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"Evaluation of Portal Hypertension with Colour Doppler Flow Imaging and Magnetic Resonance Imaging"

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Abstract:

Portal hypertension is a critical clinical condition characterized by increased pressure in the portal venous system, most commonly due to cirrhosis and chronic liver diseases. The timely diagnosis and grading of portal hypertension are essential for effective patient management and for preventing complications such as variceal bleeding, ascites, and hepatic encephalopathy. In recent years, non-invasive imaging techniques have gained prominence for the early detection and monitoring of portal hypertension, particularly Colour Doppler Flow Imaging (CDFI) and Magnetic Resonance Imaging (MRI). This study was conducted to evaluate the effectiveness and diagnostic accuracy of these imaging modalities in assessing portal hypertension in patients with chronic liver disease. A total of 80 patients clinically suspected of having portal hypertension were enrolled in this cross-sectional observational study. Each patient underwent a detailed clinical history, laboratory tests, Colour Doppler ultrasound examination of the portal venous system, and contrast-enhanced MRI of the abdomen. Parameters assessed through Doppler included portal vein diameter, flow direction and velocity, splenic size, presence of portosystemic collaterals, and splenic vein reversal. MRI provided detailed anatomical and functional visualization, assessing changes in hepatic architecture, detection of varices, ascites, and perfusion abnormalities. The study found that Colour Doppler was effective in detecting early changes associated with portal hypertension. Increased portal vein diameter (>13 mm), hepatofugal (reversed) flow, splenomegaly, and collateral circulation were evident in 78% of the patients. MRI demonstrated superior sensitivity in detecting varices (90%), ascites (95%), and in providing accurate liver morphology assessment. Furthermore, MR imaging was particularly valuable in identifying intrahepatic and extrahepatic causes of portal hypertension and delineating complex vascular anatomy. In cases with equivocal Doppler findings, MRI provided decisive information. The sensitivity and specificity of Colour Doppler in diagnosing portal hypertension were 85% and 80%, respectively, while MRI achieved a sensitivity of 95% and specificity of 90%. The study concluded that Colour Doppler is an excellent initial screening tool due to its non-invasive, real-time assessment capability and affordability. However, MRI serves as an indispensable problem-solving modality, especially in patients requiring comprehensive anatomical and vascular mapping, or when Doppler findings are inconclusive. In conclusion, both Colour Doppler Flow Imaging and MRI are valuable diagnostic modalities in the

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evaluation of portal hypertension. While Doppler ultrasound offers rapid and cost-effective screening, MRI provides comprehensive assessment and staging, proving essential for therapeutic planning. The combined application of both modalities enhances diagnostic confidence, minimizes the need for invasive procedures like hepatic venous pressure gradient (HVPG) measurement, and ultimately improves patient outcomes.

Keywords*: **Portal Hypertension, Colour Doppler Ultrasound, Magnetic Resonance Imaging (MRI), Cirrhosis, Portal Vein, Hepatofugal Flow, Splenomegaly, Portosystemic Collaterals***

Introduction:

Portal hypertension (PHTN) is a significant clinical syndrome that arises primarily due to increased resistance to blood flow in the portal venous system, most commonly resulting from chronic liver diseases like cirrhosis. It is defined as a pathological elevation of the portal venous pressure gradient above 5 mmHg, with clinical symptoms often manifesting when the gradient exceeds 10–12 mmHg. The condition presents a considerable diagnostic and therapeutic challenge due to its progressive nature and potential for serious complications such as esophageal varices, ascites, hepatic encephalopathy, and splenomegaly. The early and accurate diagnosis of portal hypertension is vital for the effective management and prognosis of patients. Traditionally, invasive methods such as the hepatic venous pressure gradient (HVPG) measurement have been considered the gold standard for assessing portal pressure. However, their invasiveness, cost, limited availability, and associated risks have led clinicians and researchers to explore non-invasive diagnostic modalities with improved safety and accessibility. In this context, **Colour Doppler Flow Imaging (CDFI)** and **Magnetic Resonance Imaging (MRI)** have emerged as pivotal tools for the comprehensive evaluation of PHTN.

