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Radiation cancer risk from doses to newborn infants hospitalized in neonatal intensive care units in children hospitals of Isfahan province

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► ***Original article***

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ABSTRACT

Background: This study aimed to investigate dose area product (DAP), effective dose, and radiation risk in newborn infants hospitalized in neonatal intensive care units in Isfahan and Kashan. ***Materials and Methods:*** During a period of six months, DAP for chest X-ray examinations for newborn infants hospitalized in NICUs of five special hospitals including Beheshti (in Kashan), Al-Zahra, Imam Hossein, Amin and Goldis (in Isfahan) were measured using DAP meter. Then, using the dose area product (DAP) and conversion coefficients, the effective dose was calculated. Radiation risk per single exposure was estimated by applying 2.8 × 10-2 and 13 × 10-2 factors per Sievert. Also, to estimate the radiation risk in the exposed population, the collective effective dose and the mentioned factors were used. ***Results:*** The mean DAP, the effective dose, the radiation risk per single exposure, and the radiation risk in the exposed population were found to be 15.37 ± (1.19), 45.52 ± (3.28), [1.27-5.91] × 10-6, and [0.0045-0.021], respectively. ***Conclusion:*** Findings indicate that the effective dose and therefore radiation risk in NICUs for newborn infants is higher than that of other studied cities in Iran. Consequently, it is necessary to attempt to reduce radiation dose while maintaining the image quality. In addition, theoretical and practical training programs are needed to increase the knowledge and skills of radiologic technologists on the concept of As Low As Reasonably Achievable (ALARA) and possible radiation cancer risks.

Keywords: *NICU, radiation cancer risk, effective dose, DAP.*

INTRODUCTION

Children who are born prematurely have higher rates of disorders compared with children born at normal term. The morbidity associated with preterm birth often extends to later life, resulting in enormous physical and psychological [1]. Prevalence of premature birth in Iran was estimated to be 9.2% in 2015 [2] and as a result, these infants usually will have much longer hospital stay than the average. However, due to recent medical advances, mortality rate of such cases has been decreased [3], and cases facing numerous complications, need to be hospitalized in NICUs. Because of their low birth weight, gestational age, and respiratory conditions frequent radiography procedure are requested [4-6]. As their body size is too small, usually large areas of their bodies are exposed to the X-ray exposure [7]. On the other hand, since their body organs are so close to each other, their organ protection is too difficult [8]. From the stochastic point of view, there is no evidence of the existence of any threshold from radiation and doses, regardless of the small body size, may have a potentially damage [9].

Furthermore, due to their longer life expectancy and chronic effects of radiation cancers may be occurred [3]. It is believed that cancer risk per unit of dose is 2-3 times higher than that in the middle-aged and 6-9 times higher than that in 60-year-old [10, 11]. Indeed, the carcinogenic effects of radiation and the cancer risk are higher in infants [12]. Measurements of the patient doses are so important from the radiation safety point of view [13]. As a result, the received dose to infants needs to be kept to As Low As Reasonably Achievable (ALARA). To maintain enough protection against radiation and considering the ALARA principle, an evaluation of newly born infant radiation dose is a vital. In order to measure and estimate of the received dose and radiation cancer risk, two quantities namely the dose area product (DAP) and the effective dose are applied [14-17]. DAP demonstrates the received dose and could not be directly used to estimate radiation risk. The effective dose is a parameter often used to express cancer risk [18]. This study aimed to investigate the DAP and the radiation risk in infants in NICUs in Isfahan and Kashan hospitals.

MATERIALS AND METHODS

This study was conducted in 5 NICUs of Beheshti Hospital in Kashan and Al-Zahra, Amin, Imam Hussein and Goldis hospitals in Isfahan. Four mobile X-ray systems (TMS 300 TECHNIX, MUX-10 Shimadzu, FO3S2O Behsaz Medical, Poly Mobile Plus Siemens) were applied for chest X-rays during a six month (January 2015 and June 2016) period. Initially, quality control tests including voltage and time accuracy, voltage repeatability and half value layer were done. To do the test, the image receptor was placed under the infant in the incubator and exposure parameters were set by a radiologic technologist's. Parameters such as gender, weight, kVp, field size and mAs were recorded for each individual case.

