EVALUATION OF REJECTED IMAGES IN COMPUTERIZED RADIOGRAPHY (CR)

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ABSTRACT

INTRODUCTION: Reject image analysis is a quality control check periodically carried out to ensure that optimally diagnostic images are produced. The overall aim ensures that patient radiation dose due to repeat exposure is drastically reduced. In order to ensure continuous optimal quality assurance of the imaging services provided by radiographers to patients, quality control checks such as reject image analysis are put in place to monitor the quality assurance program. The reject image analysis is not a new concept as it has continuously been used by radiographers to check reasons for repeat exposures and the anatomical part of the body mostly affected. **METHOD:** An audit of retrospectively acquired radiographic images of a total of 1740 patients collected from January to March 2020 was performed by two senior radiographers. A data collection chart was used to collect the data according to the causes of repeat exposures with respect to the anatomical body part examined and then the reject image rate was calculated. **RESULT:** The reject image rate (RIR) for January, February and March 2020 are 9.98%, 11.57% and 9.04% with image cut as the major reason for the reject having 3.7%, 3.35% and 4.06% RIR in the respective months. The overall RIR from January to March 2020 is 9.77%. **CONCLUSION:** Though the overall RIR is within recommended limits, continuous reject image analysis will aid in ensuring optimally diagnostic images are continuously produced with minimal repeat exposures and regular continuous professional development (CPD) is recommended for the Radiographers and Radiographer Assistants in order for them not to become rusty with time. The implications for practice is that low RIR is an indicator that optimal radiography services are rendered and also that patients are not exposed to unnecessary radiation. The choice of CPD should be tailored towards the periodic outcome of the reject image analysis especially for young radiographers. As such, a reject image analysis wallet for each radiographer is encouraged in order to identify individual radiographers' deficiencies.

Keywords: Reject image rate (RIR), repeat exposure, quality control checks, radiation dose, radiographers

Introduction

One of the three fundamental principles of radiation protection is the optimization of practice which can be achieved by ensuring that all radiation exposures are kept "As Low as Reasonably Practicable" (ALARP), taking into consideration social and economic factors. The use of maximum distance, minimum time and maximum barrier is a common practice in order to ensure optimization of radiation exposures; other ways are through quality assurance program which include reject film analysis and other quality

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control checks.[1,2,3,4] The aim of doing a reject film analysis is to ensure that optimally diagnostic images are produced with the use of the possible least radiation dose.[5]

Film reject analysis is a systematic quality control check performed in order to find out why repeat radiodiagnostic exposures are performed. When such repeat exposures are made, the patient and the radiographer are exposed to unnecessary radiation. Also, this tends to waste the patient's time and a delay in diagnosis leading to patient unsatisfaction.[6] This unnecessary repeat exposures result from poor image quality and has the potential of inducing radiobiological effects. The various reasons for poor image quality are; under-exposure, over-exposure, patient positioning, patient motion, artifact, machine fault and others.[4,6]

Despite the implication of the unnecessary radiation exposure received by the patient and the Radiographer, repeat exposures also carry some economic consequence by increasing the cost of the radiographic examination which may be shouldered by either the patient or the radio-diagnostic facility.[8]

The AAPM Imaging Physics Committee Task Group 151 recommend 5 % and 8% reject image rate target, and 7 % and 10% as a thres hold for pediatric and adult medical imaging examinations, respectively.[8] Beyond the threshold, the cause of the image reject must be investigated, and corrective measures taken. Other recommended repeat rate limits are; 5%, 10% and less than 5% but above 2% according to the world health organization (WHO), conference of radiographic control program directorates (CRCPDs) Committee on quality assurance and the Royal Australian college of radiologist (RACR).[9]

This study conducts a reject image analysis in computerized radiography (CR) generated x-ray images; and further evaluates the economic burden. However, this scrutiny does not under rate the numerous advantages of computerized radiography (CR) such as improved image quality, post-processing capabilities, cost savings, ease-of-use, fewer retakes and reduced radiation exposure.[6,10] Rather, it tends to find out the reasons for repeat in order to establish a local benchmark and take correction measures.

