Algorithm Could Reduce Radiation from Medical X-Rays by Thousands-Fold

By Chuck Dinerstein, MD, MBA — November 29, 2017

Scientific Reports published a paper on reducing medical radiation dosages, CT dose reduction factors in the thousands using X-ray phase contrast by Marcus Kitchen et. al. It is fairly technical -- more about physics and algorithms -- but it could be a very big deal.

One of the difficulties in producing readable CT studies is that our soft tissue (everything except the bones) has similar density, so X-rays penetrate these tissues pretty much equally, and it is hard to distinguish one from another. There are a variety of techniques to improve differentiating these tissues and their anatomic relationships. The breakthrough reported here is that using a new algorithm defining edges, densities, and the like, will maintain the ability in identifying tissue changes while the patient's radiation dosage is reduced, and reduced a lot – 100 fold or more. The work was performed on animals and is not yet ready for use in clinical medicine, but if it holds us, this is important.

Concerns about radiation from medical studies waxes and wanes in the public eye. Medical images produced by nuclear medicine studies and X-rays, especially CT scans, are the largest sources of medical radiation. They represent 26% of imaging but account for 89% of annual radiation exposure. The ionizing radiation from these studies have enough energy to break up DNA strands directly or by breaking up water molecules, creating very reactive compounds that damage DNA. It is important to understand that these DNA injuries are rapidly repaired, but repair and restoration, like anything else, is not perfect every time. The general belief is the greater the long-term dose of radiation, the more likely you are to have DNA damage.
Quantifying the extent of damage is very difficult for several reasons. Our most extensive data collections regarding radiation injury come from the survivors of Hiroshima and workers in the nuclear energy industry – groups that are not directly comparable to patients exposed to radiation for medical reasons. Because of the very low incidence of medical radiation resulting in cancer and the long lag time between exposure and clinical symptoms (often decades), it is difficult to study a population sample large enough to quantify the problem – consequently, no epidemiologic studies demonstrate a harmful effect of radiation for patients.

But because of concern, and out of an abundance of caution, a mathematical model, called the linear no-threshold theory, is used in setting radiation standards. Using a recognized higher dose of radiation that does have an impact on human health (think now of the Hiroshima survivors), we extrapolate linearly to lower and lower doses to determine the presumed deleterious effects. If 1000 units of radiation cause a 5% impact, then extrapolation would result in a 0.5% impact from 100 units.

All of us are exposed to radiation daily, from natural background radiation, the sun, radon in the air, cosmic rays, the Earth, and even our food – there is no way to get away from it. Medical radiation may double our annual exposure. To put medical radiation doses into perspective, consider this table comparing radiology doses with our exposure to natural background radiation.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Comparable natural background radiation for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT of abdomen and pelvis with and without contrast</td>
<td>7 years</td>
</tr>
<tr>
<td>CT of head</td>
<td>8 months</td>
</tr>
<tr>
<td>X-ray of arm or leg</td>
<td>3 hours</td>
</tr>
<tr>
<td>Mammography</td>
<td>7 weeks</td>
</tr>
<tr>
<td>Cardiac catheterization</td>
<td>20 months to 5 years of study</td>
</tr>
</tbody>
</table>

It is easy to see why reducing the radiation from CT scans can be a very big deal, because even though we have no firm evidence that medical radiation will cause cancer, less is better especially if you can get the same useful information as you would get higher dosages.

The Food and Drug Administration (FDA), along with the Nuclear Regulatory Commission (NRC), is responsible for radiation safety in medicine. They make two salient points. First, and this should allay your fears, “Although the risk to an individual from a single exam may not itself be large, millions of exams are performed each year, making radiation exposure from medical imaging an important public health issue.” The impact of medical radiation is evident only for the aggregate of all of us, not individuals.
Second, they define what is optimal “as low as reasonably achievable while maintaining sufficient image quality to meet clinical need.” And that is what the study by Kitchen and his colleagues in Scientific Reports is reporting, a new optimal that can be achieved.

Healthcare professionals have already identified and implemented measures to lessen radiation dosages. First, physicians can reduce radiation exposure by not ordering unnecessary tests or by ordering imaging studies that do not involve ionizing radiation, like ultrasounds.

Second, the manufacturers of CT scanners can reduce radiation exposure by standardizing protocols for imaging, providing notification to operators when limits are being reached, and by determining the dose received by patients during a study and entering this information into their clinical record. General Electric, among other manufacturers, have already instituted systems to collect and analyze individual patient radiation exposure across multiple facilities, devices, and vendors. This allows an ordering physician to have a sense of how much radiation a patient has received and over what time period.

For those of you still unnecessarily freaking out about medical radiation, you can find a personal dose calculator developed by the Environmental Protection Agency here [3].

Notes

[1] In a nuclear medicine study you are injected with a radioisotope that is used to detect changes in your bones, or blood flow or to identify occult infections.

[2] The are many ways to quantify radiation dosages, and they serve more to confuse than clarify, at least concerning linear extrapolation

[3] Medical radiation refers to the radiation we are exposed to as part of diagnostic studies. Radiation as a form of cancer therapy involves larger doses and has a different risk/benefit profile.

Source: CT dose reduction factors in the thousands using X-ray phase contrast Nature.com Scientific Reports 7, Article number: 15953 DOI: 10.1038/s41598-017-16264-x