

# The Book

**Basic CT for New CT Technologists**  
A Quick Guide in the Assistance of Cross Training New CT Technologists



Assembled by Christopher L. Blue RT(R)(CT)

Dedicated to Mr. Robert Blaine RT(R) at Georgetown University Hospital, for his skill in persuading me to write this book.

Also dedicated to Mr. George Armah RT(R)(CT) at Georgetown University Hospital, for his knowledge, skills, and willingness to inform.

And lastly, dedicated to all the students and X-ray techs who are willing to learn. Properly.

Told you I'd do it.

Special thanks to all the technologists I've encountered over the years, for their expertise and knowledge, and for their hard work in training the new technologists.

Special Thanks also to the founders and creators of the Internet, where there is a wealth of knowledge and information that has been used to refresh my memory.

Thanks to [www.auntminnie.com](http://www.auntminnie.com), [www.wikipedia.com](http://www.wikipedia.com),  
[www.intmed.mcw.edu/clincalc/creatinine.html](http://www.intmed.mcw.edu/clincalc/creatinine.html),  
<http://www.emedicine.com/radio/topic864.htm>, <http://enw.org/IVStarts.htm>, [www.google.com](http://www.google.com),  
David Woeber RT(R)(CT) at [www.davesplacesinradiology.com](http://www.davesplacesinradiology.com) for his extensive information,  
personality, and links, and [www.ask.com](http://www.ask.com)

A very special thanks to my wife, for putting up with me and my obsessive compulsiveness for so many years.

A very special thanks goes to all the proofreaders of "the book" from [www.auntminnie.com](http://www.auntminnie.com) and [www.radiologyforums.com](http://www.radiologyforums.com), and to my colleagues at Georgetown. I'm always eager to share, especially when you also share your expertise.

Papa

The book is designed for the new CT technologist. Everybody who cross-trains into CT will, at some point in time, find this information useful. While working at Georgetown University Hospital, I had the pleasure of working with one such individual. Mr. Robert Blaine RT(R) had so much potential, but did not have the wealth of knowledge that many of the CT registered technologists had. Many times, when I would show him a new trick, or method of doing something differently and easier, or even when he watched me do my complicated protocols, he'd tell me, "Ya know, you really should write a book."

So here it is Bob. This is my book. I've picked my brain clean, and also many other technologists either via web or email. I know that computers are not your strong point, as with many other techs in the community. Here is your book. Inspired by you, but for the training purposes of all the techs and students interested in CT.

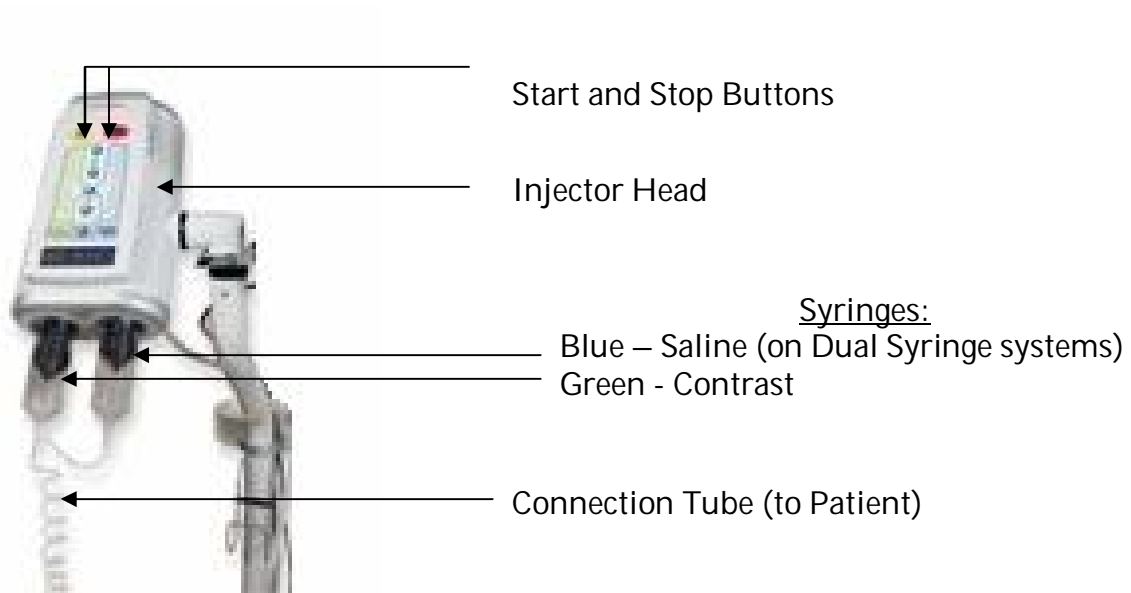
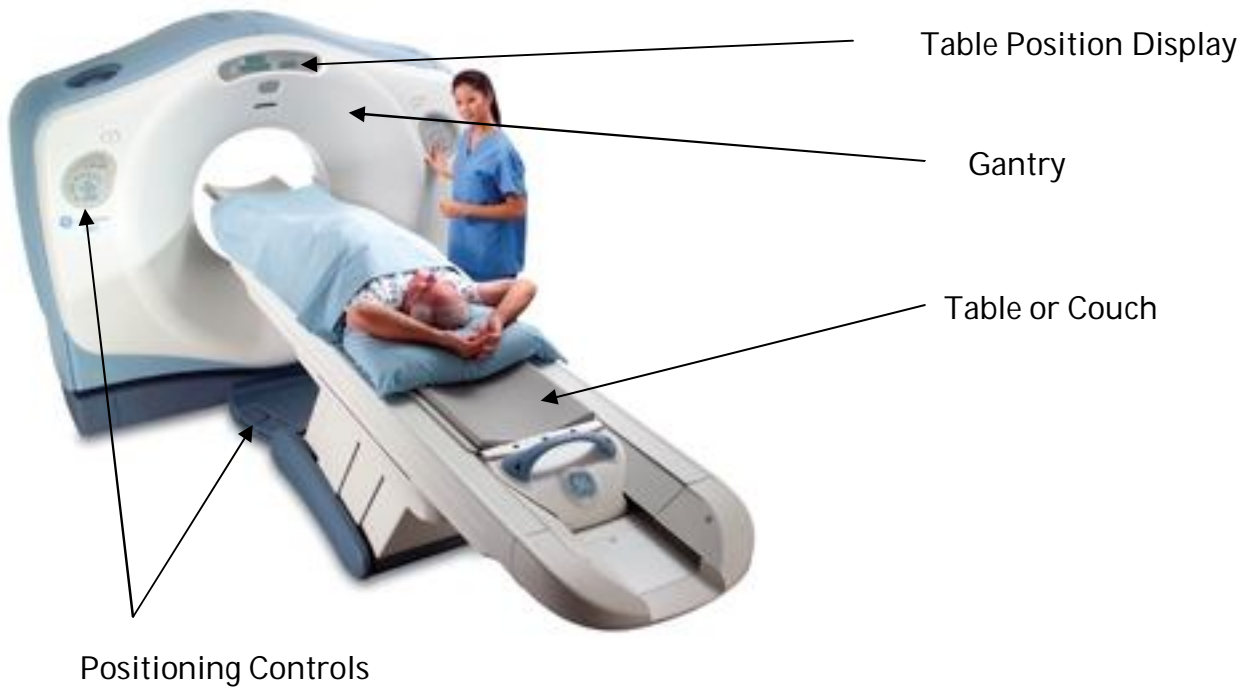
Papa.

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### Routine Equipment in the Room



Control Area

Some scanners have only one screen, and second screen is for MPR and 3D Reconstructions

Injector Console

Planning Screen

Image Screen



Contrast



Brand Name

Optiray 320

Osmolarity

With regards to the Osmolarity of contrast, the higher the number, the brighter the contrast tends to appear on the scan. However, the higher the number, the higher the possibility for renal issues post contrast.

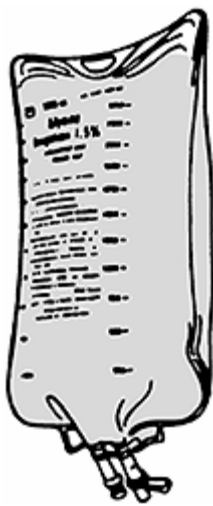
With an abnormal Creatinine level (above 1.5) check for GFR. If GFR is above 60, use Optiray. If GFR is below 60, use Visipaque. If Creatinine is above 2.0, DO NOT GIVE CONTRAST

[www.intmed.mcw.edu/clinicalcalc/creatinine.html](http://www.intmed.mcw.edu/clinicalcalc/creatinine.html)

## IV's



Gauge	Color	Description
24	Yellow	Pediatric
22	Blue	Routine Study
20	Pink	Routine/Angio
18	Green	Angio



**Sterile Saline (0.9% Sodium Chloride)**  
 (for injection use, do not use vial "for dilution of medications")

Comes in 250ml, 500ml, 1000ml, also in 3 and 10 cc syringes

Used to flush lines, test IV's, also used as a "saline chaser" with the power injector

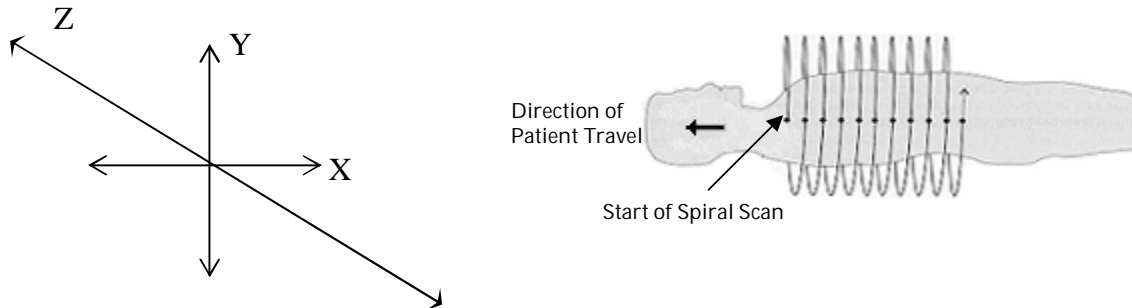
Is easily dissolved under skin in case of IV infiltration.

**Connecting tube**

Used with IV's so patient can move without being attached to the IV injector.

**ALWAYS FLUSH AND REMOVE AIR FROM LINE BEFORE ATTACHING TO PATIENT!**

## X Y Z Axis



This is the basis of Cross Sectional Imaging. X and Y will demonstrate Right, Left, Anterior and Posterior. Z gives the images an actual thickness that can be imaged. It is an imaginary line that runs the length of the CT table (or couch). It is the line that we mark our slice positions from, and can reposition to those same positions during an examination.

When setting table positions you will adjust a "box" to fill and include all the anatomy you are interested in. Example: when scanning an Abdomen and Pelvis, you need to include everything from the dome of the diaphragm, past the Pubic Symphysis. You will change the size and length of the box to include all anatomy to the skin. The length of the scan (diaphragm to Pubic Symphysis) will be the Z-axis.

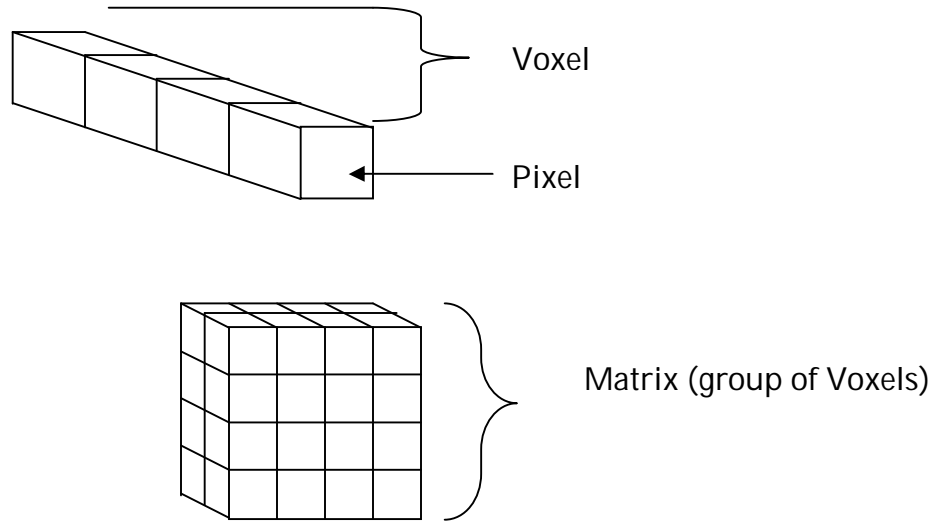
If you look at an axial image with an open Field Of View (DFOV means Display Field Of View or what is actually displayed in the image, SFOV means Scan Field Of View or what is actually scanned), the center of the image is R-0, A-0. This means that the center of the image being viewed has not been adjusted right, left, anterior or posterior. This function of CT is very helpful when reconstructing into a smaller DFOV. Sometimes a patient may be off center due to patient movement or technical error, or we just need to see something else on the scan that is not being displayed. You can use the Grid function on the scanner, and an X and Y axis will display on your axial image. Use it like finding points on a graphic chart (just like we did in geometry class), to change the center of your displayed image.

