Sonographic Evaluation of the Portal and Hepatic Systems

CINDY OWEN, RDMS, RVT
PATRICK MEYERS, RDMS, RDCS, RVT

Color and spectral Doppler are used to evaluate flow characteristics in the portal and hepatic vessels. On occasion, suprahepatic pathologies are reflected in the flow characteristics of the hepatic veins and transmitted to the portal venous system across the hepatic sinusoids. Few definitive duplex findings are pathognomic for portal hypertension. Evaluation of the portal venous system is analogous to a puzzle. A picture of the processes can only be attained after many of the pieces are assembled.

Key words: portal system, hepatic system, sonography, portal hypertension

Anatomy

PORTAL AND HEPATIC SYSTEM

The portal vein is formed by the junction of the splenic and superior mesenteric vein. The portal/splenic confluence is found posterior to the neck of the pancreas. The inferior mesenteric vein drains into the splenic vein to the left of the portal/splenic confluence. The left gastric or coronary vein usually joins the splenic vein superiorly near its junction with the superior mesenteric vein. It courses in a cranio-caudad plane. From the confluence, the portal vein courses lateral and cephalad in an oblique plane toward the porta hepatitis, where it enters the liver. Within the liver, the portal vein is found posterior to the hepatic artery and common bile duct. These three structures course together throughout the liver and are known as the portal triad.

The portal vein divides at the porta hepatis into right and left branches. The right portal vein divides into anterior and posterior branches, and the left portal vein divides into medial and lateral branches. The left portal vein is in contact with the ligamentum teres.
The branches of the portal vein are intrasegmental, traveling within the segments of the liver, whereas the branches of the hepatic veins are intersegmental, traveling between the lobes and segments of the liver.

The portal veins can be differentiated sonographically from the hepatic veins by the bright echogenic walls that surround them. This is due to the thick collagenous tissue in the portal vein walls. The hepatic veins do not exhibit echogenic borders (Fig. 1).

The cystic vein, which drains into the gallbladder, is a branch of the portal vein. Although it is not usually visualized sonographically, the cystic vein has important implications in the evaluation of portal hypertension. Impaired drainage of the cystic vein into the portal vein can result in varices within the gallbladder wall. These are recognizable by sonographic imaging.

There are usually three main hepatic veins within the liver. They are the right, middle, and left hepatic veins. The hepatic veins increase in size toward the superior aspect of the liver, where they drain into the inferior vena cava.

3D

Recent advances in imaging technology offer the user the ability to evaluate the portal venous system...
in a unique way. Using readily available 3D technology, the user can perform a sweep through the area of interest and reconstruct the pertinent anatomy (Fig. 2, 3).

**FUNCTION**

Understanding the function of the portal venous system is key to understanding the physiological responses manifested in disease processes.

1. The portal vein is 60% oxygen saturated and provides greater than 50% of the oxygen requirements to the hepatocytes.
2. It brings nutrient-rich blood to the liver from the bowel.
3. The portal vein is the primary collateral route for decompression of the liver in elevated pressure.
4. In a normal state, the portal venous system is a low-pressure system with a normal pressure of 5 to 10 mm Hg.

**DOPPLER SPECTRAL ANALYSIS**

**Portal and Hepatic System**

The portal vein normally exhibits a monophasic, low-velocity Doppler signal, with slight respiratory variation. The normal range of flow velocity is wide but is usually between 20 and 40 cm/sec. The flow is continuous and should demonstrate little pulsatility (Fig. 4). Flow should not cease or reverse in the normal individual. Prominent pulsatility of the portal vein is abnormal and may be indicative of right heart failure, tricuspid regurgitation, hepatic vein/portal vein fistula, or portal hypertension (Fig. 5). The flow in the splenic and superior mesenteric veins is toward (hepatopedal) the liver, and both exhibit a low-velocity, monophasic signal.

Hepatic artery flow is in the same direction as the portal vein (hepatopetal). The hepatic artery normally demonstrates a low-resistance waveform with continuous forward flow throughout the cardiac cycle (Fig. 6).

The hepatic veins (HVs) drain blood from the liver into the inferior vena cava. The normal Doppler waveform obtained from the HVs is triphasic (Fig. 7). This phasicity is dependent on variations in central venous pressure during the cardiac cycle. A lack of pulsatility or continuous waveform in the hepatic vein may indicate compression or stenosis (Fig. 8).

