STANDARDS FOR DIAGNOSTIC IMAGING

COMPUTED TOMOGRAPHY

Standard for Performing and Interpreting Diagnostic CT Scans
(Modified from CAR standards)

I. Introduction

Although a well established and accepted imaging technique, CT (or Computerized Axial Tomography, sometimes abbreviated as CAT scan) has continued to evolve. As such, general principles of CT will be covered, with the general understanding that differing levels of hardware/software and of scope and style of practice may dictate minor variations in the way CT is carried out and interpreted.

The applications for CT technology include:
1. Head and Neck diagnosis.
2. Evaluation of spinal disorders.
3. Assessment of the thorax.
4. Abdominal and pelvic imaging studies.
5. Imaging of the musculoskeletal system.
6. Cardiac and vascular imaging
7. Guidance of interventional procedures.

Studies should be performed by qualified and knowledgeable physicians and/or technologists using appropriate equipment and technique.

Examinations should be supervised and interpreted by appropriately trained and credentialed medical imaging specialists. All imaging facilities should have policies and procedures to reasonably attempt to identify pregnant patients prior to the performance of any diagnostic examination involving ionizing radiation. If the patient is known to be pregnant, the potential radiation risks to the fetus and clinical benefits of the procedure should be considered before proceeding with the study. Due consideration to the radiation dose of all studies needs to be revisited both in terms of general policies, and on a case by case basis.

II. Qualifications of Personnel

An Imaging Facility at which CT is performed must have a Physician Director overseeing activities, as outlined in the general Bylaws governing Diagnostic Imaging Facilities. Physicians involved in the performance, supervision and interpretation of CT should be Diagnostic Radiologists, with recognized CT training and certification. Other appropriately skilled physicians (such as Emergency Room physicians) may be involved in supervision, such as for IV contrast administration, particularly in smaller facilities where a radiologist may not be available minute by minute. However, they would not be involved in the performance or interpretation of the study. As new CT techniques are developed additional clinical training, under supervision and with proper documentation, should be obtained before radiologists interpret or perform such examinations or procedures independently. Such additional training must meet with pertinent provincial/regional regulations.

III. Technologist Credentials Criteria

The CT Technologist must have Canadian Association Medical Radiation Technologist certification or be certified by an equivalent licensing body recognized by the CAMRT. Under the overall supervision of the Radiologist the Technologist will have the responsibility for patient comfort and safety, for examination preparation and performance, for image technical evaluation and quality, and applicable quality assurance. They should also ensure that patient privacy is protected as much as reasonably possible, within the limitations of the study or procedure being performed. The training of Technologists specifically engaged in CT shall meet with applicable and valid National and Provincial Specialty qualifications.

IV. Documentation

Adequate documentation of CT studies should include a secure, permanent record of the examination and its interpretation. Images should be appropriately labelled with the Imaging Facility name, examination date and time, patient identification, image orientation, scan parameters, dose of I.V. contrast administered, radiation dose and any other information which would be necessary or useful for interpretation of the study and for comparison with previous or subsequent examinations by any qualified Radiologist. Consultation/requisition history should be included with the patient's records, with requesting physician identified, and other salient details including technologist identification, patient LMP, shielding and allergy history, where appropriate. A scout image should be included for all examinations.

Images shall be retained on file either in electronic format or hard copies for a statutory time period consistent with clinical needs and relevant legal and local health care requirements as a permanent record. Digital recording of the case to be kept for longer time periods will be at the discretion of the Imaging Department. Each examination must result in a written report (documenting any significant abnormality and generated in a timely fashion) that should remain with the patient's imaging file. Copies must also be sent to the ordering practitioner and requested/authorized 'interested parties' such as the Family Physician. Any adverse outcomes should be documented. A method must be available by which image data can be sent out from the Imaging Facility. This would preferably be in a digital format (DICOM compatible) to allow further data manipulation, such as by direct electronic transfer via PACS, or on disc (such as CR-ROM or optical disc), though hardcopy laser film is still acceptable.

Adequate measures must be in place to allow only authorized access to patient data.

V. Equipment and Quality Control

Each imaging facility should have documented policies and procedures for monitoring and evaluating the effective management, safety, and operation of imaging equipment. The quality control program should be designed to minimize patient, personnel and public radiation risks and maximize the quality of the diagnostic information.

The guidelines of the Provincial Ministries for monitoring equipment performance must be followed. There should be review of the standards for equipment and radiation safety that are currently recognized by such national organizations as the Canadian College of Physicists in

Medicine and other appropriate federal and provincial regulatory bodies. Quality control checks should be in accord with manufacturer's specifications with periods at most averaging (and for either interval, no more than half as long again as): daily for calibration; and every twelve months for accuracy of distance measurements.