**AS LONG AS YOU UNDERSTAND THE X-Y-Z AXIS, EVERYTHING ELSE IN CT IS PROTOCOLS!!**

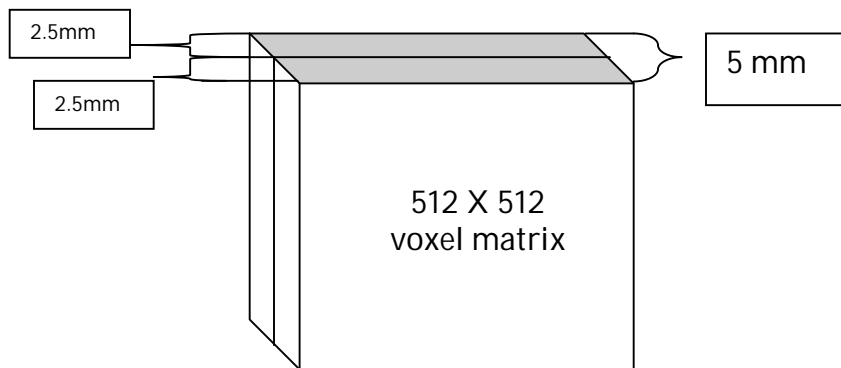
The GE 64 VCT at the AAR Woodbridge Imaging Center has been programmed to match as closely to the CT scanner up in Alexandria. However, since they only have a 2-slice (and this is a 64-slice) there are many variations. The same basic principles and theories are the same.

**Pixel, Voxel, and Matrix**

A pixel is what is used to display an image on the screen. Computer monitors use a series of thousands and thousands of pixels that display light. A voxel is a "volume of pixels."



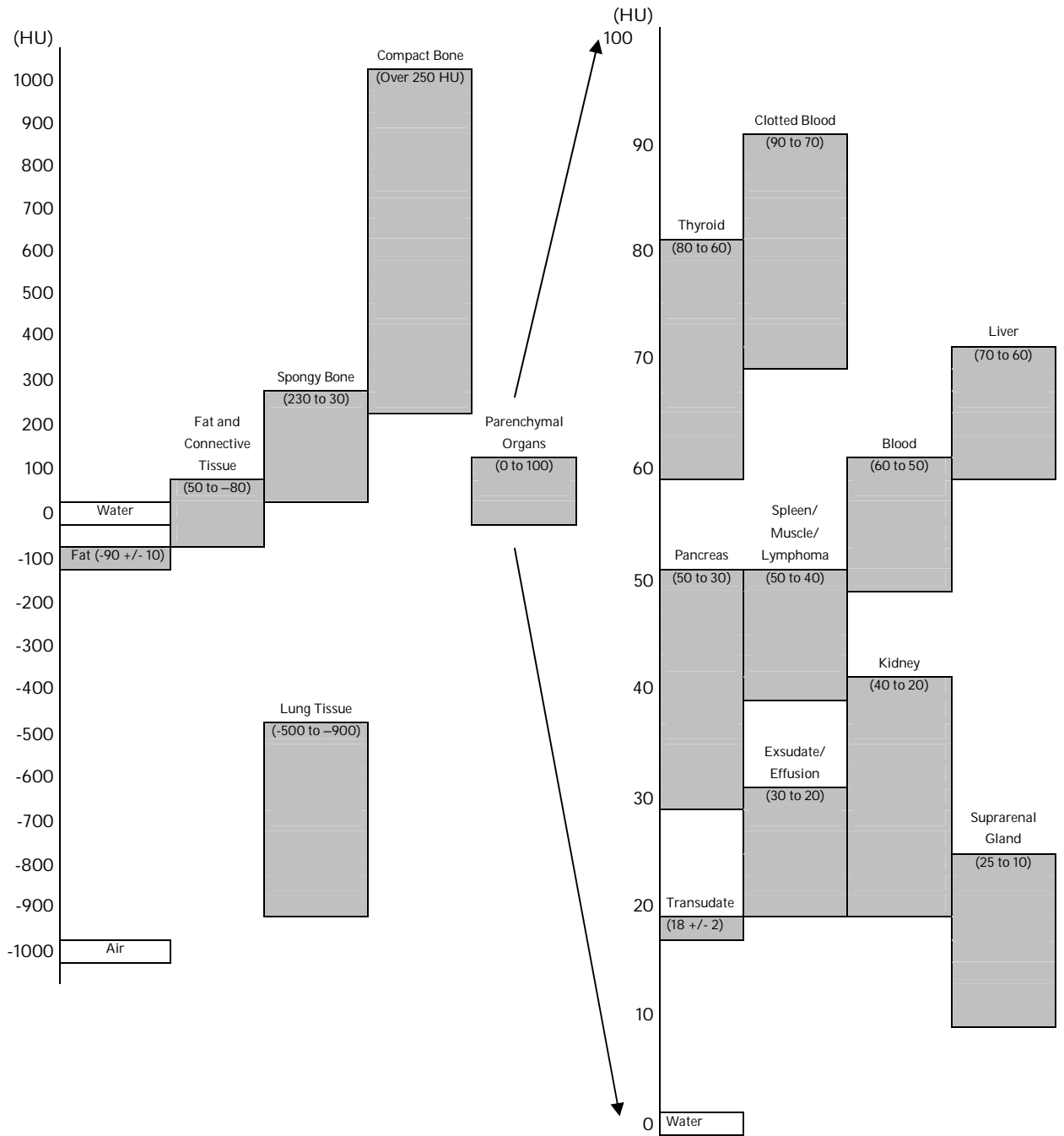
When you look at the CT computer monitor, you see the matrix. The slice thickness will be represented in the size of the voxel. Images with larger slice thickness (and thus a larger voxel) can sometimes have a blurry appearance to them. The computer is taking all the information of the voxel, and displaying it in the pixel. Therefore: the thinner the slice, the smaller the voxel, and the sharper the image.



**Hounsfield Units**

When the computer is constructing the image, each pixel is assigned a number based on density. These numbers are called Hounsfield units, and range from air at -1000 HU, through water at 0 HU, and up to bone at +1000 HU (see chart on next page). Hounsfield was an English electrical engineer who shared the 1979 Nobel Prize for Physiology or Medicine with Allan McLeod Cormack for his part in the development of CT.

### Typical Tissue Hounsfield Units



## Image Contrast Scale

### Window Width

Thinking back to X-ray School when they taught about wide and narrow scales of contrast, CT uses basically the same scales. A narrow scale of contrast will give a more contrasted look to the image, and a wide scale of contrast will give many shades of gray. Therefore, the higher window width, the more grays will be in the image.

### Window Level

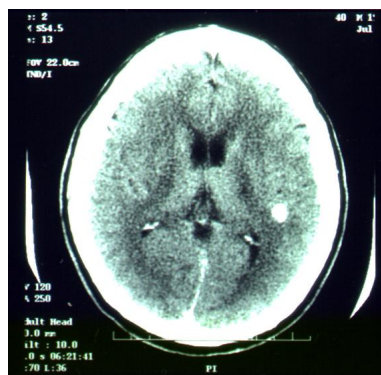
Window Level is a description of the density of the image. A higher number will give a darker image, and a lower number will give a brighter image.

The following table lists some most common window and level settings:

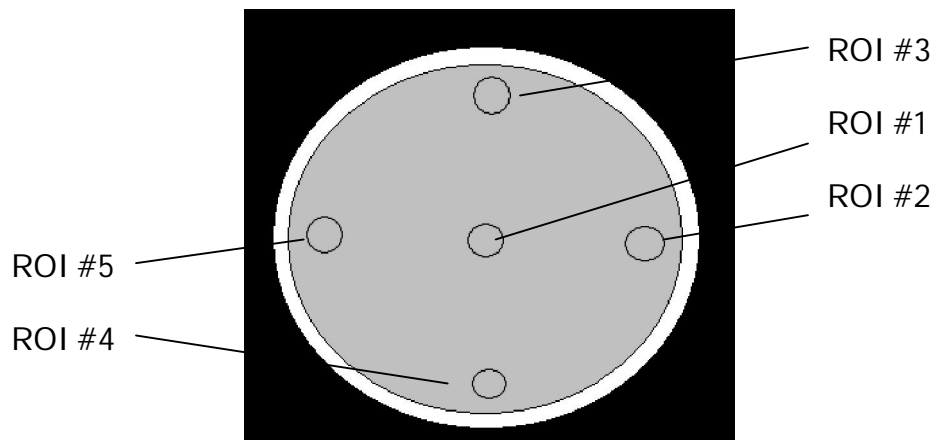
TISSUE	WINDOW WIDTH	WINDOW LEVEL
LUNG	1600	-600
SOFT TISSUE	400	40
BONE	2000	500
BRAIN	80	40

## Standard Deviation, Noise, and Uniformity

Standard Deviation is a measurement of noise, or distortion in the image. Basically, the grainier the image, the higher the noise factor, therefore the standard deviation will increase. This graininess is usually caused by an insufficient number of x-rays exposing the detectors, or too little technique. Think back to x-ray, and the new CR equipment on the market. If your technique is too low, you'll get a lighter image, or with CR, the image will be very grainy. The same concept applies to CT. If there is not enough radiation to expose the detectors, then the computer will compensate as much as possible, distorting the image with grainy texture. Adjusting window width and level settings can sometimes make the image appear to be less grainy, but the information is still the same.



Uniformity relates to the theory that one structure or material will keep the same ROI value throughout the image. Normally, this is tested during the routine QA's. The following is an image of a water phantom with ROIs taken at the appropriate positions. Referring to the Hounsfield Unit chart on the page 6, the value of water should be 0 (zero). Different brands of scanners can have different variations on this value (typically no more than  $0 \pm 5$ , meaning a range from  $-5$  to  $+5$ ), with the center value (ROI #1) as the baseline reading. As the technologist takes measurements, a reading that is not accurate can change a diagnosis.



### Artifacts

Artifacts are distortions or degradations of the CT image. They can mock pathology, block structures of the image, and can ultimately make the image unreadable. Steps need to be taken to prevent artifacts, whether it is equipment based, or patient based.

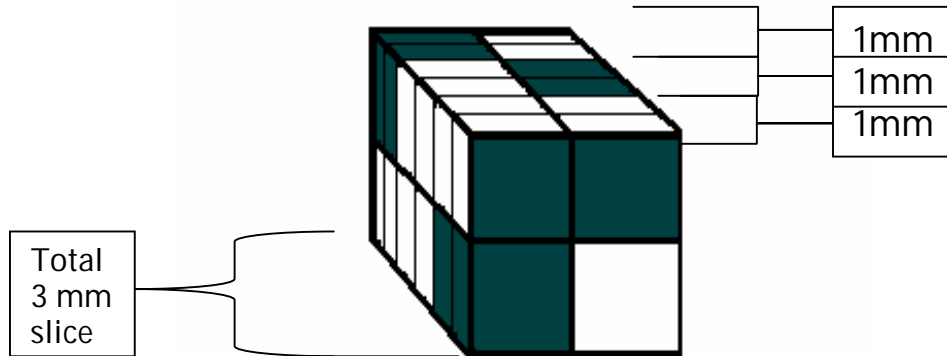
#### Beam Hardening

Beam Hardening is caused by scanning a dense object with tissues of a lesser density on the inside. The dense material or structure blocks the attenuation of the primary beam, thus losing data on the structures behind it.



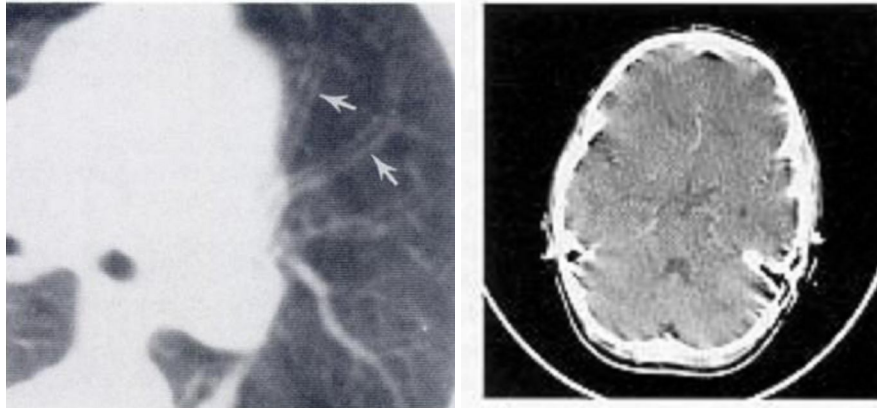
### Partial Volume Averaging

When thinking about slice thickness, what happens if a structure is smaller than the slice thickness? Partial Volume Averaging. This can become extremely frustrating during biopsies. Looking at the diagram representation of 4 voxels below, the dark shaded areas represent a 1mm structure. The image that is displayed can show a different size, shape, or even location of the structure. Basically, it is a misrepresentation of the accurate image. Better accuracy will come from a smaller image.



