NEONATAL CHEST RADIOGRAPHY - COMPARING IMAGE QUALITY AND DOSE FOR CONTACT-TECHNIQUES VS. UNDER-TRAY TECHNIQUES

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Abstract

Chest radiography is the primary and most important diagnostic study in the evaluation of neonates, due to life threating conditions. Neonatal chest images can be made using either contact-techniques or under-tray techniques, which one is superior in respect to doses and image quality? A range of exposure settings were made using a neonate phantom, and the same settings also for spatial resolution measurements. Visual scores were rated for spatial resolution tests, and for clinical phantom images rating present and absent pneumothorax. Entrance surface dose were below the European guidelines for certain exposure settings. The higher the dose, the less are images degraded by noise. The range of kV which is appropriate for the neonates is yet to be determined, though. The quality of the whole imaging chain interacts in a decision. Noise should be lowered whenever possible. Visual scores among two readers were close to each other's, both in spatial resolution, and also in correct diagnostics in relation to noise magnitude, however 1/3 of the images illustrating pneumothorax were ignored. Exposure settings should probably not be equal for the contact and under-tray techniques. There were a tiny decrease in sharpness combined with an increased noise (average 20%) noted in the radiographs obtained from the under tray techniques compared with the contact techniques. Contact techniques were found being superior.

Keywords*:* chest x-ray, neonate, entrance surface dose, ESD, neonatal chest phantom, noise, pediatric x-ray, sharpness

Introduction

Diagnostic radiology plays an important role in the assessment and treatment of neonates requiring intensive care, due to lung diseases; mainly respiratory distress symptom (RDS) that represent a life threatening conditions in the neonates (Moghadam Shahri, 2014).

Chest radiography is the primary and most important diagnostic study in the evaluation of neonates. Neonates may have to go through many chest radiographs before they are discharged from the hospital. In addition, neonates are far more susceptible and vulnerable to the effects of radiation than adults. Special attention should be given to neonatal imaging since doses during childhood results in increased risk of cancers. Therefore it is important to ensure that radiation doses from radiographic examinations are to be kept to the minimum whilst maintaining the quality of radiographic images (Armpilia, 2002).

In radiology, the outcome measure of the quality of an examination is its usefulness in determining an accurate diagnosis. Noise is inherent in imaging systems. Noise adds a random or stochastic component to s the grey levels of an image. Lower noise level results in better radiographic image because it improves contrast resolution, but normally at the cost of a higher patient dose. (Armpilia, 2002) Our aim is to use the X-ray beam efficiently, producing the best possible image with good resolution and low noise with a dose reasonable to the patient. The balance between patient dose and noise is the most challenging task in optimisation.

The resolution or resolving power of a system is a measure of its proficiency at revealing fine details. Resolution usually refers specifically to the system's ability to determine that small, high contrast objects situated close to one another are, in fact, spatially separate. Resolution is commonly measured by means of a test pattern composed of narrow stripes and reported in terms of the number of line pairs per millimetre (lp/mm) that can just barely be distinguished in the image (Wolbarst, 2005).

There are two distinctly different techniques of where to place the detector during the exposure of the neonates. The direct contact technique is to lift the baby and place the detector directly beneath the baby in the incubator. However; nowadays, many modern incubators are incorporated with a tray beneath the bed, in which the detector can be placed without the need to disturb the baby, termed as the under-tray technique. However, concern has been raised on the use of under tray technique, that it affects the radiation dose and quality in the negative way (Slade, 2005). In this study we aimed to compare the dose and image quality of neonatal chest radiographs taken using direct contact technique with those taken using under tray technique.

Absorbed dose

The absorbed dose (D) is the basic physical dose quantity and is used for all types of ionizing radiation and any irradiation geometry. It is defined as the quotient of $d\bar{E}$ by dm, where $d\bar{E}$ is the mean energy imparted to matter of mass, and dm by ionizing radiation. The SI unit of absorbed dose is J kg^{-1} and its special name is gray (Gy) (ICRP,2007).

$$D = d\bar{E}/dm$$

Entrance surface dose

Entrance surface dose (ESD) is the absorbed dose including the contribution from backscatter, which is measured at the entrance surface of a specified object. The unit of ESD is J kg^{-1} and its special name is gray (Gy) (Smans,2009).

Effective dose

Effective dose (E) is considered the most appropriate quantity for estimating the stochastic risk of exposure to ionizing radiation and can be of value for comparing the relative doses from different diagnostic procedures and for comparing the use of similar technologies and procedures in different hospitals and countries as well as the use of different technologies for the same medical examination.
The effective dose introduced in ICRP 60 is defined as the weighted sum of tissue equivalent doses. The SI unit of effective dose is J kg^{-1} and its special name is Sievert (Sv) (ICRP, 2007).

$$E = \sum wR \ . \ \sum wT \ . \ DTR$$

E is Effective dose. wR is the radiation weighting factor (wR = 1 for photons). wT is the tissue weighting factor for tissue T and $\sum$ wT = 1 and D_{TR} is the mean absorbed dose for tissue or organ T due to radiation R.

Tissue	w_T	$\sum w_T$
Bone-marrow (red), Colon, Lung, Stomach, Breast, Remainder tissues*	0.12	0.72
Gonads	0.08	0.08
Bladder, esophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04
	Total	1

Table 1: Recommended tissue weighting factors from ICRP, 2007. Remaining tissues are adrenals, extra-thoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate, small intestine, spleen, thymus, uterus/cervix.