**Etiology of Portal Hypertension**

Portal hypertension can be defined as elevated pressure within the portal venous system resulting in impaired blood flow through the liver. The main complication of portal hypertension is gastrointestinal
bleeding from ruptured esophageal and gastric varices.

Elevation of pressure within the portal system can be caused by both intrahepatic and extrahepatic pathologies. In North America, the most common cause of portal hypertension is cirrhosis of the liver. Other common causes include hepatic vein occlusion (Budd-Chiari syndrome) and schistosomiasis. Extrahepatic etiologies of portal hypertension are further subdivided into prehepatic or posthepatic.

Sonographic findings associated with portal hypertension include enlarged diameter of the portal vein, lack of respiratory variation in the portal vein or its tributaries, hepatofugal (flow away from the liver) portal flow direction, decreased portal velocity or volume, and the presence of collaterals or varices. Splenomegaly is uniformly present with portal hypertension. The spleen is enlarged when its length exceeds 13 cm. This should be measured in a cranio-caudad plane. Abnormal liver texture and ascites are also commonly seen and are
usually related to accompanying cirrhosis. A sudden onset of ascites should prompt careful examination of the portal vein for thrombosis.

Enlargement of the portal vein >13 mm is indicative of portal hypertension with a high degree of specificity (100%) but low sensitivity (45%-50%). The portal vein diameter should be measured just above the inferior vena cava (IVC) with the patient in quiet respiration. With deep inspiration, the normal diameter may increase to about 16 mm, resulting in an overestimation of portal vein diameter. It is important to recognize, however, that the portal vein is not always enlarged with portal hypertension. In some cases, portal flow may be primarily diverted through collateral channels, resulting in a small portal vein at the porta hepatis. This can be seen with diversion of flow through a large coronary vein, splenorenal shunt, or other similar channel.

Portal vein flow velocity decreases with portal hypertension due to increased resistance to flow. However, in the presence of a recannalized paraumbilical vein, the flow velocity in the main portal vein may be increased. As pressure increases, portal blood flow may become pulsatile. Helical flow may be seen in the portal vein and is more common in patients with severe liver disease. With late stages of portal hypertension, portal flow direction can reverse and course away from the liver. Hepatofugal flow is easily assessed with color Doppler. The portal flow direction can be compared with the hepatic artery. When they are in opposing directions, portal flow is reversed.

With decreasing velocity of portal flow, stagnation may occur, leading to thrombus formation. There are many other causes of portal vein thrombosis, including extrinsic compression, tumor invasion, and inflammatory processes. Following thrombosis, cavernous transformation of the portal vein may develop. It is seen as a tortuous network of blood vessels located in the porta hepatitis and extending into the liver. Doppler waveforms obtained from this area will primarily show venous signals with flow direction into the liver. Cavernous transformation most commonly occurs in patients with otherwise healthy livers.

**Portosystemic Collaterals and Varices**

There are many alternate pathways for blood from the gut to reach the heart. Sonography is a useful tool for evaluating these portosystemic collaterals. The left gastric or coronary vein is the most common portosystemic shunt, occurring in 80% to 90% of patients. The coronary vein is enlarged when its diameter exceeds 6 mm. Reversed flow in the coronary vein is a useful sign of portal hypertension. The normal flow direction is toward the splenic/portal vein. Hepatofugal flow in the coronary vein is oriented cephalad. This abnormal flow may be associated with esophageal varices and hemorrhage. Preservation of hepatopetal flow in the coronary vein may indicate a low risk of variceal hemorrhage.
The coronary vein is imaged by locating the splenic vein in a midline sagittal view and moving the probe to the right. It is recognized as a small vessel coursing cephalad from the splenic vein near the portal-splenic confluence (Fig. 9).

A recaannalized paraumbilical vein with hepatofugal flow is another important collateral pathway. It is easily recognized sonographically as a tubular structure at the ligamentum teres (Fig. 10). The paraumbilical vein exits the anterior aspect of the liver and courses near the skin surface to the umbilicus. Hepatofugal flow is typically seen in the right portal vein due to the sump effect of the paraumbilical vein. The left portal vein remains hepatopetal but may become enlarged as it feeds the paraumbilical vein. A high-frequency linear transducer can be used to follow the vessel to the level of the umbilicus, where it is seen to connect to a complex network of vessels known as the caput medusa.9

Other collaterals and varices include gastric, splenic, splenorenal, retroperitoneal/paravertebral, and gallbladder, among others (Fig. 11). Gastric varices may be seen around the stomach in the epigastrium, underneath the left lobe of the liver, and near the spleen.