Noise/uniformity and scan width should be checked periodically - it is understood that there are no current standards in this regard, but a 3 month interval is recommended. Integrity checks of lead/tin gloves, aprons, drapes and similar shielding equipment must also occur every twelve months. Permanent records of preventative maintenance results must be kept.

VI. Equipment Specifications

PERFORMANCE STANDARDS

For patient imaging, the CT scanner should meet or exceed the following specifications/capabilities:

1. Scan times: minimum, not more than 2 second.
2. Slice thickness: minimum, not more than 1.25 mm.
3. Interscan delay (say, from aortic arch to Circle of Willis):
minimum, not more than 8 seconds (may be longer if intravascular contrast material is not used).
4. Limiting spatial resolution: must be measured to verify that it meets the unit manufacturer's specifications.

Contrast injector should be accurately calibrated and capable of injection rates up to 6 ml/second, co-ordinated with CT scan functioning.

Easily accessible and visible emergency stop controls (red button) should be present in the scanner room as well as at the operator's console.

Patient monitoring equipment and facilities for cardiopulmonary resuscitation including vital signs monitoring, support equipment, and an appropriately stocked emergency crash cart should be immediately available. Radiologists, technologists, and staff members should be able to assist with procedures, patient monitoring, and patient support. A written policy should be in place for dealing with emergency procedures such as cardiopulmonary arrest. Crash cart medications/supplies must be restocked before reaching expiry dates.

Less urgently required equipment should be available as needed (including, but not limited to dressings, iv fluids, mobile lighting for procedures, linens, sterile drapes, gloves and gowns, eye rinse equipment, biohazard disposal apparatus, interventional biopsy needles, drains, chest tube trays etc.)

The overall facility structure etc must meet general provincial Imaging Facility standards for safety including, but not limited to aspects of architectural integrity, radiation protection (scanner room walls/roof/floor and observation window thickness and make-up), ventilation, toxic/biohazardous materials and electrical protection.

VI. QUALITY IMPROVEMENT

Procedures should be systematically monitored and evaluated as part of the overall quality improvement program of the facility. Monitoring by periodic audit should include the evaluation of the accuracy of radiologic interpretations as well as technical aspects and the appropriateness of examinations. Incidence of complications and adverse events should be recorded and periodically reviewed in order to identify opportunities to improve patient care. The data should be collected in a manner which complies with statutory and regulatory peer review procedures in order to protect the confidentiality of the peer review data.

VIII. GENERAL COMMENTS ON PERFORMANCE OF CT EXAMINATIONS

Although many of the operations of a CT scanner are automated, a number of technical parameters remain operator dependent. As these can significantly affect the diagnostic value of a CT examination, it is necessary to acquire thorough familiarity with the following factors which must be specified for each examination:

1. Exposure factors

Optimization of image quality requires selection of appropriate exposure factors. These may vary considerably depending on the body part being imaged, patient size, body weight and age.

2. Collimation.

Diagnostic accuracy requires appropriate selection of slice thickness.
This choice will reflect clinical indications for the study as well as the, size location and orientation of structures to be imaged.

3. Slice spacing/overlap

Scans may be acquired either contiguously or non-contiguously. This choice depends on the clinical indications for the study as well as the potential for defining select regions of interest.

4. Field of view

The diameter of the field of view has a profound effect on image quality. Although it is generally sufficient to adjust and match the diameter of the field of view to the diameter of the body part to be imaged, narrow fields of view may be selected both prospectively or retrospectively, from raw image data (targeted reconstruction).

5. Window settings and filters

For viewing each image in a CT examination, physicians reading that study must select a portion of the CT number range to be displayed using electronic windows. Window width and levels must be selected to optimize visualization of pertinent structures as well as regions of interest, both on standard axial images and on reformatted ones.
Multiple window settings may be required. For example, a minimum of 2 window settings should be obtained in CT examinations of the head: one for visualizing brain parenchyma, and

one for assessing bone. In examinations of other body regions, additional settings (e.g. to emphasize lung and soft tissue structures) may be required as well.

Filters may also be employed to soften or enhance margins of certain structures (such as bone) to facilitate interpretation. In general, use of the multiple window settings should be documented on any hard copies, with filters applied where appropriate.