Radiation sensitivity

While using digital detectors, radiation dose can increase markedly without any detectable change in the final image, therefore exposures greater than desirable may be used without being recognised. This is particularly important in case of neonates, as they often receive multiple exposures during their stay in the hospital. They are more sensitive to the effects of radiation than adults. This is because of highly mitotic state of their cells as radiation sensitivity of tissue is directly proportional to how quickly the cells in the tissue are divided. Moreover, the small body size of new-borns brings the sensitive organs like breast, thyroid, gonads, and a large fraction of blood forming red bone marrow within or closer to the irradiated area result in higher effective dose than may be case with the adult. Furthermore because of the longer life expectancy of neonates, there is a longer period for potential expression of delayed detrimental radiation related effect such as cancer especially leukaemia (Lowe, 1999). The use of ionizing radiation on neonates is indisputable as long as the examination is absolutely justified and in accordance with the principle as low as reasonably achievable (ALARA). However, the balance between patient dose and noise is the most challenging task in optimisation. The dose should not be reduced to a level below diagnostic values.

The Commission of the European Communities (CEC) quality criteria for diagnostic radiographic image in paediatrics suggests that best technique for a new-born AP (anterior posterior) chest radiograph is 60-65 kVp, 80-100 cm focus-image distance and additional filtration of 1mm Al + 0.1 mm Cu or similar materials. The CEC also provides a reference of 80µGy ESD for an AP chest examination of a neonate of 1000 g (European guidelines, 1996). In addition to the CEC reference dose, there have been a number of studies that have assessed neonatal dose, and ESD values have been reported to lie between 44µGy and 92µGy. These doses were assessed at tube potential ranging from 46kVp to 61kVp, with the lower ESD generally being observed at the higher tube potentials (Bushong, 2008).

Image quality

Image quality is a capacious term which can mean different things to different people. All have an interest nonetheless in keeping the patient's absorbed dose as low as reasonably achievable. For instance, a radiologist when viewing a radiograph may be interested primarily in the diagnostic value of an image. A radiographer may focus on how well the image represents the anatomy, and a medical physicist may be interested in the physical objective measures of image contrast, resolution and noise which can be used to compare the performance of different exposure techniques. Image quality is a combination of spatial resolution and contrast resolution, whereas the spatial resolution normally degrades by noise. Both are degraded since contrast resolution also depends on noise. Spatial resolution is the ability of an imaging system to discriminate between two adjacent high-contrast objects. Spatial resolution can be expressed by the number of line pairs per mm that is viewed. If the number is higher smaller objects and sharp edges can be imaged. Figures 1 A and B are both schematic illustrations on geometrical (spatial) resolution.

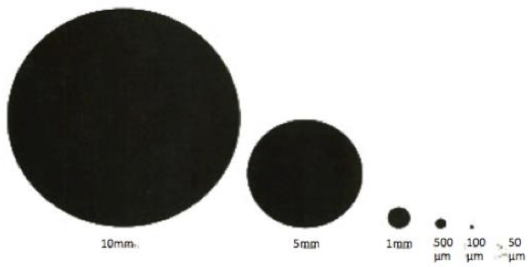

Figure 1a: *Schematic illustration on spatial resolution. Five dots range, from the largest size 10 mm to smallest, 50 µm. Some people are able to observe objects as small as 200 µm, thereby the spatial resolution of the eye can be described being equal to 200 µm.*

Noise

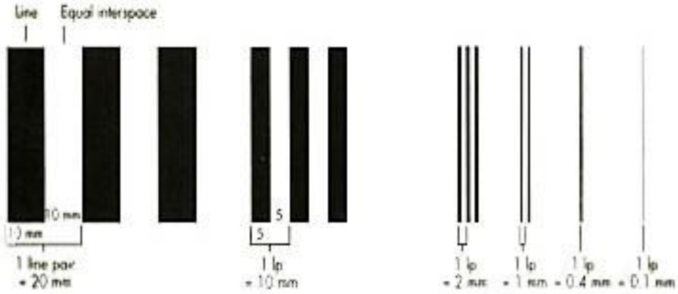

Figure 1b: *added to an interspace of equal width as the line. Units are line-pairs per millimetre; lp/mm. Spatial frequency does not refer to size but to a line pair on a white background. One line pair consists of a line and an interspace of the same width as the line. The unit of spatial frequency in medical imaging is line pair per milimetre (lp/mm).*

Radiographic noise is one of the fundamental parameters describing radiographic image quality. The presence of noise gives an image a mottled, grainy, textured or snowy appearance. There are number of factors that contribute to radiographic noise like structure mottle, quantum mottle and scatter radiation. Structure mottle refers to the size and shape inherent of the image receptor; which are not under the control of the radiographer; however, mottle contributes very little to the radiographic noise (Tapiovara, 2008).

Quantum mottle is the second factor of noise; somewhat under control of radiographer and is a principle contributor to radiographic noise in most radiographic imaging procedures. Quantum mottle refers to the random nature by which X-ray interacts with the image receptors. If an image is produced with just a few X-rays, the image obtained will be mottled or blotchy i.e. quantum mottle will be higher than if the image is formed from a large number of X-rays and the image obtained will be smooth (Tapiovara, 2008). So the challenge with all the X-ray imaging is to deliver good resolution, little noise and good low contrast. It seems we must always compromise. In X-ray imaging the primary compromise is between patient exposure and dose.

Scattered radiation is the third factor of noise, and a main cause for degraded image quality in projection imaging, as it decreases the image contrast and contrast-to-noise ratio (CNR) for the object being detected or visualized (Liua, 2007). Thereby, air-gap or grids are used. The energy of scattered radiation varies, and so also its influence on image quality.

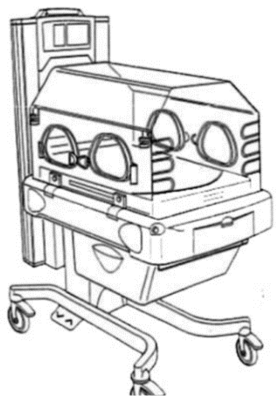

Figure 2*: Neonatal incubator. Type; Giraffe Omnibed, GE Healthcare*

In digital radiography excessive quantum noise is a potential problem because it is possible to produce images with low exposures that will still look good as far as contrast is concerned. In digital images though, the contrast still looks good even if the noise is high. Therefore it is important to use an appropriate exposure for every case. An optimum exposure is one that produces an image with an acceptable noise level without unnecessary or excessive exposure to the patient (Sprawls, 2015).

