ARTICLE IN PRESS

Radiography xxx (2018) 1–6

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Assessment of isocenter alignment during CT colonography: Implications for clinical practice

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ARTICLE INFO

Article history:
Received 18 December 2017
Received in revised form
6 April 2018
Accepted 9 April 2018
Available online xxx

Keywords:
Tomography, X-ray computed
Colonography, Computed tomographic
Patient positioning
Adult

ABSTRACT

Introduction: Optimization of image quality and patient radiation dose is achieved in part by positioning the patient at the isocenter of the CT gantry. The aim of this study was to establish whether there was increased isocenter misalignment (IM) in CT colonography (CTC) scans by comparing patient position during the prone part of a CTC to patient position during renal stone protocol CT (CT-KUB) and patient position during the supine part of a CTC to patient position during abdominopelvic CT (CT-AP).

Methods: Two hundred and twenty two consecutive outpatient adult CTC studies performed between January and December 2016 were retrospectively analyzed. Automated dose-tracking software was used to quantify IM in the x and y planes. Renal stone CT-KUB ($n = 100$) and standard CT-AP ($n = 100$) were used as comparison studies.

Results: IM during CTC was significantly greater in the y-axis compared with the x-axis for both prone ($p = 0.002$) and supine ($p < 0.001$) scanning. IM was significantly greater during prone CTC compared with CT-KUB ($p = 0.008$) and during supine CTC compared with CT-AP ($p = 0.0001$). IM was shown to be slightly greater in studies performed by more experienced radiographers ($p = 0.04$). IM was not associated with patient age, gender or size ($p > 0.05$ for all).

Conclusion: Isocenter misalignment is greater during CT colonography compared with CT-KUB or CT-AP. Strategies for improving patient positioning could include radiographer education and automated patient centering solutions.

Introduction

Radiation dose in CT

There has been a marked increase in the use of CT with the number of examinations performed increasing approximately sixfold in the United States in the past 30 years.[1] Best practice entails abiding by the ‘as low as reasonably achievable’ (ALARA) principle when exposing patients to radiation as part of diagnostic medical procedures, as recommended by the American College of Radiology (ACR) and the European Society of Radiology (ESR).[2,3] The radiation dose required for optimal CT has to be balanced with the level of image noise encountered during imaging.[4] Patient positioning relative to the isocenter of a CT scanner affects both patient dose and image noise.[5] While phantom studies have been performed to assess the interplay between positioning and image quality, there has been little clinical assessment as to causative factors, which may help inform better clinical practice.

Noise is inherent to all forms of imaging and is the random variation of image brightness that gives the image a mottled or grainy appearance.[6] In CT, image noise is a function of the radiation dose,[7] the reconstruction algorithm,[8] and the slice thickness[7] and pixel size (i.e. voxel size[4]). The image noise is dependent on the

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https://doi.org/10.1016/j.radi.2018.04.003
1078-8174/

amount of radiation reaching the receptor and, therefore, increases with decreased radiation dose. Most modern CT scanners utilize a bowtie filter, which modifies the intensity of the X-ray beam incident on the patient and subsequently the image detectors in order to facilitate more uniform irradiation and image noise (Fig. 1a). The filter has a meniscus-like configuration, which is more sculpted centrally than peripherally. When a patient is correctly centered in the CT gantry the filter ensures that the most intense components of the X-ray beam encounter the thickest part of the patient and the intensity of the beam is reduced where it encounters more peripheral, less attenuating anatomy.[5,9]

Accurate patient positioning is essential for optimal operation of bowtie filters. The isocenter of a CT scanner is defined as the axis of rotation of the CT gantry.[10] One side of the periphery of a misaligned patient will receive a more intense X-ray beam compared with the central most attenuating part of the patient which will more likely receive a suboptimal exposure,[5,11] potentially leading to increased image noise[5] (Fig. 1b). Radiation dose reductions measured in the incident surface tissues of up to 50% have been reported using bowtie filters compared with flat filters.[12] Efficient functioning of a bowtie filter assumes positioning of the patient at the scanner isocenter with misalignment resulting in both increased image noise and increased surface dose.[5] Automatic exposure control (AEC) can also contribute to the effects that isocenter misalignment (IM) has on patient dose and image noise. If AEC is employed, IM will result in increased radiation output from the scanner to ensure that image noise is within desired levels on the resultant images, thereby increasing the radiation dose to the patient.[5] One phantom study demonstrated markedly increased tube current with increasing IM when AEC was used,[13] up to 45% with 60 mm and 70% with 80 mm y-axis IM. Even in the absence of AEC, increased image noise has also been observed due to IM.[5] This can have a negative impact on the diagnostic acceptability of consequent images (Fig. 2).

Centering of the patient within the CT scanner is usually achieved manually by the radiographer adjusting the patient and table position with the help of laser guides. Further adjustments can be made once the initial scout images have been acquired. There is potential for centering error particularly in the performance of complex examinations. CT colonography (CTC) entails insertion of a rectal tube, insufflation of the colon, and supine and prone CT imaging all as part of a single examination.