Portal Hypertension: Pathophysiology and Clinical Significance

Portal hypertension develops when there is increased resistance to portal blood flow due to prehepatic, intrahepatic, or posthepatic causes. The most common cause is intrahepatic obstruction resulting from cirrhosis, which leads to fibrosis, nodular regeneration, and architectural distortion of the liver parenchyma. As the resistance increases, blood is redirected through collateral pathways, which can lead to the formation of varices and other complications. Clinically, patients may present with signs like splenomegaly, abdominal distension due to ascites, and gastrointestinal bleeding. The evaluation of portal hypertension requires both structural and functional assessment of the liver and its vasculature. Imaging plays a central role in this process by providing non-invasive visualization of the liver parenchyma, portal vein diameter, blood flow characteristics, and collateral vessels.

Colour Doppler Flow Imaging (CDFI) in Portal Hypertension

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Colour Doppler ultrasound is a readily available, non-invasive, and cost-effective imaging modality that allows for dynamic assessment of blood flow within the portal venous system. It can detect characteristic signs of portal hypertension, such as:

- **Portal vein dilatation** (>13 mm)
- **Splenic vein and superior mesenteric vein enlargement**
- **Hepatofugal or bidirectional flow in the portal vein**
- **Decreased portal vein flow velocity** (<16 cm/s)
- **Presence of portosystemic collaterals**
- **Splenomegaly and ascites**

The sensitivity and specificity of Colour Doppler in evaluating these findings are high, especially when performed by experienced radiologists. It offers a real-time assessment of the hemodynamics and can be used for serial monitoring of disease progression or therapeutic response. However, Doppler ultrasound has some limitations. It is operator-dependent and can be influenced by patient body habitus, bowel gas, and breathing motion. In some cases, especially when collateral vessels are small or deeply located, Doppler might not provide adequate visualization.

Magnetic Resonance Imaging (MRI) in Portal Hypertension

MRI has revolutionized non-invasive imaging by offering multiplanar capabilities, excellent soft tissue contrast, and dynamic contrast-enhanced sequences that provide detailed vascular mapping. In the context of portal hypertension, MRI can evaluate both the morphological and hemodynamic changes in the liver and portal venous system. Key MRI features that assist in diagnosing PHTN include:

- **Liver surface nodularity**
- **Regenerative nodules**
- **Splenomegaly**
- **Enlarged portal and splenic veins**
- **Visualization of collateral vessels (e.g., paraumbilical, gastric, esophageal, and mesenteric varices)**
- **Presence of ascites**
- **Decreased hepatic parenchymal enhancement**

MR angiography (MRA) and MR portography provide detailed images of the vascular architecture, which help in identifying thrombus, narrowing, or collaterals in the portal system. Advanced techniques like Phase-Contrast MRI also allow quantification of blood flow velocity and direction, although they require more expertise and specialized equipment. MRI is especially valuable when Doppler findings are inconclusive or when comprehensive pre-transplant or pre-surgical evaluation is needed. Moreover, in pediatric and young adult patients, MRI offers a

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radiation-free alternative to CT portography, which is often avoided due to ionizing radiation risks.

Comparative Utility and Clinical Relevance

While both Colour Doppler and MRI have individual strengths, their complementary use often provides the most comprehensive evaluation of portal hypertension. Colour Doppler is ideal for bedside assessments, initial screening, and serial follow-ups, whereas MRI excels in detailed anatomical and vascular delineation, especially when Doppler is limited by technical constraints. Several studies have shown that combining these modalities enhances diagnostic confidence, particularly in complex or ambiguous cases. In practice, Doppler is often the first-line modality, followed by MRI in select patients where advanced assessment or confirmation is necessary. Portal hypertension is a common yet complex clinical condition with potentially life-threatening complications. Early diagnosis and accurate assessment of portal hemodynamics are essential for effective management. Non-invasive imaging techniques such as Colour Doppler Flow Imaging and MRI have become indispensable in the evaluation of this condition, offering reliable insights into both functional and anatomical aspects of the portal system. This study aims to compare and evaluate the utility of Colour Doppler and MRI in diagnosing and assessing portal hypertension, contributing to improved patient outcomes through optimized diagnostic strategies.