DAP measurement

DAP was measured using a Diamentor M4 DAP meter (PTW, Germany) which was attached to the collimator. For chest X-ray examinations, measurement in NICU was performed. Measuring radiation dose using DAP has been recommended by Commission of the European Communities (CEC) [19]. It has advantage such as radiation dose measured by DAP which no change if the distance from X-ray source changed, and therefore correction of geometrical correction is not needed [18]. Also, a number of researches showed that estimation of the effective dose from DAP measurements is more reliable than that from the ESD measurements because of the former cover the radiation area as well [20, 21].

Effective dose calculation

Measured DAP values were converted to the effective dose values using conversion coefficients [18]. Then, collective effective dose was calculated using the following formula:

Collective effective dose = mean effective dose × number of examinations per year

Estimation of radiation risk

Radiation risk for the newborn infants was estimated by 2.8×10^{-2} to 13×10^{-2} per Sv according to the ICRP-60 and it was multiply by the effective dose to calculate radiation risk per examination [9]. To estimate radiation risk in the exposed population, the following formula was used [9]:

Radiation risk = risk per Sievert × collective effective dose

RESULTS

Table 1 shows the DAP values (range and mean) for chest X-ray in different studied hospitals.

As can be seen from Table 1, minimum and maximum DAP (mean) values were measured for Al-zahra and Imam hossein hospitals, respectively ($P \leq 0.05$), and mean DAP ± SE in all hospitals was found to be 15.37 ± 1.19.

Effective dose

Values for the effective dose which obtained from DAP measurements (range and mean) for chest X-ray are shown in table 2.

As table 2 shows minimum and maximum means for the effective dose pertain to Goldis and Imam hossein hospitals ($P \leq 0.05$) and overall mean effective dose ± SE in all hospitals was 45.52 ± 3.28.

Risk estimation

Table 3 shows radiation risk for newborn infants per X-ray examination in different hospitals. Radiation risk in the exposed population in 2015 can be seen in table 4.

Based on the amounts calculated, mean risk for the all hospitals was found to be (1.27- 5.91) $\times 10^{-6}$.

Total mean of the effective dose in all hospitals was 45.52 and total number of chest X-ray examinations was also 3554 suggesting a total radiation risk of 0.0045-0.021 for the exposed population.

Table 1. DAP values in five hospitals and four mobile X-ray systems.

Mobile X-ray	Hospital	Range of DAP (mGy. cm^2)	Mean DAP ± SE (mGy. cm^2)
Siemens	Beheshti	9.24-36.95	17.84 ± 2.46
Technix	Alzahra	2.96-26.89	10.56 ± 1.43
Shimadzu	Amin	3.49-36.92	15.02 ± 2.54
Siemens	Imam hossein	8.01-59.79	27.53 ± 3.86
Behsaz Medical	Goldis	4.33-18.60	10.69 ± 1.09

Table 2. The effective dose in different studied hospitals.

Hospital	Range of ED (μSv)	Mean ED ± SE (μSv)
Beheshti	25.52 ± 96.07	47.24 ± 5.58
Alzahra	105.92 ± 12.21	35.85 ± 4.41
Amin	24.45±93.85	49.46 ± 5.86
Imam hossein	6.33±159.50	76.14 ± 11.97
Goldis	9.86 ±68.83	28.60 ± 3.69

Table 3. Radiation risk in newborn infants in different studied hospitals.

Hospital	(Risk* ± SE) $\times 10^{-6}$	(Risk** ± SE) $\times 10^{-6}$
Beheshti	6.14 ± 0.72	1.32 ± 0.15
Alzahra	4.66 ± 0.57	1 ± 0.12
Amin	6.43 ± 0.76	1.38 ± 0.16
Imam hossein	9.89 ± 1.55	2.13 ± 0.33
Goldis	3.71 ± 0.48	0.80 ± 0.10

*ED×0.13
** ED×0.028

Table 4. Radiation risk in the exposed population in 2015.

