Original Article

Monitoring of measurement of radiation doses in paediatric age group in NICU and PICU

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Abstract

Radiation doses received by the different age groups in NICU and PICU and general are studied. This study was observed /done under strict observation of the radiation norms laid by the AERB and international radiation protection rules. Dedicated X-Ray Unit, Careful collimation, minimum / optimum radiation factors, appropriate FFD, 1.5 mm Aluminum filter, C.R. cassettes, verified and calibrated X-Ray Machine, calibrated X-Ray dosimeter, were taken care of. The radiation survey is made to check the radiation exposure received by the patient in multiple exposure is under the safer limit laid by the international and by Indian Radiation Authority. Critical image quality of Radiographs was evaluated by Pediatric and departmental Radiologists. The result shows a linear relationship between the dose received and age of the patient. Chest X-Ray examination for Pediatric Chest X-Ray study was studied in NICU, PICU to assess the radiation dose received and conclusion were made. ESD was calculated from quality control measurements on the X-Ray unit itself. Direct measurements of radiation doses also measured using, highly sensitive, calibrated, tested for consistency in sensitivity, dosimeter. A study has been made of X-Ray examination of Pediatric patients in the B.V.D.U. Medical College and Hospital, Sangli, to provide information on pediatric dose levels.
Keywords: Radiation, millisievert, microsievert, age, dose, chest, dose limit. Gamma Sapiens.

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INTRODUCTION

The mean radiation dose which is observed should not exceed 0.1 microsievert/h. The calibrated Phillips X - Ray Unit was used. The overall dose per patient (individual) regardless of sex is noted. The corresponding results for the chest examination are 0.08 - 0.1microsivert. The calculated total radiation risk per radiograph was found low. Results of this study are in good agreement with previous studies and international norms. Obtaining routine chest radiographs daily has become widely accepted. It is the prime study for the evaluation and to decide the line of treatment. Risk to paediatric patients from radiation exposure is acknowledged to be greater than those to other groups. It is, therefore, of particular importance to ensure that doses to these patients from X-Ray exposure are kept to a minimum. Available data on pediatric doses is limited and comparisons are difficult to make because of the range in patients size, age, etc. The exposure given for a particular examination should be closely related to patient's thickness. And here the radiographer has applied his expertise to apply the technique. AERB guidelines show that the maximum permissible dose to patient in a year should not exceed 5 rem per year. Following some of the norms laid by the AERB of India and International radiation authorities. The radiation risk in the infants is more than the adults, because increasing chances for development of delayed radiogenic cancers as consequences of reduced longer life expectancy. It is therefore important to ensure that radiation doses from radiographic examinations carried out in NICU / PICU are kept to a minimum whilst maintaining the quality of radiographic image. Paper

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describes a prospective study of paediatric study of radiation dose received in the NICU /PICU at B.V.D.U. Medical College and Hospital, Sangli, (limited) study of dose measurement is made and recorded. Finally an attempt has been made to evaluate the dose received by the NICU / PICU patient is under safe limit. The magnitude of the radiation risk also depends on the age of patient and what the exposure took place. Since they are new born with problems such as respiratory distress syndrome and congenital cardiac diseases, their monitoring and treatment often necessitates an increase no of X-Ray examinations during the first few weeks of life. The small body volume and the extremely low birth weight of neonates bring sensitive organs within the range of the X-Ray beam or close to the limits resulting in a higher overall exposure relative to adult.

MATERIAL AND METHODS

Only emergency, genuine, required X-Rays which were taken were studied. Not a single X-Ray was taken for experimental condition. Clinicians were aware of the objectives of our study. Routine radiography was conducted observing the FFD, Tube alignment, Aluminum filter, optimum / correct/ minimum exposure, proper positioning, collimeter, C.R. Cassette (Agfa made), All X-Ray machines are AERB approved and calibrated observing the norm of radiation protection. Patients information, kVp applied, mAs, FFD, age, radiation dose received, type of radiograph were reported. Data was collected for 100 patients with age ranging from 1 to 15 years. For the portable X-Rays the X-Ray units -- make Siemens --- 5510 Multimobil 2.5 with 1-phase, 3 pulse generators, and 15degree anode angle were used. And X-Ray machine make, Allens AXD – 60, 1 phase, 3 pulse generator full wave rectifier, with 15 degree anode angle was used. Both were having 2.5mm aluminum filter (including intrinsic filter). Patients who were in the NICU / PICU, only during days, on which data was collected. Radiographer along with the NICU / PICU staff was instructed about the exposure and the radiation protection and they all were observing the norms. The radiation monitoring / detecting device used was EC Test Gamma Sapiens, intellectual Gamma Radiation Detector Compatible with apps, and wireless connection with Bluetooth channel features. Built in Geiger – Muller counter of high sensitivity, communication with smart-phone and tablet PC's on the Android OS vise The Bluetooth interface.

