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Symposium Highlight

LIVER LYMPHATIC ANATOMY AND ITS ROLE IN SYSTEMIC HEALTH AND DISEASE

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ABSTRACT

Lymphatic anatomy of the abdomen is reviewed with focus on hepatic and mesenteric vessels in normal and pathologic conditions. Anatomy and pathophysiology is highlight using both specialized fluoroscopy and T2 Dynamic Contrast MR lymphangiography (DCMRL). Plastic bronchitis, chylothorax, protein losing enteropathy, and both cirrhosis and ascites due to hepatic lymphatics are highlighted.

Keywords: liver, lymphatic pathophysiology, anatomy, imaging, fluoroscopy, DCMRL

OVERVIEW

Liver Lymphatic Anatomy

The liver lymphatics produce 25-50% lymphatic flow through the thoracic duct. This primarily originates from the hepatic sinusoids, but the flow of drainage depends on location within the liver. Capsular is the most superficial and flows directly into mediastinal lymphatic vessels. Sublobular follows the hepatic veins into the wall of the IVC. The Portal is the deepest point; it follows portal veins and converge toward the liver hilum and continues through hepatoduodenal ligament into celiac network and TD.

Intrahepatic Lymphatic Imaging

Liver lymphatic access is obtained using ultrasound guidance with direct visualization of a branch of the portal vein with subsequent placement of a 25-gauge spinal needle via a percutaneous approach. Fluoroscopy is then performed and contrast is injected through the needle to confirm placement. Patients are then transferred to an MRI scanner where T2 space and Dynamic Contrast MR lymphangiography (DCMRL) is performed (*Fig. 1*).

Liver Lymphatic in Disease: Methods & Patient Characteristics

A retrospective review of all patients with liver lymphatic imaging was done, from January 2015 to May 2019. A total of 105 patients were reviewed, of those 41 had traditional liver lymphangiography and 64 patients had intrahepatic DCMRL (IH-DCMRL). Patients were classified according to their primary lymphatic disease or symptom as chylothorax, plastic bronchitis (PB), protein losing enteropathy (PLE) or ascites. Imaging was reviewed

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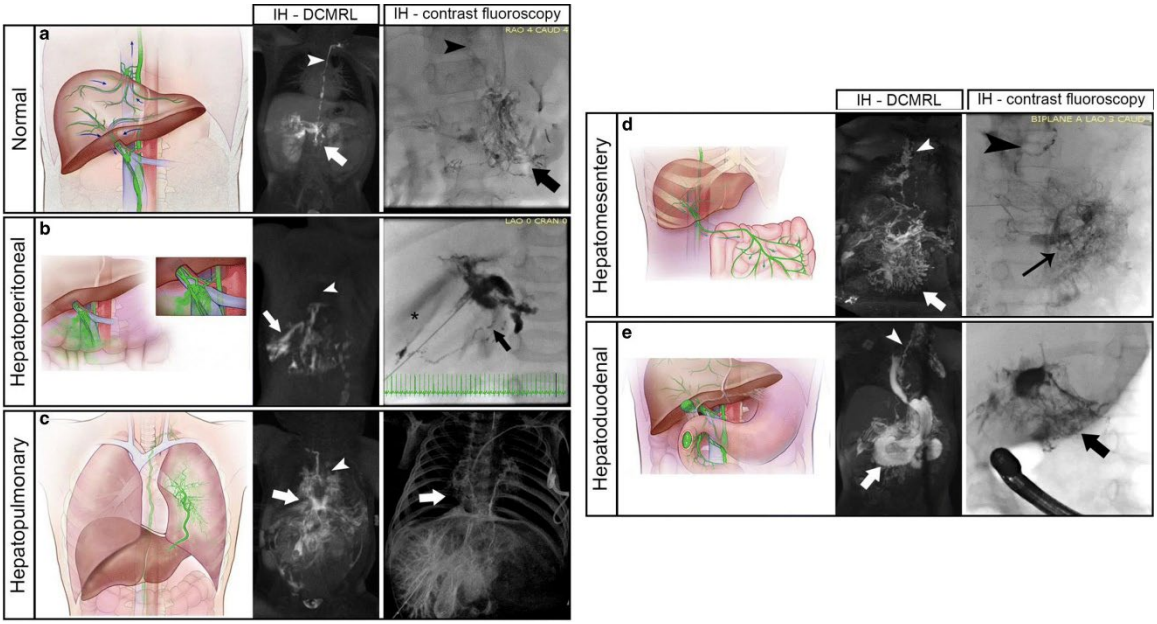

