Delayed Enhancement of Ascites after Iodine Contrast Administration Assessed with Dual-energy Computed Tomography: A Case Report

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(Received April 8, 2021; Accepted May 10, 2021)

We report a case of 71-year-old woman with lung cancer and high-attenuation ascites (HAA) due to iodine contrast material (ICM). The patient underwent two sequential CT scans at interval of 4 h between examinations by using ICM. The second scan was obtained by dual-energy CT (DE-CT), yielding the virtual non-contrast (VNC) image and iodine map, which were used to evaluate HAA. The VNC image revealed ascites with water density, and HAA was thought to contain iodine because the attenuation of ascites around the liver was similar to that of the spleen on the iodine map. The VNC image and iodine map using DE-CT were useful in differentiating HAA due to iodine (delayed enhancement of ascites) from hemorrhagic ascites in this patient.

Key words: dual-energy computed tomography, delayed enhancement of ascites, virtual non-contrast image, iodine contrast material, high-attenuation ascites

INTRODUCTION

On computed tomography (CT), simple ascites typically measures between −20 and 20 HU and is commonly seen in a wide range of conditions, including simple fluid overload, congestive heart disease, cirrhosis, intraperitoneal inflammation, neoplasm, trauma, or recent surgery [1]. In contrast, high-attenuation ascites (HAA) raises concern for acute life-threatening conditions such as hemoperitoneum, visceral perforation with intraperitoneal extravasation of iodine contrast material (ICM) from the gastrointestinal or urinary tract [2, 3], or peritonitis [4]. Some reports have shown that the X-ray attenuation of ascites increases on delayed scans obtained within 10 min to 7.5 h after an initial intravenous contrast-enhanced examination using ICM [5–9]. It is essential to differentiate HAA (which caused by delayed enhanced ascites: DEA due to iodine) from hemorrhagic ascites.

On a dual-source CT scanner, two X-ray tubes can be used at different tube settings, allowing dual-energy scanning [10–13]. Iodine effect can be assessed by generating virtual non-contrast (VNC) image and iodine map [13–15]. Herein, we report that HAA due to iodine (DEA) can be accurately diagnosed using the VNC image and iodine map obtained by dual-energy CT (DE-CT).

CASE REPORT

A 71-year-old woman with small-cell lung cancer of stage IV underwent chemotherapy for 3 months in our institution. Laboratory data were hemoglobin of 9.5 g/dl, hematocrit of 28.8%, serum creatinine level of 0.8 mg/dl, estimated glomerular filtration rate of 49 mL/min/1.73m^2, and serum albumin level of 3.4 g/dl. The first CT examination was performed to evaluate abdominal pain using 100 ml of ICM (Omnipaque 300; GE Healthcare, Tokyo, Japan) by a single-energy CT scanner (SOMATOM Perspective; Siemens Healthcare, Erlangen, Germany). Pre-contrast CT image demonstrated ascites of 10 HU around the liver (Fig. 1A). Contrast-enhanced CT (CE-CT) images with 120 s of scanning delay revealed a tumor thrombus in the suprahepatic inferior vena cava (IVC) (Fig. 1B). The second CT was performed 4 h after the first CE-CT using 80 ml of the same ICM, because the fluid–fluid level of the IVC at the hepatic level was seen on the first CE-CT and its finding could not exclude venous thrombus (Fig. 1C). Her blood pressure was 148/75mmHg before the second CT scanning. A third-generation dual-source CT scanner (SOMATOM Force; Siemens Healthcare) was used at this time because it uses low doses of ICM and radiation. Dual-energy protocol was as follows: collimation, 192 × 0.6 mm; pitch, 0.7; rotation time, 0.25 s. Tube voltages were set to 80 kVp and 150 kVp using a 0.6-mm tin filter. Predefined ratio of the quality reference tube current-time products was 1.6:1 for 80 kVp and tin-filtered imaging at 150 kVp (selected exposure: tube A, 259 mAs, and tube B, 138 mAs). An automated attenuation-based tube current modulation (Care Dose 4D; Siemens Healthcare) was applied. The mean volume CT dose index was 9.02 mGy. VNC images and iodine map were displayed using the Syngo.via Client 4 work-