Figure 1: Latest Equipment available in India and internationally

Findings were divided into the following categories

- 0 – 15 days verses Dose received.
- 16 – 90 days verses Dose received.
- 91 - 360 days verses Dose received.
- 1 year – 5 years verses Dose received.
- 5 years - above verses Dose received.

We also collected the information about the history, provisional diagnosis, results of physical examinations, laboratory results, but this information is not described here because it is out of the scope of this study. Cost: no cost is noted against this study as it was the regular routine examination.

Basic Dosimeter qualities used to indicate patient doses

Absorbed dose: the fundamental quantity for describing the effect of radiation in a tissue or organ is the absorbed dose. Or AD is defined as the quantity of radiation that results in an energy deposition of 1 Joule per Kilogram within the irradiated material. AD is the energy deposited in a small volume of a matter or tissue by the radiation beam passing through the matter divided by the mass of the matter. AD is measured in Joules/Kg, and a quantity of 1 joule/Kg has the specific unit of Gray (Gy) in the international system of qualities and units. In terms of the older system of radiation quantities and units previously used;

1Gy = 100 rad or

1 mGy = 0.1 rad.

Equivalent dose: The biological effects of an absorbed dose of a given magnitude are dependent on the type of radiation delivering the energy and the amount of radiation absorbed. The radiation weighing factor is a dimensionless constant, the value of which depends on the type of radiation. Thus absorbed dose (inGy) averaged over an entire organ and multiplied by dimensionless factor, the radiation weighting factor gives the equivalent dose. The unit for the quantity equivalent dose is the Sievert (Sv). Thus the relation is;

Equivalent dose (in Sv) = absorbed dose (in Gy) x radiation weighting factor /quality factor (Q)

In the older system of units, equivalent dose was described by the unit 'rem' (Roentgen-Equivalent Man).

1 Rem = 100 Sv = 1 rad * QF,
or
Rem, unit of **radiation** dosage (such as from X rays) applied to humans. Derived from the phrase **Roentgen equivalent man**, the **rem** is now defined as the dosage in **rads** that will cause the same amount of biological injury as **one rad** of X rays or gamma rays.
1 Sv = 100 rem or
1mSv = 0.1rem
Effective dose: The risk of cancer induction from an equivalent dose depends on the organ receiving the dose. The effective dose is calculated by determining the equivalent dose to each organ irradiated and then multiplying the equivalent dose by a tissue- specific weighting factor for each organ and tissue type. These products are then summed overall the irradiated organs to calculate the "effective dose". The effective dose is, by definition, an estimate of the uniform whole body equivalent dose that would **produce** the same level of risk for adverse effect that result from the non uniform partial body irradiation. The unit of effective dose is also the Sievert (Sv).
The Effective Dose = Equivalent Dose To Each Organ Irradiated X
Tissue- Specific Weighting Factor For Each Organ and Tissue Type
Here in this study the equivalent dose measurement is considered. An older unit for the dose equivalent is the rem, still often used in the United States. One sievert is equal to 100 rem:

100.0000 rem	=	100,000.0 mrem	=	1 Sv	=	1.000000 Sv	=	1000.000 mSv	=	1,000,000 µSv
1.0000 rem	=	1000.0 mrem	=	1 rem	=	0.010000 Sv	=	10.000 mSv	=	10000 µSv
0.1000 rem	=	100.0 mrem	=	1 mSv	=	0.001000 Sv	=	1.000 mSv	=	1000 µSv
0.0010 rem	=	1.0 mrem	=	1 mrem	=	0.000010 Sv	=	0.010 mSv	=	10 µSv
0.0001 rem	=	0.1 mrem	=	1 µSv	=	0.000001 Sv	=	0.001 mSv	=	1 µSv

