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Advances in Medical Imaging and Therapies

April 20, 2012

Radiation Exposure in Medical Imaging

Radiation exposure from medical x-rays (including CT scans) and nuclear medicine are currently in the spotlight. Data from atomic bomb survivors in Japan support that x-rays are carcinogenic. The decision of whether or not to order CT scans depends on the benefit-risk ratio. This discussion focuses on the risk side of the equation. First , how much radiation does a patient receive from a typical type of exam? Second, what is the level of risk with radiation exposure? Third, what are some current steps to reduce radiation exposure and help physicians and patients make an informed decision?

What is the risk of radiation exposure at "low levels" (i.e. < 100 mSv)?

There is some controversy as to whether or not "low levels"(i.e. < 100 mSv) of radiation exposure are carcinogenic. As stated previously, data from atomic bomb survivors support the carcinogenic effects of radiation exposure at "high levels". Currently, the majority of academicians accept the "linear-no-threshold" risk model whereby the risk of cancer from low levels of radiation is extrapolated in a linear fashion from the risk model established at high levels (atomic bomb survivors). This is the position taken in the BEIR VII report (Biologic Effects of Ionizing Radiation VII) from the National Academies. *Using this model, the estimated risk of developing cancer per 100 mSv exposure is 1 person in 100.* For reference, 42 out of 100 people will develop cancer unrelated to radiation over their lifetime. Extrapolating this data to lower doses in a linear fashion, the estimated risk of developing cancer per 10 mSv exposure is 1 person in 1000. *Note that the development of radiation-induced cancer is felt to occur 1 to 2 decades after exposure.*

Download a free summary of the BEIR VII report at the national academies website http://www.nap.edu/catalog.php?record_id=11340.

Again, there is controversy surrounding this linear-no-threshold model. There are academicians who believe that the data is not adequate to discount the notion that below a threshold level, radiation exposure is not carcinogenic. In other words, it may be that below a threshold level (e.g. < 100 mSv), radiation is not carcinogenic. *Nevertheless, it seems prudent to operate under the notion that radiation exposure at the smallest levels is carcinogenic.*

How much radiation exposure?

Radiation exposure from typical types of medical exams*:

Exam	Approximate effective radiation dose (milliSieverts) Varies from patient to patient.
CXR	0.1 mSv
CT chest	7 mSv
CT abd/pelvis	10 mSv
CT head	2 mSv
CT sinus	0.6 mSv
PET/CT	18 mSv
Mammogram	0.7 mSv

*http://www.radiologyinfo.org/en/safety/index.cfm?pg=sfty_xray. Estimated levels of radiation exposure for additional exam types also at this site.

Reference radiation exposure

Average American background radiation exposure per year (cosmic radiation, household radon, plane flights, etc.)	3 mSv
Round trip cross country flight	0.05 mSv

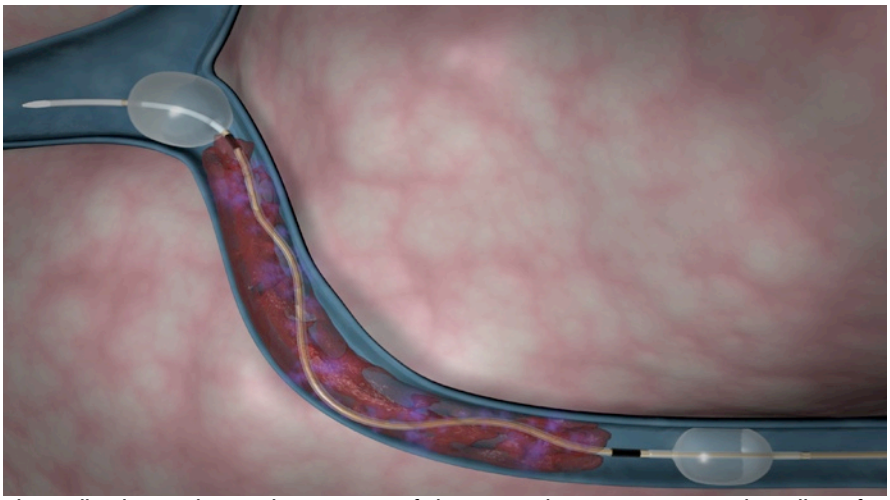
What are current strategies to reduce radiation exposure and to help physicians and patients make decisions?