### Motion

Motion artifact is caused by any kind of movement while scanning the patient. Motion can be voluntary (as in physically moving the anatomy) or involuntary (such as cardiac movement, or respirations in a vented patient). No matter which kind of motion we are dealing with, the most efficient way to reduce motion artifact is to reduce our scanning time.



### Metallic

A very dense material inside the field of view causes Metallic or streak artifacts. The X-rays cannot penetrate this material, and no information can be acquired from this area. Dental fillings, pacemakers, spinal hardware, and other metallic objects in the body will cause this artifact, and areas around the metal are unreadable.



### Edge Gradient

Edge gradient streak artifacts generally occur when the edges of a "sharp" high-density object interface with a smooth surface. They frequently occur from the edges between bone and soft tissue. Instead of imaging these two small structures as separate entities, the CT system "sees" them as one structure.

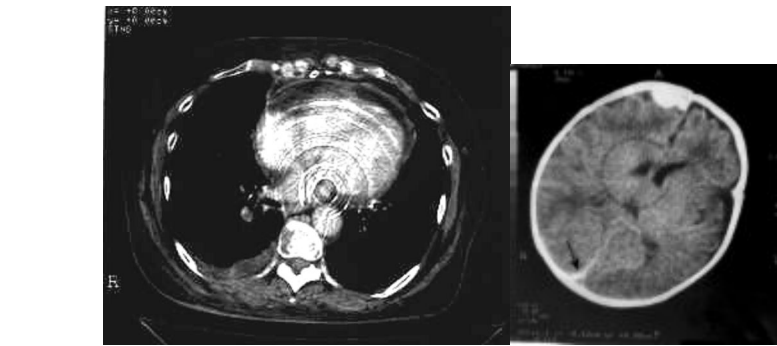
### Patient Positioning

If there is an arm on top of the body while trying to scan the liver, or if anatomy is touching the scanner while the patient is off-center, or if the patient is unable to obtain the proper positioning for the requested examination, the positioning of a patient can produce an artifact. Many things that a patient does during an examination can cause an artifact. Breathing when told to hold their breath can cause motion artifact. Keeping arms in the field while scanning the chest can cause a beam hardening artifact. Etc, etc, etc.

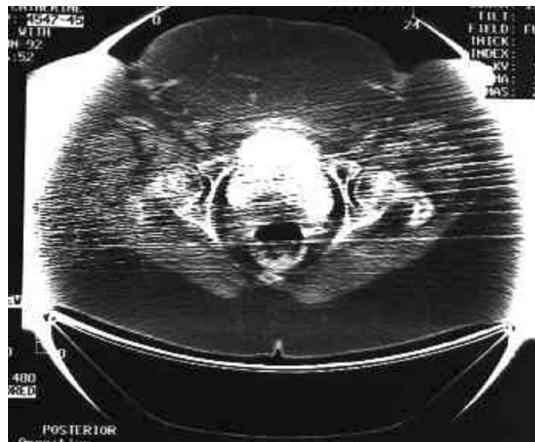
### Equipment-Induced

Equipment induced artifacts are caused by a defect or malfunction of the scanner. If one or more of these artifacts are visualized, there is nothing that the technologist can do other than to place a call for the service engineer. If the technologist is familiar with the scanner error logs, sometimes he/she can troubleshoot to find where the error is coming from.

- Rings - Probably the most common mechanical artifact, the image of one or many 'rings' appears within an image. This is due to a detector fault.



- Streaks - Streaks are caused not only by metallic structures within the FOV, but can also be caused by other structures outside the SFOV.



- Tube arcing – when an x-ray tube ages, deposits of tungsten will form along the glass tube casing. When enough of the glass is coated with tungsten, the electrons in the tube coming from the collector cup that are supposed to go to the rotating anode, travel to the glass. This is called an arc. There is no real predictable pattern or regularity for the artifact it produces, but commonly it can be visualized as noise and streak artifacts.
- Cone Beam – cone beam artifacts are limited to multi-row detector scanners that use simple filtered back projection reconstruction.

## IV Contrast

*“Normal anatomy on CAT Scan is all grey. Air shows up black, and bone shows up bright white. Without any kind of contrast, the liver mixes in with the spleen, which mixes with the bowel, and we can't make heads or tails of anything. The oral contrast that you drank will line your stomach and intestine, and the IV contrast will highlight blood vessels. The IV contrast also highlights organs like your liver, spleen, pancreas, and kidneys, so we can see all their structures. It will also highlight any kind of infection or inflammation. So if there's anything going on in there, chances are, I'm going to be able to see it. The IV contrast will give you a warm feeling all over, but sometimes it'll vary from person to person. It will also give you a*

*little bit of a metal taste. This is all normal. Sometimes the contrast will make people a little bit noxious, but if you have any kind of problems, please, let me know. Do you have any questions?"*

Whenever I start with a patient that I personally have not seen before, this is always included in my "speech". Some people want to be informed about everything that is going to happen to them. Others just want to get it over with. Those people can tune me out. It's always necessary that the patient be informed about every procedure that occurs to them.

Contrast is used to enhance various parts of the body. IV contrast is injected through the patients IV, travels up the patient's arm and into the heart. From there, the contrast travels throughout the entire body. All that we do is catch that contrast in its desired phase (usually in a venous phase, because the veins and arteries have contrast).

Body Part	Arterial Phase	Venous Phase	Delayed Phase (Routine)
Neck	20 to 30 seconds	45 seconds	No typical delays
Chest	20 to 30 seconds	50 to 70 seconds	No typical delays
Abdomen	25 to 35 seconds	60 to 80 seconds	3 to 10 minutes (Depending on Protocol)
Pelvis	30 to 40 seconds	70 to 90 seconds	Minimum of 4 minutes to fill bladder
Head	25 to 30 seconds	60 seconds to 3 minutes	No typical delays

Arterial phase injections in the body can enhance both arterial abnormalities, and some types of tumors. Some Liver tumors can only enhance with an arterial injection. Arterial injections need to have at least a 20g IV catheter (18g is preferred), and must have a flow rate of at least 3.0 to 3.5 cc/sec. This fast injection rate will put a large amount of contrast in the body at once, enhancing the arteries first, hence the quick scan times. If at all possible, start the line in the Right antecubital vein. Starting the line here, the contrast will go straight into the SVC, and into the heart. There will be less travel time and distance for the contrast, and it allows the contrast bolus to be more uniform and easier to time.

#### Allergic Reactions

Allergic reactions need to be taken very seriously. If there is any question on whether or not a patient has an allergy to IV contrast, the study needs to be STOPPED IMMEDIATELY. Do not start an IV, access a line, or even position the patient, before you speak to a radiologist, or the patient's physician (preferably the radiologist, for it is his proverbial butt that is on the line).

Allergic reactions can proceed very quickly. Usually, the first thing a patient will feel is a little bit of itching. This can happen in the back of the patient's throat, on the skin, or a multiple of other places. Basically, any itching anywhere on the body can be considered the start to an allergic reaction. Sneezing is also a prerequisite to an allergic reaction. If you notice any of these signs, STOP, TAKE THE PATIENT OUT OF THE SCANNER, CALL THE RADIOLOGIST, AND GRAB THE DRUG BOX OR CODE CART, in that order. If working in the hospital setting, you can call a code once the radiologists arrives to the department, or if the reaction is severe enough, call a code, and have somebody else call the radiologist. You will never be frowned upon for calling a code.

If the reaction has not been noticed yet, the next thing a patient will feel would be swelling of the throat, decreased breathing, sweating, and loss of consciousness. This is a bad thing. Some patients will skip the itching and sneezing, and go straight into this anaphylactic reaction. This is a very bad thing. Medical assistance is crucial for the survival of the patient. (see appendix A for further information)

### IV Contrast Preps

Whenever a patient has a CT scan with contrast, it is necessary for the patient to prepare at home (in addition to PO contrast). Usually, this means nothing but NPO (Nothing Per Oral or by mouth) for about 3 – 6 hours (prior to PO contrast if necessary). Patients with known or suspected contrast allergies need to take a specific pre-medication to prevent an allergic reaction. Examples of this premedication can be found in appendix A.

### Types of IV's and Lines

There are many ways to access the circulatory system (veins), ranging from small pediatric lines, to permanent Ports surgically placed under the skin. All lines need to be treated with caution and care.

IV Cath: This is the preferred method for delivering IV contrast media. They are quick, simple, and easy to place in just about any patient. The larger numbers correlate to a smaller IV, and the smaller numbers are the larger, stiffer IV's. Any kind of angio procedure (CTA's) requires at least a 20 gauge IV, and an 18 gauge is usually preferred.

1. 18 gauge – most likely the largest IV we would place in CT. It has a green hub (or base) and is a very large needle. Patients who have large veins, but are stiff due to scar tissue or chemotherapy drugs can usually take the 18g.
2. 20 gauge – this is the smallest IV used in any kind of CTA, and is pink (frilly with flowers and all. Just kidding). The larger bore allows the contrast to flow more freely into the veins. As with the 18g IV, patients who have stiffer veins tend to do better with the 20g IV. The 18g and 20g IV's have a thicker plastic sheath, which tends to stay ridged, and does not fold when it encounters scar tissue or other obstacles.
3. 22 gauge – the most common IV used in CT and is blue. Typical flow rates with the 22g can achieve up to 3.0 cc/sec. Anything higher than this tends to cause problems. Problems include the IV site blowing and extravagating, too high of a p.s.i. and breaking the line itself, the IV becomes disconnected from the contrast line, and many other problems.
4. 24 gauge – normally used in pediatric patients. This needle has a yellow hub, and can also be used in difficult patients. The power injector is not usually preferred, as a hand injection causes fewer problems with this small IV. If the power injector is required for the study, a low flow rate (below 1.5 cc/sec) and a decreased p.s.i. setting on the injector is highly suggested.

PICC lines: the interventional radiology department normally places PICCs (Peripherally Inserted Central Catheters) usually in the upper arms in either the brachial or radial veins. The ends of these lines typically go to the end of the SVC at the heart. These patients usually have difficulty in accessing normal IV lines. This is considered a semi-permanent line, as it stays in the body for a couple months. As long as it flushes easily with normal saline, we can power inject through these lines typically at no more than 1.2 cc/sec. These lines need to be flushed with normal saline, and then a heparin-lock solution after every medicine injected through the line. Depending on the facility or state regulations, only certain people can inject heparin. Check with your facility as to whether you can flush lines with heparin or not.

Mediports: Mediports are lines that are surgically implanted underneath the skin, and can be accessed through the skin with a special needle. Specific training is definitely recommended while accessing ports, and use of sterile technique is required. This is a device that is implanted

under the skin, and can get infected if it is not accessed properly. As with the PICC line, the decreased flow rate and heparin flush are required.

**Power Ports and Power PICCs:** recently, the invention of the Power PICC and the Power Port have made it possible for patients with poor IV access to have an Angiographic CT (CTA). The high flow rates of CTAs can blow lines and catheters and cause a lot of problems. The Power PICCs and Ports can accept up to 4.0cc/sec to accommodate for studies requiring higher injection rates (PE, CTA's, Run Offs, etc.). The same kind of care needs to be taken with these lines as with the other normal PICCs and Ports.

**Central Lines:** Central lines can be used, but as with the normal PICCs and Ports, cannot exceed 1.2cc/sec. Nurses on the floor will tell you that their central lines are very large etc, etc, etc. Remember this: the length of a catheter and the diameter both play roles in resistance. Central lines tend to be very long. Large amounts of contrast at high rates through central lines can cause problems. If this is the only access a patient can get, and it is an emergent situation, check with the radiologist. If the radiologist approves for a CTA through the central lines, do not exceed 3.0 cc/sec.

**Dialysis Caths:** NEVER USE A DIALYSIS CATHETER FOR CONTRAST ADMINISTRATION! Dialysis caths are to be used sole for dialysis of the patient due to renal insufficiency or failure. Special care from the dialysis team is taken to access these lines. One line is arterial, and one line is venous. Do not attempt to access this line, even if the nurses and doctors say that it is ok to use it. If you have problems with the nurses, call the radiologist (interventional radiologist if available).

## **Oral Contrast**

Drinking of oral contrast lines the stomach, small, and large intestine. It is to be noted that some studies of the abdomen do not require barium sulfate for the study, and some particular studies will be seriously degraded if the patient has any kind of density in their GI tract. Studies for kidney stones, CT IVP's, and many angio studies are included in this.

In addition to the oral contrast, some places require the use of rectal contrast. Mostly teaching facilities do this, but it is not unheard of to see it elsewhere. The theory of the purpose in rectal contrast is that it distends the large intestine in such a way that it will coat any diverticula that may be present in the large intestine. Places that do not do rectal contrast usually just have the patient drink more contrast, and wait a bit longer for the contrast to make it's way through the patient's system.

### PO Contrast Preparations

NPO (Nothing Per Oral or by mouth) for about 3 – 6 hours. Emergency studies can sometimes forego the patient 's NPO status, but imaging is much better if there is no other material in the GI system.