Retroperitoneal/paravertebral varices also may occur with portal hypertension but are more difficult to recognize with sonography. Careful scanning may reveal tortuous vessels between the liver and right kidney, near the left kidney or spine. With a splenorenal shunt, blood flow is diverted from the portal vein and courses directly to the left renal vein and IVC. This is best seen in a coronal plane using the enlarged spleen as a sonographic window. Color Doppler will aid in the detection of the enlarged left renal vein and its

FIG. 9. The open arrow is pointing to an enlarged coronary vein in a patient with portal hypertension. Color Doppler demonstrated reversed flow. Following the transjugular intrahepatic portosystemic shunt (TIPS) procedure, the flow direction became normal.

FIG. 10. Sagittal sonographic image through the left portal vein (closed arrow) showing a recanalized paraumbilical vein (open arrow) exiting the liver.

FIG. 11. Transverse sonographic image through the spleen in a patient with portal hypertension. Prominent varices (arrows) are seen surrounding the posterior aspect of the spleen.
connection to a dilated splenic vein. Prominent varices at the splenic hilum are commonly seen.

Gallbladder varices may occur due to a backup of blood flow in the cystic vein. This can be recognized as a thickened gallbladder wall in which tubular structures (dilated veins) are present. Color and spectral Doppler will aid in the diagnosis by showing venous flow within the dilated vessels of the gallbladder wall.

**Portal Vein Thrombosis (PVT)**

Portal hypertension can cause thrombosis of the portal vein due to stagnation of flow (Fig. 12). Hypercoagulable states can result in thrombosis of the portal vein directly or indirectly through thrombosis in the splenic or superior mesenteric vein.

Biliary atresia/cirrhosis may cause thrombus in the main portal vein or the smaller branches within the liver.

Pancreatitis and other inflammatory processes most commonly cause thrombosis that begins in the splenic or superior mesenteric veins. Portal vein compression by lymphadenopathy or tumor mass can also result in thrombosis.

Increased flow through the hepatic artery with a decrease in resistance is associated with portal vein thrombosis. The hepatic artery may appear enlarged with prominent color Doppler signals. Use of color Doppler alone to evaluate portal flow may result in the mistaken identity of an enlarged hepatic artery for the portal vein, especially when portal thrombus is isoechoic to the surrounding liver tissue. This pitfall can be avoided by always obtaining a spectral Doppler signal from the portal vein in addition to color Doppler evaluation. Partial thrombus is not associated with hepatic artery changes.

Cavernous transformation of the portal vein has been shown to occur within 6 to 20 days following the acute thrombosis. It is not commonly seen in patients with cirrhosis or other liver diseases, occurring more frequently in patients with healthier livers. Cavernous transformation is readily recognized with color Doppler as multiple, tortuous, tiny vessels at the porta hepatis with an absence of a normal portal vein (Fig. 13). Flow is hepatopetal and primarily venous.

Tumor invasion of the portal vein occurs most frequently with hepatocellular carcinoma but is also seen with liver metastases. Color Doppler can aid in differentiating thrombosis versus tumor infiltration by demonstrating tiny vessels within the tumor-filled portal vein. This can be differentiated from cavernous transformation by the presence of low-resistance arterial signals consistent with tumor infiltration.
blood flow and neovascularity. The branching pattern will be randomized and chaotic. In addition, the portal vein is commonly identified as an enlarged debris-filled tubular structure at the porta hepatis when it is filled with tumor thrombus, whereas with cavernous transformation, the main portal vein is usually not identified.

**Color Doppler Evaluation of Transjugular Intrahepatic Portosystemic Shunts (TIPS)**

This is a nonsurgical, low-invasive procedure performed to reduce portal venous pressure, variceal bleeding, and refractory ascites. Using a transjugular approach, the intrahepatic portal system is punctured, the intraparenchymal tract is balloon dilated, and a metallic stent is deployed, allowing the high-pressure portal blood to divert toward the low-pressure hepatic vein (Fig. 14). Most commonly, the right portal vein is shunted to either the right or middle hepatic vein.

Sonography with color and spectral Doppler should be used to evaluate the portal venous system prior to the TIPS procedure. The main portal vein flow velocity is measured, and the flow direction in the major branches of the portal venous system is determined. The presence of a recanalized paraumbilical vein or other portosystemic collaterals and varices is noted as well as the amount of ascites. The internal jugular vein should be assessed for patency.

