**Original Research**

# Cisterna Chyli in Patients With Portal Hypertension: Evaluation With MR Imaging

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**Purpose:** To evaluate the difference in the caliber of cisterna chyli between patients with and without portal hypertension on magnetic resonance imaging (MRI) and to assess the alteration of the caliber of cisterna chyli related to contraction waves during serial T2-weighted MRI.

**Materials and Methods:** This study included 177 patients with and without portal hypertension who underwent two sets of T2-weighted MRI. MR images were evaluated for the visibility of cisterna chyli, the difference in the diameter of cisterna chyli between two patients groups, and the alteration in the diameter of cisterna chyli during serial T2-weighted MRI.

**Results:** The mean maximal diameter of cisterna chyli in patients with portal hypertension (4.97 ± 1.87 mm, range; 2.5–13.1 mm) was significantly larger ($P < 0.001$) than that in patients without portal hypertension (3.37 ± 1.25 mm, range; 1.5–6.8 mm). In 132 patients with visible cisterna chyli and portal hypertension, 25 (19%) patients had a positive caliber change of cisterna chyli of more than 2 mm between two sets of T2-weighted MR images.

**Conclusion:** The dilatation of cisterna chyli can be demonstrated at MRI in patients with portal hypertension. Additionally, the positive caliber change of cisterna chyli related to contraction waves was observed in subsets of patients during serial T2-weighted MRI.

**Key Words:** cisterna chyli; portal hypertension; MRI; contraction wave
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THE CISTERNA CHYLI is a dilated sac at the lower end of the thoracic duct seen in the retrocrural space. It is located to the right of the aorta and anterior to the first and second lumbar vertebrae (1). The normal appearance of the cisterna chyli on ultrasound, computed tomography (CT), and lymphangiography has been described previously (1,2), and lymphangiographic study has demonstrated that the caliber of the cisterna chyli can be altered by contraction waves during a consecutive filming (3). Magnetic resonance imaging (MRI) with heavily T2-weighted sequences can visualize fluid components in the body, including lymphatic channels, as bright structures against a dark background. Recently, some investigators have reported that MRI can depict the cisterna chyli with much greater incidence than was reported for CT and lymphangiography by using highly fluid-sensitive sequences such as heavily T2-weighted fast spin echo sequences (4,5). However, the changes in the caliber of the cisterna chyli due to contraction waves during the examinations have not yet been evaluated by cross-sectional imaging.

The thoracic duct is a continuation of the cisterna chyli from its abdominal segment into the thorax, entering through the aortic hiatus of the diaphragm. Numerous reports have described the normal anatomy and appearances of the thoracic duct on imaging modalities (6–10). Additionally, thoracic duct dilatation has been demonstrated in hepatic cirrhosis and portal hypertension by lymphangiography, ultrasound, and at autopsy (11,12). Recently, dilatation of the cisterna chyli has been demonstrated in patients with uncompensated cirrhosis at MRI (13). However, there have been no reports concerning the relationship between portal hypertension and the dilatation of the cisterna chyli connecting the thoracic duct. The purpose of this study was to evaluate the difference in the caliber of the cisterna chyli, which is the origin of the thoracic duct, between patients with and without portal hypertension on MR images, and to assess whether the alteration in the caliber of the cisterna chyli related to contraction waves can be observed during the serial T2-weighted MRI.

## MATERIALS AND METHODS

### *Patients Population*

This retrospective study received approval from our Institutional Review Board, which waived the requirement for informed consent from individual patients.

