School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

CT Protocols for Revolution Frontier™ / Revolution Frontier™ ES / Revolution™ Discovery™ CT / Discovery™ CT750 HD

REF Rev: 4.0

Manufacturer:
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Manufactured in USA

University of Wisconsin-Madison CT Protocols for Revolution Frontier™ / Revolution Frontier™ ES / Revolution™ Discovery™ CT / Revolution™ HD / Discovery™ CT / Discovery™ CT750 HD

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Changes from Revision 3 to Revision 4

As part of our ongoing UW Madison CT protocol optimization, we have made the following changes between the Revision 3 and Revision 4 release. All of these changes have been internally reviewed and validated by our team of Radiologists, Physicists, and CT Technologists, thereby fulfilling The Joint Commission annual protocol review mandate. Detailed documentation of our compliance with The Joint Commission Standards regarding the performance element for CT protocol review is posted on our website, https://www.radiology.wisc.edu/uw-ge-ct-protocol-project/resources/.

New Scanners Added

Protocols for the Revolution 256 CT platform and the LightSpeed 16 will be delivered to GE by the end of the first quarter of 2019.

New Protocols Added

The Revolution 256 CT and LightSpeed 16 scanners will have the same UW protocol set as currently offered on other scanners, with an additional GSA protocol for PE for the Revolution CT scanner.

A Gemstone spectral imaging CT Head without Contrast was created for scanners that have the feature intended for Brain Post Thrombolysis.

Global Changes Made to the UW Protocols

Series descriptions have been standardized for all protocols. They are vendor neutral and will augment PACS hanging protocols. A manual for this can be found on our website, https://www.radiology.wisc.edu/uw-ge-ct-protocol-project/resources/.

A Quick Protocolling Guide now accompanies our design philosophy for all sections. It aids the technologist and/or the radiologist in selecting the proper CT protocol for the clinical scan indication. This guide is on our website, https://www.radiology.wisc.edu/uw-ge-ct-protocol-project/resources/.

We now provide guidance for GE's Metal Artifact Reduction (MAR). We no longer recommend using higher dose with metal protocols for spines and extremities. Users should turn on MAR if they have it. If the user does not have MAR, we don't advise turning up the kV and dose as it only minimally helps mitigate the metal artifact. Direct patients to scanners that have MAR capabilities whenever possible.

Abdominal Protocols

Added a dynamic transition option for the following protocols: Liver Donor, Triphasic, CTA Pancreas Transplant, Biphasic, Mesenteric Ischemia, Hepatocellular Carcinoma, Liver Transplant Recipient, Trauma Chest, and Trauma Chest/Abdomen/Pelvis. Before this change, the technologist was required to manually trigger the scan when the ROI value/s reached the defined threshold.

Added a ‘Without’ series for the Urothelial Tumor protocol.

Lowered the dose in the Pancreas Transplant Without Contrast series.

Removed the Without Contrast series in the Pancreas Cancer Protocol and included the entire abdomen on the With Contrast series.

Turned on exam split Chest/Abdomen/Pelvis Without and the Chest/Abdomen/Pelvis with Contrast protocols.

Chest Protocols

Added additional instructions for breathing on the PE protocol. These extra instructions are meant to avoid transient interruptions of contrast events from motivating a repeat scan.

Cardiovascular (CV) Protocols

Added lung recons and reformats to the CTA Chest protocols. This change should enable better harmonization of protocols covering the same body region.

Increased the ASIR to 60% for the CTA Coronary exam.

Changed the CTA Upper Extremity contrast chaser from100 mLs to 50 mLs of saline.

Moved the CTA Lower Extremity protocol from the Chest section on the scanner to the Knee section and turned on the series split.

Musculoskeletal (MSK) Protocols

We still provide “with metal” MSK protocols that have higher kV and doses; however, we now recommend using our regular MSK protocols with the GE MAR feature (if available on your scanner).

Neuroradiology (Neuro) Protocols

The Pediatric CTA Head/Neck/Perfusion protocol now uses Isovue 370 for the entire scan.

Added guidance to retro recon the cervical spine from a CTA Neck to save patient dose.

All pediatric spines were changed to a soft reconstruction.

On scanners other than the Revolution CT, the ASIR level was increased from 30% to 60% on the standard recon for the following protocols: Orbit, Pituitary Gland, Temporal Bone, Routine Soft Tissue Neck, Brachial Plexus, CTA Head, CTA Neck, Stroke Deluxe, Venography, Parathyroid Adenoma and Salivary Gland.

Included a 30% ASIR to all soft recon for the Cervical, Thoracic and Lumbar Spines.

Included the “size selection for Neck and C-spine” in the actual protocols for easier reference.

Updated the subclavian injection protocol for the dual head injector to inject 140 mLs of Isovue 370 at a rate of 4 ml/sec and then 10 mls of contrast pre-mixed with 90 mLs of saline at a rate of 3 mLs/second.

Updated the Parathyroid Adenoma Dose Check Alert.

Pediatric Protocols

We changed the Pediatric Chest/Abdomen/Pelvis protocol smart prep location to the pulmonary artery with a 20 second diagnostic delay and a contrast peak at 30 Hounsfield units. We determined a later phase for the chest is better.

Compatibility Revolution Frontier / HD & Discovery

Introduction:

Listed below are the minimum scanner options required to use this set of protocols on your Revolution Frontier™, Revolution Frontier™ ES, Revolution™ Discovery™ CT, or Discovery™ CT750 HD scanners. The protocols in this document have been validated on a scanner compatible with the requirements listed below. The portability of UW protocols to scanners with different specifications may be possible with the proper assistance from your institution's CT protocol optimization team, but should no longer be considered validated UW protocols.

As with any protocol "restore" operation, the existing "user" protocols will be deleted when these UW protocols are loaded onto your scanner. We therefore recommend you save and export a copy of your existing protocols to a CD prior to loading the UW protocols. The exported file can be used as a reference to aid in manually adding a single protocol to the UW protocol set under your "user" tab.

Protocols can be exported to CD from the Tool Chest or from Dose Check. The CD can then be viewed on a PC and converted to Excel format.

IMPORTANT—The following two rules should always be followed when restoring protocols: 1) protocols must only be transferred between scanners of the same model, and 2) protocols must only be transferred from another scanner with a software version that is older or equal in revision number, but not newer.

These protocols were built using software version number 11MW44.11.V40_PS_HD64_G_GTL. You should contact your service engineer to receive a software upgrade if your current software version is older than this.

Scanner Compatibility List:

ASiR with 64 slices acquisition at 0.625 mm

Cardiac Options: SmartScore Pro, CardIQ SnapShot, CardIQ SnapShot-Cine

Tube rotation times (helical mode, non-cardiac): 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0 second

mA limits/kV for large focal spot (except pediatric body and pediatric head): 715 mA at 140 kV, 835 mA at 120 kV, 800 mA at 100 kV, and 700 mA at 80 kV

mA limits/kV for small focal spot: 490 mA at 140 kV, 570 mA at 120 kV, 680 mA at 100 kV, and 620 mA at 80 kV

mA limits/kV for pediatric head and pediatric body: 210 mA at 140 kV, 250 mA at 120 kV, 300 mA at 100 kV, and 375 mA at 80 kV

Direct Multi-Planar Reformat (DMPR) Protocols

Introduction:

A Direct Multi-Planar Reformat (DMPR) is a process set up and is executed as part of the scan protocol. It can use the same protocol that might be used in a General Reformat. In DMPR, the user defines the reformat protocols to be executed and sets as an Automated Batch mode or a Manual Batch mode. It is then executed on the ExamRx desktop.

Reformat is available on the Image Works Desktop and requires manual loading of the data once the scan is completed.

DMPR Protocols:

A reformat protocol must be created to be selected for use in protocols with DMPR enabled. For DMPR to work with the UW protocols, reformat protocols will need to be built with the same names as those used in the protocols. To build reformat protocols, you need to select images from an exam already performed to create the initial same-name reformat protocol. Reformat protocols created for use in DMPR must be single-step protocols and can only be created in the axial, sagittal, or coronal viewports. Reformat protocols for use in DMPR need to be saved in the General category if using Volume Viewer. You must create the DMPR reformat protocol on images from the body part that the protocol will be used for (i.e., a Pediatric DMPR protocol must be created on images for a Pediatric case and an Adult DMPR protocol must be created on images for an adult case).

UW-specific DMPR reformat protocol names are identified below with window width and level values for use with UW Protocols:

BODY - WW/WL 450/50 **CO BODY** **SA BODY**	**CHEST - WW/WL 450/50** ***(created off of a C/A/P study)*** **SA** **CO**	**CHEST - WW/WL 1500/-700 off bone+ images** **MIPS**
PEDS BODY - WW/WL 450/50 **CO PEDS** **SA PEDS**	**PEDS CHEST - WW/WL 450/50** **SA PEDS CHEST** **CO PEDS CHEST**	**PEDS CHEST - WW/WL 1500/-700** **PEDS CO CHEST** **PEDS SA CHEST**

All slice thickness and intervals can be found in the actual protocols.

Manual Reformats (non DMPR, these are for populating the drop down menu in the image works utility):

Optional pre-built reformats: These need to be built manually under Image works; reformat; batch and then protocol drop down menu. (follow the instruction below)

Label	Slice Thickness (mm)	Spacing/Interval (mm)	WW	WL
Head	3	1.5	180	25
MIPS 2x1	2	1	800	200
MIPS 10x2	10	2.5	600	200
CO ST 3X1	3	1.5	450	50
CO BONE 3x1	3	1.5	2500	350
CO ST 2x1	2	1	450	50
CO BONE 2x1	2	1	2500	350

How to Create a Reformat Protocol for use in a DMPR or manual sessions:

1. Load thin slices (make your reformat 0.625/1.25) into Reformat selected on the Image Works desktop. (You must pick a study that has a wide display field of view and a long scan range, i.e. a run off works well for building these.)
2. Select Batch Reformat.
3. Set the slice thickness, interval, FOV and mode to the values for the protocol it will be used with.
4. Define the overage (number of images) for the reformat protocol according to the anatomical area for the protocol.
5. At the bottom of the Batch screen, click ADVANCED.
6. Click SAVE AS PROTOCOL.
7. Enter the Protocol Name* and click SAVE.

*The exact name listed above must be used in the naming of the protocol so DMPR will use the appropriate reformat protocol, which has been predefined in each of the protocols that use DMPR. Once you create these reformat protocols, you will not need to do it again.

Should you decide not to use these suggested reformat protocol names, slice thicknesses, or intervals, you will need to create your own reformat protocols and modify all protocols using DMPR with your selections; otherwise, DMPR will fail to output reformatted series.

Introduction Document

University of Wisconsin - Madison CT Protocols

Introduction:

We are pleased to provide you with the University of Wisconsin-Madison Computed Tomography (CT) Protocols as part of your GE CT scanner purchase. We hope you take the time to learn and understand our protocol philosophy. For some of you it will be a significant change from your current practice.

Today's imaging literature and bulletins from imaging associations are full of directives to decrease patient dose. Unfortunately we are not given much detail, and the burden of executing these changes falls on our shoulders. For many of us, it has been a long time since our physics training and few of us have really kept up on our physics skills. Most of us hire a physics consultant, and they come in and help us get our protocols to qualify for ACR accreditation and ensure the X-ray equipment is properly calibrated, but not much more. With the unique relationship between medical physics and radiology at the University of Wisconsin-Madison, we combined our expertise and developed a very robust set of CT protocols. The technical parameters have been fine-tuned specifically for this scanner and then validated using a rigorous management system based on the ISO 9001 standard.

With the help of our physicists, we juggled all technical parameters that could be modified on this scanner with careful attention to not only how each individual parameter affects image quality, but the interplay of parameters. This was a complicated task aided by specially-written software that allowed us to model the effects on dose and quality.

We anticipate that most of you will find that these protocols generate acceptable image quality. A few of you may be more evolved and may be tolerant of slightly noisier images. It is likely that some of you will find these images noisy and possibly difficult to work with initially. We would like to discourage you from modifying our protocol settings. By changing one or more parameters, you defeat the purpose of balancing the effects of all parameters on image quality and dose. Please give your eye some time to accommodate before you make changes.

If you find that you would like to change some of the acquisition or reconstruction parameters in our protocol documents, please realize some modifications may drastically change the image dose and noise level. All changes should be reviewed by your medical physicist, GE application specialists, and/or your institution's CT protocol optimization and quality control team. In many cases, CT acquisition parameters are linked to reconstruction parameters in our protocols.

For example, halving the slice thickness for the first reconstruction, while keeping the same noise index, will increase the dose by a factor of two! There is interplay between the automatic exposure control setting and the slice thickness that needs to be understood in order to make proper protocol changes. In addition, we have done our best to ensure that the mA does not "max out" for large patient sizes (or for low noise studies which require extra dose) by monitoring the effective mAs used at our institution over a wide range of patient sizes. To maintain diagnostic image quality at the lowest doses, the kV, noise index, pitch, and tube rotation times all change for different protocols and different patient sizes within each protocol.

Other seemingly trivial changes like switching from a pitch of 0.516 to 0.969, changing from the “plus” to “full” recon option, or changing from “boneplus” to “bone” reconstruction types may also have significant negative impacts on image quality and patient dose due to special characteristics of these parameters in addition to those that are most obvious to the user. Changes of any individual protocol parameter must be performed while taking into account all of the parameters making up a single protocol. Therefore, we urge you to only make protocol changes after discussing them with your institution’s CT protocol optimization team or seeking expert advice from GE application specialists.

We recognize these protocols are not complete. There are some deficiencies. We hope to correct them with future releases. We encourage your feedback. We will be reaching out to radiologists, physicists, and technologists for feedback. Hopefully, with your input, we can create an industry-wide standard for CT protocols. These protocols will be reviewed on an annual basis, which should satisfy the ACR requirement.

Networking:

We have provided guidance in the "Networking" section of each protocol on what images to send to PACS. In some cases, all images should be sent to PACS. In many cases, however, thin reconstructions are not required to be sent to PACS. Thin reconstructions are primarily used for creating reformatted volumes. "ALI_Store" is the name we use to refer to sending images to PACS. "ALI_Source" is where we send thin images that are not routinely read by the radiologists. For studies requiring 3D lab work, we instruct you to send the images to "CTAW1", which refers to a GE Advantage Workstation. Note: if you send all thin images to PACS, this may slow down your network transfer times and the time needed for a reviewing radiologist to open the study. This is why our protocols have a networking section for each protocol that gives guidance on when thin images are needed for radiologist review.

Networking for "Series Auto Transfer":

Some reconstructions in our protocol set have "Series Auto Transfer" turned on. They refer to networking names as listed above. If you want to avoid having to re-map your networking locations for every protocol, you can make a single change to your scanner's host table. You need to change the host table name of your PACS to "ALI_Store" and of your 3D lab (if used) to "CTAW1". We do not auto transfer the thin series. If you wish to auto transfer them, you can send them to your regular PACS.

AutoVoice and Breathing Lights Selection:

Like the protocols, if you download AutoVoice to your scanner from a UW disc, you will loose any pre-recorded AutoVoice options. The only custom non GE default AutoVoice recordings include: English cardiac coronaries (retro and prospective). All other UW protocol references to an AutoVoice option are to default GE recordings.

Body:

We are aware that many facilities routinely scan patients with three sequences—1) without intravenous (IV) contrast, 2) with IV contrast, and 3) delayed. Although such robust scanning may add a little bit of information, it is rarely worth the additional dose. If most of your cases can be pre-protocoled to address specific clinical concerns, we believe these protocols will provide a diagnostic study with an appropriate number of series and at an appropriate dose.

We prefer to maintain a policy of giving patients positive oral contrast for many applications. We believe it adds diagnostic value. Although many centers are now performing studies without oral contrast to save time, we stand by our position that the small amount of extra time required to opacify the gut and a small inconvenience to the patient is well worth the increase in diagnostic accuracy.

For most patients, when time is not an issue, we administer iodinated contrast in water. For patients in whom time is critical, we add dilute polyethylene glycol to help distend the lumen and accelerate transit. With a one-hour drink, the vast majority of our Emergency Department patients have contrast in the cecum. This facilitates the diagnosis of appendicitis.

We prefer iodinated contrast to barium suspension. In the patient with a moderate to severe bowel obstruction, the barium eventually will flocculate and precipitate, causing a very dense artifact if further imaging is necessary.

<u>Chest:</u>

For Chest CT's, we refrain from using IV contrast material for most indications. IV contrast adds little or no value to diagnosis and follow-up of most lung diseases. In some cases, the image quality of the lungs can be hampered by streak artifact from undiluted contrast in the SVC and other mediastinal veins. Furthermore, subtle artifacts can occur in the lungs around contrast-filled, smaller vessels, especially with thin section (high-resolution) technique and lower dose imaging. Thoracic indications requiring IV contrast include acute and chronic pulmonary thromboembolism, thoracic trauma, and acute aortic pathology. IV contrast can be helpful for known mediastinal masses or for lung neoplasms that involve the mediastinum. Nodules, infections, aortic aneurysms, pleural disease, and lymphadenopathy can usually be imaged without IV contrast.

<u>Cardiovascular:</u>

Generally, approaches to body CTA fall into two camps: 1) attempt to scan the volume along with the passage of the contrast bolus, and 2) opacify the vasculature throughout the imaged volume and then scan as fast as possible to capture a "snapshot" of the vasculature in this pseudo-steady state. The tremendous variation in bolus transit times across patients and the technical difficulty of both assessing this transit time and appropriately adjusting the scan parameters (rotation speed and pitch) make the former approach difficult for CT technologists to perform consistently without direct physician supervision. We have therefore adopted the latter approach.

Most of our body CTA protocols involve the use of SmartPrep rather than a timing bolus to trigger the acquisition, with a diagnostic delay and overall contrast bolus intended to give consistent opacification throughout the imaged volume during the scan. This approach is very easy for technologists to perform in a reliable fashion without direct physician monitoring.

<u>Musculoskeletal:</u>

CT is an excellent way to visualize bones and joints, especially when reformatted in multiple planes relative to osseous or articular landmarks. However, the role of CT for visualizing the non-radiopaque tissues around bones and within joints is extremely limited, and for the most part has been supplanted by Magnetic Resonance Imaging (MRI) and/or Ultrasonography. To emphasize this, we refer to our applications as "Bone CT" rather than "Musculoskeletal CT", since we do not use CT to image muscles.

Appropriate applications of Bone CT can be divided into two distinct patient populations:

1. those presenting with severe acute trauma to the Emergency Department (ED), and
2. those presenting to primary care or urgent care clinics.

