ORIGINAL ARTICLE

QUALITY MANAGEMENT: A PANACEA FOR PATIENT RADIATION DOSE OPTIMIZATION IN RADIOLOGY

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ABSTRACT

Background: The usefulness of reject analysis in radiography is not in doubt but, it's role and relevance in image quality improvement and patient dose optimization has not been fully evaluated. Quality management has been identified as a vital component of the quality assurance programme which ensures that corrective actions are taken to achieve optimization of image quality and patient dose.

Objective: To evaluate the use of reject/repeat analysis in patient dose optimization.

Method: Daily record of the number of X-ray examinations and rejected films done by ten intern radiographers working in pairs of two, weekly, in an X-ray room at the radiology department, UPTH was collected and analyzed on weekly basis for 12weeks after which, training/instructions on how to improve on the quality of the radiographs was given concurrently as reject analysis was being conducted for another 12weeks consecutively. The reject rates for the two 12week periods were compared and tested for any significant difference, using the t-statistic for paired-difference.

Results: 4,299 radiographs were analyzed in this study out of which 475 (11.05%) were rejected. 2,093 were analyzed in the first 12week period, out of which 274 (13.09%) were rejected. In the second period, 2,206 were analyzed out of which 201(9.11%) were rejected. The difference is significant at 5% (p 0.05) level of significance.

Conclusion: Image quality and patient dose optimization can only be achieved through a functional quality assurance programme, which emphasizes quality control, quality management, and training and retraining of personnel.

Keywords: Quality management, quality control, quality assurance, detriment.

INTRODUCTION

The relevance and role of reject analysis in diagnostic radiology has not been fully evaluated. Works on the use of film reject/repeat analysis in patient radiation dose optimization, abound in the literature but, to what extent these analyses have impacted on image quality improvement and by extension patient radiation dose optimization has not received adequate coverage in the literature. Quality control programs including film reject/retake analysis occupies a prime place in radiology as efforts are made to ensure optimal quality of radiographs and optimal patient radiation dose. However, quality management, an important component of the quality assurance programme, is often times overlooked or not mentioned at all.

Reject analysis is a quality control procedure which involves measurement of performance levels with a view to determining the variance between measured and expected levels of performance. Quality management, on the other hand, involves the evaluation, co-ordination, liaison, and institution of corrective actions to ensure the accomplishment of the expected level of performance or desired objective. Quality control and quality management makes up quality assurance. Quality assurance is a concerted effort made to ensure consistency in image quality at a low cost and minimum radiation exposure of both patient and staff. Therefore, quality management is a very vital component of the quality assurance programme.

Radiographers' level of competence in terms of technique and positioning has been identified as the major cause of high rate of rejects/repeats. Watkinson et al[1] states that 70-80% of reject and repeat films were due to incorrect exposure and positioning errors. In Tabari and Garba[2], poor patient positioning accounted for 70% of the total repeats. Schandorf and Tetteh[3]; Zewdeneh, Teferi, and Admassie[4] came up with similar findings in their separate studies of reject/repeat analysis in Ghana and Ethiopia respectively. In a recent study, Waaler and Hofmann[5] noted that:

> The digital revolution in imaging seems to have reduced the percentage of image rejects/retakes from 1015 to 35 %.
> The major contribution to the decrease appears to be the dramatic reduction of incorrect exposures. At the same time, rejects/retakes due to lack of operator competence (positioning, etc.) are almost unchanged, or perhaps slightly increased (due to lack of proper technical competence).

Whereas reject analysis may be conducted to determine the level and causes of film wastage or as a quantitative index of a quality assurance programme, it is necessary to ensure that the analysis is sensitive to all the parameters which impact on the overall reject rate[1]. Reject/repeat analysis results, in themselves, cannot produce the desired outcome. They remain mere audits of sources of resource wastages and pointers to the sources of additional radiation exposure to the patient until they are utilized and managed by those concerned, in the expectation of achieving the desired outcome.

It was the purpose of this study to evaluate the use of reject/repeat analysis in patient radiation dose optimization and to underscore quality management as a means of guaranteeing optimization of image quality and patient radiation dose in Radiology.