Method

The materials that aid in acquiring the radiographic images analyzed in this study are as follows: Philips PCR Eleva S-Hires image reader; model CR-IR368, SN 96521754, manufactured in May 2009 by Fujifilm Corporation, Tokyo, Japan. Console Advance Fuji Software, Microsoft SQL Server 2008. Different sizes of Fuji compatible image receptors (Sizes: 43 x 35cm, 24 x 30cm and 35 x 35cm). Shimadzu X-ray Machine, Model 1/2P13DK, Serial No. 83698, manufactured in 2008 by Shimadzu corporation, Japan. And Nortek X-ray machine; M125S20X Manufactured in 2013 by LUCEM Co. ltd in Korea

A retrospective study involving an audit of the radiographic images of a total of 1740 patients collected from January 2020 to March 2020 was performed by two senior radiographers. A chart was used to collect the data according to the causes of repeat exposures with respect to the anatomical body part examined. The various sources of repeat considered in this study include; exposure error, patient positioning, patient motion, image cut off, artifact, machine fault and others.

The overall reject image rate and that for the respective body regions was determined by using the formula below;

$$\text{Reject Image rate (RIR)} = \frac{\textit{Rejected images}}{\textit{Total images}} \times 100\%$$

Results

(Tab.1) shows the total number of radiographic examinations performed for the months of January to March 2020. The pelvis and chest have the least and the highest with 66 (3.79%)and 949 (54.54%), respectively.

(Fig.1) shows the radiographic examinations performed in the month of January 2020. The distribution according to anatomical body parts of the radiographic examinations performed in the month of January 2020 shows that chest radiography has the highest number of patients with 273 (51%) of the total examinations for the month. While radiography of the paranasal sinuses is the least with 12 (2%).

(Fig.2) shows radiographic examinations performed in the month of February 2020. The distribution according to anatomical body parts of the radiographic

examinations performed in the month of February 2020 shows that chest radiography has the highest number of patients with 322 (49%) of the total examinations for the month. While, skull radiography is the least with 12 (2%).

(Fig.3) shows the radiographic examinations performed in the month of March 2020. The distribution according to anatomical body parts of the radiographic examinations performed in the month of March 2020 shows that chest radiography consisting has the highest number of patients in January to March but the highest is recorded in March, 2020 with 354 (20%) of the total examinations for the months of January to March 2020.

(Fig.4) shows the distribution of radiography projections. The above figure compares the various radiographic examinations performed according to body anatomy for the months of January to March 2020. The most commonly radiographic examination is chest radiography from January to March, 2020. The second highest common radiographic examination is extremity radiography.