With regards to musculoskeletal imaging, outside of the ED, CT should never be the first study ordered. Conventional radiographs (commonly referred to as "x-rays") continue to be the primary modality used to visualize the bones and joints of the extremities and spine. Indeed, the use of CT is so limited in the evaluation of non-acute traumatic bone or joint pain that we suggest this modality not be ordered by primary care providers without first consulting with their radiologists. Certainly there are some specific indications for which scheduled outpatient CT is appropriate, but in general this is requested by specialty care providers.

In the ED, CT is the primary imaging modality when there is a concern for a spine fracture, especially in the cervical spine. (CT has been shown to be much more sensitive than radiographs for the detection of fractures in the cervical spine.) For other bones and joints, radiographs should be obtained whenever fractures or dislocations are suspected. With certain acute fractures, CT is an essential secondary imaging modality. For example, whenever an acute fracture is detected in the bony pelvis, CT is almost invariably obtained soon after to more fully evaluate the extent of pelvic ring disruption. In addition, orthopedic surgeons will often request CT for intra-articular fractures, particularly of the knee, to aid in surgical planning.

Bones and joints are complex 3-dimensional structures and their relationships are best demonstrated with 2-dimensional cross-sectional imaging reformatted in multiple planes. We have developed joint-specific reformatting protocols designed to address specific clinical needs.

Visualizing bony structures adjacent to orthopedic hardware with CT can be challenging, although metallic artifacts can be reduced by with use of 140 kV.

There are few, if any, indications for administering IV contrast for Bone CT. If there is a clinical concern for infection, an MR should be performed. If the patient is not MR compatible, the clinical service should have a discussion with their radiologist about the best way to answer the clinical questions.

The few indications for administering IV contrast for bone CTs, are as follows:

1. If there is a clinical concern for infection, an MR should be performed.
    - In cases where the clinical concern is specifically to look for soft tissue gas rather than for soft tissue abscess or osteomyelitis (e.g., necrotizing fasciitis), then CT would be the imaging modality of choice; although IV contrast would not be necessary for gas.
2. If the patient is not MR compatible, the protocoling radiologist should have a discussion with the clinical service about the best way to answer the clinical questions.
3. If it is agreed that CT is indeed the imaging modality of choice, the study can be performed without IV contrast.
4. In light of the above policy, it is appropriate for the CT technologist to confirm with the protocoling radiologist that they do indeed want to administer IV contrast.
5. Where IV contrast is deemed appropriate for a bone CT, the standard dosing guidelines should be followed:
    - Agent: Omnipaque 300
        1. If patient has an allergy to iodinate contrast, or has renal function issues, then no IV contrast should be administered.
    - Dose: Per body weight (up to 100ml)
    - Rate: As appropriate for IV access (up to 3ml/sec)
    - Delay: 90sec

Neuroradiology:

Dose reduction is an important facet to imaging that not only radiologists, but clinicians as well, need to keep in mind when protocoling or ordering studies. Certainly, the lowest dose study is the unnecessary one that is not performed. With that being said, given the complex and subtle anatomy present on neuroradiologic examinations, dose reduction is not as readily possible to the same degree as other regions of the body. Decreasing dose to the point that the study is minimally or non-diagnostic should be considered as overdosing, as the radiation delivered was essentially of no use. We have reduced the dose on our protocols as much as we feel is appropriate, while maintaining sufficient diagnostic quality.

We prefer to image the orbits on our head CTs because the orbit is an extension of the brain, and pathology, including the result of trauma, often occult, occurs there. Also, because of radiation overscan inherent in exam acquisition, the orbits receive radiation even on orbit sparing protocols. If your facility feels strongly about avoiding the orbits in scanning, we have included an orbit sparing protocol. Ultimately, it is each individual institution's and individual radiologist's decision.

Perfusion imaging is another area of some concern regarding radiation exposure. It has become important in stroke imaging and tumor imaging to help guide treatment, as well as help assess treatment response. Our protocols result in a dose that is less than FDA guidelines suggest, 0.5 Gy. Rather than the typical coverage of approximately 3-4 cm, the GE scanner with shuttle mode doubles that amount with near whole brain coverage. We are continuing to strive for even lower dose perfusion exams.

Pediatrics:

Ordering clinicians and radiologists should always consider whether or not alternative imaging modalities such as ultrasound or MR could answer the clinical question as radiation exposure would be avoided. When using CT to image children, the goal is to get diagnostic images at the lowest radiation dose possible. The scan should be confined to the region of interest so as to expose as little of the patient's body as possible. Due to their smaller size and the low radiation dose, positioning is of great importance in order to obtain adequate images for diagnosis.

Our standard pediatric CT protocols are indeed very low dose. Many of you may find these images difficult to interpret. For you, we have included a set of protocols with only moderate dose reduction to help you accommodate. We hope you will eventually transition to the lower-dose protocols.

Design Philosophy of UW Protocols

Note, we have an online resource to help you with selecting protocols. Located online, you can download our "UW Quick Protocolling Guide". That guide is a concise list of what UW protocols correspond to a variety clinical indications. https://www.radiology.wisc.edu/uw-ge-ct-protocol-project/resources/

Design Philosophy - Abdominal

GE Protocol	Protocol Type	Protocol No. on Scanner	Design Philosophy
Abd/Pelvis	Abdominal	6.1/6.2/6.3	This is standard abdomen pelvis protocol. It is the default protocol for the vast majority of studies. This one is useful when a general screening protocol is needed.
Abd/Pelvis - R/O Hernia	Abdominal	(Use routine abd/pelvis protocol)	This protocol is intended for the evaluation of hernias. It asks the patient to perform a Valsalva maneuver during the scan to enhance the prominence of any hernia.
High Image Quality Cancer Follow-Up Abd/Pelvis	Abdominal	6.7/6.8/6.9	Higher image quality version of the routine abdomen pelvis protocol. This protocol is to be used for cancer follow-up on patients with pathology known to be of a subtle nature. The order should specifically ask for this version of the abdomen pelvis routine protocol at the time of placing the order. Typically, a determination would be made based on age and disease process (usually dependent on whether they could have metastatic disease to the liver).
Abd/Pelvis - Flank Pain	Abdominal	6.10/6.11/6.12	This protocol is primarily targeted for the first-time evaluation of obstructing renal calculus. It is a non-contrast study; therefore, not optimal for imaging other causes of abdominal pain. However, it may suffice in situations where the disease processes are not subtle. We discourage it for appendicitis.
Abd/Pelvis - Pre-IVC Filter Removal	Abdominal	6.73/6.74/6.75	This protocol is used to assess for both the position and for the presence of clot in an IVC filter prior to removal. IV contrast is used and images are obtained 180 seconds after contrast injection to optimize opacification of the inferior vena cava and iliac veins.
Low Dose Renal Stone (including limited follow-up)	Abdominal	6.13/6.14/6.15	This protocol is intended for follow-up of patients with known kidney stones; those status post lithotripsy; or those presenting to the emergency department with typical flank pain and are known to have kidney stones. Image resolution is satisfactory for identifying calculi, but not optimal for other pathology.
Abd/Pelvis - Colonography	Abdominal	6.16/6.17/6.18	This protocol is used to screen the colon for polyps or colonic mass disease. Patients undergo bowel preparation prior to the scan, and are then scanned in the supine and prone positions following colonic CO_2 insufflation via rectal balloon-tipped catheter. The supine-prone positioning is meant to displace any retained fluid and fully expose all parts of the colon between the two views. A right lateral decubitus view can be added if distention is suboptimal in a colonic segment. The study is performed without IV contrast and at low dose as it is used in screening asymptomatic patients in most cases. If a patient has a known colon cancer and the referrer desires screening of the colon combined with assessment for metastatic disease, IV contrast can be administered on the supine view.
Chest/Abd/Pelvis with IV Contrast	Abdominal	5.4/5.5/5.6	This protocol is most commonly applied to patients with neoplasm that may affect the entire torso, but is not expected to affect the head and neck.
Chest/Abd/Pelvis without IV Contrast	Abdominal	5.7/5.8/5.9	This scan is usually performed for the evaluation of tumor or other conditions that may affect the entire torso in patients who cannot get IV contrast due to allergy or renal failure.
Abd/Pelvis - Urography	Abdominal	6.22/6.23/6.24	This protocol is optimized for viewing the kidneys and the renal collecting system. The most common indication is hematuria.

Urothelial Tumor Follow-up	**Abdominal**	**6.70/6.71/6.72**	**This protocol will be for patients with known urothelial cancer (bladder or ureters) and NO current evidence of or suspected metastatic disease. Also, some of these patients will not have a bladder (so no need for those to void as they will have a urostomy)** **If they have metastatic disease, routine CT A/P will suffice.**
Abd-Liver - Biphasic	**Abdominal**	**6.25/6.26/6.27**	**This protocol is optimized to evaluate cirrhotic patients and suspected liver tumors. It is also applied for the evaluation of hypervascular metastatic disease to the liver.**
Abd-Liver - Triphasic	**Abdominal**	**6.28/6.29/6.30**	**This protocol is optimized for the work-up of a potential liver transplant recipient. It has a high resolution arterial phase for precise hepatic arterial anatomy; a late arterial phase for the detection of tumor; and a portal/ parenchymal phase for the demonstration of varices and other possible pathology. Finally, a three-minute delayed phase is performed to satisfy the UNOS requirement for HCC detection.**
Abd-Liver - Hepatocellular Carcinoma (HCC)	**Abdominal**	**6.82/6.83/6.84**	**This protocol, which is used to rule out HCC, is similar to the biphasic liver protocol, except it includes an additional delayed phase as mandated by UNOS.**
Abd-Adrenal Gland - Adenoma	**Abdominal**	**6.31/6.32/6.33**	**This protocol is optimized for the characterization of adrenal enlargement specifically for a suspect adenoma. It would not be protocol of choice to rule out pheocromocytoma.**
Abd-Pancreas - Pancreas Cancer (Neoplasm Screening)	**Abdominal**	**6.40/6.41/6.42**	**This scan is used in patients where there is suspicion of pancreas mass. The first phase is scanned in the late arterial phase. Since pancreatic adenocarcinoma is hypovascular, it is best detected at 40 seconds post contrast when the normal glandular tissue enhances optimally and the hypovascular tumor does not (optimizes contrast between the lesion and the background pancreas). The second phase is portal venous, to evaluate the solid organs, particularly the liver, for metastatic disease and for routine evaluation of the abdomen and pelvis.** **Also for preoperative evaluation of known pancreatic neoplasm. It is optimized to detect vascular compromise.**
Abd/Pelvis - Kidney Tumor	**Abdominal**	**6.49/6.50/6.51**	**This protocol is optimized to evaluate patients with suspicion or evaluation of small renal neoplasm.**
CTA Abd - Renal Donor	**Abdominal**	**6.52/6.53/6.54**	**This protocol is optimized to evaluate the potential renal transplant donor.**
Abd-Small Bowel - Enterography	**Abdominal**	**6.55/6.56/6.57**	**This protocol is optimized for the evaluation of the small bowel. It is specifically designed for inflammatory bowel disease.**
CTA Abd - Obscure GI Bleed	**Abdominal**	**6.58/6.59/6.60**	**This protocol is optimized to evaluate the source of obscure gastrointestinal bleeding.**
CTA Abd - Mesenteric Ischemia	**Abdominal**	**6.61/6.62/6.63**	**This protocol is optimized to evaluate for mesenteric ischemia.**
Trauma - Chest	**Abdominal**	**5.22/5.23/5.24**	**This protocol is optimized for the emergency evaluation for aortic injury, as well as any other sequel of trauma. This is tailored for rapid deceleration injury. Note: Routine creatinine cut-off for IV contrast administration does not apply in a trauma.**
Trauma - Chest/Abd/Pelvis	**Abdominal**	**5.25/5.26/5.27**	**Emergency evaluation for aortic injury and/or organ disruption. Note: Routine creatinine cut-off for IV contrast administration does not apply in a trauma.**
Trauma - Abd/Pelvis	**Abdominal**	**6.4/6.5/6.6**	**Emergency evaluation for traumatic organ disruption. This is usually reserved for a direct blow to the abdomen or low velocity MVA. Note: Routine creatinine cut-off for IV contrast administration does not apply in a trauma.**
Cystogram	**Abdominal**	**8.10/8.11/8.12**	**In the trauma setting, to evaluate bladder for trauma-induced leak. (Typically performed when the standard trauma scan is inconclusive for a bladder leak.)** **In the non-trauma setting, specifically for the evaluation of bladder tumor and to evaluate for non traumatic or post operative bladder leak.**
Body Pelvis	**Abdominal**	**8.16/8.17/8.18**	**This is a standard or routine examination of the pelvis meant to assess for pelvic pathologies that are not hypervascular.**

Design Philosophy - Chest

GE Protocol	Protocol Type	Protocol No. on Scanner	Design Philosophy
Chest - Standard (Routine & High-Resolution)	Chest	5.1/5.2/5.3	This protocol is designed to address nearly all indications for chest CT while maintaining very low radiation exposure levels. It includes detailed information on the lungs, airways, and soft tissues. High-resolution images for evaluating the lungs are a central part of this protocol, avoiding the need to rescan patients who have diffuse lung disease. Although intravenous contrast material can be administered at the discretion of the protocolling radiologist, for the vast majority of indications, contrast is not needed.
Chest - Low Dose Follow-up/Screening	Chest	5.10/5.11/5.12	This protocol was designed for follow-up of nodules, pleural effusions, and other abnormalities using significantly lower dose than the standard CT. For nearly all patients, the effective dose will be below 3 mSv, typically in the 1 - 2 mSv range. This protocol is also designed to be used for lung cancer screening. It meets the technical standards put forth by the American College of Radiology and the Centers for Medicare and Medicaid Services (CMS).
Chest - CTA for PE	Chest	5.16/5.17/5.18	This protocol is nearly identical to the routine chest CT protocol, and reconstructed axial images are identical. Multiplanar MIPs are included to meet CPT code requirements. The contrast injection protocol is designed to limit the number of bolus failures and maximize opacification of the pulmonary vasculature.
Chest - Dynamic 3D Airway	Chest	5.70/5.71/5.72	This protocol is designed to evaluate the central airways, particularly to assess for tracheobronchomalacia or excessive dynamic airway collapse. In addition to standard high-resolution images of the lungs, the forced expiratory images accentuate collapsibility of the trachea and central bronchi. This protocol includes additional reformations including minimum intensity projections (MinIPs) and optional 3-D virtual bronchoscopic images, which referring providers might find informative. For patients who have a recent volumetric thin-section CT of the chest, the expiratory sequence of this protocol performed alone may be sufficient, minimizing additional radiation exposure. Because the breathing technique is different than traditional end-expiratory chest CT, proper training of technologists and coaching of patients with close radiologist oversight will maximize the utility of this protocol.

Design Philosophy - Cardiovascular

GE Protocol	Protocol Type	Protocol No. on Scanner	Design Philosophy
Non-Gated CTA (Chest/Abd/Pelvis)	CV	5.28/5.29/5.30	Evaluate for known or suspected type "B" (descending) aortic dissection, intramural hematoma (IMH), aneurysm, leak, tear, or vasculitis.
Retrospectively-Gated CTA Chest (Non-Coronary)	CV	5.31/5.32/5.33	Used to evaluate the heart and great vessels (aorta and pulmonary arteries) in patients with higher rates or in patients in which cardiac function is also being assessed. This is frequently used in patients with congenital heart disease that have contra-indication for MRI.
Gated Chest and Non-Gated Abd/Pelvis CTA	CV	5.34/5.35/5.36	Used to evaluate patients with ascending aorta aneurysm in addition thoracoabdominal aortic aneurysms. Retrospective gating is used to minimize the delay between the gated chest and the non-gated abdomen and pelvis sections.
Prospectively-Gated Coronary CTA	CV	5.37/5.38/5.39	Used to evaluate the coronary arteries in patients with appropriate heart rates.
Retrospectively-Gated Coronary CTA	CV	5.40/5.41/5.42	Used to evaluate the coronary arteries in patients with higher rates or in patients in which cardiac function is also being assessed.
TAVI CTA	CV	5.43/5.44/5.45	Evaluation of patients being considered for trans-catheter aortic valve replacement (TAVR). This includes a retrospectively-gated CTA of the heart to evaluate the aortic root for implantation of the valve and a non-gated CTA chest abdomen and pelvis to evaluate the aorta and iliofemoral arteries to assess access.
Prospectively-Gated CTA Chest (Non-Coronary)	CV	5.46/5.47/5.48	Evaluate for ascending aortic aneurysm, dissection, or injury. Evaluate cardiac or vascular abnormality without cardiac motion. (Note: A prospectively-gated chest CTA cannot be combined with a non-gated CTA abdomen/pelvis. If gated chest is need along with CTA abdomen/pelvis, use retrospective gating.)
Upper Extremity CTA	CV	4.10/4.11/4.12	To evaluate upper extremity ischemia. The scan includes vascular imaging from the aortic arch to the finger tips.
Lower Extremity CTA	CV	9.13/9.14/9.15	For iliac occlusive disease, peripheral vascular disease, and patients with a "cold foot".
Post-Endostent Non-Con Volume Change (Abd/Pelvis only)	CV	5.58/5.59/5.60	Measure abdominal aortic aneurysm volume after endovascular repair. If the volume is stable or has decreased since the prior examination, no hemodynamically-significant endoleak is present.
Prospectively-Gated Left Atrial Appendage	CV	5.73/5.74/5.75	Evaluation for left atrial thrombus, pre-op for device (Watchman (TM)) implant. Includes two scan phases, a CTA on expiration and a 1 minute delay. Both phases are prospectively gated.

