



Standards for Chest Radiography

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The standards of the Canadian Association of Radiologists (CAR) are not rules, but are guidelines that attempt to define principles of practice that should generally produce radiological care. The physician and medical high-quality physicist may modify an existing standard as determined by the individual patient and available resources. Adherence to CAR standards will not assure a successful outcome in every situation. The standards should not be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed to obtaining the same results. The standards are not intended to establish a legal standard of care or conduct, and deviation from a standard does not, in and of itself, indicate or imply that such medical practice is below an acceptable level of care. The ultimate judgment regarding the propriety of any specific procedure or course of conduct must be made by the physician and medical physicist in light of all circumstances presented by the individual situation.

I. INTRODUCTION

Chest radiography with the use of screen film systems is the most frequently performed radiological study and also one of the most challenging. It remains one of the prime methods for investigation of diseases of the lungs and mediastinal structures and of the heart and the pulmonary circulation despite recent advances in other non invasive techniques. Since the discovery of x-rays more than a century ago advances in technology have yielded numerous improvements in thoracic imaging. The technical aspects of conventional chest radiographic examinations have been studied extensively and effects of various parameters on the quality of chest radiographs are part of the Canadian Association of Radiologists' Standards for Chest Radiography and the ACR Standards for Chest Radiography, but still insufficient attention is being directed towards technical factors concerned with improving the diagnostic content and diminishing patient exposure in chest radiography. This communication addresses issues involved in the production of the "optimal" chest radiographs by current standards.

All radiographic examinations should be done in accordance with the CAR Standards for General (Plain) Radiography.

II. INDICATIONS

The concept of heart and lung as a single cardiopulmonary system is encouraged in this context and rigid compartmentalization of the chest is to be avoided.

Chest radiography is performed to assess the presence and nature of respiratory and cardiac disease.

Indications for chest radiography include:

- Signs and symptoms related to the respiratory and cardiac system, such as chest pain, dyspnea or cough.
- Follow-up of patients with diagnosed respiratory or cardiac disease for the evaluation of improvement, resolution or progression.
- Monitoring of patients in intensive care units, patients with life supporting devices, and patients who have undergone cardiac or thoracic surgery.
- To rule out metastasis in patients with extrathoracic malignancies, to rule out bronchogenic carcinoma or mediastinal tumors in patients with paraneoplastic syndromes, in the investigation of fever of unknown origin, and in the assessment of patients with severe trauma.
- Based on the clinical assessment and/or evaluation of the chest radiograph further examination of the chest with other imaging modalities may be indicated.

"Routine radiographs" for periodic health examinations; pre-employment health assessment; pre-admission and preoperative chest radiographs and x-rays for tuberculosis screening and screening for bronchogenic carcinoma are not warranted.

III. QUALIFICATIONS OF PERSONNEL

A. Physician Qualifications

Physicians involved in the performance, supervision and interpretation of standard radiographs should be Diagnostic Radiologists and must have a Fellowship or Certification in Diagnostic Radiology with the Royal College of Physicians and Surgeons of Canada and/or the Collège des médecins du Québec. Also acceptable are equivalent foreign Radiologist qualifications if the Radiologist is certified by a recognized certifying body and holds a valid provincial license.

As new imaging modalities and interventional 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. Continuing professional development must meet with the requirements of the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada.

B. Technologist Qualifications

The medical radiation technologist must have a Canadian Association of Medical Radiation Technologist Certification or be certified by an equivalent licensing body recognized by the C.A.M.R.T.

Under the overall supervision of the radiologists, the technologist will have the responsibility for patient comfort and safety for examination preparation and performance and for image technical evaluation and quality and applicable quality assurance.

The training of technologists engaged in specialty activities shall meet with applicable and valid national and provincial specialty qualifications.

Continued education of technologists is encouraged by the C.A.M.R.T. and should meet pertinent provincial regulations.

IV. TECHNICAL PROBLEMS OF CHEST RADIOGRAPHY

To appreciate the merits and limitations of various approaches one must understand certain basic concepts of image quality as applied to the thorax which is one of the most technically challenging regions to image radiographically due to large difference in tissue density present in the chest. Depending on beam quality (kilovolt peak) x-ray transmissions through the unobscured lung can be 100 times greater than that in the mediastinum and subdiaphragmatic area. This disparity in regional radiopacity leads to a wide range of x-ray intensities reaching the image receptor. Unfortunately, this wide dynamic range can easily exceed the sensitivity of most screen film receptors and this problem makes it difficult to depict in a single film image all regions of the chest with good contrast. Given that as much as 40% of the lung area is obscured by the heart, mediastinum and diaphragm, it is difficult to visualize adequately all regions of the thorax.

