



## Radiation exposure from conventional radiographic examinations in very and extremely low birth weight patients

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### ABSTRACT

The survival of very premature neonates has improved significantly at the last decades owing to the utilization of modern intensive care interventions that usually requires prolonged hospitalisation and are accompanied by frequent radiographic examinations. Their elevated radiosensitivity and numerous examinations combined with their greater remaining lifetime raise the issue of high risk for radiation-induced malignancies. Because it is presently impossible to substitute this type of examinations with others that do not involve radiation exposure, investigations on a hospital's routine practices becomes relevant. In this work, we present the results of an investigation on the radiation exposure of patients with birth weight lower than 1500 g in one paediatric hospital in Brazil. We analyse some important patient characteristics, like weight, gestational age, length of stay, and number of radiographs performed in the neonatal intensive care unit, in connection with the patient dose. The obtained results are compared with the existing information from other studies.

### 1. Introduction

The survival of very premature neonates has improved significantly at the last decades owing to the utilization of modern intensive care interventions that usually requires prolonged hospitalisation and are accompanied by frequent radiographic examinations.

Currently, the radiosensitivity of a newborn is considered to be higher than that of a mature child or an adult. Their elevated radiosensitivity and numerous examinations combined with their greater remaining lifetime raise the issue of high risk for radiation-induced malignancies.

Because it is presently impossible to substitute this type of examinations with others that do not involve radiation exposure, investigations on a hospital's routine practices becomes relevant. The main goal of such studies is to determine the radiographic techniques that result in the lowest possible dose in the case of un-cooperative patients that are surrounded with a number of life-support systems and X-ray equipment that was not specially designed for such small patients.

Among the studies performed in neonatal intensive care units (NICUs), some investigations separate patients with low weight in their analyses (Dabin et al., 2013; Smans et al., 2008; Datz et al., 2008; Donadieu et al., 2006; Ono et al., 2003) and only a few have

concentrated on such patients (Arad et al., 2009; Puch-Kapst et al., 2009; Sutton et al., 1998; Wilson-Costello et al., 1996).

In this work, we present the results of an investigation on the radiation exposure of patients with birth weight lower than 1500 g in one paediatric hospital in Brazil. Additionally, we analyse some important patient characteristics, like weight, gestational age (GA), length of stay (LOS), and number of radiographs performed in the NICU, in connection with the patient dose. The obtained results are compared with the existing information from other studies to find the common factors, which influence the dose received by preterm infants.

### 2. Materials and methods

The study was performed at the Waldemar Monastier public hospital, which specialises in the care of children and adolescents (Campo Largo, Brazil). The research project was approved by the Ethical Committee of the Hospital, which is associated with the Brazilian Federal Government.

The NICU of the hospital has 20 beds. This hospital does not perform cardiac or neurological surgery. For these procedures, patients are transferred to other institutions and are returned to the hospital after the surgery and recovery period.

When admitted to the hospital, premature newborns are placed in

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**Table 1**  
Patient diagnoses.

Diagnosis	Number of neonates
Hyaline membrane disease	25
Patent ductus arteriosus	16
Bronchopulmonary dysplasia	13
Late neonatal infection	10
Early neonatal infection	7
Retinopathy	6
Intra-periventricular haemorrhage Grade III	6
Enterocolitis	5
Pulmonary haemorrhage	3
Intra-periventricular haemorrhage Grade II	3
Intra-periventricular haemorrhage Grade IV	3

Fanem infant incubator model Vision 2186. Upon increase of their size (height and weight), they are transferred from the incubator to a Gigante infant warmer (model Neosolution).

All radiology examinations requested by neonatologists are performed in the NICU using VMI mobile X-ray equipment (model Aquilla Plus 300, 2008) with a CR image receptor and 4.3 mm Al total beam filtration.

The investigation included only infants with birth weight below 1500 g that were admitted to the NICU and discharged between January 2013 and December 2014. For patients temporarily transferred to other institutions for specific procedures, only the radiographic procedures performed at the hospital were considered.

**Table 2**  
Patient characteristics.

Birth weight group (g)	Gestational age (weeks)		Birth weight (g)		Reference
	Mean	Range or stand. dev.	Mean	Range or stand. dev.	
< 750	27.0	24–33	648	510–740	This work Wilson-Costello et al. (1996) Ono et al. (2003) Puch-Kapst et al. (2009)
	25.4	22–27	671	490–745	
	26.7	24–32	662	536–735	
	26.0	24–31	640	445–740	
750–1000	28.2	26–33	875	770–970	This work Ono et al. (2003) Puch-Kapst et al. (2009)
	27.3	24–34	871	756–998	
	27.5	25–36	930	770–995	
1000–1250	29.9	27–33	1135	1000–1240	This work Puch-Kapst et al. (2009)
	30.0	27–35	1150	1015–1250	
1250–1500	30.6	28–36	1376	1260–1500	This work Puch-Kapst et al. (2009)
	30.0	28–36	1356	1260–1500	
< 1500	29.5	24–36	1129	510–1500	This work Sutton et al. (1998) Puch-Kapst et al. (2009)
	28.8	24–34	1110	540–1480	
	29.5	24–36	1100	445–1500	
1000–1500	30.4	27–36	1296	1000–1500	This work Ono et al. (2003)
	31.0	26–40	1286	1001–1499	
< 1000	28.0	2.3	843	113	This work Arad et al. (2009) Arad et al. (2009)
	28.3	2.1	859	100	
	27.0	1.9	824	132	

**Table 3**  
Patients' LOS in NICU.

Birth weight group (g)	Length of stay (days)		Reference
	Mean	Range	
< 750	163	133–182	This work Wilson-Costello et al. (1996) Ono et al. (2003) Puch-Kapst et al. (2009)
	115	77–175	
	172	110–389	
750–1000	97	36–167	This work Ono et al. (2003) Puch-Kapst et al. (2009)
	126	74–236	
1000–1250	75	6–135	This work Puch-Kapst et al. (2009)
	53	36–93	
1250–1500	52	14–247	This work Puch-Kapst et al. (2009)
	55	21–114	
< 1500	46	14–286	This work Sutton et al. (1998) Puch-Kapst et al. (2009)
	73	21–182	
	60	4–239	
1000–1500	56	2–291	This work Ono et al. (2003)
	54	21–114	
	74	40–139	

The patient's sex, GA, birth weight and time spent in the NICU were recorded. Furthermore, the patient's weight was measured several times during hospitalisation and a weight gain chart was constructed. A third-degree polynomial was used to determine the weight on the day

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