

## Original Research Article

# Radiation exposure in neonatal intensive care unit of tertiary care hospital: a retrospective study

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## ABSTRACT

**Background:** This is retrospective observational study with aims to determine the mean number of radiographs exposure of neonates during their stay in the NICU and to identify risk factors for higher radiation exposure.

**Methods:** Total 1139 neonates were included in study. The following data were collected, birth weight, gestational age, risk factor, duration of stay, number and indication of radiograph and total radiation exposure. Radiograph was done by using Genuine™ portable X-ray machine. Each radiograph exposure accounts to 0.02 millisieverts (mSv) as per the manufacturer brochure. Statistical analysis was done by using SPSS var 23, ANOVA test, unpaired t-test was applied to test significance and p value of <0.05 was considered significant.

**Results:** Total 1139 neonates were enrolled of which 624 (54.8%) were male babies. Mean number of radiographs for entire sample was 2.76 (radiation exposure 0.05 mSv) with standard deviation (SD) of 2.97 (0.06mSv). Newborns < 28 weeks of gestation are more exposed to radiation with mean radiation of 0.1mSv±0.1mSv. Study observed that there is significant negative correlation of birth weight ( $r=-0.277$ ) and gestational Age ( $r=-0.345$ ) to radiation exposure. This indicates babies with prematurity and low birth weight are more exposed to radiation.

**Conclusions:** There is significant positive correlation between radiograph exposure and duration of stay ( $r=0.568$ ) showing prolonged hospitalization causes more radiation exposure. Strategies to reduce radiation exposure, like using point-of-care ultrasound thus avoiding long term adverse effect. To know whether early radiation exposure may lead to adverse long-term consequences, follow-up study is necessary.

**Keywords:** Neonatal intensive care unit, Preterm, Low birth weight, Radiation exposure, Radiographs

## INTRODUCTION

The most common indication for admission to the NICU is respiratory distress. A simple aid to diagnosis of respiratory distress is the chest radiograph.<sup>1</sup> Advanced neonatal care has increased the survival of extremely preterm and low birth weight babies.<sup>2</sup> Throughout their stay in the NICU, newborns are repeatedly subjected to radiographs.<sup>1</sup> In the NICU, radiographs are often taken following a variety of procedures. This observational study aims to determine the mean radiation exposure to

newborns from radiographs during their stay in the NICU and to identify risk factors for higher radiation exposure.

## METHODS

This was a retrospective observational study conducted between February 2022, and May 2023 in a level 3 NICU. Study place- Postgraduate Institute, Yashwantrao Chavan Memorial Hospital, Pimpri, Pune. Inclusion criteria: all neonates admitted to the NICU during study periods were included. Exclusion criteria: those neonates

who took discharge against medical advice. The following data were collected, birth weight, gestational age, risk factors (need for invasive or non-invasive ventilation (NIV), respiratory distress syndrome (RDS), surfactant requirement, necrotizing enterocolitis (NEC) and sepsis), duration of stay, number of radiographs (chest X-ray and abdominal X-ray), indication of radiograph and total radiation exposure. The radiograph was done by using a Genuine TM portable X-ray machine.

Each radiograph exposure accounts for 0.02 millisieverts (mSv) per the manufacturer brochure. RDS was defined clinically as respiratory distress (tachypnoea, retraction, cyanosis, and grunt) and radiological features of RDS on chest X-ray. Sepsis was defined as positive blood or cerebrospinal fluid culture or clinical features of sepsis. NEC was defined based on the modified Bell's classification of stage 1 or more. Statistical analysis was done by using SPSS version 23, an unpaired t-test was applied to test significance, and p value of <0.05 was considered significant. The study was approved by the institutional ethical committee.

**RESULTS**

A total of 1139 neonates were enrolled of which 624 (54.8%) were males. As per gestational age, we divided neonates into 4 subgroups. 82 (7.1%) were <28 weeks, 245 (21.5%) between 28 to 32 weeks, 379 (33.3%) between 32 to 36 weeks, and 433(38.1%) were >36 weeks of gestation. We studied the mean number of radiographs performed and the risk factors for radiograph exposure in this subgroup. The mean number of radiographs for the entire sample was 2.76 (radiation exposure 0.05 mSv) with a standard deviation (SD) of 2.97(0.06mSv). Table 1 shows radiographic exposure

was higher in newborns less than 28 weeks of gestation age and exposure reduced with increasing gestational age. The mean number of radiographs compared by gestational age was found to differ significantly based on gestational age using the ANOVA test.