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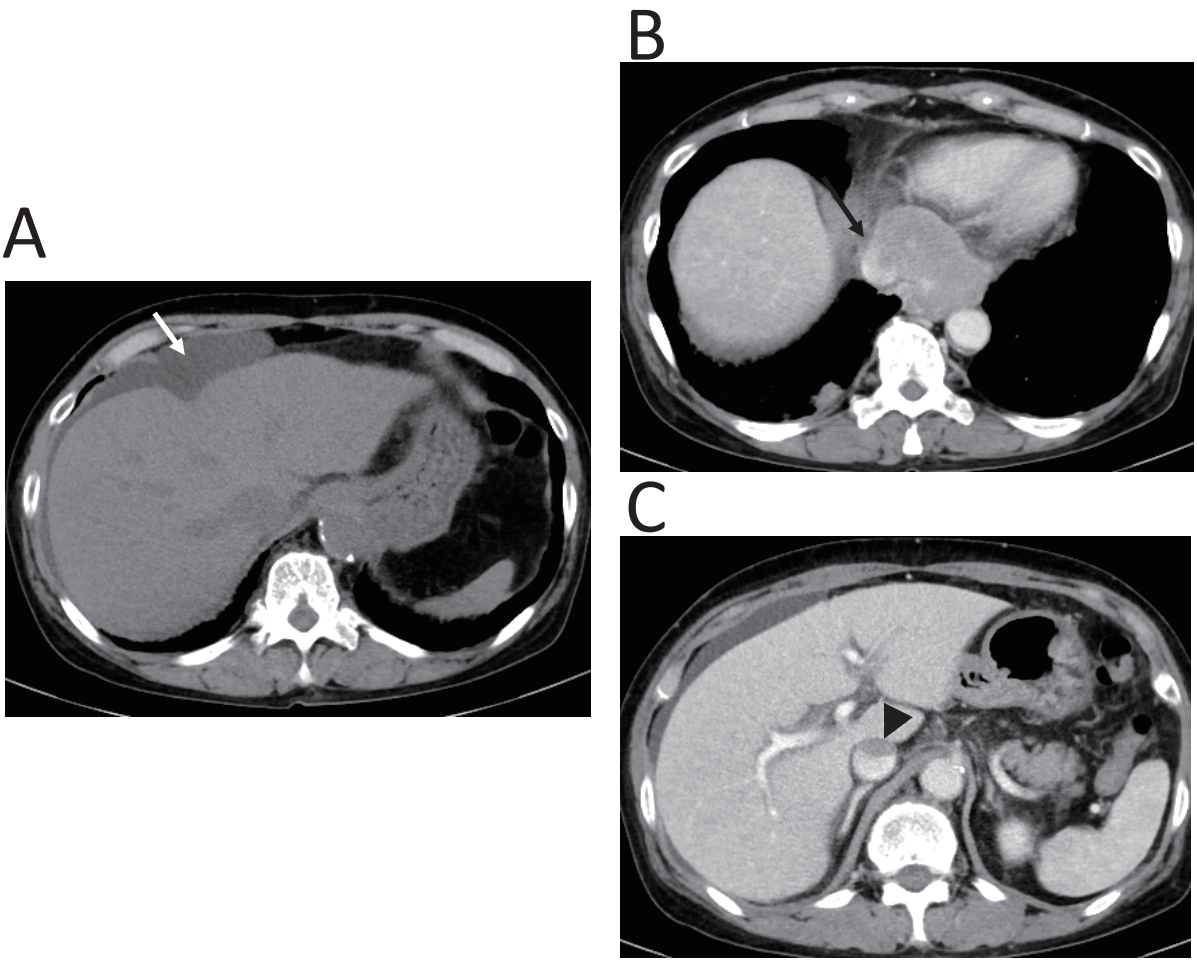

Fig. 1 Axial computed tomography (CT) images on the first CT examination using a single-energy CT scanner at 120 kV.
A. Pre-contrast CT image shows ascites of 10 HU around the liver (white arrow).
B. Contrast-enhanced CT (CE-CT) image with 120 s of scanning delay shows a large tumor thrombus (black arrow) in the suprahepatic inferior vena cava (IVC).
C. CE-CT image of the upper abdomen shows a periportal collar suspected of hepatic congestion. A low-attenuation area was found in the IVC at the hepatic level (arrowhead).

station (Siemens Healthcare).

On the second CT, CE-CT images with 180 s of scanning delay showed HAA at approximately 60 HU around the liver (Fig. 2A, B). However, VNC images revealed ascites with water density of 2HU (Fig. 2C, D). CT attenuations of spleen and bile fluid on VNC images were 45HU and 10HU. We presumed that HAA contained iodine because the attenuation of the ascites around the liver was similar to that of the spleen on the iodine map (Fig. 2E, F). These findings suggest that HAA was DEA caused by the ICM used on the first CT.

