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It's Not the Equipment!

CT radiation doses are too high in real clinical life. Knowing an institution's true data and sharing best practice examples lead out of the dilemma.

"We talk about risks and benefits in many areas of medicine, but we don't talk enough about reducing radiation," said Rebecca Smith-Bindman, practicing radiologist and epidemiologist at the University of California San Francisco, USA.

The increased use of CT and the higher doses per scan have led to a 600% increase in medical radiation exposure in the USA during the last 20 years. Many scans use radiation doses much higher than needed for diagnosis.

Radiation is definitely harmful

Smith-Bindman provided data on the Hiroshima and Nagasaki bomb survivors – they were exposed to a median dose of 40mSv. Results show that a radiation dose of 10mSv or more was already associated with an increase in leukemia and solid cancers.

Smith-Bindman strongly favors the epidemiologic, evidence-based approach for assessing radiation effects. She made her point by picking two large epidemiological studies: the Biological Effects of Atomic Radiation (BEAR)-VII report and a report published by the UK Health Protection Agency on "Risk of Solid Cancers Following Radiation Exposure Estimates for the UK population".

Not everybody follows this approach, she said, however, opponents have so far failed to provide data counterbalancing the extensive evidence linking exposure to ionizing radiation to increased cancer risk.

One CT scan can cause cell damage

A fairly recent study provides evidence for DNA damage after one CT scan (Nguyen 2015). The prospective study was rather small with 67 participants, all receiving one cardiac CT. Their mean exposure was 30mSv. "This is pretty generous for a cardiac CT," commented Smith-Bindman.

Nguyen et al. found that patients exposed to >7.5mSv of radiation from a single CTA had evidence of DNA damage. It was associated with programmed cell death and activation of genes involved in apoptosis and DNA repair. Cell death in white blood cells went up three-fold. While many damaged cells were repaired, at least three percent remained damaged for more than a month after the CTA.

Radiation effects in children

Smith-Bindman also shared insights into negative radiation effects on children (Pearce 2012). The Pearce-study shows an increased pediatric cancer risk, even after small doses of radiation from CT: Compared with children who received a small dose (less than 5mGy), the relative risk of leukemia for children with a cumulative dose of at least 30mGy was threefold; a similar tendency was found for the relative risk of brain cancer.

Ten percent of children getting a CT are exposed to these doses in only one scan.

Modeling suggests that 2-5% of all cancers in this pediatric population come from radiation. "The study has its flaws, but every flaw would underestimate the effect," she said.

Radiation dose is department-dependent

"CT doses are higher than needed and they are highly variable across institutions", said Smith-Bindman. While higher doses lead to prettier images, there is no evidence that higher doses lead to a more accurate diagnosis. "The strongest factor of dose is where the patient goes," said Smith-Bindman.

This knowledge derives in part from Smith-Bindman's own STONE trial (2014), which shed light on dose varieties in 15 centers, all under the roof of the University of California. The initial aim of the study was to compare the diagnostic accuracy of ultrasound versus CT for diagnosing kidney stones in an ER setting (ultrasound is usually enough to get the right diagnosis). "We did not standardize how CT was done – I did not realize we needed to," explained Smith-Bindman.

Incidentally, the study also exposed a wide variety of doses for CT exams across institutions. While a low-dose CT with no more than 5mSv was indicated, maximum doses were as high as 75mSv for single exams. Only 3% of all patients received the correct low-dose exam. "If we look at doses in the real world, we don't do a good job – we do an awful job," she commented.

UCDOSE Implements Best Practice

Smith-Bindman and her colleagues at the University of California medical schools have since agreed on pooling and evaluating radiation dose data. The team uses Radimetrics® for this. "We found considerable variation between the institutions," noted Smith-Bindman. "Most of the differences derive from how we like to do CT, it is a matter of personal preference".

Smith-Bindman and her team found a way to get the whole team influencing radiation dose together – i.e. physicists, radiologists, technologists, and biostatisticians – in a joint effort to try to improve radiation dose. The team scheduled in-person meetings, where they invited the clinical leaders and some other involved professional groups. Radiation data results were shared across hospitals before this meeting. If doses were too high, the teams at the hospitals were asked to either defend their practice or change it.