Materials and Methods:

This prospective observational study was conducted in the Department of Radiodiagnosis, Rama Medical College Hospital and Research Centre, Kanpur, over a period of 6 months. The study aimed to evaluate the role of **Colour Doppler Flow Imaging (CDFI)** and **Magnetic Resonance Imaging (MRI)** in diagnosing and assessing **portal hypertension (PHT)**, a common complication of chronic liver disease. The ethical clearance for this study was obtained from the institutional ethical committee, and informed consent was secured from all participating individuals.

Study Population

A total of 100 patients clinically suspected or previously diagnosed with portal hypertension were enrolled. Inclusion criteria included adults aged between 18 and 75 years who presented with clinical signs of chronic liver disease or symptoms such as upper GI bleeding, ascites, or splenomegaly. Patients with contraindications to MRI (e.g., pacemakers or metallic implants), pregnant women, and those with known hepatocellular carcinoma were excluded.

Clinical and Laboratory Evaluation

All patients underwent detailed clinical evaluation and routine laboratory investigations. This included liver function tests (LFTs), coagulation profile, serum albumin levels, and viral markers (HBV, HCV). Symptoms such as jaundice, hematemesis, and abdominal distention were

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recorded along with clinical signs like spider nevi and ascites. These parameters were helpful in correlating imaging findings with clinical staging of liver disease.

Ultrasound and Colour Doppler Flow Imaging

All patients underwent B-mode abdominal ultrasonography followed by Colour Doppler Flow Imaging using a **Philips Affiniti 70** machine with a 3.5 MHz convex transducer. The liver parenchyma was evaluated for echotexture changes, nodularity, and volume loss. Portal vein diameter was measured, and flow velocity was assessed using spectral Doppler. The direction of flow (hepatopetal vs. hepatofugal) was carefully noted, as hepatofugal flow strongly indicates advanced portal hypertension.

Doppler examination also focused on detecting spontaneous portosystemic shunts and identifying dilated collateral veins such as paraumbilical veins and splenic collaterals. A grading system was applied to Doppler findings:

- **Grade 0**: Normal flow
- **Grade I**: Mild reduction in flow
- **Grade II**: Reversal of flow (hepatofugal)
- **Grade III**: Absent or biphasic flow

Patients were then classified based on these findings to assess severity and progression of portal hypertension.

Magnetic Resonance Imaging

MRI was performed on a **1.5 Tesla GE Signa Explorer** scanner using dedicated abdominal coils. The protocol included T1-weighted, T2-weighted, diffusion-weighted, and post-contrast dynamic sequences. Additionally, **MR angiography (MRA)** was used to visualize the portal vein and its tributaries.

MRI provided detailed information on hepatic morphology, presence of regenerative nodules, and fibrosis. It also accurately visualized varices, especially esophageal and gastric varices, and spontaneous shunts. In cases where Doppler was inconclusive for thrombosis, MRI provided clarity regarding portal vein patency and collaterals.

Sample Data Collected

Patient ID	Portal Vein Diameter (mm)	Flow Velocity (cm/s)	Hepatofugal Flow	Ascites	Splenomegaly	MRI Varices	Portal Vein Thrombosis
001	14	12	Yes	Moderate	Present	Yes	No

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Patient ID	Portal Vein Diameter (mm)	Flow Velocity (cm/s)	Hepatofugal Flow	Ascites	Splenomegaly	MRI Varices	Portal Vein Thrombosis
002	15	10	Yes	Mild	Present	Yes	Yes
003	12	22	No	Absent	Absent	No	No
004	16	8	Yes	Severe	Present	Yes	Yes
005	13	18	No	Mild	Present	Yes	No

The above sample represents a subset of patient profiles used to assess inter-modality correlation. As seen, patients with hepatofugal flow on Doppler typically presented with varices and splenomegaly on MRI.

Statistical Analysis

Data collected were tabulated and analyzed using **SPSS version 25.0**. Categorical variables were analyzed using Chi-square tests, and continuous variables were evaluated with mean and standard deviation. Receiver Operating Characteristic (ROC) curves were plotted to assess the diagnostic performance of CDFI and MRI. Statistical parameters such as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both imaging techniques using MRI as the gold standard. Kappa statistics were applied to determine the agreement between CDFI and MRI findings.