Research question

What are the differences with respect to dose and image quality, among the two techniques of placing the receptor; the direct contact technique and the under-tray technique?

Methods and materials

The mobile unit and x-ray tube

A mobile X-ray unit (Shimadzu Corporation, Japan) manufactured in 2011, was used for all exposures. All radiographic exposures were performed with added filtration 1.5 aluminium (Al) at 70 kV, maximum operating at 150 kVp, collimator type R20C, tube focus 0.7/1.3 mm.
The receptor used was a Canon wireless portable detector (CXDI-80C).

Figure 3A: *The Chest Phantom shows the lung structures and two lungs different with respect to clinical features.*

Incubator

An incubator, Giraffe Omnibed, GE Healthcare, Figure 2, was used for the study. Inside, a standard nest of thin textiles were included for the image quality study, as they were normally used.

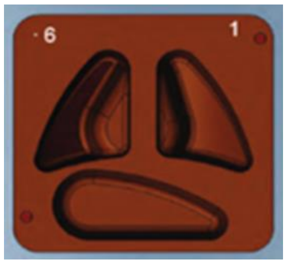

Figure 3B:*The torso consists of two parts, the removable top slice is designed to move or change the lung.*

Phantom mimicking neonate

The anthropomorphic neonatal chest phantom (Model 610, Gammex-RMI LTD) is shown in figures 3 A-E. The neonatal chest phantom is designed for testing of the entire imaging chain, for routine quality assurance of computed and digital radiography systems. The phantom mimics a 1kg to 2kg neonate in its transmission characteristics, physical size and anatomical structures. The phantom is constructed with a normal lung and with structures mimicking infant respiratory distress syndrome (RDS), with and without pneumothorax.

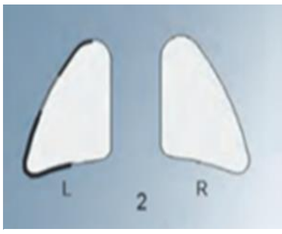

Figure 3C: *Hyaline membrane disease* (equal to respiratory distress syndrome) Lung, L: with pneumothorax R: without pneumothorax*

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Positioning, for contact-techniques and under-tray techniques

Radiographs were made in a constant focus to detector distance, 100 cm in both situations, i.e. detector directly beneath the phantom (contact-technique) shown in figure 4, and detector in the under-tray technique, shown in figure 5.

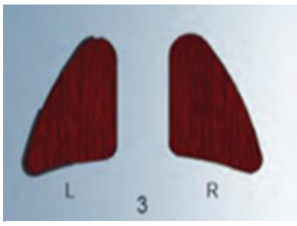

Figure 3D: *Non-disease "normal lung"; L: with pneumothorax, R: without pneumothorax.*

Figur 3E: *No. 4: Bronchial tree. No. 5: Skeletal structures*

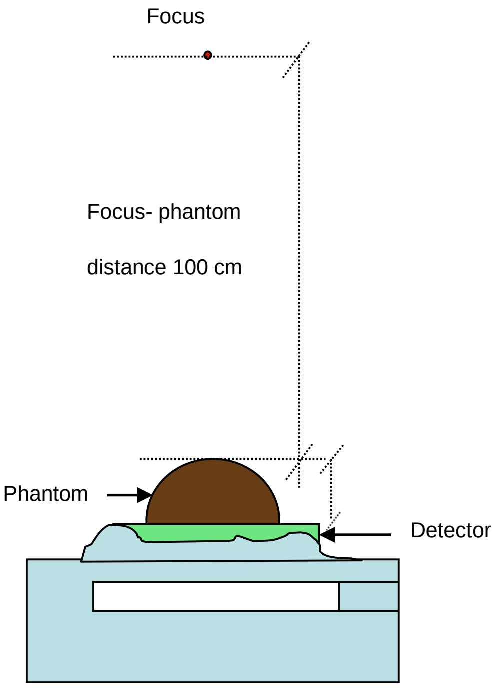

Figure 4: *Schematic diagram illustrating the contact-technique, with the detector positioned directly under the phantom*

Image production for dose measurements and for visual tests

A total of 112 radiographs were made for the study. Images were made by using the various exposure settings as follows; kV settings were 40, 45, 50, 55, 60, 65, 70, 75, and 90. For each kV, eight mAs settings were used; respectively 0.32, 0.45, 0.63, 0.9, 1.2, 1.8, 2.5 and 3.2 mAs. All exposures were made in two conditions; a) the contact techniques, and b) the under tray techniques.

Entrance surface dose

Entrance surface dose (ESD) was measured for each exposure using a RaySafe Xi (Unfors RaySafe AB, Sweden), which is a complete system for multipara meter measurements on all X-ray modalities. The system was placed just above the phantom (Figure 6). The ESD values were then plotted in the excel sheet. The noise was measured in the very same location on all images, illustrated in table 3.

Noise measurements

From each of the collected 112 radiographs, the noise (standard deviation) was calculated by using the ImageJ, an Image Processing and Analysing software for JAVA (WayneRasband, http://imagej.nih.gov/ij/). The data obtained was entered in the Excel sheet for analysis.

