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ORIGINAL ARTICLE

Utilizing dual energy CT to improve CT diagnosis of posterior fossa ischemia

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Summary
Background and purpose: Evaluation of posterior fossa ischemia on conventional CT is limited. The goal of our study was to determine if virtual monochromatic CT increases the diagnostic accuracy for the detection of posterior infarcts relative to standard CT while using diffusion-weighted MRI as a reference standard.
Methods: Thirty consecutive subjects who meet the following inclusion criteria were retrospectively enrolled: (1) symptoms of posterior fossa stroke (e.g. vertigo, fainting, and dizziness), (2) unenhanced dual-energy CT of the head performed upon admission to the emergency department, and (3) MRI of the brain within 7 days following the CT. Eight of the 30 subjects were determined to have MRI diffusion-weighted imaging findings consistent with acute posterior fossa ischemia. Monochromatic energy reconstructions at 60, 80, 100, 120 keV and the clinical CT were interpreted independently by two fellowship-trained neuroradiologists, who assessed the images for posterior fossa infarcts and for imaging quality.
Results: Reconstructions obtained at 80 keV provided the best artifact reduction and overall maximization of image quality and were statistically significantly better than standard head CT ($P < 0.001$). Sensitivity, specificity, positive predictive value, and negative predictive value were at least not less than standard CT, and there was a trend toward better values at 100 keV ($P = 0.096$).
Conclusion: Monoenergetic 80 or 100 keV reconstructions may improve the detection of posterior fossa ischemia compared to conventional CT. However, if clinical suspicion for posterior fossa ischemia warrants, a brain MRI with diffusion-weighted imaging should still be obtained, even in the presence of a negative dual energy CT of the brain.

Abbreviations: kVp, peak kilovoltage; keV, kiloelectron volts.

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Introduction

In conventional head CT, the posterior fossa is an area in which beam hardening, photon starvation, and scatter artifacts traditionally decrease both the sensitivity and specificity for detection of acute cerebral ischemia. When patients present with stroke symptoms referable to the posterior fossa, the interpreting radiologist may struggle to report a subtle finding when artifactual inhomogeneities within the posterior fossa are so frequently encountered. Many times, MRI performed subsequent to the CT examination elucidates a small posterior fossa infarct which was not otherwise apparent on the original CT. Given the speed in which CT may be performed, earlier diagnosis of posterior fossa infarcts using CT may be helpful to clinically triage patients, particularly in settings where MR may not be readily available for emergency work-up of patients suspected of posterior fossa ischemia.

A previous study demonstrated that images reconstructed at 65—75 keV (kiloelectron volts) provided images that were of a significantly improved quality relative to the conventional polychromatic CT [1]. However, it is not clear if this improved image quality translates into better detection of pathology. The goal of our study was to determine if virtual monochromatic CT increases the diagnostic accuracy (sensitivity and specificity) for the detection of posterior infarcts relative to standard CT while using diffusion-weighted MRI as a reference standard. Additionally, we sought to re-examine the effects of virtual monochromatic imaging on the perceived quality of the images rendered.

Materials and methods

Study design

This study received approval by the institutional review board with no need for informed consent considering the retrospective nature of the study. All consecutive patients who received unenhanced head CTs using dual-energy technology on a single scanner (General Electric Discovery HD CT750) from March of 2012 through October of 2012 as part of their standard of care were identified. These subjects were then cross-referenced to a list of MRI brain examinations performed during the same time period. The medical record of each of these patients was then examined to determine the presenting symptomatology.

Criteria for inclusion in this study were:

- adults with symptoms of posterior fossa stroke (e.g. vertigo, fainting, and dizziness);
- unenhanced CT of the head performed upon admission to the emergency department;
- and MRI of the brain within 5 days following the CT.

Study population

Thirty consecutive subjects were found to meet the inclusion criteria. Eight of the 30 subjects were determined to have MRI diffusion weighted imaging findings consistent with acute posterior fossa ischemia. Of these, 5 of the infarcts occurred in the pons and 3 occurred within the cerebellum. Fourteen of the subjects were male and 16 were female. Subject age ranged from 22 to 93 years with a mean of 64 years, and subject body mass index ranged from 15.7 to 54.2 kg/m^2 with a mean of 30.0 kg/m^2.

Virtual monochromatic image generation

Unenhanced CTs were obtained using dual-energy technology on a single scanner utilizing a standard protocol given in Table 1. The protocol was designed to deliver the same radiation dose as a regular unenhanced CT of the brain [2]. Subsequently, standard polychromatic axial images were reconstructed with 2.5 mm slice thickness, an interval of 20 mm, and 40 percent iterative reconstruction [3]. These images were transferred to PACS at the time of image acquisition and used for clinical evaluation. The raw 0.625 mm thick axial images with a 20 mm interval and 40 percent iterative reconstruction were transferred to the advanced workstation (General Electric Advanced Workstation Volume Share 5) where the General Electric Gemstone Spectral Imaging software was utilized to reconstruct 2.5 mm thick axial images at 60, 80, 100, and 120 keV. These image sets were then transferred to PACS (Carestream) where evaluation for this study occurred.

Image interpretation

Monochromatic energy reconstructions at 60, 80, 100, 120 keV and the clinical CT were interpreted independently by two fellowship-trained neuroradiologists. The interpreting neuroradiologists were blinded as to what energy was currently being interpreted, and the order of interpretation was randomized. Each neuroradiologist interpreted all of the reconstructed datasets and the standard CT originally used clinically.

The interpreting neuroradiologists were provided with a case report form which collected several variables: presence of a posterior fossa infarct in the posterior fossa, the maximal axial area of the infarct if present, and standard deviation of the average Hounsfield units in a region of interest measuring 1 cm^2 within the air surrounding the patient as surrogate for background noise. The reader was asked to rate the study as ''uninterpretable'', ''interpretable but limited'', ''good'', or ''excellent'' with regard to artifacts

Table 1 Standard protocol used for scanning unenhanced head CT on GE Discovery CT750 HD.

Acquisition	Tube rotation	Thickness	Interval	Gantry tilt	Single slice collimation	Total collimation	Number of detectors	SFOV	DFOV
Axial	0.8	5.0	20.0	S0.0	0.625	20	32	Head	25 cm