Chapter 4

Imaging Pediatric and Small Patients

Introduction

GE Healthcare strongly suggests reducing radiation dose to as low as reasonably achievable (ALARA) in all patients, especially pediatric and small patients, whenever it is determined that a CT scan is necessary. CT is an extremely valuable tool for diagnosing injury and disease, but its use is not without risk. This chapter discusses the importance of minimizing the radiation dose in small patients and children to as low as reasonably achievable (ALARA).

What Do I Need to Know About...

This section presents the concepts necessary to understand Pediatric CT. The concepts you need to understand are:

- Radiation Exposure Sensitivity
- Dose Reporting Considerations
- Suggestions for Minimizing Unnecessary Dose
  - Perform Only Necessary CT Examinations
  - Scan Only the Organ or Anatomical Region Indicated
  - Properly Center All Patients in the Gantry
  - Lower mA Settings for Chest and Bone Imaging
  - Scan signal-to-noise
  - Consider Using In-plane Bismuth Shields
  - Use Pediatric Positioning Accessories
  - Make a Kid Friendly Environment
  - Minimize Multi-phase Contrast CT Examinations
- Guidelines for Adjusting Individual Exposure Parameters by Patient
  - Adjust Parameters by Size, Age, Weight, Height, & Indications
  - Lower kVp
  - AutomA
  - Increase Pitch
  - Use Small SFOV Filters
- Optimize Pediatric Protocols for your Facility
- Pediatric Protocols
- Color Coding for Kids Protocol Selection
- Color Code Table
- Protocol Category Window

Radiation Exposure Sensitivity

Radiation exposure is a concern in all people of all ages, however, pediatrics are more sensitive to radiation exposure. Radiation risk is higher in young as they have more rapidly dividing cells than adults. The younger the patient, the more sensitive they are.

Dose Reporting Considerations

It is widely understood and accepted that adult techniques should never be applied to small patients or pediatrics since smaller objects have higher dose at the same technique. Figure 4-1 illustrates the sharp increases in relative dose as the part scanned gets smaller in size using the same technique.

Another consideration about dose is since it is not possible to characterize dose given to individual patients, the CT dose indices are provided to help make relative comparisons. These dose index values can be used to compare CT systems and to help select appropriate operating conditions for scanning. However, it is important to recognize that the dose reported by these indices is inversely proportional to phantom size (see Figure 4-1). This means that for the same scan technique, smaller phantoms (patients) will produce a higher absorbed dose than larger phantom (patients). Therefore, it is critical to remember that the body filter uses the 32 cm CTDI phantom and the head filter uses the 16 cm CTDI phantom for dose reporting purposes (CTDIvol displayed in the Dose Information area on the ViewEdit screen). Table 4-1 indicates the phantom size used for calculating dose for each Scan Field-Of-View (SFOV).

In other words, when looking at the actual absorbed dose to the patient, understand that the dose may be higher than reported if the part scanned is smaller than the phantom tested. Keep this in mind when adjusting scan parameters to fit patients who are smaller than the phantoms tested.

Figure 4-1 Relationship between dose and phantom size for head and body filters at 120kV. Similar curves are obtained for the 80, 100, and 140 kVs.

