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Research Paper

Radiographic Reject Film Analysis in Radiology Department of a Teaching Hospital in Jos, Plateau State, Nigeria

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Abstract

In X-ray examinations, it is common to find patients undergo repeated X-Ray examinations after the initial X-Rays films were rejected for undiagnosable image quality. This often contributes to the radiation burden of the patients and waste of resources or avoidable extra cost in most radiology departments. This study aimed at evaluating the rate at which radiographic films used for diagnoses are rejected; assess the reasons for rejection and to obtain information for further image quality at the Teaching Hospital. A prospective method was adopted using radiographic films of good and poor diagnostic quality for a period of two years (January 2015 to December 2016). A total number of 5761 radiographs were studied, out of which 5285 were of good diagnostic quality. The 476 rejected films were analyzed with respect to size, type of procedure and reasons for rejection. The analysis of the rejected films indicated that over-exposure; under-exposure, poor positioning as well as poor processing contributed 28.39%, 20.65%, 13.87% and 11.29% respectively to the rejection. The reject rate was found to be 7.76% in 2015 and 8.98% in 2016, which are above the World Health Organisation and within the Conference of Radiation Control Program Directors (CRCPD) recommended permissible rate of 5% and (5-10%) respectively. The reasons identified for the film rejection could be due to incorrect setting of exposure factors, lack of communication between the operator and the darkroom technician and quality control test on the processor could be responsible for producing over and under exposed radiographs. The findings imply that the patients may have been exposed to avoidable radiation doses. Regular training in radiographic techniques and standardization of protocols as well as quality assurance measures in the hospital could help reduce the reported reasons for rejection.

Key words: Radiographs, film reject rate, X-ray examination, radiation exposure, diagnostic radiology

Introduction

Film reject analysis is a well-established method of quality control (QC) in diagnostic radiology. A reject film is a film that does not provide diagnostic information for clinical analysis because of poor image quality and thus the image has to be retaken [1].The employment of reject analysis in the evaluation of image quality has quite a long history. It is an important component of quality assurance programs.

The analyses provide a framework to manage X-ray film used, monitor equipment performance and measure the effectiveness of the facility quality assurance and above all serves to control the dose received by patients [2]. The role of reject analysis provides valuable information that would help achieve reduction in radiation exposure and cost both for patients and personnel. It provides information about the efficiency of the radiology department, the basis for quality control and in educating the radiographer. The concern originates from the fact that, when considering stochastic effects, even small radiation doses carry potential risks [10].

Hence, clinically un-indicated, avoidable repeat or un-optimized X-ray examinations may lead to adverse health effects and need serious optimization. In general, the optimization process requires a balance between the patient dose and image quality and it is important that the diagnostic quality of the image is not lost in the cause of dose reduction. With that in mind, efforts have been made to assure both the general public and workers that may be exposed to radiation that any exposure they may receive is as low as reasonably achievable-the basis of the ALARA program [3].

A diagnostic radiology facility is any facility in which an X-ray system is used to irradiate any part of the human body for the purpose of diagnosis or visualization. In radiological procedures involving X-rays both patients and staffs are exposed to varying degrees of radiation doses. The quality of information obtained from radiographs is dependent on a number of factors such as kVp, mAs, motional factors and processing [8].

Health physics is concerned with protecting people from harmful effect of ionizing radiation while allowing its beneficial use in science, medicine and industry [1]. X-rays are known to cause malignancies, skin damage and other side effects and therefore are potentially dangerous. It is therefore essential and mandatory to reduce the radiation dose to patients in diagnostic radiology to the barest minimum [4].

The radiation dose to a patient is linked to image quality and should not be lowered to jeopardize the diagnostic outcome of a radiographic procedure. In order to produce a good quality image of anatomical structures for diagnostic purposes, both quality assurance program and quality control measures are of great importance [4, 5] . The nature and extent of this program will vary with the size and type of the facility and the type of examinations conducted.

An important goal in diagnostic radiography is to obtain radiographs of optimum diagnostic quality, reduces repeat exposures and optimizes man-hour. Unfortunately, certain factors make attainment of the much-desired goal of obtaining radiographs of optimum diagnostic quality impossible [1].

Patient radiographs therefore serve as a quality control check and should be factored into any departmental evaluation program [6] and [7]. Quality control techniques are those techniques used in either monitoring or testing and maintenance of the components of an X-ray system [8].

