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X-Ray in Neonatal Intensive Care Units: Does it go to the right direction?**Yenidoğan Yoğun Bakım Ünitelerinde Radyografi Çekimi: Ne kadar doğru yapılıyor?**Berna UÇAN¹
Çiğdem ÜNER¹ Orcid ID:0000-0002-2109-139X Orcid ID:0000-0002-4846-7764¹ SBÜ Ankara Dr. Sami Ulus Kadın-Doğum, Çocuk Sağlığı ve Hastalıkları Eğitim ve Araştırma Hastanesi Çocuk Radyoloji Bölümü, Ankara, Türkiye**ÖZ**

Amaç: Yenidoğan Yoğun Bakım Ünitelerinde (YYBÜ) radyasyon güvenliği hem hastalar hem de personel için önemli bir sorundur. Bu çalışmada üçüncü basamak bir çocuk hastanesinin YYBÜ'nde gerçekleştirilen portable grafiler kalite yönünden değerlendirilecek, aynı zamanda personelin radyasyon maruziyeti hakkında da bilgi edinilecektir. Bu çalışma ile YYBÜ'lerde radyasyon güvenliği konusunda farkındalık oluşturmak da hedeflenmektedir.

Gereç ve Yöntemler: 2017-2019 yılları arasında YYBÜ'de gerçekleştirilen portable grafiler retrospektif olarak incelenecektir. Grafiler uygun hasta pozisyonu, uygun kolimasyon (yalnızca istenilen bölgenin görüntülenmesi, kafa ve gonad korunması), ve genel değerlendirilebilirlik kalitesi yönünden ele alınacaktır. Ayrıca grafilerdeki yetişkin parmakları kullanılarak personel maruziyeti hakkında bilgi edinilecektir.

Bulgular: 1438 yenidoğana ait 7333 grafi değerlendirilmiştir. Bir yenidoğana gerçekleştirilen ortalama grafi sayısı 5.1'dir. Grafilerin %83,8'i uygun kolime edilmiştir. Uygun kolimasyon oranı yıllar içerisinde artmıştır. Grafilerin %26,7'si değerlendirme için kötü kalitededir. Grafi kalitesi yıllar içerisinde artmıştır. Tüm grafilerin %87,8'inde erişkin parmağı görülmemiştir.

Sonuç: Radyasyonun efektif kullanılması YYBÜ'lerde önemli bir meseledir. Yıllar içerisinde grafi kalitesi yükselmiştir, özellikle uygun kolimasyon oranı giderek artmıştır. Personelin radyasyon maruziyeti ise azalmaya başlamıştır.

Anahtar kelimeler: Radyasyon, maruziyet, güvenlik, yenidoğan

ABSTRACT

Aim: Radiation safety is a current and important problem for both patients and staff in Neonatal Intensive Care Units (NICUs). In this study we mainly intend to evaluate the quality of radiographic examinations performed in a NICU of a children's hospital, as well as define the amount of staff exposure. By performing this study, we also want to create awareness about the importance of an adequate radiographic examination of a preterm infant and radiation safety in NICUs.

Materials and Methods: Direct portable radiographs performed in NICUs between January 2017-January 2020 were retrospectively evaluated. The researchers have evaluated the quality of the radiographs by proper positioning, proper collimation (excluding head and gonadal areas, including only the demanded area), overall quality of the radiograph for adequate interpretation (good, acceptable, bad), evidence of staff exposure (adult fingers in the radiograph).

Results: 7333 radiographs of 1438 newborns were evaluated. Mean number of performed direct radiographs for a newborn was 5.1 times. 83.8 % of the radiographs were properly collimated. Amount of properly collimated radiographs increased over the years. 26.7 % of the all radiographs were classified as bad for interpretation. Overall quality of the radiographs was also increased over the years. 87.8 % of the radiographs did not contain any adult fingers in 2019.

Conclusion: Effective use of ionizing radiation is an important matter for NICUs. The overall quality of the radiographs has become better by time, especially number of properly collimated radiographs was increased. Exposure of the staff to ionizing radiation has begun to decrease.