Sonography is performed the day following the TIPS procedure to obtain baseline velocities throughout the stent and of the main portal vein. The position and placement of the stent within the portal and hepatic vein are carefully evaluated. Both ends should be seen to extend well into each vein. Follow-up studies are usually performed at one, three, and six months and every six months thereafter if no problems occur.

The main portal vein (MPV) velocity increases following the TIPS procedure because flow resistance has decreased. Follow-up studies should compare the current MPV velocity to the velocity obtained on the first day post-TIPS. Flow velocities throughout the shunt are robust (usually exceeding 90 cm/sec). The waveform profile through the shunt reflects the cardiac pulsation apparent in the hepatic veins.

It is common to see flow reversal (hepatofugal) in the intrahepatic portal vein branches following the TIPS procedure. Most of the intrahepatic portal flow courses toward the shunt because blood flows preferentially to the path of least resistance. A change in direction of these branches upon follow-up examinations from hepatofugal back to hepatopetal is an indirect sign of stent stenosis. Not all portal branches will become hepatofugal. It is important to note that patients must form their own baseline for comparison.

TIPSs are susceptible to malfunction over time due to stenosis of the shunt or hepatic vein or shunt thrombosis. Stenosis within the shunt is most commonly due to intimal hyperplasia. Sonography is effective in detecting shunt stenosis prior to occlusion. The primary criterion is comparison of shunt velocity to the baseline velocity. Because the hyperplasia may result in either a focal or diffuse narrowing throughout the
shunt, velocities may be either increased or decreased with stenosis (Fig. 15). Dodd\textsuperscript{13} suggested that a temporal change (increase or decrease) in peak velocity through the shunt of 50 cm/sec is highly indicative of stenosis, although flow velocities of less than 60 cm/sec are almost always associated with stenosis.

Secondary signs of stenosis include recurrence of varices and portosystemic collaterals, new onset of ascites, and change in the direction of intrahepatic portal vein branches from hepatofugal to hepatopetal. In addition, a loss of transmitted cardiac pulsatility within the stent and reversal of flow in the hepatic vein draining the stent should alert the clinician to possible stenosis.\textsuperscript{13–15} Magnified views are best to evaluate stent placement and architecture.

**Budd-Chiari Syndrome**

Obstruction or severe stenosis of some or all of the hepatic veins characterizes Budd-Chiari syndrome. The obstruction may occur due to vessel thrombosis, tumor infiltration, or a congenital web. The inferior vena cava may be involved. Patients usually present with an acute onset of ascites, right upper-quadrant pain, and hepatomegaly.

Sonography with color Doppler has been shown to be very useful in the diagnosis of Budd-Chiari syndrome. Color Doppler is a valuable tool, as the hepatic veins may be difficult to visualize with B-mode imaging alone when the liver is enlarged or cirrhotic.\textsuperscript{16} Color Doppler is also useful to evaluate the vascular shunting that occurs due to the increased hepatic pressure. Spectral Doppler is used to characterize waveform changes in the hepatic veins and IVC.

B-mode imaging will reveal hepatomegaly and ascites. Splenomegaly may be present (Fig. 16). The caudate lobe is often quite large and may appear mass-like. This enlargement results from increased blood flow through the emissary veins in the caudate lobe. Because these veins drain directly into the IVC at a lower level than the main hepatic veins, they may not be involved in the obstruction.

The obstruction of the hepatic veins results in vascular shunting that may be prehepatic, intrahepatic, or both. Color Doppler is used to locate the hepatic veins, determine patency and flow direction, and map out collateral pathways. Intrahepatic shunting has been described as demonstrating a characteristic hockey stick configuration that can be demonstrated with color Doppler.\textsuperscript{16}

This shunting may be from an obstructed hepatic vein to a nonaffected hepatic vein, or subcapsular vessels to diaphragmatic, azygos, and hemiazygos veins or through the caudate vein to the IVC.

Spectral Doppler analysis of patent hepatic veins may show abnormal waveforms. Low-velocity, continuous waveforms may be detected in front of stenotic areas. Stenotic hepatic veins may show very high velocities. However, if the main obstruction is within the IVC (Fig. 17), the flow, even
in narrowed hepatic veins, may be slow and continuous.