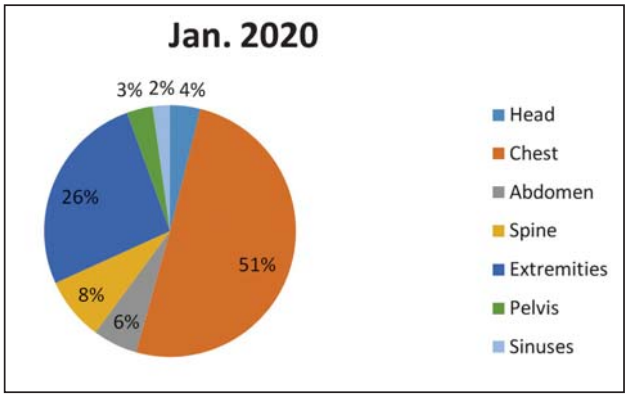

Figure 1: Radiographic examinations performed in the month of January 2020

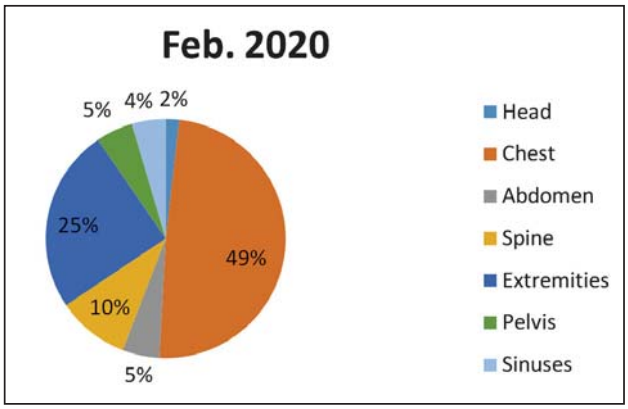

Figure 2: Radiographic examinations performed in the month of February 2020

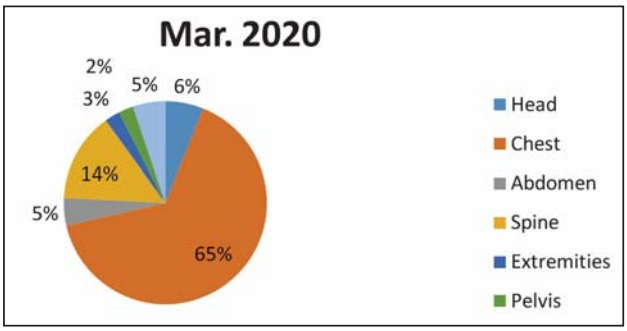

Figure 3: Radiographic examinations performed in the month of March 2020

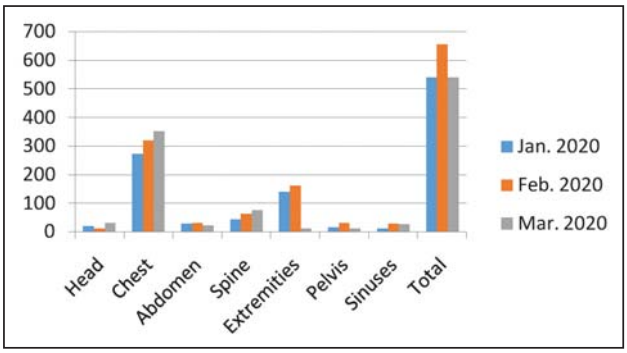

Figure 4: Distribution of radiography projections

(Tab.2) shows the rejected images for the month of January, 2020. Image cut off as reason for repeat exposure has the highest with 20 (3.70%) while exposure error and machine fault have the least with 2 (0.37%). The radiography of the para-nasal sinuses has the highest RIR with 25% while the extremities have least with 4.93%. Furthermore, the overall reject image rate for the month of January 2020 is 54 (9.98%).

(Tab.3) shows the rejected images for the month of February, 2020. Image cut off and patient positioning errors as reasons for repeat exposure have the highest with 22 (3.35%) each, respectively. Para-nasal sinuses and extremities also account for the highest and lowest RIR with 46.67% and 2.45%, respectively Exposure error accounts for the least RIR with 3%. The overall RIR for the month of February 2020 is 76 (11.57%).

(Tab.4) shows that image cut off as reasons for repeat has the highest with 22 (4.06%) while exposure error has the least with 1 (0.18%). Head radiography has

Date	Head	Chest	Abdomen	Spine	Extremities	Pelvis	Sinuses	Total
Jan. 2020	21(1.21%)	273(15.69%)	31(1.78%)	44(2.53%)	142(8.16%)	18(1.03%)	12(0.69%)	541(31.09%)
Feb. 2020	12(0.69%)	322(18.51%)	33(1.90%)	64(3.68%)	163(9.37%)	33(1.90%)	30(1.72%)	657(37.76%
Mar. 2020	33(1.90%)	354(20.34%)	24(1.38%)	77(4.43%)	13(0.75%)	13(0.75%)	28(1.61%)	542(31.15%)
Total	66(3.79%)	949(54.54%)	88(5.06%)	185(10.63%)	318(18.28%)	64(3.68%)	70(4.02%)	1740(100%)

