Vascular lesions of the liver and gastrointestinal tract

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Abstract

In the liver, imaging can show lesions of large and medium-sized vessels, perfusion disorders related to vascular lesions, and parenchymal lesions including infarcts, regenerative nodules, and focal nodular hyperplasia. In the gastrointestinal tract, vascular lesions often result in bowel ischemia. Imaging can be used to show the vascular lesions and bowel wall abnormalities, including mural thickening, lack of perfusion, and pneumatosis.

Doppler sonography, multislice helical computed tomography (CT), magnetic resonance (MR) imaging, and angiography are useful to demonstrate vascular lesions. Doppler sonography offers high spatial and temporal resolution. Information about blood flow and velocity can be obtained. However, the visualization of retroperitoneal vessels is often limited because of intestinal gas.

A global view of the abdominal vasculature can be observed by using helical CT. High spatial and temporal resolution are obtained, especially when new multislice CT scanners are used. MR imaging has a better contrast resolution than CT, but its spatial resolution is lower. MR imaging can also be used to measure flow with phase contrast methods.

The role of arteriography in the diagnosis of vascular lesions is decreasing. However, its role remains important to definitively demonstrate obstruction of the hepatic artery and to show arterial lesions in acute mesenteric ischemia. In addition, it is used as a problem-solving method to detect lesions in medium-sized vessels and to guide intravascular treatment. (Acta gastroenterol. belg., **2002**, 65, **226-229**).

Key words : vascular diseases, arteriovenous fistula, focal nodular hyperplasia, hepatic vein thrombosis, hepatic veno-occlusive disease, portal hypertension, mesenteric vascular occlusion, ischemic colitis.

Liver

Vascular lesions

In the liver, lesions can affect the hepatic artery, the portal vein, the hepatic veins, and the sinusoids. These lesions often occur together. Obstruction to the blood flow at one level often leads to secondary lesions up- and downstream from the initial lesion (1). The vascular lesions include congenital variations, especially in the origin of the hepatic artery, vascular stenosis, thrombosis or occlusion, arteriovenous fistulae, and aneurysms or dilatations.

Imaging may show the vascular lesions, heterogeneous liver enhancement that reflects perfusion disorders secondary to these lesions, and parenchymal lesions such as infarcts, regenerative nodules, and focal nodular hyperplasia. Doppler sonography, computed tomography (CT), and magnetic resonance (MR) imaging can be used to demonstrate lesions of large vessels. Each method has strengths and weaknesses. Doppler sonography offers excellent spatial and temporal resolution. Information about blood flow and velocity can be obtained. Therefore, Doppler sonography is widely used in patients with cirrhosis to show signs of portal hypertension (2).

However, the visualization of the vessels outside the liver and in the retroperitoneum is often limited because of intestinal gas. For example, the proximal extent of a portal thrombus or the portosystemic collaterals in portal hypertension may be difficult to demonstrate. It addition, it may be difficult to differentiate between slow flow and thrombosis with Doppler sonography.

Helical CT has good spatial resolution. The spatial resolution in the longitudinal axis (z axis) is greatly improved with the advent of multislice helical CT scanners (3). A global view of the abdominal vasculature can be obtained without the limitations of Doppler sonography. However, the contrast resolution of CT is less than that of MR imaging. To increase the contrast resolution, high doses of iodinated contrast agents are needed in CT examinations. This can cause problems, especially in patients with cirrhosis and impaired renal function.

MR imaging has excellent contrast resolution, but its spatial resolution is often somewhat lower than that of CT because with MR imaging, there is a trade-off between spatial resolution and speed of acquisition. In addition, MR angiography is more sensitive to motion than CT angiography. Blood flow and velocity can be measured with phase contrast methods in MR imaging (4). MR imaging is useful as a second-line examination in patients with cirrhosis and portal hypertension, especially to assess the liver and portal system before liver transplantation (2).

Arteriography or venography is less often needed to show vascular lesions. it remains useful to show lesions of medium-sized vessels such as arterial aneurysms in polyarteritis nodosa, to definitively demonstrate arterial occlusion after liver transplantation, especially in children, and to perform intravascular treatments. These treatments include embolization of aneurysms and transcatheter intravascular portosystemic shunt placements in patients with cirrhosis or Budd-Chiari syndrome. Finally, diseases of small vessels such as peliosis and veno-occlusive disease often cannot be shown directly with imaging.