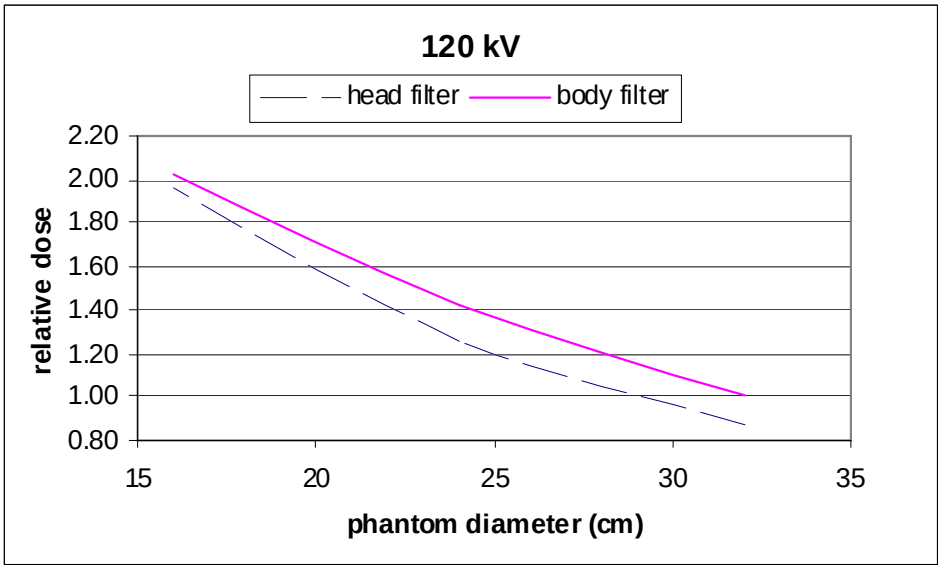


Table 4-1 CTDI phantom used dose report based on SFOV type

SFOV type	CTDI phantom
Ped Head	16 cm Phantom
Ped Body	
Small Head	
Head	
Small Body	32 cm Phantom
Medium Body	
Large Body	
Cardiac Small	
Cardiac Medium	
Cardiac Large	

Suggestions for Minimizing Unnecessary Dose

Everyone shares the responsibility of minimizing CT radiation dose. There are several steps that can be taken to reduce the amount of radiation that pediatrics and small patients receive from CT examinations.

- Perform Only Necessary CT Examinations
- Scan Only the Organ or Anatomical Region Indicated
- Minimize Multi-phase Contrast CT Examinations
- Properly Center All Patients in the Gantry
- Lower mA Settings for Chest and Bone Imaging
- Scan signal-to-noise
- Consider Using In-plane Bismuth Shields

Perform Only Necessary CT Examinations

Is CT the most appropriate study? This important communication between the patient's physician and the radiologist is essential in determining the need for the CT examination. The indications and the appropriate technique to be used should be reviewed by the radiologist prior to every scan including the patient's number of previous scans, reasons for the scan, and consideration of other effective lower dose modalities. In all circumstances, the expected benefits of the scan must always exceed the overall risk.

Scan Only the Organ or Anatomical Region Indicated

Scan coverage should be limited to cover only the organ or anatomical region of the body indicated to avoid unnecessary exposure.

Minimize Multi-phase Contrast CT Examinations

Scan only one series if possible. CT studies with and without contrast material are not always needed. Multiphase imaging may double or triple the dose and may not add diagnostic information to the study. If multi-phase studies are needed, use a lower dose techniques for the non-contrast series compared to the contrast series and limit the scan only to the organ or anatomical region indicated.

Properly Center All Patients in the Gantry

Doing so will allow the bow tie filters to deliver dose where it is needed and filter more where it's not. This is especially important using automatic exposure control techniques such as AutomA and SmartmA to further reduce unnecessary radiation exposure. Patients not properly centered may be under or over exposed to radiation if the table height is set too high or too low.

Lower mA Settings for Chest and Bone Imaging

Consideration should be given to lower mA setting and higher Noise Indexes if AutomA is used for musculoskeletal and chest/lung imaging. Higher resolution/dose imaging is typically unnecessary for these types of studies or those studies where there is high inherent contrast between the structures being imaged.

Scan signal-to-noise

Limit the highest quality images requiring the highest radiation dose to very specific indications such as angiography or visualizing small subtle lesions. Studies with higher noise may be just as diagnostic and require lower dose.

Consider Using In-plane Bismuth Shields

Recent studies have shown dose reductions to sensitive organs, such as breast tissue in females, the thyroid, and eyes without significantly affecting image quality. If used with AutomA, they should be put in place after the scout scans are acquired to reduce technique overcompensation.

Use Pediatric Positioning Accessories

If needed, papoose boards and neonatal immobilizers may be useful with certain patients. These accessories are sometimes helpful in both securing and keeping the patient still, resulting in less repeat exams and dose due to patient motion.

Make a Kid Friendly Environment

Pictures of animals on the wall or ceiling, stuffed animals, and games are all effective ways to help pediatric or small patients feel less scared. Depending on their age, explain the procedure so they know what to expect when they enter the scan room. This will aid in patient cooperation and potentially less repeat studies and dose due to patient motion.

Guidelines for Adjusting Individual Exposure Parameters by Patient

Adjust Parameters by Size, Age, Weight, Height, & Indications

The single most important thing you can do is to always use pediatric protocols based on the age, weight, height, and indications to avoid over exposure**.** Recommended pediatric color coded protocols are installed on the system and are arranged in colors according to height and weight for easy selection. These protocols should be considered as a baseline and we strongly encourage you to work with your radiologist and medical physicist to determine the lowest possible dose at the image quality desired. Also consider the diameter of the part being scanned as a final determination before scanning. For instance, the part may be smaller or larger than what is indicated by the weight of the patient.