This SI unit is named after Rolf Maximilian Sievert.
Frequently used SI prefixes are the millisievert (1 mSv = 0.001 Sv) and microsievert (1 µSv = 0.000001 Sv) and commonly used units for time derivative or "dose rate" indications on instruments and warnings for radiological protection are µSv/h and mSv/h. Regulatory limits and chronic doses are often given in units of mSv/a or Sv/a, where they are understood to represent an average over the entire year. In many occupational scenarios, the hourly dose rate might fluctuate to levels thousands of times higher for a brief period of time, without infringing on the annual limits. The conversion from hours to years varies because of leap years and exposure schedules, but approximate conversions are:
1 mSv/h = 8.766 Sv/a or 114.1 µSv/h = 1 Sv/a
Conversion from hourly rates to annual rates is further complicated by seasonal fluctuations in natural radiation, decay of artificial sources, and intermittent proximity between humans and sources. The ICRP once adopted fixed conversion for occupational exposure, although these have not appeared in recent documents:
8 h = 1 day or 40 h = 1 week or 50 weeks = 1 year
Therefore, for occupation exposures of that time period,
1 mSv/h = 2 Sv/a or 500 µSv/h = 1 Sv/a
Collection and analysis of Data:
Alteration and technical factors at radiography to reduce the doses without compromise radiographic qualities. Table contains all the data. We have examined the patients and the tabular form is as shown below. The graphical presentation is as follows, as per the categories divided.

Table 1

Sr. no	Age in Years	SEX	Kv	mAs	Dosemeter reading microSv/h
1	1	M	44	6	0.08
2	1	M	44	4	0.09
3	4	F	46	5	0.1
4	4	M	44	6	0.08
5	7	F	55	8	0.1
6	8	M	46	6	0.1
7	10	M	44	6	0.08
8	10	M	46	5	0.1
9	14	F	52	5	0.1
10	14	M	52	5	0.01
11	15	M	48	5	0.09
12	15	M	48	6	0.1
13	16	F	50	8	0.12

Table 2

Sr. no	age in days	SEX	Kv	mAs	Dosemeter reading microSv/h
1	1	F	40	3.2	0.06
2	1	M	40	3.2	0.07
3	1	M	40	3.2	0.06
4	1	M	40	3.2	0.07
5	1	F	40	2.5	0.05
6	1	M	40	3.2	0.07
7	1	F	40	2.5	0.06
8	1	M	40	3.2	0.08
9	1	F	3.2	40	0.08
10	1	M	40	2.5	0.05
11	1	F	40	3.2	0.07
12	2	M	40	3.2	0.06
13	2	M	40	4	0.06
14	2	F	40	3.2	0.06
15	2	M	40	3.2	0.08
16	2	F	40	2.5	0.05
17	2	M	40	3.2	0.07
18	3	M	40	3.2	0.06
19	3	F	40	4	0.09
20	3	F	40	4	0.09
21	3	M	40	3.2	0.07
22	3	F	40	4	0.09
23	3	F	40	4	0.09
24	3	M	40	3.2	0.07
25	4	F	40	3.2	0.1
26	4	M	40	3.2	0.1
27	5	M	40	4	0.09
28	5	F	40	3.2	0.06
29	5	F	40	3.2	0.06
30	6	M	40	4	0.09
31	8	F	40	3.2	0.08
32	6	M	40	3.2	0.08
33	6	M	40	4	0.09
34	8	F	40	3.2	0.08
35	9	M	40	3.2	0.08
36	10	F	40	3.2	0.08
37	10	M	40	3.2	0.06
38	10	M	40	4	0.09
39	10	F	40	4	0.09
40	10	M	40	4	0.09
41	10	M	40	4	0.09
42	13	M	55	6.3	0.1
43	13	F	55	6.3	0.1
44	13	M	55	6.3	0.1
45	13	F	55	6.3	0.1
46	27	M	40	3.2	0.06
47	27	M	40	3.2	0.06
48	27	M	40	3.2	0.06
49	30	M	40	3.2	0.06
50	30	M	40	4	0.09
51	30	F	40	4	0.07
52	30	M	40	4	0.08
53	30	F	40	4	0.08
54	60	M	42	4	0.08
55	60	M	46	5	0.09
56	60	F	50	6	0.09

