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CLINICAL BRIEF

Ionizing Radiation Exposure in NICU

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Abstract

The authors prospectively studied ionizing radiation exposure in consecutive 107 very low birth weight (VLBW) neonates, admitted to their Level III neonatal intensive care unit (NICU). Number of X-rays, their indications and calculated dose of radiation were documented. Their mean birth weight (±SD) and gestational age (±SD) were 1077 (±219.8) g and 29.7 (±2.57) wk respectively. Extremely low birth weight (ELBW) neonates underwent significantly higher radiographs when compared with VLBW neonates; 7.5(5–13.25) *vs.* 2(1–6); $p < 0.0001$. ELBW neonates received 3 times higher dose of radiation, when compared with VLBW neonates; 139.4 μsv (81.6–256.15) *vs.* 46.6 μsv (14.4–115.7); $p < 0.0001$. Seven percent of ELBW neonates received >1msv radiation. Lifetime risk associated with high radiation exposure during neonatal period is unknown. Every effort should be taken to reduce number of radiographs. Imaging modalities without radiation exposure such as, point of care ultrasound should be used wherever possible.

Keywords Radiation exposure · Preterm · Safety · Neonatal intensive care unit

Introduction

During pregnancy, diagnostic X-ray exposure to the maternal-fetal unit should be avoided unless absolutely necessary to avoid potential harmful effects to the developing fetus [1]. However, the same fetus if born premature and admitted to neonatal intensive care unit (NICU), gets subjected to harmful radiations for diagnostic evaluations. As the quality of neonatal care is improving, more and more sick premature babies with complex medical conditions are now surviving. By the end of their extended NICU stays, the doses of ionizing radiation to these neonates may accumulate quickly.

The purpose of this study was to audit the level of radiation exposure in very low birth weight (VLBW) infants during their NICU stay.

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Material and Methods

This was a prospective observational study conducted between October, 2017 and March, 2018 in a Level-IIIA NICU. Prospective data was collected on various radiologic examinations performed for different indications during the study period. Standard Radiographic settings were used for different radiographic procedures. Conventional radiography with digital image plate was used. For Chest Radiograph, tube voltage of 65 KV, current of 0.6 mA and film to tube distance of 90 cms was used. For abdominal examination, voltage 65–70 KV and 0.6 mA current and for infantogram 50 KV voltage and 0.5 mA current was used. Entrance skin dose (ESD) measurement for each patient during each radiographic procedure was technically and organizationally impractical, so standard reference dose of radiation in microsievert (μsv) for each radiologic examination under NICU conditions was taken from reference ranges published by Puch-Kapst and colleagues, and for CT examinations from Huda and Vance [2, 3]. Standard reference dose used were for Babygram 23.8 microSv, Chest X-ray 14.4 microSv and for Abdominal X-ray/ umbilical venous catheter (UVC)/ umbilical arterial catheter (UAC) 17.8 microSv [2]. Effective dose of

radiation exposure for a baby was calculated by adding doses from multiple examinations [1].

Number of radiologic examinations and total dose of radiation exposure were compared between the subgroups of ELBW (extremely low birth weight) and VLBW infants. Statistical analysis was done by using SPSS var. 21.0 and p value of <0.05 was considered significant. The study was approved by the institutional ethical committee.

Results

Total 107 babies, including 42(39.3%) ELBW neonates were enrolled in the study. Baseline characteristics and morbidity pattern of neonates is presented in Table 1. The mean gestational age (SD) was 29.7(±2.57) wk, and mean birth weight was 1077(± 219.8) g.

Most common primary diagnosis requiring radiographic examination in the study group was sepsis (64.5%); followed by respiratory distress syndrome (62.6%). Out of total 704 radiologic procedures, most common procedure was chest X-ray ($n = 437$, 62%). On sub-group analysis, median radiation dose exposure was significantly higher in ELBW babies when compared with VLBW group [139.4 μsv (81.6–256.15) *vs.* 46.6 μsv (14.4–115.7); p value <0.0001]. Median number of radiographs in ELBW babies were 3.7 times higher than VLBW group [7.5(5–13.25) *vs.* 2(1–6); p value <0.0001]. Three (7%) out of 42 babies in ELBW group and 1(1.5%) in VLBW group were exposed to >1mSV radiation which is the maximum allowable radiation dose exposure during the whole pregnancy [4]. Eleven babies received ≥15 X-ray (9 in ELBW *vs.* 2 in VLBW) (Table 1).

