Imaging Gently

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KEYWORDS

• Ionizing radiation • Imaging • Computed tomography (CT) utilization

KEY POINTS

- Ionizing radiation, even at low doses, imparts a small but real risk of malignancy; this impact is greater on pediatric patients. Consider this when deciding to use radiographic studies, such as plain radiography, computed tomography, and fluoroscopy, in pediatric patients.
- Clinical information is vital to the judicious use of radiographic studies.
- Ultrasound and MRI, which do not rely on ionizing radiation, have an increasing role in the evaluation of pediatric patients in the emergency setting.

BACKGROUND

Advances in medical imaging are invaluable in the care of pediatric patients in the emergent setting. The diagnostic accuracy offered by studies using ionizing radiation, such as plain radiography (XR), computed tomography (CT), and fluoroscopy, are not without inherent risks. This article reviews the evidence supporting the risk of ionizing radiation from medical imaging as well as discusses clinical scenarios in which clinicians play an important role in supporting the judicious use of imaging studies.

Biological Effects of Ionizing Radiation

People are exposed to ionizing radiation from a variety of sources. There is natural background exposure, which on average exposes a person living in the United States to 3 mSv per year.[1,2] Additional exposures come from medical imaging, occupational exposure, or industrial accidents. Unfortunately, ionizing radiation causes damage on a cellular level, and evidence supports that it exerts a linear increase in the lifetime cancer risk even at low doses.[2] The energy from ionizing radiation is capable of removing electrons from their atomic orbit, thus, creating ions. Ions either directly damage DNA molecules or cause secondary damage via hydroxyl radicals created from radiated water molecules. Often DNA strands are repaired without consequence; but double-strand breaks or errors in DNA repair can cause permanent alteration in cellular DNA, potentially inducing cancer later in life.[3]

For several reasons, children are more susceptible to the potential increased risk of cancer from ionizing radiation.

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- Actively reproducing tissue is more susceptible to DNA damage.
- A given dose of ionizing radiation is spread over a smaller area in a child, resulting in greater exposure.
- Malignancies have a very long latency; thus, a child has a longer period of life over which to develop a secondary cancer relative to an older adult.

Studies in atomic bomb survivors in Japan after World War II have provided important information in establishing the link between low levels of ionizing radiation exposure and future malignancy.[4,5]

Increasing Utilization of Computed Tomography

There has been a trend toward increased utilization of CT over the last several years, with approximately 62 million performed in 2006, 4 million of which were in children.[3] CT contributes the largest component of medical radiation exposure, accounting for approximately 40% to 67%, though only 5% to 11% of all imaging studies are CT.[2,6]

Evidence of the Role for Computed Tomography Exposure to Future Malignancy

Several studies estimated organ doses as well as estimated lifetime cancer mortality risk per dose of ionizing radiation to determine the potential impact of CT on the future development of malignancy. Brenner and colleagues[7] estimated that for all head CTs done in 1 year on children less than 15 years of age in the United States, 170 deaths from radiation-induced cancer will result. Likewise, 310 deaths may be attributed to all pediatric CTs of the abdomen and pelvis performed each year.[8] Overall, there may be one fatal radiation-induced cancer attributed to every 1000 pediatric CTs. It is important to remember that this only represents less than 0.5% increase to the overall baseline lifetime cancer mortality when balancing the diagnostic value of CT with its risks. Finally, Pearce and colleagues[9] concluded that for each head CT performed in a child less than 10 years old, there could be one extra case of leukemia and one extra brain tumor per 10,000 studies (**Table 1**).

CLINICAL SCENARIOS

Respiratory Illnesses

Respiratory illnesses comprise a significant proportion of the presenting symptoms prompting pediatric patients to seek emergency care. Various clinical guidelines look to reinforce scenarios when exposure to ionizing radiation is not necessary; however, chest XR (CXR) is still performed frequently.[12] **Table 2** summarizes guidelines for CXR utilization, emphasizing that routine CXR is not warranted for bronchiolitis, asthma, or well-appearing, otherwise healthy children with clear signs of pneumonia.

Table 1
Effective radiation doses of imaging studies

Study	Effective Dose (mSv)
Chest XR: Posteroanterior and lateral	0.02–0.1
Pelvis XR	0.6
Cervical spine XR	0.6
Head CT	2–4
Neck CT	3–4
Abdominal/pelvis CT, no contrast	5–8
Chest CT	3–8

Data from[1,3,10,11]