

Thanks Melissa. This afternoon, we are going to take a look at some of the aspects that are involved in the...in what basically has happened in the changing environment of diagnostic imaging. We'll talk about... so we'll talk a little bit about conventional imaging and I'll have some remarks about the manner in which imaging has been done up to this point in time. We'll then take a look at volume imaging, what do we mean by volume imaging, what are the types of modalities in which we do volume imaging and, more importantly, most importantly, why do people want to do volume imaging; why has this become such an important way to take a look at sick people. There have been tremendous practice implications in this conversion that's happening as we speak. Interestingly enough, happening, although, there hasn't been a lot of controlled studies and things like that, the technology is racing along as you heard earlier from Jerry. And then lastly we'll tie this together with an example of the implications of this regarding radiation dose in two settings; one of which is a diagnostic setting and the other is the setting of screening.

Well this is the way imaging was done for at least about 100 years, in which we would pass x-rays through a patient, capture those x-rays and produce a two dimensional image. This, of course, was a landmark event when it was first discovered on November 10, 1895, so much so, in fact, that much of the standard imaging that was done in the 50's was actually...had actually been invented by the early teens of the 19<sup>th</sup>...20<sup>th</sup> century. So this was very, very quick. Röntgen publication was less than a month following his discovery and, of course, the whole community thought this was so important to award the first Noble Prize in physics to him. Sir Godfrey Hounsfield, who just recently passed away, by the way, also received a Noble Prize in...actually its physiology and medicine, for development of CT. CT took imaging to a new place, there's just no question about it, it replaced things that were done in the past and that's an important thing to understand that, imaging itself has grown over the years and procedures that used to be done are no longer done anymore. The interesting thing, I think, for all of us to examine is, are we going in the direction we want to go in, are there good indicators, are there metrics for how we're getting there and, if not, what sort of things should we be looking to, to work together on, in order to direct us. Well, there's no question that the quality of imaging has changed dramatically over time. This was largely the work of folks involved in imaging science. The things like, that Jerry talked about, like imagery construction and those kinds of things. And, in fact, today, even though we did see some whiz-bang hardware just a few minutes ago, but the really big advances are actually all being made in software. Software is pretty much king right now and it's very likely that the speed at which things get done is going to increase dramatically.

Well, in the early days, of course, one of the issues that we had was that, in order to scan, we had to scan and then rotate the gantry back again because...to keep the cables from being tied up. Now that, of course, is not happening any more. Now, in present scanning, we move the patient through the gantry, we have a scanner that has multi-detectors, we produce lots of images and then we look at them on a workstation of one sort or another. How many images? Well, it's just...it's very typical now, in a diagnostic x-ray department, that typical exams will have any where from 300 to 800 images for a study. That's a very typical study, in fact, you can produce...in fact, places right now are considering protocols that will produce as much as, as many as, 8,000 images for one exam. Now what we're going to do with the data presents another problem that we'll talk about in just a minute. So, multi-detector CT is the current modality and how did it start? Well, it started back in the days with Sir Godfrey Hounsfield. Interestingly enough, that was a multi-slice scanner. The Emimark 1 produced two slices. So it

really was the first...the very first scanner was, in fact, a multi-sliced scanner. It wasn't a multi-detector, but it was a multi-slice. The next thing to come down the road was in '92, when Elscint produced the first twin or two sliced helical scans. After that we saw, very quickly, four slice scanners, 16 slice scanners and there now are eight, ten and as many as 64 slices on these systems.

We'll talk a bit, in a minute, as to why it probably will not go up a whole lot more with this kind of approach, instead, it will go to a flat panel detector. But, no one knows exactly when that's going to happen, however, all of the major companies are...I think it's pretty fair...it's pretty common street knowledge, that all major companies are working on producing images with flat panel detectors and we'll show you one such system. So, the principle is that the patient lies on the patient table, the gantry, this gantry moves through the machine as the detector rotates about the patient. The detector consists of many elements in this X-Y direction, as well as a number of rows in Z and this is where the four slice, 8 slice, 16, 32, 64 comes from. It's the number of discrete slices you get along the Z direction or the head-to-toe direction. Now these detectors look...can be in many different ways. One way to do this is to put them in just a square pattern, the trouble with that is that the fan angle of the beam gets large and, therefore, the radiation gets truncated as it goes through larger and larger slices in the Z direction and we'll show that in just a second. So that's the major reason why this particular vendor or these vendors, there's more than one, they use what's called an adaptive detector. You can see the detector's spaces at the edges are wider or bigger than the ones in the middle and you get different slices by combining them in different ways. In other words, in this particular scanner here, you can run it either at 16 slices at .75 mm or at 16 slices at 1.5 mm and you do that just by gathering the data together.