Hospital	Mean ED	Number of chest X-ray examinations per year	Radiation risk in the exposed population
Beheshti	47.24	1388	0.0018-0.008
Alzahra	35.85	1560	0.0015-0.007
Amin	49.46	322	0.0004-0.002
Imam hossein	76.14	176	0.0003-0.001
Goldis	28.60	108	0.00008-0.0004

DISCUSSION

Newborn babies with health problems and those children who were born premature, the number of X-ray examinations or hospitalized is important. Indeed, their small body size makes the internal organs be almost entirely in the radiation fields, which leads to the increase of the effective doses.

Radiation risk in the exposed population was 0.0045-0.021. Considering long hospitalized of infants in NICUs and high number of examinations causes the radiation risk per infant and exposed population increases.

Measurements of DAP, the effective dose, and radiation risk in the present study and in similar studies are illustrated in table 5. As can be seen from this table, DAP values in the present study was higher than those of relevant previous works [14-17]. Using low kVp in the studied hospitals may be a reason for these differences. It is appear that changing the exposure factors such as high kVp and low mAs are necessary for a reduction in the effective dose [16, 22, 23]. Moreover, another reason is that in mobile X-ray, mAs range choice is not wide enough, though this could be solved by additional filtration [23]. Several studies recommended the application of additional filtration for dose reduction [24, 25]. Another possible explanation for high DAP might be due to independent to dose and depended to radiation field.

As mentioned earlier, this study investigated radiation risk for newborn infants hospitalized in NICUs. Since cases were mostly premature (below 37 weeks), the fetal risk factors of (2.8 -13) $^{2-}10$ ×which is recorded by ICRP-60 (assuming that there is similar risk in the first, second, and third trimesters) was used [6, 9]. In this work, radiation risk per single exposure was (1.27-5.91) × 10^{-6}, which is higher than those reported by other researchers [14, 16]. For example, Faghihi *et al*. reported that appropriate radiology techniques and precise collimation will reduce the risk to newborn infants [26]. Moreover, it remains still uncertain whether radiation risk for infants is higher in high pressure oxygen conditions [6, 27, 28].

In general, field size should be as small as possible [24]. Large field application might be the result of radiologic technologists' tendency to avoid repeated radiologic examinations [29]. Effective dose is a quantity which could possibly be used for quantitative investigation of radiation risks [30]. The mean ED in the present study was found to be 45.52 which is higher than those reported by other similar studies [14, 16]. This could be due to applying of large radiation fields. An increase in ED and radiation risk in infants could be resulted by a minimum increase in radiation field based on Faghihi's study [26]. Compared with a study by Bouaoun *et al.* [16] on chest-abdomen X-ray radiography, ED measures for chest X-ray in the present study were comparatively higher, which is the result of large radiation field application.

This study revealed that radiologic technologists apply excessively large radiation fields resulting high DAP values, which is against the principle of ALARA. Consequently, it is necessary that radiologic technologists receive both theoretical and practical training on anatomic landmarks. Also, they need to learn that application of large radiation fields not only increases the effective dose but also, due to increased scatter rays, low contrast and low image quality would be yield [11].

Table 5. Comparison of DAP, effective dose, and radiation risk in the present study and previous researches.

Reference		Mean/ Range of DAP (mGy.cm^{-2})	ED (µSv)	Radiation Risk ×10^{-6}
Present study	Chest radiography	15.37/2.96-59.79	45.52 ± 3.28	(1.27-5.91)
Jones *et al.* [28]	Chest radiography	8.3	15.4	2
	Abdomen radiography	11.5	21.9	2.8
	Chest-abdomen radiography	18.7	35.5	4.6
Dabin *et al.* [15]	Chest radiography	1.4 –14.2	-	-
	Chest-abdomen radiography	3.8-28.1		
Bouaoun *et al.* [16]	Chest-abdomen radiography	5.0 – 43	31.6	(0.9-4.1)
Chateil *et al.* [17]	Chest radiography	2.9 -9.9	-	-

CONCLUSION

It appears that radiation risk to newborn infants is low. However, their high sensitivity to radiation, especially when they are premature and high number of radiation examinations is needed it is important. However, the Committee emphasized that radiation exposure should be restricted only to those infants requiring X-ray procedures for good medical care. It is desired that all radiologic technologists have pediatric and pathological knowledge in order to provide an appropriate limitation of the exposure field. Furthermore, since results here are related only to chest X-ray, other common X-ray such as abdomen and skull would be completed the results.

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