Discussion

The most important finding in the present study is that the extreme premature babies are exposed to significantly higher

Table 1 Summary of results

A.	**Patient Characteristics**	
	Total no. of babies (n, %)	107(100)
	Male (n, %)	59(55.1)
	Gestational Age (Mean ± SD)	29.7(2.57)
	Birth weight (Mean ± SD)	1077(219.8)
	ELBW babies (n, %)	42(39)
	Clinical sepsis (n, %)	69(64.5)
	HMD (n, %)	67(62.6)
	PDA (n, %)	27(25.2)
	Congenital pneumonia (n, %)	21(19.6)
	BPD (n, %)	14(13)
	TTN (n, %)	6(5.6)
	VAP (n, %)	6(5.6)
	Pneumothorax (n, %)	3(2.8)
B.	**Total events of radiation exposure (n = 704)**	
	Chest X-ray, [n(%)]	437(62)
	Abdominal X-ray, [n(%)]	50(7.1)
	Infantogram, [n(%)]	145(20.6)
	Barium enema, [n(%)]	6(0.85)
	CT scan, [n(%)]	3(0.42)
	X-ray for central line [n(%)]	63(8.95)
C.	**Comparison of ELBW *vs.* VLBW**	
	No. of X-rays (median, IQR)	7.5(5;13.25) *vs.* 2(1;6) ($p < 0.0001$)
	No. of babies receiving >15 X-rays [n(%)]	9(21.4) *vs.* 2(3.07)
	No. of babies requiring 1 or less X-rays [n(%)]	1(2.4) *vs.* 25(38.46)
	Radiation dose (μsv) (median, IQR)	139.4(81.6;256.15) *vs.* 46.6 (14.4;115.7); p <0.0001
	No. of babies receiving >1 mSV radiation [n(%)]	3(7.1) *vs.* 1(1.5)

BPD Bronchopulmonary dysplasia, *ELBW* Extremely low birth weight, *HMD* Hyaline membrane disease, *IQR* Interquartile range, *NICU* Neonatal intensive care unit, *PDA* Patent ductus arteriosus, *TTN* Transient tachypnea of newborn, *VAP* Ventilator associated pneumonia, *VLBW* Very low birth weight

dose of radiation. There is no recommended safe level of radiation exposure in preterm neonates. In the present study, 4 neonates were exposed to >1 mSV radiation, which is the maximum allowable radiation dose exposure during the whole pregnancy [1, 4]. Similar observations of high cumulative dose of radiation exposure was made by Lau et al. and Sutton et al. [5, 6].

Premature infants are often too small to easily target one area of the body without obscuring critical areas of interest. As a result they may receive a higher effective radiation dose than adults, and highly vulnerable tissues (thyroid, gonads and brain) are often included [2, 7]. There are reports of dose-dependent increase in the risk of leukemia and brain tumors in children exposed to CT scans during childhood [8].

Higher mitotic activity, greater radiosensitivity and longer lifetime to manifest consequences, makes preterm neonatal population more vulnerable to radiation damage. Lifetime risk of malignancies due to radiation exposure in neonatal period is not known [4, 6]. Long term follow-up studies of ELBW infants and epidemiologic studies are required to delineate this risk.

Alternative approaches are needed to reduce the use of X-rays in NICU like increase in use of point of care ultrasound for lung pathology, location of endotracheal tube and central line tip location. Studies comparing the use of ultrasound to X-rays for placement of central lines have found that ultrasound is more accurate than X-rays in determining central line route and tip placement [9, 10].

The limitation of the present study is that standard reference dose was used as dosimeter was not available. Scatter and organ specific dose was not calculated. Strength of present study is that it is a prospective study and authorrs tried to decrease the discrepancy by examining the actual radiograph instead of what was ordered. The aim of present study was to quantify level of exposure; therefore, long term effects are not studied.

Conclusions

Radiation exposure is significantly higher in ELBW neonates and it is a matter of concern as lifetime effects of ionizing radiation exposure during neonatal period are not known. Radiation exposure in the NICU should be monitored and strategies must be employed to minimize the number of X-rays and maximize the use of protective shielding. Imaging modality without risk of ionizing radiation such as ultrasound should be preferred over X-ray, wherever possible.

Authors' Contribution GAPK: Collected and analyzed the data and wrote the first draft; TBP: Conceptualized the study, supervised data collection; DP: Helped in data collection and analysis; AP: Supervised the study and will act as guarantor for the study.

Compliance with Ethical Standards

Conflict of Interest None.

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