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Dual-Energy CT and Radiation Dose

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INTRODUCTION

As dual-energy CT scanners become more common, it is worth revisiting their benefits over conventional CT. The promises to increase the conspicuity of pathology and assist in differentiating tissue are much touted, but how can we realize the benefits of radiation dose reduction [1]?

This article will briefly discuss the technology of dual-energy CT scanners, review some of the practical applications, and discuss the potential benefits and shortcomings of dose reduction.

DUAL-ENERGY TECHNOLOGY

The principle behind dual-energy CT is that scanning at two different kilovoltage peaks allows determination of attenuation curves of tissue. This can be accomplished through several different methods, including fast kilovoltage switching with single-source and single-detector, dual-layer detectors with one source, or dual detectors with dual-source, or dual-detector offset 90° from each other. The spectral information can be used to generate standard CT images in addition to mono-energetic reformats (often chosen slightly higher than the k-edge of iodine to increase conspicuity of enhancement; Fig. 1), virtual noncontrast images (Fig. 2), perfusion-like imaging (iodine-only images) [2], as well as other niche benefits to identify elements by k-edge and z-effective techniques (such as uric acid in gout) [3]. Further applications of mono-energetic selection at higher kilovoltage may allow for reduced streak artifact from beam hardening in the case of orthopedic prostheses or other hardware [4].

DOSE SAVINGS

Some of these benefits translate well into radiation dose reduction. The virtual noncontrast imaging at times permits removing a whole phase of imaging, as with renal or angiographic imaging. This could cut the dose in half for some studies.

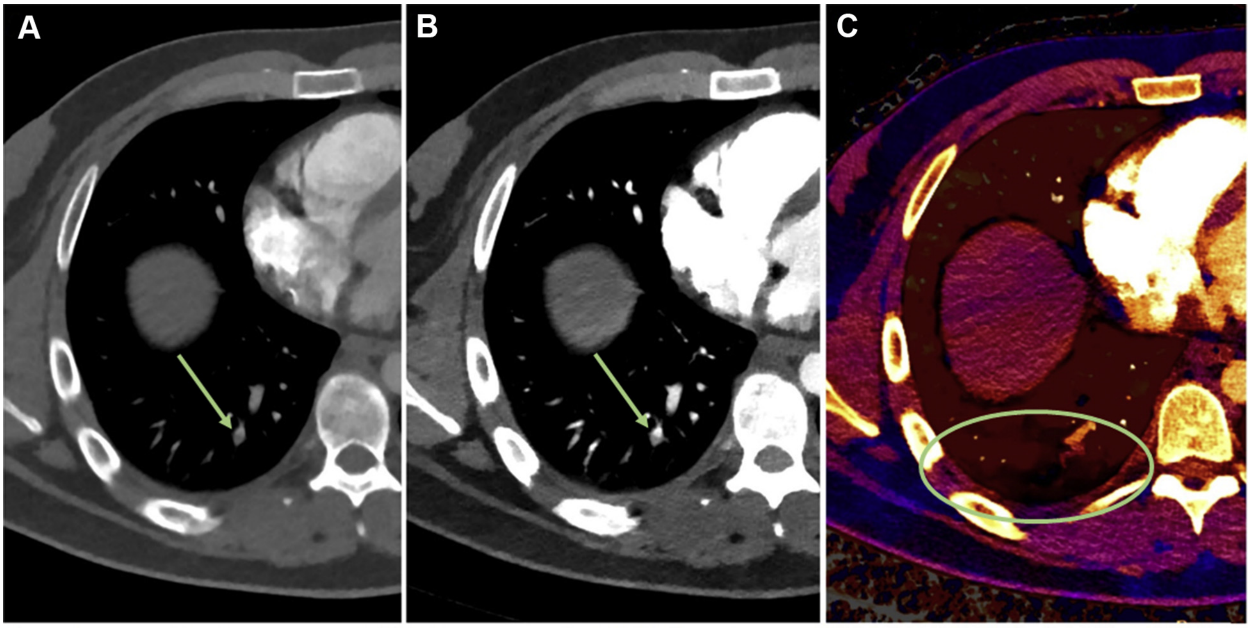

Fig 1. Conventional poly-energetic (A), mono-energetic 40 keV (B), and conventional + Z-effective (C) reformats of CTA chest examination for pulmonary embolus. Right lower lobe pulmonary embolus (arrow) on similarly windowed reformats, demonstrating improved conspicuity on mono-energetic imaging. Corresponding perfusion defect is shown (circle).

