Radiation exposure to children from dental imaging: Is there a problem?
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Benefits of medical imaging that use ionizing radiation are well known. However, there is concern that growing use may place children at increased risk for cancer later in life. This talk discusses the reasons behind the concern, relative risk from dental imaging studies and provides practical advice to radiologists specializing Oral and Maxillofacial Radiology.

Learning objectives

After completion of this learning activity the participant will be able to:

1. Understand the factors in the United States that have led to concern regarding medical imaging and radiation in children.
2. Identify factors that make children more susceptible to radiation compared to adults.
3. Understand basic risk associated with performance of cone beam CT scans.
4. Review imaging tests and their relative radiation dose
5. Provide imaging strategies for optimizing radiation dose in dental imaging
6. Discuss the Image Gently campaign and list resources for parents and physicians with questions regarding radiation dose and imaging studies in children.

Background

Cone beam computed tomography is an amazing technology
Computerized tomography is one of the greatest medical innovations in this century. CT scan’s capability to “see” inside the human body quickly and painlessly has helped revolutionize medical care throughout the world. This technology enables the radiologist to diagnose trauma, cancer and other life-threatening illness faster and more precisely. This information has enabled referring doctors to diagnose patient’s dental problems that would not have been possible 20 years ago. Yet, recent reports of medical error indicates that overdose from CT scans does occur. It behooves the medical community to act aggressively to lower radiation dose during medical imaging.
Why do we care about radiation protection now?
There are two reasons why medical professionals in imaging take radiation protection very seriously for pediatric patients. The number of CT scans in children has risen dramatically since the introduction of this amazing technology into hospital practice. The use of cone beam CT has risen due to exquisite pictures and fast scan times. Now, CT scans can be performed in less than a second. The dose from a single CT scan is significantly higher than x-rays. A single view bite wing x-ray yields an estimated effective dose of up to 0.01 mSV. Compare that with a routine chest CT of up to 3 mSV. A child could have several hundred single view chest x-rays before it would equal one chest CT. Compared to one day of background radiation for example, a single view chest x-ray is similar to one day of background radiation while an abdominal CT is similar to up to 20 months of background radiation [6]. This is why medical professionals are particularly concerned with lowering radiation dose associated with CT scans in children.

What is unique about children that make them more vulnerable to changes from radiation?
Children are more susceptible to changes in their cells from a given dose of radiation compared to adults. How do we know this? The primary risks to children from a CT scan are the slight increase risk in developing cancer and changes to their genes over their lifetime. The risk is related to the “induction of stochastic effects of carcinogenesis (developing cancer) and genetic effects (developing changes in the genes we pass to our offspring)”[7]. Stochastic means “random”. According to Slovis, a stochastic effect of radiation results from “random injury to DNA” [8]. This can theoretically result in cancer and genetic changes. While stochastic effects are random, they tend to increase in frequency with increasing dose. Therefore, the higher the radiation dose from a scan, the higher (although slight) the chances of a change at the cellular level. This also suggests that changes to children’s cells are “cumulative”.

This means that a child who has had 10 CT scans is at higher risk for cellular change than a child who has had only one CT scan. This has been the reason some hospitals are developing programs to “flag” those patients who have frequent CT scans [9]. There are a number of scientific studies that show that children are more susceptible to a given dose of radiation compared to adults. Most of the information we have comes from one-time dose of radiation associated with the dropping of the atomic bomb in Japan in 1945 (very different than a CT scan). In these studies, some children who were further away from the bombsite received radiation doses that some experts believe are similar to those received from a diagnostic CT scan. Therefore, it is useful to look at that data. From the study of Japanese children it is clear, that children are simply more sensitive to a given dose of radiation compared to adults. More children developed cancer over their lifetime compared to the adults who were with them and exposed to a similar amount of radiation [1]. Children’s cells are growing rapidly. This puts them at greater risk to many types of cell injury. There are also examples of the use of radiation to treat children with head lice many years ago. This resulted in larger numbers of cancer in those children over what you would expect to occur naturally. The organs of a child’s body that are more susceptible to changes from radiation are the lens of the eye, bone marrow, thyroid, breast and the ovaries and testes.
Another key difference between adults and children is that **children have more remaining years of life during which radiation-induced cancer could develop**. If a child’s cells change as a result of a radiation exposure, it may take 10, 20 or even thirty years for the cancer to develop. Finally, we know from phantom or simulation studies that **if a child has a CT scan using an adult technique, the child’s dose is greater**. The dose at the midpoint of a patient’s body is less than the dose at the surface (skin) of the patient. This occurs because the x-ray beam of the CT rotates around the patient’s body and because the surface layers of patient tissue reduce the radiation in the x-ray beam. In the large adult, the multiple surface layers ‘protect’ the core tissues from radiation dose. Since children have less surface layers, their core doses are significantly greater than an adult when incorrect “adult-sized” techniques are used.