CT colonography

CT colonography (CTC) is an increasingly utilized technique that allows minimally invasive assessment of the large bowel with high diagnostic accuracy.[14,15] The imaged population includes patients with symptoms suspicious for colonic neoplasia and more recently colorectal cancer screening in asymptomatic at-risk individuals. In this setting, adherence to the ALARA principle with regards to radiation exposure is of utmost important since a large proportion of screened patients will not prove to have cancer. Given that physical inactivity, increasing age, and obesity are risk factors for colorectal cancer,[16] many of the patients undergoing CTC will be overweight or infirmed. These factors may potentially impair adequate patient centering, which can introduce increased image noise and potentially impair diagnostic certainty. It is therefore of paramount importance to ensure that patients undergoing CTC are correctly positioned in the isocenter of the scanner, to optimize both radiation dose and image noise. This phenomenon has not been assessed in the clinical setting.

The aim of this study was to establish whether there was increased IM in CTC scans and to investigate if patient size, age, gender or radiographer experience were associated with IM during CTC.

Methods

Patient selection

Following institutional review board approval with the requirement for consent waived, 222 consecutive adult outpatient CT colonography studies performed on a single CT scanner, from January 2016 to December 2016, were retrospectively selected from the Picture Archiving and Communication System (PACS) database of a large tertiary referral cancer center. One hundred CT-KUB and

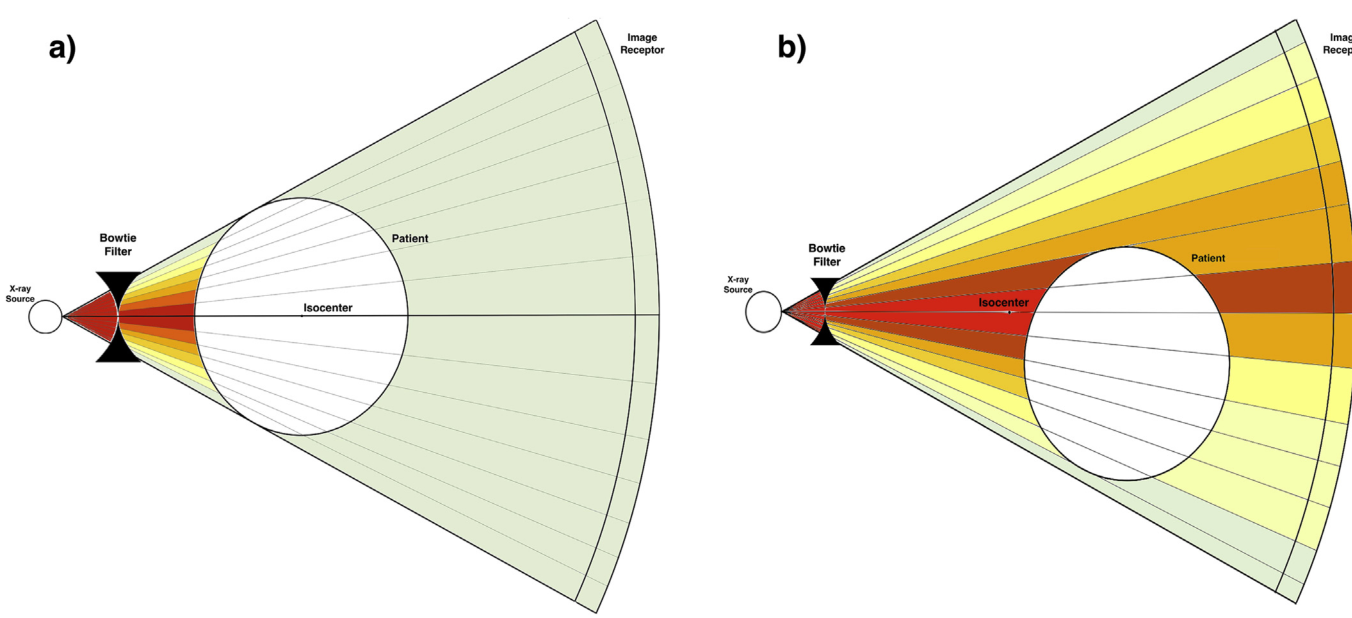

Figure 1. a) Patient at scanner isocenter with bowtie filter resulting in increased X-ray intensity through the center of the patient and decreased intensity at the peripheries and homogeneous X-ray intensity at the receptor, b) patient off isocenter with increased radiation intensity at peripheries, decreased intensity at patient center and heterogeneous intensity reaching the detector.

Please cite this article in press as: Olden KL, et al., Assessment of isocenter alignment during CT colonography: Implications for clinical practice, Radiography (2018), https://doi.org/10.1016/j.radi.2018.04.003