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Case Report

Differentiating unexpected hyperattenuating intraluminal material from gastrointestinal bleeding on contrast enhanced dual-energy CT ☆

Todd C. Soesbe, PhD, Lakshmi Ananthakrishnan, MD, Matthew A. Lewis, PhD*

Department of Radiology, The University of Texas Southwestern Medical Center, 5323 Harry Hines BLVD; Dallas, TX 75390-9316, USA

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ABSTRACT

We present the case of a 24-year-old woman who presented to the emergency department with mid-epigastric pain and nausea. Contrast enhanced dual-energy CT showed high iodine signal in the small bowel lumen concerning for gastrointestinal bleeding since oral contrast was not given. However, overt bleeding symptoms were absent. Further in-house analysis of the dual-energy CT data revealed the hyperattenuating intraluminal material to be oral indigestion medicine containing magnesium, aluminum, or bismuth, and not extravasated iodine.

Introduction

Over-the-counter oral indigestion medicines that contain magnesium, aluminum, or bismuth metals can sometimes appear as hyperattenuating intraluminal regions on X-ray CT images. If these medicines are not noted in the patient history they can be mistaken for gastrointestinal bleeds [1] or foreign bodies [2–5]. Further adding to this confusion is the fact that these hyperattenuating medicines are incorrectly identified as iodine on current dual-energy CT iodine maps even though the atomic numbers of their metals greatly differ from that of iodine. In this case report we show that the confusion over unexpected hyperattenuating intraluminal materials can be resolved with emerging dual-energy CT methods. These methods that take full advantage of the material differentiation capabilities of dual-energy CT to perform element identification and visual segmentation in a single comprehensive image.

Case report

A 24-year-old woman with a history of irritable bowel syndrome and reflux presented to the emergency department for mid-epigastric pain and nausea. The patient underwent an abdominopelvic contrast enhanced dual-energy CT (IQon;

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* Corresponding author.
E-mail address: todd.soesbe@utsouthwestern.edu (T.C. Soesbe).
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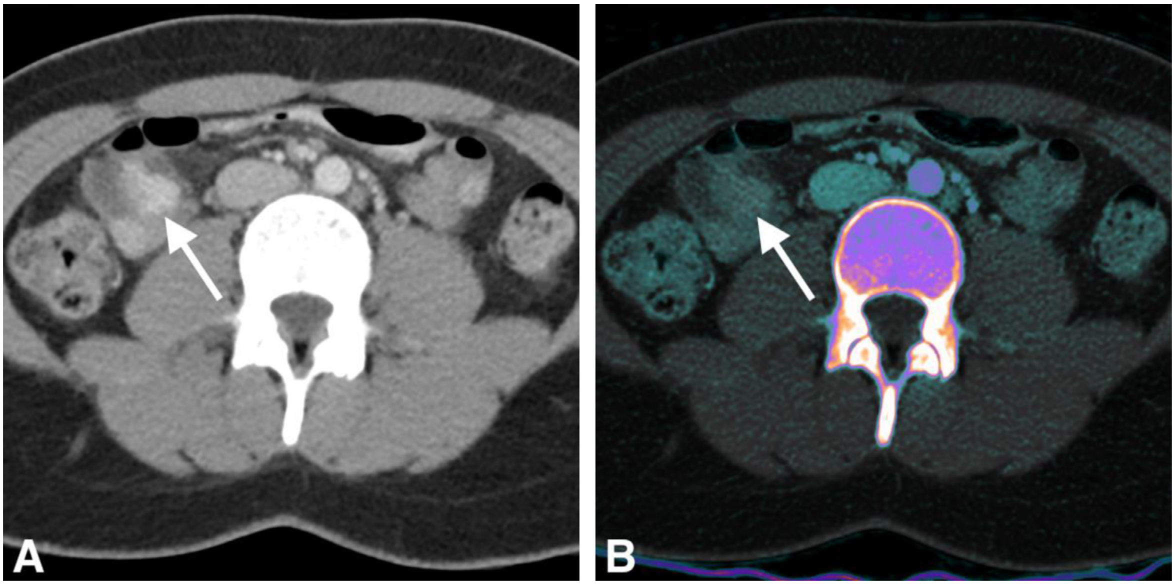

Fig. 1 – (A) Venous-phase 120-kVp CT section showing amorphous hyperattenuating areas in the small bowel lumen (arrow, 134 HU) raising concern for gastrointestinal bleeding. (B) Dual-energy CT iodine map showing iodine present in the same bowel lumen region (arrow, 1.3 mg iodine per mL).

