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Case Report

Inversion of excreted intravenous contrast-fluid levels in the urinary bladder on computed tomography

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ABSTRACT

Fluid–fluid levels occur on computed tomography due to differences in density between the 2 fluids. For example, intravenous (IV) contrast excreted into the urinary bladder layers posterior with gravity in the supine patient with normal, unopacified urine layering anterior, due to their differing densities. The rare presence of inverted fluid-contrast levels in the bladder calls attention to the existence of pathology such as microscopic hematuria, infectious debris, glycosuria, and purulent fluid. In such instances, the hypodense, non-opacified urine is the abnormality and is often only recognized due to the excreted IV contrast "floating" on top of it within the bladder. Here, we describe a case in which the development of inverted fluid-contrast levels in the urinary bladder on computed tomography during a patient's hospital stay heralded further investigation with urinalysis and urinary culture, with the known, worrisome causes able to be excluded.

Case report

A 22-year-old man with a history of Crohn's colitis complicated by sigmoid stricture necessitating a descending diverting loop colostomy 3 months prior presented to the emergency department with the sudden onset of abdominal pain, low-grade fever, and decreased stoma output over the course of one day. At the time of presentation, he was on postoperative day 7 from colostomy reversal and anterior resection of the rectum with diverting loop ileostomy.

His vital signs on arrival included a temperature of 36.6°C, heart rate of 131 beats per minute, blood pressure of 91/51, and normal oxygen saturation. Physical examination was unremarkable, including a left lower quadrant loop ileostomy that was pink and patent with gas and succus in the ostomy bag. Initial laboratory data revealed a mildly elevated white cell count of 13 with an otherwise normal complete blood count and basic metabolic panel, including normal creatinine. Urinalysis was normal. Computed tomography (CT) of the abdomen and pelvis was performed after intravenous (IV) injection of 100 mL of Omnipaque 350 (iohexol, GE Healthcare, Princeton, NJ) at a 70-second delay postcontrast administration, which demonstrated a large amount of ascites, pneumoperitoneum greater than expected for postoperative day 7 with no clear etiology, and a normal appearance of the urinary bladder (Fig. 1).

The patient was admitted to the hospital, hydrated, and started on empiric antibiotics for a presumed bowel perforation or leak. A repeat CT was performed approximately

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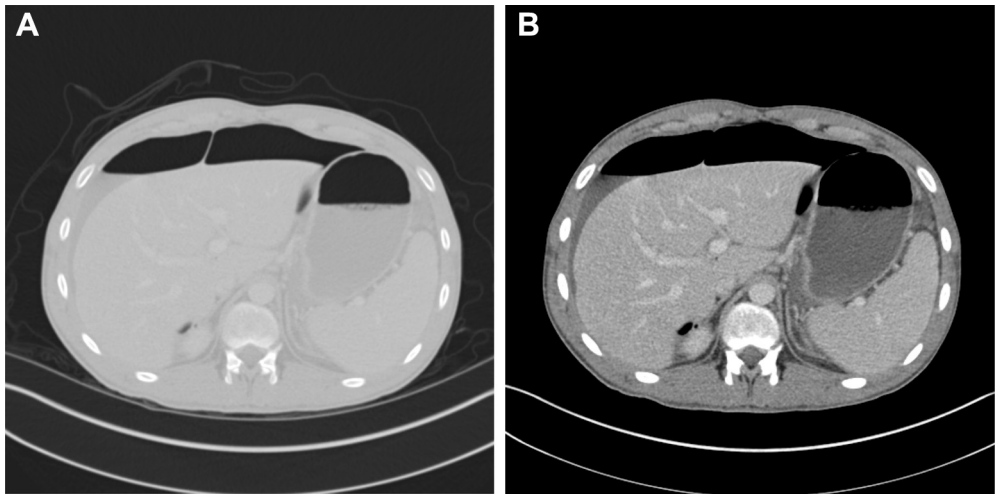

Fig. 1 – (A, B) Pneumoperitoneum and ascites. Axial IV-contrast-enhanced computed tomography demonstrates pneumoperitoneum (A) anterior to the liver and ascites (B) of uncertain etiology at the time of imaging.