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Perfusion disorders

Focal perfusion disorders are often seen in patients with vascular lesions of the liver. Areas of transient increased enhancement during the arterial phase after contrast material injection are observed when the arterial perfusion is increased due to arterioportal fistula, inflammation, radiation therapy or portal and hepatic vein obstruction (5-12).

These areas with transient enhancement often have straight borders and are important to recognize for two reasons. First, these lesions should not be misinterpreted as tumors ; second, tumor size should not be overestimated when these lesions are adjacent to tumors.

Hepatic lesions

Liver infarcts are observed as wedge-shaped, rounded or irregularly shaped lesions paralleling bile ducts. The lesions do not enhance after contrast material injection and may contain gas. The presence of nondisplaced vessels running through areas of hepatic infarction excludes space-occupying lesions (13,14). Hepatic infarction results from an insult either to the hepatic arterial supply or to both the hepatic arterial and portal venous systems.

Regenerative nodules are the result of localized proliferation of hepatocytes and their supporting stroma. Most regenerative nodules are associated with obliteration of portal or hepatic veins, so that ischemia is important. In focal nodular hyperplasia, however, the stimulus to development of the nodule is probably not a decrease of functional liver mass. In this lesion, the stimulus may be a congenital or acquired anomaly of the arterial supply leading to focal hyperperfusion of the parenchyma (15).

Monoacinar regenerative nodules in nodular regenerative hyperplasia or cirrhosis are too small to be observed at imaging. Multiacinar regenerative nodules and lobar or segmental hyperplasia can be seen with sonography, CT, and MR imaging. These regenerative nodules should be differentiated from hepatic tumors, especially hepatocellular carcinomas in cirrhosis. At imaging, this distinction is mainly based on blood supply, as most hepatocellular carcinomas appear hypervascularized during the arterial phase after injection of contrast material, whereas regenerative nodules do not have an increased arterial supply (16). However, exceptions do occur. Not all hepatocellular carcinomas are hypervascular. In contrast, some dysplastic and regenerative lesions are hypervascularized. These hypervascular lesions include regenerative nodules in Budd Chiari syndrome (17).

Gastrointestinal tract

Vascular lesions of the intestinal tract often result in bowel ischemia. Intestinal ischemia can result from various causes, including arterial or venous thrombosis, arterial embolism, low flow states, vasculitis, tumors, bowel obstruction, inflammatory diseases, trauma, and drug or radiation therapy (18-20). Classically, intestinal ischemia is divided in acute and chronic mesenteric ischemia and colonic ischemia.

Acute mesenteric ischemia

In acute mesenteric ischemia, imaging findings include thromboembolism in mesenteric vessels, lack of bowel wall enhancement, bowel wall thickening, mesenteric edema, ascitis, intramural or portal venous gas, and liver or splenic infarcts (18,21-23). None of these signs are very sensitive, but lack of bowel wall enhancement is a sign that is specific for mesenteric ischemia. This sign is more often observed when imaging of the whole bowel is performed during the early phase after injection of contrast material. This rapid imaging can be performed with multislice helical CT scanners. Although pneumatosis can occur in benign conditions, presence of air in the bowel wall, the portal vein or the peritoneum in patients with intestinal ischemia is an ominous sign, often signifying transmural. infarction (23).

CT is useful to diagnose mesenteric ischemia in patients with acute abdominal pain. Occlusion of the mesenteric artery or vein can be observed as well as findings in the bowel wall and mesentery. The CT findings of bowel ischemia secondary to vasculitis or other causes overlap. Nevertheless, the possibility of vasculitis should be considered when mesenteric ischemic changes occur in young patients, are seen at unusual sites including the duodenum, concomitantly involve the small and large bowel, and are associated with multiple organ involvement (18, 24-26). Because of the limited sensitivity of CT to detect mesenteric artery branch occlusion, some authorities recommend to perform CT only in patients with acute mesenteric ischemia secondary to venous occlusion (27). However, it is often difficult to suspect venous rather that arterial obstruction before imaging in patients with acute mesenteric ischemia.

