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A Case with Nutcracker Syndrome (NCS) with Intestinal Compression by Three-Dimensional Computed Tomography (3D-CT) Reconstruction

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Abstract

Authors have continued radiological research for the application of three-dimensional computed tomography (3D-CT) using Synapse Vincent, Japan. The patient was a 51-year-old female with bilateral flank pain. For plain and contrasted CT scan, artery and portal late phases showed possible nutcracker syndrome (NCS) or renal vein entrapment syndrome. 3D-CT images suggested that i) there was a clear relationship between the superior mesenteric artery (SMA) and inferior vena cava (IVC), ii) a collateral vessel for the left ovarian vein (LOV), and iii) compression of the small intestine on the left renal vein (LRV). Thus, her pathophysiological mechanism was probably supposed by the 3D-CT reconstruction technique method.

Keywords

Nutcracker Syndrome, Three-Dimensional Computed Tomography, Synapse Vincent, Left Renal Vein, Left Ovarian Vein

Abbreviations

NCS: Nutcracker Syndrome; 3D-CT: Three-Dimensional Computed Tomography; LRV: Left Renal Vein; LOV: Left Ovarian Vein

Introduction

In the radiologic development worldwide, the application of three-dimensional computed tomography (3D-CT) has been observed using Artificial Intelligence (AI) [1,2]. Various types of 3D-CT have been generated for several purposes for diagnosis and pre-/post-operative evaluation [3]. Among them, some software have been useful and rather easier to operate on a computer to create images according to the segmentation [4]. Among them, understanding the detailed patterns of blood vessels would be crucial for various diagnoses and treatments [5].

For such situations, authors and colleagues have continued research and reported a variety of images for clinical practice. We have used the reconstruction of 3D-CT using Synapse Vincent, Japan [6]. They included a small nodule of pulmonary lesion, Curved Planar

Reconstruction (CPR) of pancreatic tumor, and vertebrae changes with low back pain (LBP) [7,8]. By these high-quality techniques of Synapse Vincent, clinical benefits have been obtained for detailed evaluation. We have experienced a female case with abdominal pain, who received a CT scan with AI reconstruction and was diagnosed as Nutcracker Syndrome (NCS) and related pathophysiology. Her general progress and perspectives are described in this article.

Case presentation

The patient was a 51-year-old female. When she was 41 years old, her husband died of pneumonia, and then she was diagnosed with depression with anti-depressant treatment for 3 years. Since April 2024, she occasionally experienced pain from the chest to the abdomen on both sides. In December 2024, she had bilateral lower back pain that lasted for a week and visited the hospital. At the initial consultation, her medical history showed that she had undergone menopause, and she had not experienced any abnormal bleeding.

As her physicals, vital signs were BP 128/74, pulse 90/min, SpO_2 99%, and weight 63.4 kg. There were no abnormalities in her speech, consciousness, head, neck, or chest. Her abdomen was flat and soft, her bowel sounds were normal, and she had no tenderness. The pain did not move or radiate, without fever or other symptoms. The cause of the pain was not apparent, including foci of liver, biliary tract, pancreas, colon, kidney, urinary tract, gynecology, or lumbar spine.

Blood chemistry in December 2024 was as follows: AST 41 U/L, ALT 31 U/L, GGT 41 U/L, BUN 12 mg/dL, Cre 0.63 mg/dL, eGFR 77 mL/min/1.73m^2, LDL 162 mg/dL, HDL 57 mg/dL, TG 178 mg/dL, glucose 91 mg/dL, HbA1c 5.5%, CRP <0.05 mg/dL, RBC 443 x 10^4/μL, WBC 74 x 10^2/μL, Hb 13.4 g/dL, Plt 39.9 x 10^4/μL, urinalysis urobilinogen (+/-), glucose (-), protein (+), occult blood (+), pH 6.