Keywords: Radiation, exposure, safety, newborn

INTRODUCTION

Ionizing radiation has provided a great opportunity in diagnostic and therapeutic aspects of medicine. On the other hand, harmful/unintended effects of the ionizing radiation have been still a popular problem. Avoiding unnecessary exposure to diagnostic radiation is a worldwide accepted principle. Using ionizing radiation according to "as low as reasonably achievable (ALARA)" principle is crucial for a safe diagnostic/interventional procedure. A special attention should be given to the pediatric examina-

tions, and especially premature babies (1).

Nearly 12% of all births are premature, approximately 2% of these premature infants were born less than 32 weeks of gestation. Lately, the survival rates of preterm infants have been rising, nearly up to 90%. Appropriate neonatal care has played an important role in this increase. These premature infants generally are prone to a variety of diseases such as respiratory distress syndrome, bronchopulmonary dysplasia, patent ductus arteriosus, necrotizing enterocolitis etc. As a result of diverse

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medical problems, these infants might stay at Neonatal Intensive Care Units (NICUs) for long. During their prolonged stay, these children are exposed to diagnostic procedures involving ionizing radiation. Moreover, due to high incidence of respiratory disease and other comorbidities, these infants continue to be exposed diagnostic procedures with ionizing radiation during their early childhood (2,3)

It is reported in the literature that the exposed x-ray dose for a NICU infant is approximately 0.01 to 0.02 mSv for a chest radiograph and 0.02 to 0.04 mSv for a chest and abdomen examination. International Commission of Radiologic Protection (ICRP) recommends an upper limit of 1mSv per year, 20 mSv average over 5 years and a maximum of 50mSv in a single year for the general population (4). Considering these recommendations in line with exposure rates of NICUs, the importance of diagnostic exposure will become more significant. Seeing that, it is important to acquire a qualified and sufficient to interpret radiograph.

Another radiation safety problem about NICUs is exposure of the staff. Published data indicated that, if staff stay at one meter distance when a radiograph is performed, scatter doses of radiation are at acceptable levels, between 0.024 uGy-0.041 uGy (5). However, it can be clearly understood that staff generally stays much closer than one meter during a radiographic examination. Previous studies reported that 15%-42% of radiographs performed in NICUs contain an extra adult finger, indicating the exposure of staff indirectly (6,7).

Radiation safety is a current and important problem for both patients and staff in NICUs. In this study we mainly intend to evaluate the quality of radiographic examinations performed in a NICU of a children's hospital, as well as define the amount of staff exposure. By performing this study, we also want to create awareness about the importance of an adequate radiographic examination of a preterm infant and radiation safety in NICUs.

MATERIALS AND METHODS

Current retrospective study was approved by the Institutional Review Board. Informed consent was waived because of retrospective nature.

Direct portable radiographs performed in NICUs between January 2017-January 2020 were retrospectively evaluated by two radiologists. All the radiographs were evaluated by both radiologists and final decisions were made by agreement. In the cases that the researchers could not agree, the opinion of a

third radiologist were acquired.

The researchers have evaluated the quality of the radiographs by proper positioning, proper collimation (excluding head and gonadal areas, including only the demanded area), overall quality of the radiograph for adequate interpretation (good, acceptable, bad), evidence of staff exposure (adult fingers in the radiograph). In addition, the rate of babygrams were recorded. The number of radiographic examinations performed for a child, age and sex of the children were also noted.

All the radiographs were acquired with portable Roentgen device, Shimadzu, MUX 10, Kyoto, Japan. Tube settings and exposure parameters, including tube voltage, tube current was recorded.

The study was conducted in accordance with the Helsinki Declaration and ethical permission was obtained from ethical review board of Etlik Zübeyde Hanım Women's Health, Training and Research Hospital (22.07.2020, No:2020/94).

Statistical analysis: Data were analyzed using Package for Social Sciences (SPSS) 20 for Windows (IBM SPSS Inc., Chicago, IL). Normal distribution of the data was evaluated with the Kolmogorov-Smirnov test. Numerical variables with normal distribution were shown as mean \pm standard deviation. The variables not with normal distribution were shown as minimum-maximum values. Categorical variables were shown as number and percentage. Kruskal Wallis test were used to evaluate the change of the evaluated parameters according to years. Spearman correlation analysis was used to define the correlations between age, sex and evaluated quality parameters. Kappa correlation analysis was used to define interobserver variability between two radiologists.

