CT PROTOCOL MANAGEMENT

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LEARNING OBJECTIVES

1. Learn strategies for development and implementation of a CT scan protocol management system.
2. Learn methods to maintain consistent scan instructions and scanner default scan parameters for multiple CT scanners.
3. Learn methods to efficiently distribute CT scan instructions to multiple CT scanners.

ABSTRACT

Most CT scanners allow storage of scan parameter settings for a multiple clinical exams. However, the stored protocols do not include other essential information, such as patient positioning and contrast media instructions. Consequently, more complete instructions must be available to the technologist at the scanner. This is problematic for CT practices that have more than a few scanners due to the logistics of maintaining multiple sets of instructions at different locations and keeping the instructions in parity when updates are necessary. This exhibit describes the methodology of maintaining a scan protocol collection for 18 CT scanners with 8 unique scanner models and over 100 unique scan protocols (including research protocols). Scan instructions are constructed in a consistent format, with emphasis on clarity and page-space efficiency. All protocol management is handled by a single team and protocol distribution is done electronically.

THE CHALLENGE

Our institution has 18 clinical CT scanners with 8 unique scanner models. The scanners are distributed across 8 areas in 4 buildings. We employ over 100 unique scan protocols, most which have been translated across all scanners models. All of the CT scanners allow for storage of scanner parameters settings such that the operator selects the exam and the scanner automatically uses the stored values. However, the stored information does not include all of the essential information for a successful exam, such as patient positioning, scan location, contrast media, filming, etc. Consequently, supplemental instructions are required for every unique scan protocol. In the past, these instructions were authored, printed, and distributed to each scanner by one of 8 lead technologists.

The process is summarized as follows:

1. One of approximately 60 radiologists requests a lead technologist to modify or create a protocol.
2. The lead locates the electronic version of the protocol (for protocol modifications) on a centralized server, makes the suggested changes, and saves the file.
3. The lead prints multiple copies of the file, places each copy in a clear plastic sleeve, and places it in a 3-ring binder at each scanner.

Complications from this process include the following:

1. Parity among all protocol books is difficult to maintain, resulting in potentially outdated scan instructions. The implication is that a scan may be performed differently depending on which scanner a patient is scheduled on, even if the scanners are identical technologies.
2. The turn-around time from request to distribution can be excessive.
3. The amount of technologist time required to maintain the protocol books is excessive. A survey of the lead technologists indicated that the equivalent of nearly a full-time lead technologist was dedicated to protocol management and upkeep.
4. Inconsistent file-naming and file locations became problematic over time. This is a result of having many individuals managing the files without file-naming conventions or directory structure guidelines. The collection of electronic files had grown to over 450 files—many of which were duplicate or outdated versions of protocols.
5. Formatting and page layout of the protocols were loosely consistent but began diverging as protocols for newer scanners were created. This increased the potential for errors.
6. The informational content of the protocols varied, with some protocols listing only a subset of the necessary information.

THE APPROACH

The Division of Computed Tomography formed a task group to address the issues associated with maintaining the CT scan protocol collection. The task group, with input from radiologists, CT technologists, physicists and administrators, systematically analyzed issues regarding scan protocols and categorized the process into four major components, as follows:

Initialization	**Content and Presentation**
File Management	**Distribution**

The primary criterion in establishing the new process was that patient care not be compromised. Additionally, the protocol instructions must be readily available to the technologist at the scanner console and must be clear, concise, and comprehensive.

THE SOLUTION

Sub-processes, corresponding to each major category, were addressed individually but in parallel and tested in a controlled environment, such as a single scanner or work area. Each process evolved through several iterations and feedback was solicited. The development of each process is discussed below.

Initialization. *The process by which a protocol change is requested.* Multiple requests per week from individual radiologists for protocol changes represented a significant time commitment from the lead technologists. With approval of CT leadership, a system was implemented in which a radiologist proponent must submit a proposal for a change or addition to a protocol to the appropriate division. Upon completion of an evaluation period, a final draft of the protocol is submitted for approval to the CT Operations Group, consisting of radiologists, a physicist, the CT director, and the technologist and nurse supervisors. Once approved, the protocol proceeds to "publication" and distribution. After implementation of this process, the number of requests protocol changes dropped significantly.