Several Exams

For further evaluation, plain and contrasted abdominal CTs were conducted in December 2024 (**Fig-1A**, **Fig-1B**). Artery phase (35s) and portal late phases (100s) showed possible nutcracker syndrome (NCS). The internal structure of the cervix was unclear, and it was a low-density area. Based on the results of CT scans, NCS was also considered as a differential diagnosis on the images. However, it would be rather difficult to make a clear diagnosis, because the collateral circulation was developed with a chronic situation.

A detailed gynecological examination was also performed in January 2025. Pelvic examination and transvaginal ultrasound were performed at the gynecology department, but no particular abnormalities were found. A cervical cytology test was also submitted,

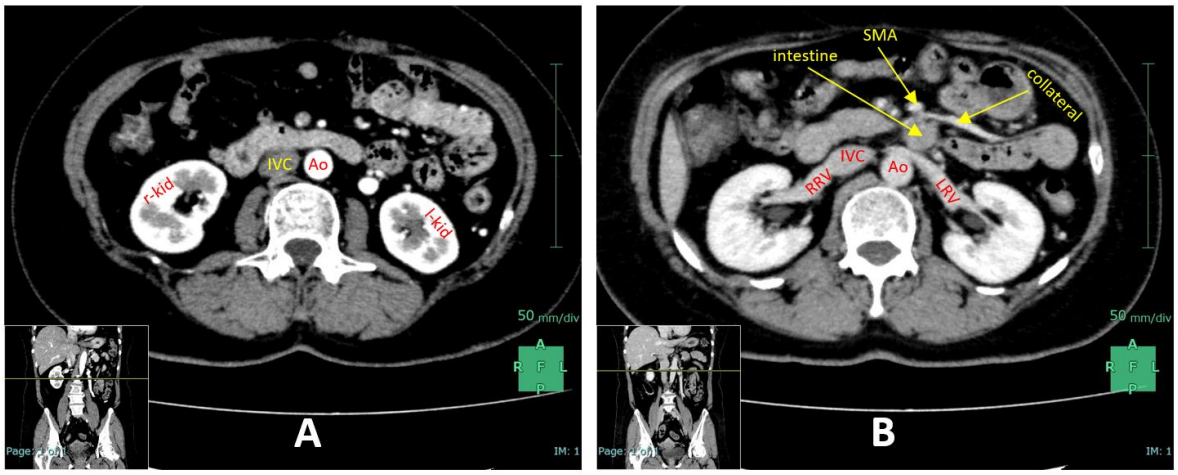

Fig-1: Abdominal Contrast CT Scan

A: Artery phase (35s) shows dense stain of aorta (Ao), inferior vena cava (IVC), right kidney (r-kid) and left kidney (l-kid).

B: Portal late phase (100s) shows possible nutcracker syndrome (NCS). Left renal vein (LRV) may be compressed by aorta (Ao) and superior mesenteric artery (SMA). Between them, small intestine can be found. Dilated collateral blood vessel is observed, which suggests the influence by the compressed left ovarian vein (LOV).