1. Appropriate ordering of exams is the most effective strategy to reduce radiation exposure in patients. What are the benefits relative to the risks of the exam? A radiologist can assist in this decision-making process.
2. When appropriate, usage of non-ionizing radiation modalities such as MRI and ultrasound. A radiologist can assist in making this decision.
3. ALARA (As Low As Reasonably Achievable). This concept is being propagated throughout the medical community. Can one perform an adequate exam with less radiation exposure to the patient? For example, to follow up incidental small lung nodules with serial CT scans, protocols can limit the coverage to just the area of the nodule(s). Also, since there is inherent high contrast between lung nodules and the air in the lungs surrounding them, protocols can decrease the radiation dosage, which would provide "fuzzier" images, but still allow adequate measurement of the lung nodule.
4. Advances in technology. Latest generation CT scanners have hardware and software techniques to dramatically reduce radiation exposure to patients. This includes shielding patients from radiation that is not useful for image generation as well as post-processing techniques (e.g. iterative reconstruction techniques) which nearly preserves image quality while reducing radiation exposure around 40%.
5. Recording of radiation exposure for each patient. Future mandates will probably require that the amount of radiation exposure for each patient will be recorded in an electronic medical record. The patient and physician will know how much cumulative radiation from CT scans the patient has had over his/her lifetime. Patients can also take this matter into their own hands with applications such as "Radiation Passport" for the iPhone which helps patients estimate and keep of track of the amount of radiation exposure and assesses the risk of such radiation exposure. Google and Microsoft are also developing personal electronic medical records that individuals can use to record and keep track of their medical records.

-Kenneth Ong, MD*

Endovascular Treatment of Deep Vein Thrombosis

Venous thromboembolic disease remains a serious and prevalent problem in the United States with 600,000 cases of Deep Vein Thrombosis (DVT). Minimally invasive technology that combines thrombolytic medications with mechanical delivery rapidly restores venous blood flow with less risk, less medication, and less cost. These drug-device techniques have streamlined DVT thrombolysis from several days in the ICU to a single procedure. Patients with successful DVT thrombolysis oftentimes experience an immediate reduction in leg pain and swelling. Thrombolysis is an adjunctive to standard anticoagulation therapy. These procedures are performed using imaging guidance and typically require only a small incision behind the knee.



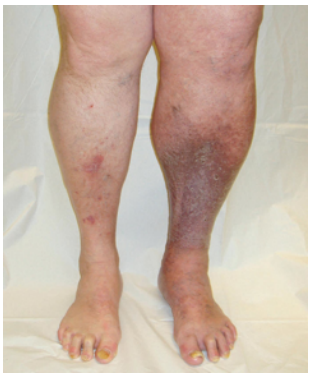
The Trellis device shown above is one of the newer therapeutic options that allows for rapid thrombolysis and mechanical removal of thrombus while allowing for reduced doses of thombolytic medications.

In 2008, the American College of Chest Physicians published evidence based clinical practice guidelines for DVT* calling for pharmacomechanical thrombolysis in certain patients to help prevent Post Thrombotic Syndrome, which may occur in 50% of patients months to years after an acute episode of DVT despite anticoagulation and resulting in chronic leg swelling, discomfort, pain and loss of function.

Consider consultation for thrombolysis if:

- There is thrombus in the common femoral or iliac veins.
- There is extensive thrombus in the (superficial) femoral vein and leg swelling in a young patient (secondary to increased risk of post-thrombotic syndrome).

Left lower extremity post-thrombotic syndrome.



Patients should be referred within a week of onset of symptoms. They should also be started on Lovenox and Coumadin and referred to a primary physician for continued anticoagulation treatment. There is evidence suggesting that percutaneous endovenous intervention combined with traditional anticoagulation can reduce the incidence of Post Thrombotic Syndrome. Newer endovascular devices which remove clot and thrombolysis medication protocols have significantly reduced the complexity and increased the safety of these interventions.

The Interventional Radiologists of RAMG, Vascular Interventional Partners (VIP), have extensive experience evaluating and treating DVT with thrombolytics. Consultations may be obtained by calling (408) 371-8346.

-Anup K. Singh, MD*

VIP Vascular Interventional Partners

*** Antithrombotic Therapy for Venous Thromboembolic Disease**
Clive Kearon et al. Chest 2008;133;454S-545S DOI 10.1378/chest.08-0658. The online version of this article, along with updated information and services can be found online on the World Wide Web at: http://chestjournal.chestpubs.org/content/133/6_suppl/454S.full.html

Guidelines for Management of Incidental Pulmonary Nodules found on non-screening CT

Data for screening CT for lung cancer is still being collected and analyzed. As of yet, CT screening has NOT been proven to help reduce mortality of lung cancer.

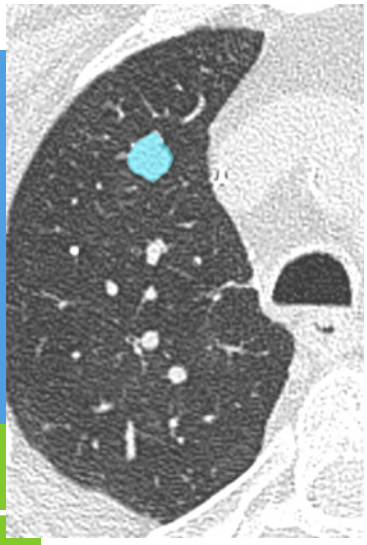
Another subset of patients undergoing CT scans that are performed for reasons other than detecting pulmonary neoplasm or metastasis are frequently found to have small, incidental lung nodules. Management of these lesions needs to balance the need to exclude malignancy and the consequences of ionization radiation exposure, in addition to additional factors such as cost of the scans and patient anxiety. Management of these nodules also takes into account that fewer than 1% of very small (< 5mm) nodules in patients without a history of cancer will demonstrate growth over 2 or more years.