So the issue is, why do people want to do volume imaging? Well, consider this; what if this was your family member and the question was a vascular abnormality, would you want the neuro imager to be looking at this image or something like this, in which you truly get a volume image that allows you to reconstruct the image in different ways and then, in fact, examine not only the single plain, the axial plain that was done, but, in fact, take a look at the interior to find an abnormality like that. There's just no question about it that you don't have to go to medical school to figure out that this is a much better image to use, and that's what's driving this whole process. That's one of the things that is driving this whole process, is the fact that the quality of the images is striking and startling and allows for a better diagnosis of sick people. Now, in addition to that, if you can do that in the skull, of course, the other big area, used for different purposes, is in the colon. This is a virtual colonoscopy study and, you take all the data in the axial plain, and then, through software, you manipulate it so that you can get a view just as if you had...just as if you were to go get a colonoscopy done. Unfortunately, right now, the preparation for this procedure is pretty close to the regular colonoscopy. Those that are not old enough to have had this done yet, you can look forward to learning what Go-Lytely is. It was a real joke by the folks that put this together to call it Go-Lytely because there's nothing lightly about it, you do a lot though. However, right on the horizon now is a way, through software, to tag the stool so that you would not have to do that kind of a prep. That would, of course, be a huge...have a huge effect on the patient side of things; patients would like this quite a bit. I think he might be hung up with the movie there. I think that we've got our movies that have out powered our machine, I'm afraid. We need some more of those custom Linux processors that Jerry talked about. Can you advance it from there? This, of course, makes virtual colonoscopy hard to do if

you can't actually move through the bowel at all. This particular piece of bowel has been very well diagnosed by now though; that's the good news.

This, of course, never happened when we used to have slides. The worst thing that could happen then was a bulb burned out. Well, perhaps you'd like to know what I did today. It's also my mother's birthday, perhaps we could all sing "Happy Birthday" to my mom, that would be a... Well, the point is that these exams are now being done to be used as tools, in the process of diagnosing the patient population, which, there is some reason to believe, they may have a disease. So, this brings up this whole issue of screening and, this is a huge issue for medical practice, for those involved in practice, for those that are involved in accrediting and adopting standards and regulating the practice of medicine and to society as a whole. This has tremendous implications, over the long run, with regard to screening. There are, not only implications regarding the individual patient and a patient exam, but there are larger issues of, for instance, how much it's going to cost to do this. As an example, CMS, The Center for Medicare Services, and other federal agencies, have estimated that, in the very near future, the cost of medical imaging will soar to 100 billion per year. Now this will bankrupt Medicare, if something's not done. So, there are lots of people that are very concerned about what's going on with regard to these imaging procedures. There's two areas, actually three areas right now that are receiving a great deal of attention, all of them doing volume imaging, by the way. It's CT, MR and PET, as you heard about earlier, and the combinations of PET CT's and PET MR's. There actually are some... a PET MR machines now as well.

So these are the areas of practice that are expanding the greatest and they're also presenting the biggest threat in terms of an economic impact upon the United States. So, this is a huge issue that will not go away easily, in fact, for this very reason, there... the American College of Radiology Counsel, at the last meeting, voted to, have introduced on the hill, legislation that would support the recommendation of a group called MedPACS. MedPACS is an acronym for Medicare Practice Advisory Committee. They advised the Congress that something must be done to examine the way in which imaging is being used and their criteria, that may be of interest to you all, is that, first of all, that to get paid, one would have to become a designated provider of medical imaging. So, it... the acronym is DPMI. In order to do that, there will be certain qualifications, first of all that the person has to demonstrate that they have more than just one modality at their imaging site. That's likely to be... well, the legislation, of course, just empowers the director of HHS to put a program together, much like what occurred with MQSA. The tenets for this that are important are that the facility would have to be accredited -- and that has tremendous ramifications in terms of the ability to have knowledge about what sort of dose is actually being utilized. In addition to that, the staff will have to show that they have qualifications; they have background and training.