**Pitfalls**

**SONOGRAPHIC WINDOW**

The best scanning approach to the main portal vein is nearly always intercostal. Although the portal vein is more easily seen with B-mode imaging in a subcostal position, this approach commonly results in a poor Doppler angle of incidence. The intercostal view results in Doppler angles that vary from 0 degrees to about 60 degrees. With color Doppler set so that flow toward the probe is red, the portal vein is seen as a red vessel adjacent to the red hepatic artery (if color Doppler invert is not selected).

When a large amount of ascites is present, the depth to the portal and hepatic veins can be quite large. Bowel loops and gas may not allow visualization at all from the subcostal approach. Using an intercostal window will usually allow adequate imaging in these cases. If cirrhosis is severe, sound penetration through the liver will be greatly decreased. It may be necessary to use a lower frequency transducer or the lowest frequency setting on a multifrequency transducer.

**FLOW DIRECTION**

Flow direction can be very important in abdominal Doppler. Confusion about the direction of flow is a common pitfall. For this reason, it is usually best to avoid use of the color and spectral Doppler invert control. Flow away from the Doppler beam is shown as blue and below the zero baseline, and flow toward the Doppler beam is shown as red and above the zero baseline. Anytime the flow direction is in question, it is helpful to check a baseline vessel in which flow direction is known. For example, to rule out hepatofugal flow in the portal vein, compare its flow direction to that of the hepatic artery. When flow direction is normal in the portal vein (toward the liver), it is the same direction as the hepatic artery. If they are on opposite sides of the spectral Doppler baseline or show opposite colors, blood flow is reversed in the portal vein (Fig. 18).

**PRESENCE OR ABSENCE OF FLOW**

Color and spectral Doppler are commonly used to determine the presence or absence of flow in a vessel. Another common pitfall is to mistakenly assume...
the absence of flow when in fact it is present. This most commonly occurs as a result of poor Doppler angles or inappropriate settings of the Doppler parameters. The Doppler controls should be sensitized for the detection of slow flow whenever thrombosis or occlusion is suspected. This requires adjustment of the pressure-regulating filter (PRF) and filter controls to very low levels. In addition, if the Doppler angle is too great, the frequency shift from slow flow may be too small to detect. This may lead the sonographer to mistakenly assume that flow is absent. Because most abdominal Doppler is performed with curved linear arrays, steering of the Doppler beam cannot be performed, and it is necessary to heel/toe the probe to achieve a good angle of incidence. Commonly, the view that gives the best B-mode image of a vessel is the poorest Doppler approach because the angle of incidence is too great. A common example of this is in evaluating the portal vein. The portal vein is best seen with B-mode imaging in a subcostal approach, where the angle of incidence is near 90 degrees. Color Doppler evaluation of the portal vein in this view may not demonstrate flow, especially if slow flow states are present. The best view of the portal vein for Doppler evaluation is an intercostal approach. In this view, the Doppler angle is much smaller, allowing demonstration of slower flow states.

### Conclusion

There are many uses for advanced color and spectral Doppler skills in the abdomen. Continuing education, dedication, and experience are the keys to success. The appropriate use of color and power Doppler will also improve the success rate.

### References


Objectives: After studying the article titled “Sonographic Evaluation of the Portal and Hepatic Systems,” you will be able to:

1. Describe the anatomy of the portal and hepatic systems.
2. Understand the etiology and sonographic findings in portal hypertension.
3. Evaluate portal vein thrombosis.
4. Discuss the transjugular intrahepatic portosystemic shunts (TIPS) procedure and the sonographic evaluation.

1. The portal vein is formed by the junction of the splenic vein with which of the following?
   a. superior mesenteric vein
   b. inferior mesenteric vein
   c. left gastric vein
   d. coronary vein

2. What three structures make up the portal triad?
   a. pancreas, kidney, and renal artery
   b. portal vein, hepatic artery, and common bile duct
   c. gall bladder, caudate lobe, and inferior vena cava
   d. splenic vein, gastric artery, and superior mesenteric vein

3. The portal veins can be differentiated sonographically from the hepatic veins by which of the following characteristics?
   a. hypoechoic interface with the surrounding tissue
   b. isoechoic to the blood flow
   c. anechoic to the liver
   d. bright echogenic walls that surround them

4. The portal venous system is a system with a normal pressure of which of the following?
   a. 0 to 5 mm Hg
   b. 5 to 10 mm Hg
   c. 10 to 15 mm Hg
   d. 15 to 20 mm Hg