Fig. 1. *Intrahepatic Lymphatic Imaging. Diagrams of normal and abnormal hepatic lymphatics with representative maximum intensity projections (MIP) of IH-DCMRL and IH contrast fluoroscopy images. Arrowhead represents the normal thoracic duct and arrows denote the abnormal lymphatic connections. (**a**) Normal lymphatic drainage diagram of superficial and deep liver lymphatic drainage. Superficial (capsular) lymphatics directly enter the central TD near the diaphragm while deep (peri-portal) lymphatics course toward the liver hilum and toward the celiac and pancreatic lymphatic networks (arrow) with further connections to the cisterna chylii and thoracic duct (arrowhead). (**b**) Hepatoperitoneal connections with disruption of liver lymphatics after exiting the liver hilum. (**c**) Hepatopulmonary connections from the pericapsular lymphatics of the left liver lobe to the left mainstem bronchus. Arrows represent the abnormal connections with the ductal remnant noted with an arrowhead. (**d**) Hepatomesenteric connections from the liver to the mesentery with intact TD and pulmonary lymphatic perfusion. (**e**) Hepatoduodenal representation of the liver lymphatics as they exit the liver hilum and course to the inner curvature of the 1st – 3rd portions of the duodenum (arrows) with significant reflux into the stomach and esophagus (arrowhead) with propagation forward to the proximal jejunum. (Modified from Smith et al (1) under Creative Commons CC BY license (http://creativecommons.org/licenses/by/4.0/))*

and classified according to abnormal hepatic connection and or flow. Lymphatic treatment procedures ranged from January 2016 to January 2023. Criteria for inclusion: lymphangiogram (MR or Direct), presence of hepatopulmonary connections, lymphatic symptoms (chylothorax, PB, PLE, ascites, anasarca).

The imaging was analyzed based on the connections or abnormal flow patterns of the hepatic lymphatics and classified into five different categories: 1) normal (liver connecting to the chylous cistern), 2) hepatoperitoneal, 3) hepatopulmonary, 4) hepatomesentery, 5) hepatoduodenal (*Fig. 2*).

RESULTS

Twenty-six of the 105 patients with PLE had drainage patterns consistent with normal lymphatic connections to the thoracic duct. The remainder of the patients had various abnormal connections. Fourteen of the 105 patients had a direct connection of the liver lymphatics to the peritoneal compartment with or without normal connections to the TD. Ten of the 105 patients showed retrograde perfusion of the mesenteric lymphatics from the liver in addition to normal connections to the central lymphatic system. Fourteen of the

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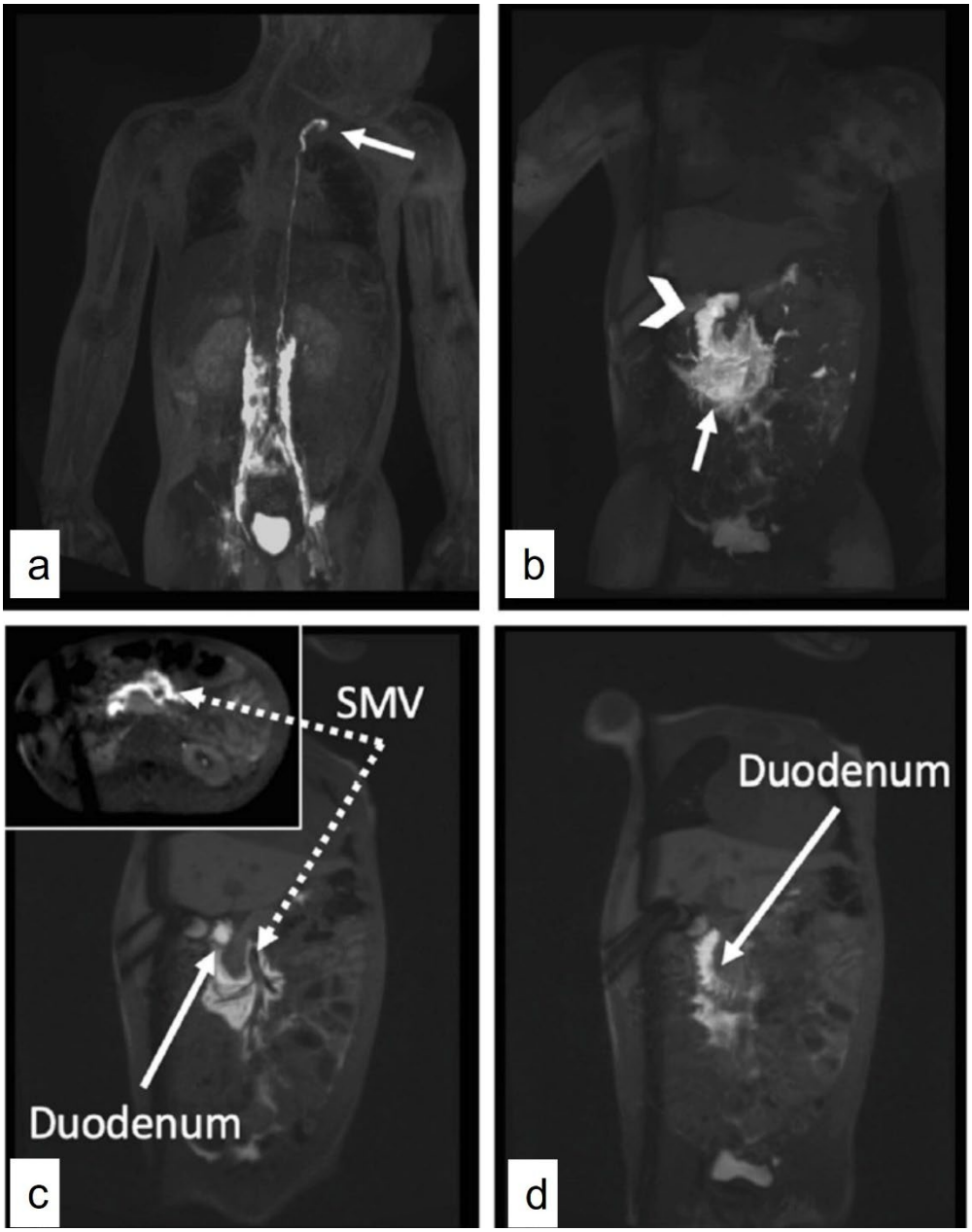

