	10*12	
B	14*17	10*12	14*14
C	14*17	8*10	
D	14*17		

Table (3.2) Shows size of X-ray films machines for all hospitals and centers

3.2 Method

Quantitative cross-sectional study was conducted from middle of October to last of November 2019 at radiology department (X-ray department) in two hospitals and two centers in Khartoum state. Data were retrieved daily from the computer system during the period of the research by standardize chick list given from CRCPD and previous study , that with helpful from radiographer to categorized the type of examinations and then explain the reasons of rejected images that were leads to repeated examination . Then data were analyzed by the Microsoft Office Excel 2007 to calculate the rejection rate and casuals rejection rate in percentage by the equations below

The rejection rate and causal rejection rate were determined using follows equations:

Rejection rate (%) $=\frac{\text{Number of rejected films}}{Total\ \boldsymbol{number}\ of\ films\ used} \times 100\%$

Causal rejection rate (%) =Number of rejected films

$$\frac{\text{for a specific cause}}{Total\ number\ of\ films\ rejected} \times 100\%$$

CHAPTER FOUR

Results

Tables and figures below shows the data of images reject and determines the causes of rejected images for five X-ray machines in four hospitals and centers (A, B,C,D) in the period of Oct to Nov 2019 in Khartoum state.

Ex.ty/Hosp	A		B		C		D	
	TI	RI%	TI	RI%	TI	RI%	TI	RI%
Chest	117	0(0%)	54	4(7.4%)	292	38(13.01%)	30	3(10%)
Spine	97	25(25.7%)	6	4(66.6%)			6	0
Skull	5	1(20%)	2	1(50%)			3	0
Pelvis	42	17(40.5%)	51	10(19.6%)			7	0
Abdomen	7	5(71.4%)					1	1(100%)
Knee	31	3(10%)	34	2(5.9%)			12	1(8.3%)
Shoulder	18	8(44.4%)	15	0			13	4(30.8%)
Extremities	49	6(12.2%)	32	2(6.3%)	3	0	63	10(15.9%)
Nasal	2	1(50%)						
PNS water	2	0(0%)						
Cervical			59	9(15.3%)	1	0	11	0
H.S.G			1	0				
Thyroid			2	0				
Thoracic			3	0			3	0
Neck			1	0			2	0
Total	**370**	**66(7.8%)**	**260**	**32(12.3%)**	**296**	**38(12.8%)**	**151**	**19(12.6%)**

Spine: lumber spine, H.S.G:Hysterosalpingography

Table (4.1)Shows the total image (TI) and reject image (RI(%))for all types Of examinations to all hospital and centers (A , B , C , D) From Oct to Nov 2019

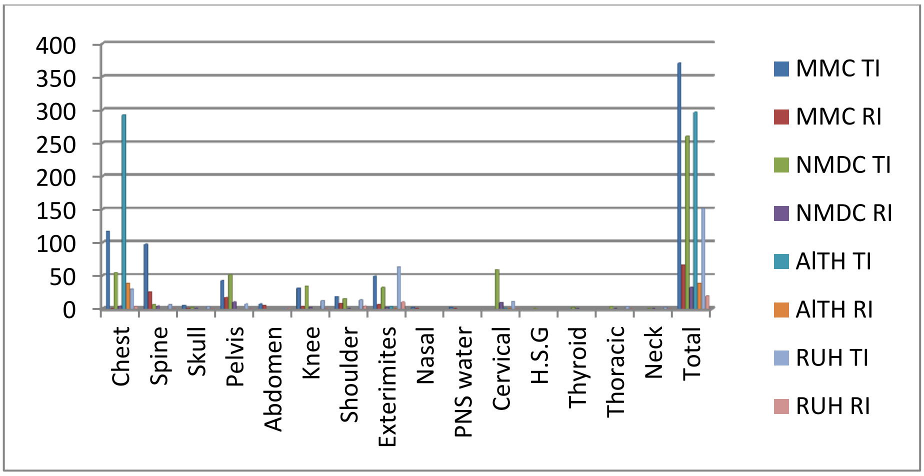

Figure (4.1) Shows the TI and RI for all types of examinations to all hospitals and centers (A , B , C , D)) from Oct to Nov 2019