MATERIALS AND METHODS

Daily record of the number of X-ray examinations and rejected films done by ten intern radiographers working in pairs of two, weekly, in an X-ray room equipped with GE Silhouette VR, a general purpose, static x-ray unit with automatic exposure timer was collected for a period of 24 weeks consecutively, between May and October, 2009 at the radiology department, University of Port Harcourt Teaching Hospital (UPTH). The data were analyzed on weekly basis for the first 12weeks after which, training/instructions on the corrective actions to take to achieve better quality radiographs was given concurrently as reject analysis was being conducted for another 12weeks consecutively. The reject rates for the two 12week periods were compared and tested for any significant difference, using the t-statistic for paired-difference. This was to assess the impact of training and supervision on film reject rates due to radiographer's fault (poor positioning and incorrect exposure factors) only. One diagnostic room was used for this study so as to afford the interns the opportunity of working with the same equipment and under the same condition. All exposed films were processed with Mediphot 903 automatic x-ray film processor.

DATA COLLECTION AND ANALYSIS

Tables were prepared by film size, type of examination and cause of reject. Daily recordings were compiled and analyzed on weekly basis. The reject rate was derived from simple percentage e.g. if the number of rejected radiographs is X and the number of good ones is Y then, reject rate =

$$\frac{X}{Y} \times 100\%$$

The analysis of data was done using SPSS16.0 statistical package. The decision criteria for the test of significance was to accept the null hypothesis, $H_0 : p_1 - p_2 = 0$ if the **t**- ratio obtained is less than the critical **t**- ratio for 11**df** at α = 5%(0.05) from the statistical table of **t**- ratios; 2-tailed test, where p_1 and p_2 are the reject rates for the two 12week periods respectively.

RESULTS

The total number of radiographs done, and rejects for the first and second 12 week periods are presented in table 1. During the first 12 week period, a total of 2,093 radiographs were taken and a total of 274, representing 13.09% were rejected. In the second 12 week period, when instructions on how to achieve the desired result was given before each rejected radiograph was repeated, a total of 2,206 radiographs were taken out of which 201, representing 9.11% were rejected. The SPSS output for the mean reject rates for the first and second periods are (13.0592 ±1.04002)% and (9.1067 ± 1.11079)% respectively. The overall mean reject rate for the 24 week period was (11.0829±2.2766)%.

Table 2 shows the reject rate per type of examination for the first and second 12 week periods. There was a general drop in the reject rates for all the examinations in the second period. Chest X-rays had the highest repeat rate of (13.64 1.40)% in the first period while pelvic x-rays had the least repeat rate of (3.75 ± 8.82)%. In the second period, pelvic x-rays also had the least repeat rate of (1.67±5.77)% while the extremities recorded the highest repeat rate of (10.24±4.19)%.

TABLE 1: WEEKLY RECORD OF THE NUMBER OF CASES DONE AND (REJECTS)