1546-1440/19/$36.00 ■ https://doi.org/10.1016/j.jacr.2019.07.016

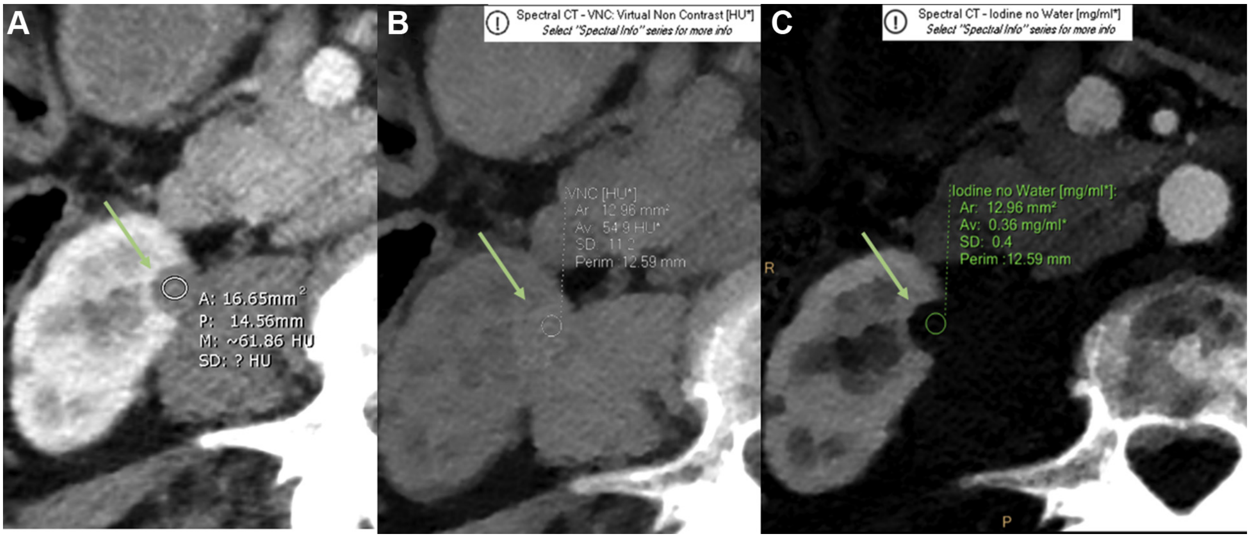

Fig 2. Traditional (A), virtual noncontrast (B), and iodine-only (C) reformats of a CT abdomen/pelvis with intravenous contrast. Indeterminate density right renal lesion (arrows). Circle region of interest on lesion with measurements of Area (A/Ar), Perimeter (P/Perim), Mean attenuation (M/Av), and Standard Deviation of attenuation (SD). Virtual noncontrast image shows similar density to traditional scan and iodine-only image shows no enhancement, confirming benign cyst.

Furthermore, if the mono-energetic imaging is sufficient to salvage a poorly timed contrast bolus, this may spare a patient from needing to return for repeat imaging, reducing dose to the patient and delay in care.

LIMITATIONS

Yet, in other ways, the dual-energy CT scanner is similar to a traditional scanner. Simply substituting a dual-energy CT scanner for a conventional scanner will not reduce dose. Automatic exposure compensation works in the same way as on a traditional scanner, and though there are additional tools at the radiologist's disposal as described previously, the intrinsic radiation exposure will be similar.

The responsibility remains with the radiologist to act as steward of diagnostic medical radiation and determine if the advantages of dual-energy CT permit a dose reduction. If protocols are not adapted to remove the noncontrast phase, optimal dose savings will not be realized. If practices do not elect to reduce dose to offset the other benefits of dual-energy imaging, dose will remain the same. The responsibility falls to the radiologist to decide conscientiously how to reduce radiation dose in keeping with the principles of "as low as reasonably allowable" and the efforts of groups like Image Wisely and Image Gently. Dual-energy CT empowers us to re-assess imaging protocols in a new light and optimize patient care.

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The author states that he has no conflict of interest related to the material discussed in this article.

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