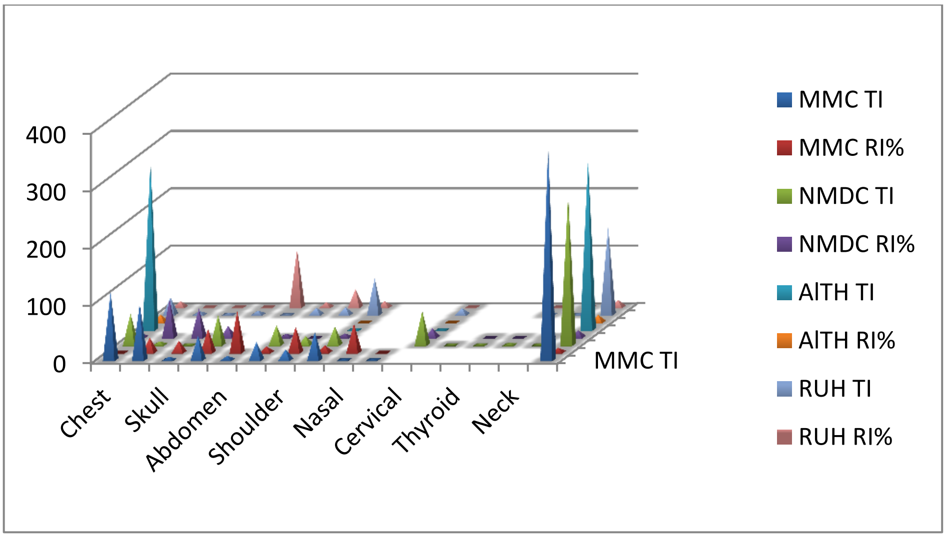

Figure (4.2) Shows the TI and RI (%) for all types of examinations to all hospitals and centers(A , B , C , D) from Oct to Nov 201

Hospital/Causes	Cut-off	OE	UE	PM	Pos	Art	Others
MMC	6	6	5	8	5	0	35
NMDC	11	6	6	9	0	0	8
AlTH	14	13	2	1	0	2	6
RUH	7	0	0	0	0	11	5
Total	38	25	13	18	5	13	54
Casuals RR (%)	22.9	15.1	7.8	10.8	3	7.8	32.5

Table (4.2) shows the casuals rejection rate RR (%) for all examinations to each hospitals and centers from Oct to Nov 2019

Figure (4.3) shows the total of all casuals reject and Casuals rejection rate RR (%) for all examination to all hospitals and centers from Oct to Nov 2019

Examination type	Total Film Used	RI	RR (%)
Chest	493	45	9.1
Spine	109	29	26.6
Skull	10	2	20
Pelvis	100	27	27
Abdomen	8	8	100
Knee	77	6	7.8
Shoulder	46	12	26.1
Extremities	147	18	12.2
Nasal	2	1	50
PNS water	2	0	0
Cervical	71	9	12.7
H.S.G	1	0	0
Thyroid	2	0	0
Thoracic	6	0	0
Neck	3	0	0
Total	1077	157	14.6

Table (4.3) Shows the Rejection rate RR (%) for all examination types to all hospitals and centers from Oct to Nov 2019

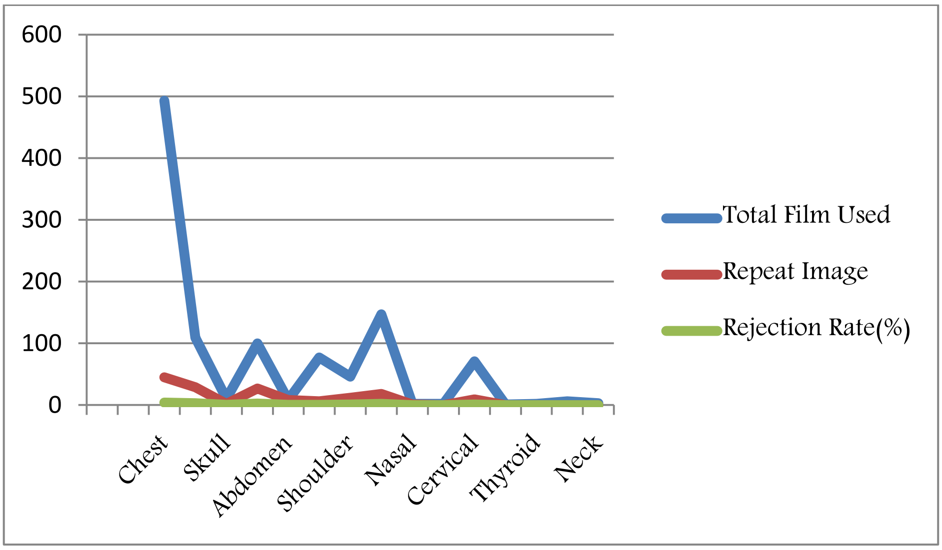

Figure (4.4) Shows the total film used, total repeat image and rejection rate (%) for all examination type to all hospitals and centers from Oct to Nov 2019