**Basic facts when discussing imaging risks with parents.** When a parent asks “can my child get cancer from this CT scan?” they are really asking you what the risk to their child is from performing this single CT scan. The problem is, **risk from CT is a very complex topic.** It is a complex topic for several reasons. Risk has to do with:

1. Populations of patients.
2. Risk compared to the benefit
3. Baseline risk of developing the disease. Cancer occurs in about 40% of all people in the United States over the course of their lifetime even if never exposed to medical radiation. Death resulting from cancer is about half that…. The risk of developing a fatal cancer is about 20% over the course of a lifetime in the United States. So cancer is a fairly common disease in the United States. So now we are talking about adding a small additional risk to the baseline cancer risk, to a population of individuals who may not get cancer at all. Yet this risk is likely real and need to be acted on now to PREVENT the possibility of reduced harm to our patients. So, when a parent asks “can my child get cancer from this CT scan?” what is a reasonable answer? The honest answer is likely “We don’t know, but we should act responsibly and as conservatively as possible and act as if it does.” This means that imaging should only be performed when appropriate from the clinical indication, that alternate imaging that does not require the use of ionizing radiation be considered, that if CT or other imaging is performed that it be “child-sized” and only image the area of interest, Another way of answering this question for parents may be the response written in the Frequently Asked Questions section on Image Gently website ([www.imagegently.org](http://spr.affiniscape.com/associations/5364/index.cfm/page=392)) edited by Dr. Brian Coley. He writes: “**Is there an increased risk of cancer from medical radiation, especially CT scans?** While no one can point to a single individual and say that their cancer was caused by medical radiation, there is evidence that exposures to radiation levels found during CT scans may slightly increase the risk
of future cancer. The risk for developing cancer is debatable and variable and may be zero, but estimates also range from about 1 in 500 to 1 in 10,000 fatal cancers from a single CT scan. This needs to be interpreted against the risk of developing cancer over one’s lifetime. Since the risk of developing a fatal cancer in an individual is about 1 in 5 during a lifetime, the extra risk from the CT is very small.”

You may wish to download the free parent brochures and the medical imaging record card (Ref Link [http://www.pedrad.org/associations/5364/ig/index.cfm?page=388](http://www.pedrad.org/associations/5364/ig/index.cfm?page=388)) from the Image Gently website or from the AAP website to use in your hospital or office. This may be useful to answer parents questions.

**Review imaging tests and their relative radiation dose.**

<table>
<thead>
<tr>
<th>TEST</th>
<th>Radiation dose estimate</th>
<th>Equivalent Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural background radiation</td>
<td>3 mSv/yr</td>
<td></td>
</tr>
<tr>
<td>Airline passenger (cross country)</td>
<td>0.04 mSv</td>
<td></td>
</tr>
<tr>
<td>Chest X-ray (single view)</td>
<td>up to 0.01 mSv</td>
<td></td>
</tr>
<tr>
<td>Chest X-ray (2 view)</td>
<td>up to .1 mSv</td>
<td></td>
</tr>
<tr>
<td>Head CT</td>
<td>up to 2 mSv</td>
<td></td>
</tr>
<tr>
<td>Chest CT</td>
<td>up to 3 mSv</td>
<td></td>
</tr>
<tr>
<td>Abdominal CT</td>
<td>up to 5 mSv</td>
<td></td>
</tr>
<tr>
<td>The radiation used in X-rays and CT scans has been compared to background radiation we are exposed to daily. This also is misleading as this refers to whole body dose which is not truly comparable to studies that image only a portion of the body. However, this comparison may be helpful in understanding relative radiation doses to the patient.</td>
<td></td>
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<tr>
<td>Background</td>
<td>1 day</td>
<td></td>
</tr>
<tr>
<td>Chest X-ray (single)</td>
<td>1 day</td>
<td></td>
</tr>
<tr>
<td>Head CT</td>
<td>up to 8 months</td>
<td></td>
</tr>
<tr>
<td>Abdominal CT</td>
<td>up to 20 months</td>
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</tbody>
</table>

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**TEST** | **Radiation dose estimate** | **Equivalent Background**
--- | --- | ---
Central line, PICC/ port placement, simple | 0.4 mSv | 1 month
Gastrostomy tube placement | 0.8 mSv | 3 months
Blood vessel central line revision or removal, difficult | 0.5-5 mSv | 2-20 months
Cerebral angiography | 3 mSv | 12 months
Angiography/venography) | 11-33 mSv | 4-11 years
CT guided IR procedures | 11-17 mSv | 4-6 years
VCUG (fluoroscopic) [11,12,13] | 9 days(pulse) -6 mo
VCUG (radionuclide) | 1 day
Video swallow | 10 days +

Source: [www.imagegently.org](http://www.imagegently.org)
Alternate imaging strategies

First and foremost when considering any medical imaging is to evaluate the benefit to the patient relative to any potential risks from performing the study. Alternate strategies may include clinical follow-up or other consultation, such as surgical consultation for suspected appendicitis. When imaging is considered, as ultrasound and MR do not use ionizing radiation, these images tests may replace CT in some instances. However, there are some instances when CT is the only test that provides the specific information. CT of the lung for suspected metastatic disease is an example of this situation.

The Image Gently campaign

Image Gently\textsuperscript{SM} is an education and awareness campaign to promote radiation protection for children worldwide [10]. Sponsored by the Alliance for Radiation Safety in Pediatric Imaging, a consortium of more than 55 groups that represents over 700,000 health care professionals, the campaign hopes to change practice locally. From its inception, the Alliance has been driven by the triad of radiologic technologists, medical physicists and radiologists working together to change practice. We are pleased to have this opportunity to talk about this important subject… radiation protection for children.

Change in practice

- Commit to investigating whether your local imaging provider has embraced the “Image Gently” dose optimization for children’s imaging.
- Assure that parents have access to medical imaging and potential radiation concerns by referring them to www.imagegently.org
- Provide parents with the medical imaging record card and the parent brochures prior to imaging procedures.

Faculty Disclosure Information- Dr. Goske

In the past 12 months, I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity.

I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.
References