One method of patient prep without the rectal contrast is to have the patient drink 450cc of barium 2 hours prior to the scan, and 450cc of barium 1 hour prior to the exam. Most places that do this also request that the patient drink as much of a cup of barium as possible just before getting on the table to ensure that the stomach is coated with barium.

Another method, uses the rectal contrast, but reduces the amount of time the patient needs to drink the contrast. A total of 900cc of barium, started 30 minutes prior to the exam, in addition to the rectal contrast usually coats the entire GI system fairly well. Patients who have had multiple CT's tend to not mind this method. Newer patients to CT tend to gag on the barium, and may vomit the barium. There are many flavors on the market, and the flavors sometimes help with the new patients.

**Barium:** Barium sulfate is a white crystalline solid as a suspension of fine particles in an aqueous solution (often with sweetening agents added). Although barium is a heavy metal, and its water-soluble compounds are often highly toxic, the extremely low solubility of barium sulfate protects the patient from absorbing harmful amounts of the metal. Patients who are about to have surgery, or patients where there is a possibility of perforated bowel, should not have barium, as it cannot be absorbed by the body (is not water-soluble).

**Gastroview:** (Gastrografin®, Gastrovist®, Gastrovision®, MD-Gastroview®) is the preferred oral contrast to be used with surgical patients. If gastroview passes through the bowel into the abdominal cavity, it is easily absorbed into the body, with little to no side effects. IV contrast can also be used in this oral contrast setting. Usually, the mixture is a ratio of 30 to 1 (30cc water or clear liquid to 1cc of contrast). It should be noted that patients with contrast allergies should not have this type of contrast, for it is very high in iodine.

**Water:** Water can be used as a negative contrast. When visualizing the pancreas, or even sometimes some specific small bowel disorders (typically looking at the bowel wall), regular oral contrast can mask pathology. Negative contrast (there are many brands) will expand the bowel, and will not degrade the anatomy needed. The cheapest form is water.

**CO<sub>2</sub>:** Carbon dioxide gas is used only as a CT contrast agent while performing virtual colonoscopies (VC). During a VC, Carbon dioxide is administered rectally, and the patient is scanned supine and prone. As with a normal colonoscopy, air is needed to expand the colon to visualize the entire structure. Rather than using liquid contrast, air does not show on the CT images. The 3D software used in VC is much more accurate and is easier to perform with air.

## Scan Types

There are three basic types of scanning. Axial scanning refers to a “image – move – image – move” type of study. Nowadays, these are normally restricted to Head CT’s, Screening Sinus CT’s, and biopsies. Helical scanning refers to the “image while in motion along the z-axis” method. The majority of scans done in CT are all helical (spiral). Dynamic scanning, more of a reconstruction method than a scan type, refers to scanning multiple series, and reconstructing the information after all the scans have been completed.

### Axial

Axial scans are the stop – go beast of CT. Older scanners take a while to perform studies, but the newer MDCT scanners are fairly quick at acquiring axial scans. While they typically are more accurate than a helical scan, they still are not able to image the body as quickly as a helical scan. This is why they are usually limited to head work and biopsies. Where contrast is concerned, Head CT’s with contrast have a wide enough range of delay that scanning the head in 1 – 2 minutes really doesn’t degrade the level of contrast in the brain. However with Brain CTA’s on the other hand, getting that arterial phase in the brain is only about a 30 sec delay. Tops. That’s why we use the helical scan while doing CTA’s

### Helical

Helical scanning is the most common scan in the CT industry. With the new MDCT scanners on the market, we can now image the entire body (Neck, Chest, Abdomen, and Pelvis) within 30 seconds, depending on the facility’s protocols. I know that on the GE 64 MDCT, I can scan an entire Chest, Abdomen, and Pelvis in under 20 seconds. With the advancement of the CT technology, the accuracy and image quality of helical scanning has drastically improved. Even still, for head work, and now with the intervention of cardiac scanning, axial images are preferred for a decreased radiation dose.

### Dynamic Scanning

On older scanners, reconstruction times were long, as the computer processing speeds were very slow. Dynamic scanning allowed the scanner to scan multiple series quickly, often after a rapid bolus injection, without reconstructing the images. Arterial and venous phases could be scanned without spending the time to reconstruct the images in between scans.

Today, with the use of faster processors, dynamic scanning is used more as part of a cinescan (or movie). Cardiac imaging, brain perfusions and the like, acquire many scans at once, and can be reconstructed once the scans are completed.

## Conclusion and Sign Off

Welcome to the wonderful world of Computed Axial Tomography. As of now (December 2007), ARRT and many state regulations do not require techs performing CT scans to be CT registered. I have heard through various grapevines, that it is coming.

This can get you started. Of course, there are many other topics and discussions regarding CT that will be needed to pass the ARRT boards, and maybe that will be in a later book. As long as you know the basics, you can start learning from there. Too many techs are learning the "push this button, wait for that light, then push this button" way of scanning. They do not learn the reasoning behind the scans, or what all is included on the scan.

I've always been a firm believer that there is a difference between a technologist and a technician, and this goes for CT, X-ray, MRI, and just about every aspect of the radiology profession. A technician just pushes buttons. A technologist knows why they're pushing that button.

I hope you've learned something from reading this book. "You learn something new every day". Anybody with any kind of questions or comments can feel free to contact me by email ([jeepsmurf@yahoo.com](mailto:jeepsmurf@yahoo.com)) and I'll do my very best to either answer your questions, or point you in the right direction.

Sincerely,



Christopher L. Blue RT(R)(CT)



# Contrast Medium Reactions, Recognition and Treatment

Taken from <http://www.emedicine.com/radio/topic864.htm>

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## INTRODUCTION

Since their introduction in 1950s, organic radiographic iodinated contrast media (ICM) have been among the most commonly prescribed drugs in the history of modern medicine. The phenomenon of present-day radiologic imaging would be lacking without them. ICM have a good safety record. Adverse effects from the intravascular administration of ICM are generally mild and self-limited. Reactions occurring from their extravascular use are rare. Nonetheless, severe or life-threatening reactions can occur with either route of administration.

Radiologists and other physicians must be aware of the risk factors for reactions to contrast media. They should use strategies to minimize adverse events and be prepared to promptly recognize and manage any reactions to the contrast media.

## TYPES OF IODINATED CONTRAST MEDIA

All currently used ICM are chemical modifications of a 2,4,6-tri-iodinated benzene ring. They are classified on the basis of their physical and chemical characteristics, including their chemical structure, osmolality, iodine content, and ionization in solution. In clinical practice, categorization based on osmolality is widely used.

### High-osmolality contrast media

High-osmolality contrast media consist of a tri-iodinated benzene ring with 2 organic side chains and a carboxyl group. The iodinated anion, diatrizoate or iohalamate, is conjugated with a cation, sodium or meglumine; the result is an ionic monomer. The ionization at the carboxyl-cation bond makes the agent water soluble. Thus, for every 3 iodine atoms, 2 particles are present in solution (ie, a ratio of 3:2).

The osmolality in solution ranges from 600 to 2100 mOsm/kg, versus 290 mOsm/kg for human plasma. The osmolality is related to some of the adverse events.

Ionic monomers are subclassified by the percentage weight of the contrast agent molecule in solution, for example, 30% or 76%.

In the United States, commonly used high-osmolality ICM are Renografin or Hypaque (diatrizoate anion) and Conray (iothalamate anion).

### Low-osmolality contrast media

Low osmolality ICM are of 3 types: (1) nonionic monomers, (2) ionic dimers, and (3) nonionic dimers.

#### Nonionic monomers

In nonionic monomers, the tri-iodinated benzene ring is made water soluble by the addition of hydrophilic hydroxyl groups to organic side chains placed at the 1, 3, and 5 positions. Lacking a carboxyl group, nonionic monomers do not ionize in solution. Thus, for every 3 iodine atoms, only 1 particle is present in solution (ie, a ratio of 3:1). Thus, at a given iodine concentration, nonionic

monomers have approximately one half the osmolality of ionic monomers in solution. At normally used concentrations, 25-76%, nonionic monomers are 290-860 mOsm/kg.

Nonionic monomers are subclassified according to the number of milligrams of iodine in 1 mL of solution, for example, 240, 300, or 370 mg I/mL.

The larger side chains increase the viscosity of nonionic monomers compared with ionic monomers. The increased viscosity makes nonionic monomers harder to inject, but it does not appear to be related to the frequency of adverse events.

Common nonionic monomers are iohexol (Omnipaque), iopamidol (Isovue), ioversol (Optiray), and iopromide (Ultravist).

The nonionic monomers are the contrast agents of choice. In addition to their nonionic nature and lower osmolalities, they are potentially less chemotoxic than the ionic monomers.

#### Ionic dimers

Ionic dimers are formed by joining 2 ionic monomers and eliminating 1 carboxyl group. These agents contain 6 iodine atoms for every 2 particles in solution (ie, a ratio of 6:2). The only commercially available ionic dimer is ioxaglate (Hexabrix). Ioxaglate has a concentration of 59%, or 320 mg I/mL, and an osmolality of 600 mOsm/kg. Because of its high viscosity, ioxaglate is not manufactured at higher concentrations. Ioxaglate is used primarily for peripheral arteriography.

#### Nonionic dimers

Nonionic dimers consist of 2 joined nonionic monomers. These substances contain 6 iodine atoms for every 1 particle in solution (ie, ratio of 6:1). For a given iodine concentration, they have the lowest osmolality of all the contrast agents. At approximately 60% concentration by weight, they are iso-osmolar with plasma. They are highly viscous and, thus, have limited clinical usefulness. Examples of nonionic dimers are iotrol and iodixanol.

### **ADVERSE REACTIONS TO ICM**

Adverse reactions to ICM are classified as idiosyncratic and nonidiosyncratic. The pathogenesis of adverse reactions probably involves direct cellular effects; enzyme induction; and activation of the complement, fibrinolytic, kinin, and other systems.

#### **Idiosyncratic reactions**

Idiosyncratic reactions typically begin within 20 minutes of the injection, independent of the dose administered. A severe idiosyncratic reaction can occur after an injection of less than 1 mL of ICM.

Although reactions to ICM have the same manifestations as anaphylactic reactions, they are not true hypersensitivity reactions. Immunoglobulin E (IgE) antibodies are not involved. Prior sensitization is not required, nor do they consistently recur in a given patient. For these reasons, idiosyncratic reactions to ICM are called anaphylactic reactions.

The symptoms of anaphylactic reaction can be classified as mild, moderate, and severe.

#### Mild symptoms

Mild symptoms include the following: scattered urticaria, the most commonly reported adverse reaction; pruritus; rhinorrhea; nausea, brief retching, and/or vomiting; diaphoresis; coughing; and dizziness.

Patients with mild symptoms should be observed for the progression or evolution of more severe reaction, which requires treatment.

#### Moderate symptoms

Moderate symptoms include the following: persistent vomiting; diffuse urticaria; headache; facial edema; laryngeal edema; mild bronchospasm or dyspnea; palpitations, tachycardia, or bradycardia; hypertension; and abdominal cramps.

#### Severe symptoms

Severe symptoms include the following: life-threatening arrhythmias (ie, ventricular tachycardia), hypotension, overt bronchospasm, laryngeal edema, pulmonary edema, seizures, syncope, and death.

#### **Nonidiosyncratic reactions**

Nonidiosyncratic reactions include the following: bradycardia, hypotension, and vasovagal reactions; neuropathy; cardiovascular reactions; extravasation; and delayed reactions. Other nonidiosyncratic reactions include sensations of warmth, a metallic taste in the mouth, and nausea and vomiting.

#### **Bradycardia, hypotension, and vasovagal reactions**

By inducing heightened systemic parasympathetic activity, ICM can precipitate bradycardia (eg, decreased discharge rate of sinoatrial node, delayed atrioventricular nodal conduction) and peripheral vasodilatation. The end result is systemic hypotension with bradycardia. This may be accompanied by other autonomic manifestations, including nausea, vomiting, diaphoresis, sphincter dysfunction, and mental status changes. Untreated, these effects can lead to cardiovascular collapse and death.

Some vasovagal reactions may be a result of coexisting circumstances such as emotion, apprehension, pain, and abdominal compression, rather than ICM administration.

#### Nephropathy

Contrast agent–related nephropathy is an elevation of serum creatinine level of more than 0.5 mg% or more than 50% of baseline at 1-3 days after the ICM injection. The elevation peaks by 3-7 days, and the creatinine level usually returns to baseline in 10-14 days. The incidence of contrast agent–related nephropathy in the general population is estimated to be 2-7%. As many as 25% of patients with this nephropathy have a sustained reduction in renal function, most commonly when the nephropathy is oliguric.

The mechanism of this nephropathy is thought to be a combination of preexisting hemodynamic alterations; renal vasoconstriction, possibly through mediators such as endothelin and adenosine; and direct ICM cellular toxicity.