Examination type	Causes Of Repeat						
	Cut-off	OE	UE	PM	Pos	Art	others
Chest	2 14	2 13	2	1		2 3	6 1
Spine		3	4 4		3	7	8
Skull		1					1
Pelvis	3 6 2	1		1	1	10 2	4 2
Abdomen	1	1	1				2 1
Knee	2 1						1
Shoulder	1			8	2		1
Extremities	1 3				3	0 4	3 2
Nasal		1					
PNS water							
Cervical	2					1	
H.S.G							
Thyroid							
Thoracic						1	
Total	6 11 14 7	6 6 13 0	5 6 2 0	8 9 1 0	6 0 0 3	17 0 2 11	18 8 6 5
Casuals RR%	9.2 27.5 36.8 26.9	9.2 15 34.2 0	7.7 15 5.3 0	12.3 22.5 2.6 0	7.7 0 0 11.5	25.8 0 5.3 42.3	27.3 20 15.8 19.2

Table (4.4) Shows the causes of rejection image and casuals RR (%) for all types of examinations to all hospitals and centers (A, B, C, D) From Oct to Nov 2019

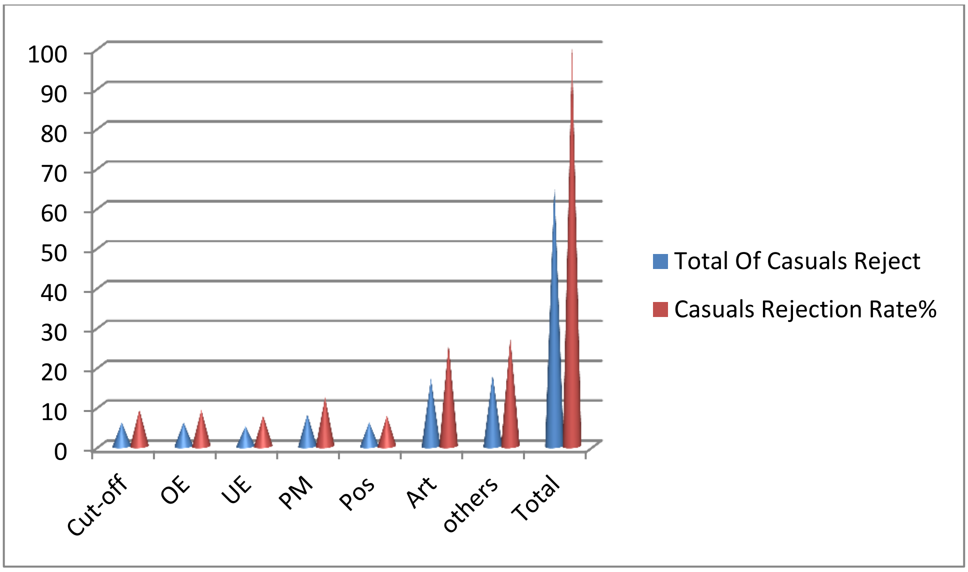

Figure (4.5) shows the total of casuals reject and casuals rejection rate of the A for all examination types from Oct to Nov 2019