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Our hospital MR records between February 2005 and December 2006 were searched to identify cirrhotic patients with portal hypertension and patients without chronic liver diseases who underwent superparamagnetic iron oxide (SPIO)-enhanced MRI of the liver. Among these, the following patients were eligible for enrollment in this study; 1) the protocol of SPIO-enhanced MRI was completed, including heavily T2-weighted fast spin echo (FSE) images and two sets of T2-weighted FSE images (before and after injection of contrast materials) with fat suppression obtained with identical imaging parameters; 2) SPIO-enhanced MRI and multiphasic contrast-enhanced dynamic helical CT were performed with an interval of at least 3 months; and 3) any signs of portal hypertension (eg, development of collateral pathways and splenomegaly) and cirrhosis (eg, enlargement of hilar periportal space, expanded gallbladder fossa sign, and/or liver surface nodularity) were observed at contrast-enhanced dynamic CT or SPIO-enhanced MRI for cirrhotic patients with portal hypertension. Patients with a history of the therapy for portal hypertension were excluded from this study. Finally, this study population consisted of a total of 177 patients, including 139 patients with portal hypertension and 38 patients with no portal hypertension and no clinical evidence of chronic liver diseases. The patients' population consisted of 97 male patients and 80 female patients with a mean age of 67 years (range, 25–86 years). Clinical MR indications for the 139 cirrhotic patients with portal hypertension used in the final analysis were as follows: further evaluation of hepatic nodules suspected with other imaging modalities or screening examination of hepatic lesions. The origin of cirrhosis was as follows: viral infection (hepatitis B [$n = 18$] or C [$n = 87$]), alcohol abuse ($n = 9$), primary biliary cirrhosis ($n = 1$), cryptogenic ($n = 1$) and undetermined due to insufficient clinical data ($n = 23$). Patients without portal hypertension had been referred for MRI for reasons other than chronic liver diseases (eg, preoperative evaluation for liver metastasis in patients with malignancies).

### *MRI Techniques*

MRI was performed with a 1.5-T system (Magnetom Vision; Siemens Medical System, Erlangen, Germany) using a phased-array torso coil. The patients were asked to fast for at least 8 hours before examination. As a part of routine liver MR examination, heavily T2-weighted FSE images (TR/TE = 4000/259) were obtained during suspended respiration. Then, T2-weighted FSE images (TR/TE = 3800/93) with fat suppression were obtained before and after administration of contrast materials using identical imaging parameters. The remaining imaging parameters were as follows: a section thickness of 8 mm, an interscan gap of 2 mm or less, an image matrix of 160–192 × 256 and a rectangular field of view optimized for each patient's body habitus with the largest dimension of 30–40 cm. Parallel imaging techniques were not applied. After obtaining unenhanced T2-weighted MR images, SPIO (Ferucarbotran, Bayer, Osaka, Japan) was administered at a dose of 8 μmol of iron per kg of body weight. SPIO was administered as a rapid bolus by the hand injection method and was immediately followed by a saline solution flush of 15–20 mL at a rate of ≈2 mL/s. SPIO-enhanced T2-weighted MR images were obtained about 30 minutes after the SPIO administration.

### *Imaging Interpretation*

All examinations were interpreted by two radiologists experienced in abdominal MRI (18 years and 15 years) without knowledge of the final diagnosis; any interpretation discrepancies were resolved by consensus. All cases were reviewed randomly on clinical imaging viewers (imageVINS, Yokogawa Electric, Tokyo) without providing the patients' clinical information. The images were magnified and electronic calipers were used for measurements. MR images were evaluated for 1) visibility of the cisterna chyli; 2) the difference in the diameter of the cisterna chyli between patients with and without portal hypertension; and 3) alteration in the diameter of the cisterna chyli during the serial T2-weighted MRI. The cisterna chyli was considered identifiable when a rounded or oval tubular structure with high signal intensity similar to that of cerebrospinal fluid in the prevertebral region below the diaphragm was visible in the retrocrural space on the heavily T2-weighted MR images and was found on three or more sequential sections. The maximal transverse diameter of the cisterna chyli was measured on two sets of T2-weighted FSE images obtained before and after administration of SPIO at the same level to determine whether the alteration in the caliber of the cisterna chyli can be demonstrated during a serial T2-weighted MRI. An alteration in the maximal transverse diameter of the cisterna chyli of more than 2 mm between two sets of T2-weighted FSE images was considered positive for the caliber change related to contraction waves of the cisterna chyli. Furthermore, data analysis was performed to establish whether the maximal diameter of the cisterna chyli was correlated with the severity of portal hypertension. In this study patients with portal hypertension were divided into three groups; 1) mild group, patients with the development of a small collateral pathway (<2 mm) (eg, spotty esophageal varix on CT); 2) moderate group, patients with the development of a moderate size of collateral pathway (≥2 mm, ≤5 mm) or two small collaterals (eg, spotty esophageal varix and small paraumbilical vein); 3) severe group, patients with the development of a large size of collateral pathway (>5 mm) or multiple collaterals with splenomegaly.