The region of interest (ROI) was at the same size and placed on the same spot for all radiographs (figure 7). The data obtained was entered in the Excel sheet for analysis

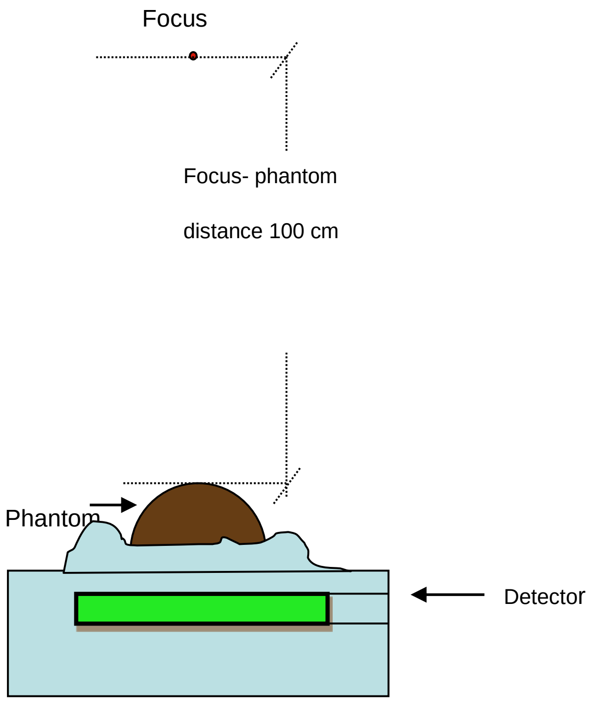

Figure 5: *Schematic diagram illustrating the under.tray technique, with the detector in the position directly under the phantom, at similar geometry ad for contact-techniqe.*

Visual image reading tests of clinical features

Two consultant radiologists reviewed the images independently, unaware of how the exposure techniques were made. Certain diagnostic criteria were used to evaluate the images such as visibility of pneumothorax and respiratory distress syndrome. Those results were also entered into an Excel sheet for analysis.

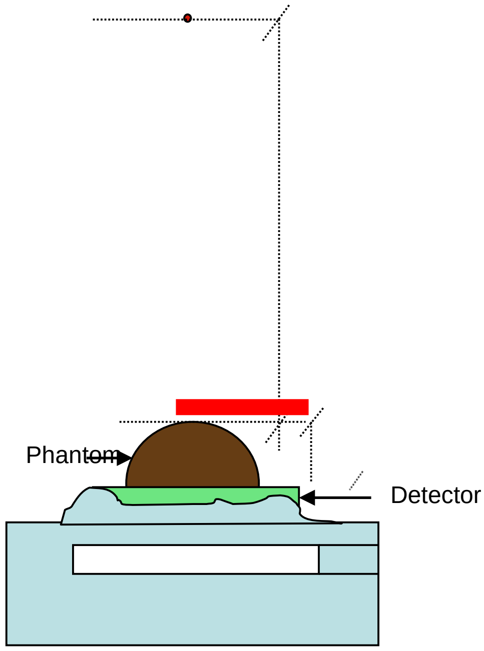

Figure 6*: Localization for the RaySafe Xi tool (the red area), for measurements of entrance doses.*

Spatial resolution test

The second part of the project dealt with assessing the geometrical resolution of the images. For this purpose the test phantom named ETR-1 testplatte from Wellhoffer Dosimetrie, Schwarenbruck, Germany (figure 8) was used.

It is a multipurpose test tool. It contained a test pattern composed of narrow stripes of lead, for to measure the geometrical resolution. The test pattern had 20 line pairs in the range of 0.6 lp/mm to 5.0 lp/mm.

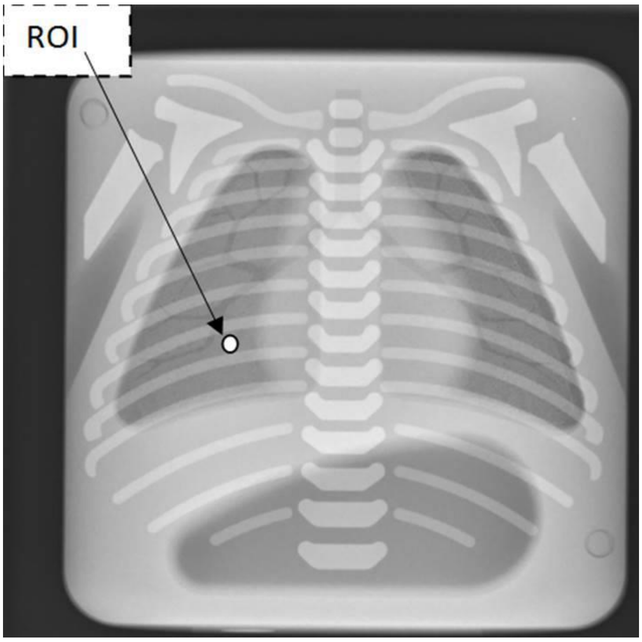

***Figure 7**: The point for measurements of region of interest for noise levels*

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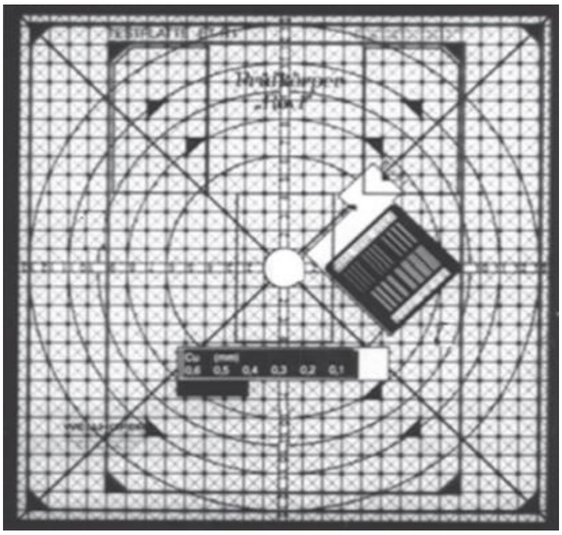

***Figure 8**: Geometrical resolution test tool. ETR-1 testplate. Wellhoffer Dosimetrie, Schwarenbruck, Germany*

ETR-1 was exposed by laying the test pattern in the two positions; i.e. detector position 1 (the test pattern directly upon the phantom whereas the detector was under the phantom, inside the incubator) and thereafter detector position 2, with the test pattern upon the phantom whereas the detector was in the tray. All the radiographs were scored at the very same monitor, under the same light and other standardized conditions. By using software Image J, the number of line pairs per millimetre were visually scored by the two researchers, recorded and plotted in an excel sheet.