File Management. *Organization of electronic files.* The directory structure consists of a single folder corresponding to each Division in the Department of Radiology, as well as a separate folder for research protocols:

Abdominal	Research
Cardiac	Thoracic
Musculoskeletal	Vascular
Neuro	

Each protocol is assigned to a division in the initialization process thereby determining the directory of the electronic file. The electronic file is named according to the following convention:

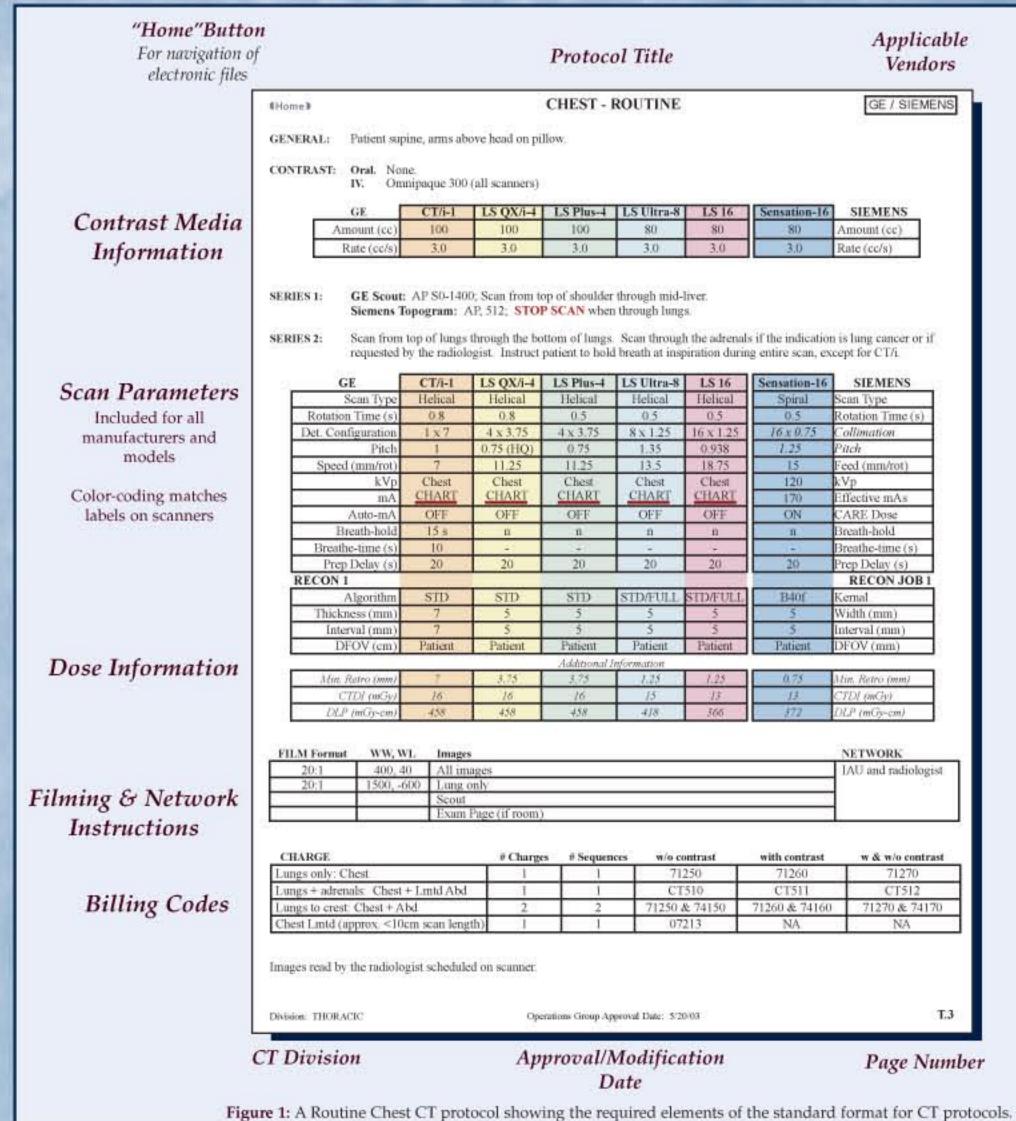|	Clinical Protocol	Research Protocol
Generic	Body Part - Exam	IRB #.Description
Example **Protocol Title**	Chest - Routine	IRB 689-02.NLST Study
File Name	Chest - Routine.doc	IRB 689-02.NLST Study.doc

Additionally, folders for supplemental materials, such as protocol drafts, technique charts, and archived protocols were created.

Content and Presentation. *Protocol information and structure.* The content of each protocol must include all essential information for performing a successful CT scan. In addition to the scan parameters, information regarding patient positioning and preparatory information, contrast agent instructions (including delays and tracking), scheduling considerations, scan instructions, filming and networking/archiving instructions, billing information, and the radiologist responsible for reading the images are listed. Additional information may be required for special examinations and research studies. A primary goal in the development of this component of the protocol management system was to provide all information in a clear, consistent, and concise manner. The format that evolved is shown in the sample Routine Chest protocol **(Figure 1)**.

Distribution. *Protocol availability to the technologist.* The single most important criterion in scan protocol distribution is that the protocol must be available *at the scanner*. This has previously been achieved by placing the printed protocols in a three-ring binder located in the scan room. There were many disadvantages to maintaining the protocol collection in three-ring binders. Consequently, electronic distribution of the protocols was adopted.