Design Philosophy - Musculoskeletal

GE Protocol	Protocol Type	Protocol No. on Scanner	Design Philosophy
Bony Pelvis/Hips/SI/Femur/FAI (Without Metal) and Bony Pelvis/Hips/SI/Femur/FAI (With Metal)	MSK	8.1/8.2/8.3 and 8.4/8.5/8.6	This protocol is designed to examine the cortex of the pelvic ring and acetabuli. Scans of the Bony Pelvis are most often obtained in the setting of acute trauma, or in the evaluation of fracture, SI joints, and prosthesis. Orthopedic surgeons may request post-operative scans to assess healing, hardware, or osteolysis.
Knee/Tibia (Without Metal) and Knee/Tibia (With Metal)	MSK	9.3 and 9.4	The primary indication for a knee CT is to assess the alignment and degree of displacement of fracture fragments, particularly at the articular surfaces. These can also be used to assess the integrity of the bone around prosthesis. On rare occasions, a CT will be done immediately after an arthrogram of the knee.
Ankle/Foot/Distal Tibia (Without Metal) and Ankle/Foot/Distal Tibia (With Metal)	MSK	9.1 and 9.2	There is one single scanning protocol for all ankles and feet, which is typically used to evaluate for trauma. In most cases it is desirable to scan both ankles/feet at the same time.
Femoral Anteversion/Lower extremity rotational study	MSK	9.8/9.9/9.10	This protocol is a non-contrast CT through bilateral hips, knees, and ankles (excluding the femur, tibia, and fibula shafts) to allow for measurement of the version angles of the femora and, if desired, tibiae.
Shoulder/Humerus (With or Without Metal)	MSK	4.1/4.2/4.3	A routine shoulder CT (non-arthogram) is used to evaluate for fractures of the scapula and/or proximal humerus, dislocation, shoulder prosthesis, or masses/infection in a patient who is not MR compatible. The primary indication for a shoulder arthrogram CT is to evaluate the rotator cuff and labrum in a patient who is not MR compatible.
Elbow/Forearm (Without Metal) and Elbow/Forearm (With Metal)	MSK	4.6 and 4.7	This primary indication is to evaluate for fracture, dislocation, or osteochrondritis. The elbow is the most difficult joint to scan as it is usually difficult to optimally position the elbow, particularly when it is in a cast.
Wrist (Without Metal) and Wrist (With Metal)	MSK	4.8 and 4.9	This scan is used to evaluate for wrist fracture, and similar to the elbow, it is important to position the arm over the head, with the arm as straight as possible.
Soft Tissue Extremity with IV Contrast	MSK	9.24/9.25/9.26	This protocol is used for detection or characterization of mass or infection. Bony detail is not important for these scans which use a dose level similar to an extremity CTA.
Chest Wall/Clavicle/AC Joint/SC Joint/Sternum/Ribs	MSK	4.13/4.14/4.15	Detection or characterization of fractures, evaluation of treated fractures to evaluate the progress of osseous healing or adequacy of fracture fixation. Also for the evaluation of arthritis, mineralized bone and soft tissue lesions, and to evaluate osteoarthritis. For infection, contrast will likely be needed.

Design Philosophy - Neuroradiology

GE Protocol	Protocol Type	Protocol No. on Scanner	Design Philosophy
Brain - Routine and Pediatric NAT/Trauma (Helical Mode)	Neuro	1.1/11.1/11.2	For routine head imaging and emergent imaging including trauma, hemorrhage, hydrocephalus, tumor, and preliminary stroke screening. May need to add contrast for more sensitive evaluation of tumor or infection.
Brain - Helical Scan with Angled Axial Reformations	Neuro	1.2/11.3/11.4	Use this protocol when the head cannot be properly positioned for a routine helical head scan. Example: when you cannot move the patient's head into proper position (trauma, cervical collar, rigid neck). For routine head imaging and emergent imaging including trauma, hemorrhage, hydrocephalus, tumor, and preliminary stroke screening. May need to add contrast for more sensitive evaluation of tumor or infection.
Brain (Axial Mode)	Neuro	1.3/11.5/11.6	Helical mode should be used routinely for adult head CT scans. Only use axial mode when you cannot move the patient's head into proper position (trauma, cervical collar, rigid neck), and do not wish to perform a helical scan with angled axial reformats. This axial mode can also be used in unstable patients in the ED when the CT scan time must be expedited.
Stealth - Stereotactic Head (Whole Brain Treatment Planning)	Neuro	1.10/11.11/11.12	This is a protocol which delivers thin section images for use in whole brain radiation treatment planning, intraoperative neuronavigation, and cranioplasty planning. Image requirements for the software associated with these uses varies, and verification of compatibility is recommended.
Orbit - Routine	Neuro	2.1/12.1/12.2	For evaluation of infection, inflammatory, or neoplastic processes may add contrast as needed to increase sensitivity. May also be used for trauma, blunt or penetrating, localized to the orbit. Not to evaluate diffuse facial trauma or infection/inflammatory processes, as this requires a CT maxillofacial.
Facial Trauma - Routine	Neuro	2.5/12.9/12.10	Maxillofacial CT done for evaluation of facial trauma, blunt or penetrating, facial infections or inflammation, as well as assessment of congenital abnormalities. Contrast may be added for sensitivity, particularly in infection, as warranted. 3D reconstructions may be performed if requested by clinical service.
Sinuses - Diagnostic	Neuro	2.7/12.13/12.14	For evaluation of routine sinus inflammatory disease, assessment of bone involvement from infectious, inflammatory, or neoplastic processes, and sinonasal neoplasms. May add contrast as needed typically for non-routine sinus inflammatory disease. Not for evaluation of facial trauma or orbital processes.
Temporal Bone (without Contrast)	Neuro	2.10/12.18/12.19	For evaluation of hearing loss, congenital abnormalities, infection, trauma, and neoplasms. Contrast may be added as needed for infection or neoplasms. Used in conjunction with MRI to evaluate neoplasms typically unless contraindication to MRI.
Temporal Bone (with Contrast Only or with & without Contrast)	Neuro	2.11/12.20/12.21	This protocol adds contrast to the standard CT temporal bone, for use in cases of inflammation / infection or concern for sigmoid sinus compromise. This protocol is also used for cases in which there is a concern for a cerebellopontine angle mass causing sensorineural hearing loss.

Adult Neck - Routine	**Neuro**	**3.1/3.2/3.3**	**For evaluation of head and neck cancer (pre and post treatment), infection, soft tissue trauma, or inflammatory processes. Not for evaluation of cervical spine trauma or suspected vascular injury.**
Pediatric Neck - Routine	**Neuro**	**13.1.1/13.2.1/13.4.1/13.6.1/13.8.1**	**This is an age-specific protocol designed to give a diagnostic and appropriately low dose examination through the neck. This protocol is for evaluation of cervical lymphadenopathy, developmental anomalies (such a branchial cleft cysts), as well as infectious, and inflammatory conditions within the pediatric neck.**
Neck (Parathyroid Adenoma) Adult	**Neuro**	**3.5/3.6/3.7**	**Indications include hypercalcemia, parathryoid adenoma (suspected or confirmed), and parathyroid surgical planning. On early arterial and delayed contrast enhanced images the enhancement of parathyroid adenomas can be confused with the intrinsically CT hyperdense thyroid gland. This protocol includes an additional non contrast phase to enable more confident detection and discrimination of parathyroid adenomas from the adjacent thyroid tissue.**
Adult Cervical Spine (without Metal) and Adult Cervical Spine (With Metal)	**Neuro**	**3.16/3.17/3.18 and 3.19/3.20/3.21**	**For evaluation of spine trauma, degenerative disease, infection, and bone tumors. May add contrast as needed. Not for primary evaluation of soft tissues.**
Adult Thoracic Spine (without Metal) and Adult Thoracic Spine (with Metal)	**Neuro**	**7.4/7.5/7.6 and 7.13/7.14/7.15**	**For evaluation of trauma, degenerative disease, infection, and bone tumors. May add contrast as needed.**
Adult Lumbar Spine (without Metal) and Adult Lumbar Spine (with Metal)	**Neuro**	**7.1/7.2/7.3 and 7.10/7.11/7.12**	**For evaluation of trauma, degenerative disease, infection, and bone tumors. May add contrast as needed.**
Stroke Deluxe – Total Cerebrovascular	**Neuro**	**1.6/1.13/11.16/11.17**	**For evaluation of stroke, vascular trauma, aneurysm, vasospasm, and atherosclerotic disease. Requires administration of IV contrast.**
CTA Head Only (Stenosis, Aneurysm, Unknown Bleed)	**Neuro**	**1.7/11.18/11.19**	**For evaluation of intracranial stenosis, aneurysm, vascular malformation, unknown bleed, vasospasm.**
CTA Neck Only (Cerebrovascular Disease)	**Neuro**	**3.11/11.22/11.23**	**Assessment of atherosclerotic disease, trauma with suspected vascular injury, or vascular neoplasms. Requires administration of IV contrast.**
CT Venography	**Neuro**	**1.9/11.24/11.25**	**This protocol consists of a slightly delayed phase of vascular imaging, for use in cases of suspected venous sinus thrombosis or occlusion.**
Brain Post Thrombolysis Helical (GSI)	**Neuro**	**1.4/11.13/11.14**	**This protocol is for post thrombolysis patients who may have contrast staining or hemorrhage in the tissues of the brain - we use iodine overlays to visualize hemorrhage from Iodine.**

Design Philosophy - Pediatrics

GE Protocol	Protocol Type	Protocol No. on Scanner	Design Philosophy
Routine Abdomen/Pelvis	**Peds**	**16.1.1/16.2.1/16.4.1/16.6.1/16.8.1 --- for Higher Image Quality: 16.1.6/16.2.6/16.4.6/16.6.6/16.8.6**	**For evaluation of nonspecific abdominal pain, abscesses in postoperative patients or acutely ill inflammatory bowel disease patients, fever of unknown origin, as well as for appendicitis in outpatients. Additionally used for initial diagnosis and follow-up of abdominal neoplasm when concurrent chest CT imaging is not indicated.**
Acute Appendicitis - Abdomen/Pelvis	**Peds**	**16.1.1/16.2.1/16.4.1/16.6.1/16.8.1 --- for Higher Image Quality: 16.1.6/16.2.6/16.4.6/16.6.6/16.8.6**	**A low dose protocol for patients in whom the only clinical concern is to rule out appendicitis. This will not image the lung bases and will minimally image the inferior aspects of the solid organs.**
Renal Stone/Flank Pain	**Peds**	**16.1.2/16.2.2/16.4.2/16.6.2/16.8.2 --- for Higher Image Quality: 16.1.7/16.2.7/16.4.7/16.6.7/16.8.7**	**This protocol aims to evaluate patients with renal colic or hematuria in whom renal and bladder ultrasound has been unable to identify a source for the symptoms or on whom renal and bladder ultrasound cannot be performed.**
Triphasic Liver	**Peds**	**16.1.3/16.2.3/16.4.3/16.6.3/16.8.3 --- for Higher Image Quality: 16.1.8/16.2.8/16.4.8/16.6.8/16.8.8**	**This protocol should only be ordered by surgeons for liver tumor evaluation prior to surgical resection in order to fully assess the tumor's relationship to the hepatic arteries, portal veins, and hepatic veins. This will also assess for variant arterial or venous anatomy.**
Trauma Abdomen/Pelvis	**Peds**	**16.1.4/16.2.4/16.4.4/16.6.4/16.8.4 --- for Higher Image Quality: 16.1.9/16.2.9/16.4.9/16.6.9/16.8.9**	**This protocol is designed to evaluate patients who have suffered from blunt or penetrating trauma for possible internal injuries. Delayed images may be required at the radiologist's discretion to evaluate for active bleeding, but the field of view should be limited to the area of concern only so as to keep radiation dose as low as possible. This protocol should always be done following administration of IV contrast as evaluation for solid organ injuries, and to a lesser extent bowel/mesenteric injuries is significantly limited on non-contrast examinations. This is especially true in pediatric patients with little mesenteric fat.**

Chest - Standard (Routine & High-Resolution)	**Peds**	**15.1.1/15.2.1/15.4.1/15.6.1/15.8.1 --- for Higher Image Quality: 15.1.8/15.2.8/15.4.8/15.6.8/15.8.8**	**This non-contrast protocol is performed to evaluate the lung parenchyma for evidence of interstitial lung disease, bronchiectasis, or aspiration. As pediatric patients have little mediastinal fat, evaluation for mediastinal or hilar lymphadenopathy, as well as mediastinal pathology in general, would be limited.**
Chest with IV Contrast	**Peds**	**XXX --- for Higher Image Quality: xxxxx**	**This protocol is designed to further evaluate patients with chest infections such as pneumonia with or without empyema, neoplasm, fever of unknown origin, vascular rings and slings, as well as mass lesions such as congenital cystic adenomatoid malformation and sequestration. Additionally, this could be used in evaluation of patients who have suffered blunt or penetrating trauma to the chest only.**
Chest Pectus	**Peds**	**15.1.3/15.2.3/15.4.3/15.6.3/15.8.3 --- for Higher Image Quality: 15.1.10/15.2.10/15.4.10/15.6.10/15.8.10**	**Technique for the pectus excavatum protocol was optimized for evaluating the bony thorax. These images allow for precise calculation of the Haller and correction indices, as well as for pre-surgical planning.**
CTA Chest for PE	**Peds**	**15.1.4/15.2.4/15.4.4/15.6.4/15.8.4 --- for Higher Image Quality: 15.1.11/15.2.11/15.4.11/15.6.11/15.8.11**	**This protocol is designed to evaluate patients who are suspected of having pulmonary embolism.**
Routine Chest/Abdomen/Pelvis	**Peds**	**15.1.5/15.2.5/15.4.5/15.6.5/15.8.5 --- for Higher Image Quality: 15.1.12/15.2.12/15.4.12/15.6.12/15.8.12**	**This protocol is intended to initially diagnose and follow-up malignancy and to evaluate for infection/fever of unknown origin in patients with nonspecific symptoms or who are immunocompromised.**
Trauma Chest/Abdomen/Pelvis	**Peds**	**15.1.6/15.2.6/15.4.6/15.6.6/15.8.6 --- for Higher Image Quality: 15.1.13/15.2.13/15.4.13/15.6.13/15.8.13**	**This protocol is designed to evaluate patients who have suffered from blunt or penetrating trauma for possible internal injuries. Delayed images may be required at the radiologist's discretion to evaluate for active bleeding, but the field of view should be limited to the area of concern only so as to keep radiation dose as low as possible. This protocol should always be done following administration of IV contrast as evaluation for vascular and solid organ injuries, and to a lesser extent bowel/ mesenteric injuries is significantly limited on non-contrast examinations. This is especially true in pediatric patients who have little mediastinal and mesenteric fat.**
Peds Chest Dynamic 3D Airway	**Peds**	**15.1.2/15.2.2/15.4.2/15.6.2/15.8.2 --- No higher image quality version of this protocol**	**This protocol is designed to evaluate the central airways, particularly to assess for tracheobronchomalacia or excessive dynamic airway collapse. In addition to standard high-resolution images of the lungs, the forced expiratory images accentuate collapsibility of the trachea and central bronchi. This protocol includes additional reformations including minimum intensity projections (MinIPs) and optional 3-D virtual bronchoscopic images, which referring providers might find informative. For patients who have a recent volumetric thin-section CT of the chest, the expiratory sequence of this protocol performed alone may be sufficient, minimizing additional radiation exposure. Because the breathing technique is different than traditional end-expiratory chest CT, proper training of technologists and coaching of patients with close radiologist oversight will maximize the utility of this protocol.**

Peds Bony Pelvis Protocol Selection

If you get an order for a pediatric bony pelvis:

Is the pediatric a teen/obese with an AP + LAT size over 55 cm?

Yes

Use the appropriate adult protocol (probably the adult small without metal)

No

Is the order for a spica casting for developmental dysplasia of the hips (probably on a kid < 1 yo)?

Yes

Use the pediatric chest pectus protocol but change the coverage to top of the illiac crests to the lesser trochanters

Why use a chest protocol on the pelvis? This is our lowest dose pediatric protocol so it has the right technique for spica planning

No

The order should be for a trauma or avascular necrosis (AVN), if it is not please consult the pediatric attending. Use the pediatric trauma abd/pelvis protocol with a coverage of top of the illiac crests to the lesser trochanters

Note: you will need to adjust the scout landmark and scan ranges based on the flow chart above to cover the desired anatomy.
Note: please provide the radiologist with 3 mm by 3 mm coronal and sagittal reformats using a boneplus recon.

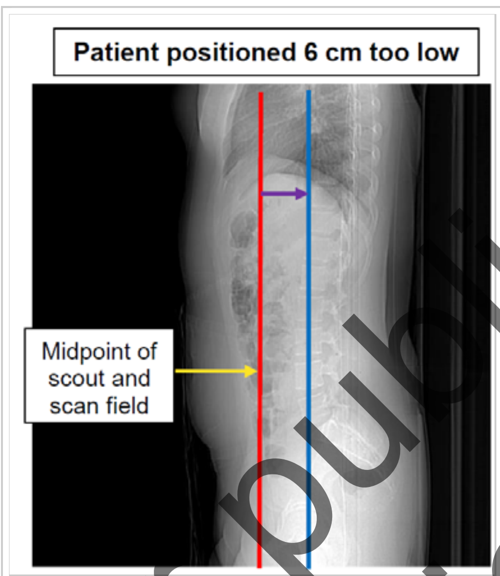
DEPARTMENT OF Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

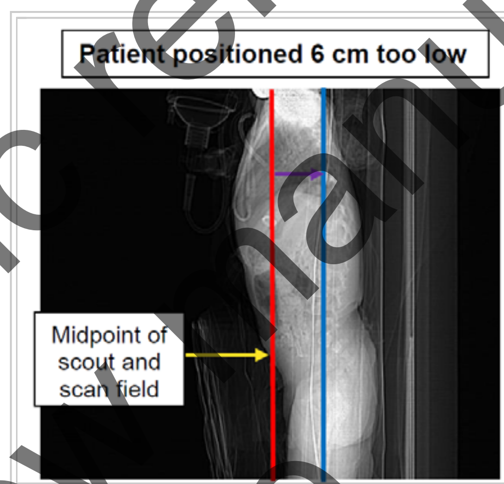
Position Tutorial

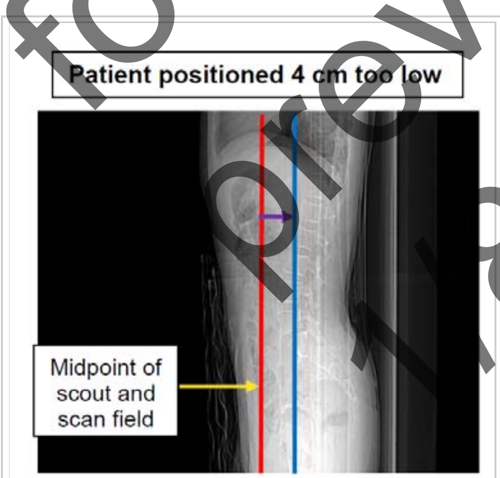
Body Positioning

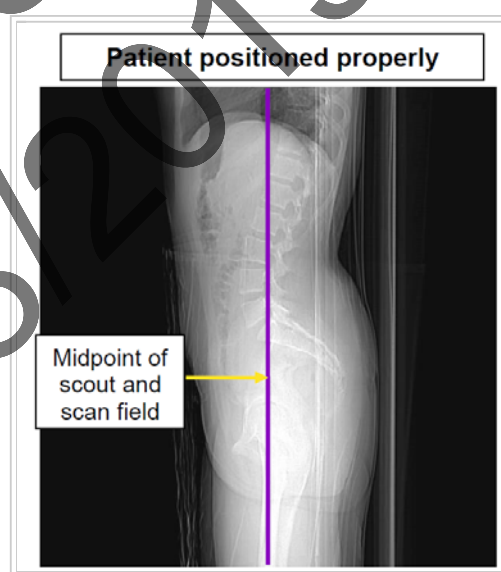
- **Particularly important for Pediatrics and Small Adults**

To provide the best image quality at the lowest dose, proper patient positioning is always important. It is particularly important with the smaller patients scanned as small adults and in pediatric imaging using low kV techniques. Positioning errors usually occur with the patient being positioned too low. This error causes significant problems with pediatric protocols in which the patient may actually need to be positioned a bit high to outward appearances: Ideally the most attenuating part of the patient should be centered in the scan. To accomplish this, one should position the patient high enough so that the horizontal laser light is centered on the lumbar spine and is just anterior to the thoracic spine. This is demonstrated in the scout images below, where the red line is the actual midpoint of the scout image and the blue line is where the patient should have been centered on the scout. Only the scout on the upper right shows correct positioning; the midpoint of this scout is shown as a purple line. All the rest are centered too low.