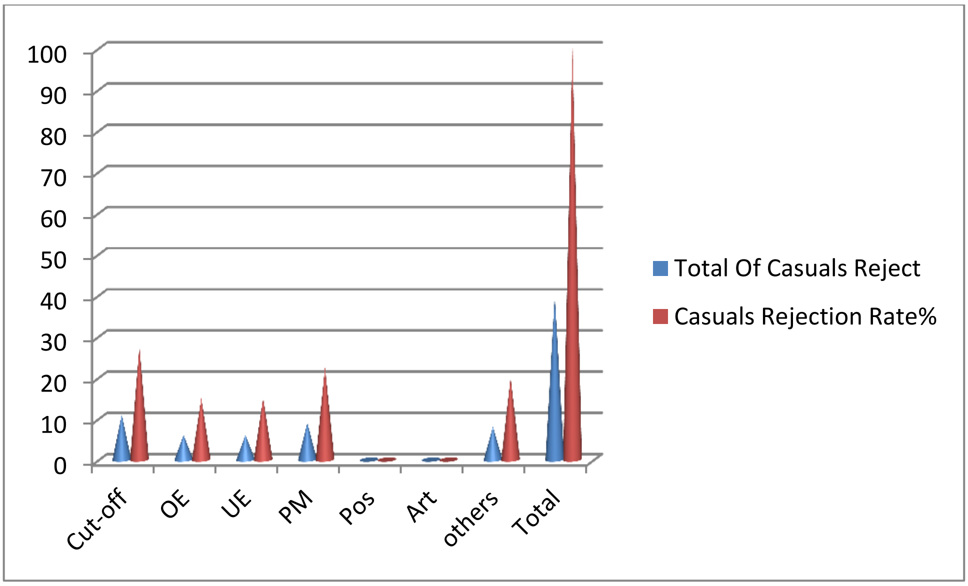

Figure (4.6) shows the total of casuals reject and casuals rejection rate of the B for all examination types from Oct to Nov 2019

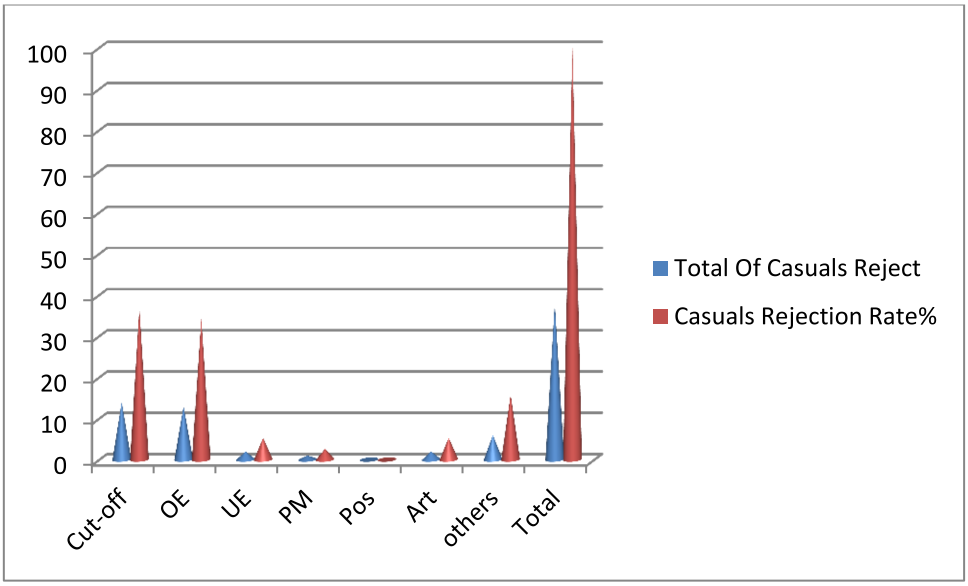

Figure (4.7) Shows the Total of casuals reject and casuals rejection rate of the C hospital for all examination types from Oct to Nov 2019