RESULTS

7333 radiographs of 1438 newborns were evaluated. Median age of the newborns were 22 days (0-60 days). 819 (56.9%) newborns were female and 619 (43%) newborns were male. Imaging parameters were 50 (45-55) kVp and 2 (1.5-2.5) mAs at our portabl machine with no grid.

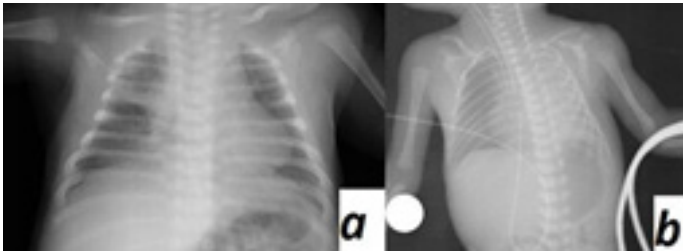
Mean number of performed direct radiographs for a newborn was 5.1 times for whole population. It was 5.8 times in 2017, 5.2 times in 2018 and 4.3 times in 2019. Median number of performed radiographs were significantly reduced over the years ($p=0.01$).

6005/7333 (81.8%) of the radiographs were chest radiographs.

730 of them were babygrams, 483 of them were direct abdominal radiographs, 63 of them cranial radiographs and 52 of them were performed for extremities. Amount of babygrams were decreased over the years: the rate was 12.7% in 2017, 9.9% in 2018 and 7.3% in 2019 ($p=0.002$).

78.3% of the radiographs were properly positioned. Proper positioning rate of the radiographs in 2017 is 76.4%, in 2018 is 78.8%, in 2019 79.7%. Proper positioning rate of the radiographs did not change significantly over the years ($p=0.07$) (Figure 1).

Figure 1: A properly positioned (a) and a mispositioned (b) chest radiograph.



83.8 % of the radiographs were properly collimated. Properly collimated radiographs rate in 2017 78.4%, in 2018 84.8%, in 2019 88.2%. Amount of properly collimated radiographs increased over the years ($p=0.00$) (Figure 2).

Figure 2: Poorly collimated radiographs. (a) An abdominal radiograph was demanded however a babygram was acquired. (b) Head is completely included into a chest radiograph.



26.7% of the all radiographs were classified as bad for interpretation. Overall quality of the radiographs was also increased over the years ($p=0.00$) (Table 1).

Table 1: Overall quality of the radiographs according to years

Years	Quality	Percentage (%)
2017	Good	43.3
	Acceptable	25.8
	Bad	29.9
2018	Good	50
	Acceptable	24.1
	Bad	26.9
2019	Good	53.8
	Acceptable	22.9
	Bad	23.3

Exposure of the staff to ionizing radiation did not change between 2017 and 2018, however it was reduced in 2019 ($p=0.04$). 87.8% of the radiographs did not contain any adult fingers in 2019.

No significant correlation was detected between age, sex and the evaluated quality parameters.

Kappa values for agreement about proper position, proper collimation and overall quality of the radiographs between two radiologists were almost perfect (0.88, 0.87, 0.82 accordingly).

DISCUSSION

We mainly aimed to review our performance about portable radiographs performed in NICUs. Over the years, from 2017 to 2019, overall quality for interpretation and proper collimation gradually increased. Staff exposure to ionizing radiation decreased in 2019. However, a significant progress could not be achieved in proper positioning of newborns. Our imaging parameters 50 (45-55) kVp and 2 (1.5–2.5) mAs were compatible with, Commission of European Communities recommendations 60-65 kVp for neonatal and Turkish reference study (46-51 kVp and 1.6-3.5 mAs) (8,9).

Radiation safety and concerns about side effects of ionizing radiation are popular subjects that have been attracting attention of the both health care professionals and public. Seeing that newborns are a sensitive group for the harmful effects of ionizing radiation, quality of the radiographic examinations became important to acquire as much information as possible with a single radiograph or fewer radiographs (10,11).