* What is good chest radiography? In a good image of the chest it should be possible to see:

- lung tissue

- the vascular pattern of the lung including that behind the heart
- areas along the chest wall
- the trachea and main bronchi
- bone detail of the thorax

The contrast provided by the alveolar air surrounding the heart, great vessels and pulmonary vessels allows us to identify and assess these structures. The lung structure as seen on the chest radiograph is composed almost entirely of vessels. In addition, it is necessary to penetrate the dense tissues of the thorax in order to observe abnormalities in the lung which may be superimposed on these structures. The optimal chest radiograph then must provide a combination of wide latitude at lower density and contrast at higher density in the same radiograph. More than in other areas of imaging there is an inherent conflict between the desire for high contrast (to facilitate recognition of subtle lung detail and abnormalities) and wide latitude to enable the full range of tissue opacities encountered in the thorax. The chest radiograph is therefore a technically challenging examination and must be made within relatively narrow technical parameters.

V. SPECIFICATIONS FOR THE PERFORMANCE OF THE EXAMINATION

The written request for the chest radiographic examination should contain appropriate clinical history and the reason for the examination. If at all possible, this request should be completed by the referring physician.

A. Standard Chest Radiography

* Global image contrast and density: Factors determining the global (large area) contrast of chest radiographs include:

- the tube kV (the x-ray spectrum)
- the efficiency of scatter rejection
- the shape of the sensitometric curve of the film
- exposure level
- conditions of development

* Image fine detail: Depiction of fine detail is determined by:

- local image contrast
- spatial resolution
- noise

A standard chest examination should include an erect posterior-anterior (PA) and left lateral projection made in full inspiration (total lung capacity). The examination may be modified by the physician as dictated by the clinical circumstances or the condition of the patient.

The chest radiograph should include both lung apices and costophrenic angles. There should be appropriate definition of the vertebral bodies and the left retrocardiac vascular pattern should be visible. The scapulae should be positioned outside the lungs on the PA view and the arms elevated for the lateral view. The medial ends of the clavicles should be projected equidistant from the margins of the vertebral column.

* Films and Screens

· Conventional Chest Radiography: The screen film detector is by far the most commonly used image recorder, a fact that attests to its practical benefits including low cost, high spatial resolution, operational simplicity, and dependability. However, there are limitations in its ability to provide contrast in both lungs and mediastinum as well as overall image latitude. The exposure range (dynamic range) that a conventional chest film can record is approximately 2 orders of magnitude. Standard radiographic films have a relatively narrow latitude and a low linear response as depicted by the Hurter & Driffield (H&D) characteristic curve. As a result contrast in a film varies with local background optical density and structures with inherent low subject contrast may not be detectable if they are in a region of low optical density on the "toe" of the H&D curve.

· New Screen Film Systems in Chest Radiography:

The ideal image receptor for chest radiography should be highly sensitive to radiation and be able to respond to a wide range of exposures (wide latitude). In the past decade several innovations in screen film systems have been developed to address this problem and have established a new standard for radiographic image quality.

These systems have raised the quality of chest radiography by further increasing the information that can be recorded and displayed. The use of asymmetric film screen systems is the current Canadian standard for conventional chest radiography.

* Grids: In a conventional radiograph acquired without an anti scatter grid more than 90% of all detected radiation in the mediastinal region is from scattered (non information containing) photons and in the lung approximately 50% of the detected radiation is scatter. Even when a 12 to 1 anti scatter grid is used, only half of the potential subject contrast in the retro cardiac and retro diaphragmatic regions is available to the image recorder, and this improvement is achieved only at the expense of higher patient radiation dose levels. The image degradation caused by scattered radiation almost always dictates the use of a grid. The best radiographic rule for the use of grids includes all structures where the anatomy is greater than 10 cm thick. If this rule is properly applied, then all chest imaging other than neonates should be done with a grid including portable radiographs. The grid ratio must be appropriate for the kVp range that is commonly used. Most grids in chest

radiography have either 8 to 1 or 10 to 1 ratios with 103 lines/cm and a focal range between 90 cm and 180 cm.

* Focal Spot Size: Focal spot size of the radiographic tube used for chest x-rays should not exceed 1.2 mm (numerous studies have concluded that a spatial resolution of 2.5 line pairs per mm is sufficient for most diagnostic tasks in chest imaging).