Angiography remains an important diagnostic method in patients with acute mesenteric ischemia. Angiography is clearly superior to CT for detecting mesenteric artery branch occlusion, identifying medium-sized vessel vasculitis or diagnosing vasospasm (21, 24,26). According to the American Gastroenterological Association, arteriography is the definitive examination to identify patients with acute mesenteric ischemia secondary to arterial obstruction or vasoconstriction (27). Angiography can also been used to infuse papaverine or thrombolytics. However, in actual clinical practice, mesenteric ischemia is only one of a number of potential diagnoses in patients with signs of acute abdomen. Therefore, a large number of negative results should be expected when angiography is performed routinely to identify patients with acute mesenteric ischemia early in the course of the disease. This suggests that

CT scanning may be useful as a triage examination before angiography in patients without peritoneal signs (21). Further studies are needed to support this diagnostic algorithm.

Occlusion of the mesenteric artery or vein can be detected with Doppler sonography. This method can also show lack of perfusion of the bowel wall (28). Nevertheless, examination of the mesenteric vessels with Doppler sonography is limited in patients with acute mesenteric ischemia because of large amounts of intestinal gas (adynamic ileus).

In an animal model of acute intestinal ischemia, it has been shown that contrast enhanced MR imaging can be used to demonstrate modifications of the enhancement in the intestinal wall. Using different contrast agents, specific enhancement patterns were observed in occlusive ischemia, reperfused reversible ischemia, and reperfused irreversible ischemia (29-31). Until now, MR imaging is not routinely used in patients with acute abdominal pain (20).

Chronic mesenteric ischemia

Stenoses of the celiac trunk, superior and inferior mesenteric arteries can be demonstrated with Doppler sonography, CT angiography, and MR angiography (32-35). However, partial or complete occlusion of one or more of the splanchnic vessels may be seen in the absence of chronic mesenteric ischemia (36). Therefore, several tests have been proposed for use in diagnosing chronic mesenteric ischemia, but are currently not used in clinical routine (25,27). The diagnosis of chronic mesenteric ischemia is based on clinical symptoms, demonstration of an occlusive process of the splanchnic vessels, and exclusion of other gastrointestinal disorders (27).

Colon ischemia

The role of imaging in ischemia of the large bowel remains debated as most cases of colon ischemia, do not have a recognizable cause (27). Colon ischemia comprises a spectrum of diseases ranging from reversible colopathy to gangrene. Colic lesions including wall thickening, heterogeneity, and pneumatosis can be shown with sonography and CT (37,38). It has been suggested that absence of flow at Doppler sonography is a sign of severe colon ischemia (39).

Conclusion

Because of the increasing role of cross-sectional imaging in patients with vascular lesions of the liver and gastrointestinal tract, arteriography is less often used. It remains the definitive examination to show obstruction of the hepatic artery in liver transplantation and to demonstrate arterial lesions in acute mesenteric ischemia. In addition, angiography is used as a problem-solving method especially for the detection of lesions in medium-sized vessels and for intravascular treatment.