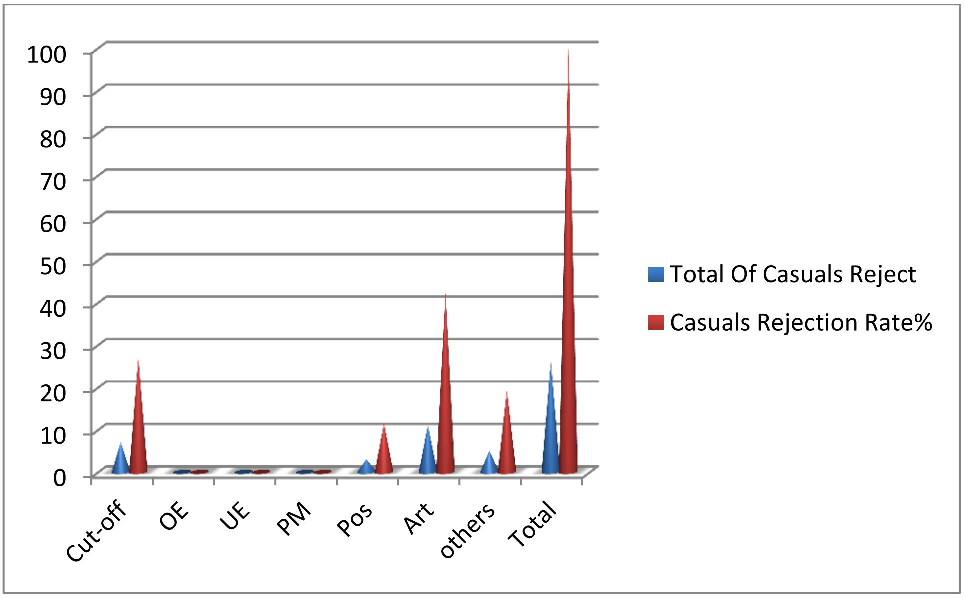

Figure (4.8) Shows the total of casuals reject and casuals rejection rate of the D hospital for all examination types from Oct to Nov 2019

Chapter five

Discussion, Conclusion and Recommendation

5-1 Discussion

Total of 1077 X-ray films were exposed for all types of examinations , that were performed in four hospitals and centers in Khartoum state a period of one month ,157(14.6%) X-ray images were rejected that shown on the table (4.3) and fig (4.4).

The rejection rates by each hospital were (7.8%) in A, (12.3) in B, (12.8%) in C and (12.6%) in D. The casual rejection rates of all hospitals and centers were (22.9%) for anatomical cut-off, (15.1%) for OE , (7.8%) for UE and Art , (10.8%) for PM , (3%) for Pos that is only one in acceptable range , and (32.5%) for others (patients wearing something , not shooting , double print , incorrect patient ID , no image) that is shows on the table (4.2) and fig (4.3) with the explaining of the total casuals reject image In A and D the highest rejection images despite of the most frequent examination were abdomen examinations with (71.4%) and (100%) rejection rate respectively in the period of study . In the normal state require for make examination patient would be in case of expiration because in this case the abdomen was extended and the lung was shrunked for take better view of the abdomen .

The highest rejection images were L-spine examinations with (66.6%) rejection rate in B , that require for done remain patient and hold the breath during the passage of X-ray through the body on the normal Situation , so that the movement that occur during the inhale and exhale didn't affect the clarity of the X-ray image .

The most frequent and highest rejection images were chest X-ray with (13.01%) in C, that require for done patient taken full inspiration to ensure that the entire lung fields are visualized. That is all show on table (4.1) and fig (4.1) (4.2).

The main causes of image rejection in A were artifact and others (patients wearing something, not shooting, double print, incorrect patient ID, no image) with (25.8%, 27.3%) reject rate respectively. Anatomical cut-off and patient motion in B with (27.5%, 22.5%) reject rate. In C hospital the cut-off and over exposure with (36.8%, 34.2%) reject rate .Artifact and anatomical cut-off were main causes of image rejection in D with (42.3%, 26.9%) reject rate. That all shows on the tables (4.4) and figures ((4.5) (4.6) (4.7) (4.8)).

5-2 Conclusion

The overall reject rate on this study for all hospitals and centers in the period of study was (14.6%) and it is not complies with the IAEA and CRCPD: Conference of Radiographic Control Programme Directorate recommended range of 5% - 10 % .That hospitals and centers on Khartoum state didn’t care to apply the quality assurance and quality control to the machines except in the case of stopped generally , why ? because that need a lot of money and time that lead to consume the profit of the centers or hospitals .

The causes of image rejection were cut-off , over exposure , under exposure , patient motion , position that include patient and collimator , artifact and finally others causes like (patients wearing something , not shooting , double print , incorrect patient ID , no image), and overall the main cause of repeat image were others with (32.5%) and cut-off (22.9%) causal rejection rate .

5-3 Recommendation

Despite of CR system reducing the repeat of image but the reject analysis still was very important program to monitor the quality of image and unnecessary dose arrive to patient, staff and member.

