Cancer Association of South Africa (CANSA)

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Fact Sheet
on
Safe Paediatric X-ray Imaging

Introduction

Medical X-ray imaging has led to improvements in the diagnosis and treatment of numerous medical conditions in paediatric patients. For medical X-ray imaging, the paediatric patient's size is more important to consider than age, because patient size determines how much radiation is needed to produce a quality medical image. For purposes of this Fact Sheet, paediatric patients include children up to the age of 19.

[Picture Credit: Paediatric Imaging]

The individual risk from X-ray imaging is small when compared to the benefits that it can provide through helping with accurate diagnosis. Efforts should, however, be made to minimise risk for children by reducing unnecessary exposure to ionizing radiation.

Like all other medical procedures, X-ray imaging examinations present both benefits and risks. These imaging procedures have led to improvements in the diagnosis and treatment of numerous medical conditions. At the same time, these types of examinations expose patients to ionizing radiation, which may elevate a person's lifetime risk of developing cancer.

Exposure to ionizing radiation is of particular concern in paediatric patients for three reasons:

- Younger patients are more radiosensitive than adults, i.e., the cancer risk per unit dose of ionizing radiation is higher for younger patients;
- Younger patients have a longer expected lifetime for the effects of radiation exposure to manifest as cancer; and
- Use of equipment and exposure settings designed for adult use can result in excessive radiation exposure to the smaller patient. This is of special concern because many paediatric imaging examinations are performed in facilities where paediatric imaging is not a majority of the workload.

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Ionizing Radiation

Ionizing radiation is not detectable by human senses, so radiation detection instruments such as Geiger counters must be used to indicate its presence and measure it. However, high intensities can cause emission of visible light upon interaction with matter, such as inChrenkov radiation and radioluminescence.

Ionizing radiation is used in a wide variety of fields such as medicine, nuclear power, research, manufacturing, construction, and many other areas, but presents a health hazard if proper measures against undesired exposure aren't followed. Exposure to ionizing radiation causes damage to living tissue, and can result in radiation burns, cell damage, radiation sickness, cancer and death.

Gamma rays, X-rays, and the higher ultraviolet part of the electromagnetic spectrum are ionizing, whereas the lower ultraviolet part of the electromagnetic spectrum and all the spectrum below UV, including visible light (including nearly all types of laser light), infrared, microwaves, and radio waves are considered non-ionizing radiation.

X-ray Imaging for Paediatrics

Medical X-ray imaging has led to improvements in the diagnosis and treatment of numerous medical conditions in paediatric patients. The United States Federal Food, Drug, and Cosmetics Act defines paediatric patients as persons aged 21 or younger at the time of their diagnosis or treatment. Typically these are broken down into different groups based on age ranges (neonates, infants, children, and adolescents). For medical X-ray imaging, the paediatric patient's size is even more important to consider than age, because patient size determines how much radiation is needed to produce a quality medical image.

The individual risk from X-ray imaging is small when compared to the benefits that it can provide through helping with accurate diagnosis. Still, efforts should be made to minimize risk by reducing unnecessary exposure to ionizing radiation. This is important because:

- Paediatric patients are more radiosensitive than adults (i.e., the cancer risk per unit dose of ionizing radiation is higher);
- Use of equipment and exposure settings designed for adults may result in excessive radiation exposure if used on smaller patients;
- Paediatric patients have a longer expected lifetime, putting them at higher risk of cancer from the effects of radiation exposure.

The FDA recommends that medical x-ray imaging exams, which include computed tomography (CT), fluoroscopy, and conventional X-rays, use the lowest radiation dose necessary, taking into account the size and age of the patient. Whether grouped by age or by size, an x-ray image should always be adjusted to meet the needs of the specific type of paediatric patient receiving the exam.

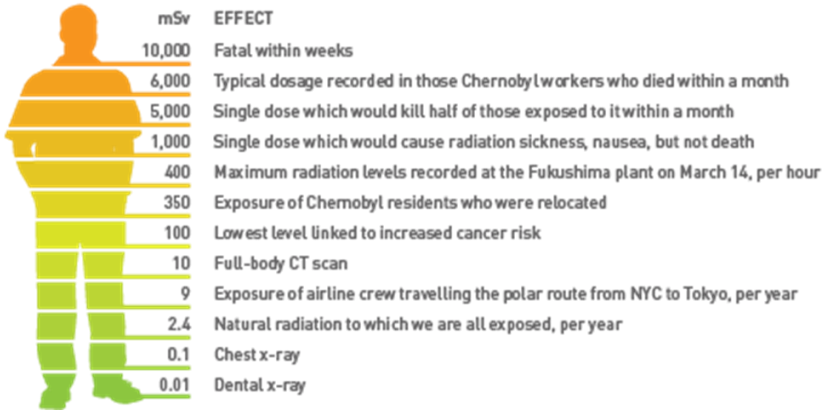
X-ray examinations should be performed for children only when the child's physician believes they are necessary to answer the clinical question or to guide treatment. Medical imaging professionals should use techniques that are adjusted to administer the lowest radiation dose that yields an image quality adequate for diagnosis or intervention (i.e., radiation doses should be "As Low as Reasonably Achievable"). The technique factors used should be chosen based on the clinical indication, patient size, and anatomical area scanned, and the equipment should be properly maintained and tested.