Decubitus Positioning

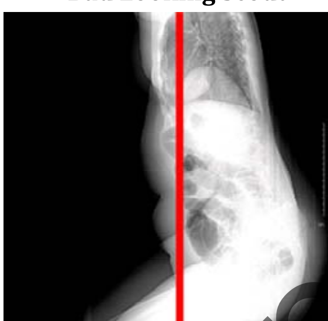
- **Proper positioning for the decubitus portion of the CTC screening exam**

Just as patient positioning is critical in our routine supine and prone exams, it is also critical in the decubitus portion of our virtual colonoscopy screening exam. To provide the best image quality at the lowest dose, proper patient centering in the scanner gantry is critically important.
You cannot simply have the patient roll to their side, this will leave their pelvis in an off center position! You must have the patient roll and then confirm that they have shifted their pelvis back to the scanner of the couch. **Roll and shift!** Aim to get the patient's ilium bones centered in the scanner.
Note, it is also possible that after proper positioning, the patient may tilt to the side before the scan. Tilting to the side is a natural response to being placed in the decubitus position. Please watch for this and instruct the patient to return to the proper position.

Poor Position

Good Position

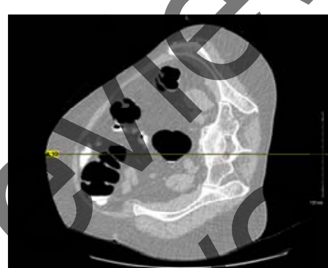
Bad Looking Scout



Good Looking Scout

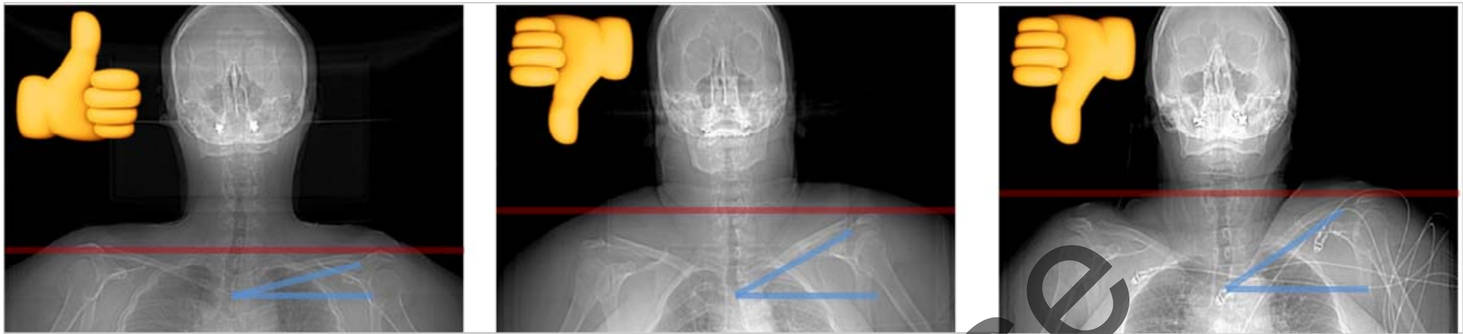
Resulting Bad Looking Image

Resulting Good Looking Image



Shoulder Relaxation

- Lowering the position of the shoulders is important in both allowing adequate visualization of the cervicothoracic junction and in lowering the dose required for the exam.
- Fastening the CT table strap around the torso only, as compared to around the torso and arms, decreases the level of the shoulders by one vertebral body level.
- Simply encouraging appropriate patients to “pull” their shoulders down has also been found to be effective.
- Having patients “walk” their hands down a folded bedsheet wrapped around the feet is also helpful for challenging cases.



Examples of good and bad shoulder position relative to the neck. The techniques listed above can get a patient from having a poor positioning of the shoulder to a good position. Note: try to recognize improper shoulder relaxation before you scout. If, however, you only notice this after you scout, there is no need to re-scout the patient after they move their shoulders.

Patient unable to raise arms for torso (CAP) scanning

- Cannot raise arms, but can move them
  - Position the patient centered in the scanner as usual, then lay as many pillows as you can on their abdomen and place the patient's arms on the pillows. This will move the arms away from the body, largely mitigating any streaking artifact they would have caused for the scan.
- Cannot raise or move arms (i.e. arms are broken)
  - Position the patient centered in the scanner as usual.
    - If you are scanning a routine abdomen pelvis: Scan the patient with the cancer follow up protocol, it delivers more dose than the routine.
    - If you are not scanning a routine abdomen pelvis: go to the next higher size protocol which should increase the kV mitigating some of the noise streaking and beam hardening caused by the arms.

Size Selection

Adults:Small/Medium/Large

All Adult Body Protocols are divided into **Small**, **Medium**, and **Large** Adult Protocols.

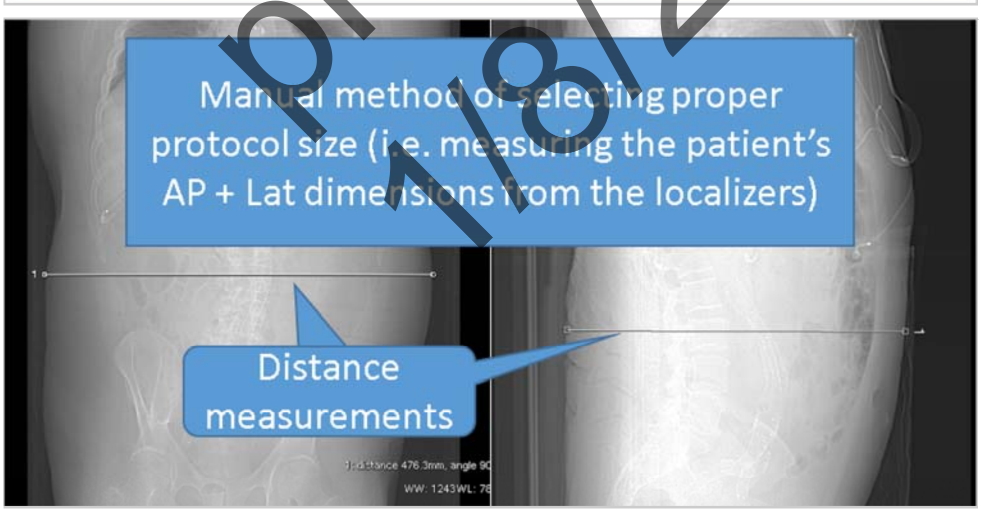
Small Adult Body Protocols shall be used for all patients with a combined AP plus Lateral size of 60 cm or less.

Medium Adult Body Protocols shall be used for all patients with a combined AP plus Lateral size of greater than 60 cm and less than 80 cm.

Large Adult Body Protocols shall be used for all patients with a combined AP plus Lateral size of 80 cm or greater.

These sizes shall be measured off of the Scout image over the largest anatomy of clinical interest.

With the use of these 3 protocols, matched to patient size, there should not be any need for the CT technologist to make further adjustments to the scan techniques when scanning any patient.



Pediatrics: Color Code

When selecting the patient size protocol to use, the combined AP plus Lateral Size of the patient is the primary determining factor. This sum of the AP plus Lateral dimensions of the patient should be measured off of the scout image over the largest anatomy of clinical interest. For accurate measurement, the patient must be properly centered. Also the window width must be adjusted wide enough so that the measurements can be taken from the surface of the skin. For patients with a combined AP plus Lateral Size above 60 cm, use a Medium Adult protocol. Between 55 and 60 cm, use a small adult protocol.

The pediatric color coding scheme divides pediatric into five sizes coded by color. The approximate age of patients and size ranges are given as follows:

Pink Newborns. Typical AP + Lateral size of 0-26 cm.

Red/Purple 6 months-2.5 years. Typical AP + Lateral size of 27-31 cm.

Yellow/White 3-7 years. Typical AP + Lateral size of 32-37 cm.

Blue/Orange 8-12 years. Typical AP + Lateral size of 38-43 cm.

Green/Black 13-18 years. Typical AP + Lateral size of 44-55 cm.

The 9 colors that are used in this scheme are derived from the Broselow tape scale which was originally used to color code doses of medication given in pediatric care.

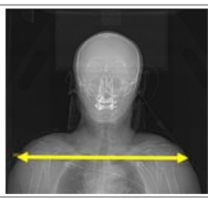
Neuro: Adult/Child/Infant

Some of the neuro protocols have scan parameters that are divided into three groups for: Adults, children (3-6 years old), and infants (0-3 years old).

Size Selection for Neck and C-spine

NOTE - if the patient has lymphoma and the study is a follow-up, use the small neck protocol (regardless of the patients actual size) since it will provide a lower dose

- Verify that the arms are outside of the CT wrap, and that the shoulders are relaxed down toward the feet as far as possible. Measure the width of the shoulders through the level of the mid-humeral head, as shown below.
- Check BMI
- Select small, medium and large based on the table below.

Measure width through mid-humeral heads	Small	Medium	Large
	**Shoulder width less than 46 cm *OR* BMI less than 26**	**Shoulder Width 46 to 50 cm**	**Shoulder width greater than 50 cm *OR* BMI greater than 35**

Instructions for Adjusting Protocols for Pediatric Extremities and Bariatric Patients

Pediatric Extremity Adjustments

We do not have separate pediatric protocols for extremity imaging in the MSK section of our manual. To image pediatric extremities **for patients less than 13 years old**, please select the adult extremity protocol and lower the kV 1 step. These protocols are all set to use manual mA, so decreasing the kV will decrease the patient dose by roughly 50%.

These instructions apply to the following protocols

1. Knee/Tibia (Without Metal) 9.3
2. Knee/Tibia (With Metal) 9.4
3. Ankle/Foot/Distal Tibia (Without Metal) 9.1
4. Ankle/Foot/Distal Tibia (With Metal) 9.2
5. Elbow/Forearm (Without Metal) 4.6
6. Elbow/Forearm (With Metal) 4.7
7. Wrist (Without Metal) 4.8
8. Wrist (With Metal) 4.9

For example, you get an order for a pediatric ankle scan. There is no metal in the field of view so you select the protocol: Ankle/Foot/Distal Tibia (Without Metal) 9.1 . When you get to the tomographic phases of the exam (helical scan series), simply change the kV from 120 kV to 100 kV.

kV Steps

By 1 step, we mean the following:

If the adult is kV	Then change the kV to
140	120
120	100
100	80

Note: we do not have any MSK extremity protocols that use 80 kV for adults.

Note: you do not have to change the kV for the scouts.

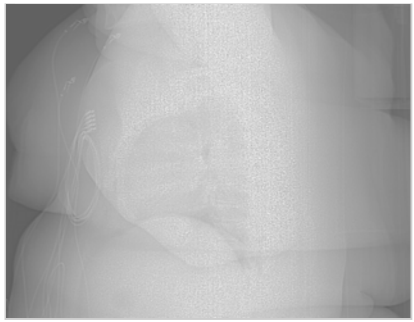
Adjustments for Bariatric PE and Cardiac Studies

We do not have a bariatric protocol for chest PE or cardiac (retrospectively or prospectively gated coronaries) studies. Our large protocol is already designed to deliver a higher maximum dose than the medium and small adult protocols, but it uses 120 kV to maximize iodine contrast. Other large adult protocols that are not angiograms use 140 kV for large adults. Therefore, for bariatric patients who 1. **fill the scout view** or 2. **max out the mA table** please increase the kV from 120 kV to 140 kV.

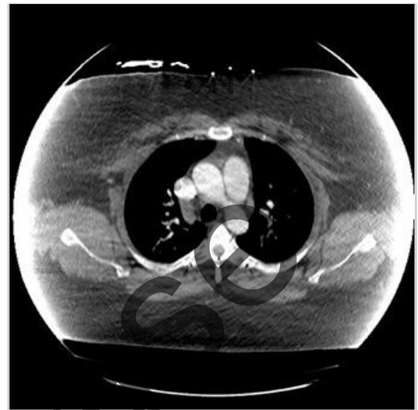
Note: If you know the patient is likely to max out the mA table before taking the scout, you should increase the scout kV from 120 to 140.

Example of a patient filling the scout view

Example patient **filling the scout AP view**



Example patient **filling the scout lateral view**



resulting poor image quality from a patient who **fills the scout**

Weight-Based Contrast Instructions

Need to convert between pounds (lbs), kilograms (kg), and or stones (st)? See the weight conversion table.

All injections should include a saline chaser. See the IVC section of each protocol for more details.

Contrast volume for users without the Medrad P3T Option (what UW uses for most routine non angio imaging)

This table assumes use of contrast strength at 300 mg I/cc and an injection rate of 3 ml/sec

Patient Weight (lbs)	Contrast Volume (ml or cc)
130 and less	80 (minimum amount to load)
140	86
150	92
160	98
165	101
170	104
175	107
180	110
190	116
200	122
210	129
220	135
230	141
240	147
250 and larger	150 (max amount to load)

Contrast volume for users without the Medrad P3T PA Option (what UW uses for angios)

This table assumes use of contrast strength at 370 mg I/cc and an injection rate of 5 ml/sec

Patient Weight (lbs)	Contrast Volume (ml or cc)	Saline chaser Volume (ml or cc)
150 and less	100	60
150-200	125	60
200 and higher	150	60

Creatinine Guidelines (with values for eGFR)

Creatinine Guidelines

If a patient has 1 Kidney, partial Nephrectomy, kidney transplant, or RCC and they are borderline for our non-diabetic criteria identify creatinine trend. If the creatinine has been stable follow our current guidelines without changing to Iodixanol.

Diabetic	Creatinine	eGFR
Iohexol	<1.4	>50
Iodixanol	1.4-1.8	40-50
No Contrast	>1.8	<40

Non- Diabetic	Creatinine	eGFR
Iohexol	<1.8	>40
Iodixanol	1.8-2.4	30-40
No Contrast	>2.4	<30

Creatinine Testing Guidelines for CT Patients

Purpose

The purpose of this document is to provide the CT Technologists a clear guideline for when creatinine testing is required.

Scope

This SOP is for ED, outpatients, inpatients requiring Computed Tomography (CT) examinations.

Prerequisites

- Age > 60 years of age
- Patients whose diabetes is being managed with medication therapy by a physician
- Patients receiving metformin or metformin containing drug combinations
- Receiving chemotherapy or aminoglycoside within the previous one month
- Patients with a history of renal disease including tumor, surgery, solitary kidney, kidney transplantation, or dialysis
- Patients with hypertension requiring medical therapy

Responsibilities

Adults

- Outpatients: Meeting the above Prerequisites, require a CRT within the past 30 days.
- Inpatients: Meeting the above Prerequisites, require a CRT within the past week.
- ED patients: Regardless of prerequisites, ED patients require a same day creatinine. If the patient is leveled as a trauma I or II, follow section 5.2 Trauma Patients.

Pediatric age 0-18 years

- All Pediatric ED, Inpatients and outpatients do not need a creatinine level unless they have acute or chronic renal disease.

Procedure

Verifying Creatinine Status

- Upon receiving an order for a CT exam requiring IV contrast, the CT technologist must verify appropriate creatinine level prior to administering contrast media.

Trauma Patients

- For an acutely traumatized patient for whom there is insufficient time to obtain a creatinine level, it is understood that the benefit of making an emergent diagnosis of a life-threatening injury outweighs the risk of contrast nephrotoxicity.

References

ACR Manual on Contrast Media, Version 10.2, 2016.

Creatinine Orders for Patients Undergoing CT Examinations – Adult/Pediatric – Ambulatory/ED. Delegation Protocol Number 35. https://uconnect.wisc.edu/clinical/cckm-tools/content/delegationpractice-protocols/ambulatory-delegation-protocols/name-97397-en.cckm

Pediatric Contrast Guidelines

Need to convert between pounds (lbs), kilograms (kg), and or stones (st)? See the weight conversion table.

Purpose: To identify appropriate intravenous (IV) access for CT studies requiring intravenous contrast. Achieving appropriate contrast injection rates is critical to achieving a quality diagnostic study.

- In order to decrease delays from injection to image acquisition, a power-injector will be used by the CT technologists.
- If a patient arrives for the CT and has an IV or central line that is not functioning appropriately for contrast injection at the

required rate, the patient will not be scanned until a new IV is placed.

- Preferably IV access should be obtained in an upper extremity.

PIV = peripheral IV

Type of Exam	IV Catheter Requirements	Power Injector Rate	RN to Accompany to CT for Injection
CT Angio Exams	PIV (<1 year): 22G	22G: 3mL/sec	No
	PIV (>1 year): 18G-20G	18G-20G: 4mL/sec	No
	Power injectable central catheter (tunneled or non-tunneled)	Power injectable catheter: 4mL/sec	No
Routine CT Exam	PIV: 22G or larger	> 22G: 2mL/sec	No
	24G catheter (must flush well)	24G: HAND INJECT0.8-1mL/sec	Yes
	Power injectable central catheter (tunneled or non-tunneled)	Power injectable catheter: 2mL/sec	No
	Non-power injectable central catheter (tunneled or non-tunneled): <4 Fr	Place PIV > 22G: 2mL/sec	No
	Non-power injectable central catheter (tunneled or non-tunneled): >5 Fr	Non-power injectable catheter: HAND INJECT1-1.5 mL/sec	*Yes

Hand Injection by RN: Patient's RN must accompany patient or CT if a non-power-injectable line is to be used for hand injection of contrast for a CT. The RN will be in the room and inject the contrast. The CT tech can then start the scan at the appropriate time following contrast administration. If there are clinical concerns regarding IV/central line size or function limiting our ability to perform a diagnostic CT scan, a discussion should be had between the patient's attending physician and the attending pediatric radiologist.

Radiation Safety Guidelines for RNs in room during the start of CT exams:

- The RN should be wearing a lead apron (wrap around type) and thyroid shield.
- The RN should try to stand as far as possible from the patient while still being able to administer the contrast agent during the time when the CT scanner is on (the scanner has a notification light on the front and back sides to show people in the room when it is creating x-rays).
- After the injection is complete, the RN should back/step away from the patient/scanner and leave the room if time allows
- For pregnant RN's in the room, refer to your sites own internal policy guidelines.

