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CT Scan Parameters and Radiation Dose: Practical Advice for Radiologists

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Although there has been increasing recognition of the importance of reducing radiation dose when performing multidetector CT examinations, the increasing complexity of CT scanner technology, as well as confusion about the importance of many different CT scan parameters, has served as an impediment to radiologists seeking to create lower dose protocols. The authors seek to guide radiologists through the manipulation of 8 fundamental CT scan parameters that can be altered or optimized to reduce patient radiation dose, including detector configuration, tube current, tube potential, reconstruction algorithm, patient positioning, scan range, reconstructed slice thickness, and pitch. Although there is always an inherent trade-off between image quality or noise and patient radiation dose, in many cases, a reasoned manipulation of these 8 parameters can allow the safer imaging of patients (with lower dose) while preserving diagnostic image quality.

Introduction

Over the past several years, there has been increasing recognition of the importance of reducing radiation dose in radiologic studies, particularly with regard to multidetector CT. The growth in the volume of multidetector CT studies performed in the United States, the increasing use of CT in susceptible populations (including children), and growing concerns on the part of the general public with regard to radiation exposure have provided an impetus for performing these studies with the least possible radiation dose [1]. It is now believed that as many as 0.4% of all malignancies in the United States can be traced back to radiation from CT studies performed between 1991 and 1996 and that radiation from CT studies currently being performed may ultimately account for 1.5% to 2% of all cancers in the future [2]. Unfortunately, despite this growing awareness among radiologists, the introduction of each new generation of CT scanners has resulted in scanning protocols that are increasingly complex and difficult to manipulate for a radiologist whose primary expertise lies in clinical imaging rather than medical physics. When facing increasing criticism regarding CT dose, the best way to tackle the issue is to understand all the factors and parameters that can affect radiation dose and image quality and examine how these can be altered to reduce dose.

In this review, we seek to provide radiologists with a simple approach to the manipulation of 8 CT parameters that can be changed by the radiologist, while designing or altering scan protocols, to reduce patient radiation dose: (1) detector configuration, (2) tube current, (3) tube potential (kVp), (4) reconstruction algorithm, (5) patient positioning, (6) scan range, (7) reconstructed slice thickness, and (8) pitch.

Section snippets

Detector Configuration

Detector configuration is a term encompassing the number of data channels being used in the z axis and the "effective detector thickness" of each data channel. For example, a detector configuration of 64 × 0.5 mm would suggest the use of 64 data channels in the z-axis, each of which has an effective thickness of 0.5 mm. Notably, the effective detector thickness represents the smallest possible reconstructed slice thickness: if a study is acquired with an effective detector thickness of 0.5 mm, …

Tube Current

Increases in tube current or the product of tube current and scan time (mAs) result in improved image quality, decreased image noise, and increased patient dose. In general, the relationship between tube current and patient dose is essentially linear, with increases in mAs resulting in a comparable percentage increase in patient dose [3]. Although tube current can be manually controlled, most operators use automated tube current modulation (also known as automated exposure control) for most …

Reconstruction Algorithm

Traditionally, CT reconstruction algorithms have used filtered back projection (FBP). The mathematical algorithms underlying FBP assume a "nonexact" relationship between the projection data acquired at the CT scanner and the data displayed in the final image. As a result, FBP removes very little noise from the final image, is limited in the use of data with lower contrast-to-noise ratios, and generally requires studies to be performed with larger radiation doses to be of diagnostic quality [1, …

Patient Positioning

In a study by Li et al [24] in 2006, 95% of patients in the series were found to be improperly centered within the scanner gantry by the CT technologist. Although this may seem to be of only minimal importance, improper positioning can have a significant impact on both image noise and patient surface dose. Habibzadeh et al [25] found improper centering of phantoms in the scanner gantry to be associated with an average surface dose increase of 23% and an image noise increase of 7%. Abnormal …

Scan Range

For many CT applications, significant reductions in scan range may be neither possible nor desirable. Nevertheless, the scan range should be reduced to the needed minimum for any examination, particularly when imaging structures such as the heart, for which an increased scan range is unnecessary (Fig. 3). Although cardiac studies are certainly the most obvious applications in which a limited scan length can be used, a small scan range may be possible in many traditional body imaging …

Reconstructed Slice Thickness

As the reconstructed slice thickness decreases, the number of photons within each voxel also decreases, resulting in increased image noise. To maintain constant noise levels within an image with a smaller slice thickness, the radiation dose must be consequently increased [3]. With the introduction of automatic tube current modulation, the interaction between the user-specified level of acceptable noise, reconstructed slice thickness, and radiation dose can be quite complex and will undoubtedly …

Pitch

Pitch in the multidetector, spiral CT era is defined as table travel per rotation divided by beam collimation. Pitch <1 suggests overlap between adjacent acquisitions, pitch >1 implies gaps between adjacent acquisitions, and pitch of 1 suggests that acquisitions are contiguous, with neither overlap nor gaps [7]. A smaller pitch, with increased overlap of anatomy and increased sampling at each location, results in an increased radiation dose. Alternatively, a larger pitch implies gaps in the …

Conclusions

As both the general public and clinicians have become increasingly aware of the concerns associated with multidetector CT–related radiation dose, it has become critical for radiologists to better understand the CT scanner technology they work with. In particular, a detailed understanding of a few basic CT scan parameters is essential, and knowledge of how to manipulate these parameters to produce diagnostic images at lower doses is critical for safe imaging. ...

Take-Home Points

- Several multidetector CT parameters can be changed to reduce radiation dose, including detector configuration, tube current, kVp, reconstruction algorithm, patient positioning, scan range, reconstructed slice thickness, and pitch. ...
- Although all users should generally use automated tube current modulation, users must be careful about using this software in obese patients, children, and patients with metallic hardware. ...
- Low-kVp protocols may be most useful in thin, non-obese patients, particularly ...

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