Original Investigation

Variability of CT Attenuation Measurements in Virtual Unenhanced Images Generated Using Multimaterial Decomposition from Fast Kilovoltage-switching Dual-energy CT

Ravi K. Kaza, MD, Evan A. Raff, MD, MHA, Matthew S. Davenport, MD, Shokoufeh Khalatbari, MS

Rationale and Objectives: To compare Hounsfield unit (HU) data obtained from true-unenhanced (TUE) and virtual-unenhanced (VUE) imaging obtained with a fast kv-switching dual-energy computed tomography (CT) scanner using multimaterial decomposition algorithm.

Materials and Methods: In this Institutional Review Board-approved, Health Insurance Portability and Accountability Act-compliant, retrospective cohort study, CT scans of 19 patients undergoing multiphasic renal protocol abdominal CT on a fast kv-switching dual-energy CT scanner were reviewed. CT numbers were measured on the matched TUE and VUE generated using a multimaterial decomposition algorithm with selective iodine suppression, and postcontrast images at predefined locations in seven organs. Six hundred sixty regions of interest were placed at 132 locations. Agreement was assessed with paired *t* test, Pearson's correlation, and Bland-Altman analysis.

Results: Mean TUE and VUE measurements were not significantly different in the corticomedullary ($P = 0.25$) or nephrographic ($P = 0.10$) phases. There was a strong correlation between TUE and VUE CT numbers (corticomedullary: $r = 0.90$, nephrographic: $r = 0.90$, each $P < 0.001$). Discrepancies ≥5 HU occurred 46 times (35%, 46 of 132) in the corticomedullary phase and 44 times (33%, 44 of 132) in the nephrographic phase. Discrepancies ≥10 HU occurred in 7% (9 of 132 in both corticomedullary and nephrographic phases). Interphase, intrasubject VUE CT numbers were strongly correlated ($r = 0.93$, $P < 0.001$), but discrepancies ≥5 HU (22% [29 of 132]) and ≥10 HU (2% [3 of 132]) occurred. There was no significant correlation between the true postcontrast CT number and the magnitude of VUE-TUE discrepancy ($r = –0.04$, $P = 0.6$).

Conclusion: CT numbers on VUE images generated from fast kv-switching dual-energy CT scans strongly correlate with TUE CT numbers on a population basis, but commonly vary 5–9 HU on a per-patient basis.

Key Words: Dual-energy CT; Virtual unenhanced imaging; multimaterial decomposition.

© 2016 The Association of University Radiologists. Published by Elsevier Inc. All rights reserved.

INTRODUCTION

One of the principal advantages of dual-energy computed tomography (DECT) is its ability to derive material-specific information using material decomposition algorithms that analyze the change in attenuation of tissues between the low and high-energy scans (1–3). This enables differentiation of materials with a high atomic number (eg, iodine) from those with a low atomic number (eg, soft tissue, water). With fast kv-switching DECT, a "basis material decomposition algorithm" is used to generate material-specific information that enables selective identification of iodine on contrast-enhanced DECT and generation of virtual unenhanced (VUE) images (1). However, unlike with dual-source DECT, in which material decomposition is performed in image space, material decomposition with fast kv-switching DECT is performed in projection space, which has limited the ability of users to translate the VUE data into Hounsfield units (HU) (4,5).

An advanced material analysis algorithm known as multimaterial decomposition (MMD) has recently been made available for clinical use, and extends the material discrimination capability of fast kv-switching DECT to more than

Acad Radiol 2016; ■:■■–■■

From the Department of Radiology, Division of Abdominal Imaging, University of Michigan Health System, University of Michigan Hospital, Ann Arbor, Michigan 48109 (R.K.K., E.A.R., M.S.D.); Department of Radiology, University of Southern California, Los Angeles, California (E.A.R.); Michigan Institute for Clinical and Health Research, University of Michigan, Ann Arbor, Michigan (S.K.). Received July 27, 2016; revised September 8, 2016; accepted September 19, 2016. IRB statement: The study was approved by the University of Michigan institutional review board. **Address correspondence to:** R.K.K. e-mail: ravikaza@med.umich.edu

© 2016 The Association of University Radiologists. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.acra.2016.09.002

two materials (6). As opposed to VUE images generated using an iodine:water material basis pair, in which the image pixels containing iodine are removed, with MMD algorithm image voxels of iodine are replaced by voxels simulating the same volume and attenuation of blood that would have been displaced by the iodine (6). These images are referred to as material suppressed iodine (MSI) images, and they enable measurement of HU in the VUE images (6). If accurate, they would allow the translation of these virtual HU data into commonly used attenuation-based diagnostic algorithms (eg, renal mass and adrenal nodule characterization) that rely on specific HU criteria to discriminate benign from potentially malignant pathology (7).