Contraindications for Using the Power-Injector

- Tunneled catheters that are not power-injectable (silicone Hickman or Broviac catheter): Due to the inability to inject at an appropriate rate.
    - Patient will need to have a peripheral line placed for any CTA
    - If the tunneled catheter is smaller than 5 French or does not flush well, a peripheral line will need to be placed
- Umbilical venous catheters: due to the possibility of injecting the contrast bolus directly into the liver.
    - Patients will need to have a peripheral line placed.
    - If no other venous access can be attained, the patient's attending physician needs to speak with the attending pediatric radiologist prior to the scan being performed to discuss options.

A study by Amaral et al showed that 24-gauge angiocatheters in a peripheral location can be safely power injected using a maximum flow rate of approximately 1.5 mL/sec and a maximum pressure of 150 psi. Amaral, J. G., Traubici, J., BenDavid, G., Reintamm, G., & Daneman, A. (2006). Safety of power injector use in children as measured by incidence of extravasation. American Journal of Roentgenology, 187(2), 580-583.

Weight Conversions

Conversion table for going between pounds (lbs), kilograms (kg) and stones (st).

lbs	kg	st		lbs	kg	st		lbs	kg	st
0	0	0		101	45.9	7.2		201	91.4	14.4
1	0.5	0.1		102	46.4	7.3		202	91.8	14.4
2	0.9	0.1		103	46.8	7.4		203	92.3	14.5
3	1.4	0.2		104	47.3	7.4		204	92.7	14.6
4	1.8	0.3		105	47.7	7.5		205	93.2	14.6
5	2.3	0.4		106	48.2	7.6		206	93.6	14.7
6	2.7	0.4		107	48.6	7.6		207	94.1	14.8
7	3.2	0.5		108	49.1	7.7		208	94.5	14.9
8	3.6	0.6		109	49.5	7.8		209	95	14.9
9	4.1	0.6		110	50	7.9		210	95.5	15
10	4.5	0.7		111	50.5	7.9		211	95.9	15.1
11	5	0.8		112	50.9	8		212	96.4	15.1
12	5.5	0.9		113	51.4	8.1		213	96.8	15.2
13	5.9	0.9		114	51.8	8.1		214	97.3	15.3
14	6.4	1		115	52.3	8.2		215	97.7	15.4
15	6.8	1.1		116	52.7	8.3		216	98.2	15.4
16	7.3	1.1		117	53.2	8.4		217	98.6	15.5
17	7.7	1.2		118	53.6	8.4		218	99.1	15.6
18	8.2	1.3		119	54.1	8.5		219	99.5	15.6
19	8.6	1.4		120	54.5	8.6		220	100	15.7
20	9.1	1.4		121	55	8.6		221	100.5	15.8
21	9.5	1.5		122	55.5	8.7		222	100.9	15.9
22	10	1.6		123	55.9	8.8		223	101.4	15.9
23	10.5	1.6		124	56.4	8.9		224	101.8	16
24	10.9	1.7		125	56.8	8.9		225	102.3	16.1
25	11.4	1.8		126	57.3	9		226	102.7	16.1
26	11.8	1.9		127	57.7	9.1		227	103.2	16.2
27	12.3	1.9		128	58.2	9.1		228	103.6	16.3
28	12.7	2		129	58.6	9.2		229	104.1	16.4
29	13.2	2.1		130	59.1	9.3		230	104.5	16.4
30	13.6	2.1		131	59.5	9.4		231	105	16.5
31	14.1	2.2		132	60	9.4		232	105.5	16.6
32	14.5	2.3		133	60.5	9.5		233	105.9	16.6
33	15	2.4		134	60.9	9.6		234	106.4	16.7

lbs	kg	st		lbs	kg	st		lbs	kg	st
34	15.5	2.4		135	61.4	9.6		235	106.8	16.8
35	15.9	2.5		136	61.8	9.7		236	107.3	16.9
36	16.4	2.6		137	62.3	9.8		237	107.7	16.9
37	16.8	2.6		138	62.7	9.9		238	108.2	17
38	17.3	2.7		139	63.2	9.9		239	108.6	17.1
39	17.7	2.8		140	63.6	10		240	109.1	17.1
40	18.2	2.9		141	64.1	10.1		241	109.5	17.2
41	18.6	2.9		142	64.5	10.1		242	110	17.3
42	19.1	3		143	65	10.2		243	110.5	17.4
43	19.5	3.1		144	65.5	10.3		244	110.9	17.4
44	20	3.1		145	65.9	10.4		245	111.4	17.5
45	20.5	3.2		146	66.4	10.4		246	111.8	17.6
46	20.9	3.3		147	66.8	10.5		247	112.3	17.6
47	21.4	3.4		148	67.3	10.6		248	112.7	17.7
48	21.8	3.4		149	67.7	10.6		249	113.2	17.8
49	22.3	3.5		150	68.2	10.7		250	113.6	17.9
50	22.7	3.6		151	68.6	10.8		251	114.1	17.9
51	23.2	3.6		152	69.1	10.9		252	114.5	18
52	23.6	3.7		153	69.5	10.9		253	115	18.1
53	24.1	3.8		154	70	11		254	115.5	18.1
54	24.5	3.9		155	70.5	11.1		255	115.9	18.2
55	25	3.9		156	70.9	11.1		256	116.4	18.3
56	25.5	4		157	71.4	11.2		257	116.8	18.4
57	25.9	4.1		158	71.8	11.3		258	117.3	18.4
58	26.4	4.1		159	72.3	11.4		259	117.7	18.5
59	26.8	4.2		160	72.7	11.4		260	118.2	18.6
60	27.3	4.3		161	73.2	11.5		261	118.6	18.6
61	27.7	4.4		162	73.6	11.6		262	119.1	18.7
62	28.2	4.4		163	74.1	11.6		263	119.5	18.8
63	28.6	4.5		164	74.5	11.7		264	120	18.9
64	29.1	4.6		165	75	11.8		265	120.5	18.9
65	29.5	4.6		166	75.5	11.9		266	120.9	19
66	30	4.7		167	75.9	11.9		267	121.4	19.1

lbs	kg	st		lbs	kg	st		lbs	kg	st
67	30.5	4.8		168	76.4	12		268	121.8	19.1
68	30.9	4.9		169	76.8	12.1		269	122.3	19.2
69	31.4	4.9		170	77.3	12.1		270	122.7	19.3
70	31.8	5		171	77.7	12.2		271	123.2	19.4
71	32.3	5.1		172	78.2	12.3		272	123.6	19.4
72	32.7	5.1		173	78.6	12.4		273	124.1	19.5
73	33.2	5.2		174	79.1	12.4		274	124.5	19.6
74	33.6	5.3		175	79.5	12.5		275	125	19.6
75	34.1	5.4		176	80	12.6		276	125.5	19.7
76	34.5	5.4		177	80.5	12.6		277	125.9	19.8
77	35	5.5		178	80.9	12.7		278	126.4	19.9
78	35.5	5.6		179	81.4	12.8		279	126.8	19.9
79	35.9	5.6		180	81.8	12.9		280	127.3	20
80	36.4	5.7		181	82.3	12.9		281	127.7	20.1
81	36.8	5.8		182	82.7	13		282	128.2	20.1
82	37.3	5.9		183	83.2	13.1		283	128.6	20.2
83	37.7	5.9		184	83.6	13.1		284	129.1	20.3
84	38.2	6		185	84.1	13.2		285	129.5	20.4
85	38.6	6.1		186	84.5	13.3		286	130	20.4
86	39.1	6.1		187	85	13.4		287	130.5	20.5
87	39.5	6.2		188	85.5	13.4		288	130.9	20.6
88	40	6.3		189	85.9	13.5		289	131.4	20.6
89	40.5	6.4		190	86.4	13.6		290	131.8	20.7
90	40.9	6.4		191	86.8	13.6		291	132.3	20.8
91	41.4	6.5		192	87.3	13.7		292	132.7	20.9
92	41.8	6.6		193	87.7	13.8		293	133.2	20.9
93	42.3	6.6		194	88.2	13.9		294	133.6	21
94	42.7	6.7		195	88.6	13.9		295	134.1	21.1
95	43.2	6.8		196	89.1	14		296	134.5	21.1
96	43.6	6.9		197	89.5	14.1		297	135	21.2
97	44.1	6.9		198	90	14.1		298	135.5	21.3
98	44.5	7		199	90.5	14.2		299	135.9	21.4
99	45	7.1		200	90.9	14.3		300	136.4	21.4
100	45.5	7.1		201	91.4	14.4		301	136.8	21.5

CT Perfusion Protocol: (Specific Instructions)

Setup

1. Patient Supine, AP and lateral scouts, no gantry tilt
2. Patient Positioning: Tilt the patient's head so that a line connecting the lateral canthus of the eye and the EAC is perpendicular to the CT tabletop (see head CT protocol).
3. Usually done in conjunction with a CT/CTA of the Head or CT/CTA of Head/Neck
4. Best to use 64 (4 cm detector coverage) slice scanners

Exam

CT Perfusion

1. Scan Type Cine
2. Cine Duration 65 seconds
3. Perfusion Area (next page)
4. Contrast Adult: 40 ml of 370 Isovue (14.8 g Iodine) with 30 ml saline chase

Peds: 0.25 mg/kg Isovue 370 with 10 ml saline chase

1. Injection Rate Adult: 5 ml per sec

Peds: 3-4 ml per sec (Depends on size of needle and age of patient)

1. Prep Delay 5 seconds
2. Perfusion Slabs Use maximum number (4-8-16) of contiguous 5 mm slabs allowed by each specific CT scanner (use toggle/shuttle mode if possible)

DFOV

1. Preferred 22 cm

Perfusion Post Processing

(see below for further details):

1. Prospectively reconstruct the images to .5 seconds. This is found under thick/speed - (under recon 2).
2. When you are in recon 2, enter the RAS coordinates manually.
3. Network raw perfusion images to ALI Store

Acquisition Parameters
Cine

	Adult and Child non Revolution	Adult and Child Revolution
Scan Type	Cine	Cine
Rotation Time	1.0	1.0
Beam Collimation	40	80
Detector Rows	64	128
Detector Configuration	64 x 0.625	128 x 0.625
Scan FOV	Head	Head
Number of images per rotation	8i	16i
kV	80	80
Smart or Manual mA	Manual mA	Manual mA
Manual mA for Adults	150	200
Manual mA for Ped < 6 y/o	75	100
Cine Duration (sec)	65	65
Slice Thickness (mm)	5.0	5.0
Interval (mm)	0	0

Note: Apply 30% ASiR/ASiR-V to the perfusion recons.

Shuttle

	Adult and Child
Scan Type	Shuttle
Rotation Time	0.5
Beam Collimation	40
Detector Rows	64
Detector Configuration	64 x 0.625
Scan FOV	Head
Number of images per rotation	8i
kV	80
Smart or Manual mA	Manual mA
Manual mA for Adults	400
Manual mA for Ped < 6 y/o	no shuttle scans for peds
Cine Duration (sec)	65
Slice Thickness (mm)	5.0
Interval (mm)	0

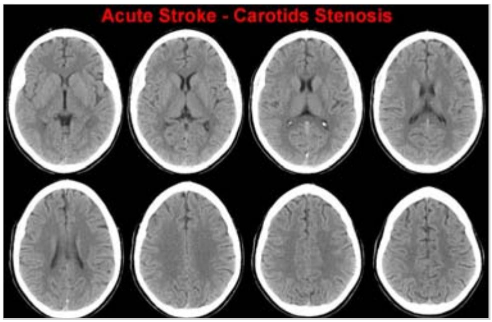
Note: Apply 30% ASiR/ASiR-V to the perfusion recons.

CT Perfusion Coverage

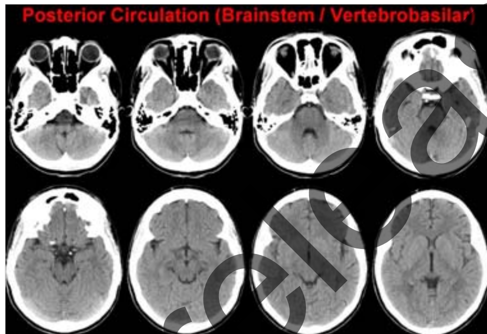
32 and higher slice scanners (shuttle mode)

Obtain 16 contiguous 5 mm slices from EAC Upward

32 and higher slice scanners (cine mode)

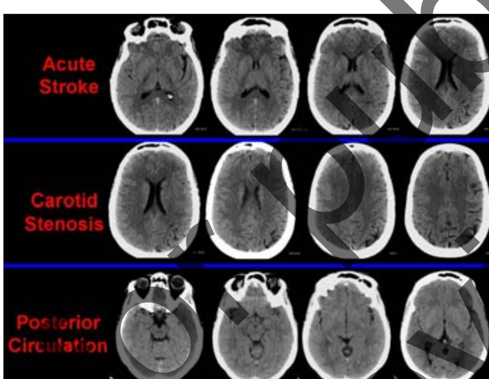


64 Channel CT Perfusion: Non-shuttle Mode (8x5 mm slice coverage)



64 Channel CT Perfusion: Non-shuttle Mode (8x5 mm slice coverage)

8-16 Slice scanners (cine mode)



8-16 Channel CT Perfusion: (4x5 mm slice coverage)

Thoracic Outlet Instructions

Indication

Evaluation for suspected unilateral thoracic outlet obstruction.

Oral Contrast

None

Pre-Scan Instructions

Two CTA scans, one with both arms down and one with affected arm up. Make sure hand in affected arm is warm. If ordered as a bilateral scan: Do two CTA scans, (A) one with right arm down and left arm up and (B) one with right arm up and left arm down. Make sure hands are warm.

IV Contrast Parameters

Load 135 cc contrast Isovue 370 and 80 cc saline.

Field of View

Same as previous study or as small as appropriate

Scan Description

- Part 1
  - Scan Description: Arms Down
    - Series 1: PA and Lateral Scout
      - Coverage:From lower neck to diaphragm on inspiration. Scan with the scouts from the routine neck protocol.
    - Series 2: Smart Prep
      - Coverage: Center over the aortic arch and place the ROI on the proximal aortic arch. Starts canning at 100 HU trigger level.
    - Series 2: Scan Phase CTA
      - Coverage: From below the carina to lower neck on inspiration.
      - IV: 50 mL IV contrast at 5 mL/sec followed by 40 mL saline at 5 mL/sec
- Part 2
  - Scan Description: Affected Arm Up
    - Series 3: PA and Lateral Scout
      - Coverage: From carina through finger tips on inspiration.
    - Series 4: Smart Prep
      - Coverage: Center over the aortic arch and place the ROI on the proximal aortic arch. Start scanning at 100 HU trigger level.
    - Series 4: Scan Phase CTA
      - Coverage: From aortic arch through finger tips on inspiration.
      - IV: 25 mL IV contrast at 5 mL/sec followed by 60 mL IV contrast at 4 mL/sec then 40 mL saline at 4 mL/sec
- Part 3
  - Scan Description: Delayed CTA (Have the patient keep their arm raised as it was in the previous series)
    - Series 5: Scan Phase CTA
      - Timing: This scan should be started 70 seconds after the contrast injection from the previous series.
      - Coverage: Scan from the carina to the elbow.

Acquisition Parameters

Scan the scouts from the routine neck protocol when the arms are down and the upper extremity run off protocol when the arms are up. Scan the tomographic portions with the upper extremity run off protocol (turn the smart prep option on).

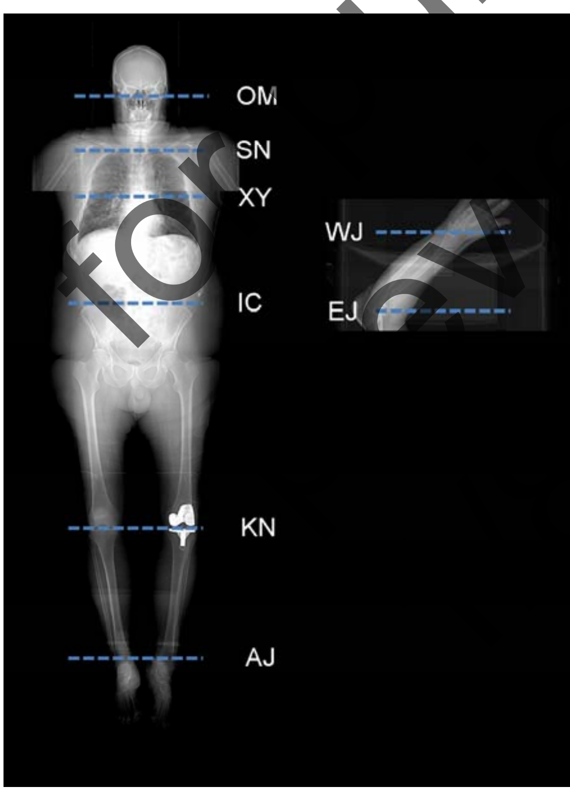
Scout Ranges and Anatomical Landmarks

The table below lists scout start and end ranges appropriate for most adults. For pediatrics, adjustment of these values should be based on patient height.

Protocol Name/Type	Anatomical Landmark	Scout Start Location	Scout End Location
Head (Brain), Orbits, Facial Trauma, Sinus, Temporal Bone, Stereotactic head	OM	S 150	I 150
CTA head, AND any of the following that need to smart prep over the aortic arch: Head (Brain), Orbits, Facial Trauma, Sinus	OM	S 150	I 300
Stroke Deluxe, Head/Neck Venography	SN	S 300	I 200
Neck, CTA neck, Cervical Spine	SN	S 200	I 200
Shoulder/Humerus	SN	S 150	I 150
Elbow/Forearm	EJ	S 150	I 150
Wrist/Hand	WJ	S 150	I 150
Chest, Lung Cancer Screening, Pulmonary Embolism, All Cardiac Protocols (gated/non-gated), Dynamic Airway	SN	S 50	I 350
Subclavian venogram, Pectus	SN	S 75	I 350
Abdomen/Pelvis (this includes all protocols starting with Abd-Pelvis unless otherwise noted), Lumbar Spine	XY	S 50	I 500
Chest Abdomen Pelvis, TAVI/TAVR, PE/Abd/Pelvis Combo, Thoracic Spine	SN	S 50	I 600
Bony Pelvis, Cystogram, Body Pelvis	IC	S 50	I 300
MAKO Hip and MAKO Knee	IC	S 50	I 650
Knee/Tibia	KN	S 150	I 150
Femoral Anteversion	IC	S 100	I 1000
Ankle Foot, Distal Tibia	AJ	S 150	I 150
Upper Extremity CTA (run off)	SN	S 800	I 300
Lower Extremity CTA (run off)	SN	S 100	I 1700*

*Note, some scanners may only be capable of going to I1450.