So, once again, those issues of education and training are going to become very, very important as well. They will have to demonstrate continuous medical education, lifelong learning -- that kind of thing, and, interestingly enough, by the way, in the model right now, is that the facility will be required to have an annual inspection by a qualified medical physicist. So, this could have a very, very large impact on the interactions that we have with one another and how these things play out in the future. Now, why is this important? It's important because this kind of approach was shown by Med Pac to save anywhere between \$4 - \$12 billion a year; and that's enough money to get Congress interested. So, these are issues that are coming up and they'd related directly back to the fact that with volume imaging now, more and more can be done. So, in the times previously, we couldn't actually ever produce this kind of imaging. We

also have seen, over the last year, the introduction of a new x-ray tube design -- I don't know how many of you have seen these in the latest generation of Siemens equipment they use a tube called a Stratton Tube and in that tube, the entire assembly rotates and is adjacent to circulating oil to cool it, you effectively have an infinite number of heat units. We have such a system at our place and during the break between Christmas and New Year's, we were doing lots of phantom experiments and, if we hadn't burned up a tube that time then, no tube was ever going to burn up because we did just about everything you could do with that system. However, that tells you though that it is possible to produce that amount of radiation and so, therefore, it's possible to have these exams that soar in the number of slices and in, concomitantly, the radiation dose.

So, this is a very, very important issue. It's one that hasn't been discussed a lot, prior to now, because the focus was on what we just saw before we had the technical difficulty and that is, that the quality of the images, the ability to see better detail, the ability to move faster, opening up a whole new area of investigation -- that of cardiac scanning, was now possible. And so, it was the science, if you will, and quality patient care that had been driving this. However, it is going to be time, and certainly the time is coming rapidly, when there needs to be serious discussion about how the equipment is being utilized and what the implications of this are for, not only individual patients, but society as a whole; both with regard to dose, expenses, etc. This is a multifaceted problem that will demand a solution, but it won't go away. There is just no way that we're going to turn back the clock and say, "Well, we're going to stop at 64 slices and that's it, we just won't do anymore." That surely will not happen. So, we need to be working together a lot more, I think, in generating data about the way in which these imaging exams are actually done and the associated doses. As you all know, of course, because you do it, the next survey is perhaps our best source of information regarding radiation dose to the general public in the United States. However, as I think also everyone would agree, it is a dose index of a sense, it doesn't actually measure the actual dose that a population gets for a particular exam. There obviously are trade-offs involved and the trade-offs have to do with any phantom that's used -- which all these neck studies use a phantom to measure image quality in dose, no matter which phantom is utilized, that doesn't necessarily reflect the entire population. We were very close.

Well, let's see if I can advance this. I'm not getting anywhere. Ah, okay. This is it, we moved up from the colon to something...another organ that's very important to us and that is lungs. So, in the typical study like this, this would be a screening study and perhaps an abnormality is located, is located in the study. The data can then be reformatted to isolate a particular nodule and investigate whether this nodule is benign or is likely to be cancer. Now, keep in mind that, this display and this 3D rendering did not acquire...did not require additional data. Those all came in the initial acquisition of the scan and that's what I meant by the advances in software are really driving things quite...>> Slow. >> Yeah, I would agree with that. >>(inaudible) >>

Well, there's only three or four more left so...Well, in this...once again brings home the point though, the data are acquired in a manner that the resolution of current scanners is truly isotropic. So, the resolution in all three plains is the same. Once you have that, you've met the fundamental criteria for reformatting of image data. To say that I can now take data that were acquired in an axial mode and I could reconstruct data as if it were a chest x-ray -- that is in a coronal plain or from right to left in a sagittal plain, or, in fact, turn it at an angle if I want to see the way a vessel is angulating through the liver or something like that. So, this ability to do this allows more and more examination, of course, of the imaging data. That's true in CT, it's also true in MR, it's also true in PET, and so, therefore, these volume imaging techniques have begun

to produce a type of imaging we just simply didn't know before and we didn't...and we hadn't seen these kind of things before. Previously, the use of this 3D rendering and those kinds of things, was really limited to academic centers that had a strong interest in a particular kind of study like, renal arteries or something like that. It was not wide spread. The current technology is pretty much off the shelf and people can buy it and learn how to run these scanners quite easily.