According to our results, a newborn received a radiograph for a mean of 5.1 times during their hospitalization, and the mean times of receiving a radiograph has decreased over years. In the literature, a mean number of received radiographs for a newborn, changes between 3.9-15 times (1,3,12); our results

are closer to lower bound. Considering along with the literature, efforts has been made to lower the numbers of radiographic examinations to decrease exposure to ionizing radiation. Our data reveals that, our institution is in a relatively better position according to number of radiographs. Mean value of the radiographs decreased over the years, we cannot find a similar result in the literature about the annual changes of the performed radiographs. We consider this decrease as an important sign for the increasing awareness about radiation safety (for both clinicians and radiologists) and examination quality. We are aware that the number of performed radiographs is closely correlated with the clinical condition of the newborns. We cannot offer a detailed information about clinical conditions of the participating newborns, however our NICU is an important equipped nationwide center and related with that from a long period of time, a wide range of seriously conditioned newborns has been followed. Seeing that, we humbly believe that seriousness of the clinical conditions has minimal effect on our data.

In line with the literature (11,12) most of the evaluated radiographs were chest radiographs, followed by babygrams. Babygrams refer to radiographic examinations taken by using a very large field of view, generally whole body of the newborns. Babygrams creates an important amount of ionizing radiation burden; such as a chest radiograph creates a dose of 0.01-0.02 mGy, an abdominal radiograph 0.02-0.04 mGy, on the other hand a babygram creates a dose of approximately 0.024 mGy (1,13). As a common habit, radiology technicians tend to create a babygram when a chest and/or abdominal radiograph is taken. As radiology department, since 2016, we have been warning our technical team not to shoot unnecessary babygrams. Babygrams can be created by only the specific demand of the clinician and/or radiologist since 2016. As a result of these warnings, we have managed to decrease the number of babygrams over years. We cannot find a similar study in English literature to examine the change of babygrams in time.

Proper positioning of a radiograph is important for an adequate interpretation. However, when it comes to newborns, it can be difficult to obtain a properly positioned radiograph, especially when it is a portable radiograph. Similar with the literature (9), we cannot detect a significant change about the amount of properly positioning radiographs. To obtain a properly positioned radiograph, occasionally, NICU staff or radiology technicians put the newborns. In these cases, we have the opportunity for a better radiograph, however the amount of staff exposure to ionizing radiation increases. Since 2016, we occasionally warn

radiology team and NICU staff to keep a safe distance (at least one meter) when a portable radiograph is obtained. We regularly check the presence of adult fingers in NICU radiographs and do the necessary warnings. As a result, we managed to decrease the amount of radiograph with an adult finger in 2019, and relatively we managed to decrease the amount of occupational exposure of the staff. In previous studies (6,9,14), similar with our data, adult fingers in radiographs were considered as a sign for occupational exposure and a common effort has been made to reduce the exposure of the staff. In line with our data, radiation safety educations decrease the number of adult fingers in radiographs (9,14).

Large field sizes are a result of poor or inappropriate collimation. Inappropriate collimation gives rise to an unnecessary high patient dose, as well as deteriorates the image quality. Seeing that bad collimation is not consistent with agreement with the ALARA principle. In Bader et al.'s study (3), it is stated that most of the included NICU radiographs was inappropriately collimated. Wallingford et al. (1) could not manage to increase the quality of collimation after a radiation safety education. On the other hand, the quality of the collimation has gradually increased after an education in Hellwig et al.'s study (9). According to our results, we have managed to decrease the amount of inappropriately collimated radiographs over the examined years. We think that this result is the consequence of our radiologists' close follow up and repeated warnings about proper collimation.

A qualified radiograph enables radiologists a good interpretation and it can reduce the need for further examinations (15). Along with the general improvements in radiographs performed in NICU, overall quality of the radiographs has increased gradually from 2017 to 2019. This kind of increase was also noted with radiation safety educations in a previous study (9).

This study has some limitations worth mentioning. We have only evaluated the radiographs performed in a limited time, between 2017-2019. Our data belongs to only one center, multicentric research might change the results. We did not include clinical information of the newborns into the study; clinical condition might affect the number and overall quality of the radiographs. We only strictly followed up the quality of the radiographs and warned our team for necessary issues. We did not perform a scheduled education program. A study performed short after a planned education program might change the results.

Conclusion: Effective use of ionizing radiation is an important matter for NICUs. The overall quality of the radiographs has be-

come better by time, especially number of properly collimated radiographs was increased. Exposure of the staff to ionizing radiation has begun to decrease.

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