10.5 hours later with oral contrast only to better evaluate for a site of leak. This CT showed unchanged ascites and pneumoperitoneum but no evidence of oral contrast leak from the bowel. At this time, the urinary bladder was completely opacified with contrast excreted from the recent IV contrast-enhanced CT (Fig. 2). Given the persistent ascites seen on CT and his leukocytosis, an ultrasound-guided paracentesis was performed. Along with the 80 mL of slightly blood-tinged peritoneal fluid that was aspirated, the ultrasound showed that the ascites was loculated (Fig. 3). The resulting cultures returned positive for *Streptococcus viridans* group, characteristic of *Streptococcus anginosus*.

The following day, approximately 33 hours after the initial IV-contrast-enhanced CT, a repeat IV contrast-enhanced CT with 100 mL of IV Omnipaque-350 with imaging again performed at a 70-second delay postcontrast administration was performed to specifically evaluate for underlying venous thrombosis as an etiology for the ascites. The CT revealed persistent ascites, pneumoperitoneum, and enhancement of the peritoneal lining. There was also marked interval diffuse thickening of the urinary bladder wall that contained persistent, residual excreted intraluminal contrast from the initial CT scan. However, instead of layering dependently within the bladder, the residual excreted contrast was seen floating on top of the hypodense urine (Fig. 4). Given the new, abnormal bladder findings of both wall thickening and inversion of expected contrast-urine layers, a repeat urinalysis was recommended, which was now positive for ketones (>80 mg/dL), protein (15 mg/dL), and red blood cells (5-9/high powered field), all of which were previously normal.

Due to the significant increase in ketonuria and concern for malnutrition, an albumin level was ordered and returned low at 2.8 g/dL. The patient was started on a full liquid diet. He continued to receive antibiotics and his clinical status, including fever and leukocytosis, began to improve. His abdominal distension resolved and at the time of discharge, the patient was stable and tolerating a low residue diet. During

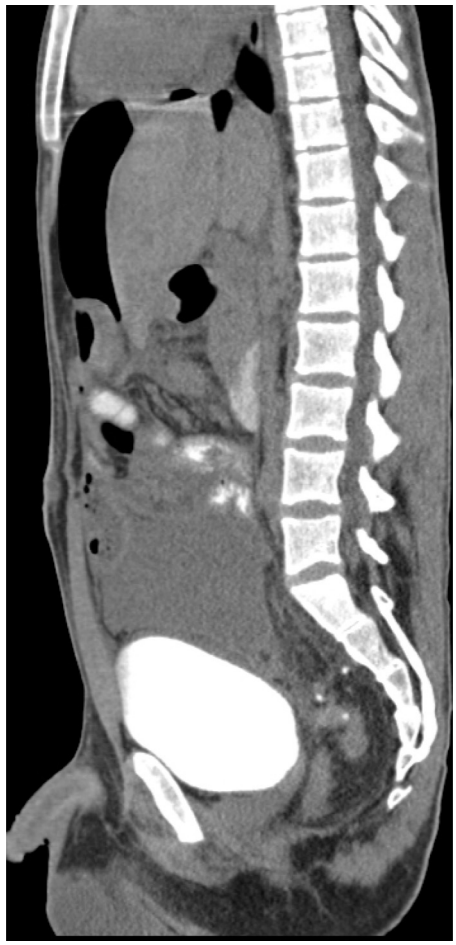

Fig. 2 – Opacified urinary bladder with excreted contrast. Oral contrast-enhanced computed tomography performed over 10 hours after the initial IV contrast-enhanced computed tomography, which demonstrates persistent upper abdominal pneumoperitoneum, ascites, and excreted IV contrast opacifying the urinary bladder.

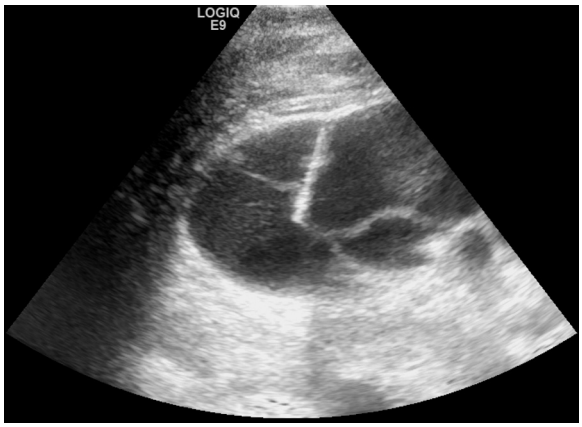

Fig. 3 – Loculated ascites. Grayscale ultrasound images from the paracentesis show that the ascites was not simple, anechoic fluid, and contained loculations.

his follow-up clinic appointment 1 week later, the patient had no concerns and reported normal ileostomy output.