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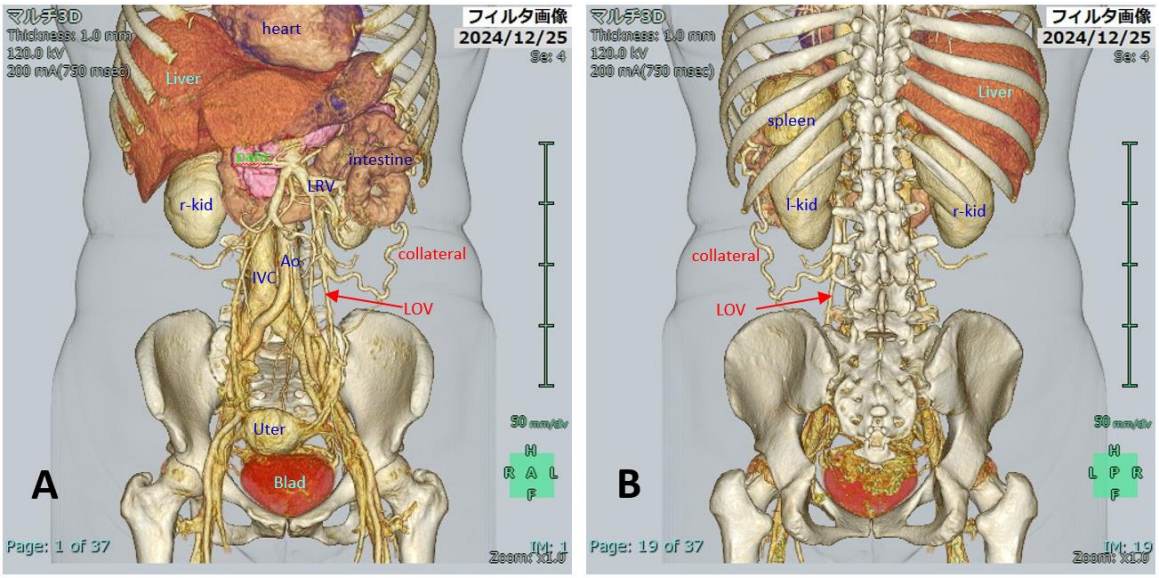

Fig-2: Reconstruction of Abdominal CT by Synapse Vincent

A: Anterior angle: Compressed left renal vein (LRV) brings the development of the collateral vessel connecting to the left ovarian vein (LOV). When adding the image of small intestine, it may show the compression point of the LRV, which causes the dilatation of the collateral vessel.

B: Posterior angle: This image can present the mutual position and relationship among visceral organs and blood vessels.