Statistical analysis was performed using unpaired Student's *t*-test for the comparison among each patient group. For the prevalence of the positive caliber change of the cisterna chyli a chi-square test was used. $P < 0.05$ was considered significant.

## RESULTS

The cisterna chyli was observed in 36 (95%) of the 38 patients without portal hypertension, while it was

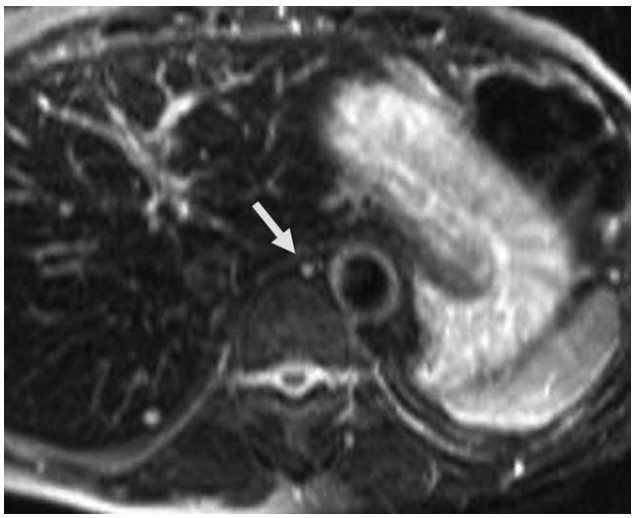

**Figure 1.** T2-weighted MR image (TR/TE = 3800/93) shows the normal cisterna chyli (arrow) with high signal intensity in the retrocrural space.

seen in 132 (95%) of the 139 patients with portal hypertension, showing no statistically significant difference in the frequency of the visible cisterna chyli between these two groups (Fig. 1). The mean maximal transverse diameter of the cisterna chyli in patients with portal hypertension (4.97 ± 1.87 mm, range; 2.5–13.1 mm) was significantly larger ($P < 0.001$) than that in patients without portal hypertension (3.37 ± 1.25 mm, range; 1.5–6.8 mm). Regarding the severity of portal hypertension in 139 patients, 46 were classified as having mild, 48 patients as having moderate, and 45 patients as having severe portal hypertension. In the mean maximal transverse diameter of the cisterna chyli, there were no significant differences among patients with mild (4.92 ± 1.69 mm), moderate (5.01 ± 1.61 mm), or severe portal hypertension (4.99 ± 2.30 mm).

In 132 patients with portal hypertension and visible cisterna chyli, 25 (19%) patients had a positive caliber change of the cisterna chyli of more than 2 mm between two sets of T2-weighted FSE images (6 patients with mild, 8 with moderate, and 11 with severe portal hypertension) (Fig. 2). Conversely, in 4 (11%) of 36 patients having visible cisterna chyli without portal hypertension, a positive alteration in the diameter of the cisterna chyli of more than 2 mm was observed between two sets of T2-weighted FSE images. With regard to the prevalence of the positive caliber change of the cisterna chyli during serial T2-weighted FSE imaging, however, there was no significant difference between patients with and without portal hypertension ($P = 0.27$). The change in diameter of the cisterna chyli was random, regardless of first or second set of T2-weighted imaging.