**Table 1: Mean number of radiographs according to gestational age.**

Gestational age (weeks)	N	Mean number of radiographs ± SD
<28	82	5.28±5.12 (0.10±0.10 MSV)
28-32	245	3.85±3.43 (0.08±0.06 MSV)
32-36	379	2.34±2.18 (0.05±0.04 MSV)
>36	433	2.05±2.22 (0.04±0.05 MSV)
<b>Total</b>	<b>1139</b>	<b>2.76±2.97 (0.06±0.06 MSV)</b>

Values are mean±SD. Comparison by one-way ANOVA-f=46.691, p<0.001 (significant).

Table 2 shows various risk factors for radiograph exposure and observed that newborns with risk factors had a statistically higher radiograph exposure than newborns without risk factors. Table 3-5, we studied risk factors for radiograph exposure in gestational age subgroups.

We observed that babies having risk factors were exposed to a greater number of radiographs. Table 6 shows that there is a significant negative correlation between birth weight (r=-0.277) and gestational Age (r=0.345) to radiation exposure. This shows babies with prematurity and low birth weight are more exposed to radiation. There is a significant positive correlation between radiograph exposure and duration of stay (r=0.568) showing prolonged hospitalization causes more radiation exposure.

**Table 2: Association of clinical risk factors with number of radiographs.**

Risk factor	Present	Absent	Mean±SD (present)	Mean±SD (absent)	P value
<b>Ventilation</b>	404	735	4.87±3.95	1.60±1.14	<0.001
<b>NIV</b>	604	535	3.23±3.06	2.24±2.77	<0.001
<b>RDS</b>	209	930	5.37±4.45	2.18±2.12	<0.001
<b>Surfactant therapy</b>	170	969	6.05±4.60	2.19±2.10	<0.001
<b>Sepsis</b>	625	514	3.24±3.38	2.18±2.24	<0.001
<b>NEC</b>	92	1047	5.24±3.27	2.55±2.84	<0.001

Values are mean±SD. Comparisons performed using independent t-test. NIV: non-invasive ventilation, RDS: respiratory distress syndrome, NEC: necrotizing enterocolitis.

**Table 3: Mean number of radiographs according to ventilation status and gestational age.**

Gestational age (weeks)	Invasive ventilation (yes)	Invasive ventilation (no)	P value	NIV (yes)	NIV (no)	P value
<28	6.93±4.89	2.83±1.47	0.04	8.42±5.87	3.98±4.18	<0.001
28-32	5.18±3.91	2.17±1.53	<0.001	3.75±3.03	2.73±1.95	0.01
32-36	4.63±2.91	1.57±1.09	<0.001	2.73±2.21	1.84±2.05	<0.001
>36	4.26±3.65	1.42±0.86	<0.001	2.65±2.71	1.56±1.58	<0.001

Values are presented as mean±standard deviation (SD). Comparisons were made using independent t-test. NIV: non-invasive ventilation. A p value <0.05 was considered statistically significant.

**Table 4: Mean number of radiographs in neonates with RDS and surfactant therapy by gestational age.**

Gestational age (weeks)	RDS (yes)	RDS (no)	P value	Surfactant (yes)	Surfactant (no)	P value
<28	7.48±5.01	1.67±0.58	0.047	6.26±5.42	2.25±2.17	0.002
28-32	5.43±4.15	2.61±2.01	<0.001	6.12±4.37	2.69±2.03	<0.001
32-36	5.16±2.97	2.19±2.03	<0.001	5.36±3.06	2.15±1.97	<0.001
>36	4.67±2.08	2.04±2.21	0.04	4.67±2.52	2.03±2.21	0.04

