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# Comparison of the perceived image quality between two digital imaging systems for neonatal bedside radiography – A case study

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ABSTRACT

*Background:* Chest X-rays are performed daily in the neonatal intensive care and high care units. The skill of the radiographer is critical for obtaining the best image quality and limiting the patient's radiation exposure. The literature states that indirect flat panel detectors produce images of superior quality in comparison to computed radiography systems. At Steve Biko Academic Hospital a decision was made to revert from the direct digital radiography (DR) system to the computed radiography (CR) system, due to poor image quality experienced.

*Method:* The case study objective was to conduct a comparative analysis describing key technical factors contributing to image quality. The analysis entailed retrospectively comparing the images obtained during 2010 and 2011. An image analysis form was utilised in evaluating the technical aspects of the image. A total of 160 images were viewed by 16 participants sampled from the radiography, radiology and paediatric departments. The participants were asked to re-evaluate two of their allotted images after five days to determine their reliability.

*Results:* Findings were that the DR system provides significantly better image quality than the CR system ($p < 0.05$) for all the technical factors evaluated. However technical improvements are recommended. A wide variance in intra-observer reliability was also found.

*Conclusion:* This case study demonstrated that DR images were considered to be superior to CR images. Recommendations include: a standardised technique for imaging the neonates; optimisation of the imaging software for the digital detectors, improved feedback systems in terms of exposure index values, and the training of radiographers and referring physicians in technical image analysis.



## Introduction

Chest X-rays are taken on a daily basis in the neonatal intensive care units (NICUs) and high care units (HCUs). Doctors rely on images of optimal quality to determine the diagnosis and to monitor the neonate's treatment. Research conducted confirms the importance of the relationship between image quality and radiation dose for radiographic investigations performed in the wards with the use of a mobile x-ray unit.[1–4] Comparisons between photostimulable phosphor (computed radiography (CR) imaging systems) and indirect flat panel detectors (IFPDs) have been made with regard to image quality and radiation dose.[1–4] Theoretically, the IFPDs should produce images of superior quality, as the detector quantum efficiency (DQE) and modulation transfer function (MTF) are superior to those of CR imaging systems.[1–4]

Steve Biko Academic Hospital (SBAH) is a tertiary academic institution situated in Pretoria, South Africa. This hospital serves as a referral hospital for most district and regional hospitals. The hospital manages a great variety of clinical conditions and also has operating theatres, intensive and high care units where mobile radiographic examinations are performed. Digital radiography using portable indirect flat panel detector technology was implemented in 2006. The assumption made by radiographers in this institution was that the introduction of digital imaging systems would aid in reducing the radiation dose to the neonates.[3] However, the overexposure in digital radiography is rewarded by high quality images, which then subjects neonates to high doses of radiation.[4] Failure to observe the exposure index values is one area that need to be drawn to the attention of the radiographers continuously, especially when imaging children, to aid in prevention of unnecessary higher exposure to radiation.

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Towards the end of 2010 a decision was made to revert to CR cassettes where 18 × 24 cm cassette size was used. The chief radiographers outlined a number of problems they had experienced with the DR system. The problems ranged from the size of the direct flat panel detector (35 × 43 cm) in relation to the incubators, the presence of severe image noise, and an image that was consistently of reduced brightness prior to post-processing. Prior to the images being uploaded onto the picture archiving and communication system (PACS), the images experienced a loss of resolution due to the automatic magnification, which could be attributed to the large detector size. There were also no standardised image quality criteria at SBAH, according to which the images are evaluated. No research was conducted in this department to establish the factors contributing to the deterioration of the image quality, however it was assumed to be the result of the use of the flat panel detectors.

This assumption, without scientific evidence, resulted in the department reverting to the use of CR system when performing bedside radiography on neonates. It should be noted that acceptability of image quality is not a set international standard.[5] The Commission of the European Communities (CEC) gives recommendations on image quality criteria and that each radiology department must establishes its own quality standards as part of their quality assurance.[5–7] Quality assurance is a joint effort by the radiographers, radiologists, referring doctors, medical physicists and technicians.[6,8]

The DR images were obtained by the use of the GE Definium 800 AMX digital mobile x-ray unit with permanent filtration of 1.3 aluminium equivalence, and a 32 kW generator. The CR system utilised was the Agfa NX 3.0.8300, and the same mobile unit was used to obtain the images for the DR and CR systems. Each mobile unit had technique charts and radiographers were encouraged to use these exposure factors to obtain the images.