Overall this study of rejection rate was not within acceptable range that need to remedial action suitable with this case. Others (patients wearing something, not shooting, double print, incorrect patient ID, no image) were the highest contributor of reject images and anatomical cut-off this need:

- Staff continuously attend refresher training courses to be aware about the common faults which lead rejects of film.
- Continues of making rejection analysis that is the important evidence of image quality.
- Necessity to a medical physicist to stay on the hospitals and centers to make periodic maintenance to machines
- We need to make periodic quality control to machines.

References

- American Association of Physicist in Medicine [AAPM] (2002). Quality Control in Diagnostic Radiology, Report of AAPM Task Group #12, AAPM Report No. 74.

- Arbes M.Y , Abebe T.D , Mesele A.B. Determination and Analysis of Film Reject Rate at Eight Selected Governmental Diagnostic X-ray Facilities in Tigray Region , North Ethiopian . Journal of Medical Physics 2018; 43: 270-276.

- Attix F. Introduction to Radiological Physics and Radiation Dosimetry. Weinheim: Federal Republic of Germany, 1986.

- Benza Ch et al. The causes of reject images in a radiology department at a state hospital in Windhoek, Namibia. The South African Radiographer. 2018; 56(1): 35-39.

- Bushong S. Radiologic Science for Technologists (Physics, Radiology, and Protection). Tenth edition. Canada: St.Louis, Missouri: Elservier, 2017.

- Bushong S. Radiologic Science for Technologists (Physics, Radiology, and Protection). Eleventh edition. United State of America: St.Louis, Missouri: Elservier, 2013.

- Bushong S. Radiologic Science for Technologists (Physics, Radiology, and Protection). Eleventh edition. United State of America: St.Louis, Missouri: Elservier, 2001.

- Conference of Radiation Control Program Directors [CRCPD. Quality Control Recomindations for Diagnostic Radiography, Volume 3: Radiographic or fluoroscopic machines. Frankfort, Kentaky: CRCPD committee on quality assurance in diagnostic x-ray (H-7), 2001.

- Dance DR et al. Diagnostic Radiology Physics a Hand book for teachers and student .Vienna: International Atomic Energy Agency [IAEA], 2014.

- Dowesett D.J at el. The Physics of Diagnostic Imaging. Second edition. Bodmin, Cornwak: MBG Books education, 2006 .
- Emmanuel M.W, Samuel A.O. Radiographic Reject Film Analysis in Radiology Department of a Teaching Hospital in Jos, Plateau State, Nigeria. African journal of medical physics 2019; 1(1): 1-7.
- Linet MS, Slovs TL, Miller DL, Kleinerman R, Lee C, Rajaraman P, et al. Cancer risks associated with external radiation from diagnostic procedures . CA Cancer Journal for Clinicians, 2012; 62 (2):75-100.
- Lloyd P.J. Quality assurance workbook for radiographer & radiological technologists. Geneva: World Health Organization, 2001.
- Miftaudeen M.N, Abubakar U. X-ray Film Reject Analysis as a Quality Indicator in a Tertiary Health Center in Northwestern Nigeria. Journal of the Association of Radiographers of Nigeria 2017, 31(1):38-44.
- Munro L. Basic of radiation protection: how to achieve ALARA: working tips and Guidelines. Geneva: World Health Organization (WHO), 2004.
- Périard M.A Chaloner P et al. Diagnostic X-Ray Imaging Quality Assurance: An Overview. Candian Journal of Medical Radiation Technology October 1996; 27(4): 171-177.
- Radiological Protection of Patent in Diagnostic and Interventional Radiology, Nuclear Medicine and Radiotherapy. Vienna: International Atomic Energy Agency [IAEA], 2001.
- Teferi S, Zewdneh D, Admassie D, Nigatu B, Kebeta K. X-ray film reject rate analysis at eight selected government hospitals in Addis Ababa, Ethiopia , 2010 . Ethiop. J. Health Dev. 2012; 26(1):54-59.
- Wikipedia (2020), Date of access: December 15 2020, Available from:http://en.m.wikipedia.org/wiki/Radiation.

- Yousef M, Edward C, Ahmed H, Bushara L , Namdan A , Elnaiem N. Film reject analysis for conventional radiography in Khartoum hospitals . Asian Journal of Medical Radiological Research, 2013; 1(1):34-8.

Appendixes

Appendix (1) Shows X-ray machine of (D) hospital

Appendix (2) Shows X-ray machine of (B) center

Appendix (3) Shows X-ray machine of (C) hospital