

GE Healthcare

DoseWatch

Protocol Management
in Computed Tomography



Introduction

The growth in utilization of Computed Tomography is based on its ability to extend the clinical capabilities of x-ray imaging. CT offers enhanced visualization of a wide range of anatomical sites and pathological conditions - achieved by harmonizing adjustable features detailed in the **Computed Tomography Examination Protocol**. The protocol consists of scanning parameters for a specific CT imaging sequence and takes into consideration many variables.

Protocol Management is the systematic review, implementation and verification of CT protocols within a facility's practice and is recognized by the Joint Commission, American College of Radiology (ACR) and American Association of Physicists in Medicine (AAPM) as an essential activity in ensuring patient safety and maintaining image quality.¹

Protocol settings have an important influence on image quality and patient radiation dose and are dependent on each other. Changes in one setting may require modification of other parameters to maintain image quality and patient radiation dose at appropriate levels. For example, increasing pitch will result in lower patient dose provided all other imaging parameters remain constant. Increasing pitch, however, may also affect image quality (i.e. limit spatial resolution and increase image noise.)

In CT imaging, there is no single correct imaging protocol. Different combinations of imaging parameters can result in obtaining an answer to a specific clinical question. The goal of protocol optimization is to realize opportunities for dose conservation while maintaining image quality at levels acceptable for clinical interpretation.²

Another goal of protocol management is to promote enterprise-wide consistency in image quality. Diagnostic Imaging facilities are performing large numbers of CT examinations on a daily basis. Protocol management provides an opportunity to address potential variations in image quality and patient radiation dose across multiple practices and equipment models.

The purpose of this paper is to introduce the reader to dose optimization efforts currently underway in the U.S. Key components of CT protocol management include:

- **Standardization**
- **Measurement**
- **Analysis**
- **Review**
- **Training**

1. Standardization

Radiologists employ a wide range of terminologies and standards to describe imaging protocols. An important step in CT protocol optimization is the need for **standardization** to organize and manage each protocol. In 2005, the Radiological Society of North America³ commenced work on a tool to unify radiology terms under one comprehensive lexicon - the **Radiology Lexicon - RadLex**[®]

RadLex allows for standardized indexing and retrieval of radiology information resources. One component of RadLex is the **RadLex Playbook**. The playbook is a comprehensive dictionary of radiology orderables and procedure step names. Each playbook entry includes:

1. A **unique identifier (RPID)** used in information systems to recognize the playbook name;
2. A **long version of the protocol name**, composed according to established playbook conventions;
3. A **short version of the protocol name**, used in DICOM header information; and
4. A **human-readable definition**.

For example, CT examinations of the abdomen and pelvis are valuable diagnostic tools. The protocol would appear in the following format:

1. Unique identifier

RPID1

2. Long version of the protocol name

CT ABDOMEN PELVIS LOWER EXTREMITY ANGIOGRAPHY WITHOUT THEN WITH IV CONTRAST

3. Short version of the protocol name

CT ABD PELVIS LE ANGIO WO & W IVCON

4. Human readable definition

A computed tomography ANGIOGRAPHY procedure focused on the ABDOMEN and PELVIS and LOWER EXTREMITY WITHOUT THEN WITH IV CONTRAST

RadLex also provides mapping capability for specific terms within the playbook (i.e. modality, body region, clinical indication.) The RSNA has developed a standard charge master, which matches exams to CPT codes and departmental charges - enhancing interoperability between radiology sites.

The American College of Radiology adopted the RadLex playbook in their **CT Dose Index Registry**.⁴ Standardized procedure names are essential to the development of national benchmarks.

The standardization of protocols afforded by the RadLex playbook offers many benefits:

- Clear and unambiguous protocol names enable more accurate ordering and scheduling;
- Improved interoperability, data sharing, and reporting to support emerging national initiatives (i.e. image and dose registries);

- The ability to standardize imaging acquisition protocols and dictation templates;
- The ability to map procedure names to ICD and CTP codes for more efficient and accurate coding and billing;
- Automatic generation of exam protocols based on community standards such as **Uniform Protocols for Imaging in Clinical Trials (UPICT)**; and
- Automated workflows of post processing keyed on the imaging procedure.

2. Measurement

The next step in CT protocol management is **Measurement**. There is a wealth of measurable parameters contained in CT protocols:

- Scanner Manufacturer/Model
- Scan Type
- Beam Collimation
- Detector Rows
- Pitch
- Speed
- Detector Configuration
- Slice Thickness
- Scan Field-of-View
- Tube Potential (kV)
- Tube Current (mA)
- Noise Index
- Image Reconstruction Technique
- Patient Positioning
- Contrast Media
- Patient Age
- Scan Range
- Rotation Time

The above parameters should all be measured in conjunction with protocol management and optimization.