The Film Reject Analysis (FRA) method will be used in this study to assess the causes of poor image quality. The results obtained from the study will also be useful for the diagnostic radiology department to identify problem areas, scrutinize the reasons for these problems and finding ways of rectifying them. It is common to encounter patients undergo repeat X-ray examinations after their initial X-rays are rejected for poor image quality thereby subjecting them to excess radiation exposure and avoidable extra cost. This creates a situation, which necessitates the need to explore causes of reject and repeat of X-ray examinations.

The employment of reject analysis as part of overall Quality Assurance (QA) programs in clinical radiography and radiology services in the evaluation of image quality is a well-established practice. Reject analysis would help achieve good reduction in radiation exposure and cost as well as develop acceptable image quality.

Materials and Methods

A prospective method of data collection was adopted using radiographic films that have been described as being of poor diagnostic quality. Four hundred and seventy six (476) films rejected within the period of two (2) years (January 2015- December 2016) were collected. The rejected radiographs were kept in X-ray jacket in the duty room during the study period and were later analyzed. The rejected radiographs consisted of the basic X-ray projections (antero-posterior (AP), post-anterior (PA), and Lateral) in general radiography of adult and pediatric patients. The films were assessed on a viewing box under similar conditions of room light and temperature. The Chief Radiographer did the evaluation. Rejected radiographs were analyzed and categorized according to body parts that included chest, skull, C-spine, lumber, pelvis, femur, pelvis, and Tibia examinations. The reasons for the reject were also categorized as over-exposure, under-exposure, positioning error, poor processing, wrong positioning of marker, fog, unexposed films and exposed to light films.

Over penetration

This is a factor that could lead to film default, that is its often resulted when the factor selected is higher than the normal factor expected for an exposure of a particular organ which implies too dark with a decrease resolution.

Under exposure

Under exposure: This is a factor responsible for film default, that is its often occur when the factor selected is smaller than the normal factor expected and this implies too light and drop out the detail.

Poor positioning

Is also a factor which could lead to film default and its often occur as a result of the patient incorporation.

Poor processing

Processing is where the number of rejected films or defaulted films was found to be enormous; this is because x-ray films can easily be rejected when processing as a result of many factors such as: Marks and defects, wrong identity and artefacts

Exposed to light

So far in the course of this research work, it was also found out that exposure to light is responsible for some of the rejected films and this case occurs when a film is being exposed to white light carelessly before using the film to exposure the patient to radiation.

Wrong placing of marker

This is also a factor which leads to film reject and it occurs when the marker is mistakenly placed at the region of the body being examined.

Calculation of reject rate

The reject rate was determined as follows:

$$\text{Reject Rate} = \frac{\boldsymbol{No\ of\ rejected\ films}}{\boldsymbol{No\ of\ examinations}} \times 100\% \qquad (1)$$

The data was analysed using t-test to determine the significant levels of the rejected films as follows:

$$\boldsymbol{t} = \frac{\boldsymbol{X_{ave} - \mu}}{\boldsymbol{S/\sqrt{n}}} \qquad (2)$$

where X_{ave} is the average number of reject films, μ is the population mean, S is the standard deviation and $\sqrt{\boldsymbol{n}}$ is the square of the number of examination.

From the t-test, the statistical significant t-test at 5% shows that the number of rejected films is not increasing and this implies that, the hospital is still operating within the permissible limits.

Results and Discussion

The analysis for the rejected (default) films was from January 2015 to December 2016 of the seven (7) anatomical parts of the human body as a case of study. Accurate exposure is one of the important factors providing a good quality image with high resolution. High-resolution image means an image that shows good structural details.

Table 1 shows the standard exposure factors for various examinations with respect to sizes in the teaching hospital. Tables 2, 3, 4, 5 and 6 show the common reasons for the rejection, distribution of rejected films according to body parts under examination, reasons for reject radiographs and body parts under examination for the period under review.

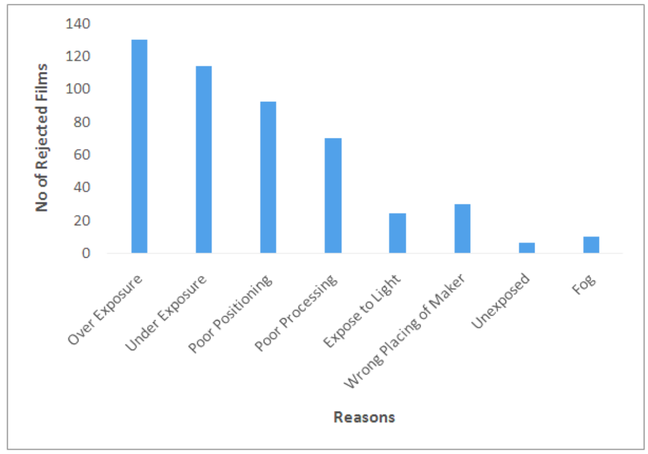

Figure 1. Reasons for reject radiographs for period under review.