In patients for which the purpose of the CT scan is to detect pulmonary neoplasm or metastasis and for which indeterminate pulmonary nodules are found, more frequent follow up may be indicated. The traditional management recommendation of CT follow-up intervals of 3, 6, 12, and 24 months to establish 24 month stability would be a reasonable approach. Note that this is regardless of nodule size.

Also note that in young patients (< 35 years old), primary lung cancer is rare (< 1% of all cases). In balancing the risk of radiation exposure in this relatively "young" population, a single low-dose CT follow up in 6-12 months would be reasonable for management of small, incidental nodules.

It is reasonable to protocol CT scans for which follow up of lung nodules is the only indication to be low-dose, thin-section, unenhanced scans targeted to the nodule(s) (i.e. not full coverage of the entire chest).

-Kenneth Ong, MD*



The following recommendations for management of incidental lung nodules found on CT scans performed for reasons other than detection of pulmonary neoplasm or metastasis are from a statement of the Fleischner Society and outlined in great detail in McMahon H, et al. Guidelines for Management of Small Pulmonary Nodules Detected on CT scans: A Statement form the Fleischner Society. Radiology

Nodule Size (mm)*	Low-Risk Patient†	High-Risk Patient‡
≤4	No follow-up needed§	Follow-up CT at 12 mo; if unchanged, no further follow-up‖
>4-6	Follow-up CT at 12 mo; if unchanged, no further follow-up‖	Initial follow-up CT at 6–12 mo then at 18–24 mo if no change‖
>6-8	Initial follow-up CT at 6–12 mo then at 18–24 mo if no change	Initial follow-up CT at 3–6 mo then at 9–12 and 24 mo if no change
>8	Follow-up CT at around 3, 9, and 24 mo, dynamic contrast-enhanced CT, PET, and/or biopsy	Same as for low-risk patient

Note.—Newly detected indeterminate nodule in persons 35 years of age or older.
* Average of length and width.
† Minimal or absent history of smoking and of other known risk factors.
‡ History of smoking or of other known risk factors.
§ The risk of malignancy in this category (<1%) is substantially less than that in a baseline CT scan of an asymptomatic smoker.
‖ Nonsolid (ground-glass) or partly solid nodules may require longer follow-up to exclude indolent adenocarcinoma.

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SERVING THE BAY AREA FOR OVER 40 YEARS

Radiological Associates Medical Group (RAMG) is proud to have been serving the community and physicians of Good Samaritan Hospital (GSH) for over 40 years. We provide subspecialty expertise in the fields of neuroradiology, pediatrics, musculoskeletal, women's imaging, nuclear medicine, and interventional radiology. The Department of Radiology at GSH has some of the most advanced imaging equipment available with 3 Tesla MRI, 64-detector multislice CT, PET/CT, digital radiography, 3-D ultrasound, and picture archiving system. At Samaritan Breast Care Center, digital mammography is being implemented.
Our interventional radiology arm, Vascular Interventional Partners, provides consultations in our clinic and provides interventional care at O'Connor hospital and Good Samaritan hospital.

O'Connor Hospital
It's the Way We Care

GOOD SAMARITAN HOSPITAL

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To schedule an appointment at Good Samaritan Hospital, please call (408) 559-2148. To schedule a breast imaging appointment, please call the Samaritan Breast Care Center at (408) 358 - 8414.

To schedule an interventional radiology appointment at O'Connor Hospital, please call (408) 947-2808.

For outpatient consultation, please call the VIP Clinic at (408) 371-8346.

About the Authors:

Dr. Singh completed his fellowship in Vascular and Interventional Radiology at UCLA in 2003. His interventional practice consists of a variety of vascular and nonvascular minimally invasive procedures including vascular stents, embolizations, locoregional cancer therapies, spine procedures, and treatment of venous disease. He currently serves as the Chair of RAMG and is the Medical Director for Radiology of Good Samaritan Hospital. Dr. Singh lives in Fremont with his wife and two children.

Dr. Ong completed his radiology residency at UCLA in 2000 and a 2-yr neuroradiology fellowship at UCSF in 2002. In addition to brain and spine disorders, his areas of interest include head and neck cancers, neuro-otology, coronary artery imaging, and oncology imaging. Dr. Ong has been with Radiological Associates Medical Group since 2002 and was the past chair of the department of diagnostic imaging at Good Samaritan Hospital.

The radiologists of RAMG are:

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