Health Effects of Ionizing Radiation

Key facts of ionizing radiation:

- Ionizing radiation has many beneficial applications, including uses in medicine, industry, agriculture and research.
- As the use of ionizing radiation increases, so does the potential for health hazards if not properly used or contained.
- Acute health effects such as skin burns or acute radiation syndrome can occur when doses of radiation exceed certain levels.
- Low doses of ionizing radiation can increase the risk of longer term effects such as cancer.

RADIATION DOSES AND EFFECTS



Importance of Keeping Paediatric Exposure to Ionizing Radiation as Low as Possible

There are two principles of radiation protection developed by the International Commission on Radiological Protection:

- Justification: Examinations using ionizing radiation should be performed only when necessary to answer a medical question, help treat a disease, or guide a procedure.

- Dose Optimisation: Examinations should use techniques that are adjusted to administer the lowest radiation dose that yields an image quality adequate for diagnosis or intervention, i.e., radiation doses should be "As Low as Reasonably Achievable" (ALARA).

Exposure to ionizing radiation must be kept especially low in young persons, because their tissues are highly radiosensitive.

Children, have many years left to live and:

- are more likely than adults to develop radiation-induced cancer
- as possible future parents, they are at risk for passing on radiation-induced genetic defects to the next generation

- Paediatric patients have a longer expected lifetime, putting them at higher risk of cancer from the effects of radiation exposure
- Paediatric patients are more radiosensitive than adults (i.e., the cancer risk per unit dose of ionizing radiation is higher)
- Use of equipment and exposure settings designed for adults may result in excessive radiation exposure if used on smaller patients
- Exposure to ionizing radiation is known to increase the future incidence of cancer, particularly Leukaemia. The mechanism by which this occurs is well understood, but quantitative models predicting the level of risk remain controversial. The most widely accepted model posits that the incidence of cancers due to ionizing radiation increases linearly with effective radiation dose at a rate of 5.5% per sievert. If the linear model is correct, then natural background radiation is the most hazardous source of radiation to general public health, followed by medical imaging as a close second.

Whenever possible, radiological studies on children and adolescents should be of a type that does not involve ionizing radiation, such as ultrasonography or magnetic resonance imaging. Paediatric conventional X-rays and computerised tomography (CT) require special examining techniques and protocols that are adapted to the patient's age, body size, and to the indication for the study.

Ultrasonography is a diagnostic medical procedure that uses sound waves to produce images on a screen, which allows medical providers to view internal structures of the body.

One of the challenges for clinical care personnel is to gain the child's trust and co-operation before and throughout the duration of an examination, which can prove to be difficult in children who may be ill and/or have pain. This is important to acquire quality images and prevent repeat imaging examinations.

Imaging paediatric patients in a dedicated paediatric imaging department with dedicated paediatric CT technologists may result in greater compliance with paediatric protocols and significantly reduced patient exposure dose.

In order to prevent the harmful effects of ionizing radiation, the 'As Low As Reasonably Achievable' (ALARA) principle should be strictly followed.

For some radiation-induced cancers, children are more vulnerable than adults; for some others there is not yet sufficient information available.

The susceptibility of children to radiation-induced cancer has been a focus of interest for over half a century. Recent reviews report that (in general) children might be two or three times more sensitive to radiation than adults.

Cancers related to childhood exposure on average result in more years of life lost than those related to exposure in adulthood. Children have a longer life expectancy resulting in a larger window for manifesting long-term radiation-induced health effects.

Radiation-induced cancer may have a long latency period that varies with the type of malignancy and the dose received. The latency period for childhood leukaemia is generally less than 5 years, while the latency period for some solid tumours can be measured in decades.

Paediatric patients can range in weight from less than 500 grams to more than 120 kg. As a result, a device designed for paediatric use (across all paediatric population subgroups) will also be adequate for the entire size range of the general adult population; conversely, devices designed only for adults may not be optimised for use on many smaller patients.

When imaging small children and infants, failure to adjust exposure parameters/settings that are used for adults and larger children will result in a higher dose than is necessary. Such unnecessary higher doses (i.e. higher risks) can be substantially reduced without affecting image quality.