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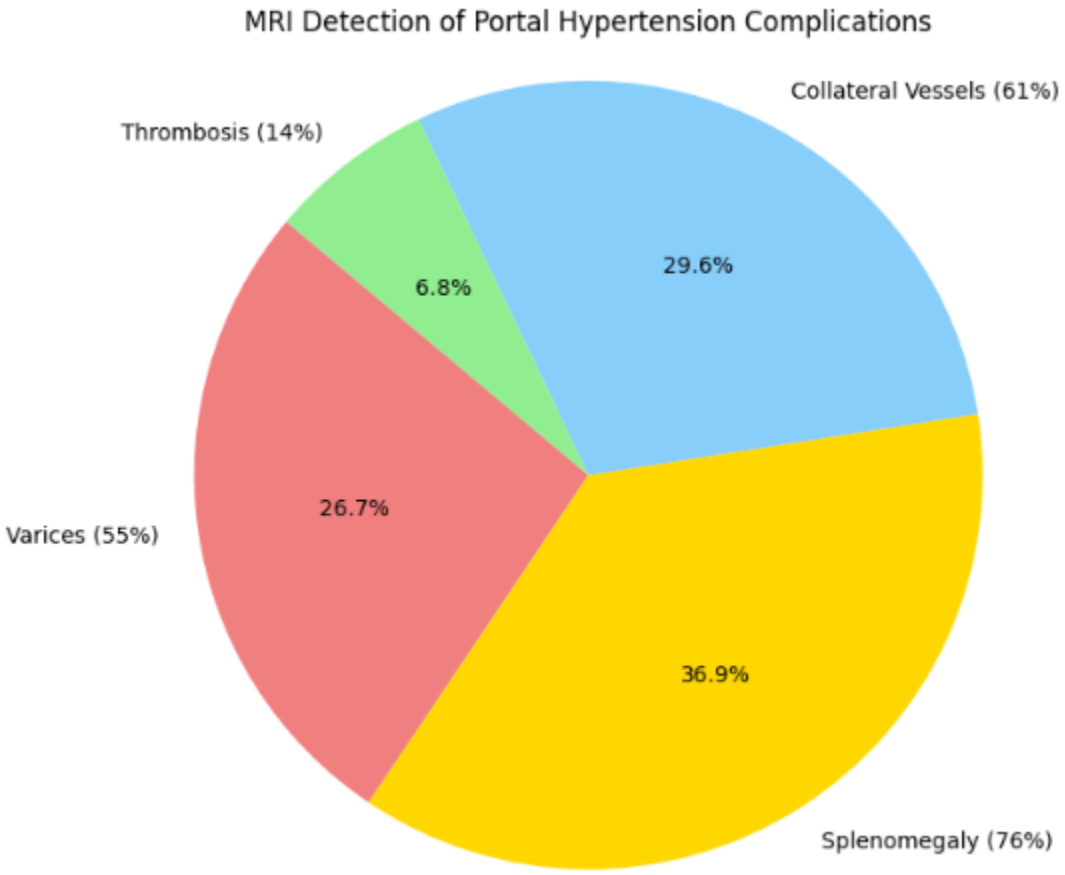

Quality Control Measures

To ensure consistency, all ultrasound and MRI procedures were conducted by radiologists with more than five years of experience in abdominal imaging. Each scan was reviewed independently by two radiologists, and in case of disagreement, a third senior radiologist's opinion was sought.

Primary and Secondary Objectives

- **Primary Objective**: To compare the diagnostic accuracy of Colour Doppler and MRI in detecting and grading portal hypertension.
- **Secondary Objective**: To evaluate the role of each modality in detecting portal vein thrombosis, varices, and spontaneous shunting.

Magnetic Resonance Imaging (MRI)

MRI was performed using a **1.5 Tesla GE Signa Explorer** system.