OM = orbital meatal, SN = sternal notch, EJ = elbow joint, WJ = wrist joint, XY = xyphoid process, IC = iliac crest, KN = knee, AJ = ankle joint



Window Width and Window Level

Note: ST refers to *soft tissue*, ww refers to *window width*, wl refers to *window level*, PE refers to *pulmonary embolism*.

All scouts (CT localizer radiographs)

WW/WL = 500/50

Abdominal

Anatomy being scanned	WW/WL
ST	450/50

Chest

Anatomy being scanned	WW/WL
Lungs	1500/-700
ST	450/50
PE AX MIPS	920/125

Cardiovascular

Anatomy being scanned	WW/WL
ST	450/50
Wall Flap	800/150

Neuro

Anatomy being scanned	WW/WL
Bone (temporal and spines)	2500/350
Thick ST (general head/brain)	80/25
CTA head, CTA neck, Sinus and Maxiface	450/50
Thin ST Head, Perfusion	180/25
Neck ST	300/35
Orbits ST	300/0

MSK

Anatomy being scanned	WW/WL
Bone	2500/350
ST	450/50

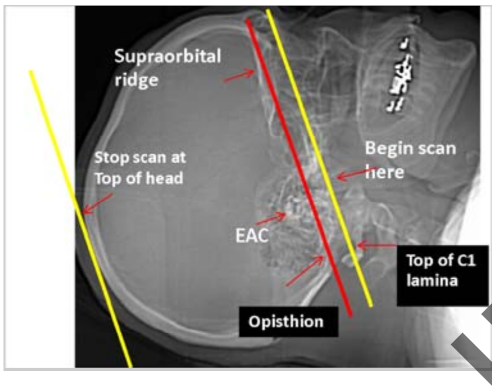
Peds

Anatomy being scanned	WW/WL
Chest/Body	450/50
Lung	1700/-500

Instructions for Avoiding the Lens of the Eye on Head Exams

For routine head exams where one desires to avoid the lens of the eye:

1. Positioning: Tilt the patients chin toward their chest "tucked position" (or tilt gantry alternatively) to produce a scan angle that is parallel to a line created by the supraorbital ridge and the inner table of the posterior margin of the foramen magnum (opisthion).
2. Helical mode should be used routinely for adult head CT scans. If you cannot move the patient's head into proper position (trauma, cervical collar, rigid neck) then perform a helical scan with angled axial reformats or perform an axial scan with gantry tilt.
3. Start scans at the top of the C1 lamina and scan through the top of the calvarium.
4. The figure below details the scan ranges



Scan range for routine head imaging if the eye lens is to be avoided (scan from yellow line to yellow line, the red line denotes the bony landmarks you want to get aligned with the scan plane)

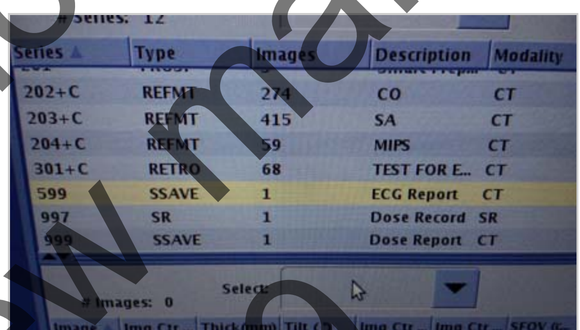
How to Send the ECG Trace to PACS

For all gated exams (prospective and retrospective for all indications/contrast phases/body regions (non contrast chest, CTA non coronaries, CTA coronaries, etc.) please send the ECG trace to PACS. This will help document the patients heart rate, heart rate variability, and the presence of any irregular beats during the scan. If you perform any trigger editing, it will also document how that editing was performed.

To send the ECG trace to PACS

1. After completing all of the needed reformats and pushing the study to PACS, open the retro reconstruction screen and select the gated series. Do not select the smart prep or bolus tracking series if present. For coronary CTA, pick the coronary CTA, not calcium scoring.
2. Adjust the scan reconstruction range to as small as possible (we will be doing a retro recon only to save the ECG trace, not to actually send the images so the range doesn't matter and therefore should be as small as possible to save space on the scanner). For example, if the scan started at S40 and ended at I250, you could just do a retro recon from S40 to S39.
3. Make sure the button that says "ECG Viewer" is selected (you should see the ECG trace when it is selected in the top right hand corner of the screen)
4. Hit the save icon on the ECG trace (it is in the upper right and corner of the screen and looks like a floppy disc).
5. Name the series "Recon for ECG Trace".
6. Click confirm.
7. Two new series will show up for the patient, the one you just made named "Recon for ECG Trace" and one named "ECG Report". Only send the "ECG Report" to PACS.

ECG trace shown on retro recon viewer

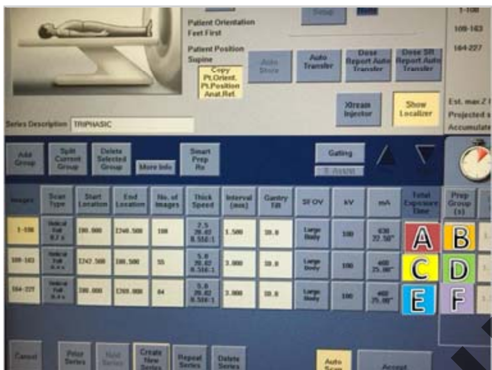


How the ECG report shows up on the image browser tab

Triphasic Timing with No Dynamic Transition

Triphasic Liver and Liver Recipient Work-up

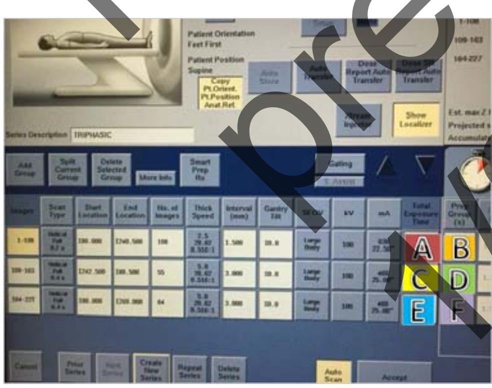
- Timing (you need to set-up the scan ranges for each group before adjusting the timing)
  - Timing Arterial phase: enter the timing bolus delay in the prep group
  - Timing bolus time to peak + timing bolus upfront delay = B
  - Timing Late arterial phase: Take 20 seconds - "total exposure time" number from the arterial phase
    - 20 – A = D
  - Timing Hepatic Venous phase: Add up all four numbers (total exposure time and prep group) for the arterial and late arterial phase, then subtract from 70 seconds, enter this number in the "prep group" for the hepatic venous phase
    - A+B+C+D = G, then take 70-G = F



Where to edit intergroup delays

Liver Donor

- Timing (you need to set-up the scan ranges for each group before adjusting the timing)
  - Timing Arterial phase: enter the timing bolus delay in the prep group
  - Timing bolus time to peak + timing bolus upfront delay = B
  - Timing Late arterial phase: Take 20 seconds - "total exposure time" number from the arterial phase
    - 30 – A = D
  - Timing Hepatic Venous phase: Add up all four numbers (total exposure time and prep group) for the arterial and late arterial phase, then subtract from 70 seconds, enter this number in the "prep group" for the hepatic venous phase
    - A+B+C+D = G, then take 90-G = F

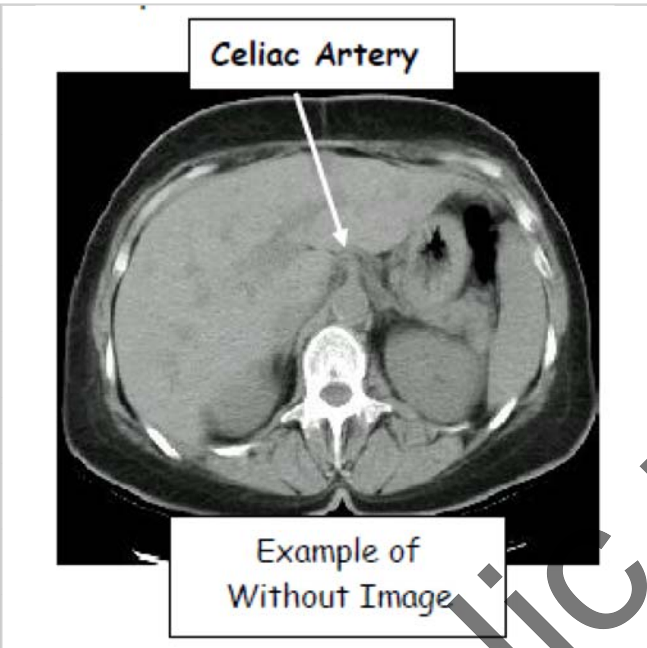


Where to edit intergroup delays

Bolus Tracking for Triphasic Liver, Liver Recipient Work-up, and Liver Donor

Timing bolus

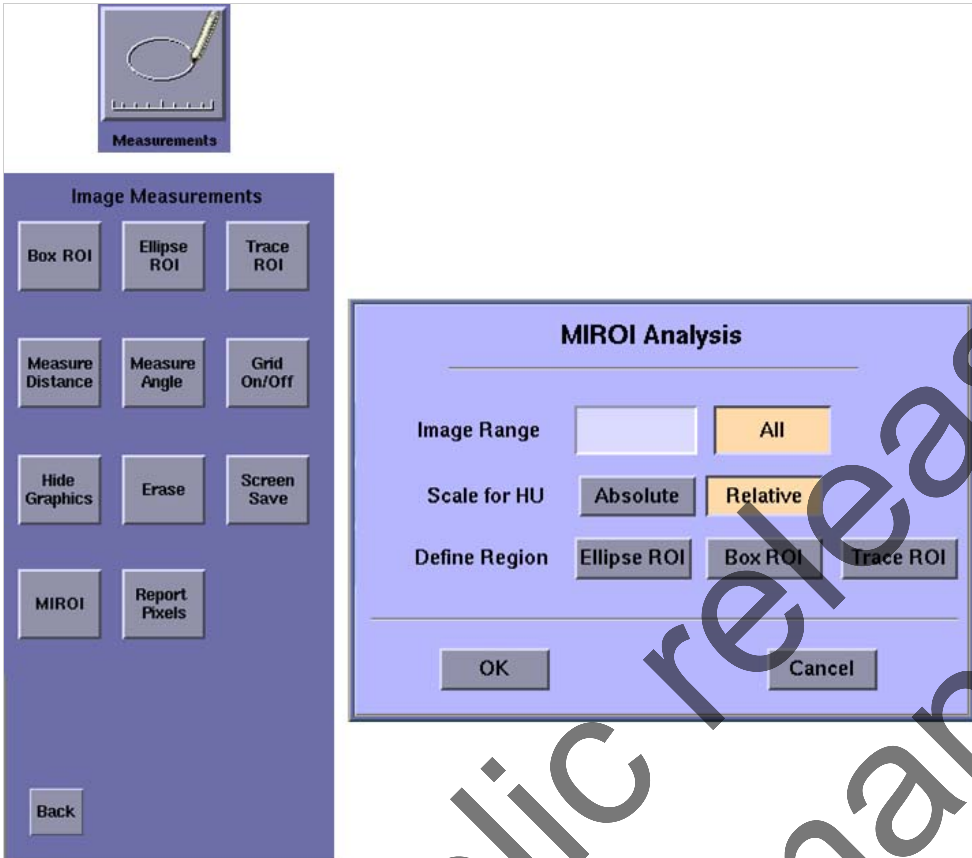
- From the without images, choose the level of the celiac artery



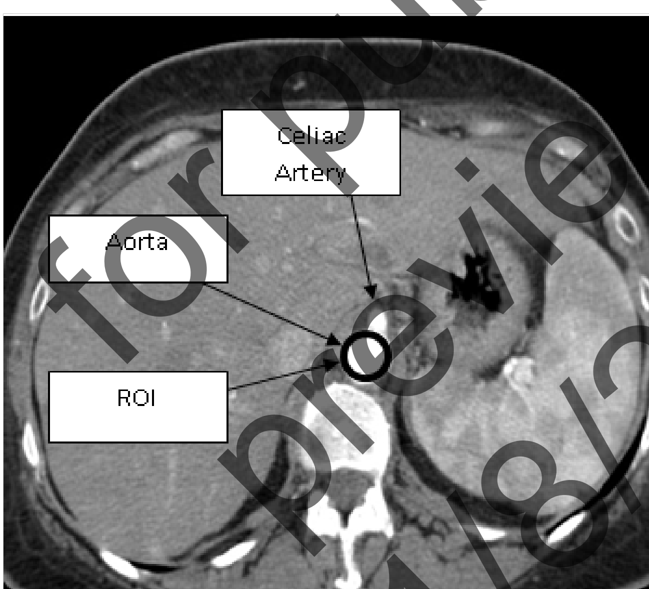
- Put level of the celiac artery under the start location and the same level for the end location (the table will not move)
- 5mm thick @ 1i
- 0 Interval
- Low mA - 80 (use the same kV as the subsequent scan, 80/100/120 for small/med/large)

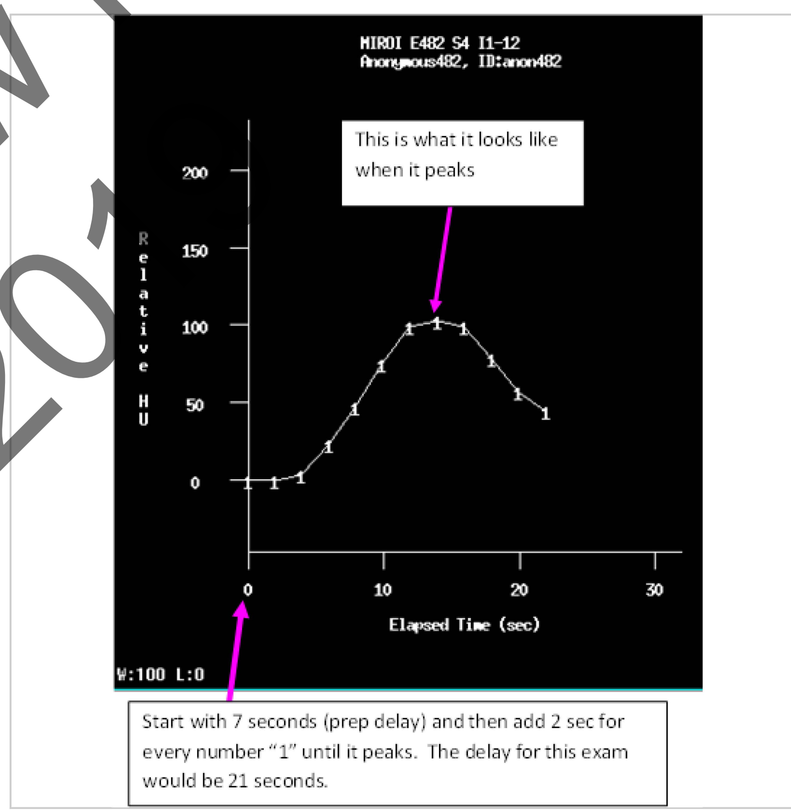
Images	Scan Type	Start Location	End Location	No. of Images	Thick Speed	Interval (mm)	Gantry Tilt	SFOV	kV	mA	Total Exposure Time
1-14	Axial Full 1.0 sec.	I100.000	I100.000	14	5.0 1i	0.000	S0.0	Small Body	120	80	14.0

- Inject 5cc per second for 20cc
- Use 7 sec prep delay (if patient is large use a 10 sec delay) - must be confident of the IV
- Start the contrast and the scan at the same time
- Should be able to see the contrast enhance the artery. When the scan is completed - about 15-20 images, select measurement and choose MIROI- Relative should be selected and then choose elliptical ROI.



- Put circle in the aorta





- Select OK
- Read Graph
- Every number one equals 2 seconds

Frequently-Asked Questions (FAQ's)

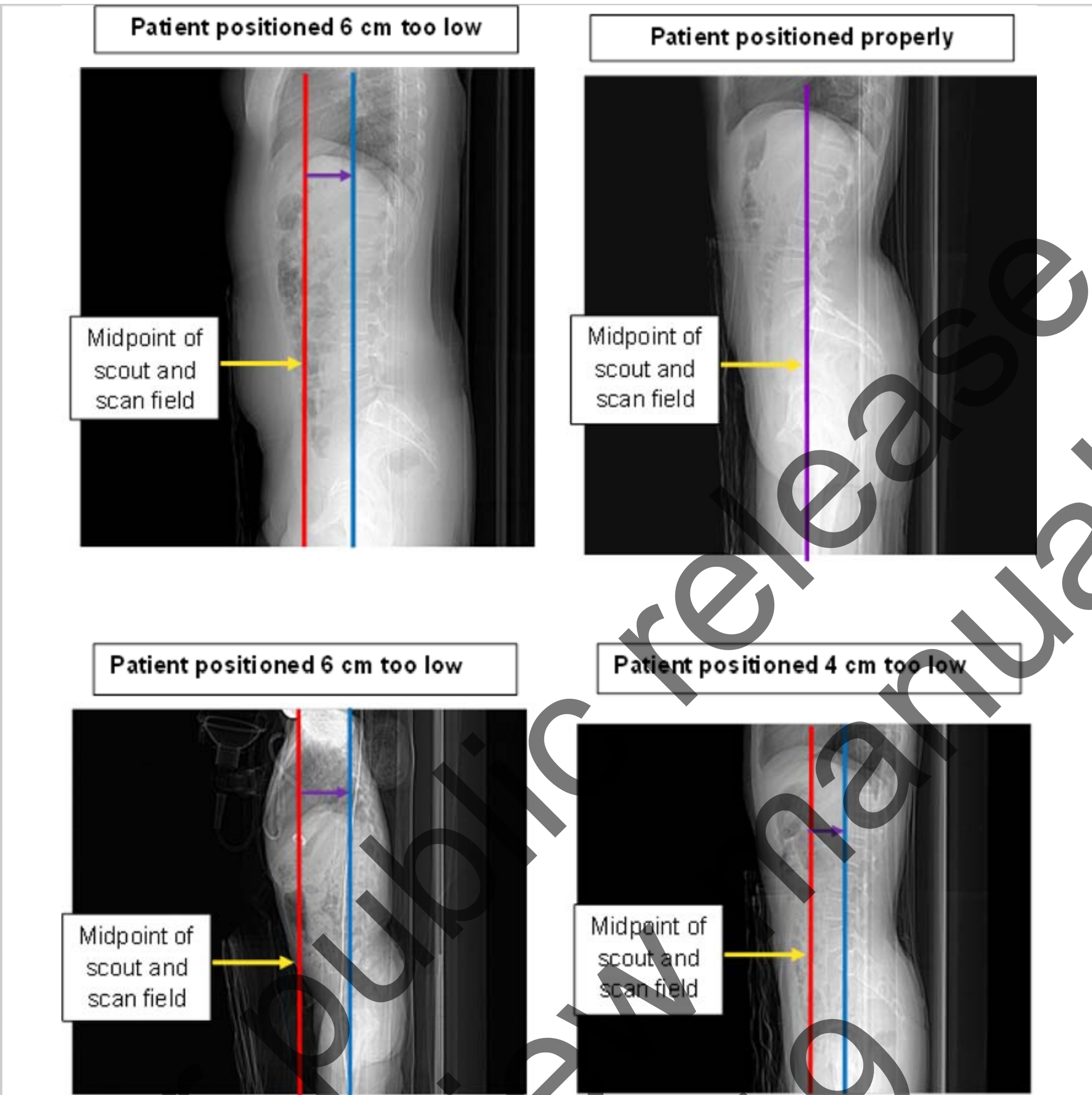
Critical Comments on Proper Patient Centering

1. **Using the UW protocols, I sometimes find that parts of the image are too noisy, particularly towards the posterior part of the patient. Why?**
   To ensure uniform image quality at the lowest dose, proper patient positioning is very important. Current scanner technology incorporates bowtie filters. Their purpose is to decrease radiation to the periphery of the patient. This results in a sweet spot for patient positioning. Improper positioning will result in degraded image quality. It is particularly important in pediatric imaging and the small adults specifically, whenever the smaller bowtie filter is used relative to the selected Scan Field of View (SFOV). The small bowtie filter is used for all pediatric SFOV's, for the Small Body and Small Head SFOV's on the LightSpeed VCT and the Revolution Frontier™, Revolution™ HD, and Discovery™ Series scanners; and for the Small Body and Head SFOV's on the Revolution EVO and the Optima CT660 scanners. Proper centering is also more important when using low kV technique.