So, once again, these scanners are very likely to continue to develop and to be found in all kinds of settings, not just in high-end, high academic type places. They will be...in fact they are right now, they're going into lots of private practices and private...independent imaging centers. So, these are the kind of things that we will be seeing more and more of. Interestingly enough, although...let's go ahead a couple of slides. One of the things that does become an issue, by the way, is that these scanners also are made to be run on a menu basis or driven by a menu that is...that, you can leave it there, that's fine...that makes it very, very easy for the operator to run. The trouble is, that in order for us to understand what's really going on, particularly with regard to dose, we often don't have the control over the equipment that we did before and I know all of you experienced this with the higher-end gear. Right now in hospitals, if you get the latest interventional suites or the latest CT scanners, it is very difficult, in fact, to make some of our basic measurements. Well, what's happened with volume imaging is the following; that if you're interested in something like sudden death due to cardiovascular disease, the number one killer of adults, at least, in the United States, what you would like to do is, from before the patient really had symptoms, you would like to identify those patients that are high risk.

This is where imaging plays a role. This is cardiac CT, the same thing is true with a virtual colonoscopy and with lung cancer screening. The idea is that this weeds out those people that have a high risk of disease and then you can work them up. You can either do therapy; in this case it's a statin therapy like Lipitor or something like that, and stabilize the patient so you prevent ever having that myocardial infarction in the future. It is this idea that is so important in volume imaging. It is the idea that you can prevent an event that would otherwise have occurred, which would be far more devastating, not only to the patient, but also to society in general because the caring of patient's as they get sick is far, far more expensive than the prevention of illness in general. As an example of this...now this is not in the states, but the same thing is happening here. As we saw the movement from a four slice scanner to a 16 slice scanner, this distribution, this pie chart shows different types of CT exams, okay. And in the old days, this would only have...this would have one big one that said head, one big one that said body and that was about it. But, nowadays, that's not the case. And you can see that this section here, which is oncology, is shrinking now because this section here of cardiac screening has doubled and their practices, as well as, CT and geography. So, there's little question that this is being implemented and that a practice pattern is being changed, and that's an important feature. That's something that we want to remember is that, what's happening with volume imaging is that, practice patterns are changing and those practice patterns and how they change have an effect upon the things that are important to all of us. Now, I mentioned the issue about dose and one of the things that you may hear of, and see in the vendor's literature, is that more...that multi-slice scanners with higher slice numbers -- that is 32 to 64, actually are a dose savings. That's the way they'll phrase it. Here's what they mean, this wasted dose here...and this is for a detector ray that is square in nature, that is it's not adaptive, so it doesn't help reduce...doesn't do anything to reduce this. You can see this beam that's diverging, the problem is, that it's going to

get cut off by the columnation. So that means that, this area right here is wasted dose, with regard to these four detectors. What the vendors do, and I think this is important to make sure -- this is not to be mean to the vendor's, it's just for the sake of clarity. What they do is they've got the same wasted dose here as they do over here, but now they've got 16 slices. So, what they do is they say, "We've got the same dose, but now that the denominator is less...is greater, so the overall wasted dose is now X percent less than it was before. That's not really true though. We are still irradiating part of the body that we're not going to get any information from. And, in fact, by the way, for those of you that may not know, there is a scanner out there that's made by Phillips and then to be a cardiac scanner, in which it does scan around the entire body, but it only presents, to the imager, the area of the heart. This is a real interesting phenomena that's going to occur; these boutique-type scanners, and before, that was considered to be something that would not be suitable to sell because, in fact, there might be disease out of the lungs and that kind of thing. But, this has other issues that have to do with practice issues and referral patterns and lots of other things that we talk...won't discuss today. This is the new scanner from...that one of the...that uses this flat panel. This scanner not only goes around the patient in the way you see here, but also around the patient in this direction. So, you can, in fact, now produce images that in the laboratory versions of this, produce images that have higher resolution than conventional CT scanners. So, that has proven that this technology can work. Now, there are a lot of problems to be resolved and if you looked at the images that are available in departments right now, you might say, "No, that's not...it doesn't look very good." But, keep in mind it wasn't that long ago that heads look pixely and that kind of thing, and so the software is going to have a great effect. So, what about the dose? Let's talk about the dose itself and what these practice patterns mean. We have here a listing of dose values for various CT exams and you can see one thing right off the bat, right, and that is that the doses vary by a factor of ten or so depending upon the area of the body that's being examined and the type of study that the facility is doing. In addition, it's important to realize that these are for single slice scans. We're going to talk about another setting in just a couple of minutes. In these settings though, it is important that the doses that we've measured do not reflect, necessarily, potentially dose savings that will come about due to the use of, essentially, an automatic exposure control on CT systems.