DISCUSSION

On CT, simple ascites generally measures 0–30 HU. Higher CT numbers can be seen in fluids containing protein, white blood cells or cellular debris, blood, and extravasated contrast material from the bowel or urinary tract [5]. An increasing CT number of the intraperitoneal fluid during a single CT examination has been reported in the presence of active bleeding or extravasation of contrast material from the bowel or urinary tract perforations [16–18]. Enhancement of ascitic fluid occurs in patients with a wide range of clinical conditions [5–9]. Previous reports have shown delayed enhancement with increases in attenuation of 7–90 HU [5–8], and the highest attenuation was seen in a patient with malignant peritonitis using a high dose of ICM [7]. Cooper *et al.* reported that fluid attenuation increased 25 HU on average, with a maximum increase of more than 50 HU [5]. However, the mechanism remains unclear [5]. The phenomenon probably results from increased vascular–peritoneal permeability due to abdominal disease or injury [5]. Ascitic enhancement on CT images of patients with tumors may result from the fragile neovascularity in peritoneal metastases with leakage of proteins and blood or may reflect the presence of tumor-produced vascular permeability factors [19, 20]. Cooper *et al.* reported that DEA occurred in both malignant and benign diseases and more likely occur when small amounts of ascites were present [5]. Benedetti *et al.* concluded that a short time interval between examinations, increased serum creatinine level, and presence of loculated ascites were independent predictors of the magnitude of DEA [6]. Delayed contrast enhancement in loculated ascites suggests that the inflammatory process leading to loculation also increases the permeability of the blood–peritoneum barrier [6]. In a previous study, no correlation was found between increased attenuation