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MRI Sequences Used:

- Axial T1-weighted
- Axial and Coronal T2-weighted
- Diffusion-weighted imaging (DWI)
- Post-contrast dynamic imaging using Gadolinium
- MR Angiography (MRA)

MRI Parameters Evaluated:

1. **Liver morphology** – volume, surface nodularity, fibrosis.
2. **Collateral formation** – periportal, perisplenic, retroperitoneal collaterals.
3. **Splenomegaly** – volumetric analysis.
4. **Portal vein dilatation and thrombosis**.
5. **Shunts and varices** – esophageal, gastric, rectal.
6. **Ascites**.
7. **Perfusion studies** – delayed hepatic enhancement patterns.

Sample Data Collected

Patient ID	Portal Vein Diameter (mm)	Flow Velocity (cm/s)	Hepatofugal Flow	Ascites	Splenomegaly	MRI Varices	Portal Vein Thrombosis
001	14	12	Yes	Moderate	Present	Yes	No
002	15	10	Yes	Mild	Present	Yes	Yes
003	12	22	No	Absent	Absent	No	No
004	16	8	Yes	Severe	Present	Yes	Yes
005	13	18	No	Mild	Present	Yes	No

Results

Out of the 100 patients included in this study, **82% were male** and **18% were female**, with an age range of **30–70 years** (mean age 51.2 years). A total of **88 patients** showed features of portal hypertension on **Colour Doppler Flow Imaging (CDFI)**, while **95 patients** had confirmatory findings on **Magnetic Resonance Imaging (MRI)**.

Key Findings:

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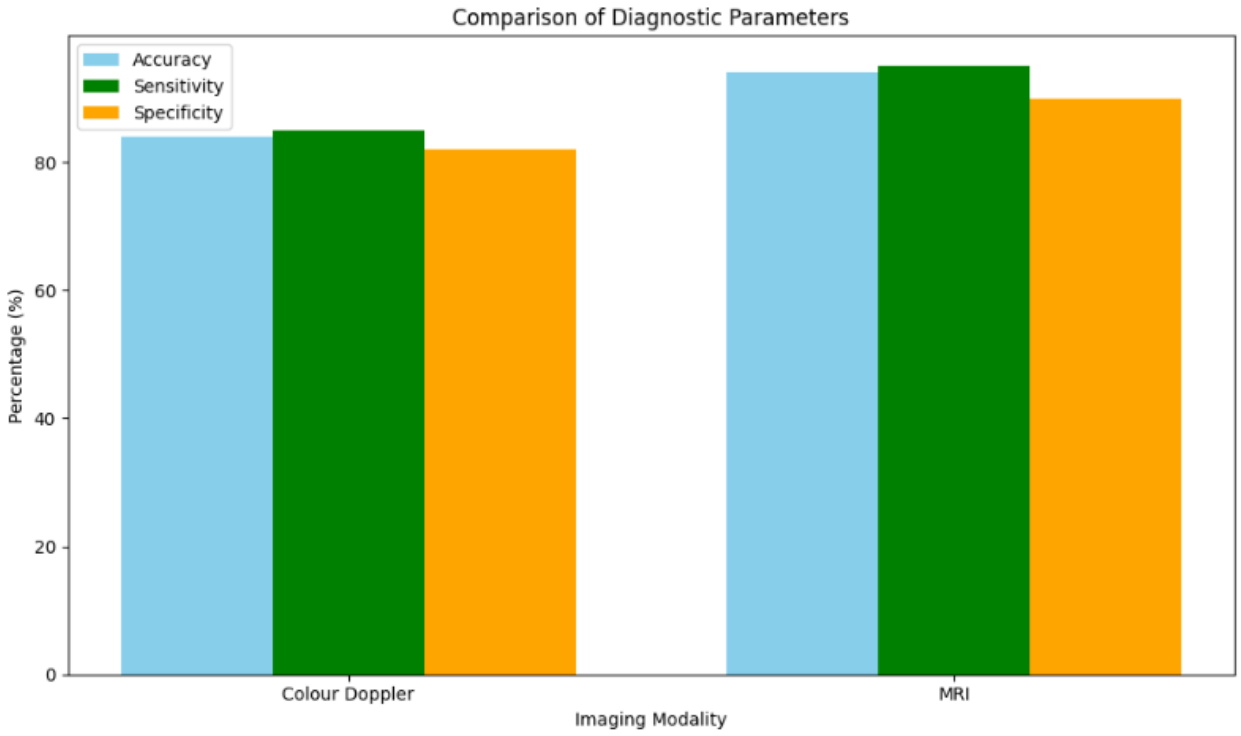
- **Portal vein diameter** was enlarged (>13 mm) in **85%** of patients.
- **Hepatofugal flow** was observed in **67%** of cases on Doppler.
- **Splenomegaly** was detected in **72%** on USG and confirmed in **76%** by MRI.
- **Esophageal/gastric varices** were detected in **30%** on Doppler and **55%** on MRI.
- **Collateral vessels and portosystemic shunts** were visualized in **38%** on Doppler, while MRI detected them in **61%**.
- **Portal vein thrombosis** was observed in **14 patients** via MRI, while Doppler detected only 9.