57	60	M	54	7	0.08
58	90	F	46	5	0.09
59	90	M	44	6	0.09
60	90	F	44	6	0.09
61	90	M	44	6	0.08
62	90	F	44	6	0.08
63	90	F	46	5	0.09
64	90	F	40	3.2	0.1
65	120	M	44	6	0.08
66	130	F	46	5	0.09
67	150	F	48	5	0.1
68	180	F	46	5	0.09
69	180	F	44	6	0.08
70	210	M	44	4	0.1
71	210	F	42	36/ 60 mA	0.09
72	210	F	46	5	0.09
73	210	F	44	6	0.08
74	210	M	44	6	0.08
75	240	M	48	5	0.09
76	240	M	44	4	0.1
77	240	M	48	5	0.09
78	240	M	44	4	0.1
79	270	F	46	5	0.09
80	270	F	46	5	0.1
81	270	M	46	5	0.09
82	300	M	46	6	0.1
83	330	M	44	4	0.09
84	330	M	44	4	0.08
85	330	M	44	6	0.08
86	340	F	44	4	0.08
87	360	M	44	4	0.09

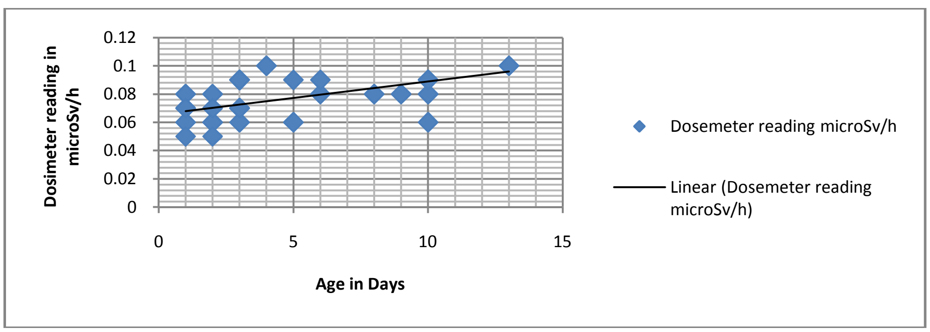

Figure 1: **0 – 15 days verses dose received**

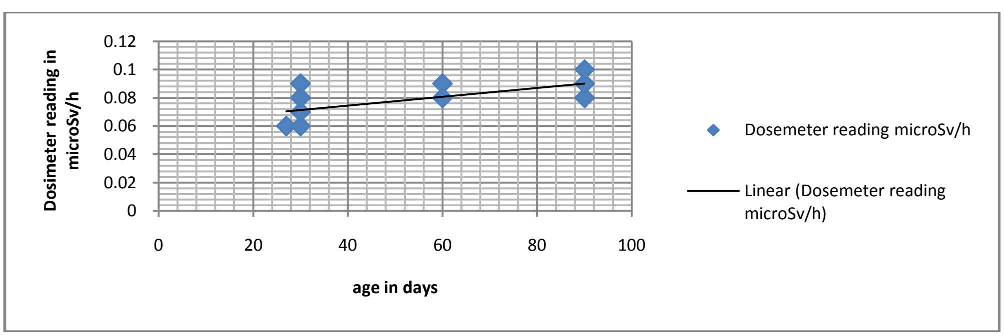

Figure 2: 16 – 90 days verses dose received

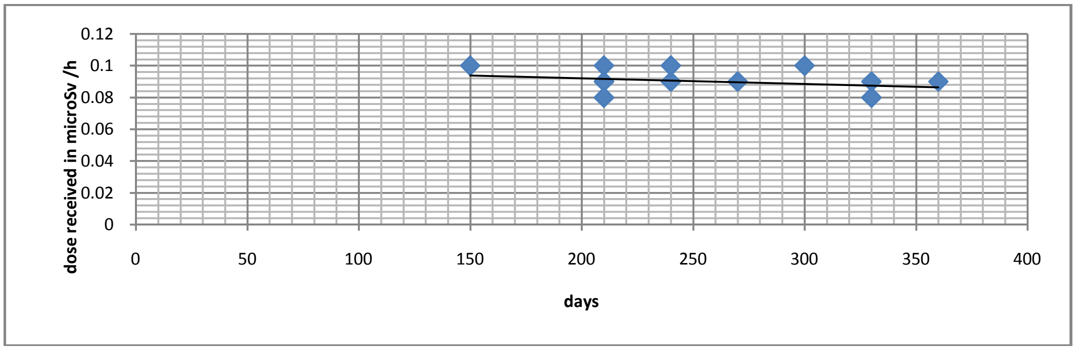

Figure 3: 91 -360 days verses dose received

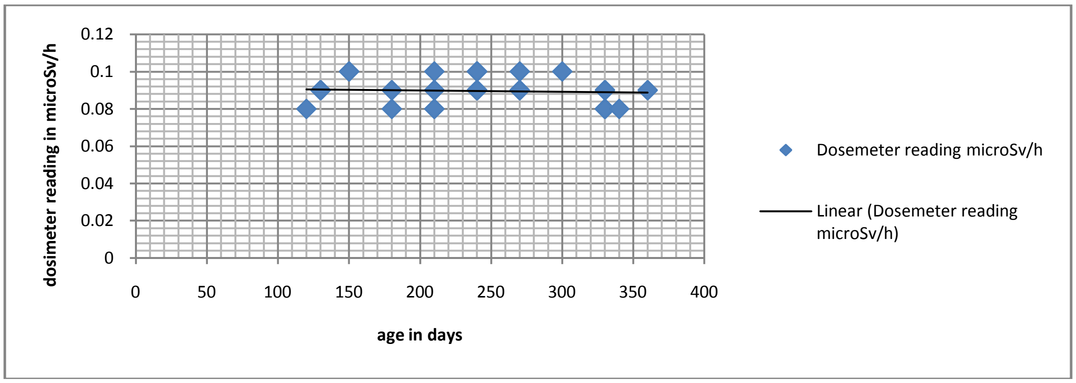

Figure 4: 91 - 360 days verses dose received

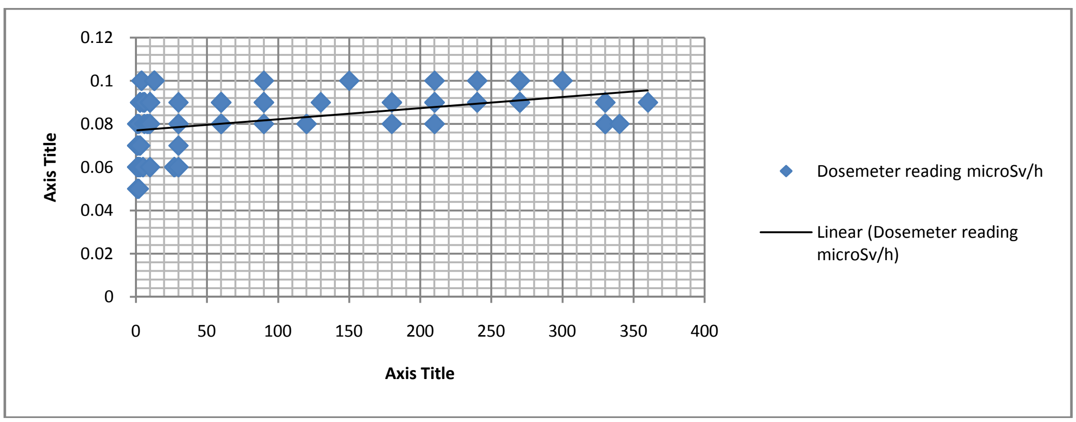

Figure 4a: 0-365 days verses Dose received

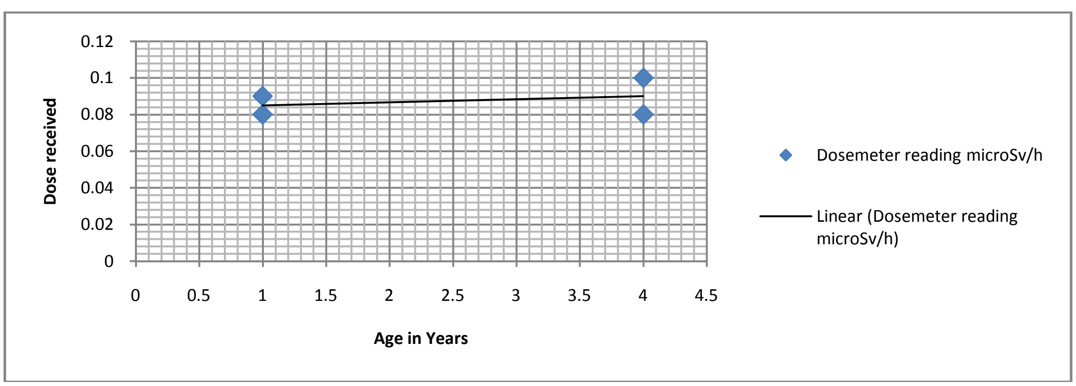

Figure 5: 1 year – 5 years verses dose received

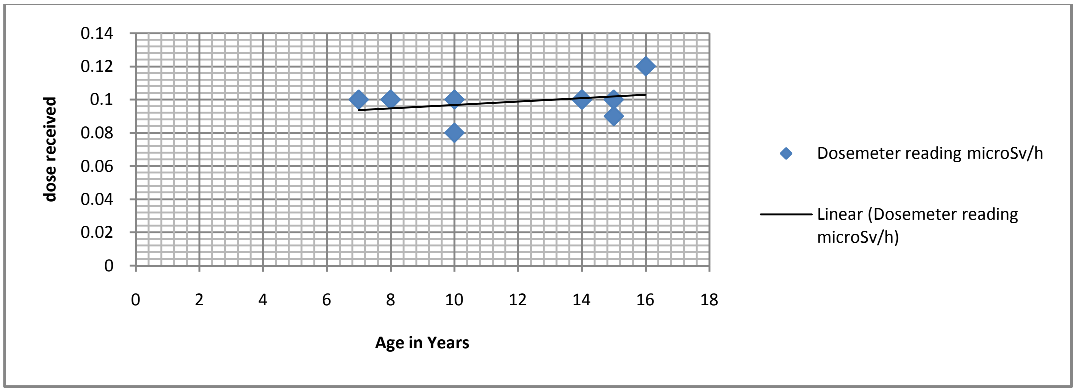

Figure 6: 5 years – above verses dose received

RESULT AND DISCUSSION

Conversion of Radiation dose units from microSv/hour to milliSv/annum

We have to convert the dose units because the dose readings were taken in microSv/hour and according to the SI norms and AERB and ICRP norm the safer limits are given in milliSv / annum or in millirem / annum; according to old system.

