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Radiation Protection in the Neonatal Intensive Care Unit

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Introduction

In western countries, the percentage of preterm infants below 37 weeks gestation is around 15%, with most of them requiring admission to Neonatal Intensive Care Unit (NICU).

Problem: Although preterm infants (< 3kg) and newborns (< 5kg) are the most radiation sensitive age-group, they require frequent chest and abdominal X-ray studies during their stays in NICU. Moreover, lower birth weight and gestational age, and longer hospital stays are associated with more frequent X-ray studies.(1)

Introduction

- Mean number of radiographs performed in different NICUs largely varies, ranging from 3 to 35 examinations per infant.[1,2]
- Furthermore, there is large variation in patient's dose applied in different facilities.[3]
- Problem: These differences across published data do not reflect differences in variable severity of illness, only, but differing radiographic techniques or standards of practice.

Solution: Justification & Optimisation

In paediatric radiology, strict and clear operation procedures are required to implement the principles of radiation protection. This involves:

- Compliance with national diagnostic reference levels (DRLs), if existing, or with European DRLs:

		European DRL[4]	IT DRL [4]	German DRL[5]
Thorax AP/PA	< 3kg			DAP= 3 mGy cm^2
	< 5kg	DAP = 15 mGy cm^2	ESD=80µGy	DAP= 5 mGy cm^2
Abdomen AP	< 5 kg	DAP= 45 mGy cm^2		DAP=20 mGy cm^2

AP: anterior-posterior; PA: posterior-anterior; DAP: dose area product; ESD: entrance surface dose.

Solution: Optimisation

- Use of modern systems (e.g., high detective dose efficiency, digital).
- Adaption of protocol parameters such as the mAs-product, tube voltage (low tube voltages, < 80kV) and filter (add 0,1 mm copper filter) to the size of patient's body region being examined.(6)
- Proper centering and collimation.(7)
- Reduction of magnification. For this, the imaging plate should be wrapped in a disposable polyethylene bag and placed under the newborn in direct contact with their body.
- Adequate immobilisation (e.g., restless kids should be kept still by parents).

Chest X-ray: the requisites[8-10]

- Patient supine - centralise chin to limit rotation.
- Symmetric view of the thorax with no rotation.
- Region of interest should extend from lower jaw bone (to see the proper position of a ventilation tube) to 1st lumbar vertebrae and to skin borders laterally.
- Visualisation of the trachea, proximal bronchi, vascular pattern, diaphragm and costophrenic angles, spine, paraspinal structures, retrocardiac lung, mediastinum, clavicles, rips.

Abdomen X-ray: the requisites[8-10]

- Patient supine – centralise chin to avoid rotation.
- Visualisation from the diaphragm to ischial tuberosities, including the lateral abdominal walls.
- Reproduction of the properitoneal fat lines consistent with age.
- Clear visualisation of the spine, kidney outlines, psoas outline, and bones.
- Lateral projection (after supine has been performed) may be required to evaluate air-fluid levels and free peritoneal air.

Chest and abdomen combined studies

- Because nearly all radiosenstive body organs are involved during a combined thoracic-abdominal radiograph, these examinations should be performed with caution.
- On average, a dose value of DAP=10 mGycm^2 can be achieved in newborns when modern X-ray devices are used.(11)
- The only indication for a combined chest and abdomen radiograph is the visualisation of umbilical catheters spanning both body compartments.

Shielding

- Direct shielding of the ovaries or testes is very difficult, because newborns are very small and their limbs are often contracted.
- The dose exposure caused by an abdomen X-ray is very low. Right placement of the patient, correct collimation, and added filtration limit the gonad exposure to few dozens of μGy.
- For these reasons, shielding should be avoided, as it could hide anatomical structures and cause the repetition of the examination.

Environmental radiation exposure in NICU

- A few studies have addressed the issue of radiation exposure for medical staff and family members in proximity of a X-ray study performed in the NICU.
- These studies have demonstrated that scatter radiation is extremely limited:[12,13]
  - scatter radiation levels of 0.024 µGy, 0.0027 µGy, and 0.041 µGy for chest X-ray, babygrams and skull radiography have been reported[13]

Environmental radiation exposure in NICU

- Consequently, shifting or shielding of adjacent patients is not necessary if they remain at least one meter from the radiation isocenter.(16)
- When distance is less than one meter, scattered radiation can be avoided with movable lead wall placed between adjacent isolettes.
- Similarly, as long as at a sufficient distance, medical staff and caregivers do not need to leave the vicinity when a radiographic examination is performed in the NICU.(14)

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