# IMPLEMENTATION OF DIGITAL RADIOGRAPHY IN A NEONATAL INTENSIVE CARE UNIT. ASSESSING THE ROLE OF CLINICAL AUDITS IN AVOIDING UNNECESSARY PATIENT IMAGING AND RADIATION EXPOSURE

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**Abstract**

**Aim:** To investigate variations in radiation exposure after the implementation of digital radiography in a neonatal intensive care unit. **Methods:** The number of chest and abdominal portable exams obtained over years 2000-2004 versus 2006-2010 on infants of 1.00-1.50 kg were compared. Patient demographics and illness severity indicators were reviewed. Entrance surface doses were used as patient dose indicators. Imaging systems were conventional film/screen and portable flat detector respectively. Patient’s radiation exposure was estimated prior to and after the transition. **Results:** Accounting for variations in the patient’s burden of illness, there was a significant increase in the number of portable radiographs per patient (+8.1%, p=0.0009). The X ray system, techniques and geometry factors were identical. Thus, radiation exposure per image and total exposure may be assumed to be the same and proportional to the number of images. **Conclusions:** Transition to digital radiology may reduce patient dose from portable exams. However, proactive strategies are required during this transition to avoid unnecessary exposures. Clinical audits and referral criteria guidelines should be stressed in order to avoid an unnecessary increase in the number of images and radiation exposure.

## 1. INTRODUCTION

Conventional film/screen radiography has been nearly completely replaced by digital imaging. Digital technology has multiple advantages. It allows less patient exposure, has faster direct readout, immediate availability of images, easy numerical processing, electronic archiving and transmission. It also the ability to reduce retakes due to improper technique and the potential to decrease radiation dose per exposure.

On the other hand, digital radiology may have some disadvantages. It decreases clinician–radiologist interactions. Multiple exposures can be obtained and visualized in the span of a few seconds. Non useful images may be easily deleted. The wide dynamic range may lead to significant radiation overexposure with no impact on the image quality.

Systematic review of radiological procedures, awareness and appropriateness are considered the basic approaches to assure quality and reduce unnecessary radiation exposure [1].

## 2. MATERIAL AND METHODS

Institutional review board approval was granted. A query was performed to identify all 1.00-1.50 kg birth weight Neonatal Intensive Care Unit (NICU) admissions during the 2000-2004 and 2006-2010 time periods. This population was chosen to limit any potential bias due to change in attitudes and treatment methodology.

The number of portable chest and abdominal radiographs was reviewed; demographic data, relevant clinical history and illness severity indicators were collected.

A comparison of the number of exams over the years 2000-2004 (pre-digital era) versus 2006-10 (digital era) was made using log-linear model. An adjusted analysis (intended to account for differences in number of examinations performed related to variations in the patient's burden of illness) was performed.

A comparison was made of patients' demographics and patient illness indicators using Fisher's Exact for binary data, and t-test for continuous data. Transition from conventional radiography (Kodak films and rare earth Lanex screens, 400 speed; Rochester, NY) to digital radiography (portable flat detector Canon Lanmix-50 G; Mississauga, ON) occurred in July 2005 and thus studies performed in 2005 were not included. The X ray system was a GE AMX 4 (Waukesha, WI). Radiographic techniques used in both periods were the same. Entrance surface air doses were calculated from the experimental measurement of the X ray tube output, radiographic techniques (kV and mAs) and focus to skin distances.

## 3. RESULTS

Entrance surface dose for the radiographic techniques and geometry used in the pre-digital and digital periods were estimated (Table 1).

TABLE I. INITIAL RADIOGRAPHIC TECHNIQUES USED IN BOTH PERIODS (PRE-DIGITAL AND DIGITAL ERAS).

| Procedure | kV | mAs | Distance focus-image detector (inches/cm) | Calculated entrance surface dose in microGy |
|---|---|---|---|---|
| Chest AP | 62 | 1.25 | 27/68.5 | 130 |
| Chest LAT (cross table) | 66 | 2.0 | 40/101.6 | 123 |
| Abdomen AP | 62 | 1.5 | 27/68.5 | 156 |
| Abdomen LAT (cross table) | 66 | 2.5 | 40/101.6 | 154 |

AP: antero-posterior. Lat: lateral. kV: kilovolts. mAs: milliampere second.