Lower kVp

Consider decreasing the kilovoltage to 80 or 100kVp for smaller patients. Significant decreases in dose can be achieved with lower kVp selections, but decreases in kVp should not be done without increasing the mA to maintain noise levels and contrast to noise ratios. Lower kV selections also increase HU values so the window width for viewing images will need to be increased to maintain a similar appearance. Since lower kVp selections lower x-ray penetration, it is important to not use low kV selections on too large of a patient, which can potentially result in compromised image quality. Work with your radiologist and medical physicist to establish low kV protocols and patient size limits. Table 4-2 and Table 4-4 can be used as guide for making adjustments to mAs for changes in kV in a protocol.

Table 4-2 kV and mAs Adjustment Factors

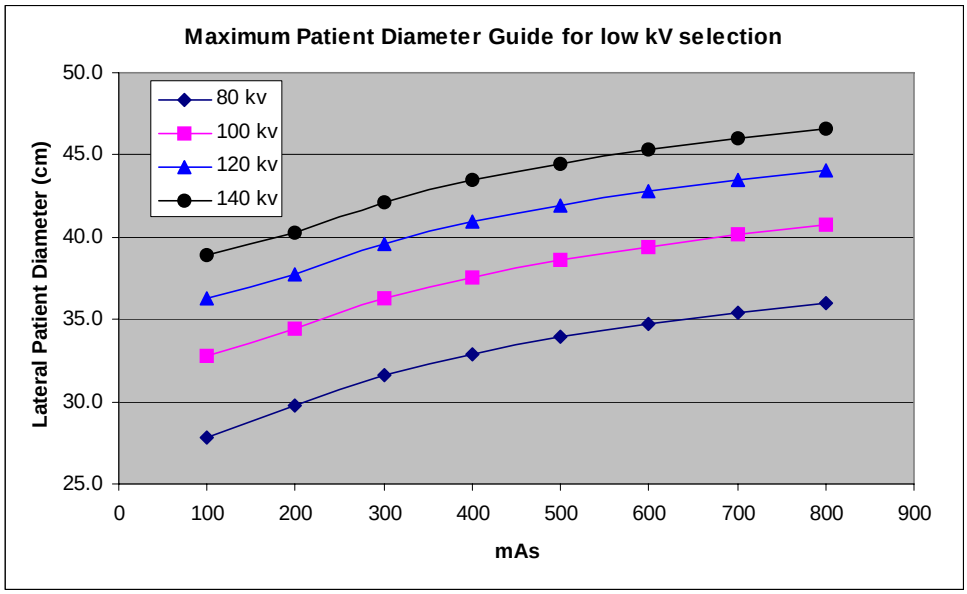
KV Adjustment Factor				
kV	80	100	120	140
Factor	0.3	0.6	1.0	1.4
mAs ADJUSTMENT FACTOR = Rx mA * Rx single rotation time in seconds/ 260				

NOTE: The kV and mA adjustment factors are estimated using a $CTDI_{100}$ dose.

For example, keeping everything constant at a technique of 120kv at 150mA you would get:

- 100kV at 190mA
- 80kV at 250mA
- 140kV at 95mA

Figure 4-2



To assure sufficient x-ray penetration, this chart is intended as a relative guide to the maximum patient diameter that can be scanned based on a kV and mAs selection. It does not indicate, a recommended technique factor (that is generally higher) since the technique factor also depends on the image quality needed for the diagnostic task.

AutomA

If using AutomA, **proper patient centering is critical**. Double check and verify the table height is centered to the patient. Raise or lower the table as needed before taking the scouts. After the scouts are taken and prescription is done, verify the **mA table** calculations before confirming the scan. Make sure **minimum mA** and **maximum mA** values are set appropriately. See section on **AutomA** for more detail.

Increase Pitch

Increasing pitch will decrease the amount of radiation needed to cover the region indicated, usually without compromising the diagnostic quality of the scan. Increasing pitch from 1.0 to 1.375:1 decreases dose by a factor of about 27%.

Table 4-3 Helical Travel and Scan Mode Adjustment Factors

Acquisition Mode Parameters for $CTDI_{100}$ and $CTDI_w$										
	Helical mm/Rotation per Pitch and Acquisition Mode			Axial and Cine Slice Thickness						
	(mm)			(mm)						
Acq.	**~0.5:1**	**~0.9:1**	**1.375:1**	**64i**	**32i**	**16i**	**8i**	**4i**	**2i**	**1i**
64 X 0.625	20.62	39.37	55.00	*0.625	*1.25	2.50	5.00	N/A	N/A	N/A
32 X 0.625	10.62	19.37	27.50	N/A	0.625	1.25	2.5	5	N/A	N/A
16 X 0.625	N/A	N/A	N/A	N/A	N/A	0.625	1.25	2.50	5.00	N/A
8 X 0.625	N/A	N/A	N/A	N/A	N/A	N/A	0.625	1.25	2.50	5.00
4 X 0.625	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.25	2.50
2 X 0.625	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.25

NOTE: *only avaible in Retro Recon

Use Small SFOV Filters

The smallest SFOV should be used whenever possible depending on the exam and size of the patient. Matching the appropriate SFOV bowtie filter to the size of the patient will ensure dose delivered where it is needed, and filtered where not needed.