**Table 5: Mean number of radiographs in neonates with sepsis and NEC by gestational age.**

Gestational age (weeks)	Sepsis (yes)	Sepsis (no)	P value	NEC (yes)	NEC (no)	P value
<28	8.18±5.08	3.33±4.17	<0.001	8.50±4.34	4.73±5.06	0.017
28-32	4.07±3.69	2.96±2.01	0.03	5.33±3.28	3.52±3.38	0.001
32-36	2.28±2.18	1.57±0.77	0.01	4.17±1.79	2.18±2.14	<0.001
>36	3.09±3.49	1.82±1.74	<0.001	3.17±1.72	2.03±2.22	0.213

A significant negative correlation was observed between the number of radiographs and both birth weight and gestational age. Lower birth weight was associated with a greater number of radiographs and similarly, infants with lower gestational age underwent more radiographic examinations. In contrast, there was a strong positive correlation between duration of hospital stay and radiograph exposure, indicating that infants requiring prolonged hospitalization were more frequently subjected to imaging.

**Table 6: Correlation between number of radiographs and clinical variables.**

Variable	Pearson correlation (r)	P value
Birth weight	-0.277	<0.001
Gestational age	-0.345	<0.001
Duration of hospital stay	0.568	<0.001

N- numbers, SD- standard deviation, SE- standard error.

## DISCUSSION

The important findings in the present study are babies with extreme prematurity, extremely low birth weight babies, and babies having prolonged hospitalization in NICU were exposed to more radiographs. The mean number of radiographs for the entire sample size is 2.76 (0.06mSv) with SD 2.97 (0.06mSv). Neonates less than 28 weeks of gestation are more exposed to radiation with mean radiation of 0.1mSv±0.1mSv. We studied different risk factors and observed that babies with risk factors are more exposed to radiographs than babies with no risk factors. Similar to our finding Ono et al in 2002 analysed the relationship between the frequency of radiographic examination to birth weight, gestation age, and stays in NICU and observed that prematurity, low birth weight, and prolonged hospitalization were associated with a greater number of radiographs performed.<sup>3</sup> Similar findings were also reported by Donadieu J et al in 2006.<sup>4</sup> There is no recommended safe level of radiation exposure

in neonates. However, there are reference dose limits based on general radiography of newborns which do not consider the unique NICU imaging environment and radiosensitivity of newborns. The recommended dose limit for radiation exposure by the International Commission on Radiological Protection in 1991 for newborns was 1mSv which is used for reference.<sup>5</sup> No neonates in the present study were exposed to radiation ≥1mSv while 11 (5.1%) neonates in a study by MV Scott et al and 4 neonates in a study by G Kartikeshwar et al received more than the maximum recommended radiation from radiographs.<sup>6,7</sup> In our centre, we minimized radiation exposure by only ordering radiographs of babies in whom radiographs were clinically warranted.

Radiation exposure to extremely susceptible tissues such as the brain, gonads, and thyroid gland occurs frequently during radiography because premature neonates are too small to target a single part of the body.<sup>3-8</sup> According to several research, children who undergo high radiation exposure are more likely to develop brain tumours and leukemia.<sup>9-11</sup> There are strategies to reduce radiation exposure, like using point-of-care ultrasound thus avoiding long-term adverse effects. A study by Copetti R et al speculated that lung ultrasound is a reliable tool in the diagnosis of RDS and a guide for the administration of surfactant.<sup>12</sup>

Divya Durga et al in their study concluded that bedside lung ultrasound has emerged as an accurate, early, cost-effective, and radiation-free tool for the diagnosis of respiratory distress in neonates requiring NICU admission.<sup>13</sup> The study's strength lies in its large sample size, which allows for the analysis of mean radiation exposure and risk factors for higher radiation exposure in each gestational age grouping. The two main limitations of this study are that the radiation doses employed were published average effective doses for newborns obtained from the scientific literature, and the study is a retrospective observational study of NICU infants. To know whether early radiation exposure may lead to

adverse long-term consequences, a follow-up study is necessary.

## CONCLUSION

There is significant positive correlation between radiograph exposure and duration of stay ( $r=0.568$ ) showing prolonged hospitalisation causes more radiation exposure. Strategies to reduce radiation exposure, like using point-of-care ultrasound thus avoiding long term adverse effect.

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