5. The normal range of flow velocity in the portal vein is between which of the following?
   a. 0 to 20 cm/s
   b. 20 to 40 cm/s
   c. 40 to 60 cm/s
   d. 60 to 80 cm/s

6. The main complication of portal hypertension is which of the following?
   a. pedal edema
   b. cirrhosis
   c. gastrointestinal bleeding
   d. bile duct stenosis

7. Which of the following is not a common cause of intrahepatic portal hypertension?
   a. lymphoma
   b. veno-occlusive disease
   c. sarcoidosis
   d. inferior vena cava obstruction

8. Which of the following is not a sonographic finding associated with portal hypertension?
   a. decreased diameter of the portal vein
   b. lack of respiratory variation in the portal vein
   c. hepatofugal (flow away from the liver) portal flow direction
   d. decreased portal velocity or volume

9. Portal vein thrombosis may be caused by which of the following?
   a. intrinsic compression
   b. inflammatory processes
   c. decrease in output
   d. esophageal varices

10. Which of the following is the most common portosystemic shunt?
    a. superior mesenteric vein
    b. inferior mesenteric vein
    c. left gastric or coronary vein
    d. inferior vena cava

11. The TIPS procedure reduces portal venous pressure by which of the following methods?
    a. shunting blood into the mesenteric system
    b. providing a connection with the gastrointestinal veins
c. diverting portal blood to the hepatic veins
d. connecting the portal system with the renal veins to release the pressure

12. Stenosis within the TIPS is most commonly due to which of the following abnormalities?
   a. intimal hyperplasia
   b. stent bending
   c. improper placement
   d. recannulation of the umbilical vein

13. Which of the following is not a cause of obstruction seen in Budd-Chiari syndrome?
   a. vessel thrombosis
   b. tumor infiltration
   c. congenital web
   d. tricuspid stenosis

14. Which of the following is a sonographic finding in Budd-Chiari syndrome?
   a. renal stenosis
   b. esophageal varices
   c. ascites
   d. superior mesenteric artery stenosis

15. The best view of the portal vein for Doppler evaluation is from which scanning window?
   a. subxiphoid
   b. intercostal
   c. right oblique
   d. sagittal
INSTRUCTIONS

1. Each question has only one correct answer. Answer all of the questions.
2. The nonrefundable processing fee for SDMS members is $10.00; $25.00 for nonmembers. This fee can be paid by check or international money order (U.S. funds drawn on a U.S. bank only). CASH PAYMENTS ARE NOT ACCEPTED.
3. Return your completed answer form along with the processing fee and stamped, self-addressed envelope to the Society of Diagnostic Medical Sonography, P.O. Box 200971, Dallas, TX 75320-0971, USA.
4. Note: SDMS members can complete the JDMS CME test at no cost by accessing the test online at http://www.sdms.org/jdms/cme.asp. This free JDMS CME test is an SDMS member benefit. (Access the online CME test using your SDMS membership number.)
5. An ungraded test will be returned for any of the following reasons: test received after the expiration date, incorrect processing fee, or missing stamped, self-addressed envelope. If you are unable to provide a self-addressed, stamped envelope, please include an additional $0.50 for the United States, Canada, and Mexico; include an additional $1.00 for all other countries.

NOTE: Tests postmarked after October 31, 2009 will not be accepted. Allow 4-6 weeks for processing. A score of 70% or better must be achieved to receive SDMS CME credit. This answer form will be returned to you and will be your proof of earning SDMS CME credit.

Type or Print:

Name: _________________________________________________________________________________________
Address: _______________________________________________________________________________________
City: _______________________ State/Province/Country: ______________ ZIP + 4/Postal Code: _______________
Daytime Phone: ________________________________ E-mail Address: ____________________________________

Required (for CME tracking purposes)
SDMS Members: SDMS Member #: _______________ Membership Expiration Date: _______________
Nonmembers: ARDMS/CCI#: _____________ OR Social Security #: XXX-XX-_______________ (last 4 digits only)

<p>| | | | | | | | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Office Use Only: Check #: _________ Amount: $ _____________

1) Please rate the JDMS CME activity in the following areas:

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relevance to your practice needs</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>Quality of the content</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>Content coverage of the objectives</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>Appropriateness of the CME test questions</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

2) Was bias shown toward any commercial product or service? ☐ Yes ☐ No

3) Other comments on the JDMS CME activity, the JDMS, or suggested topics for future issues: ____________________________