Dual-Energy Computed Tomography

Dose Reduction, Series Reduction, and Contrast Load Reduction in Dual-Energy Computed Tomography

Anushri Parakh, MD[a], Francesco Macri, MD, PhD[a,b], Dushyant Sahani, MD[a,*]

KEYWORDS

• Dual-energy CT • Spectral CT • Radiation dose • Contrast media • Iodine • Virtual unenhanced • Material density • Split-bolus

KEY POINTS

- Dual energy computed tomography entails balancing of radiation dose and image quality without affecting spectral separation for the clinical context being assessed.
- Existing dual energy computed tomography platforms meet diagnostic and radiation dose expectation as compared with single energy computed tomography protocols.
- Low energy virtual monochromatic (40–60 keV) images enable reduction in iodine dose while providing good contrast-to-noise ratio and image quality.
- Dual energy computed tomography can also decrease radiation and/or iodine contrast dose by decreasing the number of unequivocal scans that warrant follow-up and number of acquisitions in multiphasic examinations.

INTRODUCTION

Patient safety is paramount when adopting any new technology into clinical care. Despite the recognized clinical benefits of dual energy computed tomography (DECT), wide adoption of DECT was limited initially owing to workflow constraints and reports of higher radiation dose. Understanding the technology and its potential is key. Refinements in DECT technology, image reconstruction and material separation algorithms over the past decade has given the opportunity to optimize DECT and create double-low (radiation and contrast) protocols in accordance with basic principle of as low as reasonable achievable for good clinical practice. The ability to generate material density images (virtual unenhanced [VUE] or water images) also decreases the dose by reducing the number of true acquisitions performed in multiphasic examinations. Another indirect effect on dose reduction is the ability to reduce the absolute amount of contrast media owing to the generation of low-energy virtual monochromatic images. In addition to its

Disclosure Statement: No relevant disclosures (A. Parakh, F. Macri); Royalties from Elsevier, Research Grant from GE Healthcare and Bayer. Consultant for Allena (D. Sahani).

[a] Department of Radiology, Abdominal Imaging Division, Massachusetts General Hospital, White 270, 55 Fruit Street, Boston, MA 02114, USA; [b] Department of Radiology, University Hospital of Nimes, Place di Pr Debre, Nimes 30029, France

* Corresponding author.

E-mail address: dsahani@partners.org

Radiol Clin N Am 56 (2018) 601–624
https://doi.org/10.1016/j.rcl.2018.03.002

radiologic.theclinics.com

diagnostic and functional capability, this flexibility of DECT to reduce radiation dose, series, and contrast gives it a unique advantage over single energy CT (SECT).

We aim to provide an overview of existing evidence, and suggestions for protocols, on DECT in the perspective of improving patient care while minimizing overall exposure to ionizing radiation and iodinated contrast media.

DOSE REDUCTION

Keeping other parameters constant, the relationship between tube voltage and radiation dose is exponential, that is, a change from 120 to 140 kVp increases the radiation dose by 30% to 40%, whereas a shift from 120 to 100 or 80 kVp decreases it by 38% to 67%.[1] When DECT was first commercially available, an initial study by Ho and colleagues[2] suggested that radiation doses from DECT (80/140 kVp) were up to 3 times higher than SECT performed at 140 kVp. Such reports coupled with connotation of the word dual in the name coincided with the surging interest in medical and lay community about the potential long-term risks from ionizing radiation in medical imaging.[3] This limited early widespread clinical adoption of DECT. As a result, although truly convincing deleterious effects of cancer secondary to radiation from diagnostic imaging are debatable, considerable efforts to reduce radiation doses for all relevant modalities are being made by different stakeholders in radiology.[4] Since the initial investigations, there have been considerable refinements in hardware, software, and image reconstruction techniques for DECT to mitigate radiation dose. Furthermore, much of the initial literature did not normalize for image noise or perform image quality analysis.

Unlike SECT, in which modulating tube current is a significant factor for reducing radiation dose, optimizing radiation dose in DECT depends largely on the platform. An overview of these efforts on commercial DECT scanners is provided in **Table 1**.

Rapid kVp Switching Dual Energy Computed Tomography

This platform is limited by fixed tube current. The mA is contained by allocating a relatively longer time for 80 kVp acquisition than for 140 kVp.[5] The radiation dose is, therefore, curbed by using an appropriate gemstone spectral imaging preset that is chosen according to clinical indication and body habitus. This preset is dictated by varying combinations of tube current and pitch. Accordingly, the lowest limit of radiation dose achievable on rapid kVp switching DECT (rsDECT) is a volumetric CT dose index of 5 mGy.

Dual Source Dual Energy Computed Tomography

Tube current can be modulated in this platform, just like for SECT. There is no lower limit for

Table 1
Methods used by a few commercially available DECT scanners to curb radiation dose

DECT Basis	Source-Based			Detector-Based
DECT Technique	**Rapid kV Switching**	**Dual-Source**	**Twin Beam**	**Dual Layer**
Additional filtration at the x-ray tube output	None	Second- and third-generation scanners are equipped with different thickness of tin (Sn) filter at higher kVp tube	Equal halves of gold (Au) and Tin (Sn) filters at the single x-ray tube output	None
Percent low kVp state during a scan	65% scan time – 80 kVp 35% scan time – 140 kVp	Equal duration of low and high kVp states	Not applicable (single 120 kVp applied)	Not applicable (single 120 or 140 kVp applied)
Automatic tube current modulation	Not available	Available	Available	Available
Iterative reconstruction	Available	Available	Available	Available

Abbreviation: DECT, dual energy computed tomography.