Dr. Willie Collinder invented a way to actually do this in real time as the gantry or the tube is rotating about the patient to measure the dose and, in fact, modulate the beams and the x-ray beams intensity and so, that should help quite a bit and should make a significant dose savings. Depending upon the particular exam, you're talking about anywhere from 15 to 40 percent dose savings. So, it could be very substantial. Yeah...you want to try that one for me? As I said, practice patterns are changing and so, what I wanted to take a look at now, as one of the slides come up to speed here is, one exam and this is Medicare data that we're going to take a look at and it's looking at an exam called an excretory urogram, also known as an IVP, and how those practice patterns have changed over the last several years using those data. While they're switching over to another computer here, I did want to go back to the point about these boutique scanning. There have been devices, of course, over the years that have irradiated parts of the body and we didn't get all the information...oh, that's it. Good, thank you. These are the Medicare data and in the orange kind of...the yellow kind of bars here, are IVP's or EXU's, excretory urograms, and you can see what's happened between 1970 and 2002. This is a steady decline. The orange bars are CT excretory urograms and you can see that they started off fairly low. These have been normalized so that you can look at them on the same graph. And they've risen quite dramatically and, in fact, that's happening almost everywhere.

Now what are the dose implications of that? Well, depending upon sources, there's lots of sources, as I mentioned, whether you look at Nex data or you look at Published data or you measure it yourself, there are assumptions made in the calculation of the dose. So, for EXU's, it's somewhere between 1 to 11 milliseverts (mSv) and, interestingly enough, for an Excretory Urogram, you actually do three abdominal pelvic exams. You do one without contrast, one with contrast and then one delayed, at some point in time, to see how the kidneys and bladder clear the contrast media. So that, essentially, is three studies and that's what bumps this up now to something between 50 to 70 milliseverts (mSv). A substantial difference than what we saw in the previous table. So, if we take just the average values, let's say that the regular EXU is around 6 milliseverts (mSv) and the CT EXU is right about 60; there's a factor of ten difference. What are the implications of that? What does that mean in terms of overall and how these exams are done? In the last year that we had the data there, in 2002, there were, for Medicare studies alone -- and that number's probably multiplied by three if you include all studies. There were almost a million exams; about 930,000 EXU's were done. If all of...and so, those data will have...would have exposed that population to something around the order of about five megaseverts. If you then take a look at EXU's, the number jumps, obviously, about a factor of ten; up to 51 megaseverts.

So, this dose implication for the entire population is a non-trivial issue as you convert more and more radiographic procedures over to CT procedures. It's something that we really need to take a look at and for something that we really need data. One of the hottest items that...hottest topics right now in all of medicine is called evidence-based medicine. The generation of metrics to measure how a surgeon performs, how an internal medicine physician performs in terms of correctly diagnosing a patient, how many...this is a metric that you've certainly heard about, how many wrong side surgeries are there, how many limbs have been amputated on the wrong side and that kind of thing. These are very, very important topics and throughout all of medicine, this has become a war cry, if you will, to increase patient quality, the quality of care of patient's and patient safety. The same is true in radiology, it's receiving a great deal of attention in all the professional and national bodies and I think it's time that we should begin to get together, that we should get together actively in order to produce evidence based regulations. One of the things that we've been hampered by before is ability to gather the data to really know, what are the doses that the population is actually getting, it's a very difficult thing to do. There were companies, at one point, that provided subscribers with TLD's to put on them as they got radiological examinations; Proved not to be very easy to do and very hard to interpret.

