Original Article

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Assessment of Cumulative Radiation Dose of Neonate Hospitalized in Intensive Care Units

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ABSTRACT

BACKGROUND AND OBJECTIVE: Newborns admitted to the neonatal intensive care unit (NICU) , would be undergo a large number of X-ray imaging due to their involvement with various diseases The most important complication of receiving too much X-rays is an increased risk of various cancers. The aim of this study was to determine the average cumulative dose received by neonates admitted to the neonatal intensive care unit.

METHODS: This cross-sectional study was performed on 20 neonates admitted to the intensive care unit of Taleghani Children's Hospital who were randomly selected. Infant information registrated including time of birth, arrival time, duration of hospitalization, age, sex, weight and number of radiographs performed on the infant and radiographic information including tube-to-patient distance, tube voltage (kVp) and milliamperes (mAs). The amount of skin absorption dose of each patient was evaluated using MTS700 thermoluminescence dosimeter and the number of imaging was examined.

FINDINGS: The amount of entrance skin dose of the studied neonates with an average of 78 micrograys varied from 42 to 121 micrograys (78±19.6). The mean number of imaging and cumulative dose were 6 (6±7.71) and 521 micrograys (521±547.99), respectively. The highest cumulative dose (2106 µg) was related to a neonate who underwent 27 imaging.

CONCLUSION: According to the results of this study, the need for multiple imaging of these infants can significantly increase their absorption dose, especially in infants with very low weight.

KEY WORDS: *Diagnostic X-Ray, Newborn, Entrance Skin Doses, Cumulative Effective Dose*.

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Introduction

Since the discovery of X-rays by Roentgen, X-rays have been used as an essential diagnostic and therapeutic tool so that not using them can harm public health (1, 2). Despite the benefits of X-rays, from a radiation protection perspective it can be a source of potential risks, especially at a young age. According to studies, the most important complications of X-ray overdose can increase the risk of blood cancers and tumor malignancies (1, 3).

Newborns admitted to the intensive care unit are among the patients who may be exposed to excessive amounts of X-rays. Conventional radiology is one of the most important diagnostic tools in neonatal intensive care units due to its availability, relatively low absorption radiation dose per graph, and low cost. Radiographic imaging is used for early neonatal examination, assessment during acute exacerbation, and specific clinical conditions such as intubation. According to studies, the risk of radiation exposure in these infants, especially premature infants, is much higher than adults in several ways. The small size and low weight of these infants have caused most of their sensitive organs, including the thyroid, gonads, red bone marrow, to be irradiated directly, their radiation is considered as whole body (Whole body), in which case the effective dose is higher (4, 5).

On the other hand, their high rate of cell proliferation and their high mitotic activity make the risk of radiation in infants, especially premature infants, much higher than adults. It is noteworthy that due to the higher volume of red bone marrow in infants than in children, the effective dose and the risk of radiation in infants is about 3 to 4 times more than children. Therefore, it is necessary to keep the radiation dose from radiographic imaging low in the neonatal intensive care unit as long as the image quality is maintained.

According to the International Commission on Radiological Protection (ICRP), the reference dose in neonatal radiology is 80 micro-grays. According to studies in Europe, due to the lack of a single radiographic protocol and based on different radiology techniques, a wide range of skin absorption doses (30-174 micro-grays) has been estimated in these infants, which in some centers was below the reference limit (6-7) and in some above the reference limit (5). In addition, the cumulative dose received by these infants, which can be significant due to the need to repeat imaging of the target area (about 20% repetition) as well as the need for consecutive imaging of the treatment process, should not be ignored. Significant number of imaging of these infants and increasing cumulative doses can increase the risk of cancer, non-cancerous diseases, and genetic diseases (4, 8).

Few studies have been performed on cumulative doses in infants, especially premature infants. For example, the cumulative dose on two preterm infants exposed to 40 (5) and 29 (9) radiographs was 4181 and 609 macro-grays, respectively. On the other hand, infants admitted to Intensive care unit, in addition to radiography, also undergo CT scan and fluoroscopy, the absorption dose of which is 1000 times more than a radiograph (10). Therefore, due to the importance of radiation protection, especially in this age group and in order to maintain the minimum absorbed radiation dose, in the present study, the cumulative dose received by newborns admitted to Taleghani Pediatric Hospital in Gorgan due to diagnostic radiography during hospitalization was examined.

Methods

This cross-sectional study was approved by the ethics committee of Golestan University of Medical Sciences with the code of IR.GOUMS.REC.1397.265 and was performed on 20 newborns admitted to the neonatal intensive care unit of Taleghani Children Specialized Hospital of Gorgan in the three months of summer 2019. Patients were randomly selected regardless of the type of disease, duration of hospitalization, sex and age. Following the hospitalization of each infant, information including birth time, arrival time, and duration of hospitalization, infant age, sex, weight, and number of radiographs performed on the infant were recorded. Radiographic data including tube-to-patient distance, tube voltage (kVp), and milliamperes (mAs) were also recorded.

All images were taken by a portable radiology device located in the intensive care unit. Due to the fact that the imaging protocol can be different depending on the patient's condition, and also in cases where the imaging of the infant needs to be repeated, which unfortunately will not be recorded in their file, in order to investigate more accurately, in the neonatal intensive care unit, it was estimated by MTS700 thermoluminescence personal dosimeters. For each infant, a Termoluminescent Dosimeter (TLD) tablet

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was placed in a plastic container to protect against moisture and dust, which was with the patient from admission to discharge or death. Direct measurement of absorption dose by TLD is the best indicator of accurate evaluation of a clinical function. It should be noted that before using TLD tablets, their response should be calibrated based on the radiation range. For this purpose, all tablets were given a voltage equal to 44 kV. Then all the tablets were placed in the reader. The calibration factor of each detector is equal to the ratio of the average readings in each channel of the device to the readings of each tablet. Then the dose value is obtained by multiplying the count read (by the device) by the calibration factor and then reducing the background beam. The difference between the given and calculated dose should not be more than 5%. The dose stored in TLDs was read by TLD Reader 3500 in Mashhad University of Medical Sciences - Department of Medical Physics.