#### Cardiovascular reactions

ICM can cause hypotension and bradycardia. Vasovagal reactions, a direct negative inotropic effect on the myocardium, and peripheral vasodilatation probably contribute to these effects. The latter 2 effects may represent the actions of cardioactive and vasoactive substances released after the anaphylactic reaction to ICM. This effect is generally self-limiting, but it can also be an indicator of a more severe evolving reaction.

ICM can lower the ventricular arrhythmia threshold and precipitate cardiac arrhythmias and cardiac arrest. Fluid shifts due to an infusion of hyperosmolar intravascular fluid can produce an intravascular hypervolemic state, systemic hypertension, and pulmonary edema. Also, ICM can precipitate angina.

The similarity of the cardiovascular and anaphylactic reactions to ICM can create confusion in identifying the true nature of the type and severity of an adverse reaction, and the confusion can lead to the overtreatment or undertreatment of symptoms.

Other nonidiosyncratic reactions include syncope; seizures; and the aggravation of underlying diseases, including pheochromocytomas, sickle cell anemia, hyperthyroidism, and myasthenia gravis.

#### Extravasation

Extravasation of ICM into soft tissues during an injection can lead to tissue damage as a result of direct toxicity of the contrast agent or pressure effects, such as compartment syndrome.

#### Delayed reactions

Delayed reactions become apparent at least 30 minutes after but within 7 days of the injection of ICM. These reactions are identified in as many as 14-30% of patients after the injection of ionic monomers and in 8-10% of patients after the injection of nonionic monomers.

Common delayed reactions include the development of flulike symptoms, including the following: fatigue, weakness, upper respiratory tract congestion, fevers, chills, nausea, vomiting, diarrhea, abdominal pain, pain in the injected extremity, rash, dizziness, and headache.

Less frequently reported manifestations are pruritus, parotitis, polyarthropathy, constipation, and depression.

These signs and symptoms almost always resolve spontaneously; usually, little or no treatment is required. Some delayed reactions may be coincidental.

#### INCIDENCE OF ADVERSE REACTIONS TO ICM

The incidence of any adverse reaction to ICM is about 15%. Most of these reactions are mild and require no treatment.

#### Ionic ICM versus nonionic ICM

In 1 large series, the overall risk of any adverse reaction was 12.66% with ionic ICM and 3.13% with nonionic ICM. The risk of a severe adverse drug reaction is 0.2% for ionic ICM and 0.04% for nonionic ICM. The risk of a very severe adverse drug reaction is 0.04% for ionic ICM and 0.004% for nonionic ICM.

In another study, the incidences of mild, moderate, and severe reactions were 2.5%, 1.2%, and 0.4%, respectively, in 6000 patients who received ionic ICM. However, the incidences were only 0.58%, 0.11%, and 0%, respectively, in 7170 patients who received nonionic ICM.

#### High-osmolality ICM versus low-osmolality ICM

A meta-analysis of the published data from 1980-1989 revealed that the risk of severe adverse reaction is 0.157% for high-osmolality ICM and 0.031% for nonionic ICM. Caro et al found that the risk of death was 1 death in 100,000 patients with either type of agent.

Recent reports indicate that low-osmolality agents are somewhat less nephrotoxic in patients with azotemia than in other patients. Nonionic ICM are less likely than conventional ionic ICM to cause tissue damage when they are extravasated. Nonetheless, compartment syndromes and skin blistering are reported after the extravasation of nonionic agents.

Some toxic effects of ICM, such as nausea and vomiting, are more common with ionic dimers than with nonionic monomers (Foord, 1985).

Most authorities believe that the preponderance of evidence supporting the lower rate of adverse reactions with low-osmolality ICM compared with high-osmolality ICM is conclusive.

The reason that low-osmolality ICM have not completely replaced the older higher-osmolality ICM is their higher cost. Professional organizations have formulated guidelines regarding the selective use of low-osmolality ICM for certain high-risk patients. However, with the selective use of nonionic ICM, severe adverse contrast reactions are 3 times as likely in low-risk patients who receive conventional ionic agents (0.09%) than in high-risk patients who receive nonionic agents (0.03%). Thus, the single most important risk factor for an adverse reaction is the type of contrast agent chosen for injection. RISK FACTORS FOR

### ADVERSE REACTIONS TO ICM

Regarding the risk for ICM related reactions, patients can be assigned to 3 categories, as follows: (1) those with an increased risk for idiosyncratic reactions, (2) those with an increased risk for contrast agent–induced nephropathy, and (3) those with an increased risk for nonidiosyncratic reactions.

#### Risk factors related to idiosyncratic reactions

Idiosyncratic reactions may occur in people with a previous reaction to ionic or nonionic ICM, asthma, and/or food or medication allergies.

Previous reactions to ionic or nonionic ICM increases the relative risk of repeat reaction 3.3- to 6.9-fold compared with the risk in general population. Approximately 60% of patients who had hives after ICM administration in the past have hives with a repeat exposure. Similarly, facial edema, difficulty breathing, and bronchospasm recur in 68%, 59%, and 38% of patients, respectively.

Reactions do not recur in all patients. Patients with a history of a reaction to ICM may report having undergone a recent contrast-enhanced study without adverse manifestations. Nevertheless, these patients still have a higher risk than that of the general population.

People with asthma have 1.2-2.5 times the risk of the general population. When reactions occur, they are more likely to be severe. Severe reactions are 5-9 times more common in people with asthma than in others.

Patients with allergies, including hay fever, are 1.5-3 times more likely to have an adverse reaction to ICM than other people. No consistent data warrant the use of any unique precautions in patients who have seafood or shellfish allergies.

#### Risk factors related to contrast agent–induced nephropathy

Patients with preexisting renal insufficiency have 5-10 times the risk of ICM-related nephropathy. Patients whose renal failure is the result of diabetic nephropathy are at the greatest risk. Azotemic diabetic patients also have the highest incidence of irreversible renal deterioration. In general, the higher the preexisting serum creatinine level, the greater the likelihood of contrast agent-induced nephrotoxicity.

Other factors implicated in increasing the risk of renal failure after ICM administration include the following: American Heart Association class IV congestive heart failure, dehydration, hyperuricemia, concomitant use of nephrotoxic drugs such as aminoglycoside antibiotics and nonsteroidal anti-inflammatory agents, advanced age, and large doses of ICM for 1 study or multiple contrast-enhanced studies performed within a short period.

Diseases that affect renal hemodynamics, such as cirrhosis and nephrotic syndrome, are also suspected of increasing the patient's susceptibility to renal damage from ICM. Diabetes mellitus alone is a controversial risk factor. Many authorities do not regard the presence of diabetes mellitus in the absence of renal failure as a risk factor for contrast agent–induced nephropathy.

The risk of nephropathy is magnified when multiple risk factors are present in the same patient. Well-hydrated patients with myeloma who receive contrast material have a low incidence of subsequent renal failure of 0.6-1.25%.

#### Risk factors related to nonidiosyncratic reactions

ICM administration can aggravate diseases such as cardiac arrhythmias, angina, and pheochromocytoma.

In patients who have received interleukin-2 immunotherapy for cancer, ICM administration increases the incidence and severity of delayed reactions. These reactions primarily include fevers; chills; rigors; flushing; dizziness; and, occasionally, hypotension. These reactions can occur even if immunotherapy is administered as long as 2 years before ICM administration.

Metformin (Glucophage), an oral antihyperglycemic medication excreted predominantly by the kidneys, is not nephrotoxic per se. If patients receiving metformin become azotemic, increased tissue levels of metformin may rarely induce life-threatening lactic acidosis. The drug should be discontinued in all patients at the time of or before any intravascular contrast-enhanced study. Metformin administration should be withheld for at least 48 hours after the contrast-enhanced study, and its administration should be resumed only after the absence of renal dysfunction has been documented.

Through their pharmacodynamic effects, beta-blockers can aggravate ICM-induced bradycardia, other cardiac arrhythmias, hypotension, and bronchospasm; these conditions can interfere with the treatment.

When possible, the intravenous (IV) administration of contrast material should be avoided in pregnant women. Results of in vitro experiments have shown that contrast material is mutagenic to human cells; however, a few studies have failed to reveal a teratogenic effect in animals. Intravascular ICM crosses the placenta and can potentially produce transient fetal hypothyroidism. Lasting adverse effects on the fetus or neonates have not been identified. Nonetheless, nonionic agents are preferred to conventional ionic agents in pregnant women.

#### PROPHYLAXIS FOR ADVERSE REACTIONS TO ICM

##### Prophylactic medications

Methylprednisolone, 2 oral doses of 32 mg each administered 12 and 2 hours before ICM administration, can reduce the incidence of all adverse reactions to ionic ICM from 9% to 6.4%. It can reduce the frequency of severe reactions that require treatment from 2% to 1.2%. A single dose of 32 mg of methylprednisolone administered 2 hours before ICM administration has virtually no effect (Lasser, 1987).

Oral corticosteroid premedication in 2 doses, one 6-24 hours before and the other 2 hours before ICM injection, significantly reduces the incidence of the total number of reactions from 5% to 2% in one study (Lasser, 1987). Greenberger et al showed that a premedication regimen of prednisolone, 50 mg orally administered 13 hours, 7 hours, and 1 hour before injection of contrast material, and diphenhydramine, 50 mg orally administered 1 hour before ICM injection, substantially reduced the rate of the adverse reactions from 9% to 7% in those with prior reactions, compared with historical control subjects.

Premedication with a single 100-mg tablet of hydroxyzine 12 hours before the IV injection of the ionic dimer ioxaglate reduces the incidence of adverse reactions compared with placebo (2 reactions in the treatment group vs 25 reactions in placebo group, all mild).

Studies of the potential role of H2 blockers, such as cimetidine, have shown a beneficial effect, no effect, or even adverse effects with the addition of H2 blockers to the premedication regimen.

Some investigators have incorporated ephedrine into their premedication regimens. Because of concern about the sympathomimetic cardiac effects of ephedrine, its use has not gained wide acceptance.

### **Recommended prophylactic regimens**

Methylprednisolone, one 32-mg tablet, may be orally administered 12 and 2 hours before the study, or prednisone, one 50-mg tablet, may be orally administered 13 hours, 7 hours, and 1 hour before the study.

If the patient had a previous moderate or severe reaction or one that included a respiratory component, an alternate study, such as sonography or MRI, should be considered. Otherwise, the following may be used: H1 antihistamines; diphenhydramine, one 50-mg tablet orally administered 1 hour before the study; H2-histamine receptor blockers, which is optional; cimetidine, 300 mg orally administered 1 hour before study; and/or ranitidine 50 mg orally administered 1 hour before the study.

Most authorities restrict corticosteroid pretreatment to patients in whom previous idiosyncratic adverse reactions to ICM were moderate or severe. Usually, corticosteroids are well tolerated and cause no adverse effects when only a few doses are administered.

Although the utility of H2-receptor blockers is questionable, these agents are well tolerated and might be of benefit, particularly because they are effective in the treatment of at least some allergic cutaneous reactions to agents other than ICM. However, H2 blockers should not be used without H1 blockers.

The treatment of the nonidiosyncratic adverse reactions of nausea and vomiting is not considered a routine indication for corticosteroid premedication or the use of nonionic ICM.

### **Reducing the incidence of ICM nephropathy**

Other nephrotoxic drugs should be discontinued whenever possible. The minimal amount of contrast material needed to perform a diagnostic study should be used. Nonionic agents are the ICM of choice. If multiple studies are required, time (as long as 5 days) should be allotted between studies to allow the kidneys to recover fully from the ICM injection. Patients can be well hydrated until 12 hours before a contrast-enhanced study, and hydration should be continued for at least 2 hours after a contrast-enhanced procedure is performed.

### **Other measures**

Use of mannitol or furosemide is not recommended, at least in patients with diabetic nephropathy. In several studies, these medications were not effective in reducing the incidence of ICM nephropathy. In other studies, the incidence of nephropathy was higher in patients who were given mannitol or furosemide. The use of mannitol or dopamine at renal vasodilatory doses or atrial natriuretic peptide reduced the incidence of ICM nephropathy in nondiabetic azotemic patients, compared with azotemic patients who received only hydration with sodium chloride solution.

Several recent investigators have suggested that ICM nephrotoxicity can be reduced with use of oral or IV theophylline, acetylcysteine, fenoldopam, or bosentan (an endothelin antagonist). Research with these agents is promising, but results are preliminary. Recent prospective studies have suggested that prophylactic administration of 600 mg acetylcysteine twice daily in combination with hydration reduces the incidence of ICM nephrotoxicity.

### **Prophylaxis in nonvascular studies**

Although rare, systemic reactions are reported after extravascular instillation of ICM, for example, during retrograde pyelography.

When patients have had previous severe idiosyncratic or anaphylactic reactions to IV ICM, premedication with corticosteroids should be considered, even in nonvascular studies.

### **Rate and temperature of ICM injection**

The perception that adverse reactions to ICM, particularly nausea and vomiting, are more common with a rapid rate of injection than with a slow injection has been refuted by findings from 2 studies.

Warming ICM to body temperature reduces their viscosity and may make the injection more comfortable for the patient.