Results

Entrance surface dose

Dose range 3.25 –227.2 µGy was obtained with the lowest setting 40kV and 0.32 mAs, up to the highest setting 90 kV and 3.2 mAs, respectively; shown in table 2. Entrance Surface Doses (ESD) has been plotted against selected mAs (range 0.32- 3,2) for the various kV (range 40-90).

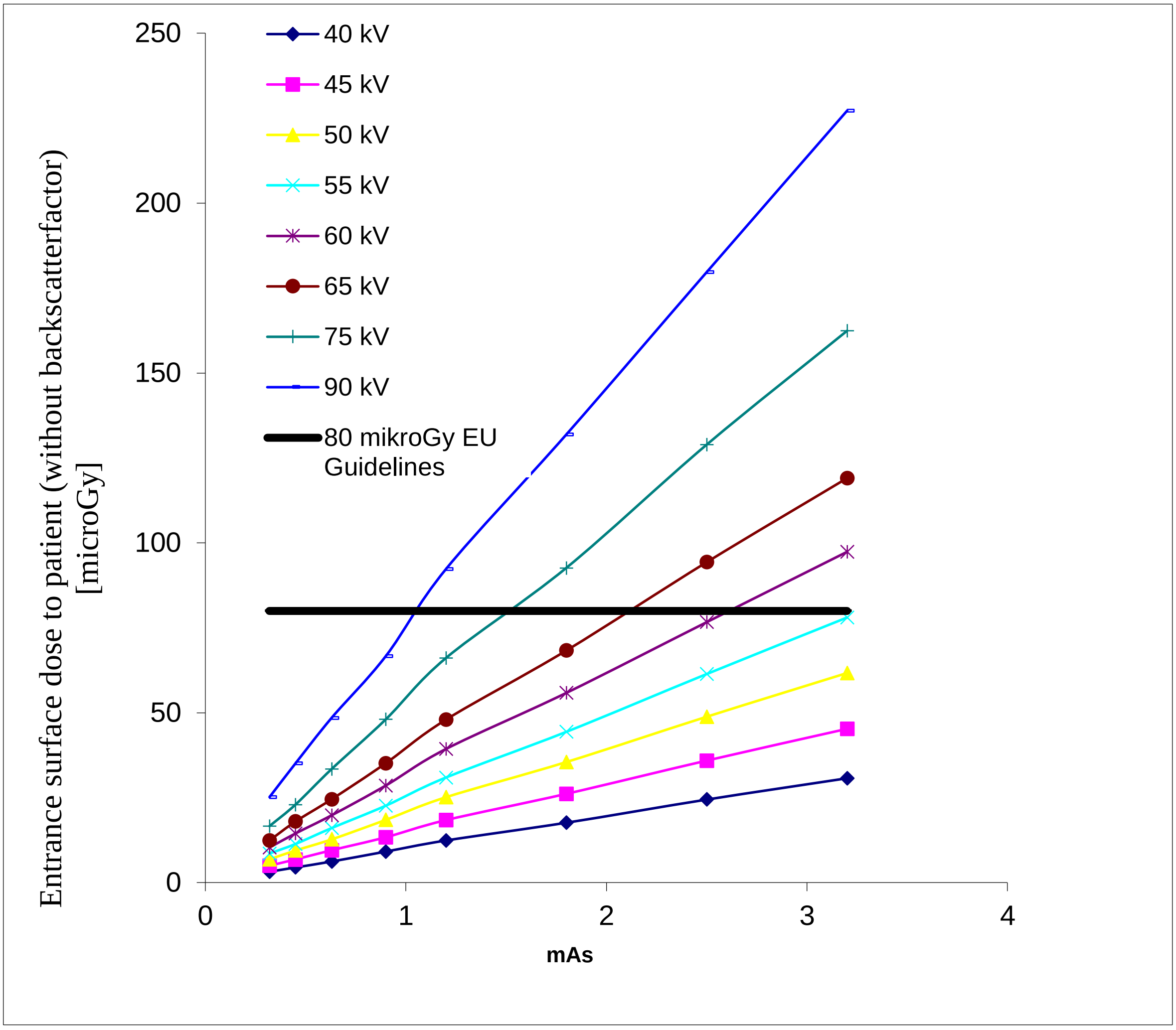

Table 2: *The grapg shows Entrance Surface Dose versus mAs for various kV settings. The horizontal line illustrates the ESD of 80 Gy, which is set by the European Guidelines on Quality Criteria for Diagnostic Radiographic Images in Pediatrics [EUR 16261]*

Noise

Table 3 shows noise versus dose to the patient. The higher the dose, the lesser the noise. Contact-techniques shows lesser noise than the under-tray techniques. The mean percentage difference in noise level between detector position 1 and 2 is 20% with a standard deviation of 12.

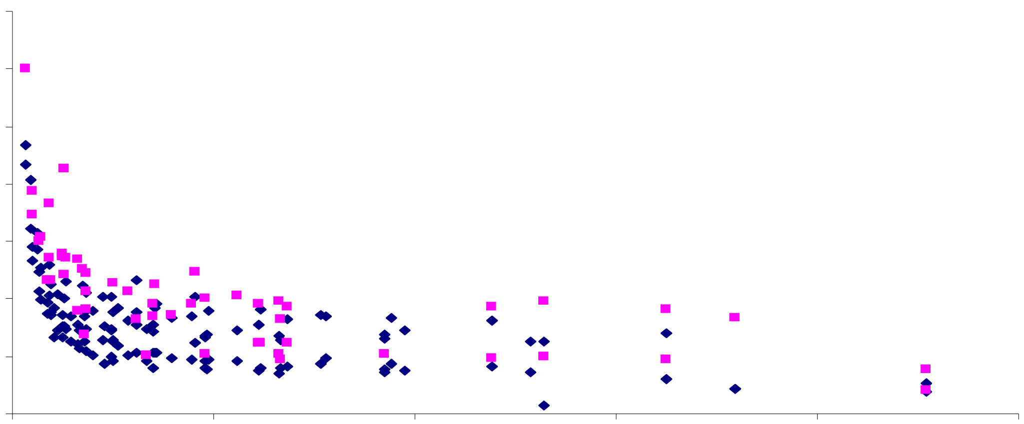

Table 3: *Noise spread versus dose. Blue dots illustrate noise grades versus dose for the situation of contact-techniques, and the red dots with detector in the tray.*

Clinical image evaluation

Two radiologists read all images, blindly, for visibility of pneumothorax and respiratory distress syndrome, which is a feature in this phantom (see figure 3B, number 2- Hyaline membrane disease, which is equal to respiratory distress syndrom, and number 3- with and without pneumothorax).