6. Algorithm of reconstruction
The computed software used to reconstruct the CT image can markedly affect image characteristics. Choice of the appropriate algorithm or algorithms correspondingly also affects diagnostic accuracy. A proper understanding of high contrast/standard resolution algorithms versus high spatial resolution or edge enhancing algorithms is necessary for optimal performance of CT imaging.

7. Reformats and Analysis software packages Reformats (commonly including multi-planar, volume rendering and Maximum Intensity Pixel) may be created and/or manipulated either by the technologist or interpreting physician (and even by others viewing CT data on newer PACS equipment). Familiarity with the associated parameters and variables is needed to optimize interpretation and to avoid pitfalls (e.g. a coronal MIP slab that is too thick may obscure an embolus). Other techniques may assist viewing and interpretation (such as virtual disarticulation, and rotational, zoomed, fly-by or combination 3-D 'movies' of constructs). Further levels of post-processing analysis software may be available (e.g. virtual colonoscopy, lung nodule or vessel stenosis analysis), but these are certainly not universally installed, often being purchased along with the scanner hardware; their use is desirable where a department or unit specializes in the type of imaging for which such analysis software was developed.

8. Patient factors
In general, patients are scanned in the supine position. However changes in patient position including the use of prone and/or decubitus positioning may be of value in select cases, e.g. for patient comfort, to optimize visibility of certain structures, to reduce artifact, for procedural access and to show influences of gravity (say, demonstrating a stone is free in the bladder rather than lodged in the ureteric meatus). Phase of respiration must also be taken into consideration during imaging of the neck, chest, abdomen and pelvis. In general, images should be obtained at the same phase of respiration during the imaging of a particular body region. Scans obtained in various phases of respiration may be of some additional value in select cases. Respiratory and cardiac gating is more recently being used, too.

9. Contrast media
The choice of whether or not to administer intravenous contrast will depend on the clinical indication for the study, as well as potential contraindications. A questionnaire or checklist of potential complicating factors must be used for patients needing iv contrast, in all but extremely emergent situations. Such a questionnaire may need to be administered by CT personnel via a family member, guardian or interpreter, as needed. Operators should be knowledgeable concerning various means of administering intravenous contrast including what

lines may or may not be used, various rates and volumes of administration, and be informed regarding the timing of various vascular phases. New iv's should only be established/inserted by trained and certified personnel. Bolus detection software has become standard of care in this province and operators need to be conversant with its use.

The decision to use (or not), and timing of oral contrast will also depend on clinical indications, though the potential for adverse events is less than with iv contrast. Operators should be knowledgeable regarding mix concentrations, volumes and rates of administration of oral contrast (and be able to convey explicit instructions to ward staff, where and when this function is transferred). Operators should also be familiar with less common contrast administration routes (e.g. rectum and bladder). Other specialized contrast uses are well established (e.g. CT arthrography or post-myelogram CT), while others will need to have protocols developed as they evolve (e.g. CT enteroclysis currently usually needs a perfusionist to monitor and adjust flow rates of negative contrast agents).

10. On-line monitoring

Ideally each study would be monitored directly by the interpreting physician. However realities of time constraints and potential limitations on physician availability necessitate that many scans be performed without immediate monitoring by the interpreting physician, or with remote monitoring (i.e. by tele-radiology). In such settings, optimization of the CT examination requires development of an appropriate CT protocol based on careful review of clinical indications as well as all prior available imaging studies. The supervising radiologist or a physician designate who has agreed to this role (e.g. covering ER physician) must be on site when intravenous contrast is used, in case of adverse reaction.

11. Scan Protocols

Protocols should be prepared by region of interest and medical indication for investigation. For each area of interest or indication they should specify the following:

a. The volume, rate and type of oral contrast material to be administered .
b. The volume and rate of administration of intravenous contrast material, and the timing relationship to initiating scanning, and delayed phases.
c. Slice thickness.
d. Slice interval.
e. Pitch.
f. Kilovoltage.
g. Reconstruction algorithm.
h. Rotation.
i. Milli-amperage and where available, Auto-milli-amperage.
j. Noise index.
k. Superior and inferior extent of the region of interest to be imaged, generally from a level just cephalad to the structure or region of interest to a level just caudad to the structure or region of interest.

These protocols should be reviewed and updated periodically. Default protocols have already been issued by the College, for CT in acute settings.

The Canadian Association of Radiologists CT guidelines offer specific comments about CT examinations for particular anatomic regions and indications, and these could be very useful in establishing a CT department's own protocols (potentially adopting them entirely or in part). They are necessarily general, recognizing that the performance of any examination should be tailored depending on the individual characteristics of each patient, the clinical problem and the available equipment, as well as the changing hardware, software and standards of practice over time.