### **EVALUATING THE PATIENT BEFORE ICM ADMINISTRATION**

A pertinent history should be obtained. The following elements should be stressed: history of allergies, asthma, diabetes mellitus, renal insufficiency, and/or cardiac diseases; currently or recently used medicines; possibility of pregnancy; and prior contrast agent administration. If the patient had a reaction in the past, the nature of the reaction must be determined. Also, serum creatinine levels should be determined.

### **TREATMENT OF ADVERSE REACTIONS**

Most acute severe adverse reactions to ICM occur within 20 minutes of injection. For this reason, the patient should be monitored for a minimum of 20 minutes after an ICM injection. Furthermore, any physician who is responsible for an imaging study that requires the use of ICM must be able to recognize and treat acute adverse reactions.

Rooms in which contrast material is administered should be stocked with appropriate basic and advanced life support and monitoring equipment and drugs. The equipment should be regularly checked.

In the examination of a patient with an adverse reaction, a brief history should be obtained, including a summary of the current symptoms, any medical conditions (eg, heart disease), and the patient's medications. Vital signs should be assessed, and any patient with an adverse reaction should be closely monitored until the symptoms have stabilized or resolved. Assessment of the patient's airway, breathing, and circulation (ABCs) remain the cornerstone of the management of moderate or severe adverse reactions to ICM.

In the treatment of adverse reactions, discontinue ICM administration immediately. Monitor the patient's cardiac rhythm, blood pressure, and oxygen saturation. Mild reactions are self-limiting and do not require treatment. However, the patient should be closely monitored until the symptoms resolve.

## Treatment of anaphylactic reactions

The treatment of most anaphylactic reactions, once they are recognized and differentiated from other types of reactions, is often straightforward. These are summarized below.

### **Urticaria**

- Asymptomatic: No treatment is needed.
- Symptomatic, mild or moderate: Diphenhydramine 50 mg may be administered orally, intramuscularly, or IV.
- Severe: Treatment is as above, and consider adding cimetidine 300 mg by slow IV injection or ranitidine 50 mg by slow IV injection.

### **Bronchospasm**

- Mild: Treatment includes oxygen 10-12 L by face mask, close observation, and/or 2 puffs of an albuterol or metaproterenol inhaler.
- Moderate, without hypotension: Treatment is as above, with epinephrine 1:1000, 0.1-0.3 mL given subcutaneously, repeated every 10-15 minutes as needed until 1 mL is administered.
- Severe: Administer epinephrine 1:10,000 1 mL slow IV injection over approximately 5 minutes, repeated every 5-10 minutes as needed.

### **Laryngeal edema**

- Mild to moderate: Treatment includes oxygen 10-12 L by face mask and epinephrine 1:1000 0.1-0.3 mL given subcutaneously, repeated every 10-15 minutes as needed until 1 mL is administered.
- Moderate to severe: Consider calling a code or intubating the patient. Consider adding diphenhydramine 50 mg slow IV injection and cimetidine 300 mg slow IV injection or ranitidine 50 mg slow IV injection.

### **Isolated hypotension**

- Raise the patient's legs as much as possible while preparing to administer IV fluids.
- The Trendelenburg position can also be effective, but many radiographic tables do not tilt.
- Oxygen should be administered in high doses.

### **Hypotension with tachycardia**

- Mild to moderate: Elevate the patient's legs. Administer oxygen 10-12 L by face mask, and IV isotonic fluid (eg, 0.9% isotonic sodium chloride solution, Ringer lactate solution).
- Severe or unresponsive: Treatment is as above, with dopamine 2-20 mcg/kg/min. Call a code if no response occurs.

### **Vasovagal reaction**

- Mild-to-moderate reaction: Elevate the patient's legs. Administer oxygen 10-12 L by face mask, and IV isotonic fluid (eg, 0.9% isotonic sodium chloride solution, Ringer lactate solution).
- Severe reaction or unresponsive patient: Administer atropine 0.6-1 mg IV repeated every 3-5 minutes as needed until a total of 3 mg is administered.

## Unresponsive patient

- **Call a code.**
- Defibrillation may be needed to treat ventricular fibrillation and pulseless ventricular tachycardia.
- **Administer basic life support.**

A respiratory component to an adverse reaction requires more aggressive therapy. Oxygen administration, 10-12 L/min via a partial nonbreathing mask, should be considered in any patient with respiratory difficulty. If bronchospasm is accelerating or severe, if it does not respond to inhalers, or if an upper airway edema (including laryngospasm) is present, epinephrine should be injected promptly. IV use of epinephrine is optional in normotensive patients, but it is necessary in hypotensive patients with respiratory reactions.

Epinephrine must be administered with care to patients who have cardiac disease or those who are taking beta-blockers such as atenolol, propranolol, metoprolol, and nadolol, because the unopposed alpha effects of epinephrine in these patients may cause severe hypertension or angina.

H1 antihistamines, such as diphenhydramine, and H2-receptor blockers, such as cimetidine, do not have a major role in the treatment of respiratory reactions, but they may be administered after epinephrine.

Vital signs can be helpful in determining the cause of the hypotension. Tachycardia (ie, heart rate more than 100 bpm) indicates that an anaphylactic reaction is more likely than other type of reaction. If the patient is bradycardic (ie, heart rate less than 60 bpm), a vasovagal reaction is probable, provided that the patient is not receiving beta-blockers.

Hypotension resulting from an anaphylactic reaction is treated with iso-osmolar IV fluid (ie, normal saline, Ringer lactate solution) in large volumes. Several liters of fluid may be required. If fluid and oxygen are unsuccessful in reversing the patient's hypotension, the use of vasopressors should be considered. The most specifically effective vasopressor is dopamine; at infusion rates of 2-10 mcg/kg/min, the cerebral, renal, and splanchnic vessels remain dilated, whereas the peripheral vessels constrict. Epinephrine is less useful, its results are less predictable, and it has more adverse effects.

### Treatment of nonidiosyncratic reactions

Treatments for nonidiosyncratic reactions depend on the type of reaction.

Vasovagal reaction: Hypotension resulting from a vasovagal reaction also is treated with iso-osmolar fluid; however, if the patient remains symptomatic, bradycardia can be reversed with atropine 0.6-1 mg IV repeated every 3-5 minutes to a total dose of 3 mg if needed. Low doses of atropine, those less than 0.5 mg, are contraindicated because they may have the paradoxical effect of accentuating bradycardia or causing sudden respiratory or cardiac arrest.

In these instances, as well as in other circumstances in which preliminary treatment of a moderate or severe reaction does not seem to be effective, call a code. Administer basic life support and, if necessary, advanced cardiac life support techniques should be initiated.

Cardiac arrhythmias: A defibrillator should be obtained immediately, and cardioversion or defibrillation should be performed. The response of ventricular fibrillation to defibrillation decreases dramatically in the first few minutes, and with the likelihood of success diminishes by approximately 10% with each minute. For this reason, physicians who administer contrast material should be capable of using defibrillators.

Hypertensive reactions: Hypertensive reactions can be initially treated with oxygen and appropriate antihypertensive medications. Nifedipine, a 10-mg tablet punctured with a needle tip

and allowed to drip sublingually, was commonly used in the past; however, it is no longer the favored drug because of the unpredictability of its response, its hemodynamic profile, and the risk of reflex sympathetic hyperactivity.

Additional doses of the patient's usual antihypertensive medications may be helpful. IV fenoldopam, labetalol, and nitroglycerine and oral clonidine or captopril are reasonable choices, depending on the particular clinical situation. IV furosemide 40 mg also can be used.

Seizure: Seizure can occur as a result of hypoxia due to respiratory insufficiency or an intrinsic central nervous system (CNS) response to the ICM. Patients should be turned on their side to prevent aspiration, and high-dose oxygen should be administered. When hypoxia is the cause, intubation may be required for adequate oxygenation. In the case of primary CNS seizure activity, diazepam 5 mg IV may be injected and repeated if necessary. An emergency medical specialist should be consulted.

Pulmonary edema: Pulmonary edema is initially treated by elevating the patient's head, administering oxygen, and IV injecting furosemide and morphine 1-3 mg every 5-10 minutes as needed.

Angina: Patients with angina should be given sublingual nitroglycerin and oxygen. An electrocardiogram (ECG) may be obtained to assess ischemic changes. If symptoms persist or are new (ie, if the patient has no previous history of cardiac disease), a cardiologist should be consulted, or the patient should be transferred to an emergency department.

Contrast agent–induced nephropathy: In most cases, only watchful waiting, adequate hydration, and follow-up of serum chemical findings are required. In a few patients, temporary or permanent hemodialysis may be needed.

Delayed reactions: Delayed reactions are treated in a supportive manner with analgesics administered to treat headaches; antipyretics, and high temperatures; meperidine to treat rigors; and isotonic fluid to treat hypotension.

Extravasation injuries: Extravasation injuries are treated by elevating the affected extremity and applying cold compresses. A plastic surgeon should be consulted if the patient's pain gradually increases over 2-4 hours, if skin blistering or ulceration develops, or if circulation or sensation changes at or distal to the level of the extravasation. No specific treatment is unequivocally effective; therefore, most extravasation injuries are conservatively treated with supportive measures.

## Summary

A basic understanding of ICM, the risks of their administration, the choice of agents, and premedication regimens for high-risk patients is beneficial in preparing patients for their examinations. Radiologists are the primary physicians who administer contrast material. Because reactions to ICM may occur unexpectedly, radiologists should be able to recognize and treat the various types of adverse reactions, and they should seek clinical assistance as needed.

## I.V. Starts . . . --improving your odds! By Tom Trimble, RN CEN

adapted from <http://enw.org/IVStarts.htm>

**A Calm Start:** Ensure the patient is comfortable and sufficiently warm to prevent vasoconstriction, allay his apprehension, and have him understand the necessity of the procedure and how best he may help.

**Enter Confidently:** Do not say, "I'm here to try and start your IV." Boldly state "I'm here to start your IV." The patient will be encouraged by your confidence, and you might believe it better yourself! "Are you good at it?" "I'll do the best that anyone reasonably can!" (You have just promised an earnest effort and set a limit to false hopes.)

**Gravity & Position:** Hang the patient's arm down as low as possible, to employ gravity to assist in the venous filling. Raise the gurney sufficiently high that you can work in good light without hurting your back. If the intended site is distal, kneel or seat yourself so that you can work closely and steadily. For lower-extremity IV's, one may need to dangle the limb over the side of the bed to encourage dependent filling of vessels. If the patient is hypovolemic or in shock, one may need to tilt the bed head-down in Trendelenburg's Position to permit access, or to fill neck-veins for access and minimize air embolism. If the patient is on the floor or the bed cannot be tilted, or the need is extreme, a helper may raise and hold the patient's legs as high as possible to achieve the same effect.

**Stabilize Your Position & Approach:** Sit whenever possible. Hold and stabilize the body part with your non-dominant arm. Try to set up a "Three-Point Touchdown Landing":

1. Rest the heel of your dominant hand on the body part.
2. Lower your flexed thumb and index finger grasping the cannula controls to just touch.
3. Lower the flat-underside of the point gently, then firmly, against the skin; "I'm just going to touch you right there so that you know where it is . . . (allow a few moments as you are doing this to fatigue the nociceptors in the skin) . . . then, One, Two, Three-e-e" (gently and quickly pop through the skin).

You will have the most stable and delicate approach, full control of the extremity, and will have set up in the patient mental and physical conditions that make it least likely for him to "jump."

**Universal Precautions:** If the IV cannot be started with gloves on, ---it cannot and should not be started. The operator must protect himself with adequate body-substance isolation at all times. Glasses, goggles, or splash shields, should also be worn. While some marginally feasible vessels may need, by this rule, to be foregone, it is essential for operator safety to observe these precautions at all times. With increased practice, there need be no detriment to one's "success-rate." Palpation, and IV access, are learned skills, and will grow to meet any occasion. ALL patients must be considered infective at all times. It is NOT ACCEPTABLE to compromise precautions for any reason [this includes tearing off a finger tip of one's glove to permit palpation].

**Failed? Give A Reasonable Explanation:** Explain in frank and friendly manner, why it didn't work, as best as you can tell. Most patients with "bad veins" know they do, and have been through it before. Even a plausible explanation that you're not sure of may still be sufficient. It can be useful to say, "These things sometimes happen. It's not your fault. It's not my fault. It can just be the way it is this time.

**Shaving?:** Never shave the patient to start an IV. It is not necessary and may cause nicks. I haven't shaved a patient for nearly two decades. If the skin and hair is vigorously scrubbed widely around the intended venipuncture site and is clean and dry, the adhesive will stick well.

**Removing Tape:** Removing adhesive and dressings from the site is easy, and need not take any hair with it, if you will rub the tape with alcohol to soften the adhesive. Pick up an edge dabbing at it at the edge with the alcohol while peeling back slowly at an acute angle in the direction in which

the hair lies down. Almost every hair will be spared, and the slightly greater time to do this allows you time to teach and talk with your patient who will be grateful for the care that is taken.