Statistically significant illness severity indicators changes over the two time periods were: gastrointestinal perforation, surgery for NEC and length of stay ($p<0.5$) (Table 2).

TABLE II. ILLNESS SEVERITY INDICATORS.

| | Conventional radiography era (2000-2004), N=272<br>n (%) | Digital radiography era (2006-2010), N=268<br>n (%) | p-value |
|---|---|---|---|
| RDS | 177 (65.1%) | 154 (57.5%) | 0.0690 |
| GI perforation* | 6 (2.2%) | 18 (6.7%) | **0.0110*** |
| Pneumothorax | 10 (3.7%) | 17 (6.3%) | 0.1550 |
| NEC | 15 (5.5%) | 27 (10.1%) | 0.0480 |
| Surgery for NEC* | 8 (2.9%) | 18 (6.7%) | **0.0400*** |
| Sepsis (onset > day 7) | 35 (12.9%) | 48 (17.9%) | 0.1040 |
| Mortality | 30 (11.0%) | 21 (7.8%) | 0.2050 |
| Length of stay (days, mean $\pm$SD)* | 40.5 $\pm$ 27.2 | 47.5 $\pm$ 28.3 | **0.0040*** |
| Mechanical ventilation (days, mean/median $\pm$SD) | 5$\pm$17 | 3$\pm$ 16 | 0.0720 |

RDS: respiratory distress syndrome. I: gastrointestinal. NEC: necrotizing enterocolitis. SD: standard deviation.
*Statistically significant illness severity indicators.

The average number of radiographs per patient for both time periods, and the percentage difference between 2000-2004 and 2006-2010 were calculated. When the analysis was performed after adjusting for changes in illness severity indicators, the total number of examinations also increased by 8.1% ($p=0.0009$) (Table 3).

TABLE III. AVERAGE NUMBER OF EXAMS PER PATIENT FOR YEARS 2000-2004 AND 2006-2010, AND % CHANGE.

| Exam | Average number of exams/Pt | | | 95% Confidence interval | p-value |
|---|---|---|---|---|---|
| | 2000-2004 | 2006-2010 | Change 2000-4 to 2006-10 | | |
| Total (combined chest and abdomen) | 22.20 | 24.01 | +8.1% | (+3.3%,+13.2%) | 0.0009 |

Covariates: Ventilation days; gastrointestinal perforation; respiratory distress syndrome; pneumothorax; necrotizing enterocolitis; necrotizing enterocolitis surgery; length of stay; death and late sepsis.

## 4. DISCUSSION

Digital radiography can reduce the number of repetitions due to improper settings [2] and technique, but it can also lead to significant radiation overexposure unrecognized by technologists and radiologists [3].

The ICRP and the IAEA recommend frequent patient dose quality control audits when new digital imaging techniques are implemented, in order to avoid unnecessary radiation and to assure adequate image quality [4, 5].

Frequent patient dose audits have proven to be useful in order to optimize radiation dose when digital imaging techniques are implemented [6, 7]. Our results show that the combined average number of portable chest and abdomen examinations increased by 8.1 % with the corresponding increase in patient dose.

Regarding patient dose (reported as entrance surface air dose), the radiographic techniques used after the transition to digital technology have the potential to be reduced. As a consequence of the current results, we have adjusted our radiographic techniques and reduced incident dose. We are also evaluating resulting image quality with the new technique.

## 5. CONCLUSIONS:

The total number of portable radiography images per patient in our NICU has increased during the transition to digital radiography. Transition to digital radiology may reduce patient dose from portable exams. However, proactive strategies are required during this transition to avoid unnecessary exposures. Clinical audits and referral criteria guidelines should be emphasized in order to avoid an unnecessary increase of the number of images and radiation exposure.

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