Small SFOV Supports DFOV's up to 32 cm in diameter.

- **Ped Head** SFOV supports DFOV's up to 32 cm in diameter and uses IBO processing to correct for beam hardening effects. Ped Head is a field of view that is particularly useful for infants 18 months or less in age.
- **Small Head** SFOV should be used for patients from 1.5 years old to 10 years old.
- **Ped Body** SFOV supports DFOV's up to 32 cm in diameter.

Both the Ped Body and Ped Head SFOV's are limited to 45kW. This limits the maximum mA possible to 250 at 120kVp.

Optimize Pediatric Protocols for your Facility

Work with your team of radiologists, medical physicists, and CT technologists to evaluate techniques that may reduce radiation dose and still provide adequate diagnostic information. In addition to the recommended protocols installed on your system and suggestions in this guide, these websites offer excellent sources of additional information on how to optimize scanning protocols:

- **American College of Radiology** (ACR): http://www.acr.org/
- **Society of Pediatric Radiology** (SPR): http://www.pedrad.org/
- **National Cancer Institute** (NCI): http://www.nci.nih.gov/aboutnci
- **Image Gently**: http://www.imagegently.com/
- **FDA website**: http://www.fda.gov/

Pediatric Protocols

The Pediatric protocol area was designed to help facilitate protocol selection for pediatric patients by providing age based protocol areas for Head, Orbit and Miscellaneous and color coding system for Neck, Upper Extremity, Chest, Abdomen, Spine and Pelvis. It is highly recommended to place and select pediatric protocols from the pediatric selector based on age, height and weight.

By entering the pediatric patient's weight in the New Patient screen, the system will automatically select the appropriate color code area for the anatomical area selected.

After the patient information has been entered, click on the <**Pediatric**> button to bring up the anatomical selection area. The anatomical areas are indicated by text.

Figure 4-3 Pediatric Selector

Color Coding for Kids Protocol Selection

Based on the Broselow-Luten Pediatric System, the Color Coding for Kids system was developed to help the user select the correct pediatric CT protocol based on the height and weight. The system divides the protocols into nine color zones based on height and weight, and incrementally increases scan technique as the patient's size increases. This arrangement of protocols will assist the user in reducing the variations in pediatric protocol selection. If the patient weight is unavailable, a Broselow-Luten Tape can also be used to obtain the weight based on the length.

Once the anatomical area is selected, the rainbow bars (Figure 4-5) containing the Color Coding for Kids weight based selections appear. Select the color category based on the size of your patient, or verify that the correct color has been selected if a weight was entered.

The protocols in the selected color code are then displayed accordingly. If there is no weight-specific protocol associated with the selected anatomical area, the **Protocol Category** window appears (Figure 4-5). The default weight/color selector will show the patient weight entered in the patient information screen, or the last weight/color selection (if no patient information was entered).

NOTE: If you enter a patient weight on the patient information screen and select a color/weight that is not consistent with the entered information, an error message appears (Figure 4-4). You must acknowledge that you have chosen a protocol that does NOT match the patient size.

Selectors on the color/weight bar are labeled with the zone ranges for weight and length, with the word of the selected color and with the weight/color zone number as indicated in Color Code Table 4-4

NOTE: Weight-specific protocols are enforced for all anatomical areas except Head, Orbit, and Miscellaneous. Protocols in the Head and Orbit categories are usually defined based on patient age as opposed to patient weight/height.