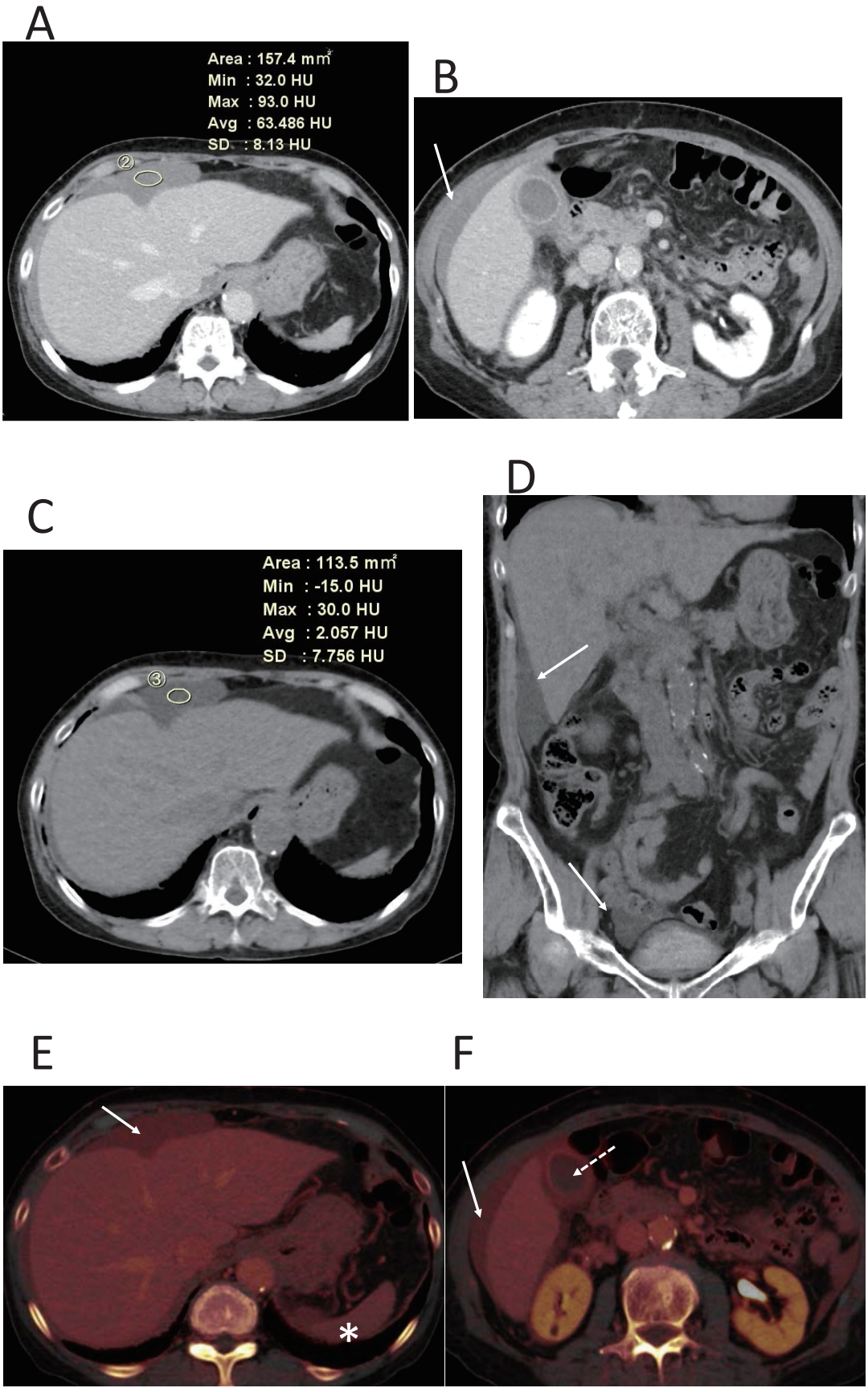

Fig. 2 Computed tomography (CT) images of the second CT examination by dual-energy CT
A. CE-CT images with 180 s of scanning delay shows ascites of 63 HU around the liver.
B. Density of ascites (arrow) indicates higher than that of the bile in the gallbladder.
C. Axial virtual non-contrast (VNC) image shows ascites of 2 HU around the liver.
D. Coronal VNC image shows low-attenuation ascites around the liver and pelvic floor (arrows).
E. The iodine map shows that the ascites (arrow) has almost the same attenuation with the spleen (asterisk).
F. The iodine map shows that the ascites (arrow) has higher attenuation than that of the bile in the gallbladder (dotted arrow).

and increasing time delays of 10–104 min [5]. This suggests that enhancement occurs chiefly within the first 10 min of contrast administration [5]. Previous studies have not described the relationship between ICM dose and DEA.

In the present case, the patient with advanced lung cancer did not have malignant peritonitis. Mild ascites may be caused by hepatic congestion due to IVC thrombosis. Her ascites was located around the liver and pelvic floor. Her serum creatinine level was not increased. Time interval between examinations was 4 h. The mechanism of DEA on our patient remained unknown; thus, DEA should not be misdiagnosed as active intraperitoneal bleeding or contrast extravasation. Unclotted extravascular blood usually has a measured attenuation of 30–45 HU and clotted blood is 45–70 HU by arterial hemorrhage [21]. HAA with 60 HU on our patient was higher as unclotted extravascular blood. Our case was not associated with arterial hemorrhage because of the clinical course. If there was intraperitoneal oozing hemorrhage, CT attenuation must not be increased by small amount of iodine and blood. Therefore, HAA on our patient was diagnosed as DEA because of clinical and CT image findings. Moreover, it is important for radiologists to check whether the previous CE-CT examination was performed or not when HAA was seen.

DE-CT is a promising imaging technique that provides better tissue characterization than single-energy CT [10–13]. Based on two synchronous CT acquisitions at different tube voltages, this technology allows the identification and visualization of materials that have different X-ray absorptions on low and high kV [11]. Two materials are best differentiated if such materials have a high difference in atomic numbers, such as iodine-based contrast agents and normal tissue. Iodine mapping is an image-processing technique used with DE-CT to improve iodine contrast resolution [22]. On iodine mapping, the ICM distribution can be displayed with color-coding. This makes it a suitable imaging method for diseases in which abnormal ICM accumulation needs to be visualized [22]. This feature enables virtual "subtraction" of the iodine content from a contrast-enhanced DE-CT image, resulting in a VNC image [13–15]. Toepker *et al.* reported that differences in attenuation values between VNC and true non-contrast (TNC) images were below 10 HU, and VNC images provided attenuation values close to those of TNC [13]. Attenuation differences of fluid between VNC and TNC ranged from 0. 7 HU to 2.6 HU [13]. On our patient, CT number of ascites was 60 HU on the VNC image. VNC images and iodine map can be used in the evaluation of renal or hepatic tumor and gastrointestinal bleeding [14, 15, 23]. Some authors suggested that VNC images can be used clinically in fluid-filled structures when TNC images are needed to determine presence or absence of enhancement, such as differentiating a hyperdense hemorrhagic or proteinaceous renal cyst from a renal cell carcinoma [24, 25].

To our knowledge, this is the first reported case of HAA due to iodine (DEA) that was accurately diagnosed using VNC image and iodine map. Further studies on DEA are needed, because its mechanism remained unknown in this case. DE-CT provided less radiation exposure, so it will become more useful in diagnosis, increasing the opportunities to encounter similar cases in clinical practice.

In conclusion, we presented a case of HAA due to iodine (DEA) without renal dysfunction. This case highlights the usefulness of VNC image and iodine map using DE-CT because HAA due to iodine could be distinguished from hemorrhagic ascites without the need for ascites puncture.

ACKNOWLEDGEMENTS

The authors thank Mr. Yoshida R and Mr. Sato Y for their technical assistance.

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