Direct digital radiograph. *Technicians role in obtaining good images*

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ABSTRACT

Objectives: To determine the rejected rate of direct digital radiography (DRs) in our hospital, benchmark it with other institutes, and explore the causes of rejection.

Methods: Data were collected between June 2012 and May 2013 at King Abdulaziz University Hospital, Jeddah, Kingdom of Saudi Arabia. The rejected analysis was registered in the system, which is a built in software. Reasons for rejection could not be deleted, and no further imaging is allowed for the same patient without reporting the reason for rejection. Reasons for rejection are predefined by the machine.

Results: Of 89,797 images that were acquired, 13,371 were rejected, with a rejection rate of 15%. Positioning errors were the main reason for rejection, followed by artifact 28.5%, and motion 17.1%. As for body parts pelvis, abdomen, spine, and knee were recorded as rejected with higher rates than the average.

Conclusion: This study has shown a number of unnecessary repeated imaging of patients. In addition, reject analysis in DR is proven to be an indicator for quality in imaging, the reasons of rejection that have high percentage for occurrence should be given more focus during patients scan.

Direct digital radiography (DR) is a relatively new imaging technique, and the new replacement for computed radiography (CR) in imaging. In 2011, King Abdulaziz University Hospital, Jeddah, Kingdom Saudi Arabia installed 6 DR machines in which 5 are in the Radiology Department and one in the Emergency Department of the hospital. Good quality images in radiography depend not only on the machine, but also on the radiographer.[1] Since the 1980's, the reject analysis in DR is considered a useful measure to evaluate the performance and training of a radiographer (a way for determining the ability to identify good image and any low quality images will be repeated at the request of the radiologist).[2,3] Reject analysis is the rate of images repeated for a patient for quality reasons. The World Health Organization (WHO) considers a Radiology Department of high quality only if they consistently provide dequate clinical information with the lowest cost and lowest radiation exposure.[4] Therefore, the reject analysis in DR is an important tool to measure the efficiency of a diagnostic Radiology Department with regards to optimizing the patient's dose and increasing the cost effectiveness.[5]

The rejected rates of the film based system varied between 2.1% and 33%, and it was correlated to the film condition, position errors, miscellaneous errors, and exposure errors,[2,6] thus, CR systems have been proven to lower the rejected rates to 5%.[2,7-9] The suppliers of DR claim that it reduces unnecessary repeat imaging, which results in reducing patient exposure to unnecessary radiation and increases the cost effectiveness as the DR transmits the image immediately to the viewing screen with no processing, saving time for patients and staff. In Anderson et al's study in 2011,[9] they reported a rejected rate of 12% after 3 months of audit from the installed DRs. The aim of the current study is to determine the rejected rate of DR systems in a large educational hospital over a longer period of time (12 months), reveal the main causes of rejection, and address a plan to reduce the reject rates.

Methods.

Direct digital imaging system and personnel. Related research were sourced in PubMed using the following keywords: direct digital imaging, reject rates in radiography, and quality in radiography. Data from the reject analysis were stored in the system and was collected over a period of 12 months between June 2012 and May 2013 from 6 Kodak DR Evolution machine (Kodak Dr-Evo, Rochester, USA) in King Abdulaziz University Hospital, Jeddah, Kingdom of Saudi Arabia. When the machines were installed, 19 technicians attended the training and then trained their remaining 8 staff. Technicians would rotate over the year to work on every machine.

The rejected analysis was registered in the system, which is Kodak installed software built into the machine. All rejected images were registered according to the radiographer's report. Reasons for rejection could not be deleted, and no repeat imaging were allowed for the same patient without reporting the reason for rejection. The possible reasons for rejection are predefined by the machine (**Table 1**).

Reasons for rejection. The system provides various reasons to reject in which the radiographer has to choose in order to repeat the image. Reasons for rejection are artifact, clipped anatomy, duplicate, motion, positioning error, technique, and test/service/blank.

Data collection and analysis. This is a retrospective study using the data collected monthly from all machines, but only analyzed at the end of the year. The inclusion criteria includes performed examinations on patients of all ages and both genders (including body parts) and the technicians who administered the exam. Although all exams were included in the calculations of the average rejected rate, only 14.3% over 500 were presented and used in the study.

The statistical analysis was carried out using the IBM SPSS Version 22 (SPSS Inc., Armonk, NY, USA), reject rates were calculated as an average over the 12 month period, descriptive values were used for comparison, the significance of comparison was calculated at $p<0.05$, and was considered significantly high compared with the average we calculated.

The sample does not fall under any aspect of the Helsinki declaration as it does not involve human experimentation in medicine.

Results. During the 12-month period, 89,797 images were collected. From all the machines in the Radiology and Emergency Department, 13,371 images were rejected, with a rejection rate of 14.9%. The monthly rejection rates ranged between 13.12% and 18.37%.