Several studies have evaluated the reliability of HU measurements of VUE images generated from dual-source DECT (8–10). An initial evaluation of HU values on VUE images generated using MMD in a small clinical cohort has been reported to have a variance of ±10 HU as compared to true unenhanced (TUE) images (6). However, to our knowledge there are no subsequently published clinical studies evaluating the reliability of HU values measured on MSI-VUE generated from fast kV-switching DECT.

Because of the importance CT numbers have on patient management, it is important to verify that the VUE HU data are identical or very similar to (within <5 HU) TUE data. The purpose of our study was to determine the rate and magnitude of CT number discrepancies between TUE and VUE images generated from a fast kv-switching DECT scanner using an iodine material suppression algorithm.

MATERIALS AND METHODS

Institutional review board approval was obtained for this Health Insurance Portability and Accountability Act-compliant retrospective cohort study. The requirement for informed consent was waived.

Study Subjects

The following inclusion criteria were utilized: (1) DECT performed of the abdomen in the corticomedullary and nephrographic phases as part of follow-up for a previous renal mass ablation, (2) DECT performed on a fast kv-switching scanner, and (3) examination performed between July 1, 2011 and June 30, 2014. Patients with weight greater than 300 lb are not scanned using DECT at our institution and hence were not included. There were no exclusion criteria specific for this study. Nineteen subjects (9 males and 10 females; age range 40–84 years) were included in the study.

CT Technique

All examinations were performed on a fast kv-switching DECT scanner (GE Discovery CT750 HD, GE Healthcare, Waukesha, WI). A single-energy unenhanced scan of the abdomen was obtained followed by multiphasic dual-energy enhanced scan in the corticomedullary and nephrographic phases after administration of 100 mL of nonionic iodinated contrast material (Isovue 300, Bracco Diagnostics, Princeton, NJ, USA). The following scan parameters for the single-energy and dual-energy scans were utilized: scan type: helical; detector coverage: 40 mm; slice thickness: 2.5 mm; interval: 2.5 mm; pitch: 1.375:1; and speed: 55 cm. The single-energy scans were performed at 120 kVp with a gantry rotation time of 0.8 second and automated dose modulated mA using a Noise Index of 21.6 with minimum/maximum mA of 100/400, which is identical to the institutional protocol for routine abdominal CT. For the dual-energy scans, a scan protocol with a volume CT dose index ($CTDI_{vol}$) that closely matched the radiation dose of the single-energy scan protocol was selected from the available 21 preset fast-kVp switching DECT acquisition protocols that vary in tube current, pitch, and gantry rotation time. Once a protocol was selected for each subject, the flux ratio between the dual-energy acquisitions was automatically optimized during fast switching of tube potential between 80 and 140 kVp at a constant tube current.

All scans imaged the entirety of both kidneys. For the unenhanced series, axial 2.5-mm thick sections were reconstructed. For the dual-energy enhanced series, monochromatic images at 75 keV were reconstructed at 2.5 mm thickness, which was the default monochromatic energy level for image interpretation. Using the multimaterial decomposition algorithm, axial 2.5-mm-thick MSI-VUE images were then generated from the contrast-enhanced scans on a dual-energy analysis workstation (Advantage Workstation [GE Healthcare]) using Gemstone Spectral Imaging software (GE Healthcare).

Image Analysis

Five sets of axial 2.5-mm thick images were generated for each subject: (1) single-energy TUE, (2) 75 keV dual-energy corticomedullary phase, (3) 75 keV dual-energy nephrographic phase, (4) MSI-VUE from corticomedullary phase, and (5) MSI-VUE from nephrographic phase. CT numbers were measured by placing a region of interest (ROI) on the matched TUE, VUE, and postcontrast images at seven predefined locations: (1) right lobe of liver, (2) body of pancreas, (3) midportion of spleen, (4) left kidney at the level of the renal hilum (avoiding any prior ablation change), (5) main portal vein at the porta hepatis, (6) aorta at the level of celiac artery ostium, and (7) erector spinae muscle at the level of celiac axis origin. The size and location of each ROI on each image set were matched within subjects using a copy/paste function on the workstation. Parenchymal ROIs were placed in a manner that excluded major vessels, and vascular ROIs were placed to be entirely intraluminal. One subject had undergone prior splenectomy and therefore no spleen ROI was available for that subject. A total of 660 ROI measurements were recorded at 132 distinct organ locations.

Download English Version:

https://daneshyari.com/en/article/5725594

Download Persian Version:

https://daneshyari.com/article/5725594

Daneshyari.com