Images were within the range of 55 kV -65 kV (data not shown). Theirs results are shown in table 4 and 5. Both radiologists correlated well on visualization of pneumothorax on phantom images made at the contact and under-tray techniques. The category 'interval' is noise magnitude; the noise grades. They were quite equal also at the different noise levels. The visibility of pneumothorax was scored being best for the lowest noise grades (30 -60). Among the 112 radiographs, scored by two radiologists; pneumothorax could be detected in 88 radiographs; whereas in 40 radiographs, pneumothorax could not be detected. Similar results were found for the visibility of RDS (data not shown).

Radiologist A		*Radiologist B*	
Interval	*Frequency*	*Interval*	*Frequency*
0	0	0	0
10	4	10	1
20	1	20	0
30	9	30	2
40	10	40	10
50	4	50	10
60	4	60	7
70	1	70	2
80	0	80	4
90	2	90	2
100	1	100	0
110	0	110	0
120	0	120	1
130	0	130	1
140	0	140	0
	36		40

Table 4: Two radiologists' visual reading of pneumothorax on phantom images made by the contact techniques. The category 'Interval' is noise magnitude, the noise levels are illustrated in the table Noise versus dose to the patient. Frequency is the number of correct diagnosis.

Radiologist A		*Radiologist B*	
Interval	*Frequency*	*Interval*	*Frequency*
0	0	0	0
10	0	10	0
20	26	20	9
30	30	30	29
40	24	40	22
50	9	50	22
60	2	60	4
70	1	70	0
80	0	80	1
90	0	90	1
100	0	100	0
110	0	110	0
120	0	120	0
130	0	130	0
140	0	140	0
	92		88

Table 5: *Two radiologists' visual reading for pneumothorax on phantom images made by the under-tray techniques. The category 'Interval' is noise magnitude; illustrated in the table Noise versus dose to the patient. Frequency is the number of correct diagnosis.*

Readers agreed pretty well with respect to visualization of structures, table 6 and 7.

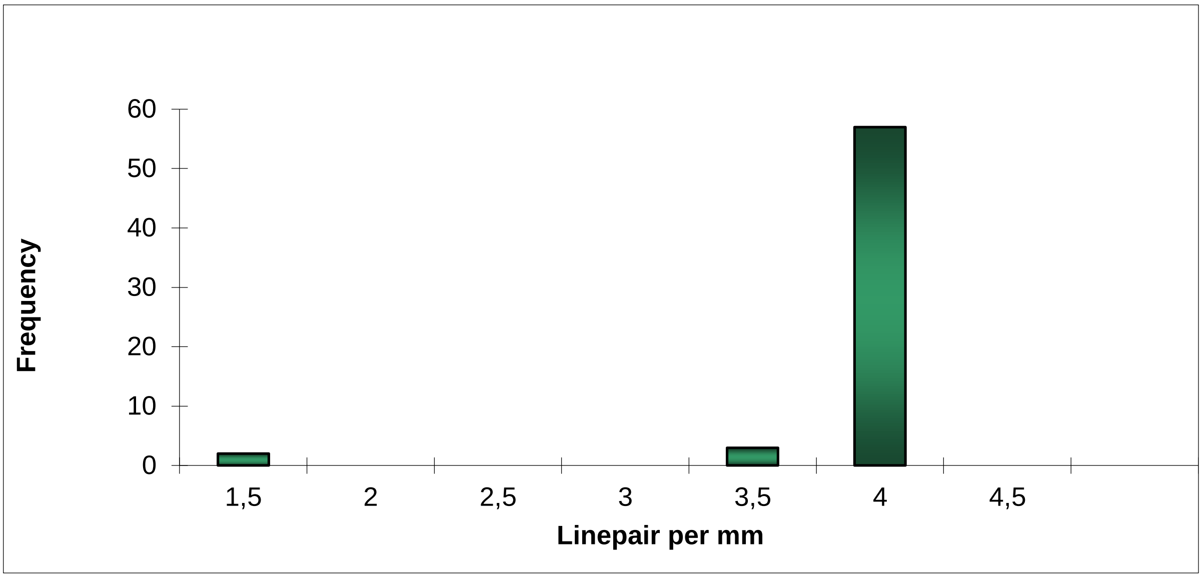

Table 6: *Histogram showing the geometric resolution rated in frequency of line pairs per mm, whereas the detector is placed in position 1, under beneath the neonate, using the contact technique.*