Reasons for rejection (**Table 1**) show that positioning errors are approximately one-third of rejected images. Other reasons include artifact and motion (**Table 1**). Significance of the reject rates of different body parts compared with the calculated average rejected rate was measured at $p<0.05$. All rejected rates higher than 16.33 were considered highly significant (**Figure 1**). The rejected rates varied for body parts between 6.4% for the foot and 25.8% for the pelvis. Pelvis, abdomen, spine, and knee recorded reject rates higher than the average. There was no correlation between the number of images taken for a certain body part and rejected rates obtained for the same part, thus, a high number of images of the organ did not mean that this will result a high reject rates. In addition to the previous reasons for repeating the scan images, the technician's experience and their skills were investigated. In this study, the technician experience had no influence on the rates of rejection. The radiographers had undergone training sessions upon machine installations. Other technicians who were not included in the training sessions were also trained (**Figure 2**).

Discussion. Reject analysis in DR is used as a quality indicator in imaging, and was used historically for film based and CR imaging systems. The current study is conducted on 6 DR machines with an average reject rate was 14.9%. This is significantly higher than the average reported by Anderson et al in 2012[9] ($p<0.05$). The system will not allow any removal of rejected images unless the reason is specified. It was stored in the picture archiving and communication system (PACs) and it cannot be removed afterwards.

Table 1 - Reasons for rejection of images in direct digital radiography among 13,371 images.

Reject reason	Rejected images	
	n	(%)
Artifact	3,805	(28.5)
Clipped anatomy	220	(1.7)
Duplicate	567	(4.2)
Motion	2,286	(17.1)
Other reason	33	(0.3)
Positioning error	4,134	(30.9)
Technique	2,166	(16.2)
Test/service/blank	160	(1.2)
Total	**13,371**	**(100.0)**

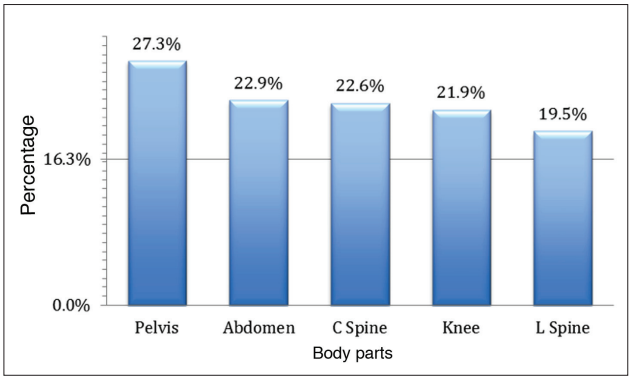

Figure 1 - Reject rates of images with regards to body parts. C - cervical, L - lumbar

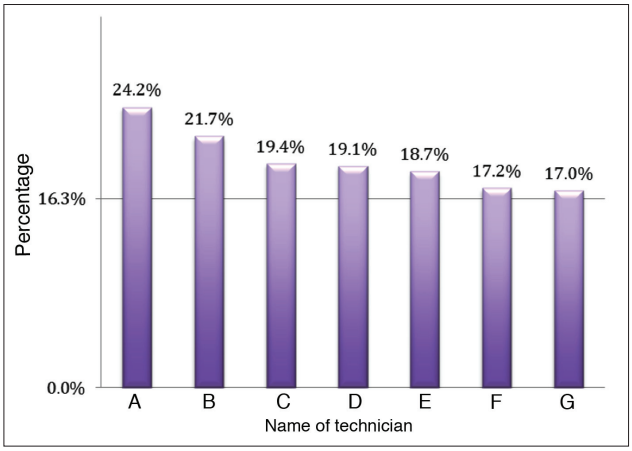

Figure 2 - Reject rates of images with regards to technician experience.

More than 89,000 images were involved in the current study, and the high number of used images provide more information in terms of auditing and monitoring radiographers performance. The rejected images are equivalent to 2 months of work for a single machine, which means that any reduction in the rejected rates will result in a rise in the cost effectiveness of the machine and the performance of the radiographers. Although, the reasons for rejection were slightly different from the study of Anderson et al;[9] however, the main reason for rejection was almost the same. Positioning error is also the main reason for rejecting images in CR systems according to the previous studies.[3,4] The technicians' experience and their skills had no influence on the rejected rates as DR is a new technique that was recently introduced. It is also possible that the radiographers to find it easy to repeat the images so they do not put a lot of effort into getting the required quality image the first time.[2] Comparisons with other types of machines, or within different settings, will result in more valued information with regards to the rate of rejection.

Study limitations. The results of this study could have been affected by the fact that the radiographer is the one who evaluated the image acquired and the reason for rejection, and that there is no audit for such issue as the machine will discard the rejected images as soon as the reject reason is selected.

In conclusion, DR a is relatively new technology that is supposed to eliminate any film errors and reduce repeated imaging. The reject rate for DR was 14.9% in our institute, which is higher than another study.[9] Positioning errors are responsible for one-third of the rejected images. High rejected rates were reported in pelvis, abdomen, and cervical spine imaging. Optimization requires alert in order to reduce unnecessary exposure of the patients to the technicians and to pay more attention on the positioning of the patients. The results obtained in this study will be part of the development plan for radiographers, especially in the orientation of new staff joining the department, and to raise awareness of the issue for radiographer performance.

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