Table 1: Total Radiographic Examinations from January to March 2020

Criteria	Head	Chest	Abdomen	Spine	Extremities	Pelvis	Sinuses	Total Rejected images
Image cut off	1	17	0	1	1	0	0	20(3.70%)
Exposure error	0	2	0	0	0	0	0	2(0.37%)
Patient Positioning	3	1	3	3	5	1	2	18(3.33%)
Patient motion	0	0	2	0	0	1	1	4(0.74%)
Artifact	1	2	0	0	1	1	0	5(0.92%)
Machine fault	0	0	0	2	0	0	0	2(0.37%)
Others	0	1	0	2	0	0	0	3(0.55%)
Reject image rate per body anatomy	5(23.81%)	23(8.42%)	5(16.13%)	8(18.18%)	7(4.93%)	3(16.67%)	3(25%)	**54(9.98%)**

Table 2: Rejected Images for January 2020

Criteria	Head	Chest	Abdomen	Spine	Extremities	Pelvis	Sinuses	Total Rejected images
Image cut off	0	16	0	3	1	2	0	22(3.35%)
Exposure error	0	1	0	1	1	0	0	3(0.46%)
Patient Positioning	2	2	0	5	1	2	10	22(3.35%)
Patient motion	0	2	0	0	0	0	0	2(0.30%)
Artifact	0	2	1	2	0	0	0	5(0.76%)
Machine fault	0	4	2	4	0	0	1	11(1.67%)
Others	0	7	0	0	1	0	3	11(1.67%)
Reject image rate per body anatomy	2(16.67%)	34(10.56%)	3(9.09%)	15(23.44%)	4(2.45%)	4(12.12%)	14(46.67%)	**76(11.57%)**

Table 3: Rejected Images for February 2020

Criteria	Head	Chest	Abdomen	Spine	Extremities	Pelvis	Sinuses	Total Rejected images
Image cut off	0	21	0	0	0	1	0	22(4.06%)
Exposure error	0	1	0	0	0	0	0	1(0.18%)
Patient Positioning	3	4	0	5	0	0	2	14(2.58%)
Patient motion	0	1	0	1	0	0	0	2(0.37%)
Artifact	0	1	0	1	0	0	0	2(0.37%)
Machine fault	0	1	0	1	0	0	0	2(0.37%)
Others	1	2	0	1	1	0	1	6(1.11%)
Reject image rate per body anatomy	4(12.12%)	31(8.76%)	0(0.00%)	9(11.69%)	1(7.69%)	1(7.69%)	3(10.71%)	**49(9.04%)**

Table 4: Rejected Images for March 2020

the highest repeat rate with 12.12% while abdominal radiography has the least with 0%. The overall reject image rate for the month of March, 2020 is 49 (9.04%).
(Tab.5) shows the rejected images from January to March, 2020. Image cut off as reasons for repeat has the overall highest with 64 (37.00%) while exposure error has the least with 6 (3.53%). Chest radiography has the highest RIR with 88 (51.76%) while pelvic radiography has the least with 7 (4.12%).
(Tab.6) compares the RIR for the months of January, February and March 2020. February has the highest RIR with 11.57% while March has the least with 9.04%. The overall RIR for January to March 2020 is 9.77%.

Criteria	Head	Chest	Abdomen	Spine	Extremities	Pelvis	Sinuses	Total Rejected images
Image cut off	1	54	0	4	2	3	0	64(37.00%)
Exposure error	0	4	0	1	1	0	0	6(3.53%)
Patient Positioning	8	7	3	13	6	2	6	45(26.5%)
Patient motion	0	3	2	1	0	1	1	8(4.70%)
Artifact	1	5	1	3	1	1	0	12(7.06%)
Machine fault	0	5	2	7	0	0	1	15(8.82%)
Others	1	10	0	3	2	0	4	20(11.76%)
Reject image rate per body anatomy	11(6.47%)	88(51.76%)	8(4.71%)	32(18.82%)	12(7.06%)	7(4.12%)	12(7.06%)	**170(100%)**