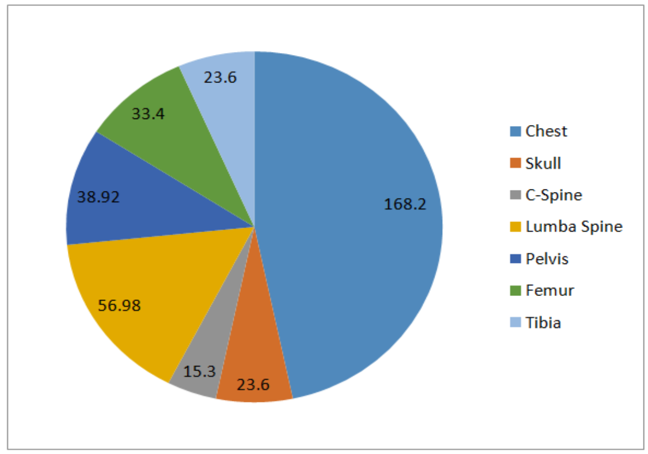

Figure 2. Pie chart showing the distribution of rejected films according to body parts under examination from January –December 2015.

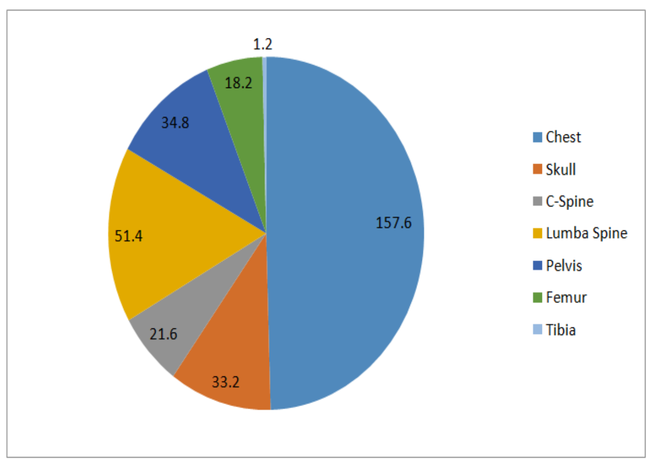

Figure 3. Pie chart showing the distribution of rejected films according to body parts under examination from January-December 2016.

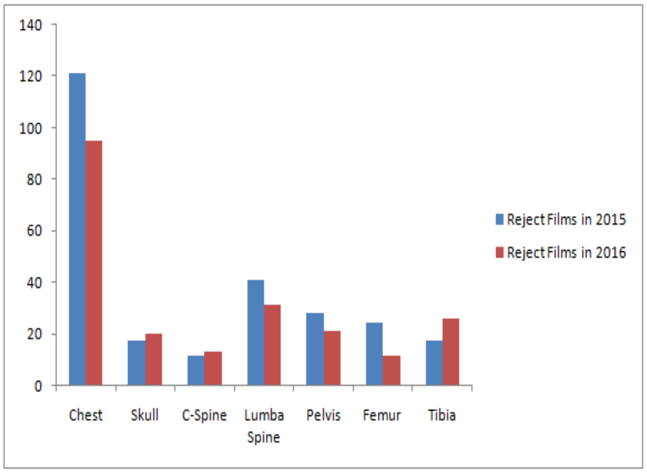

Figure 4. Bar chart representing the comparison between the reject films due to different Examinations in 2015 and 2016.

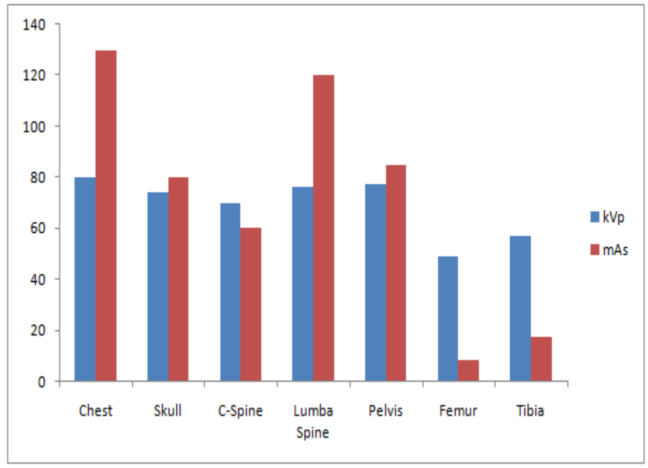

Figure 7. Bar chart representing extra fat size with kVp and mAs for each type of examination.