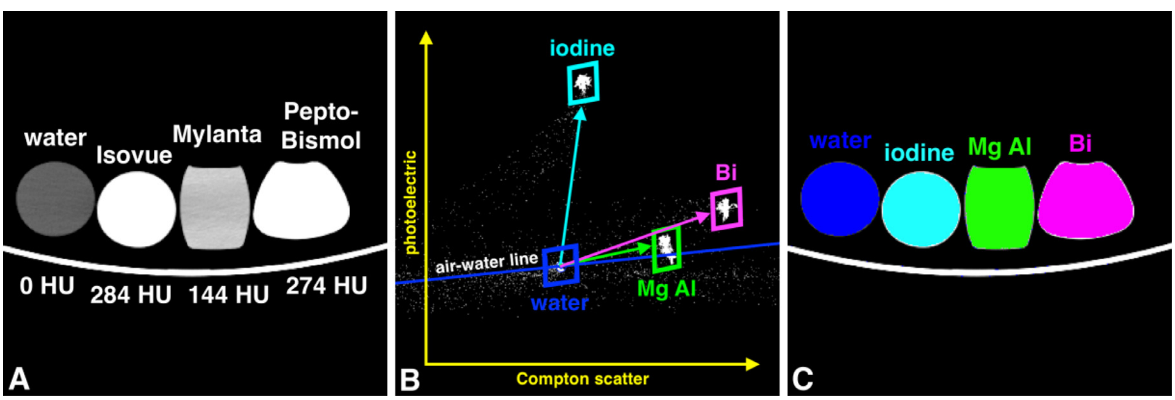

Fig. 2 – (A) CT image of bottles containing (from left to right) water, diluted Isovue (iodine), Mylanta (magnesium and aluminum), and Pepto-Bismol (bismuth). (B) 2-dimensional histogram of the Compton and photoelectric data from the axial section in A. Note that the elements have unique concentration vectors from water (arrows) as well as different 2-dimensional locations (rectangular ROIs) that permit differentiation, even when isoattenuating (e.g., the iodine and bismuth bottles). (C) Segmented image of A based on the colored rectangular ROIs in B that identifies the elements.

Philips Healthcare, Best, Netherlands). No oral contrast material was administered. Hyperattenuating material was noted in the small bowel lumen (Fig. 1A), which also appeared on the color iodine map (Fig. 1B), raising concern for gastrointestinal bleeding. However, the patient's clinical picture did not support a diagnosis of gastrointestinal bleeding as she had no blood in the stool and had normal hemoglobin levels.

To help resolve this disagreement bottles of water, diluted Isovue-370 (Bracco Diagnostics, Monroe Township, NJ), Mylanta (Infirst Healthcare, Westport, CT), and Pepto-Bismol (Procter & Gamble, Cincinnati, OH) were scanned on the same dual-energy CT scanner (Fig. 2A). The Isovue bottle contained 10 mg of iodine per mL (diluted from 370 mg of iodine per mL) with a total attenuation of 284 HU. The Mylanta bottle contained 33.3 mg of magnesium per mL (400 mg of magnesium hydroxide in 5 mL) and 27.7 mg of aluminum per mL (400 mg of aluminum hydroxide in 5 mL) with a total attenuation of 144 HU. The Pepto-Bismol bottle contained 10.1 mg of bismuth per mL (525 mg of bismuth subsalicylate in 30 mL) with a total attenuation of 274 HU. The unique locations of iodine, magnesium and aluminum, and bismuth within a 2-dimensional histogram of the dual-energy CT data (Fig. 2B) [6] allowed for material differentiation and visual segmentation within the CT image (Fig. 2C). Note in Figure 2B that increasing concentrations of iodine move vertically while increasing concentrations of magnesium, aluminum, or bismuth move toward the right.