   Patients of all sizes are frequently positioned too low in the gantry, primarily because it can be difficult to correctly estimate the AP center of the patient since part of the patient is effectively hidden by the curve of the table. Generally it is better to have the patient centered a bit high rather than low, since it is optimal to place the most attenuating part of the patient at the center of the scan. The patient's center of mass is usually a bit posterior to the measured center point of the patient from skin line to skin line. Thus, make sure that the table is properly elevated. (To accomplish this with smaller and pediatric patients, one should position the patient high enough so that the horizontal laser light is centered on the lumbar spine and is just anterior to the thoracic spine. This is demonstrated by the figures on the next page.)

   If the patient is positioned too low in the gantry, several detrimental effects occur. They are most problematic when using the smaller SFOV bowtie filter or lower kV settings. First the image noise will increase, particularly toward the posterior part of the patient. Second the patient dose will increase. The proper solution is NOT to avoid the use of the smaller SFOV bowtie filter or to avoid the use of lower kV when appropriate. Rather the best solution is proper patient positioning – to obtain the best overall image quality at the lowest dose.

   The principals of properly centering small and pediatric patients are demonstrated in the scout images below, where the red line is the actual midpoint of the scout image and the blue line is where the patient should have been centered on the scout. Only the scout on the upper right shows correct positioning; the midpoint of this scout is shown as a purple line. All the rest are centered too low.



Positioning Examples

General

1. **Why did GE partner with the University of Wisconsin-Madison?**
   University of Wisconsin-Madison has one of the largest medical physics departments of any major institution offering this type of program, and their Department of Radiology has years of experience in refining and improving CT protocols. Together, these two departments have developed clinically relevant and technically sound CT protocols. The University of Wisconsin-Madison and GE Healthcare have had a long-standing working relationship and strategic alliance. This is partly due to geographic proximity.
2. **When I buy a new GE scanner, must I use these protocols?**
   We encourage you to take the time to review the protocols and apply them as they are written. These protocols have been refined to provide optimal imaging for a numerous set of conditions. They have been fine-tuned to each specific CT scanner and refined for the varying size of our population. But you may choose to use your own protocols. Just please take the time to optimize them for your new scanner. That's the right thing to do to make sure your patients get the best scan at the safest dose.
3. **Why are there so many different protocols?**
   The protocols are refined for certain disease states. Modifications in patient positioning, oral and intravenous contrast administration, and timing of series acquisition can help to optimize visualization of the suspect clinical condition.
4. **Will these protocols change?**
   It is inevitable that with further improvements in CT technology and/or a growing understanding of disease conditions, the University of Wisconsin-Madison protocols will evolve. Our intention is to release new versions of improved protocols on an annual basis; however, an earlier release may be provided if a major medical advance or a protocol issue comes to light.
5. **Is there a reason why Dose Reduction Guidance is not used in the protocols?**

1. When the Dose Reduction Guidance is used, there is a limit imposed on the min mA allowed, which poses a problem for our protocols.
2. Dose Reduction Guidance is not available on the Revolution Frontier™, Revolution™ HD, and Discovery™ Series scanners, and we wished to be consistent in our protocols across GE CT platforms.
3. Our radiologists have approved the use of a certain percent ASiR for the different exams and do not want to have it altered by the Dose Reduction Guidance.

6. **These protocols incorporate oral contrast. How do we use the protocols if our institution has gotten away from using oral contrast in our emergency department?**
The University of Wisconsin-Madison firmly believes that imaging of certain disease states is enhanced by the addition of oral contrast. If your institution is comfortable with scanning the abdomen in the absence of oral contrast, that's fine. However, you are encouraged to consider one unique aspect of the oral contrast cocktail that we recommend. The University of Wisconsin-Madison routinely adds polyethylene glycol (PEG) to the oral contrast mix. This accelerates transit through the intestine. When our patients drink this contrast mixture for one hour, we routinely see opacification of the gut to the level of the cecum. This significantly increases confidence and interpretation, especially for enteric conditions.
7. **I just scanned a small patient and the image quality is not very good. Why?**
Patient centering is critically important to achieve uniform image quality. Please refer to the Proper Patient Centering in this section for more information.
8. **Why do you use Smart mA instead of Auto mA or Manual mA?**
The UW protocols always rely on the Smart mA function when the Auto mA is turned on. We do not see any situation in which it would be advantageous to turn the Smart mA function off. Smart mA includes both mA modulation as the patient attenuation changes along the length of the patient and also mA modulation as the tube rotates around the patient. This is always advantageous and is essential in areas of the anatomy where patient size / attenuation varies dramatically with direction, such as the shoulders and pelvis. It is even useful in scanning the head, since the AP and lateral dimensions of the head are not the same.
9. **Why don't all protocols use Dynamic Transition on Smart Prep?**
Dynamic Transition triggers the scan automatically when IV contrast enhancement in the selected region of interest reaches a predetermined HU value. Some patients, however, are startled by the influx of contrast and may move or breathe differently. This could shift the region of interest and result in an attenuation spike which may prematurely trigger the scan to start before optimal contrast opacification.

<u>**Abdominal CT Protocols**</u>

1. **Why are there two flank pain protocols?**
The standard dose flank pain protocol is appropriate for the patient presenting for the first time to the emergency room with suspicion of renal calculi or appendicitis (although we encourage oral contrast for suspect enteric pathology). The low-dose flank pain protocol is more appropriate for the follow-up of patients with known kidney stones who are receiving numerous scans. It is tailored to provide a level of resolution good enough to visualize renal calculi, but not to characterize other renal abnormalities.
2. **Why is there an hepatocellular carcinoma protocol in addition to the biphasic CT?**
The United Network for Organ Sharing (UNOS) has mandated that prior to listing a patient for transplantation, the CT scan evaluating the possibility of neoplasm must include a delayed phase. Therefore, a special protocol was created to accommodate this mandate. The biphasic CT, however, is preferred for evaluation of hypervascular metastases to the liver.
3. **Why are there so many reformatted images on a trauma study?**
The University of Wisconsin-Madison trauma CT of the chest is performed with angiographic technique. However, many centers do not provide in-house 3-D services off-hours. Therefore this protocol includes an oblique MIP reconstruction of the great vasculature. It provides a candy cane projection of the aortic arch, ideal to rule out aortic injury.
4. **Why do you scan the trauma chest from bottom up?**
By the time the scan arrives at the apex of the chest, most of the intravenous contrast has been washed out of the veins of the upper thorax by the saline chaser. This decreases the streak artifacts from veins. If scanned top down, these veins would be filled with very dense contrast as it is being actively injected at the time of acquisition.
5. **The dose for the trauma chest abdomen pelvis appears relatively high compared to a standard chest abdomen pelvis study. Why is that so?**
A trauma study routinely results in additional reformatted images of the spine. To obtain appropriate resolution for imaging of fractures, the technique must be relatively robust. This is major reason why trauma imaging is performed at a higher dose than standard body imaging.
6. **Why is a 0.5xx:1 pitch used?**
University of Wisconsin-Madison uses the 0.5xx:1 pitch for several reasons: (1) it provides optimized helical reconstructions, compared to higher pitches; and (2) for the same image noise, it produces a 20% lower dose than does the 0.9 pitch (which is why that pitch is avoided). University of Wisconsin-Madison uses 0.4s or 0.5s rotation times when possible to reduce scan times with the lower pitch. When that is not sufficient, as in PE studies, the pitch is increased to 1.375. The use of a lower pitch is

possible with the GE 64-slice scanners because of the wider beam collimation of 40mm compared to 20mm, which doubles the table speed for any particular pitch and rotation time. This also allows the scanning of larger patients without hitting max mA and degrading image quality.

Chest CT Protocols

1. **Please explain why Bone Plus (thin cuts) are prescribed in Recon4?**
   Bone Plus is used as a “lung algorithm”. We prefer its diagnostic image quality compared to the “Lung” or “Bone” algorithm. Thin cuts for both soft tissue and lung images are performed to create the Sagittal and Coronal reformatted images.
2. **Why is a 0.5xx:1 pitch used except for PE studies?**
   See same question under "Abdominal CT Protocols.

CV CT Protocols

1. **Why is a separate non-contrast scan included with the CTA studies?**
   It allows us to differentiate contrast from calcium when looking for extravasation or a leak. Also, the non-contrast scan is essential for detection of intramural hematoma in acute aortic syndrome.
2. **Why doesn’t University of Wisconsin-Madison use prospective gating on the chest portion of a combined CTA chest/abdomen/pelvis in which gating is needed in the chest?**
   GE scanners are not currently able to combine a prospectively gated chest with a non-gated abdomen/pelvis in a single acquisition. Therefore, when it is essential to use ECG-gating on the chest portion of a CTA chest/abdomen/pelvis, retrospective gating must be used.

MSK CT Protocols

1. **Why does the wrist/elbow need to be over the head?**
   This positioning eliminates both exposure to and scatter from the rest of the body.
2. **When positioning the patient with their arm over their head, does it matter if they are prone, supine, or decubitus?** No. Use whatever position makes the patient most comfortable.
3. **When scanning ankles/feet, why are both ankles/feet included in the scanning FOV?**
   Because there is no appreciable scatter from the normal contralateral side, and sometimes it is useful to have the contralateral side for comparison.
4. **If, when scanning a knee/ankle/foot, there is metal in the contralateral side, what should be done?**
   The contralateral knee should be bent to move the metal knee/ankle/foot out of the scanning FOV.
5. **How should the arm be positioned when there is a cast in place?**
   The ideal position for scanning the elbow/forearm/wrist is with the arm and elbow straight so that the arm is perpendicular to the CT gantry. When there is a cast across the elbow, then the forearm should be positioned so it is oblique to the CT gantry.
6. **Why shouldn't the patient be positioned with the forearm parallel to the CT gantry?**
   This creates an unacceptable amount of streaking along the length of the forearm due to greatly increased x-ray attenuation. The forearm should be positioned perpendicular (preferred) or oblique to the CT gantry.
7. **Why are some of my bone images too blurry, especially those of the shoulders?**
   There are two important requirements to retain the image sharpness that can be provided by the sharper image algorithms such as “bone”, “bone plus”, “edge”, and “ultra”. The first requirement is the use of a **small DFOV**, ideally of less than 20 cm. This produces a pixel size that is capable of reproducing the full resolution of the sharp algorithms. The larger pixel size that results with the use of larger DFOV’s will limit the resolution of which the sharp algorithms are capable.
   The second requirement is that the anatomy for which you need high resolution be positioned close to the **center of the scan field of view**. Due to the effects of focal spot size and detector size, the maximum limiting resolution degrades significantly as you move farther from the center of the scan field. For example, when using any of the sharp algorithms, the actual resolution near the outer edge of the scan field can degrade to that of a “soft” algorithm. To avoid this blurring, the best policy is to position the anatomy within a central area with a diameter of 15 cm or less.
   Another recommendation, which will increase size of this central sharp area a bit, is to use a small focal spot. To make sure that the scanner is actually using a small focal spot, the mA in manual mA mode must be no more than a value that depends on the kV setting and that can be found in the Technical Reference Manual for the scanner being used. In auto or smart mA mode the maximum mA setting must be limited to no more than that same value. Here are example values for the Revolution EVO/Optima CT660 scanners and for the Revolution Frontier™, Revolution™ HD, and Discovery™ Series scanners, indicating the maximum mA allowed for the small focal spot:

	Revolution EVO/Optima CT660 mA limits for small focal spot	Revolution Frontier™/Revolution™ HD/Discovery™ mA limits for small focal spot
kV	Normal Scan Mode	Normal/Hi Res Scan Mode
80	300 mA	620/610 mA
100	240 mA	650/490 mA
120	200 mA	540/405 mA
140	170 mA	460/350 mA

As you can see from the above table, the Revolution Frontier™, Revolution™ HD, and Discovery™ Series scanners have an additional scan mode--“Hi Res”. This allows an even greater increase in the size of the sharp central “sweet spot” in the scan. This scan mode can be used with either the large or small focal spot, but the greatest advantage is with the use of the small focal spot. Please note that to take advantage of this benefit of using the “Hi Res” scan mode, you DO NOT need to use the additional “HD” reconstruction algorithms that are available when using this scan mode. In fact, you may prefer the normal, non-HD algorithms since the HD algorithms may cause an unacceptable increase in image noise and artifacts. The HD algorithms used in the Hi Res scan mode can produce a resolution limit in the center of the scan field that is up to 50% greater than achievable with the normal scan mode, but this greater resolution is seldom needed or desirable considering the increase in image noise and artifacts that can result.

Neuro CT Protocols

Adult Brain

1. **Why is helical mode used?**
   1. Helical scanning allows recon intervals at less than the slice thickness. The best z-resolution, along with the fullest display of the clinical information obtained in the scan, is obtained at recon intervals of one-half of the actual slice thickness. The source images that are used for any reformatted images must be thin slices (1.25 mm for soft tissue and 0.625mm for bone) with recon intervals of one-half the slice thickness for optimal image quality. The nearly isotropic voxel volumetric data that this provides can then be used to generate axial images at any angle through the brain or straighten the images through the brain if the patient is not properly positioned. It also allows for the ability to create 2-D reconstructions.

    2. When the patient's head can be positioned and angled properly for the scan, use helical mode and the axial images can be read without reformatting.
    3. A helical scan mode followed by angled recons can be used when one cannot adequately position the patient's head (e.g., cervical collar).
2. **Why is axial mode used?**
   This is used when the patient's head cannot be positioned properly and also when helical scans would produce artifact from metal projecting over the posterior fossa.
3. **Why not use an even lower dose than what's in the protocol?**
   This would result in decreased contrast resolution and a worse signal-to-noise ratio making subtle lesions imperceptible. Grey-white matter differentiation would also become more difficult.
4. **Do you scan the head CT to include orbits or tip the head down to exclude orbits?**
   The head is scanned to include the orbits since we consider it to be an important part of the exam. It is acknowledged that some facilities do not wish to image the orbits because of fear of inducing cataracts. Many of these facilities may not realize that by just missing the orbits, they are still exposing them to the radiation beam. University of Wisconsin-Madison does not believe that the very small level of possible risk for inducing cataracts is sufficient to exclude the diagnostic information obtained in this method of imaging.
5. **Why is Auto/Smart mA used on heads?**
   Auto mA or Smart mA is used to optimize image quality at the lowest dose. The brain is not a uniform cylinder—obviously it is smaller toward the top and its cross-section is oval and not circular. Head attenuation is also not the same for all patients (bone density and thickness). Thus there is definitely an advantage to using Smart mA, and it does not cause any imaging problems. When the axial mode is used to perform head scans, then Manual mA is used. The problem here is the noticeable change in noise texture between axial slabs if the mA were to change. This problem is not seen with helical scanning. Helical scanning allows one to reconstruct at intervals of ½ the actual slice thickness, which improves diagnostic information in the axial scans and improves Sagittal and Coronal reformats.
6. **Why is the noise index different between the adult brain routine and adult brain helical scan with angled axial reformats?**
   Effectively they are the same. One noise index is set for an initial slice thickness of 5.0mm while the other is set for a slice thickness of 1.25mm and therefore needs to be twice the setting used for 5.0mm.

<u>Adult Orbit</u>

1. **When is intravenous contrast used?**
   IV contrast is useful in suspected or known tumor, infection, or vascular malformation.
2. **Why is the bone plus algorithm utilzied?**
   This helps in assessing bony changes from tumor (e.g., smooth remodeling versus aggressive destruction) or infection.
3. **Why can't one simply use soft tissue algorithm with bone windows?**
   This would have diminished bony detail compared to true bone plus algorithm, and subtle destructive lesions could be obscured.
4. **Why use Auto/Smart mA?**
   Except for scanning using the axial mode, for all standard scanning helical mode is used with Smart mA. This includes the protocols for the orbit, sinus, facial bones and temporal bones. Using Smart mA simply gives more consistent image quality at the lowest dose and does not produce any image quality problems. We are unaware of any situation in which it would be advantageous to turn the Smart mA function off when using Auto mA.

<u>Adult Maxillofacial</u>

1. **Do I need to scan the mandible, as well as the face?**
   Yes. Up to 10% of patients with facial trauma will have coexistent mandibular fractures.
2. **Why do I need 0.625 mm slices?**
   This slice thickness is needed for isotropic voxel resolution allowing for high quality multiplanar reconstructions.
3. **Why isn't a lower dose used?**
   Soft tissue evaluation is also mandatory with facial trauma and higher dose is needed for adequate soft tissue imaging.
4. **Why do I need so many different reconstructions?**
   Different planes may better demonstrate subtle fractures, allowing for more accurate diagnosis.
5. **Do I need to do soft tissue reconstructions in facial trauma patients?**
   Facial trauma also affects the soft tissues of the orbit and face. These lesions will not be adequately visualized on the bone algorithm images.
6. **Why use Auto/Smart mA?**
   See same question under 'Adult Orbit' subsection of "Neuro CT Protocols".