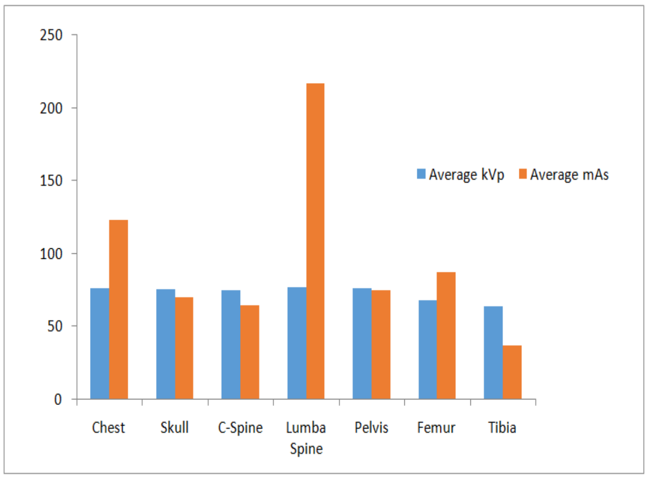

Figure 5. Bar chart representing the slim size with kVp and mAs for each type of examinations.

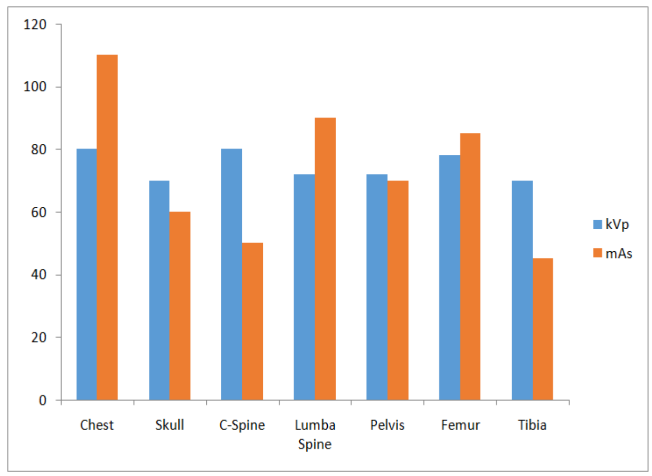

Figure 6. Bar chart representing the fat size with kVp and mAs for each type of examination

Table 1. KVp, mA and mAS used for various examinations with respect to sizes

Size	Small			Fat			Extra fat			Average	
Types of exams	**KVp**	**mA**	**mAS**	**KVp**	**Ma**	**mAS**	**KVp**	**mA**	**mAS**	**KVp**	**mAS**
Chess	80	150	110	70	300	130	80	300	130	76.67	123.30
Skull	70	300	60	84	300	70	74	300	80	76.00	70.00
C/spine	80	300	50	76	300	85	70	300	60	75.30	65.00
Lumber spine	72	300	90	84	300	440	76	300	120	77.30	216.67
Pelvis	72	300	70	80	300	70	77	300	85	76.30	75.00
Femur	78	300	85	78	300	170	49	300	8	68.30	87.67
Tibia	70	300	45	65	300	50	57	300	17	64.00	37.3

Table 2. Reasons for rejecting films in the hospital for the period under review

Reasons	Rejected films	Percentage (%)
Over exposure	130	27.31
Under exposure	114	23.95
Poor positioning	92	19.33
Poor processing	70	14.71
Exposure to light	24	5.04
Wrong placing of marker	30	6.30
Unexposed	06	1.26
Fog	10	2.10
Total	476	100

Table 3. Distribution of rejected films according to body parts under examination from January-December 2015

Type of examination	Number of Examination	Number of accepted films	Number of rejected films	Reject Rate (%)
Chest	2084	1963	121	3.62
Skull	236	219	17	0.51
C/spine	110	99	11	0.33
Lumber	212	171	41	1.23
Pelvis	235	207	28	0.84
Femur	198	174	24	0.72
Tibia	268	251	17	0.51
Total	3343	3084	259	7.76

Table 4. Distribution of rejected films according to body parts under examination from January-December 2016

Type of examination	Over exposure	Under exposure	Position error	Poor processing	Expose to light	Wrong placing of marker	Unexposed	Fog
Chest	38	25	20	18	11	7	1	1
Skull	6	3	5	1	-	2	-	-
C/spine	4	4	2	1	-	-	-	-
Lumber spine	10	10	7	6	3	4	-	1
Pelvis	8	12	3	5	-	-	-	-
Femur	13	5	3	-	-	-	-	-
Tibia	9	5	3	-	-	-	-	-