Discussion

Fluid–fluid levels are commonly seen in radiology and are due to differences in density between the 2 fluids, allowing the fluids to separate into distinct layers. Many types of contrast are injected or ingested in cross-sectional imaging, which can create fluid–fluid levels with physiologic or abnormal fluid within the body that can yield useful diagnostic information. Fluid-contrast levels are most frequently seen in the urinary bladder, stomach, and occasionally gallbladder, with the contrast-laden fluid typically having a higher specific gravity compared to the usual simple fluid within the organ (urine, bile, and ingested water) and thus layering dependently on a cross-sectional study. To the authors' knowledge, inversion of normal contrast-fluid levels in organs other than the renal collecting system and urinary bladder has not been reported in the literature. This is likely because contrast-fluid layers will occur consistently only when the fluids in question meet specific criteria within a hollow organ. First, there must be enough time to allow for the contrast and physiologic fluid to separate and layer. Second, there needs to be a relative lack of motion so that the layering is not disturbed, which usually occurs during peristalsis in normal bowel, gallbladder contraction, or moving blood within blood vessels. Since IV contrast used for CT is nearly exclusively excreted by the kidneys, contrast-fluid levels frequently occur within the collecting system or bladder with contrast layering posteriorly. Inversion of this has been previously reported [1–5]. In cases of renal dysfunction, excreted contrast is occasionally seen within the gallbladder and is a normal finding on magnetic resonance imaging scans performed with Eovist (Gd-EOB-DTPA, Bayer, Whippany, NJ) due to partial biliary excretion of the

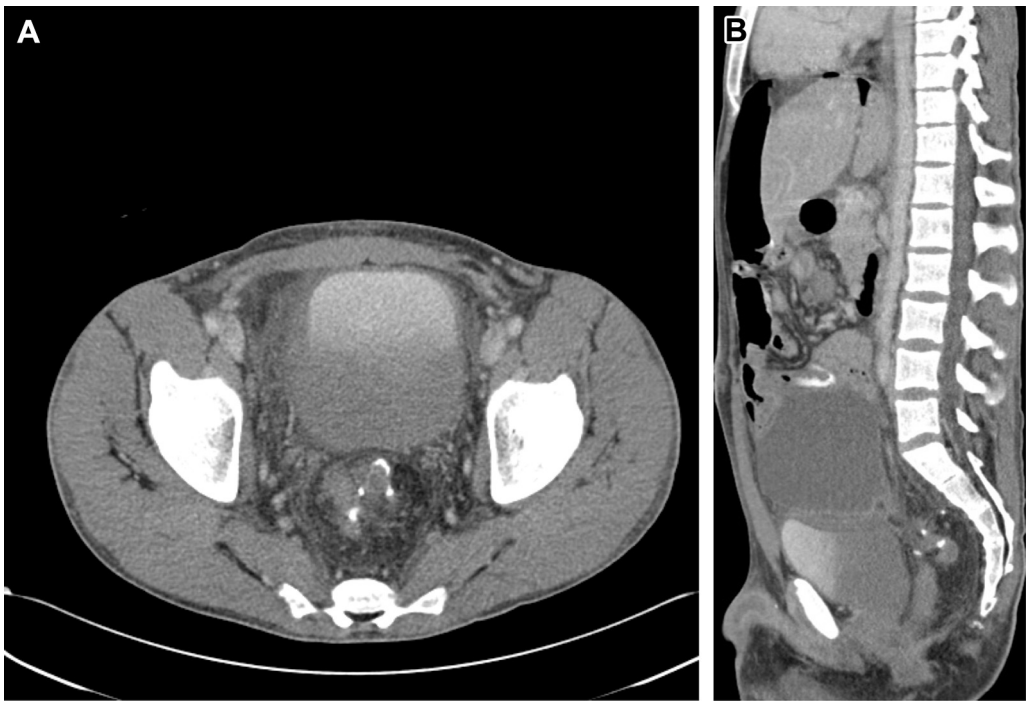

Fig. 4 – (A, B) Inverted contrast-urine levels within the bladder. Axial (A) and sagittal (B) computed tomography performed over 30 hours after the initial IV contrast bolus, demonstrates persistent excreted contrast in the urinary bladder. In addition, the contrast does not settle to the dependent portion of the bladder as is usually seen but instead layers anterior above the hypodense urine. Peritoneal enhancement and bladder wall thickening are now present along with persistent ascites and pneumoperitoneum.

