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Accessory spleen versus lymph node: Value of iodine quantification with dual-energy computed tomography

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ABSTRACT

Objectives: To evaluate whether iodine quantification with Dual-Energy Computed Tomography (DECT) improves the differentiation of accessory spleens (AS) from lymph nodes (LN) compared to CT number measurements.

Methods: Abdominal DECT images of 75 patients with either AS (n = 35) or LN (n = 48) (benign entity) were retrospectively evaluated. Hounsfield Units (HU) and iodine concentrations of AS, LN and the main spleen were measured. Receiver operating characteristics (ROC) were performed to calculate an optimal threshold for distinguishing AS from LN. Sensitivity, specificity, and accuracy were calculated for distinguishing AS from LN by iodine concentration measurements.

Results: Mean CT numbers and iodine concentrations were higher for AS (148 ± 29 HU and 48.2 ± 11 × 100 μg/cc) than LN (83 ± 19 HU and 31.5 ± 6.2 × 100 μg/cc, respectively, P < 0.001 each). Mean CT numbers were lower for AS compared to the main spleen (161 ± 29HU, P < 0.01), whereas mean iodine concentrations (47.7 ± 10 × 100 μg/cc) were not significantly different (P = 0.095). An iodine concentration greater than 38 × 100 μg/cc suggested AS with a sensitivity, specificity and accuracy of 91%, 85%, and 88%, respectively (Area under ROC curve 0.941).

Conclusions: Iodine measurements might contribute to the differentiation of AS from LN. Iodine concentrations similar to that of the main spleen may help to confirm the diagnosis of AS.

1. Introduction

Accessory spleens (AS), also referred to as "splenules", are a common incidental finding in abdominal computed tomography (CT) and are seen in 10–20% of the population [1,2]. Even though most AS are asymptomatic and require no further medical interventions, their correct diagnosis is of great importance. Three major clinical scenarios might result in complications from misdiagnosis from CT: first, a potentially malignant lymph node (LN) or a soft tissue metastasis may be incorrectly called an AS or vice versa [3]. This may occur in staging of lymphoma, cases after splenectomy, or if an AS were to be found in an atypical location, such as the pancreatic tail or in the pelvis [4,5]. Second, if an AS were to be missed in the diagnostic workup prior to splenectomy, it may be a cause of recurrence of an underlying (predominantly hematologic) disease [6,7]. Third, in rare cases an AS could become symptomatic and present with abdominal pain due to hemorrhage, infarction or torsion [8–11].

The most common differential diagnosis for AS are LN which can have a similar appearance both at CT imaging and macroscopically [12,13]. Other considerations include soft tissue metastases and hypervascular neoplasms, such as pancreatic endocrine tumors [14,15]. Improvements in the diagnosis of AS are desired to avoid additional procedures for ambiguous lesions such as follow up examinations, invasive biopsies or imaging with different modalities including magnetic resonance imaging (MRI), positron emission tomography (PET)-CT or ultrasound. The characteristic appearance of AS in CT has been described qualitatively and quantitatively in prior studies [2,16,17]. However, these studies only included single energy CT with evaluation by CT numbers

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(Hounsfield Units [HU]) and did not investigate the value of Dual-Energy Computed Tomography (DECT).

Material differentiation by DECT is becoming increasingly utilized [18–20]. Due to their different linear attenuation coefficients of various materials at two different tube potentials (kVp) [21], DECT can provide paired material decomposition images such as iodine(-water) reconstructions [19,22]. The latter are provided with units of 100 μg iodine/cc tissue and can be used to quantitatively assess the amount of iodine in soft tissues.

The aim of our study was to evaluate whether iodine quantification with Dual-Energy Computed Tomography (DECT) improves the differentiation of accessory spleens (AS) from lymph nodes (LN) compared to CT number measurements.

Our hypothesis was that iodine concentrations between AS and the main spleen would exhibit more consistent values compared to their relative CT numbers, helping to diagnose AS from other lesion types.

2. Materials and methods

Our retrospective study was approved by our Committee on Human Research and compliant with requirements of the Health Insurance Portability and Accountability Act. Our institutional review board waived the need for patient consent for this study.

2.1. Study population

Venous phase abdominal DECT scans from 203 consecutive unique patients between November 2013 and June 2015 were retrospectively screened for the presence of either AS or LN by a radiologist with six years experience of abdominal imaging (SW).

Three cases were excluded due to prior splenectomy and one case was excluded due to severe metal artifacts. This resulted in a total of 199 study cases (109 men, 90 women, mean age 57 ± 16 years, range 22–88 years). No patients with a known or in CT salient cirrhotic liver disease were included in the study population.

Categorized indications for CT scanning were as follows: possible or known malignancy (n = 79), abdominal pain (n = 48), sepsis (n = 39), and other (n = 33).