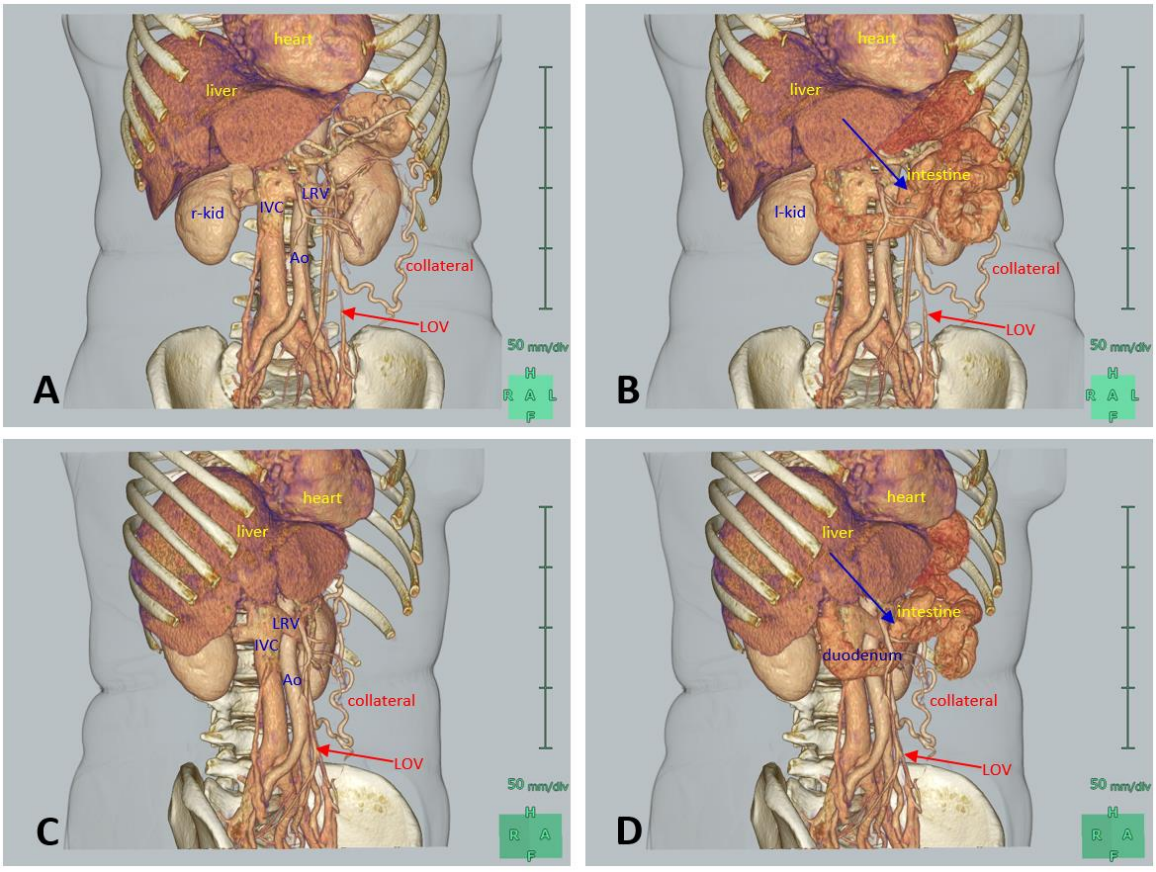

Fig-3: CT Reconstruction with/without the Images of Intestine

A: Anterior aspect: left renal vein (LRV) can be clearly observed.

B: Adding the image of intestine, the arrow shows probable compression point by the presence of small intestine.

C: Oblique aspect: LRV connects to IVC. This image is clearly observed.

D: This image shows the compression of small intestine on LRV, and the 3rd portion of duodenum.

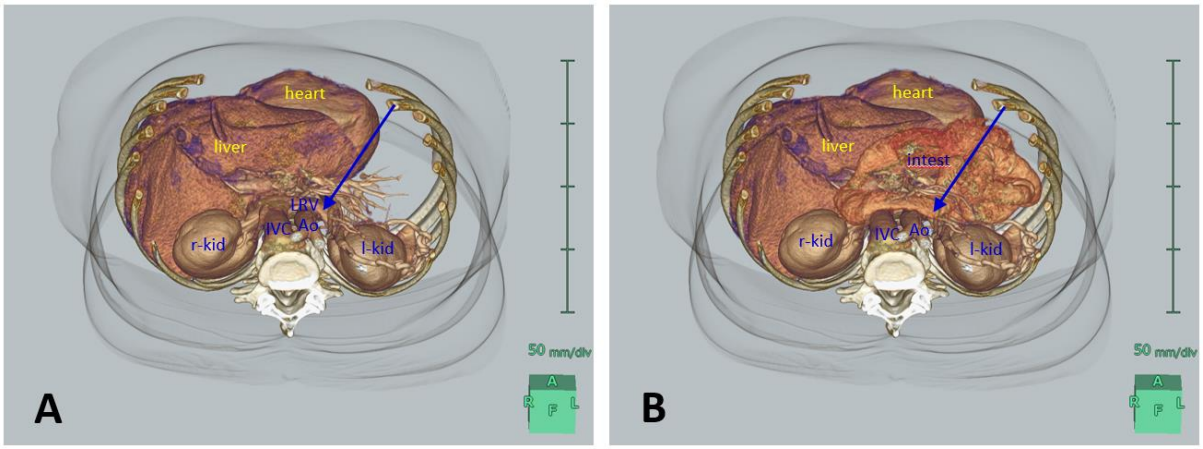

Fig-4: CT Reconstruction with/without the Images of intestine

A: The image without intestine may suggest possible compression point on the LRV.

B: The image with intestine shows probable compression point of the small intestine on the LRV.

but no particular abnormalities were found. Endometriosis is certainly included as a differential diagnosis, but it is not actively suspected. In February 2025, an examination of the upper and lower digestive tract was performed, but no abnormalities were found.