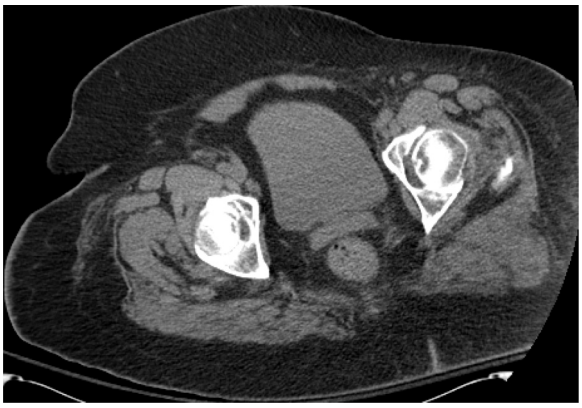

Fig. 5 – Artifactual fluid–fluid levels in the urinary bladder. On this noncontrast computed tomography scan, there is an apparent fluid–fluid level in the urinary bladder, where the fluid anterior is denser than the fluid posterior. However, this was a noncontrast scan, urinary analysis was unrevealing, and the fluid levels layer with the hips instead of with gravity suggesting that the findings are artifactual.

agent. No articles specifically report on the expected layering order of these excreted contrast materials in relation to bile, which may be due to the variable viscosity and density of unopacified bile, so that no "normal" layering order is expected. The use of Eovist has also been reported as a possible modality for evaluating bile duct leak, but as in the gallbladder, layering within an adjacent collection would be dependent on time, stasis, and most importantly, the contents of the fluid that it is collecting within, which is likely variable [6,7]. Contrast also is used in the gastrointestinal tract. However, the presence of layering would rely on the contents already present, lack of peristalsis, and the type of contrast used, which varies between institutions. Thus, no standard layering order can be expected. Contrast-blood levels have also been reported within blood vessels and the heart in cardiogenic and/or shock patients with contrast layering dependently, instead of the usual mixing occurring [8–10]. However, to our knowledge, no articles have reported a reversal of these layers.

The rare presence of inverted fluid-contrast levels in the urinary bladder, where the hyperdense contrast instead layers anteriorly over the dependent, hypodense fluid, is a pathologic finding and is seen in only a few etiologies described in the literature, including microscopic and/or infectious debris [1–3], purulent fluid [5], glycosuria [4], mucous threads, and microscopic hematuria [11]. This phenomenon, interestingly, has also been documented in canines [12].

It is important to note that in such cases, the hypodense urine is the abnormality but is only recognizable by the excreted contrast floating on top of it. As was seen in our patient, the Hounsfield units (HU) of the dependent "normal-appearing hypodense" urine layer is often elevated above that expected of simple urine (35 HU for example, in our patient) due to the abnormal composition that causes this to be heavier than the excreted IV contrast. If seen, a urinalysis with culture should be performed, as the contrast-fluid inversion may be the first signal that an abnormality is occurring within the bladder and/or kidneys.

It should be noted that this sign in its subtle forms can also be artifactual, due to the density of the pelvic bones creating the appearance of an inverted fluid–fluid level in the bladder due to the higher amount of radiation required during CT to penetrate the pelvic bones (Fig. 5). If the patient is slightly rotated, this phenomenon will not layer with gravity but instead follow the positioning of the hips.

In this case, several bladder abnormalities were present on the final CT that warranted further investigation with a urinalysis and culture, including inverted contrast-fluid levels, retained contrast in the bladder from a CT performed over one day prior, and new bladder wall thickening. In our case, the urinalysis was not revealing for any of the known entities to cause contrast-fluid inversion, which was reassuring. Initially, it was unclear why the patient had retained contrast in his bladder when his last contrast-enhanced CT scan was performed 33 hours prior. Overall, his urine output during this time period was at the low end of normal (51 mL/h with normal range for a patient of his size being 43-72 mL/h), despite rigorous IV hydration. This suggests intravascular depletion and diminished urine output overall. In fact, the patient over this time period urinated approximately 7 times with small reported volumes. In addition, the patient was receiving morphine, a well-known cause of urinary retention. His urinary output coupled with possible urinary retention, likely account for the continued presence of contrast in the bladder, but may not account for the abnormal unenhanced urine layering posteriorly.

Acknowledgment

None.

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