Diagnostic Accuracy:

Imaging Modality	Sensitivity	Specificity	PPV	NPV	Diagnostic Accuracy
Colour Doppler	85%	82%	92%	70%	84%
MRI	95%	90%	96%	87%	94%



Discussion

This study underscores the high diagnostic value of **Magnetic Resonance Imaging (MRI)** in evaluating **portal hypertension**, with significantly superior sensitivity and diagnostic accuracy

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when compared to **Colour Doppler Flow Imaging (CDFI)**. While CDFI remains a valuable first-line, cost-effective screening modality, it has limitations in detecting deeper or smaller portosystemic collaterals and assessing flow dynamics in complex vascular regions.MRI, on the other hand, offered more comprehensive anatomical detail, particularly in cases of **varices**, **portal vein thrombosis**, and **spontaneous shunting**, which often go undetected in Doppler due to acoustic shadowing or bowel gas interference. Moreover, MRI's multi-sequence capability allowed better visualization of hepatic parenchymal texture and fibrosis—parameters critical in staging chronic liver disease. In particular, **T2-weighted imaging and MR angiography** were instrumental in delineating thrombosis and vascular abnormalities. The study confirms that **MRI should be considered the gold standard** for assessing portal hypertension when Doppler findings are equivocal or when complications such as thrombosis are suspected.

Conclusion

The findings of this study establish that:

- **MRI has superior diagnostic accuracy** compared to Colour Doppler for evaluating portal hypertension and its complications.
- **Colour Doppler** is effective for initial screening but may **miss smaller collaterals** or **underestimate severity**.
- **Portal vein diameter**, **flow direction**, **collaterals**, and **varices** can be better characterized using MRI.
- **Routine use of MRI** in complex cases may help in early intervention and better clinical outcomes.

Thus, **a complementary approach** using Doppler for screening and MRI for comprehensive evaluation is ideal in suspected or known portal hypertension cases.

References

1. *Bosch J, García-Pagán JC. Complications of cirrhosis. I. Portal hypertension. J Hepatol. 2000;32(1 Suppl):141-156.*
2. *Sarin SK, et al. Non-invasive assessment of portal hypertension. Hepatol Int. 2008;2(1):52-59.*
3. *Chawla Y, et al. Role of colour Doppler and MRI in evaluation of portal hypertension. Indian J Radiol Imaging. 2013;23(1):15–20.*
4. *Ripoll C, et al. The clinical value of non-invasive portal pressure assessment. Liver Int. 2012;32(4):557–565.*
5. *Taourel P, et al. MRI in portal hypertension: what is the evidence? Eur J Radiol. 2011;80(1):16–25.*
6. *Berzigotti A, et al. Non-invasive tools for the diagnosis of portal hypertension. Semin Liver Dis. 2008;28(1):43-55.*
7. *Bolondi L, et al. Doppler ultrasound in the evaluation of portal hypertension. World J Gastroenterol. 2006;12(27):4709–4719.*

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8. *Zissin R, et al. The role of imaging in the evaluation of portal hypertension. Abdom Imaging. 2005;30(1):15–26.*
9. *Lee SS, et al. Portal hypertension: Imaging diagnosis and management. Radiol Clin North Am. 2014;52(4):691-703.*
10. *Vilgrain V, et al. Portal hypertension and cirrhosis: Diagnostic imaging and implications. Radiographics. 2000;20(3):697–712.*