Table 5. Reasons for reject radiographs from January-December 2016

Type of examination	Number of Examination	Number of accepted films	Number of rejected films	Reject Rate (%)
Chest	1256	1161	95	3.93
Skull	192	172	20	0.83
C/spine	84	71	13	0.54
Lumber	346	315	31	1.28
Pelvis	202	181	21	0.87
Femur	134	123	11	0.45
Tibia	204	178	26	1.08
Total	2418	2201	217	8.98

Table 6. Reasons for reject radiographs from January-December 2016

Type of examination	Over exposure	Under exposure	Position error	Poor processing	Expose to light	Wrong placing of marker	Unexposed	Fog
Chest	15	18	22	13	7	8	3	6
Skull	2	6	4	3	-	1	2	2
C/spine	2	3	2	2	1	3	-	-
Lumber spine	6	4	13	4	1	3	-	-
Pelvis	7	5	3	6	-	-	-	-
Femur	3	2	2	3	1	-	-	-
Tibia	7	12	3	4	-	-	-	-

Figure 1 shows the bar charts representing the common reasons for rejecting films in the teaching hospital from January 2015 to December 2016. It is observed from the bar chart that the highest reason for the film reject was the over-exposure which is as a result of improper selection of technique factors during exposure and the least reasons for the film reject were unexposed films and fogged films.

Figures 2 and 3 show pie charts representing the rejected films due to different examinations in 2015 and 2016 respectively. It is observed that the chest radiographs have the percentage of rejects (46.7%) and (43.8%) respectively. This is properly so because majority of the cases handled in the department were chest examinations. This is in keeping to the findings of [3]. The incidence of high rate of rejection of chest radiographs could also be attributed to the clinical conditions of the patient who came for chest x-ray. Some of the patients for chest examination were HIV, AIDS, TB and acute bronchitis patients. Some of them are usually very weak and hence find it difficult to assume the proper erect position resulting in radiographs of suboptimal quality.

Figure 4 shows the comparison between the reject films in 2015 and 2016. It is obvious from the charts that films were more rejected in 2015 than 2016, this could be because the majority of the cases done were more in 2015 than in 2016 in the following body parts under examination such as chest, lumbar spine, pelvis and femur, and the films rejected in 2016 than 2015 in the following body parts such as skull, c-spine and tibia.

It is also observed that the CXR radiographs has the highest film reject in 2015 and 2016 due to un-cooperating patients, over- exposure, under- exposure poor positioning etc. and c-spine radiographs has the least film reject in 2015 and 2016.

Figure 5 shows the bar chart representing small size with kVp and mAs for each type of examinations. It is observed from the bar chart the kVp is higher in skull, c-spine, pelvis and tibia and the mAs is higher in chest, lumbar spine and femur.

Figure 6 represents the bar chart for the fat size with kVp and mAs for each type of examinations. It is observed from the bar chart that the kVp is higher in the skull, pelvis and tibia and the mAs is higher in chest, c-spine, lumbar spine and femur. It is also observed that the highest kVp is lumbar spine and skull and the least kVp is tibia, the highest mAs is found in lumbar and the least mAs is found in tibia.

Figure7 shows bar chart representing the extra fat size with kVp and mAs for each type of examinations. It is observed that the highest kVp and mAs is chest, followed by Lumbar Spine and then Pelvis and the least kVp and mAs is the Femur.

Conclusions

The reject rates were found to be 10.4% in 2015 and 10.5% in 2016, which are by far above the recommendation of the World Health Organization (WHO) criteria of 5%; although the Conference of Radiographic Control Programme Directorate (CRCPD's) Committee on Quality Assurance increased the reject rates up to 10% [9]. This study has shown over- exposure, under-exposure, poor positioning as well as poor processing to be the main reasons of reject. This could be because of incorrect setting of exposure factors by operators, lack of communication between the operators and the darkroom technicians as well as lack of Quality Control (QC) test on the processor. The statistical significant t-test at 5% significant level shows that the numbers of rejected films are not increasing. This implies that the hospital is still operating within permissible limits. However, there is the need to strengthen quality assurance programmes for corrective measures in this hospital.

Abbreviations

CRCPD: Conference of Radiographic Control Programme Directorate; QC: Quality Control.

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Author Contributions

MWE and ASO contributed equally to this study. All authors gave their final approval.

Competing Interests

The authors have declared that no competing interest exists.

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