**Removing the Cannula:** When removing an IV catheter, loosen the dressing. When it is free, place the adhesive bandage over the site while the needle is still present. Withdraw the catheter while simultaneously pressing down with gauze to control bleeding. This is swift, bloodless, and discrete. If the patient has an especially excitable and apprehensive imagination, distract his gaze and attention momentarily, perhaps, even by exclaiming some feigned startle towards something that will require his gaze to be averted thus permitting you to quickly and smoothly withdraw the cannula unbeknownst to the patient. Steady pressure for 2-3 minutes by you or the patient will stop any bleeding usually, but longer may be needed if anticoagulated, coagulopathic, larger gauge IVs or marked hypertension. Acutely flexing the arm over the site may increase the size of the wound in the vessel wall, which may increase the leak and should not be done.

**Make the blood go where you want it to go:** Always disinfect the insertion site in the direction of the venous flow so as to improve the filling of the vein by pushing the blood past the one-way valves. Clean vigorously and widely in case a better vein presents itself nearby and to have the tape and dressings adhere tightly to clean dry skin.

**Can't see a vein?:** Trust your fingers even more than your eyes when trying to find a suitable vein.

**What is this I feel?:** A tendon may seem like the vein for which you are hoping, but palpating it through a range of motion may prove that it is not.

**"Hardened" Veins?:** If the vessel is hard, or scarred, try for another. Occasionally, one can, however, get through a scar to a usable portion of vein. There is a risk of fraying or kinking the cannula, however.

**Patient Reports:** Question, and believe, the patient about his previous IV history as to what is successful. But trust your own instincts and do not be unduly daunted by the reports. He may never have had someone as good and careful as yourself, or so willing to pursue any reasonable alternative.

**Awkward Angle?:** Sometimes, when attempting a very superficial vein at an awkward angle, gently bending the needle into a slight arc without collapsing the lumen will allow easier cannulation. Using a syringe as a "handle" may permit easier viewing or working angle, or a chance to stabilize the entire unit by resting the heel of your needle hand on the limb or bed so that the other hand may more freely advance the catheter.

**Difficult Advance?:** Mild obstructions, tortuosity of the vessel, vessel fragility, and frictional resistance can often be overcome by "twirling" the catheter hub, imparting a rotatory motion, as it is advanced to help glide over some points of hang-up. This will require a free and gentle hand or a trusted assistant. Some "safety" cannulae with sheathing devices are more awkward with which to do this than older styles.

**Less Often Used Vessels:** Consider uncommonly used vessels, even radical locations. Digits, medial wrists, basilic veins on the ulnar aspect of the forearms, cutaneous veins of the thigh, shoulder, chest, mammaries, or scalp veins in adults. Be sure that your proposed unusual location is approved by local policies and is truly needed due to exigent circumstances. Consider, also, using a "second-best possibility", of which you are confident, to save the better vein for another day or for someone who may need to find a suitable vein for this patient more than you do presently, or as a fall-back plan. c.f.: *Peripheral Catheters Placed in Atypical Locations* by Lynn Hadaway, M.Ed. RNC CRNI

**Bottom's Up:** Learn to work "upside-down" to take advantage of basilic veins under the forearm. It is frequently easiest to acutely flex the forearm at the elbow (enhancing vein filling and minimizing "rolling" also), while facing the patient's feet to work on the now-exposed

underside of the arm. An adequate working angle can be gotten at times by full extension and hyper-pronation (inwardly rolling the arm until the palm is now up again). One may need to sit lower than the arm to do this. Arthritic joints, contractures, spasticity or paralysis, may preclude this.

**The Stroke Side?:** Paralyzed limbs will usually be stable for an IV, but neither very forgiving of infiltration, nor, in permanent paralysis, having a sufficiency of usable veins.

**Right or Left?:** When feasible, it is a kindness and convenience to the patient to start the IV in the non-dominant side, but when veins are few there will be more and larger ones on the side used most due to the greater exercise encouraging better and more collateral circulation. If the forearm is used, an IV need not be bothersome to patient movement as the site will be more stable whereas those in the hand or antecubital fossa will impede flow as position is changed and endure more intimal wear and tear to the vein with movement or require onerous splinting.

**Out of the Way?:** If, however, surgery, cardiac catheterization, or other major procedure is anticipated, the contra-lateral side is to be preferred for the greater convenience of the surgeon or operator and of the anesthetist/airway management person. Don't forget to add extension tubing, and possibly stopcocks.

**A Moving Target:** It is usually best if the patient is persuaded to completely relax the limb for the venipuncture. Some persons will tend to stiffen out of apprehension or in the mistaken belief that this will help you. Worse still, is when the patient keeps trying to raise the arm in the same error so that one is confronted with a moving floating target. I prefer that the patient recline on the bed rather than be bobbing in a "sitting" position. Drug addicts may suggest using greater-than-systolic pressure of the tourniquet coupled with vigorous exercise of the arm or even "push-ups" to force engorgement of their usually vasculopathic circulation. This method is detrimental to any sought-for laboratory specimens, and is mostly unnecessary.

**Moving With the Moving Target:** When dealing with limb motion, or motion from the mobile environment (ambulance, air or watercraft, etc.), lock the arm in extension and block flexion at the elbow. It may be necessary to tuck the distal part of the limb under one's own humerus or axilla to control motion. Maintain braced contact positions of one's hands on the patient's limbs, be aware of and "get in the rhythm of the motion" of the vehicle or patient, and perform venipuncture.

**Sharps Safety & Volatile Situations:** Use safe "needle-less" equipment whenever possible, especially with agitated or convulsing patients. Retractable sheathing cannulae sets, such as Critikon™ (Protectiv-Plus)™, should be used in such instances if at all possible. The patient may need to be restrained, if needed, by overwhelming manpower or even "chemical restraint", to permit your safety from him while any sharp is exposed.

Avoid sticking an exposed sharp into the mattress. This is an unsafe and unsanitary practice. The needle will be accidentally knocked, covered, or overlooked, thus remaining dangerous to all who are near, and to the patient. Puncturing the mattress cover converts the mattress pad into a "culture medium" which can no longer be disinfected, and is the beginning of rips and tears.

**Continuous Drip or IV Lock:** Whenever possible for other than brief infusion therapy, set up the IV as a Saline Lock, then prepare the infusion set, thus for nursing and patient convenience one can readily change from continuous to intermittent infusion and preserve patient mobility. Be cautious, however, at discharge that the patient has not already dressed and covered his overlooked IV lock in haste to leave. Verify discontinuation of any intravenous device before discharge.

**A Matter of Gravity -Go With The Flow!:** It is common to use a saline lock primarily, especially if the patient should be fluid-restricted, as in renal failure or heart failure. However, if the patient is unstable, being resuscitated, or is to undergo rapid sequence intubation, always connect running infusion fluid. You must not waste time doing repeated flushes. Drugs that drop blood pressure or cause a "rush" can be given slowly more easily via a running line. The visible

continuous drip monitors the quality of the flow so that the patient does not receive the medication if the tubing is kinked or pinched only to rush in rapidly when flow resumes and so that incompatible meds do not mix in the tubing instead of flowing into the patient.

**Watch The Drip As You Secure The Line:** Frequently in rushed situations, a cannula can be taped with a little too much pull on the (elastic) skin, so that it is drawn proximally and against a lumen wall, valve, or flexion point, which may slow or stop flow. This is especially true if the lock is flushed then taped. Using running fluid will allow you to observe for best flow as you adjust final position and tape. The time and aggravation saved during critical work will repay this effort.

If the tape job has pulled the cannula into a position where it does not flow well, and there is no time to re-do the tape job, a temporary fix is to place tape over the cannula hub and dressing and use traction to draw it distally and tape against the skin.

**Finger Tourniquet or Less:** If the patient is very hypertensive, and the vessels appear to be fragile or tense, one can decrease the chance of "blowing" the vein or causing ecchymosis by using only finger tamponade to tourniquet the vein momentarily for the puncture, or even no tourniquet at all but merely fixing the vein from rolling with distal and proximal traction.

**"Tourniquet Sign":** If a "positive tourniquet sign" of fresh petechiae under or distal to the tourniquet, be sure to check Platelets, Coagulation studies, and Complete Blood Count, in addition to other studies planned. While dyscrasias may be found this way, remember also that tourniquet time may have been too prolonged (which can also cause hemolysis in the specimen) or too forceful.

**Think Small:** Be willing to use even the smallest cannulae. Conventional thinking regarding desired size of cannula, unless immediate massive resuscitation is needed, may often be discarded as delivery can be ensured through infusion pumps, pressure bags, syringe and stopcock, etc. One liter/hour via pump equals 24 liters/day ---more than most patients will require.

**What Size Cannula?:** Choose the cannula size with which you are most confident of inserting. If labs are essential, it may be necessary to downsize your choice by one size to provide enough caliber of lumen that blood can easily flow around the cannula to allow it to be drawn. Too tight a fit can make it impossible to draw labs at that site.

**Is This A Hose?:** Rapid flows are more easily achieved with cannulae with larger diameter and shorter length. Flow increases by the square of the diameter. Flow decreases with longer cannulae due to additional resistance.

**Plan Ahead For Diagnostic Studies:** An increasingly important consideration in planning cannula size and placement is the likely diagnostic imaging strategy that the patient will need. If computed tomography (CT scan) with intravenous contrast will be needed, e.g., spiral thoracic CT to rule out pulmonary embolism, etc., then it is usually necessary to have a 20 gauge or 18 gauge or larger short cannula peripheral IV in place using an upper extremity. This is so because the scan involves "power injection" of 75 milliliters of contrast at a rate of 10-20 milliliters/second with pressures up to 300 p.s.i. The scan travel is timed and calibrated to this injection rate as it seeks the pathology. This may be in contradistinction to the perhaps lesser cannula requirements of the patient's clinical condition.

Central lines, peripherally inserted central lines (PICC), and other vascular access devices (VAD), are usually excluded to avoid rupture of the catheter. When such lines must be used, "hand" injection is required and imposes some technical difficulty; planning for use of such lines must be done at the physician level.

Whenever there is conflict between the feasibility of available access and the technical requirements of proposed imaging studies, closely involve the responsible physicians with the radiologists in planning and providing the needed access.

**Think Small - Plan Ahead:** "Vasculopathic" patients such as diabetics, patients with chronic steroid use or chemotherapy history, long history of IV drug abuse, fragile vessels, extensive medical-surgical history with "used-up" veins, should have smaller cannulae used whenever feasible to preserve the available vessel. If long term or frequent use is foreseen, plan prospectively and refer for PICC insertion, tunneled vascular access device, or other long-term indwelling access. This should be done before the patient's veins are "used-up" so that useable vessels remain for emergency or for when vascular access devices are infected or fail. IV drug abusers should be encouraged "to save a vein for the hospital!" It's worth trying; some will actually see the wisdom of this.

**Rapier or Broadsword?:** Smaller needles are more flexible and whippy and may be deflected by a tough vein wall. Larger needles are stiffer and may have the requisite ability to fix and penetrate the vessel.

**Bigger=Thicker:** Thinner needles and cannulae penetrate more easily. Larger sizes have a greater cross-section and exponentially increase the friction resistance of penetrating skin and vessel. If distal traction is insufficient, or the resistance under-appreciated and the insertion is hesitant, one may have gained the lumen and flash-back with the bevel of the needle and lose the IV by pushing the vein right off the needle with the additional bluntness and friction of the catheter.

**Confusing the Nerves:** Firmly rubbing the skin during the preparatory disinfection in itself diminishes the amount of perception of the needle. Simply pressing against the skin firmly with the underside of the needle for several seconds before venipuncture fatigues the nerves before the skin puncture occurs.

**Loose Skin?:** Prior to insertion, loose skin and connective tissue may need to be fixed with stretching by the fingers both distally and proximally to straighten and hold the vein in place. Very loose and thin skin may need to be drawn downwards from underneath by the hand in C-clamp fashion to fix its position.

**Sticking it in - Sticking it down to stay:** Extra steps to prevent loss of the difficult IV, might include using Compound Tincture of Benzoin, or even Flexible Collodion, as a skin-protectant and "tackifier" so that tape sticks better and longer. Steri-Strips® will enhance the strength of the taping, are hypoallergenic, and in convenient lengths. Stoma-Hesive® (or Skin Blanket®) can protect very fragile papyraceous skin, and stabilize very loose skin from movement.

If the patient's skin is so diaphoretic, oily, friable, or sensitive to adhesives that nothing will stick, wrap the IV in place with a loose weave or knit bandage, or consider having it sutured in.

**Securing it against loss:** Protection of the IV by wrapping or splinting should be avoided whenever possible when planning your access. However, to do so may be essential, with that "last available" vein, awkward locations (e.g. in digits, or protrusion of the hub beyond the knuckles), children below the age of understanding and cooperation, delirium, etc. When it must be done, custom-design your protection for the problem at hand to meet any foreseeable problem. Plastic domes may shield the site from tampering and still allow some visualization of the site.