References

1. WANLESS I.R. Vascular disorders. *In* : MAC SWEEN R.N., ANTHONY P.P., SCHEUER P.J., BURT A.D. (eds). Pathology of the liver. Edinburgh : Churchill Livingstone, 1994.
2. ROSSI P., RICCI P., BROGLIA L. Portal hypertension. Diagnostic imaging and imaging guided therapy. Heidelberg : Springer Verlag, 2000.
3. WONG K., PAULSON E.K., NELSON R.C. Breath-hold three-dimensional CT of the liver with multi-detector row helical CT. *Radiology*, 2001, **219** : 75-79.
4. PELC N.J., SOMMER F.G., LI K.C., BROSNAN T.J., HERFKENS R.J., ENZMANN D.R. Quantitative magnetic resonance flow imaging. *Magn. Reson. Q.*, 1994, **10** : 125-147.
5. VAN BEERS B., PRINGOT J., TRIGAUX J.P., DAUTREBANDE J., MATHURIN P. Hepatic heterogeneity on CT in Budd-Chiari syndrome : correlation with regional disturbances in Portal flow. *Gastrointest. Radiol.*, 1988, **13** : 61-66.
6. VAN BEERS B., PRINGOT J., GIGOT J.F., DAUTREBANDE J., MATHURIN P. Nontumorous attenuation differences on computed tomographic portography. *Gastrointest. Radiol.*, 1990, **15** : 107-111.
7. ITAI Y., MURATA S., KUROSAKI Y. Straight border sign of the liver : spectrum of CT appearances and causes. *Radiographics*, 1995, **15** : 1089-1102.
8. YAMASAKI S.A., MARN C.S., FRANCIS K., ROBERTSON J.M., LAWRENCE T.S. High-dose localized radiation therapy for treatment of hepatic malignant tumors : CT findings and their relation to radiation hepatitis. *AJR, Am. J. Roentgenol.*, 1995, **165** : 79-84.
9. SEMPOUX C., HORSMANS Y., GEUBEL A. *et al.* Severe radiation-induced liver disease following localized radiation therapy for biliopancreatic carcinoma : activation of hepatic stellate cells as an early event. *Hepatology*, 1997, **26** : 128-134.
10. GRYSPEERDT S., VAN HOE L., MARCHAL G., BAERT A.L. Evaluation of hepatic perfusion disorders with double-phase spiral CT. *Radiographics*, 1997, **17** : 337-348.
11. IBUKURO K., TSUKIYAMA T., MORI K., INOUE Y. Transhepatic portosystemic shunts : CT appearance and anatomic correlation. *AJR, Am. J. Roentgenol.*, 2000, **175** : 153-157.
12. QUIROGA S., SEBASTIA C., PALLISA E., CASTELLA E., PEREZ-LAFUENTE M., ALVAREZ-CASTELLS A. Improved diagnosis of hepatic perfusion disorders : value of hepatic arterial phase imaging during helical CT. *Radiographics*, 2001, **21** : 65-81.
13. HOLBERT B.L., BARON R.L., DODD III G.D. Hepatic infarction caused by arterial insufficiency : spectrum and evolution of CT findings. *AJR, Am. J. Roentgenol.*, 1996, **166** : 815-820.
14. SMITH G.S., BIRNBAUM B.A., JACOBS J.E. Hepatic infarction secondary to arterial insufficiency in native livers : CT findings in 10 patients. *Radiology*, 1998, **208**, 223-229.
15. International Working Party. Terminology of nodular hepatocellular lesions, *Hepatology*, 1995, **22** : 983-993.
16. HAYASHI M., MATSUI O., UEDA K. Correlation between the blood supply and grade of malignancy of hepatocellular nodules associated with liver cirrhosis : evaluation by CT during intraarterial injection of contrast medium. *AJR, Am. J. Roentgenol.*, 1999, **172** : 969-976.
17. VILGRAIN V., LEWIN M., VONS C. *et al.* Hepatic nodules in Budd-Chiari syndrome : imaging features. *Radiology*, 1999, **210** : 443-450.
18. RHA S.E., HA H.K., LEE S.H. *et al.* CT and MR imaging findings of bowel ischemia from various primary causes. *Radiographics*, 2000, **20** : 29-42.
19. BYUN J.Y., HA H.K., YU S.Y. *et al.* CT features of systemic lupus erythematosus in patients with acute abdominal pain : emphasis on ischemic bowel disease. *Radiology*, 1999, **211** : 203-209.
20. HA H.K., RHA S.E., KIM A.Y., AUH Y.H. CT and MR diagnoses of intestinal ischemia. *Semin. Ultrasound CT MR*, 2000, **21** : 40-55.
21. TAOUREL T.G., DENEUVILLE M., PRADEL J.A., RÉGENT D., BRUEL J.M. Acute mesenteric ischemia : diagnosis with contrast-enhanced CT. *Radiology*, 1996, **199** : 632-636.
22. ZALCMAN M., SY M., DONCKIER V., CLOSSET J., VAN GANSBEKE D. Helical CT signs in the diagnosis of intestinal ischemia in small-bowel obstruction. *AJR, Am. J. Roentgenol.*, 2000, **175** : 1601-1607.
23. HORTON K.M., FISHMAN E.K. Computed tomography evaluation of intestinal ischemia. *Semin. Roentgenol.*, 2001, **36** : 118-125.
24. HA H.K., LEE S.H., RHA S.E. *et al.* Radiologic features of vasculitis involving the gastrointestinal tract. *Radiographics*, 2000, **20** : 779-794.
25. LI K.C., DALMAN R.L., CH'EN I.Y. *et al.* Chronic mesenteric ischemia : use of in vivo MR imaging measurements of blood oxygen saturation in the superior mesenteric vein for diagnosis. *Radiology*, 1997, **204** : 71-77.
26. JEE K.N., HA H.K., LEE I.J. *et al.* Radiologic findings of abdominal polyarteritis nodosa. *AJR, Am. J. Roentgenol.*, 2000, **174** : 1675-1679.