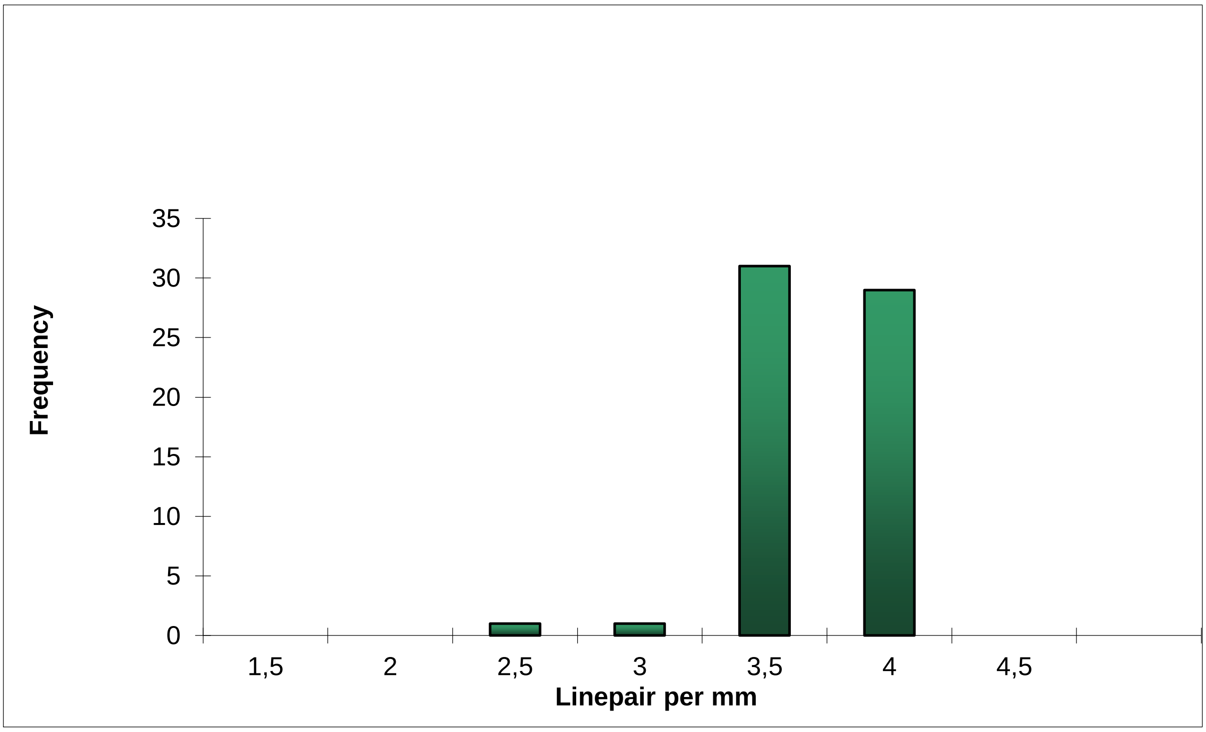

Table 7: *Histogram showing the geometric resolution rated in frequency of line pairs mm, whereas the detector is placed in position 2, using the under-tray technique.*

Discussion

A close clinical–radiological correlation is essential for a correct diagnostic interpretation. Acute respiratory failures are frequently encountered in neonatal intensive care units. One of the most serious lung diseases, the respiratory distress syndrome (RDS), occurs due to lack of surfactant in the lungs, which is common in small gestational-age babies. Meconium aspiration is also an important cause. However, respiratory failures can also be confused with a large number of other problems in the first few days of life, as e.g. pneumothorax, congenital heart disease, congenital diaphragmatic hernia, or transient tachypnea. Even though; combination of the clinical evaluation (shortness of breath, tachypnea and hypoxia) with the radiological evaluation, may not lead to the correct diagnosis. The tiny lung structures and the noise may hinder diagnosing RDS that can be illustrated as pulmonary oedema, bilateral airspace opacities spreading from the hilar regions into the lungs with relative sparing of the peripheral lungs (Listle, 2012). Pneumonia is a common cause of respiratory distress in neonates (Mathur, 2002).

A diagnostic utility evaluation of chest X-rays in RDS (Moghadam Shahri, 2014), presented specificity (the percentage of healthy people who are correctly identified as not having the condition) and sensitivity (the percentage of sick people who are correctly identified as having the condition), for different diseases. For pneumothorax, both specificity and sensitivity of the test in diagnosing pneumothorax were 100%. For pneumonia, the sensitivity and specificity of the radiographic tests were respectively 73% and 87% in Moghadam Shahri's study, while in another study (Mathur, 2002), chest x-rays were normal in 15% of patients suffering from pneumonia (sensitivity 15).

An optimum exposure is the one that produces a diagnostically acceptable radiograph with minimum patient dose. Neonate chest images cover a large area of the body, included radiation sensitive organs as bone-marrow, breasts, and thyroid. The doses to the patient (neonate) for both contact and under-tray positions were thus equal when using the same exposure settings. The doses to the image detector will differ for contact and under-tray positions with the same exposure settings.

The horizontal line on table 2, illustrates the level of ESD at 80 μGy, set by the European Guidelines on Quality Critera for Diagnostic Radiographic Images in Pediaterics [EUR 16261], Our findings show that a combination of 40 kV, 45 kV, 50 kV, 55 kV up to 3,2mAs is within the EU guidelines. But as the kV increases, there seemed to be a limitation in the mAs used. For 60 kV the maximum was 2.5 mAs and for 65 kV the maximum was 2 mAs. Similarly, for 75 kV the maximum was 1.5 mAs and for 90 kV it was 1.0 mAs. When the images were viewed by the radiologists, the visibility of pneumothorax and RDS was moreover within the range of 55 kV to 65 kV (data not shown). Both radiologists' opinions correlated well on the above criteria.

It is not only the entrance dose that has to be considered, the lower the kV the more radiation is absorbed in the neonate, thereby increasing dose to internal organs, and decreasing dose to the image detector. The kV must be chosen both to give an acceptable entrance dose at an acceptable dose to the irradiated organs. Just enough dose has to penetrate the baby and reach the image receptor to give an image at an acceptable level of noise in the image.

Visual tests concluded that the contact-technique (table 3) showed a higher agreement for details 4 lp/mm, which is slightly better than for the under-tray technique. Even those results seem be quite equal, they will have impact for the visualization of thin structures in a neonate lune. Different persons might differ in the ability of seeing the tiniest structures. Even the type of textiles use in the neonate nest, will impact; and so also dust on the monitor or light conditions in the reading room.