3D-CT Reconstruction

This case underwent plain and contrasted CT scan in December 2024. From these data, 3D-CT reconstruction was conducted using Synapse Vincent (Fuji Inc., Japan). The anterior and posterior angles of 3D-CT reconstruction showed probable compression by the presence of the small intestine on the left renal vein (LRV) (**Fig-2**). By the comparison between the images with/without the intestine, the oblique aspect made the apparent situation that the small intestine is involved in the compression on LRV (**Fig-3**). CT reconstruction can detect the point that the small intestine gives oppression on the LRV (**Fig-4**).

Discussion

In this case, back pain and lower abdominal pain were observed, and various possibilities were suggested during the detailed examination. These included urinary tract stones, nutcracker syndrome (NCS), compression of the abdominal aorta due to ossification of the anterior cruciate ligament of the lumbar spine, and compression by the small intestine. By using the 3D-CT construction that we have been using, we can add each organ in three dimensions in various layers. These layers were 1) artery, 2) artery + vein, 3) artery + vein + pancreas, 4) artery + vein + small intestine, 5) artery + vein + pancreas + small intestine, 6) arterial phase axial image (confirmation of the left ovarian vein), and 7) portal vein late phase axial image (the small intestine is located between SMA and LRV).

By using these 3D-CT reconstructions, the presence of the small intestine was confirmed between the SMA and LRV in the portal vein late phase axial image. This caused compression, which led to the retention of blood flow in the LRV, and this led to the collateral vein from the left ovarian vein (LOV). This was made possible by the comparative analysis and comprehensive judgment of the seven types of images mentioned above as part of the work process.

Nutcracker syndrome (NCS) or left renal vein entrapment syndrome has been symptomatic compression of the LRV [9]. It is often observed between the aorta and SMA. Its clinical manifestation is variable, including hematuria, flank pain, proteinuria, varices, varicocele, dysmenorrhea, tachycardia, or hypotension. NCS sometimes results in crucial morbidity, such as venous thrombosis or chronic kidney disease (CKD). The term NCS was first established in 1972 by de Schepper to refer to the compressive situation on LRV, abdominal aorta, and SMA [10]. The precise prevalence of NCS remains unknown, but approximately 4% of cases may be present in patients with hematuria.

NCS has been a rather uncommon vascular dysfunction that involves compression of the LRV. It

results in variable symptoms such as flank pain, hematuria, pelvic congestion, and varicocele [11]. NCS has anterior and posterior types according to the origin of the LRV compression situation [12]. NCS represents symptomatic compression of the LRV between the aorta and SMA. Although asymptomatic compression is found rather commonly in radiological exams, cases with NCS develop a variety of symptoms. No specific diagnostic criteria have been reported and then, a 3-stage modified Delphi consensus has been tried [13].

When venous outflow via the LRV into the IVC is reduced, it may develop reno-venous hypertension. Further, it can cause venous collateral development, incompetence, or retrograde flowing, where it may affect secondary influence on the lower limbs and pelvis [14]. Regarding NCS, a retrospective review was conducted for 38 cases over 12 years [15]. Among them, 21 (55%) showed symptoms of abdominal pain, flank pain, fatigue, and hematuria. The remaining 17 cases (45%) showed the nutcracker phenomenon. Within the cases diagnosed with NCS, 11 cases received the operation of transposition of the LRV. Then, 10 cases showed improvement of NCS symptoms. Consequently, transposition of the LRV seemed to be effective for NCS treatment. No operative follow-up would be needed for cases with less severe symptoms.

Certain limitations may exist. This case was diagnosed as nutcracker syndrome (NCS) associated with the involvement of small intestine compression of the left renal vein (LRV). This pathophysiology was detected by the technique of 3D-CT reconstruction. There may be other possible associated mechanisms in the abdomen. In summary, a 51-year-old female developed abdominal pain and back pain. From history and 3D-CT reconstruction, NCS with intestine involvement was diagnosed. The current impressive case will become a useful reference in the fields of gastroenterology and radiology in the future.

Conflict of Interest

The authors have read and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

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