The aim of the study was to compare the perceived quality of the neonatal chest images obtained with the CR and DR systems during bedside radiography at SBAH. The objective was to make the evaluation on technical image quality only, which includes factors such as brightness, contrast, penetration, noise and resolution. These technical factors were assessed to establish which factors contributed to the poor image quality experienced, and which system was superior.

## Materials and methods

Image quality produced by the two digital imaging systems was compared. The data collection instrument used for this study was a self-designed image analysis form. To ensure validity, this form was derived from the image analysis protocol set by Mcquillen-Martenson[9] as well as the standardised technique recommended by the Commission of the European Communities.[10] The designed image analysis form provided the participants with the imaging criteria to guide them during the evaluation sessions.

The data collection form consisted of a:

- Visual analogue scale (VAS) to determine the overall image quality. Six scales in the first section of the analysis form consisted of 100 mm lines with descriptors below the lines to indicate to the participants the ranges of acceptability. Each scale was preceded with a positive statement concerning technical image quality factors to be assessed (including density, contrast, resolution, penetration and noise). A key (seen in Fig. 1) provided an indication of the location of the ranges of acceptability on the scale. The descriptors included: unacceptable, suboptimal but acceptable, acceptable and optimal.

The ranges of acceptability were established in a pre-test conducted prior to the commencement of the study, as well as the use of literature.[5] The VAS was chosen as the receiver operating characteristic (ROC) curve has various criteria or categories, but does not allow one to choose in between the categories when one is unsure of an answer. The VAS allows the participant to overcome the uncertainty, as there are no specific criteria to choose from.[11,12] The methodology used was adopted from Balassy et al.[11] No post processing by manipulation of the image brightness or contrast was performed during the study. Participants were asked to rate the following technical qualities, which were posed as positive questions, on the VAS, namely; 1) overall image quality, 2) bony cortical outlines sharply defined, 3) soft tissue structures appear sharply defined, 4) brightness, 5) penetration sufficient to demonstrate the cortical outlines and 6) image contrast sufficient to demonstrate bony and soft tissue structures.

- An ordinal technical factor table listing five technical factors in the second section of the analysis form is presented in Table 1. The form presented guidance for the participants to indicate to which degree they perceived the image quality factors listed.

The researcher collected over 500 images from the PACS at SBAH that were taken during January to August 2010, and January to August 2011. The collected images were saved in the Joint Photographic Experts Group (JPEG) format. The collected images included normal chest images and images of a variety of disease states. The radiographers at that stage were not monitoring the exposure index values but relying on their subjectivity in analysing the quality of the images produced, a practice which should be discouraged.[13] The collected images were labelled with specific image codes, which made the DR and CR images discernable to the researchers only. They were then randomly grouped so that each participant could evaluate ten images given to them. The images were stored on compact discs (CD) that were not labelled, which ensured that the researcher could not know which group of images were selected by each participant.

The images were displayed on a computer monitor that is similar to the viewing computer monitors in SBAH – this was an NEC MultiSync LCD monitor (model: 1980 SXi), with 96 DPI and a resolution of 1280 × 1024. The brightness was set to 100% and the contrast to 50%, which are the same percentages as the computer monitors utilised in the various departments in SBAH are set at. The participants were then asked to return for a re-analysis session five days after the main analysis session (day 5). The re-analysis session was done so that they could re-analyse two images (one from each imaging system) previously analysed, to establish intra-reader reliability.

For this study convenience sampling was used, because the researchers used subjects that were available to participate in the research study.[14] A total of 16 participants were invited. They were

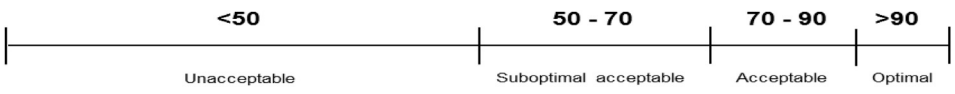


**Figure 1.** Visual analogue scale key.