27. BRANDT L.J., BOLEY S.J. AGA technical review on intestinal ischemia. *Gastroenterology*, 2000, **118** : 954-968.
28. DANSE E.M., VAN BEERS B.E., GOFFETTE P., DARDENNE A.N., LATERRE P.F., PRINGOT J. Acute intestinal ischemia due to occlusion of the superior mesenteric artery : detection with Doppler sonography. *J. Ultrasound Med.*, 1996, **15** : 323-326.
29. VAN BEERS B.E., MOTTET I., DELOS M., GOUDEMANT J.F., DEMEURE R., PRINGOT J. Acute occlusive ischemia of the rat intestine : early detection by MR imaging with polylysine-Gd-DTPA enhancement. *J. Magn. Reson. Imaging*, 1995, **5** : 509-513.
30. MOTTET L., VAN BEERS B.E., DELOS M. Reperfused ischemia of the rat intestine : detection by MR imaging with polylysine-Gd-DTPA enhancement. *Magn. Reson. Med.*, 1996, **35** : 131-135.
31. VAN BEERS B.E., GOUDEMANT J.F., OKSENDAL A. *et al.* Detection of reperfused ischemia of the rat intestine : value of MR imaging with small-molecular-weight dysprosium and gadolinium chelates. *Acad. Radiol.*, 1997, **4** : 35-42.
32. CARLOS R.C., STANLEY J.C., STAFFORD-JOHNSON D., PRINCE M.R. Interobserver variability in the evaluation of chronic mesenteric ischemia with gadolinium-enhanced MR angiography. *Acad. Radiol.*, 2001, **8** : 879-887.
33. HARWARD T.R., SMITH S., SEEGER J.M. Detection of celiac axis and superior mesenteric artery occlusive disease with use of abdominal duplex scanning. *J. Vasc. Surg.*, 1993, **17** : 738-745.
34. MONETA G.L., LEE R.W., YEAGER R.A., TAYLOR L.M., Jr., PORTER J.M. Mesenteric duplex scanning : a blinded prospective study. *J. Vasc. Surg.*, 1993, **17** : 79-84.
35. LIM H.K., LEE W.J., KIM S.H. *et al.* Splanchnic arterial stenosis or occlusion : diagnosis at Doppler US. *Radiology*, 1999, **211** : 405-410.
36. ROOBOTTOM C.A., DUBBINS P.A. Significant disease of the celiac and superior mesenteric arteries in asymptomatic patients : predictive value of Doppler sonography. *AJR, Am. J. Roentgenol.*, 1993, **161** : 985-988.
37. BALTHAZAR E.J., YEN B.C., GORDON R.B. Ischemic colitis : CT evaluation of 54 cases. *Radiology*, 1999, **211** : 381-388.
38. TRUONG M., ATRI M., BRET P.M. *et al.* Sonographic appearance of benign and malignant conditions of the colon. *AJR, Am. J. Roentgenol.*, 1998, **170** : 1451-1455.
39. DANSE E.M., VAN BEERS B.E., JAMART J. Prognosis of ischemic colitis : comparison of color Doppler sonography with early clinical and laboratory findings. *AJR, Am. J. Roentgenol.*, 2000, **175** : 1151-1154.