Fig. 2. *IM-DCMRL, IH-DCMRL, and IN-DCMRL in an 8-year-old male patient with congenital PLE.* ***(a)*** *MIP coronal projection of a FLASH-IR sequence after IN injection demonstrating normal TD coursing towards the innominate vein on the left (arrow).* ***(b)*** *MIP coronal projection of a FLASH-IR sequence after IM injection demonstrating mesenteric opacification without opacification of the TD and contrast flowing towards the right and connecting to the duodenum with spillage of contrast into the duodenal lumen (arrowhead).* ***(c)*** *Coronal slice of a FLASH-IR sequence after IM injection demonstrating the SMV and its branches outlines by the now contrast-enhanced mesentery (dashed arrow) and contrast in the duodenal lumen on the right (arrow). Insert is a transverse slice demonstrating the SMV surrounded by contrast (dashed arrow).* ***(d)*** *Coronal slice of a FLASH-IR sequence after IM injection demonstrating contrast filling of the duodenal lumen (arrow). Modified from Dori et al. (2).*

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105 patients showed direct drainage from the liver lymphatics via abnormal connections to the perihilar or intrapulmonary lymphatics from the deep hepatic lymphatics through continuity with the subcapsular lymphatics. The largest group with 47 of the 105 patients had abnormal liver to duodenal lymphatic connections (or flow).

Outcome with Abnormal Liver Lymphatics

Seventy-six patients underwent lymphatic intervention including 18 patients with normal hepatic lymphatics, but with other observed abnormalities in the lymphatics system visualized by IH-DCMRL and/or IN-DCMRL, and 58 with abnormal hepatic lymphatics. The presence of abnormal liver lymphatics was also associated with a longer time to symptom resolution and a higher probability of non-resolution of symptoms.

Hepatopulmonary as an Important Consideration in Plastic Bronchitis and Chylothorax

Several patients in our study with PB and/or chylothorax with no significant PLP were identified from the thoracic duct, suggesting another possible lymphatic source. This is different than previously published studies. With organ-specific intrahepatic lymphangiography, we identified a subset of patients who have abnormal connections from the liver lymphatics with direct connections to the pulmonary lymphatics bypassing the central lymphatic system. Liver lymphatic imaging should likely be performed in all patients with chylothorax and PB when central lymphatic imaging is normal. 30/46 patients underwent successful selective hepatopulmonary embolization and 27/30 patients with improvement on pleural effusion and/or casts.

Protein Losing Enteropathy

Subsets of PLE, particularly patients that have congenital heart disease, are known to have abnormal hepatoduodenal connections that were seen in a small series of patients. In our larger cohort of 47 patients with PLE, hepatoduodenal connections were almost pathognomonic in our study population, suggesting that abnormal hepatic connections could be much more common in this patient population than previously thought. Very limited follow up data has been published, of that, small patient volumes with short post-procedure range. But there are clearly multiple sources of lymphatic leaks seen in PLE, particularly the hepatic and mesenteric lymphatics.

Hepatic Lymphatics: Cirrhosis and Ascites

Liver lymphatics are a major contributor to central lymphatic flow and while their role in systemic diseases such as liver cirrhosis and heart failure have been studied previously, there is little information about the involvement in systemic lymphatic disorders. This has in part been limited by the inability to clinically visualize the liver lymphatics.

CONFLICT OF INTEREST AND DISCLOSURE

The author declares no competing financial interests exist.

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