Kung, S.M. 2020.
"The demand for drug-induced sedation for magnetic resonance imaging (MRI) scans have substantially increased in response to increases in MRI utilization and growing interest in anxiety in children. Understanding the pharmacologic options for deep sedation and general anesthesia in an MRI environment is essential to achieve immobility for the successful completion of the procedure and ensure rapid and safe discharge of children undergoing ambulatory MRI. For painless diagnostic MRI, a single sedative/anesthetic agent without analgesia is safer than a combination of multiple sedatives. The traditional drugs, such as chloral hydrate, pentobarbital, midazolam, and ketamine, are still used due to the ease of administration despite low sedation success rate, prolonged recovery, and significant adverse events. Currently, dexmedetomidine, with respiratory drive preservation, and propofol, with high effectiveness and rapid recovery, are preferred for children undergoing ambulatory MRI. General anesthesia using propofol or sevoflurane can also provide predictable rapid time to readiness and scan times in infant or children with comorbidities. The selection of appropriate drugs as well as sufficient monitoring equipment are vital for effective and safe sedation and anesthesia for ambulatory pediatric MRI."

Is the benefit worth the small risk?
To determine if the benefit is worth the risk, there are some questions you should ask your doctor, including:
Is the imaging test medically necessary?
If the answer is yes, then the benefit will most certainly outweigh the risk.

Can previous tests substitute for this exam?
If your child has had other exams that your doctor is not aware of, make sure your doctor receives copies of those exams. You may be able to avoid repeating exams your child has already undergone.

Are there alternative exams that do not require radiation?
Ask your doctor if ultrasound or MRI can be substituted.

Is the facility familiar with imaging children?
Children should have examinations properly tailored for their size.

Challenges in Paediatric Imaging

- Paediatric radiologists and radiographers require additional training so that they can conduct anxiety-free examinations and reduce potentially damaging X-ray radiation.

- Ultrasound is the preferred paediatric imaging method. The range of applications is growing.
- MRI scans can be stressful because of the noise and duration. Sedation can be avoided if trained therapists playfully educate the child.
- CT is often essential for accuracy and speed (e.g. in emergencies). Modern scanners and data-analysis methods have reduced radiation exposure.
- Conventional X-rays and fluoroscopies use less radiation thanks to new imaging technologies.

Special Technical Considerations are Required to Reduce Patient Exposure and Maintain Good Image Quality in Paediatric Radiography

According to the International Atomic Energy Agency (IAEA) specific actions include the following:

- Anti-scatter grids are normally not required in paediatric radiography as the gain in image quality does not justify the increase in patient dose, except in children in their teens and when the body build is such as to increase scatter;
- Good image detail is achieved by maintaining a balance between the use of a small focal spot size and a short exposure time;
- High speed screen-film combinations should be used where possible to enable reduction in radiation exposure and exposure time as the reduced resolution obtained is comparatively insignificant for the majority of clinical indications;
- The use of Automatic Exposure Control (AEC) is generally not appropriate in children as the sensors (size and geometry) are normally designed for adult patients. Instead, exposure charts corresponding to radiographic technique, patient thickness in the X-ray beam and presence or absence of anti-scatter grid are much safer and easier to use;
- The radiation beam should be limited using collimation;
- Shielding devices should be appropriately positioned to be efficient for protecting the tissues for which they are placed and to avoid unnecessary repeat examinations;
- Immobilization, when required, should be provided by specialized devices, if possible.

Information for Patients, Parents, Legal Guardians, and Caregivers

X-ray imaging examinations are non-invasive tests that produce images of inside one's body and provide valuable information to help with diagnosis of illnesses and injuries. X-rays use ionizing radiation, a form of energy, which can present risks to the patients.

However, when used appropriately, the benefit of an X-ray imaging examinations far outweighs any risk from ionizing radiation. Understanding the benefits and risks of X-ray imaging can help one make the best decision about one's child's health. The FDA recommends that X-ray examinations be performed when the child's physician determines the results would help in a diagnosis or treatment.

Tips about X-ray imaging for parents and caregivers:

- Keep a record of a child's x-ray imaging to help inform discussion with the referring physician when a new X-ray is recommended
- Ask the referring physician about the benefits and risks of imaging procedures, such as:
  - How will an X-ray improve the child's health?
  - Are there other options we could consider that do not use ionizing radiation and are equally useful?

- Ask the imaging facility:
  - Does the facility use reduced radiation for children X-ray imaging?
  - Is there any preparation necessary to perform the X-ray (e.g., administration of a contrast agent, sedation, or advanced preparation)?

Medical Disclaimer

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