Table 5: Total Rejected Images for January to March 2020

Date	Rejected Images	Total Images	Rejected Image Rate
January, 2020	54	541	9.98%
February, 2020	76	657	11.57%
March, 2020	49	542	9.04%
Jan - Mar., 2020	170	1740	9.77%

Table 6: Reject Image Rate for January to March, 2020

Discussion

A total of 1740 patients from January to March, 2020 underwent radiographic examinations of the various anatomical parts of the body. Chest radiography followed by extremity radiography accounted for the highest and second highest radiographic examinations performed in the radio-diagnostic facility with 949 (54.54%) and 318 (18.28%) of the total number of radiographic examinations, respectively (Tab.1). This is similar to the findings of Owusu-Bahanene et al.,[7] Arbese et al.,[11] Osahon et al.,[12] Lin et al.[13] and Awad et al.[14] who reported chest as the common radiographic examination performed. The high frequency of chest radiography is not unassociated with the several organs it contains. This examination is not only performed when an individual is sick but it is also an essential part of medical fitness examination for the purpose of employment[15] and tertiary school admissions.
Image cut off and positioning error as reason for image reject account for the two top most frequent rejected images with 3.7% and 3.33%, 3.35% and 3.35% and 4.06% and 2.58% in the months of January, February and March 2020, respectively (Tab.2, 3 & 4). This is similar to findings of Atkinson et al6 and Rastegar et al[16] that reported positioning error and anatomy cut-off as the most frequent reasons for image rejection. Also, similar studies are by Andersenet al.[17] and Benza et al.[18] who reported that 77% and 63% of the rejected images were from positioning errors. However, Benza et al.[18] also reported exposure error as the second top reason for most reject with 24% reject rate which is in contrast with the present study. Other contrasting studies are; Essien et al.[9] reported that 42.2% film rejected were due to under exposure and 20.7% were due to over-exposure as top two most frequent and Osahon et al.[12] reported that the most frequent cause of film rejects was due to exposure factor (41.6%). Computerized radiography (CR) gives the advantage of image post processing especially contrast adjustments which tends to some extent correct problems of

exposure factor errors thereby reducing image reject rate.

Furthermore, the anatomical parts with the top two reject rates are; sinuses and head with 25% and 23% in January 2020 (Tab.2), sinuses and spine with 14% and 15% in February 2020 (Tab.3) and head and spine with 12.12% and 11.69% for March, 2020 (Tab.4). However, the chest radiography comprises the largest portion of the overall RIR with 88 (51%), followed by the spine with 32 (18.82%) (Tab.5).

The RIR for the months of January, February and March 2020 are 9.98%, 11.57% and 9.04% (Tab.6). From a total of 1740 patients (radiographic examinations) from January to March, 2020, an overall reject image rate of 9.77%. This value is within the recommended repeat limit of 10% by AAPM Imaging Physics Committee Task Group 151 and CRCPDs Committee on quality assurance but above the WHO and RACR recommended limits of 5%.[8,9] Osahon et al.[12] Benza et al.,[18] Joseph et al.,[19] have similar findings to the present study but in contrast with studies by Essien et al.[9] Andersenet al.,[17] Zewdu et al.[20] and Monfared et al.[21]

Conclusion

The overall RIR is 9.77%, though this is within the recommended limits of 10% by AAPM Imaging Physics Committee Task Group 151 and CRCPDs Committee on quality assurance, corrective measures should be taken in order to further improve quality assurance. Also, CPD to be undertaken regularly by the radiographers and Radiographer Assistants is recommended.

Implications for practice

The imaging services rendered by Radiographers are continuously monitored through quality control checks in order to achieve optimal diagnostic images. The reject image analysis as a quality control check shows areas of weaknesses as a result of repeat patient exposures. The corrective measures that would be taken after each reject image analysis would improve the quality of the radiographic images to be produced subsequently and reduce repeat. The RIR can be used as an indicator of the subject areas CPD should be undertaken.

Conflict of Interest

There is no conflict of interest either financial or personal that might have influenced the result of this research study.

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