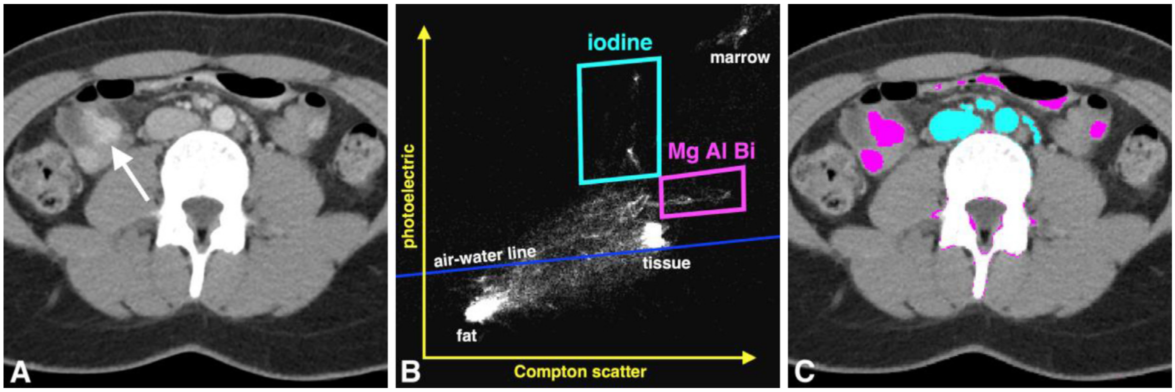

Fig. 3 – (A) CT image of the patient from Fig. 1A showing the suspicious region (arrow). (B) 2-dimensional histogram of the Compton and photoelectric data from the axial section in A. Rectangular ROIs differentiate pixels containing iodine (blue) from those containing magnesium, aluminum, or bismuth (pink). (C) Segmented image of A based on the ROIs in B indicating that hyperattenuating regions in the small bowel are due to magnesium, aluminum, or bismuth (pink), and not iodine (blue).

When this method was applied to the patient data (Fig. 3A) the 2-dimensional histogram revealed that pixels corresponding to the hyperattenuating intraluminal material did not appear in the iodine region (Fig. 3B). Rather, these pixels appeared in the region corresponding to magnesium, aluminum, or bismuth. ROIs (region of interest) were drawn around these 2 regions in the 2-dimensional histogram (Fig. 3B) and the pixels inside them were correlated back to the original CT image and color-coded. The resulting segmented image (Fig. 3C) showed the hyperattenuating material in the small bowel to be consistent with indigestion medicine rather than iodine. Follow-up revealed the patient had taken 30 mL of oral indigestion medicine containing magnesium and aluminum approximately 2 hours before the CT scan.

Discussion

Over-the-counter oral indigestion medicines can be mistaken for iodine by current dual-energy CT iodine maps leading to the question of gastrointestinal bleeding, particularly in the acute setting. This uncertainty can increase both the time to diagnosis and cost with further imaging [1,2,7] and even endoscopy for suspected foreign bodies [3,5]. Therefore, until improved material specific dual-energy CT reconstructions are available, it is important to consider these medicines as possible sources of unexpected hyperattenuating intraluminal material.

Previous phantom and pre-clinical publications have also demonstrated the potential for dual-energy CT to differentiate bismuth from iodine. However, these previous methods either required separate iodine, and bismuth images [8,9] or had unrealistic artifacts like hyperattenuating air in the bowel [10]. In contrast, our initial clinical data show that emerging dual-energy CT methods can differentiate magnesium, aluminum, or bismuth from iodine in a single comprehensive image, thereby resolving any suspicion of gastrointestinal bleeding even when the materials are isoattenuating with iodine [11].

One current limitation of this method is that these materials cannot be differentiated if they exist in the same voxel, although this was not a problem in this particular case report. Also, we used a 2-dimensional histogram made from the Compton, and photoelectric data available on dual-layer dual-energy CT systems. This method needs to be developed further for dual-source and fast kVp switching dual-energy CT systems using alternative histogram data since Compton and photoelectric data might not be available. Finally, although these liquid oral medicines might not be apparent on planar X-ray [7] they are significantly more apparent on CT due to the improved sensitivity. This is especially true if the maximum strength versions of these medicines are used that have double the metal concentrations of regular strength.

In conclusion, we have used an in-house dual-energy CT method to differentiate an unexpected hyperattenuating intraluminal material from iodine, and exclude gastrointestinal bleeding as a potential cause. Although this material was initially identified as iodine on the CT system's iodine map it was correctly identified as metallic oral indigestion medicine by our method, therefore eliminating the need for further testing.

Patient consent

Written consent from the patient was not needed because the study involved the retrospective analysis of data that were collected as part of routine medical care with all data being anonymized for publication.

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Non–applicable.

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