However, as a first step in this...and so, what do we mean by evidence-based regulations? What we mean is that, we feel it should be the duty of the scientific medical physics community to gather the data to be able to present to regulatory and standardizing bodies so that they know exactly what the issues are and what is actually going on in practice throughout the United States. That would allow the regulations then to be geared toward actually what's going on and set the stage for what professionals in the field legitimately feel to be the right levels. So, what do I mean by this? Well, for instance, in the area of computed radiography, all the vendors have an exposure index; it is not necessarily the radiation dose, but it is the exposure index. In addition, in CT right now, the term or the quantity CTDIvol or Volume CTDI, as well as the dose in your product, is calculated for each exam, for each patient, on every machine that's sold. What we are starting to do as a joint project between the American College of Radiology and the AAPM, is a project in which we would look at the headers, the

DICOM headers, and extract those dose indexes. From that exercise, we could actually gather, in real time, data from that actual facility on what their dose levels are, anonymous, so there's no HIPAA issue here and all that. You would, therefore, be able to tell a facility that the doses that you're using for chest x-rays are three standard deviations higher than everybody in your region or in the country or in the state or in the world, for that matter; however you wanted to attack it. But, I think it's very important to begin to think about how, what data do we want and how can we go about getting it through the use of software techniques on the image data that we're gathering right now. We are also working very hard, the college and the AAPM are working jointly with NEMA to get the CT vendors to put those calculated values into the header so that they can be extracted. The vendors right now actually do that, if you talk to them...well, allegedly the vendors do that, if you allegedly talk to them in private. They just keep it in shadow fields that is not in labeled fields and would like to see that changed.

So, we think this is a very important issue in future and the place where we ought to go and we think this is crucial to directing things, in the future, with regard to the use of imaging to make...to assure ourselves that we are imaging the highest quality that we possibly can and maintaining patient safety as high as it is possible. I'd like to close with just another part of the practice that I thought you might find interesting and that is, what happens on the other side of this? We've got all these thousands of images, what happens with that? Another important issue about why we're here even talking about this, and volume imaging has come about, is because electronic practice has now become more standard than non-standard, and so, therefore, that has enabled this technology to come about. No one would ever even thought of doing a thousand slices, printing it on film 9 up or 12 up or something like that; you wouldn't be able to carry the exam around. Now, with electronic practice, that is possible. So, for many years, this is the practice of radiology in Rochester in the '50's and this is in Jacksonville in the '80's...in the '90's rather, early '90's, and you can see how much has changed, right, there's hardly anything has changed. You'd still have a human looking at rear-illuminated x-ray film, dictating to a person who then transcribes that report. The computer has replaced the typewriter; aside from that, nothing's changed. Well, now there's a big change, now we have monitors at workstations throughout the department, in order to read the images. We also have...we also replaced all of our male radiologists with women. No, well actually, we didn't quite take that step, that would be a little tough to do in our culture. But, we do now dictate into a machine and that report pops up over here, Dr. Duperry then, will look at their report, electronically sign it right then and so, therefore, that exam, where that could have hundreds and hundreds of images, can be read and can be available to the referring physician in as little as ten minutes. So, that means that this is very, very efficient. This has allowed this whole practice to change, to drive this. It's produced problems. These workstations have lots of different features and keyboards and you got a keyboard for the RAS terminal and for the electronic health record and that kind of thing so, that has become a problem.

Now, we've, of course, provided the radiologist with lots of solutions, but these have been good at solving the symptoms, not the disease. So, what we need is a paradigm shift in image interpretation and this is actually going on right now as well. This volume imaging has caused a complete shift in things, and why; well the basic problem is, we've got too many bloody images. If we take a look at the practices, we are doing more and more per day, we're doing more studies per patient and we're doing more images in each study. So, you put all of that together and that compounds the growth of imaging in all of our departments. We took a look at our own practice and back in '94, the typical cross-sectional imager, that's somebody that