3. Analysis

Analysis of measured data represents an important component in the protocol management process. Description of **mean** and **median** CTDI_{vol} for each protocol is a solid starting point. Dose estimate analysis should also be considered as a function of:

- Individual institution
- Specific scanner
- Patient age
- Patient BMI
- Responsible Physician
- Responsible Technologist
- Day of the week / Hour of the day

Another valuable statistical tool is a description of **standard deviation** within a specific CT protocol. A reduction in variation of dose within a given protocol is a reliable indicator of protocol optimization.

In addition to analyzing and documenting improvement within the enterprise, an organization may also facilitate optimization by **benchmarking** against accepted standards. **Diagnostic Reference Levels**⁵ supplement professional judgment and provide a simple tool for identifying opportunities for protocol optimization. Organizations may also choose to set reference levels as a percentage (i.e. 75%) of average dose values within a given protocol.

4. Review

The review and management of CT protocols is an institutions' ongoing mechanism of ensuring clinical examinations are performed in a manner achieving appropriate image quality at the lowest reasonable radiation dose. Protocol review also requires continuing education so a facility is aware of current good practices employed by other institutions.

The American Association of Physicists in Medicine⁶ recommends the establishment of a **CT Protocol and Management Review Team**. The team should include the following members:

- CT Radiologist
- Lead CT Technologist
- Qualified Medical Physicist

The review process must be consistent with federal, state and local regulations. In the absence of a regulatory standard, biannual protocol review is recommended as a minimum frequency.⁶ Certain **Clinically Significant Protocols** may require a minimum review cycle of one year (or more frequently if required by state and local regulations.) Clinically Significant Protocols include:

- Pediatric Head (1 year old)*
- Pediatric Abdomen (5 year old; ≈ 20 kg)*
- Adult Head
- Adult Abdomen (70 kg)
- High Resolution Chest

- Brain Perfusion*

*If performed at institution. Otherwise, consider inclusion of alternative, frequently used protocols.

The Conference of Radiation Control Program Directors⁷ recommends the team consider reviewing the following:

- Review CT default protocols to ensure accuracy and confirm the protocol is the one intended.
- Compare dose estimates to the values at installation and during the most recent review by a qualified medical physicist.
- Optimize the parameter settings for each protocol to ensure the $CTDI_{vol}$ is appropriate and the study will provide the required image quality.
- Determine whether the $CTDI_{vol}$ is appropriate or whether there is an opportunity to reduce the technique and lower the $CTDI_{vol}$.
- Record the techniques and establish guidelines for variability. The CT medical director should approve the variability range. Some organizations grant CT technologists privileges to adjust protocols provided they remain within the approved limits.
- Ensure protocols are password-protected to prohibit unauthorized alteration of protocols without approval of the CT Medical Director.
- Ensure the service provider does not change protocols without approval from the committee.
- Ensure dose estimates are forwarding to the interpreting radiologist for review.
- Conduct ongoing reviews of all protocols with specified subsets reviewed on a rotating schedule.
- Consider monthly review of protocols by the lead CT technologist with annual review by the qualified medical physicist.
- Review the control parameters of the Automatic Exposure Control (AEC) system. The committee should ensure AEC parameters are optimized with respect to the imaging requirements of each CT imaging protocol.
- Ensure interpreting physicians and technologists are properly educated on the definition of $CTDI_{vol}$. CT dose estimates should be available for each patient case and periodically reviewed by appropriate facility staff. Dose estimates should be recorded as part of the patients' medical record.
- Ensure technologists are monitoring available dose estimates for each patient to make certain the displayed values are within an acceptable range. Reviewable logs ensure consistency and enable an ongoing review process.
- Consider establishing threshold values to trigger investigations of dose estimates exceeding certain values.

5. Training

CT protocol management is a people process. Technology and process are important components of CT protocol management but people implement the program. Ongoing education is a key component of protocol management and should include:

- Ensure all physicians and technologists who prescribe diagnostic radiation or use diagnostic radiation equipment receive dosing information and are trained in the specific model of equipment being used⁸; and
- Each member of the CT Protocol Management and Review team should receive periodic vendor-specific education.

Conclusion

Establishing and managing CT Protocols is an essential component of dose optimization and the cornerstone of quality assurance, which has been specifically identified by the Joint Commission, ACR and AAPM as a required component for promoting patient safety. While CT Protocol Management is a complex activity, using the SMART formula outlined in this paper can help facilities address potential variations in image quality and patient radiation dose. Then by combining SMART processes with strong leadership and dose optimization technology, facilities can develop and implement an overall dose strategy that enables compliance, helps improve clinical and quality outcomes, and also enhances their reputations in their communities.

References

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