At these meetings, the participants created concrete lists of changes for reducing radiation dose and agreed on implementing them within weeks after the meeting.

"We did not make these changes, but we helped to facilitate discussion – there is no magic, our method was basically meeting and sharing best practices," commented Smith-Bindman. This has resulted in a 25% reduction in average doses and a 50% reduction of high doses since May 2010. In addition, dose variability between and within institutions has markedly decreased.

Why are doses so variable?

The lack of comprehensive standards or guidelines for CT is one reason for the wide dose variety, said Smith-Bindman. No organization holds responsible for dose data in the US. Additionally, technologists do not receive consistent education. "Basically a Californian hairdresser gets more training," she said. The current radiological practice does largely not comply with the ALARA principle – As Low As Reasonably Achievable – which should serve as every radiologist's guiding principle. "Personally I do not like ALARA that much, because every single radiologist defines what it means – it has no enforcement to it," she noted.

Optimizing dose

Smith-Bindman recommends facilities to assess their own radiation doses, compare them with benchmarks and develop strategies to get the dose down. "We have a fear of lowering dose – that is crazy," she said. Behind this might be the concerns about missing a relevant finding. From an epidemiological perspective, it seems appropriate to miss a finding once in a while in very few patients, if it reduces potential harm in many. "We have to miss stuff once in a while, if we use radiation correctly – nothing horrific will happen, because the dose was too low."

CT Dose Collaboration

Smith-Bindman has extended UCDOSE to an international level. Almost 150 institutions from all care levels now take part in the study on a global scale. Partnering institutions all need to use Radimetrics. The data goes into a new CT dose registry at UCSF. Currently data from 5000 CT scans is flowing in every day; 3 million records are in the registry already.

A team of six biostatisticians helps participating institutions to understand factors influencing radiation dose. One main first finding is that it is not the equipment that matters, but how it is used. "You do not have to have the best equipment to go low on dose," said Smith-Bindman.

The profound variety in dose is also found on an international level. Smith-Bindman shared preliminary data in abdomen CT doses: So far, sites in Germany perform best, and worst in Japan. The UCSF team now gives very detailed reports and specific feedback to the institutions to guide improvement. "The response so far has been very positive," said Smith-Bindman.

Lowering kVp, reducing the scanning area and omitting multiple phases, if possible, have turned out to be simple measurements to reduce dose.

Factors associated with dose

Some factors influencing radiation dose can already be deducted from the initial data:

- Reporting measurements of imaging unit performance for comparison with peers
- Tracking some patient safety performance measures besides radiation dosage
- Using standardized processes that make it easier to optimize or lower radiation dose from CT exams
- Organizing people into teams focused on improving an institution's approach to CT exams
- Setting specific goals for improving radiation dose.

Smith-Bindman eventually plans to derive a blueprint for how radiation dose can be improved.

With regard to high doses in children, Smith-Bindman noted that cutting down dose outliers alone would prevent cancers from radiation by 44%.

Conclusion

Smith-Bindman drew four main conclusions form her work on radiation dose optimization:

1. It is important to optimize dose!
2. It is the right thing to do: The harm of imaging must be minimized.
3. Organizations tasked with oversight will increasingly demand that radiologists make sure CT doses they use are the lowest possible doses.
4. Reducing radiation is not that hard – small and large quality improvement efforts can have very large impact.

At the end of her presentation, Smith-Bindman explicitly offered to talk to anybody who wants to talk or share information about radiation dose reduction.

Limit rather than expand!

The presentation discussion evolved mainly around the correlation between high radiation dose and image quality. "There is a direct correlation between dose and image quality – the pictures are prettier with higher doses", said Smith-Bindman. This plus the increased speed of CT examinations and multi-phase imaging may be tempting for radiologists. "You can scan a patient within seconds and get prettier pictures – but that has not improved diagnosis," she said. A radiologist should answer the clinical question with the lowest dose possible.

With regard to the scan area, Smith-Bindman recommended to just use the region necessary to answer the clinical question: "Limit rather than expand," was her advice.

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