Lesions were defined to be AS when typical CT imaging features were present (proximity and location to the main spleen, round shape, homogeneous contrast enhancement, absence of a hilum and the typical size of 1–2 cm [2,12,16]) and when the appearance of the lesion did not change in prior or follow up imaging studies for a minimum interval of 12 months.

Lesions were defined as a benign LN when typical CT imaging features were present (mesenteric-, celiac-, or paraaortal location, oval shape, presence of a hilum, and a typical size of 0.5–1.5 cm [23,24]) and when the lesion did not show substantial growth for a minimum interval of 12 months. In addition, care was taken not to include lesions of other entity (e.g. peritoneal carcinomatosis) which could resemble a lymph node.

To avoid partial volume errors in quantitative region of interest (ROI) measurements, only lesions with a minimum diameter of 7 mm were included in the analysis [2].

2.2. Imaging and post-processing

Imaging was performed using a rapid kVp switching DECT scanner (Discovery CT750 HD, GE Healthcare, Waukesha, WI, USA) in dual-energy (Gemstone Spectral Imaging or GSI) mode (fast kVp switching between 80 and 140 kVp). Intravenous iohexol 350 mgI/mL (Omnipaque 350, General Electric Healthcare, Princeton, New Jersey) was administered at a dose of 1 mL/pound patient weight (up to maximum dose 150 mL), injected at 3 mL/s. in order to acquire a venous phase abdominal CT scan.

In all cases the GSI preset was chosen to approximate the CTDIvol of a scan obtained with single energy with a 1.25 mm prescribed image thickness, a Noise Index (GE's reference image quality parameter) of 31, a helical pitch of 1.375:1, and an iterative reconstruction blend of 40% (Adaptive Statistical Iterative Reconstruction, GE Healthcare, Waukesha, WI, USA). This was achieved by specifying the protocol for this unperformed single energy CT following the acquisition of the localizer radiograph, and then choosing the GSI preset accordingly.

Post-processing of the CT data was performed on an Advantage Windows Server (Version 2.02, GSI Viewer, GE Healthcare, Waukesha, WI, USA) to generate iodine(-water) material decomposition images and 70 keV virtual monochromatic (VMC) images, which resemble conventional 120 kVp single energy CT images. Both post-processed datasets are routinely generated at our institution and form part of the basic image types generated in abdominal DECT imaging.

2.3. Image analysis

The image analysis was carried out on axial images using a standard workstation (GSI viewer, AW Server 2.02, GE Healthcare, Waukesha, WI, USA) by one radiologist (SW–*blinded for review* –) with six years of experience in abdominal DECT.

In order to determine the intra-reader reliability, measurements of 30% of the included cases were repeated after a time interval of two weeks to avoid recall bias. In addition, a second reader (WL–*blinded for review*- with ten years of experience in abdominal CT) evaluated 30% of the cases to identify the inter-reader reliability of quantitative measurement.

Circular ROIs were manually drawn in the center of each lesion (AS or LN) as well as in the main spleen of the 70 keV images (Figs. 1 and 2). The minimum ROI size was 2 cm^2 for the measurements in the spleen and was chosen as large as possible for AS and LN measurements. Care was taken to avoid areas of inhomogeneity (e.g. tissue borders, hilum with vessels) in ROI measurements and to avoid lesion edges due to the partial volume effect. The ROIs were automatically duplicated by the workstation from the 70 keV images to iodine(-water) images in identical size and location.

Both readers were blinded to the image type and to the results from the readout of the other data sets. The latter was achieved by hiding the ROI measurements while ROI drawing and only displaying them when the ROI position was determined.

In the VMC 70 keV images the units of quantitative ROI measurements are given in HU, whereas units of the quantitative measurements in iodine(-water) images are given in concentrations of iodine (100 μg/cc).

2.4. Statistical analysis

Continuous variables were expressed as mean ± standard deviation, categorical variables as frequencies (n) and percentages (%). The Shapiro-Wilk test was performed for testing of normality.

The intra-reader and inter-reader reliability for CT number measurements and iodine concentration measurements of AS, LN, and the main spleen were analyzed by using intraclass correlation coefficients (ICCs). According to Landis and Koch [25], ICC values of 0.81–1.00, were interpreted as excellent agreement.

Pairwise comparison of CT numbers and iodine concentrations among AS and the main spleen, among LN and the main spleen, as well as among AS and LN were performed using paired *t*-tests to assess for significant differences. Receiver operating characteristics (ROC) analysis was conducted to distinguish between AS and LN by means of CT numbers and iodine concentrations. Point estimates, 95% confidence intervals (CIs), and areas under the ROC curve (AUCs) were calculated. An optimal cut-off was determined