**"High Security":** Very agitated, delirious, and combative patients can have their IVs protected widely, above and below the insertion site, with 4" wide Elastoplast® (tape to resist removal by the patient). If need be, encase the circumference of the extremity with two hemi-circumferential strips of the Elastoplast® under loose tension as the elasticity will allow for movement or swelling and prevent a tourniquet effect. If a T-set is used, access to the injection port can be provided with a small slit in the tape.

**Weighty Matters:** Weak, but restless, patients such as infants and the feeble elderly, may have the extremity with the IV immobilized by weighting it down on the bed by a 20 lb. sandbag on the tip of the splint, or two 10 lb. sandbags slung together straddling the limb.

**Restrain Before Starting?:** Infants and small children may need to have their limb splinted or restrained before starting the IV. {Remember to include the tourniquet before securing the splint so as not to have to fish it through to begin the venipuncture, and to be able to remove it afterwards.} It is best to have all materials, alternatives and spares, within reach. Often, an assistant will be needed to secure the IV, advance the catheter, flush and test, etc.

**"Do You Have To Restrain Him Like That?":** For some children or patients in whom their agitation and potential combativeness cannot yet be safely relieved, it can be wise to restrain or use a "Papoose" or "Mummy" wrap, but this can be unsettling to the feelings of the family. Explain as you set up and proceed that you want very much to make the best possible chance for success on the first effort. "Imagine that you are a Diamond Cutter or someone going to do some very precise work that could only be done once, you would set up an assembly jig so that it couldn't move at the wrong moment, wouldn't you?"

**Light Work:** In infants and small children, veins can be located by transilluminating the skin or limb with a bright light such as a halogen diagnostic light, otoscope, or Intubation Lighted Stylet. Be wary of burning skin and limit duration of contact.

**Hand Tools:** Sometimes, the best tourniquet will be a human one, squeezing the limb above, while assisting in holding the patient.

**Did It Leak?:** The most sensitive indicator of extravasated fluid or "infiltration" is to transilluminate the skin with a small penlight and look for the enhanced halo of light diffusion in the fluid filled area. Checking flow of infusion does not tell you where the fluid is going. Checking a "backflow" or aspirate only tells you that the catheter tip communicates with blood, not whether the fluid infused leaks at some point.

**How does it infuse?:** If a small leak occurs at the point and moment of insertion, the vein may still be usable if the catheter tip can be fully advanced proximal to the leakage. Observe carefully a test infusion of non-irritating fluid for any extravasation before other use.

**Natural Motion:** Taping down the tubing should always be done with regard to the natural movements of the body thus running all tubing laterally on the limb in the direction of motion. You can prevent many future tubing tangles by "going with the flow." Function follows form.

**Connectors=Disconnectors:** Do not place tape directly over any connector. It may be necessary to "break into" the line to change tubing urgently, rescue from any clot, bubble, or drug given in error, or to tighten a leaking connector. One or two stress tapings to prevent a direct yank upon an IV site if the tubing is snagged should be sufficient. Do not tape down excessive loops or coils that shorten the working length of tubing. Except for stress taping IVs of the hand or foot and ankle, one should not tape on the proximal side of a flexing joint. The IV will have positional variability of flow and may clot off entirely. Do not wrap the tubing around a digit when taping [it makes it easier for the patient to clench and pull out or alter the flow. Merely double-back the tubing with a short loop and secure well. It is appropriate to tape central line connectors to prevent exsanguination or air embolism if the line separates.

**Spare Access/Other Purposes:** Plan ahead. If the patient with hemorrhage is hemodynamically stable so that the customary second IV access is not actively needed for transfusion or resuscitation, "lock" the access so that it might be used to obtain serial lab studies without repeated venipuncture of the patient.

**"Locking" the Lock:** Clamp off the extension during positive pressure on the fluid to best maintain patency of the lumen; this helps prevent a mini-aspirate of blood at the tip (when pressure is slack) which might become a clot.

**Know When To Quit:** Not being a "quitter" is admirable when persistence is necessary to achieve a reasonable goal. However, it is the right thing to do:

- If the requested access is not possible.
- If you are becoming frustrated and aggravated or are feeling "unlucky" in your efforts.

- If the patient-tech relationship is being damaged.
- If the patient is undergoing an unreasonable number of attempts, or doesn't tolerate further effort.
- If vascular access has quite reasonably become a matter for the physician requiring special skills or permitted locations.
- If the purpose or intent of the line does not justify the efforts involved. Another plan should be tried.

**Advocate For Proactive Planning:** When patients are encountered early in the course of serious progressive illness, and it is obvious that ongoing vascular access will be a recurring problem, speak appropriately to the medical team and the patient regarding the early insertion of a Vascular Access Device (e.g., Porta-Cath®, Peripherally Inserted Central Catheter or Midline Catheter, Broviac®, Groshong®, etc., before all peripheral veins are lost) that might need to be used when the line is infected or non-functional, peripheral blood cultures are needed, or other emergency occurs.

The following was aired on NBC Nightly News on 11/28/2007. I've included this in the appendix to help with patients' questions about radiation dose.



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### **CT scans may raise cancer risk, study says**

2 percent of future malignancies may be due to 'super X-rays,' study says

**MSNBC News Services**

updated 7:18 p.m. ET, Wed., Nov. 28, 2007

Millions of Americans, especially children, are needlessly getting dangerous radiation from "super X-rays" that raise the risk of cancer and are increasingly used to diagnose medical problems, a new report warns.

In a few decades, as many as 2 percent of all cancers in the United States might be due to radiation from CT scans given now, according to the authors of the report. Some experts say that estimate is overly alarming. But they agree with the need to curb these tests particularly in children, who are more susceptible to radiation and more likely to develop cancer from it.

"There are some serious concerns about the methodology used," but the authors "have brought to attention some real serious potential public health issues," said Dr. Arl Van Moore, head of the American College of Radiology's board of chancellors.

### **Unnecessary scans**

Because doctors underestimate the radiation risk from computed tomography or CT scans, a type of souped-up X-ray, they may be ordering too many of the scans, David Brenner and Eric Hall of Columbia University Medical Center in New York said.

They also said a straw poll of physicians has suggested that perhaps one-third of the scans may be unnecessary or could be replaced by alternative technique, such as ultrasound.

"If it is true that about one-third of all CT scans are not justified by medical need, and it appears to be likely, perhaps 20 million adults and, crucially, more than 1 million children per year in the United States are being irradiated unnecessarily," they wrote in a report in the New England Journal of Medicine.

But they acknowledged in a telephone briefing that the assertion is a "back of the envelope" estimate based on the impressions of doctors. They said no study has tried to gauge the problem of unnecessary CT scans.

### **Doubled radiation exposure**

The average American's total radiation exposure has nearly doubled since 1980, largely because of CT scans. Medical radiation now accounts for more than half of the population's total exposure; it used to be just one-sixth, and the top source was the normal background rate in the environment, from things like radon in soil and cosmic energy from the sun.

A previous study by the same scientists in 2001 led the federal Food and Drug Administration to recommend ways to limit scans and risks in children.

But CT use continued to soar. About 62 million scans were done in the U.S. last year, up from 3 million in 1980. More than 4 million were in children.

Since previous studies suggest that a third of all diagnostic tests are unnecessary, that means that 20 million adults and more than 1 million children getting CT scans are needlessly being put at risk, Brenner and Hall write.

Ultrasound and MRI, or magnetic resonance imaging, scans often are safer options that do not expose people to radiation, they contend.

CT scans became popular because they offer a quick, relatively cheap and painless way to get 3D pictures so detailed they give an almost surgical view into the body. Doctors use them to evaluate trauma, belly pain, seizures, chronic headaches, kidney stones and other woes, especially in busy emergency rooms. In kids, they are used to diagnose or rule out appendicitis.

But they put out a lot of radiation. A CT scan of the chest involves 10 to 15 millisieverts (a measure of dose) versus 0.01 to 0.15 for a regular chest X-ray, 3 for a mammogram and a mere 0.005 for a dental X-ray.

The dose depends on the type of machine and the person — obese people require more radiation than slim ones — and the risk accumulates over a lifetime.

“Medical care in this country is naturally so fragmented. Any one doctor is not going to be aware of the fact that a particular patient has had three or four CT scans at some point in the past,” said Dr. Michael Lauer, prevention chief at the National Heart, Lung and Blood Institute.

People with chronic problems like kidney stones are likely to get too many scans, said Dr. Fred Mettler, radiology chief in the New Mexico Veterans Administration health care system. “I’ve seen people who are 30 years old who have had at least 18 scans done,” he said.

### **As much radiation as atomic bomb survivors?**

That puts them at risk of developing radiation-induced cancer, Brenner and Hall said. They base this on studies of thousands of Japanese atomic bomb survivors who had excess cancer risk after exposures of 50 to 150 millisieverts — the equivalent of several big CT scans.

“That’s very controversial. There’s a large portion of the medical physics community that would disagree with that” comparison, said Richard Morin, a medical physicist at the Mayo Clinic in Jacksonville, Fla.

However, others defended the data, which has been widely cited in other radiation studies. “It’s the best evidence we’ve got” on cancer risks, Lauer said.

Dr. Robert Smith, the American Cancer Society’s director of screening, said the authors’ estimate that 2 percent of future cancers may be due to CT scans “seems high.” But since cancers take 10 to 20 years to develop, “the ability to even observe that kind of an increase is going to be very difficult,” he said.

The authors stressed that they were not trying to scare people who need CT scans away from having them. In most cases, the benefits exceed the risks, especially for diagnostic scans.

However, using the scans to screen people with no symptoms of illness — like screening smokers for signs of lung cancer — has not been shown to save lives and is not currently recommended.

### **Whole-body scans discouraged by many**

Many groups also condemn whole-body scans, often peddled by private practitioners in shopping centers as peace of mind to the worried well. Many of these centers are not accredited by the College of Radiology; only a third of all places that do CT scans in the U.S. are, although insurers are starting to require it for reimbursement, Moore said.

Many CT centers also are set up for adults and rarely image children, who need adjustments to limit dose and radiation risk, said Dr. Alan Brody, a radiologist at Cincinnati Children’s Hospital Medical Center who wrote a report on the topic. He said parents should seek a center that often handles children.

Both doctors and patients need to be more aware of radiation risks and discuss them openly, Brenner and Hall said.

"We were astonished to find, when we were researching materials for this paper, how many doctors, particularly emergency room physicians, really had no idea of the magnitude of the doses or the potential risks that were involved," Hall said.

Other studies found the opposite problem: Three out of 10 parents in one study insisted on CT scans instead of observing the child's condition for awhile even after they were told of the radiation risk, Brody said.

"This is what our patients want," and they expect fast answers from doctors, he said. The pressure is greatest for ER doctors who "are in a bind ... they have all these patients stacked up" and need to make quick decisions, Mettler said.

Future generations of devices using less radiation should help alleviate the concern, but these mostly are directed at the emerging field of heart scans, Lauer said.

"When we order a CT scan it just doesn't seem like such a big deal" but it should be, he said. "The threshold for ordering these tests is low and it's getting lower and lower over time, which means that the risks become potentially all that more important."

*AP and Reuters contributed to this story.*

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The following was included with the article, and these are the answers that I would use.

Some experts recommend that people keep a diary of any tests they or their children get involving radiation, because risk accumulates over a lifetime. Here are questions for any doctor who recommends a computed tomography, or CT scan:

- ***How will my medical care be affected by the results? Will the scan determine my treatment?***

Probably not, the treatment is determined by your physician. CT scan is only a tool used to diagnose, or assist in the diagnosis.

- ***What about alternatives like ultrasound or MRIs?***

Whenever possible, non-ionizing radiating imaging should be used. However, for example, if your physician is looking for a brain bleed with ultrasound, he's not going to see much.

- ***How about just waiting? What are the risks of not doing the test?***

As with many diseases or pathology, if you catch it early, usually treatment is easier and more likely to succeed. What happens if little Johnny has appendicitis? Do you really want to wait and see if he becomes septic, or find the appendicitis and take care of it surgically before he becomes septic?

- ***Does any research show this test will help me or lessen my chances of dying?***

It all depends on the diagnosis. We won't know if this will help, until we know what's wrong. We won't know what's wrong until we can see it.

- ***Is this being done to diagnose a specific problem? (CT scans for people with no symptoms are not recommended).***

As long as there is an issue with the patient, not necessarily a specific diagnosis, we can perform a scan. I personally am against Full Body CT that is found in shopping malls. Having a CT scan "just to have a look" is definitely unnecessary. If you have chest pains, the docs may be looking for a pulmonary embolism, or something vascular, which does not show on a normal chest x-ray.

- ***Is more than one scan truly necessary?***

Again, it depends on the diagnosis.

- ***Is the facility accredited by the American College of Radiology?***

This is actually a good question. Facilities that are accredited have a specific QA that needs to be done, and various images need to be submitted to ACR, to verify image quality and regulate dose.

- ***What is being done to make sure I receive the lowest possible radiation dose?***

Well, hopefully, the facility is using some sort of auto mA. Otherwise, the tech better have a great technique chart.

- ***Does this center regularly do scans on children and follow guidelines for adjusting doses to reduce radiation?***

Most facilities that scan pediatrics have specific protocols for children.