Practice point

Radiation Protection in Pediatric Radiology

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The radiation risk is higher for children than for adults, as children's tissues have a higher cell division rate, and cells can be damaged during this process. Children's bodies also have a higher water content and therefore absorb more radiation, which can cause damage to their genes. There are also differences in the location of particularly at-risk tissues such as hematopoietic bone marrow. In adults, 74% (spine, ribs, pelvis) is located in the skeleton or the trunk, and only 9% in the extremities. In infants, 29% is located in the skeleton of the trunk and 35% in the extremities. In adults, 8% is located in the cranial bones; in infants, 27%. This means that infants have large proportions of hematopoietic bone marrow in all parts of the body, including the extremities and any radiograph irradiates a substantial proportion of the hematopoietic marrow. As radiation-induced malignant lesions remain latent for years, children and adolescents are prone to experience them.

The biggest difference between adult and pediatric radiology is the divergent disease profile of children. Targeted, or, if necessary, staged, diagnostic procedures must be arranged with the doctor requesting the procedures, on the basis of reliable clinical information. With the availability of non-ionizing imaging modalities like USG and MRI, procedures with high levels of radiation exposure such as computed tomography and angiography may only be needed in a small number of cases. Ultrasonography can be used to find answers to many clinical questions regarding almost all organ systems from primary diagnosis to progress the evaluation. Strict adherence to indication guidelines for

children are one of the most essential factors in radiation protection.

The most common examinations performed in pediatric radiology are plain film radiography procedures such as X-rays of the chest and individual regions of the skeleton. Because of the frequency with which these X-ray procedures are performed, every effort must be made to provide radiation protection and effectively standardize image-capturing techniques with the lowest possible doses.

The increase in computed tomographies at all ages is a major problem. Although many CTs could be replaced by MRI, the fact that MRI is more time-consuming and expensive, machines are less available, and uncooperative patients need to be sedated restricts its use.

Radiation protection measures in plain film radiography

The optimum dose for an X-ray examination should correspond to the ALARA (as low as reasonably achievable) principle as long as the image quality is acceptable.

Generator

X-ray generators convert alternating current into direct current. Older generators (1, 2, 6 and 12 pulses) produce a direct current that also possesses a ripple of varying strength. This lengthens the switching time. At the same time, the proportion of weak radiation that is of no use in imaging but increases the dose rises. Ideal results are achieved using high- and medium-frequency generators.

Tube voltage

The higher the voltage selected, the more penetrating the radiation. As the target is thinner in children, the absolute dose of radiation needed is lower than for adults. Only a

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small amount of radiation is absorbed into the body and the necessary dose reaches the imaging system (film, storage plate, or image intensifier) quickly. The voltage used to obtain images of the trunk should therefore not exceed 65 kV. In adolescents with thoracic diameter greater than 15 cm, images are captured using a high-kilovoltage technique (125 kV), as in adults.

Tube filters

X-ray examinations of adults must be performed with a tube filter of at least 2 mm aluminum. For children and adolescents, an additional tube filter of 1 mm aluminum (Al) and 0.1 to 0.2 mm copper (Cu) must be used so that the surface dose is simultaneously halved with no negative effect on image quality.

Collimation

X-ray images must be as well collimated as possible. This reduces primary and scattered radiation. Even if poor collimation does not expose any additional parts of the body, the dose is still increased as a result of the higher proportion of scattered radiation which degrades the image quality. Correct gonad protection must be used.

Patient position

The patient should be in as close contact as possible with the imaging equipment, so that none of the dose of radiation is wasted by escaping from the body. X-ray machines with as short a distance as possible between the table and the cassette or the table and the image intensifier input level should therefore be preferred. For images with no scattered-radiation grids, the patient should lie directly on the cassette. Unlike adults, in infants and small children,

thoracic images are captured using an anterior-posterior (AP) projection, because more hematopoietic bone marrow (vertebrae, ribs, shoulder blades) is located in the dorsal part of the body.

Scattered-radiation grids

The use of scattered-radiation grids is not recommended with thin objects. The proportion of scattered radiation in such cases is so low that no discernible improvement in resolution can be achieved.

Image-capturing systems

Film-screen systems in sensitivity class 400 to 800 are recommended for pediatric radiology. Newer storage plates achieve excellent levels of detail for a given dose, or make it possible to reduce the dose, for example using additional filters, without affecting resolution. Older storage plates require doses up to 30% higher than film-screen systems in sensitivity class 400 and should therefore not be used for children. Flat panel detectors also perform well with low doses of radiation.

Planning examinations for individual patients requires a precise indication and close cooperation with the referring physicians. Only when the question to be answered is clear can the most effective radiation protection be provided, minimizing or even avoiding exposure to ionizing radiation. A CT scan can often be optimized or even avoided using a previous ultrasound or MRI examination. The complexity of age- and indication-dependent machine adjustment in pediatric radiology requires compulsory general examination strategies in the form of operating procedures (OPs), guidelines and dose limits.