Color Code Table

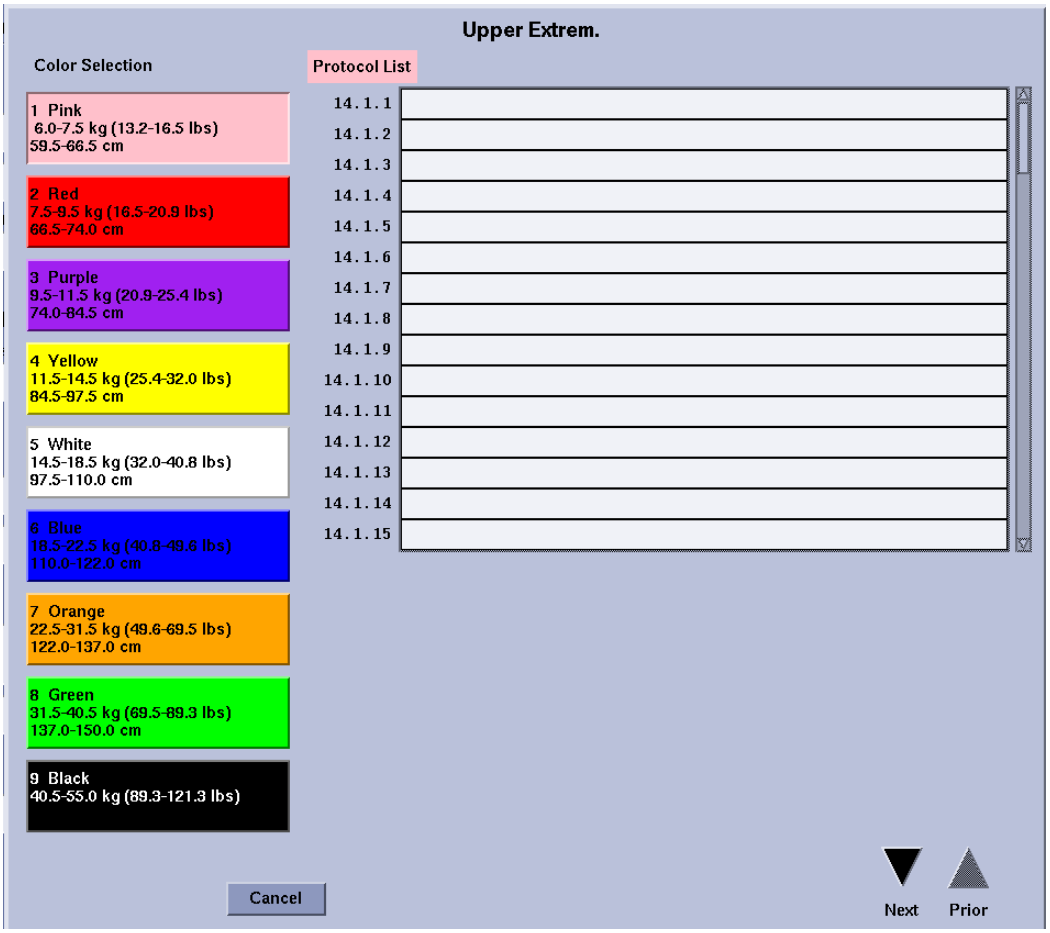
Table 4-4 Color Code Table

Zone Number	Zone Color	Zone Weight (kg)	Zone Weight (lb)	Zone Length (cm)
1	Pink	6 - 7.5	13.2 - 16.5	59.5 - 66.5
2	Red	7.5 - 9.5	16.5 - 20.9	66.5 - 74
3	Purple	9.5 -11.5	20.9 - 25.4	74 - 84.5
4	Yellow	11.5 - 14.5	25.4 - 32.0	84.5 - 97.5
5	White	14.5 - 18.5	32.0 - 40.8	97.5 - 110
6	Blue	18.5 - 22.5	40.8 - 49.6	110 - 122
7	Orange	22.5 - 31.5	49.6 - 69.5	122 - 137
8	Green	31.5 - 40.5	69.5 - 89.3	137 - 150
9	Black	40.5 - 55	89.3 - 121.3	--

Figure 4-4 Protocol Category Warning

Protocol Category Window

Figure 4-5 Protocol Category Window



Chapter 5
Getting Started

Introduction

The Getting Started chapter provides you with information about the hardware components and users conventions, as well as the shutdown and startup procedures of the system. The chapter is broken into three parts: hardware components, users conventions, and shutdown and startup. The purpose of this chapter is to provide the necessary background information about the system that may be important in understanding other topics presented in subsequent chapters.

This chapter explains the process of shutting down and starting up the system. It provides step-by-step instructions to learn how to:

- Shut Down and Start Up System
- Login and Logout
- Configure HIPPA (EA3) Properties
- Configure Local Users
  - Add a Local User
  - Change a User Password
  - Change a User Full Name
  - Remove a User
  - Add or Remove a User from a Group
  - Change User Roles
  - Locking / Unlocking a User
  - Force a User to Change Password on Next Login