Results

The weight of the studied neonates with an average of 1440±735.78 g ranged from 550 to 3300 g. The number of imaging was dependent on the patient's clinical condition (6±7.71) so that in several patients the number of imaging reached 25-30. As expected, the number of images increased as the number of hospitalization days increased. The mean number of images in the very low weight group (weight less than 1500 g) (8.2±8.7) was significantly higher than the higher weights (3.1±1.8) ($p<0.05$) (Table 1).

In some cases, the average skin absorption dose is higher per graph and in some cases less than the reference level reported by the ICRP. Although the mean absorption dose per graph in infants weighing less than 1,500 is significantly lower than in infants weighing more than 1,500 ($p<0.05$), however, due to the number of images taken on very low weight infants, the cumulative skin dose in them (595±633.6) was significantly higher than infants with higher weights (318±183.12) ($p<0.05$) (Table 2).

The tube voltage with an average of 43±0.6 has changed from 39 to 47 kV as well as 1.5 to 3 mA (Table 3). Due to the fact that imaging is performed by several radiology technologists and each person adjusts a different imaging protocol according to their level of education, we will see a wide variety of doses received by a baby. This phenomenon is due to the lack of a standard imaging protocol for infants.

Table 1. Clinical information about each infant studied

Patient identification code	Number of imaging taken	Number of hospitalization days	Patient age of birth (weeks)	Patient weight(G)
1	5	10	27	1200
2	4	3	29	1100
3	4	8	26	2800
4	3	3	29	1620
5	2	1	27	550
6	3	3	29	1230
7	1	1	36	2300
8	5	3	28	650
9	2	11	30	1280
10	5	9	31	1460
11	27	202	29	1200
12	1	1	35	2610
13	27	25	29	900
14	5	7	30	2150
15	3	18	29	1220
16	2	2	31	1400
17	15	10	29	770
18	5	3	29	1230
19	12	18	28	720
20	4	6	30	1400

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Table 2. Mean skin absorption dose per imaging and cumulative skin dose per infant

Patient identification code	Cumulative skin absorption dose (micro-grays)	Mean skin absorption dose per graph (micro-grays)	Number of imaging taken
1	437.64	87.5	5
2	356.6	89.15	4
3	441	110.25	4
4	228.5	76	3
5	120	60	2
6	261.6	87	3
7	221.8	121.8	1
8	305.3	61	5
9	185.6	61	2
10	479.2	95.8	5
11	1890	70	27
12	42	42	1
13	2106	78	27
14	500	100	5
15	229.9	76	3
16	167.4	83	2
17	975	65	15
18	365	73	5
19	600	50	12
20	320	80	4

Table 3. Imaging parameters affecting the skin absorption dose

Imaging physics specifications	Mean±SD	Maximum	Minimum
Kilo voltage (KV)	43±0.6	47	39
Mili amper second (mAs)	2±0.2	3	1.5
Distance from the tube to the patient's body	62±0.2	70	50
Length of the field	12±0.5	15	9
Width of the field	10±0.4	12	9

Discussion

In the present study, the amount of skin absorption varied from 42 to 120 µgrays, which in many cases was below the ICRP reference limit (80 µgrays). In order to reduce the neonatal dose, the ICRP recommends a tube voltage 60-65 KV, film and screen speed 200 to 400, and recommends head-to-patient distance about 100 to 150 cm (5, 11). The most important reason for the high dose in some centers compared to the reference dose is the three main factors of low KV, high mAs and short distance. Increasing KV and decreasing mAs increases penetration and decreases the absorbed dose of the skin and consequently decreases the patient dose. Similar to other studies (6, 7, 12, 13) in the present study, in some cases, low kVp, high mAs and low distance from the body to the tube are factors that have increased the amount of skin absorption dose in some infants. In addition to the above, insufficient accuracy of timer systems, kV, etc of imaging device can affect the output of the device (14). Although in most articles the skin absorption dose per image is less than the reference limit, the need for multiple imaging of these infants can significantly increase their absorption dose. In a study conducted by Komatsu et al. X-ray irradiation was considered 12 for neonates during NICU hospitalization. The mean cumulative dose was 864 micro-grays (12 irradiations x 72 micro-grays (mean ESD) which increased to 4680 micro-grays by multiplying 65 radiographs by 72 micro-grays for a sick infant during a 203-day hospitalization (15). Despite the fact that the amount of absorption dose per imaging in infants weighing less than 1.5 kg was less than normal weight infants, but due to the higher number of imaging in this weight group caused a significant increase in cumulative absorption dose so that in two neonates underwent 27 imaging cumulative absorption doses reached 1890 and 2160 μg, respectively. The purpose of imaging should be to achieve a sufficient quality image instead of achieving an optimal quality image in order to increase radiation protection. Due to the high rate of skin absorption dose per imaging in a number of infants in the present study, it is necessary to encourage radiographs to use appropriate radiation factors and appropriate climates to reduce the rate of skin absorption dose. In addition to keeping the skin absorption dose low, due to the importance of the number of images in the cumulative absorption dose, specialists should be cautious about requesting radiology and make sure that imaging is necessary.

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