## DISCUSSION

This study showed that the cisterna chyli can be detected with high frequency (95%) by MRI in patients with and without portal hypertension, compared with previously reported visibility on lymphangiography (30%–53%) (3) and CT (1.7%) (2). Our result in MR detectability of the cisterna chyli agrees with those of Erden et al (4). High contrast and high signal intensity provided by heavily T2-weighted MR images yielded a high incidence of visualization of the cisterna chyli without confusing it with small vessels and lymph nodes in the retrocrural space or other retroperitoneal fluid containing organs (4,5,13). High frequency in MR detection of the normal cisterna chyli validates

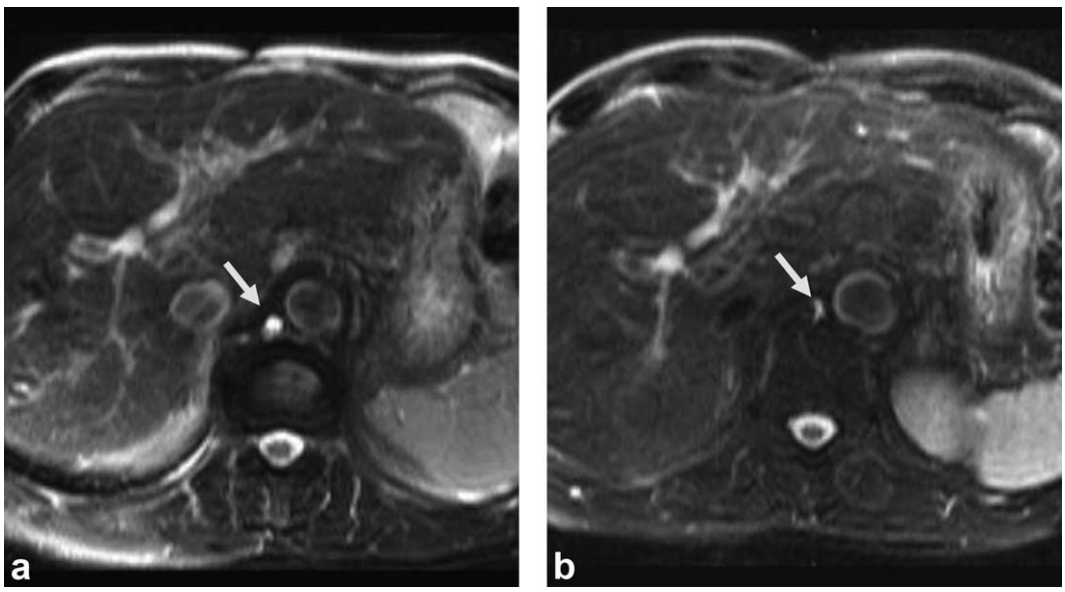


**Figure 2.** Serial T2-weighted MR images (TR/TE = 3800/93) in patients with portal hypertension. A positive caliber change (arrows) of the cisterna chyli of more than 2 mm was observed between two sets of T2-weighted FSE images (**a**: after SPIO administration, and **b**: before SPIO administration).

the use of MR measurements in this study to evaluate the alteration in the diameter of the cisterna chyli.

In this study the mean maximal diameter of the cisterna chyli in patients with portal hypertension was significantly larger than that in patients without portal hypertension. More than 80% of the lymph from the liver is drained by collecting lymphatic vessels that run along the portal triad (4). These collecting lymphatic vessels eventually drain into the cisterna chyli. Additionally, the cisterna chyli is supplied by the two lumbar lymphatic trunks, right and left, and the intestinal lymphatic trunk, which receives the lymph from the stomach and intestine, and from the pancreas and the spleen. In the portal hypertensive state, any rise in pressure in the portal system will induce an increased lymph production from the liver, stomach, small bowel, and colon which drains into the cisterna chyli (14,15). Therefore, it will be reasonable that the size and flow capacity of the cisterna chyli could be increased in patients with portal hypertension, inducing ductal dilatation of the cisterna chyli. Our results are supported by a study that the dilated cisterna chyli was significantly more frequent in uncompensated cirrhotic patients who tended to be accompanied with portal hypertension, compared with control subjects and patients with compensated cirrhosis (13).