* kVp Range: Chest radiography is usually performed with moderately high kilovoltage technique (120-140 kVp) which allows for better penetration of the mediastinum and retrocardiac and subdiaphragmatic lung and a decrease in the range of transmitted radiation as well as shorter exposure times.

* mAs and mA and time: Whether the exposure is set in mAs-or mA time is not important as long as the essential criteria is recognized. When working with mAs a combination must be selected that will yield the shortest exposure time. When the operator can select mA and time, there is more control over the technical factors, and again the shortest possible exposure time is essential.

* Distance: The depiction of fine detail on chest radiographs is principally determined by the screen film system used as geometric effects are usually small because of the large distance between focal spot and film. Distance in chest imaging is also important to minimize magnification of the heart and mediastinal structures. A 180 cm SID is most commonly used.

* Equipment: all these principles apply to both automated chest units and standard radiographic units. While it is possible to obtain excellent chest radiographs with general purpose radiographic equipment, high quality images in a routine clinical practice are most easily obtained with dedicated chest radiographic systems. These systems typically include an automated film changer, an integrated docked processor, a high-ratio focussed anti-scatter grid, a servo linked x-ray tube stand to simplify height adjustment and proper alignment of the x-ray source with the image receptor, and multi-cell photo timers to ensure proper x-ray exposure levels for posterior, anterior and lateral examinations. In principle it is possible to obtain high quality chest radiographs without the use of dedicated chest radiographic equipment. Most standard wall bucky arrangements for chest radiography, however, incorporate antiscatter grids with a lower ratio and/or lead content than grids in dedicated chest radiography units. In addition, grid alignment tends to be less accurate in this situation.

* Technical Advances in Chest Radiography: New approaches to image acquisition and display have been introduced in the last decade to circumvent the limitation of conventional film screen studies. Digital radiography with its wide exposure latitude, low scatter images and flexible display capabilities can compensate for the limited spatial resolution in standard radiographic systems. Also with modern computer technology it is feasible to replace film screen systems with digital methodology to improve image acquisition.

These advances include:

- storage phosphor systems
- selenium detector systems
- silicon flat panel detectors

The diagnostic performance of these systems is equivalent or superior to that of the conventional screen film systems for clinical chest imaging and can replace conventional radiography systems. This new technology offers transmission and storage capabilities inherent to digital radiology.

B. Bedside (Portable) Chest Radiography

1. The technologist should seek and expect assistance of nursing personnel in positioning unstable patients and adjusting and removing support apparatus from the radiologic field.

2. In cooperative patients, erect radiographs at 180 cm target-film distance are preferred. In uncooperative or comatose patients, a semi-erect or supine radiograph may be necessary, and a 125 cm target-film distance is acceptable.

3. Radiographic exposure should be made during peak inspiration.

4. The kilovoltage should be between 80 and 90 kVp in order to optimize penetration and minimize the effects of scattered radiation. Grids should be used whenever possible. If grids are used, higher

kilovoltage ranges of 100-120 kVp may be employed. To minimize patient motion, mobile equipment should have adequate capacity to make a radiographic exposure in less than 0.1 seconds.

5. Film with medium scale contrast should be used to maximize image contrast. Photostimulable phosphor plates are an acceptable alternative to film screen radiography but require careful quality control. An optimally exposed radiograph presents the lung at a mid-gray level (optical density approximately 1.4-1.7).

6. Exposure parameters (i.e. mAs, kVp, distance and patient position) should be recorded for each film, as they may be helpful in future radiographs taken at the bedside.

C. Chest Fluoroscopy

Chest fluoroscopy has been largely superseded by other noninvasive techniques.

VI. QUALITY CONTROL PROCEDURES

* Quality Management

A wide range of radiographic techniques, processing conditions and film screen combinations and speeds are still being used in conventional chest radiography. Exposure monitoring is done quite consistently, but this is just part of quality management.

Quality management policies and procedures must be in keeping with quality management principles of Standards for General Radiography.

VII. REQUISITION AND REPORT

· Reports:

Interpretation of chest radiographs requires assessment of the thoracic cage and soft tissues; diaphragms, pleura, mediastinum, heart, hila and lungs. Requisitions and reports must meet with the CAR Standards for General Radiography.

· It is of particular importance that the most recent radiograph be compared with prior chest radiographs and/or chest computed tomography, if those examinations are available.

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