Pneumothorax could be detected in 88 radiographs; whereas pneumothorax could not be detected in 40 radiographs. Similar results were found for the visibility of RDS (data not shown). This points out the fact that 1/3 of the images which in real presented pneumothorax, an extremely serious event for a neonate, was undetected. The correct diagnose was unable to decide. However, the radiologists merely agreed in their decision-making. Double-reading is a must for radiologists.

The resolution of the radiographs is reported in terms of line pairs per millimetre that can just be distinguished. The spatial resolution for digital radiography is 4 lp/mm. In detector position 1, the resolution was found from 3.7 - 4 lp/mm in most of the radiographs i.e. in 57 out of 64 radiographs, which is close to the limit. In detector position 2, the resolution was found being 3.7 -4 lp/mm in 29 radiographs, and 3.1 -3.4 lp/mm in 31 radiographs. It is a tiny degradation in geometrical resolution using the under-tray technique.

The image quality is influenced by both exposure settings i.e. contrast and noise levels and detector performance i.e. resolution. With the same image detector it is solely the dose and difference in distance that affects the image quality. However, the radiation dose is linked to image quality and image quality may not be lowered so far that it endangers the diagnostic outcome.

Radiographic challenges

Imaging of the neonatal chests, utilising Computed radiography plates, means very careful handling of the baby, as for other imaging techniques. The same mobile X-ray unit, the very careful optimal positioning and collimation allow both contact technique and under-tray technique. The fundamental image parameters are contrast properties, spatial resolution properties and noise properties. For CR, contrast is easily increased with post-processing.

Spatial resolution and noise are connected to properties that also might be balanced, the information versus what degrade the quality; namely scatter and noise. For the under-tray technique, its rated being a small loss of sharpness and also a small increase in noise, leading to it probably is necessary to increase the exposure factors due to the attenuation of the mattress and bed, as it affects the image quality. The exposure settings should probably not be equal for the contact and under-tray techniques. The distance between the focal spot and the image detector is increased and that means that the dose to the detector will be lower in the tray than directly under the baby for the same exposure settings. Comparing noise evaluation between contact and under-tray technique illustrate this, that the mattress and the incubators bottom affect the noise, and thereby the image quality.

Furthermore some "nest mattresses" can be quite high absorbing. The slightly longer distance caused a tiny air-gap from the incubators lowest plastics bottom, as a small air-gap also could be preferable to absorb some scattered radiation. However, the amount of scatter from a 1-2kg neonate and a thin mattress is estimated being minimal.

The range of kV which is appropriate for the neonates is yet to be determined, though. The phantom consists of clinical features of a pneumothorax, an infant respiratory distress syndrome (RDS), and there are anatomic structural dimensions as clavicles, spine, and bronchial three. For each clinical task, it might be preferable to have the best visual information on arteries in the lateral parts of the lung, and at other occasions there might be the most important to know the exact end position of an endotracheal tube, in the trachea. For the first solution, the most important is the tiniest lateral part of the chest, for the second solution, the most important is the thickest part of the chest. Those two different clinical questions might ask for a tiny difference in what ought to be the most preferable image quality. Digital imaging allows windowing, zoom and other options, which is imperative for neonate diagnostics.

Conclusion

Diagnostics of neonate chests are a difficult task, because of the combination of tiny structures and sparsely contrast. This study showed that one third of the phantom images illustrating pneumothorax were not diagnosed by the radiologists, reading blindly phantom images; which will be serious in a clinical setting. There were a tiny decrease in sharpness combined with an increased noise (average 20%) noted in the radiographs obtained from the under tray technique compared with the contact technique. Exposure settings should probably not be equal for the contact and under-tray techniques because the dose to the image detector will be lower in the under-tray position.

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References

1 Moghadam Shahri HH, Naghibi S, Mahdavi E, Khademi G. Diagnostic Utility of Chest X-rays in Neonatal Respiratory Distress: Determining the Sensitivity and Specificity. International Journal of Pediatrics (Supplement 6), 2014 Vol.2, N.4-2, Serial No.11, pp 65-72

2 Armpilia CI, Fife IAJ, Croasdale PL. Radiation dose quantities and risk in neonates in a special care baby unit. British Journal of Radiology 2002: 75, 590-595

3 Wolbrast, AB. Physics of Radiology. Medical Physics Pub Corp. 2005, 2th Ed.

4 International Commission on Radiological Protection. The 2007 Recommendations of the International Commission on Radiological Protection, IRCP Publication 103

5 Smans K. The development of dose optimisation strategies for x-ray examination of newborns. PhD thesis. Leuven, Belgium, 2009 http://hdl.handle.net/10038/1211

6 Lowe A, Finch A, Boniface D, Chaudhuri R, Shekhdar J. Diagnostic image quality of mobile neonatal chest X-rays and the radiation exposure incurred. British Journal of Radiology, 1999: 72, 55-61

7 Commission of European Communities (CEC). European guidelines on quality criteria for diagnostic radiographic images in paediatrics. EUR 16261 EN; 1996

8 Bushong SC. Radiologic Science for Technologists. Physics, Biology, and Protection. 9th Ed. Mosby, St.Louis, Missuri 2008

9 Tapiovara MJ. Review of relationships between physical measurements and user evaluation of image quality. Radiation Protection Dosimetry. 2008, no 3: 129(1-3) pp 244-8.

10 Liua X, Shaw CC. Rejection and redistribution of scattered radiation in Scan Equalization Digital Radiography (SEDR): simulation with spot images. Medical Physics 2007 July ; 34(7): 2718–2729

11 Sprawls P. Image Noise. [Chapter] In: Sprawls P. The web-based edition of The Physical Principles of Medical Imaging, 2nd Ed. Assessed October 12th 2015

12 Listle DA. Imaging for Students. 4th Eds. 2012, Hodder Arnold

13 Mathur NB, Gary K, Kumar S. Respiratory distress in neonates with special reference to pneumonia. Indian paediatrics. 2002; 39(6): 529-37

Figure 6: *Localization for the RaySafe Xi tool (red area), for measurements of entrance surface doses.*