Adult Sinuses

1. **When is contrast needed?**
   For evaluation of suspected tumors, atypical infections, suspected extra-sinus spread of infections, or possible vascular lesions.
2. **Is CT as good as MRI for evaluating the sinuses?**
   It depends on the problem that is being evaluated. They are often complimentary studies, especially for assessment of sino-nasal masses, and both may be required in some instances.
3. **Why use Auto/Smart mA?**
   See same question under 'Adult Orbit' subsection of "Neuro CT Protocols".

Adult Temporal Bone

1. **What is the optimal slice thickness?**
   For temporal bone imaging, in general, the thinner the slice, the better.
2. **When is contrast needed?**
   For evaluation of infection or inflammatory processes. In addition, it can be used in evaluation of possible tumors in patients who cannot have an MRI, although it is not typically as sensitive as MRI. Please note that adequate mAs must be utilized for soft tissue resolution.
3. **Why aren't direct coronal images obtained?**
   If adequate slice thickness (i.e., 0.625 mm) is obtained, then multiplanar reconstructions will be comparable in quality without the additional patient dose. It saves a great deal of time and shortens the exam considerably. The coronal plane can be correct for each patient and not limited by tilt or ability to position patient in direct coronal position.
4. **Why use Auto/Smart mA?** See same question under 'Adult Orbit' subsection of "Neuro CT Protocols".

Adult Neck

1. **Why is 140 kV used?**
   This higher kV is needed for adequate penetration of the shoulders. The use of a lower kV setting would result in streaking artifacts through the shoulders and reduced image quality including increased image noise.
2. **Why do we scan to the carina?**
   1. Needed for evaluation of left vocal fold palsy.
   2. Allows assessment of mediastinal nodal disease, which is often present in head and neck cancer.
   3. Allows for evaluation for the lower limit of retropharyngeal pathology.
3. **Why is the scan started at the orbits and scanned down to the carina?**
   1. This is done to give more time for contrast to wash out of the subclavian. Excess contrast in the subclavian will cause streaking artifacts which can decrease visualization of structures in the neck, most importantly the lymph nodes
4. **Why is only a 0.5xx:1 pitch used for a CTA neck?**The low pitch reduces helical artifacts, particularly when the anatomy is changing so rapidly as in the neck/shoulder region. Also, the low pitch avoids reaching the scanner's maximum mA value in the lateral direction through the shoulder, which would compromise the image quality.
5. **Please explain the rationale for 140 kV and 0.5xx:1 pitch.**
   140 kV is used to assure proper penetration through the shoulders, which can otherwise be an annoying source of noise and artifact. The 0.5xx:1 pitch is to minimize artifacts due to the substantial attenuation changes from the transitions from the shoulders and to allow enough effective mAs to penetrate the shoulders. For the same image noise the dose is lower using the 0.5xx:1 pitch compared to the 0.9xx:1 pitch on the GE 64-slice scanners, as noted previously.

Adult Cervical Spine

1. **Why is 140 kV used?**
   This higher kV is needed for adequate penetration of the shoulders. The use of a lower kV setting would result in streaking artifacts through the shoulders and reduced image quality including increased image noise.
2. **Why are images so grainy in the lower cervical spine with soft tissue windows?**
   The exam is obtained with a noise index, which allows for good visualization of the bones for fractures and adequate evaluation of most significant soft tissue pathology with this dose. Adjustments can be made for dosing per preference.
3. **Why are soft tissue reconstructions obtained in trauma?**
   These are used to detect additional trauma such as soft tissue hematomas, epidural or subdural hematoma, traumatic disc herniation, and possible spinal cord injury.
4. **Why are 2-D multiplanar bone reformations obtained?**
   Because 1) some fractures may be more adequately seen in different planes than others; and 2) multiplanar 2-D reformations allow for improved visualization of subluxation.

Pediatric Routine Cervical Spine

1. **Why use 0.8s rotation time on a child, age 3 to 6 years?**
   To avoid reaching the scanner's maximum mA in the lateral direction through the shoulder, which would compromise the image quality.

Adult Thoracic Spine

1. **Why are reformats created on trauma CT chest/abdomen/pelvis?**
   1. This option can be used with unstable patients who need multiple body parts to be quickly scanned and there is not adequate time to obtain standard thoracic spine CT images.
   2. Additionally, in patients with low likelihood of trauma, this helps to reduce radiation dose. If there is a high likelihood of significant thoracic spine fracture, a dedicated thoracic spine CT should obtained.
2. **Why are the axial soft tissue reconstructions and sagittal 2D reformatted thoracic spine images that are obtained from secondary reconstructions of trauma CT chest/abdomen/pelvis studies so grainy?**
   A lower mA is utilized with this option to limit radiation dose. If there is a high likelihood of thoracic spinal injury, a dedicated thoracic spine study should be performed. Individual institutions may also increase the dose per preference.

Vascular CTA

1. **Why are images obtained cranial to caudal with a head and neck CT angiography protocol?**
   This is designed to reduce venous contamination intracranially, allowing for improved sensitivity for aneurysm detection.
2. **Why is smart prep used instead of a timing bolus?**
   Less contrast is utilized. Venous contamination is also avoided.
3. **Why are so many reconstructions obtained?**
   This allows for improved pathology detection. Individual institutions may modify the reconstructions created per preference.

Intracranial Perfusion

1. **Can I modify the radiation dose?**
   The FDA has strict regulations regarding dose with perfusion imaging, and therefore, it is not recommended. Future updates to these protocols may utilize even lower dose parameters.
2. **Why is VolumeShuttle mode used?**
   This increases the area of brain that can be covered.

Axial vs. Helical Pediatric Head

1. **In pediatric protocols for the head, does the University of Wisconsin-Madison use Manual mA or Automatic Exposure Control? If Automatic Exposure Control, is the max mA listed in the protocols too high for a 3-6 year old compared to that listed for a 0-3 year old?**
   The University of Wisconsin-Madison uses Smart mA for all scans performed with helical scanning. In the unusual circumstance that Manual mA is used, the scan parameters are selected to give a comparable dose and image quality as compared to the helical scanning. With helical scanning, the Noise Index is slightly higher with the 0-3 year old protocol compared with the 3-6 year old protocol, but the image quality is similar since the 0-3 year old protocol is performed using a lower kV (better contrast). In protocols that use Manual mA, the mA settings are adjusted to give comparable image quality with a lower kV, reducing dose and increasing image contrast for the 0-3 year old protocol compared to the 3-6 year old protocol.

Pediatric CT Protocols

1. **Why are there only five different size-based protocols from the University of Wisconsin-Madison whereas GE has nine?**
   GE has set up nine separate protocols based on the Broselow color-based system. This system is predominantly used for the purposes of emergent medication dosing and equipment selection such as catheter and endotracheal tube size during pediatric resuscitation. There is not enough difference between each of these nine categories in terms of scan parameters and dose to warrant this many gradations. University of Wisconsin-Madison uses AP + lateral measurements to place the pediatric patients into 5 categories, correlating with approximate ages of newborn (Broselow pink); 6 months-2.5 years (Broselow red and

purple); 3-7 years (Broselow yellow and white); 8-12 years (Broselow blue and orange); and 13-18 years (Broselow green and black).

2. **The University of Wisconsin-Madison pediatric protocols have doses that are actually higher than what our institution has been using lately. What is the rationale behind the pediatric parameters?**
   We at the University of Wisconsin-Madison applaud your dose reduction in pediatric imaging. As these protocols are being introduced they are going to a wide spectrum of imaging centers, some of which have not yet reduced pediatric CT dose. In order to provide imaging quality to the unaccustomed eye of a radiology group scanning at a higher dose, we have provided two different sets of pediatric protocols. One set contains the relatively low dose protocols that we use at the University of Wisconsin-Madison. A second set contains higher image quality, higher dose protocols for those more comfortable with this image quality level. If you would like to continue using your existing pediatric protocols, we encourage you to confirm that they are at an appropriately low dose with adequate image quality, across the spectrum of pediatric sizes.
3. **Why are some pediatric images so noisy?**
   It is mandatory to keep the dose low for pediatric patients. However, image quality should be interpretable. If you are intermittently having poor quality pediatric studies, we encourage you to reevaluate patient centering in the gantry. In our experience, it is the most frequent cause of poor image quality. Proper centering is critical to image quality in small patients.
4. **Why is the protocol different for outpatients versus ER patients in the evaluation of appendicitis?**
   Outpatients are generally not as sick. They are less likely to have appendicitis, but may be more likely to have another reason for their abdominal pain, thus we should image the entire abdomen and pelvis rather than decrease the FOV to include only the lower abdomen and pelvis where the appendix lives.
5. **Why is there no protocol for pediatric patients with bowel obstruction?**
   The most common cause of bowel obstruction in a child is intussusception, for which ultrasound is the appropriate test to perform. Unlike adults, most children have not had surgery and therefore do not have adhesions causing obstruction. If a child has had prior surgery, then the routine abdomen and pelvis protocol should be used.
6. **Why do pediatric CTA's not include a non-contrast enhanced set of images?**
   These most often do not provide additional information in children and only add to the total radiation dose.
7. **When evaluating the chest for metastatic disease in patients with osteosarcoma, why do you not give contrast?**
   Osteosarcoma metastases often calcify, making them easy to detect. Unlike other types of tumors, osteosarcoma does not metastasize to lymph nodes, so contrast is not necessary to delineate normal mediastinal structures from abnormal lymph nodes.
8. **When evaluating for infection and/or empyema in a child, why is contrast given?**
   Contrast is helpful in evaluation of pleural thickening and septations. Additionally, the presence or absence of enhancement in the involved lung is helpful in determining the presence of necrotizing pneumonia.
9. **Why is there a separate protocol for non-contrast chest CT in evaluation of pectus excavatum?**
   A routine non-contrast CT of the chest does not include the entire rib cage. Additionally, since the concern is only about the osseous structures, dose can be reduced even farther.
10. **Why is a routine chest CT with contrast performed rather than a CTA when evaluating patients with clinical suspicion of a vascular ring?**
    Vascular rings can involve the aortic arch or pulmonary veins, so both need to be opacified during image acquisition. Performing a CTA would only opacify the aorta and branch vessels. Additional scans might be required to evaluate for pulmonary sling, adding to the total radiation dose.
11. **Why is a 0.5xx:1 pitch used on the 13-18 age group?**
    This allows sufficient mA range with the fastest rotation time. The 0.5xx:1 pitch provides the best helical image quality and also a lower dose than the 0.9xx:1 pitch at a given image quality.

<u>Physics/Technical Comments on Scan & Reconstruction Parameters</u>

1. **Is there a reason why Dose Reduction Guidance is not used in the protocols?**
   1. When the Dose Reduction Guidance is used, there is a limit imposed on the min mA allowed, which poses a problem for our protocols.
   2. Dose Reduction Guidance is not available on the Revolution Frontier™, Revolution™ HD, and Discovery™ Series scanners, and we wished to be consistent in the protocols across GE CT platforms.
   3. Our radiologists have approved the use of a certain percent ASiR for the different exams and do not want to have it altered by the Dose Reduction Guidance.
2. **Why do you use Smart mA instead of Auto mA or Manual mA?**
   The UW protocols always rely on the Smart mA function when the Auto mA is turned on. We do not see any situation in which it would be advantageous to turn the Smart mA function off. Smart mA includes both mA modulation as the patient attenuation changes along the length of the patient and also mA modulation as the tube rotates around the patient. This is always advantageous and is essential in areas of the anatomy where the patient size / attenuation varies dramatically with direction, such as the shoulders and pelvis. It is even useful in scanning the head, since the AP and lateral dimensions of the head are not the same.

3. **Why use Auto/Smart mA?**
Except for scanning using the axial mode, for all standard scanning helical mode is used with Smart mA. This includes the protocols for the orbit, sinus, facial bones and temporal bones. Using Smart mA simply gives consistent image quality at the lowest dose and has not produced any image quality problems. Also, no situation has been identified in which it would be advantageous to turn the Smart mA function off when using Auto mA.
4. **Why is a 0.5xx:1 pitch used for most of the UW protocols?**
University of Wisconsin-Madison uses the 0.5xx:1 pitch for several reasons: (1) it provides optimized helical reconstructions, compared to higher pitches; and (2) for the same image noise, it produces a 20% lower dose than does the 0.9 pitch (which is why that pitch is avoided). University of Wisconsin-Madison uses 0.4s or 0.5s rotation times when possible to reduce scan times with the lower pitch. When that is not sufficient, as in PE studies, the pitch is increased to 1.375. The use of a lower pitch is possible with the GE 64-slice scanners because of the wider beam collimation of 40mm compared to 20mm, which doubles the table speed for any particular pitch and rotation time. This also allows the scanning of larger patients without hitting max mA and degrading image quality.
5. **Why do you use a Helical Scan Type instead of Axial for nearly all your protocols?**
The use of Helical scanning has several advantages over Axial. Faster area coverage, with less chance of patient motion during the scan, is an obvious advantage. Helical scanning decreases the effects of cone-beam artifacts with multi-slice scanning. One great advantage of helical scanning is the ability to prescribe Recon Intervals at less than the slice thickness. The best z-resolution, along with the fullest display of the clinical information obtained in the scan, is obtained at intervals of one-half of the actual slice thickness. In addition, the source images that are used to create any reformatted images must be thin slices (1.25mm for soft tissue and 0.625mm for bone) with recon intervals of one-half the slice thickness for optimal image quality. This is an advantage of helical scanning that is often not utilized.
6. **Why do you consistently use a Recon Interval that is smaller than the slice thickness? Doesn't a Recon Interval equal to the slice thickness provide all the available clinical information?**
The University of Wisconsin-Madison uses a reconstruction Interval that is half of the actual slice thickness because using a Recon Interval equal to the slice thickness does not in fact provide all the available clinical information from the patient scan. Both mathematics and clinical experience show that the full display of the clinical information obtained in the scan is obtained by using intervals of one-half of the actual slice thickness. You DO NOT want to waste any information obtained from the radiation exposure of a patient.
7. **Why do you not use the Pediatric Scan Field of View (SFOV) for any of your pediatric protocols?**
The Pediatric Head and Body protocols substantially limit the maximum allowed mA that can be used in manual or Auto/ Smart mA modes. At 140, 120, 100, and 80 kV, the maximum mA is limited to 210, 250, 300, and 375, respectively. The rationale is to limit the dose to pediatric patients. However, the actual result is to limit the use of faster rotation times or higher pitches that will allow a faster exam with less motion artifact. Thus we avoid the use of the pediatric SFOV's for this reason. We would prefer to obtain a given patient dose and image quality with a higher mA and shorter rotation time.
8. **Why are some of my bone images too blurry, especially those of the shoulders?**
See same question under "MSK CT Protocols".
9. **Why do you tend to use a fast rotation time with a low pitch? Would not a pitch of 0.9xx:1 and a rotation time of 1.0 s be equivalent to a pitch of 0.5xx:1 and a rotation time of 0.5 sec?**
While it is true that a pitch of 0.9xx:1 and a rotation time of 1.0 s would produce an exam time essentially equal to a pitch of 0.5xx:1 and a rotation time of 0.5 s, and would also require about the same mA values, it would NOT result in the same image quality. The 0.5xx:1 pitch will have less helical artifact than the 0.9xx:1 pitch and the 0.5 s rotation time will have less motion artifact than the 1.0 s rotation time. Additionally, the 0.5xx:1 pitch is about 20% more dose efficient in the GE 64 slice scanners than the 0.9xx:1 pitch. For these reasons a pitch of 0.5xx:1 and a rotation time of 0.5 sec is much preferable to a pitch of 0.9xx:1 and a rotation time of 1.0 s. With scanners that have this option, we even prefer to use the shortest rotation time of 0.4 s when possible.
For obese patients, the use of a 0.5xx:1 pitch allows an appropriate technique to be used to obtain a satisfactorily diagnostic image. If needed, the rotation time can be increased up to 1.0 s for these patients.
10. **When is a pitch higher than 0.5xx:1 used and why is the 1.375 pitch then generally used instead of a pitch of 0.9xx.1?**
University of Wisconsin-Madison principally uses the 0.5xx:1 pitch for several reasons: (1) it provides optimized helical reconstructions, compared to higher pitches; and (2) for the same image noise, it produces a 20% lower dose than does the 0.9xx.1 pitch (which is why that pitch is avoided). University of Wisconsin-Madison uses 0.4s or 0.5s rotation times when possible to reduce scan times with the lower pitch. When that is not sufficient, as in PE studies and others requiring a very short exam time, the pitch is increased to 1.375. This is often preferred to the 0.9xx:1 pitch because of better dose efficiency at the 1.375 pitch. The use of a lower pitch is possible with the GE 64-slice scanners because of the wider beam collimation of 40mm compared to 20mm, which doubles the table speed for any particular pitch and rotation time. This also allows the scanning of larger patients without hitting max mA and degrading image quality.
11. **What is your strategy for selection of kV?**
The selection of optimal kV is dependent on the patient size and the importance of the visualization of iodine contrast in the images. As an example, for abdominal non-contrast scans the kV will vary from 80 for the small pediatric patient to 140 kV for a

very obese patient. If the visualization of iodine contrast is important in the imaging, such as for angiography, the same range of patient size will have a kV variation of 80 to 120 kV. 140 kV is never optimal for visualizing iodine contrast, even in the largest patients.

12. **Why do you consistently use a “Plus” Recon Option for Helical Scanning instead of “Full”?**

    The “Plus” Recon Option provides better image quality than “Full” by reducing Helical artifacts in the images. It also reduces image noise by about 10% by increasing the actual slice thickness by about 20% from the nominal slice thickness. If a specific noise index is used, then a change from “Full” to “Plus” will reduce patient dose by about 20%. The following table provides approximate changes in actual slice thickness in ”Plus” mode:

Normal Slice Thickness	Actual Slice Thickness using "Plus" Recon Option	Optimal Recon Interval
5.0mm	**6.0mm**	**3.0mm**
3.75mm	**4.5mm**	**2.25mm**
2.5mm	**3.0mm**	**1.5mm**
1.25mm	**1.5mm**	**0.625mm**
0.625mm	**0.8mm**	**0.312mm**

The 20% increase in slice thickness generally has little negative clinical effect compared to the advantages of using the “Plus” option. In fact, it is possible to improve z-resolution even with the greater slice thickness by using a reconstruction interval that is one-half of the actual slice thickness, as shown in the table above. The reconstruction interval for the 1.25 and 0.625 mm nominal slice thickness remains at half of the nominal slice thickness. This allows the use of “IQ Enhance” to further improve image quality by reducing helical artifacts in thin slices.