Low-Dose Computed Tomography Colonography Technique

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KEYWORDS

• Computed tomography colonography • Virtual colonoscopy • Radiation dose reduction • Automatic dose modulation • Iterative reconstruction • kVp

KEY POINTS

- The role of radiation is of debatable importance for computed tomography (CT) colonography in the screening age population (generally over the age of 50) but consistent with the As Low As Reasonably Achievable (ALARA) principle only a very low radiation dose is necessary for colonic polyp detection.
- A wide variety of CT scan parameters can be adjusted or utilized to significantly reduce radiation dose such as reducing tube current (mAs), reducing tube voltage in smaller patients (kVp), using automatic dose modulation, and incorporating iterative reconstruction.
- Other practical approaches can also be used to help reduce radiation dose such as proper patient isocentering, optimizing colonic distension to minimize scan phases, limiting the scan volume to the colon, and varying view settings to reduce the impact of image noise.

INTRODUCTION

For much of the past 2 decades, computed tomography (CT) colonography (CTC) has fought an uphill battle to become an accepted option for colorectal screening. One of the major impediments to the eventual acceptance of CT colonography as a screening test has been the perceived risk of radiation associated with CT. In fact, theoretic radiation risks were specifically used by the US Preventative Services Task Force to delay the eventual "A" recommendation of CTC for colorectal screening[1] and are still used as an argument by the Centers for Medicare and Medicaid Services (CMS) against a national coverage determination (NCD) to include CTC as a Medicare/Medicaid-reimbursed colorectal screening option.[2] Patients, the lay press, referring physicians, and even some radiologists have also expressed concern about CT radiation.[3–5]

PUTTING RADIATION RISKS IN PERSPECTIVE

The theoretic risks of a small dose of radiation associated with a low-dose examination such as CTC need to be weighed realistically against the benefits of colorectal screening. The theoretic risks associated with medical sources of radiation are based on a linear extrapolation of the cancer-induction risks associated with ultrahigh doses of radiation from atomic bomb exposures in Japan. This linear no-threshold model (BEIR VII)[6] remains

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highly controversial and unproven at low doses associated with medical imaging.[7] The Health Physics Society in 2016 stated that below an exposure of 100 mSv, the observed radiation effects in people are not statistically different from zero."[8] If one assumes a CTC dose of 5 mSv, the theoretic risk of cancer induction at the initial screening age of 50 is 0.04%, dropping to 0.02% by age 70,[9] numbers difficult to compare much less prove when the comparable lifetime risk of developing cancer is 39%.[10] Compared with a 5% lifetime risk of developing colon cancer in particular, the benefits of preventing colon cancer vastly outweigh the theoretic risks of cancer induction, even when accounting for surveillance imaging at 5-year intervals. When compared with the real risks of colonic perforation at optical colonoscopy of 0.1% to 0.2%,[11] these theoretic risks of radiation are put into even greater perspective. These unproven risks are likely to be even lower, with average CTC doses at many institutions now lower than 3 mSv, a dose comparable to annual environmental background radiation exposure in the Unites States and a fraction of the dose associated with a routine abdomen/pelvis CT. With further vendor advances in CT radiation dose-reduction techniques, there is room for even further reductions, as one only needs enough photons to resolve a soft-tissue/gas interface for detection of polyps measuring larger than 5 mm in size.

Regardless of exactly what risks, if any, may be associated with such low doses of radiation, out of concern for patients and the public, it behooves the medical community to keep CT radiation dose As Low As Reasonably Achievable (the ALARA principle),[12] especially when it comes to a screening examination repeated at regular intervals that potentially every person of average risk qualifies for.

RADIATION DOSE METRICS AND TARGETS

All CT manufacturers are required to provide dose metrics, including a CT dose index ($CTDI_{vol}$) measured in mGy and a dose length product (DLP) in mGy-cm (the $CTDI_{vol}$ integrated over the scan length) for each scan series (see an example in **Fig. 1**). For a CTC, this includes summing doses for each scan position such as supine and prone, and occasionally a third position when troubleshooting an underdistended colonic segment. The $CTDI_{vol}$ is a measure of the average radiation output intensity of the CT scanner for a particular scan, whereas the DLP is a quantitative measure of the total radiation output when accounting for the scan length. To convert these measures of CT scan output to estimated patient-absorbed radiation doses, a conversion factor (*k*) based on the use of standardized body phantoms is multiplied by the total summed DLP to generate the estimated effective dose in mSv. Currently, the *k* value used to estimate effective dose in abdomen/pelvis CT examinations is 0.0171.[13,14] However, this *k* value can also be size-corrected for each particular patient to more closely estimate the dose absorbed, as this estimate is highly dependent on each patient's body habitus.[15,16] Nevertheless, multiplying the total summed DLP by approximately 1.5% serves as an easy estimate for the dose of each examination. An initial goal would be to reduce the dose to less than that of a double-contrast barium

Exam Description: CT COLONOG DIAG WO CON

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	–	–	–	–
2	Helical	I33.000–I364.200	3.21	121.14	Body 32
4	Scout	–	–	–	–
5	Helical	I142.500–I484.500	2.32	90.19	Body 32
			Total Exam DLP:	211.33	

211.33 x 1.5% ≈ 3.2 mSv

Rough estimate of Effective Dose in mSv

Fig. 1. Using the CT dose page to estimate radiation dose. Adding the dose-length product (DLP) of the 2 CTC scan positions (series 2 and 5 above) and multiplying this by a *k* factor of approximately 1.5% yields a rough estimate of the estimated effective dose in mSv.