Effective dose to Public should not exceed 1milliSv per year = 1 mSv/a equivalent = 100mrem / annum. Converting the units

- 500microSv/ h = 1Sv/a
- 0.1 microSv/h = 0.2 milliSv/a

1. That means 0.2 milliSv/a = one chest X-Ray = 20mrem / annum.
2. Therefore 1 milliSv/a = 5 chest X-Rays = 100 mrem / annum

The average effective dose received by a neonate in this study per chest X-Ray ranges in between 0.08 to 0.1 microSv/h = 0.16 to 0.2 mSv/annum. The mean value of measured radiation dose to a neonate is found to in safer limit**.** The increased trend of a graph is due to increase in age and hence mass/weight. The radiographs which were taken were of good quality, the good exposure factor, and hence result show an appropriate radiation factors applied and those radiation dose were also under safer limits. The result show that the in Graph no 1, to graph 6 the radiation dose to a neonate has not exceeded the limit. i.e. greater than 0.1 microSv/h or 0.2 milliSv/annum. The mean radiation dose received by the patient is found to be 0.09 microSv/h. The vertical deflection of the radiation dose is due to weight or the thickness of the patient, which is not the scope of this study. But it well agrees with the study done by the different authors.

CONCLUSION

Radiography of the newborn and infants should be performed with full knowledge and carefulness to avoid possible harmful effects. Observing the norms and the radiation protection the high image quality was also a concern. Although the radiation risk of the X-Ray examination was found to be low. Repetition of radiograph should be maintained at 0.09% to avoid additional needless dose to the patient. Dose measurements in this study show clear relationship of patient's age with the radiation dose received and it indicates that reference doses are well below the safer limits. The data that has been collected and the graphical interpretation and the comparison with the AERB and International norms, the radiation dose to patient from NICU and PICU are well within the safer limit. The multiple exposures can be allowed, if it is necessary, otherwise no. Hence the radiographic study that has been performed in the B.V.D.U. Medical College and Hospital, Sangli is found to be within the safe limits as laid down by radiation authority. Comparison between different age groups and the dose received shows consistency and almost constant linear relationship. Measured dose was found below the current reference dose levels. The increase number of radiographic examinations that a neonate may receive during hospitalization in a neonatal intensive care unit should not be disregarded. The steady linear rise in the exposure dose is due to the increase of age and their increased weight accordingly.

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