		TYPE OF EXAMINATION								
WEEK	Chest	Abd.	Pelvis	Skull/ Fac. S.	PNS	Neck/ PostNS	Spine	Extre-mities	TOTAL	Reject rate
1	120 (15)	5 (0)	4 (0)	13 (3)	3 (1)	5 (1)	15 (1)	22 (3)	187 (24)	12.83
2	121 (17)	3 (0)	3 (0)	15 (1)	5 (1)	2 (0)	13 (2)	18 (2)	180 (23)	12.78
3	96 (13)	11 (1)	1 (0)	13 (2)	2 (0)	3 (0)	14 (1)	20 (2)	160 (19)	11.88
4	131 (19)	1 (0)	0 (0)	14 (2)	6 (1)	11 (2)	18 (2)	11 (1)	192 (27)	14.06
5	119 (16)	4 (1)	1 (0)	14 (2)	4(0)	2 (0)	12 (1)	17 (3)	173 (23)	13.29
6	113 (15)	0 (0)	1 (0)	12 (1)	7 (2)	5 (1)	13 (2)	20 (4)	171 (25)	14.62
7	109 (13)	3 (0)	1 (0)	10 (2)	3 (0)	6 (1)	16 (1)	21 (3)	169 (20)	11.83
8	98 (13)	3 (0)	2 (0)	13(1)	1 (0)	0 (0)	17 (2)	22 (2)	156 (18)	11.54
9	104 (18)	0 (0)	5 (1)	11 (1)	7 (1)	9 (1)	15 (1)	23 (2)	174 (25)	14.37
10	124 (15)	6 (1)	4 (1)	12(1)	2(0)	4(1)	13 (2)	13 (1)	178 (22)	12.36
11	113 (16)	1 (0)	2 (0)	12 (2)	6 (1)	5 (1)	10 (0)	18 (2)	167 (22)	13.17
12	125 (17)	4 (1)	3 (0)	11 (2)	1 (0)	5 (1)	17 (2)	20 (3)	186 (26)	13.98
TOTAL	1373(187)	41 (4)	27(2)	150(20)	47(7)	57(9)	173(17)	225(28)	2093 (274)	
13	128 (14)	2 (0)	3 (0)	11(1)	3 (0)	5 (0)	13 (1)	19 (1)	184 (17)	9.24
14	142 (13)	3 (0)	5 (1)	13(2)	1 (0)	2 (0)	11 (1)	18 (3)	195 (20)	10.26
15	121 (10)	6(1)	1 (0)	9 (0)	7 (1)	5 (1)	14 (2)	20 (2)	183 (17)	9.29
16	111 (13)	4(1)	0 (0)	15 (2)	5 (1)	3 (0)	17 (2)	23 (1)	178 (20)	11.24
17	117 (11)	1 (0)	2 (0)	16 (2)	8 (0)	7 (1)	15 (1)	23 (4)	189 (19)	10.05
18	103 (9)	0 (0)	3 (0)	12 (1)	2 (0)	9 (2)	16 (1)	25 (2)	170 (15)	8.82
19	110 (12)	4 (0)	1 (0)	14 (1)	3 (0)	3 (0)	15 (1)	21 (2)	171 (16)	9.36
20	133 (10)	7 (0)	4 (0)	7 (0)	9 (1)	6 (0)	12 (2)	19 (2)	197 (15)	7.61
21	125 (12)	2 (0)	1 (0)	10 (0)	4 (0)	4 (0)	18 (1)	25 (3)	189 (16)	8.47
22	119 (9)	3 (0)	2 (0)	11 (0)	6 (1)	4 (1)	9 (0)	14 (1)	168 (12)	7.14
23	147 (12)	1 (0)	0 (0)	13 (1)	2 (0)	1 (0)	7 (1)	21 (3)	192 (17)	8.85
24	151 (11)	3 (1)	1 (0)	8 (2)	1 (0)	3 (1)	10 (1)	13 (1)	190 (17)	8.95
TOTAL	1507(136)	36(3)	23(1)	139(12)	51(4)	52(6)	157(14)	241(25)	2206 (201)	

Table 2: Reject Rates (in %) per type of examination

EXAM	1ST 12 WEEKS			2ND 12 WEEKS		
	Mean ±S D	MIN.	MAX.	Mean ±S D	MIN.	MAX.
Chest	13.64 1.40	11.93	17.31	9.10 1.47	7.28	11.71
Abdomen	6.31 10.15	0	25.00	6.25 11.85	0	33.33
Pelvis	3.75 8.82	0	25.00	1.67 5.77	0	20.00
Skull / facial bone	13.50 5.43	6.67	23.08	8.21 7.69	0	25.00
PNS	10.79 12.39	0	33.33	5.17 7.89	0	20.00
Neck / Post NS	12.58 9.81	0	25.00	9.57 12.56	0	33.33
space						
Spine	9.65 4.67	0	15.38	9.08 4.63	0	16.67
Extremities	12.28 3.86	7.69	20.00	10.24 4.19	4.35	17.39

Table 3 presents the percentage distribution of rejects according to reason.

The distribution shows that 49.64% and 27.36% of the rejected radiographs were due to poor positioning while 40.51% and 50.75% of the rejected radiographs were due to incorrect exposures in the first and second 12 week periods respectively. We want to note that in the second period particularly, the film processor performance dropped as the temperature regulator became erratic. Hence, we believe that quite a proportion of the radiographs rejected on account of being too dark or too light may have been the direct consequence of the variation in the automatic film processor performance.

Table 3: Percentage distribution of rejects according to reason

	1ST 12 WEEKS	2ND 12 WEEKS
Positioning	136 (49.64%)	55 (27.36%)
Too dark	59 (21.53%)	62 (30.85%)
Too light	52 (18.98%)	40 (19.90%)
Motional blurring	14 (5.11%)	13 (6.47%)
Processor	8 (2.92%)	27 (13.43%)
Equipment	0	0
Others (film handling, etc.)	5 (1.82%)	4 (1.99%)
Total	**274 (100%)**	**201 (100%)**

The test of significance for difference in the reject rates observed for the two periods showed that the difference is significant at p 0.05. The **t**- ratio at **df** 11 from the SPSS output is 10.663. This is greater than the critical **t**- ratio ($\mathbf{t}_{11,\,0.05}$) = 2.201. Hence, we reject the null hypothesis, H_0: $p_1 - p_2 = 0$.