General Electric scanners are well suited for transfer and display of Adobe PDF files. The scanners have Adobe Acrobat Reader pre-installed, allow for file transfer via standard FTP (File Transfer Protocol), and have the capability to execute custom computer code by means of a user-changeable graphic element in the interface. The following steps were required to implement viewing of the protocols directly on a GE scanner monitor.

1. The protocol files were converted to the PDF format from MS Word using Adobe Acrobat. A navigation PDF file was also created. The navigation file consists of a "home" page, showing a list of CT Divisions, and Division pages, showing the list of protocols for each division **(Figure 2 & 3)**. Navigation and display of the protocols is achieved through hyperlinked text. A home button was also added in the upper left-hand corner of each protocol page. When applicable, additional links to supplemental information, such as technique charts, were added to the protocol file.
2. On the GE scanners, a "Protocols" button was created in the ToolChest window of the scanner interface **(Figure 4)**. The function of this button is to open the PDF navigation file. Once the navigation file is open, all navigation within the protocol file collection is done entirely through the Acrobat Reader application (via hyperlinks, "back" and "forward" buttons, etc.).
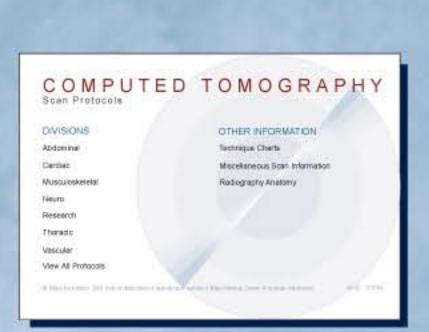3. The entire protocol collection was transferred via FTP into a user directory of the scanner.

Elements of the Protocol Page

All protocols are formatted in the same manner, with each component in the same order and with consistent phrasing. These consistencies reduce the need for searching the page for relevant information and also reduce interpretation errors. An attempt is made to constrain the protocol to a single page whenever possible.

The scan parameter grid includes scan parameters for all relevant scanner models for each scan protocol. This reduces the number of electronic files and avoids the need for duplicate instructions across multiple protocol files. Note that in some cases the instructions for scanners of different manufacturers deviate sufficiently such that the protocol must be separated into multiple manufacturer-specific sections. The scanner model columns are color-coded to match printed labels placed on the monitor at each scanner console. Each color represents only a single scanner model. The terminology for the parameter labels in the grid correspond to those used by the scanner manufacturer. Some items, such as the CTDI and DLP, also appear in the grid to assist physicists and radiologists in comparing scanner models' dose efficiency. All items that do not have an associated button or entry field on the scanner are typed in italics.

Grids are also used to display the filming and networking instructions, contrast information (when applicable), prep-delay instructions, and charge codes. Several possible relevant charge codes are listed for the convenience of the technologist.

Items displayed with a red underline are hyperlinks to other documents. The "home" button in the upper left-hand corner of every page is also hyperlink to a main navigation page. These items pertain only to electronic viewing and navigation of the protocol collection.

Research studies may also require other special considerations, such as phantom calibration scans, patient breathing instructions, etc. These items can be incorporated into the appropriate section of the protocol.

The protocols are authored using standard features in Microsoft Word 2003. To assure future compatibility, custom colors, non-standard fonts, and macros are not used.

Figure 1: A Routine Chest CT protocol showing the required elements of the standard format for CT protocols.

Figure 2: The "home" page for the scan protocol collection. The division titles are hyperlinks to each Division page.

Figure 3: The collection of protocols associated with the abdominal division. The protocol titles are hyperlinks to the protocol pages.

Figure 4: The "PROTOCOLS" button. The button launches the Adobe Acrobat application and opens the navigation pdf file, presenting the technologist with the home page.

Steps 2 and 3 require special access permissions to the scanner during the initial set-up and should only be performed by someone familiar with the scanner operating system. After the initial set-up, files can be transferred to the scanner routinely using only the user name, password, and IP address of the scanner.

Thorough testing of the scanner was performed to insure that the modifications and file transfer did not interfere with data acquisition, reconstruction, networking, etc. Transfer time for the entire protocol collection is approximately 1 minute per scanner.

Additionally, the protocols are available on our internal web site. The web site is updated in a manner similar to the scanner updates (i.e., via FTP). This assures that the protocols on the web site are identical to those on the scanner.

The capability to view protocols directly on the scanner's second monitor have been added to about half of the scanners at our institution, with plans to modify the remaining scanners over the next few months. By default, the protocols appear on the right-hand monitor of the dual-monitor GE systems. This can be problematic for protocols requiring image reformatting, which is performed on the right-hand monitor. Therefore, the ability to drag the protocol window from one monitor to the other is being explored.

Our institution also has several Siemens scanners, which use a single display. Since the protocols cannot be displayed on the monitor without interfering with the operator, implementation of the on-line protocols using a stand-alone dedicated personal computer and flat-panel display is underway.

The new management and distribution system has many advantages over the previous process. Nearly immediate updates are possible and parity of the protocol instructions among all scanners (and web site) is assured.