does body CT and ultrasound, usually, in most practices. Now, that typical person would look at about 1500 images in a day. By 2002, now with electronic practice, it mushroomed up to 16,000. Unfortunately, by 2006, we predicted, if it goes the same way, it's going to be 80,000 images a day. What does that mean? Well, if we looked at each image for one second, or if someone looked at each image for one second, that would take an astounding 22.2 hours. So, it is clear that a train wreck is going to occur. There's no radiologist in the world that's going to sit there for 22.2 hours, there's no bunches of radiologist that are going to sit there. Not to mention the fact that there is not an over supply of radiologists so, something is going to have to be done. Oops. You might ask, "Why are we so far behind? Well, how'd this all occur?" Well, there's a lot of reasons why. We mentioned some of them, we mentioned the whole issue of the technology and how that has changed our...the way in which we do things and that kind of thing. Also, though, this is a reflection of medicine. Medicine is not a very quick adapter to new things, even though we like to see the commercials from the companies about how wonderful drugs are and all the rest of this. In truth, medicine doesn't adapt to the new technologies as quickly as other industries, such as the auto industry and those kinds of places. So, this should not be a surprise to us that this has occurred. I just wanted to mention briefly and this is an unabashed plug, for an initiative from The Society for Computer Applications and Radiology, its called The TRIP Initiative. TRIP stands for, transforming the radiological interpretation process. SCAR's embarked upon this initiative to solve this and there's basically six areas in which we think are important in terms of solving this problem and moving...changing the paradigm. One is perception, the whole issue of human perception is surprising...has been surprisingly under-studied, we don't really know the details that we need to about how do people detect things. You clearly can't interpret an exam if you don't see the finding, so, the issue is here, maybe we could, if we knew something more about perception, maybe we could also adapt to have computer assisted detection. That is, only have the human look at those cases that we know are abnormal in one way or another, they don't fit the pattern of the average chest exam, for instance. Some sort of new techniques, we'll take a look at those in a second, visualization are going to be necessary.

You can't just look at 80,000 axial images a day because you don't have the time in order to do that. In addition then, we'll need to have better ways to navigate through the work stations, we'll need to take a look at the data bases and how they support the decisions that are to be made, and most...not to be forgotten here, we must develop metrics; we must have objective ways to know that the changes that we're putting in are positive changes and which...how's that going to be done. Well, are we going to end up like this? Is this going to be a virtual reality kind of thing and wear goggles and a radiologist will stand in a little cubicle and stuff like that? Maybe, who knows? SCAR doesn't know for sure, but they want...but they are starting this initiative in order to get the discussion going, in order to adapt to a new way to do things and that is going to include volume imaging. Some techniques have already been developed. This was developed by a department chair of radiology attaching a speedometer to the workstations so that he could measure the actual efficiency of a body imager. The administration thought this was so good and they thought about what...where are hours wasted per day, and we could make better use of those for the imagers, so they, of course, came up with this device, which was not appreciated by the staff; they didn't laugh, they thought this was serious. Well, just to close to look at the future a little bit here and Yogi(43:01) has been quoted quiet a bit here today, I see. He's a very quotable fellow and one of his memorable quotes is, "It's tough to make predictions, especially about the future." And that is undoubtedly correct, but we do think the workstations

of the future will have lots of features that we can envision now, 1) They will have a lot more things integrated. The radiology information system, the electronic medical record, the ability to look at image data bases. RSNA is building a...what's called the MIC, and so, if you were looking at a study and you wondered if this was of a hepatoma and you say, "Give me five cases of clinically diagnosed and verified hepatoma and you could use that to compare; that kind of thing. In addition, other decision support tools are going to be necessary. Are there other information about disease that would lead us down a path to make one diagnosis over the other? This is beginning to happen now. The residents are going to Google in order to find reference materials for things that they're looking at. And, I think, in general, the most important issue here is, will practice drive the technology or...in fact, is the technology driving the practice. I think we can conclude by saying that, for the most part, right now, there's more...technology is driving practices more than practices are driving technologies, and I think that is a very important issue; one that we need to make sure that we raise together to both the users -- that is the folks in our departments, as well as to the folks that produced the imaging equipment, to understand how the changes are taking place and to ask the question, "Is this a good thing or not?" And I think that's an important issue.

Well, that's an overview of volume imaging and how it reflects upon dose, and there's no question that these will continue to evolve over the future and...this one's really not going to work. And whether we'll end up with more and more of imaging techniques, but one thing is for sure, that we will have an interesting ride ahead of us. Thanks very much.