

Imaging And Repeat Imaging

All areas of medicine are highly dependent on tools to extend our diagnostic capabilities. Since very early times, healers have relied extensively upon history and physical exam to allow them to make diagnoses and, when available, prescribe treatments.

As technology has advanced, we've found ways to look at and touch the human body in new and more discerning ways. However, **everything in medicine (and in life) is a balancing act between risk and benefit.** With anything involving diagnostic imaging, this balance involves the additional information provided by the test versus the risk of administering it.

For lab tests, the initial risk is negligible, basically a needlestick and some missing blood from one's body. More invasive tests pose additional risk of injury, and hopefully the benefit is proportionately greater.

But radiographic imaging is different in many ways.

It lets us peer deeply into the body in what *appears* to be a noninvasive manner. Just because it's noninvasive doesn't mean it's harmless, though. Our brains tell us that there is nothing visible happening when we use x-rays. But intellectually, we know better. Unfortunately, the existing data that tell us how bad radiation can really be is very old (World War II) and difficult to extrapolate to medical radiation.

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TRAUMA CALENDAR OF EVENTS

ORTHOPEDIC TRAUMA ASSOCIATION ANNUAL MEETING

LOCATION: MANCHESTER GRAND HYATT, SAN DIEGO, CALIFORNIA

DATE: OCTOBER 7-10, 2015

EASTERN ASSOCIATION FOR THE SURGERY OF TRAUMA

LOCATION: JW MARRIOTT, SAN ANTONIO, TEXAS

DATE: JANUARY 12-16, 2015

This month, I'll look at the impact of imaging and re-imaging during the initial evaluation of trauma. How much radiation do the various studies deliver? Why do they get repeated? And what can be done to avoid repetition.

Radiation Dosing From Common Studies

First, let's look at the common radiation measurements that you may see reported in textbooks or research papers. They are the rad, the rem, the sievert, and the gray. So what's the difference?

First, let's look at measures of dosing, or delivery.

- **rem** (Roentgen equivalent man) – This term has been around since World War II, and was designed to describe radiation effects on biological tissue, specifically cancer. A rem is a pretty large dose, and most medical imaging devices deliver fractions of a rem. For that reason, you will frequently encounter measurements in millirem (mrem), or thousandths of a rem.
- **sievert** (Sv) – This is the dosing measurement that the rest of the world (other than the US) uses. It is also a large unit, and

we usually cut it down by a factor of a thousand to a millisievert (mSv).

These two dosing systems are interchangeable, but beware! There is a factor of 100 difference between the two:

$$1 \text{ mSv} = 100 \text{ mrem}$$

or

$$1 \text{ mrem} = .01 \text{ mSv}$$

And then there are the measures of actual absorbed dose. They are the gray (Gy) and the rad, which I will not discuss further. There is no convenient equivalent or conversion between the delivered dose units and the absorbed dose units, because a huge number of factors are involved.

To put things in perspective, remember that we are exposed to a small amount of radiation all the time. Cosmic rays from the heavens, radioactive elements in the soil and air (radon), stone or brick from your house, for example. And you get even more if you fly in jets a lot.

The average person receives about 3 mSv of background radiation per year.

So how much radiation exposure is there with standard imaging tests? Have a look at the table below. These are ballpark figures. Be aware that "results may vary" depending on the equipment, software, and settings used.

Test	Dose (mSv)	Years of background radiation / test
Chest x-ray	0.1	10 days
Pelvis x-ray	0.1	10 days
CT Head	2	8 months
CT Cervical spine	3	1 year
Plain c-spine	0.2	3 weeks
CT Chest	7	2 years
CT Abdomen/pelvis	10	3 years
CT T&L spine	7	2 years
Plan T&L spine	3	1 year
Millimeter wave scanner (that hands in the air thing at the airport)	0.0001	15 minutes
Scatter from chest x-ray in trauma bay when standing one meter from patient	0.0002	45 minutes

Bottom line: The effects of those invisible rays do add up. Be aware of how much radiation you are delivering as you evaluate your patients. And do everything you can to avoid having to repeat radiographic tests. Radiation is very valuable; don't waste it!

Repeat Imaging: How Often?

Smaller trauma hospitals, both designated and undesignated, are the front line for the initial care of the majority of trauma patients. Many patients can be evaluated and sent home or admitted to the initial hospital. More severely injured patients are commonly transferred to the nearest Level I or Level II trauma center for care of injuries requiring specialists.

Imaging studies such as conventional x-ray and CT scan are a necessary part of the initial trauma evaluation. **But is it necessary to do a full radiographic evaluation, even when it is known that the patient will have to be transferred?**

Researchers at Dartmouth Hitchcock Medical Center examined the issue of repeat imaging at their Level I center. They looked at 138 patients that were transferred to them from other rural hospitals. They found that **75% underwent CT scanning prior to transfer, and 58% underwent repeat scanning upon arriving** at Dartmouth.

The authors discovered the following:

- Head CTs were repeated 52% of the time, primarily due to clinical indications
- Spine reconstructions were repeated 33-50% of the time due to inadequate reconstruction technique
- Chest (31%) and abdomen (20%) were repeated due to inappropriate use of IV contrast
- 13% of image disks used incompatible software
- 7% of images were not sent with the patient

Here are my recommendations for imaging by hospitals that refer patients to Level I or II trauma center:

- Obtain the essential plain films recommended by ATLS (chest, pelvis)
- If an obvious injury requiring transfer is found on exam (e.g. open fracture) do no further studies

- Obtain any imaging studies needed to decide if you can admit the patient to your own hospital (example: abdominal CT for abdominal pain and negative FAST. Keep if no injury, transfer if solid organ injury)
- As soon as an injury is identified that mandates transfer, do no further studies
- Always send image disks with the patient
- Work with your referral trauma center to obtain a copy of their CT imaging protocols so if you do need to perform a study you can duplicate their technique

Reference: Gupta et al. Inefficiencies in a Rural Trauma System: The Burden of Repeat Imaging in Interfacility Transfers. J Trauma 69(2):253-255, 2010.