Regarding the relationship between the severity of portal hypertension and the size of the cisterna chyli, there were no significant differences in the mean maximal diameter of the cisterna chyli among patients with mild, moderate, and severe portal hypertension. This fact indicated that the dilatation of the cisterna chyli is related only to the presence of portal hypertension and not to the severity of the disease. The decompression of the portal pressure due to the development of large collateral pathways might restrain the lymph flow to the cisterna chyli in a certain degree in advanced portal hypertension.

Previous studies have reported the location, morphologic patterns, and the diameter of the normal cisterna chyli using various imaging modalities (2,4,5,13,16,17). However, there have been no reports assessing the frequency and the detectability of the alteration in the diameter of the cisterna chyli due to contraction waves by MRI. Contraction waves caused by the alternation of constriction and dilatation of the smooth muscle of the lymphatic wall are the characteristic appearances of lymphatic vessels. In the current study, the positive caliber change of the cisterna chyli was observed in subsets of patients during the serial T2-weighted MRI, although the prevalence of this caliber change was not statistically different between patients with and without portal hypertension (19% vs. 11%). This finding indicates that serial MRI has the potential to detect the caliber change of the cisterna chyli related to possible contraction waves as the physiological changes in both normal and portal hypertensive subjects. In other cases that did not show the caliber change of the cisterna chyli, our MRI protocol may not have had sufficient temporal resolution to document these physiological contractions, or may have missed an appropriate timing to image physiological contractions.

It would be important to determine whether the increased diameter of the cisterna chyli is an indicator of portal hypertension or a normal variation. However, a substantial overlap in the diameter of the cisterna chyli exists between patients with and without portal hypertension despite the statistically significant difference between them. Lymphatic contractions can also influence the size of the cisterna chyli, as shown in this study. Therefore, it may be difficult to establish a cutoff value for diagnosing normal versus abnormal size of the cisterna chyli. In addition, the size of the cisterna chyli could be influenced by the changes in intraabdominal pressure, the phases of the respiration, postprandial status, the state of hydration (1), congestive heart failure (18), and the presence of malignant diseases (19) other than portal hypertension. Unusually large cisterna chyli can be also seen in healthy individuals (3,20).

This study is limited by the fact that we did not compare MRI with another gold standard in the detection and alteration in diameter of cisterna chyli. However, it will not be practical to perform invasive, direct lymphography in patients with or without portal hypertension. Based on the signal intensity, longitudinal continuity, and the anatomical location in the retrocrural space, we believe that it is unlikely that other structures were incorrectly categorized as the cisterna chyli. In this study the second T2-weighted MRI was carried out after the administration of SPIO. However, most SPIO with relatively large size are taken up by the liver, spleen, and bone marrow. Therefore, the influence of T2 shortening effect by the agent in the lymphatic flow (cisterna chyli) should be quite limited. Another limitation was that the measurement of cisterna chyli diameter was accomplished on two sets of moderately T2-weighted images while the cisterna chyli was primarily identified using heavily T2-weighted images. However, once the cisterna chyli was identified, there has been no problem in the measurement of cisterna chyli diameter on moderately T2-weighted images.

In conclusion, the dilatation of the cisterna chyli can be demonstrated at MRI in patients with portal hypertension. Additionally, the positive caliber change of the cisterna chyli related to contraction waves was observed in subsets of patients during the serial T2-weighted MRI. Awareness of these MR appearances may help understand the physiologic and pathologic changes of the cisterna chyli.

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