DISCUSSION

Our findings on reject rates, and reasons for the rejects are in agreement with earlier studies reported in the literature but, our finding on the impact of training and supervision on reject rates reduction is quite revealing. We discovered that the study groups, made up of intern radiographers, have varying degree of challenges regarding the radiographic technique for skull, sinuses, post nasal space and extremities of babies in particular. For chest radiography, quite a number of them have problem of clearing the scapulae off the lungs fields. The test of significance showed that the reduction in the reject rate achieved was not coincidental but real thus, giving credence to training and supervision as a means of assuring image quality and patient dose optimization.

Training, which is a deliberate attempt to positively influence another's behaviour towards the accomplishment of a desired objective; and supervision, an activity concerned with controlling, directing, co-ordinating, evaluating and institution of corrective actions, where necessary, for the purpose of accomplishment of a desired objective, are components of quality management. Quality management is therefore vital for the success of a quality assurance programme.

The importance of quality management in a quality assurance programme cannot be overemphasized especially, as it concerns the institution of corrective actions. The result of a survey of image quality and patient dose in simple radiographic examination in Madagascar showed that "when corrective actions were taken in a quality assurance assessment, the image quality improved by up to 35% and patient dose reduction ranging from 2 - 82% were achieved6 ". However, some factors including inadequate staffing, non availability of quality control test gadgets and paucity of qualified and experienced radiographers and radiologists impact negatively on the implementation of quality assurance programmes, in Nigeria.

Radiographers generally, work under pressure as the patients to radiographer ratio is usually overwhelming in busy departments thus, giving room for avoidable errors of positioning and exposure factor selection. Often times, radiographers working under pressure hardly consider the impact of variation in the sensitivity of the recording medium on density when exposure factors are being selected or when phototimers are in use. Research has shown that phototimers, particularly when used with modern screens such as the rare earth screens, are responsible for about 50% of discarded films[7]. Also, inadequate staffing pose challenges to the establishment of an effective, functional, in-house quality assurance programme as there are no enough staff to constitute an independent quality assurance team. Staff who are stressed up, already, by heavy workload cannot function optimally as members of a quality assurance team.

Quality assurance programme is erroneously believed to be expensive because of the high cost involved in the procurement of quality control test gadgets and as a result, is not in place in many radiology departments in Nigeria. However, studies have shown that comparatively, the financial loss associated with reject/repeat radiographs far outweighs the cost of running a comprehensive quality assurance programme in a year[8]. Suffice it to say that the socio-economic cost of increased radiation dose to patient, staff and the public is even much higher. The detriment from annual radiation exposure has been quantified in monetary terms. Russell and Wrigley[9] stated that:

> The National Radiological Protection Board suggests taking as the value of the detriment from annual exposure of less than 0.05mSv as 3,000 Pounds(1985 value), the range of 0.05-0.5mSv 15,000 Pounds, and 75,000 Pounds in the 0.5-5mSv range. As most examinations lie in the middle range it is reasonable to cost the detriment from medical radiological examinations at 15,000 Pounds/mSv.

The mean absorbed dose for different radiological examinations has been published[10]. Using these values, the mean dose for the reject/repeat cases can be determined and, multiplying the mean dose by the cost of the detriment from medical radiological examinations will give the cost of the detriment from the reject/repeat cases.

CONCLUSION

The lack of concerted effort to rectify a problem implies a failure to recognize it. If corrective action would not be taken after a reject/repeat analysis then, the whole exercise is futile. It is my considered opinion that patient radiation dose optimization cannot be achieved without an effective quality assurance programme in place. A quality assurance programme can be said to be effective if, and only if, all its components (quality control and quality management) are implemented to the letter. Training, by way of seminars, continuous professional development programmes, and on-the-job instructions, is hereby recommended as a way of improving the radiographer's competence on the job. This is the only way a safe patient dose reduction, and sound resource management can be achieved. Otherwise, film reject analysis will remain just one of the numerous parameters for appraising the extent of quality compromise in radiography service delivery.

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