Image Quality in Chest Radiography
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An Executive Summary

Chest radiography is an enormously successful medical diagnostic examination. It has played an important role in clinical medical practice since shortly after the discovery of X rays, and there are no indications that this importance will diminish in the foreseeable future. Today, chest radiography is used for evaluation of a very wide range of clinical complaints. Physicians of all specialties rely on the results of chest radiographs, and a normal chest radiograph remains a favorable indicator in innumerable clinical situations.

The basic features of the chest radiographic image are familiar to physicians as well as to many outside the profession. Even those with little interest in the examination would have no difficulty in discerning that some chest radiographs appear superior to others. All forms of subtlety and nuance are manifested when image quality in chest radiography is studied in a careful and systematic manner, however. Essentially the entire scope of medical radiographic science is required for an understanding of the issues that arise. A full consideration of psychophysical issues is also needed as the interaction between the human observer and the chest image can be very complex. Perhaps for these reasons, the questions related to image quality in chest radiography have been among the most extensively studied in all of clinical radiography.

Chest radiographic technique

The radiographic depiction of thoracic anatomy poses many technical challenges. The early development of radiographic technology for the chest examination first focused on generation of sufficiently intense X ray beams to allow visualisation of basic anatomy with short exposure times and favorable geometry. Later developments allowed issues related to the wide range of X ray attenuations resulting from normal thoracic structures to be addressed.
At most centres today, chest radiography is still performed with highly conventional radiographic methods. The basic equipment used for performance of the examination remains an X-ray tube and generator, a screen-film system, and often a means for X-ray scatter rejection such as a grid. Each element of the imaging chain can be modified in the effort to produce high quality radiographs.

All manner of technical innovations have been used for improving chest radiographic technique. Examples include differential filtration or modulation of the X-ray beam to compensate for the wide range of X-ray attenuations in the thorax and specialised screen-film systems that can record a wide range of X-ray intensities. The recent development of digital X-ray receptors shows great promise for chest radiography and allows the application of novel imaging approaches such as energy subtraction or new tomographic methods, as well as the direct utilisation of computer-assisted diagnosis.

**Image quality in chest radiography**

Image quality in chest radiography is usually considered in terms of the portrayal of normal anatomy or the depiction of potential pathology. Radiographic display of normal anatomy provides examples of the compromises that arise when image quality is considered. As one example, technical factors that might improve the visibility of unobscured lung may tend to diminish the visibility of lung projecting behind the heart or mediastinum. Consideration of such compromises often dominates careful investigations of image quality for the examination.

Although thoracic anatomy is predictable in a given patient, potential abnormal findings are much less so and it is not advisable to discuss image quality without reference to a target abnormality of interest. Lesions of clinical importance in chest radiography that might typically escape detection due to poor image quality include small, faint, opacities resulting from an early neoplasm or faint linear opacities caused by early interstitial disease. Technical approaches that might increase the likelihood that one type of target is detected can often decrease the likelihood of the detection of another. Discussions of image quality in chest radiography are most
frequently framed in the context of detection of early neoplastic manifestations.

The concepts of image contrast, image sharpness and image noise are the mainstays in the quantification of image quality in medical radiographic science. These are used throughout the report as the basis for discussions of technical image quality in chest radiography.

**Image quality and observer performance**

Ideally, the radiographic process should render the anatomy or pathology of interest as conspicuously as possible against the background of noise. In this regard, technical strategies that allow all portions of the chest to be imaged on usable portions of the gray scale of the recording medium tend to yield the best results when the examination is considered as a whole. These strategies include the use of high X ray voltage or wide latitude recording systems. The radiation contrast for findings of interest will typically be improved by X ray scatter rejection. Quantum noise in the image can be reduced with increasingly efficient recording systems such as those in new digital detectors.

The concept of structured noise is very important in the understanding of image quality in chest radiography. Normal anatomic structures, the chief source of structured noise, may camouflage subtle abnormalities or distract the observer's attention. Structured noise dominates quantum noise in chest radiography and can be a source of counterintuitive predictions about image quality. One example might be the increase in structured noise that results when image sharpness is improved. The importance of structured noise requires that the detection of truly subtle findings on chest radiographs depend not only upon technical excellence, but ultimately also upon chance and good fortune.

For the many reasons discussed, the literature does not support the existence of an optimum technique in chest radiography that can be applied across all patients or in all clinical circumstances. The present report therefore does not make prescriptive recommendations for everyday clinical practice. The many approaches described by authors for improving image
quality or for lowering patient radiation exposure are described in the report.

Assessment of image quality

The full armamentarium of medical radiographic science has been brought to bear on the study of chest radiography. The large-area contrast properties of chest images have been studied quantitatively with both experimental and simulation techniques. Sharpness and noise characteristics of chest radiographs have also been examined in detail. Computational methods that model the radiographic process, particularly contrast and quantum noise, form the basis for optimisation studies in image quality.

The evaluation of image quality in the clinic often falls under the general category of quality assurance in the radiology department. A number of simple tests can be performed that assess the performance of various components of the imaging chain or that assess the final chest image. Experienced practitioners may also perform quality assessments of clinical images with criteria for such assessments being readily available. Information gathered from quality assurance tests and from clinical image quality assessments should be considered together.

Conclusions

More than a century after its introduction into clinical practice, chest radiography remains an important subject for study. Additionally, in no other radiographic examination does the relationship between the physical image and the care of the patient have the potential to confound or to instruct. A thorough discussion of chest radiography within the framework of modern medical radiographic science can therefore be viewed as a potentially useful undertaking.