Ask EuroSafe Imaging Tips & Tricks

Paediatric Imaging Working Group

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:

<table>
<thead>
<tr>
<th></th>
<th>European DRL(^{(4)})</th>
<th>IT DRL (^{(4)})</th>
<th>German DRL(^{(5)})</th>
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<tbody>
<tr>
<td><strong>Thorax</strong></td>
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<tr>
<td>AP/PA &lt; 3kg</td>
<td></td>
<td></td>
<td>DAP = 3 mGy cm(^2)</td>
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<tr>
<td>AP/PA &lt; 5kg</td>
<td>DAP = 15 mGy cm(^2)</td>
<td>ESD = 80µGy</td>
<td>DAP = 5 mGy cm(^2)</td>
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<tr>
<td><strong>Abdomen</strong></td>
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<tr>
<td>AP &lt; 5 kg</td>
<td>DAP = 45 mGy cm(^2)</td>
<td></td>
<td>DAP = 20 mGy cm(^2)</td>
</tr>
</tbody>
</table>

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 1\(^{st}\) 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 radiosensitive 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 mGycm² 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.\(^{(14)}\)
References