Repeat Imaging: What Good Is It?

I've written previously about how often imaging gets repeated once a trauma patient gets transferred to a trauma center. There are many reasons, including clinical indications, need for advanced imaging (reconstructions), or lack of contrast. But at least 20% have to be repeated because the media is incompatible or not sent with the patient. Sounds like a problem, but is it a significant one?

A recent retrospective analysis of about 2,000 transfers to a Level I center looked at the reasons for repeat imaging and changes in outcome due to it. The paper found several interesting things:

- Repeat imaging was more likely in more severely injured patients
- Hospitals that transferred more patients to the trauma center tended to do more scans before transfer
- Patients who had repeat imaging stayed in the ED longer waiting for definitive disposition
- Repeat images did not improve outcomes (LOS, DC home, mortality)
- A rough estimate of \$354 more in charges was attributed to repeat imaging

Bottom line: Repeat imaging is wasteful, expensive and increases time in the ED. And don't forget about the radiation exposure. With all the emphasis on pushing hospitals to use an electronic medical record, there needs to be a

similar push to standardize methods for transferring radiographic images between hospitals to address the problem of repeat imaging.

Reference: Repeat imaging in trauma transfers: A retrospective analysis of computed tomography scans repeated upon arrival to a Level I trauma center. J Trauma 72(5):1255-1262, 2012.

Radiology Cloud Services: The Basics

Cloud computing has been one of the more common and probably over-used buzzwords in recent years. People are so used to hearing it now, that they don't really give any thought to what it really means and how it works.

What is cloud computing, exactly? Simple. It's an easily accessible and always available pool of computing resources that is not on your computer. It's somewhere else. Some computer hardware makers have designed hard drives with network connections that plug into your home or office network to allow you to access your own data from anywhere. But this isn't really the cloud most think of. It's just a few drops of water vapor, in my opinion.

Cloud service providers are generally housed in huge data centers located strategically around the globe. These centers have thousands of computer servers and even more hard drives that can provide computing power or storage on demand. They can be dynamically configured to create virtual computers, dynamic websites, or allow for offsite data storage.

Many companies have chosen to abandon the model of buying their own hardware, software, and storage capacity. This requires money, technical expertise, and a lot of attention to physical and virtual security. There is now a shift toward using cloud-based computers, subscriptions to cloud-based software, and storing data on cloud-based hard drives. Although there will always be technical and security concerns, many of these costs are borne by the cloud providers, making it much less expensive for end users to operate using these services.

Several companies that you use regularly are based on Amazon Web Services, probably the biggest cloud provider in the world:

- Netflix
- Parts of Apple's iCloud service
- Spotify
- The CIA (yes, that *Company*)

A number of cloud services are available for allowing health care organizations share and transfer imaging studies to each other. Since every hospital now has electronic storage of these studies (picture archiving and communication system, PACS), and the interface to it has been reasonably well defined, it is fairly straightforward to set up a transfer system between different organizations.

Prior to this, hospitals could create virtual private networks (VPN) to transfer studies in a secure manner. However, some technical expertise is necessary, and there is some advance work needed for each connection to an outside hospital. Major receiving hospital may need dozens of individual VPNs to service their referral base.

Some states have developed their own PACS cloud services. They can be either administered by the state or by a hosting institution. Costs tend to be low, but so does funding. Quality can be quite variable.

Finally, there are a number of commercial products available. They create a virtual PACS system in the cloud. Receiving hospitals purchase access to web-based software that allows them to interact with the cloud PACS. The receiving hospital can provide secure access to their referral partners. This allows the referring hospital to upload their imaging securely to the cloud. The receiving hospital can view the images, and optionally, download them into their own PACS system. The subscription / access fees help to guarantee quality and performance, since there are enough products out there to provide healthy competition

Radiology Cloud Services: How Effective?

Radiation exposure from diagnostic imaging remains of high interest to all trauma professionals and the lay public. A number of papers noted above have already been written showing that repeat imaging in transferred patients is high due to issues with transmitting images between sending and receiving trauma centers.

A variety of solutions exist for reducing this problem. One of the more technically oriented ones is LifelImage,

a cloud based service. Images from just about any PACS system can be uploaded to the service by a referring hospital. The receiving center can peruse the images using a sophisticated browser based tool, or they can merge the PACS data for any or all studies into their own PACS system.

ShockTrauma in Baltimore receives severely injured patients for the entire state of Maryland. They reported their experience with this cloud service over a 6 month period, and compared it to 6 months before use during the prior year.

Here are the factoids:

- A total of 1,950 transfers were reviewed (!). Data was collected prospectively.
- The number of patients undergoing repeat imaging decreased significantly, from 62% to 47%
- Cost also decreased significantly, from \$402K to \$327K during the study periods
- Hospital length of stay decreased from 4.4 to 3.8 days
- There was no difference in mortality

Bottom line: Cloud solutions for transferring imaging information work! A lot of radiation and money was saved! Frankly, I'm puzzled as to why the decreases were so modest. I suspect that some or many of the potential referring hospitals were not participating at the time of the study. Nevertheless, it looks like the savings should easily pay for the cost of the service.

Reference: Reduction in repeat imaging in patients transferred to a Level I urban trauma center decreases cost and radiation exposure. EAST 2014, poster #28.

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