

# The Abernethy malformation—myriad imaging manifestations of a single entity

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## Abstract

Abernethy malformation, also known as congenital extrahepatic portosystemic shunts (CEPS) is a rare clinical entity and manifests with different clinical symptoms. CEPS are abnormalities of vascular development where there is shunting of portal blood into the systemic venous system. Multidetector computed tomography (MDCT) is a fast and effective modality for evaluation of CEPS. CT displays all the information desired by the surgeon as well as the clinician including the anatomy of the splenic and superior mesenteric veins, size and site of the shunt, presence or absence of the portal vein radicles, and helps to plan the therapy and even the follow-up of these patients. Contrast-enhanced magnetic resonance imaging (MRI) has also emerged as a promising tool for the evaluation of liver lesions associated with the malformation. The Radiologist should be aware of the various imaging appearances of this entity including its complications. In this article, we describe the imaging appearances of CEPS, their complications, and their imaging appearances on CT and MRI. We have also described various associated anomalies.

**Key words:** Abernethy malformation; congenital extrahepatic portosystemic shunts; portosystemic shunts

## Introduction

Congenital extrahepatic portosystemic shunt (CEPS) is a condition in which portal blood is shunted partially or completely into the systemic circulation via an abnormal communication of the portal system with the systemic circulation. The first account of this malformation was provided by John Abernethy in 1793<sup>[1]</sup>, after whom it is also known as the Abernethy malformation.

The clinical presentation of these patients is varied and these shunts are often unsuspected and picked up either on ultrasound or computed tomography/magnetic resonance imaging (CT/MRI) for evaluation of the varied

symptomatology they cause, which includes jaundice, difficulty in breathing, cyanosis, clubbing, and abdominal mass. Multidetector CT (MDCT) is a fast and effective modality for the evaluation of patients with suspected or confirmed portocaval shunts; it displays all the information desired by the surgeon and the clinician including the anatomy of the splenic and superior mesenteric veins (SMV), size and site of the shunt, presence or absence of the portal vein (PV) radicles, and helps to plan the therapy and even the follow-up of these patients. MRI may provide similar information, and though CT has the advantage in speed and spatial resolution; however, MRI scores in the characterization of liver lesions and patients who need long term follow up.

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## Anatomy of the Normal Portal Vein

Normally, the venous drainage of the abdomen consists of two separate circulations—the systemic venous drainage and the portal circulation. The PV is formed by the union of the SMV with the splenic vein (SV). The portal system carries blood into the liver.<sup>[2]</sup> Blood exits the liver through the hepatic veins.

In normal individuals, there are no anatomical connections between the components of the portal system and the systemic or hepatic veins within or outside the liver.<sup>[3]</sup>

A portosystemic shunt leads to “short circuiting” of all or parts of portal blood, which passes into the systemic circulation without perfusing the liver.

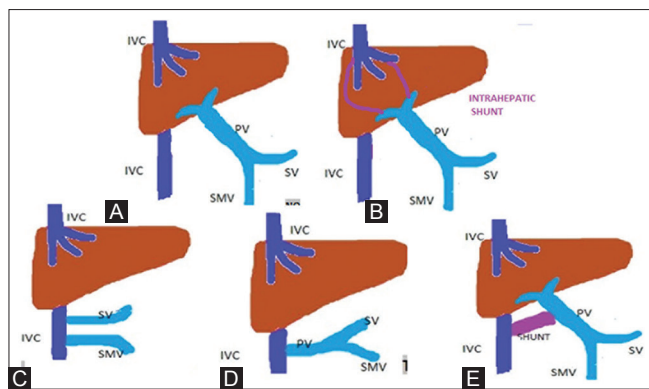
## Classification of Congenital Portosystemic Shunts

Congenital portosystemic shunts are classified into intrahepatic and extrahepatic. In the intrahepatic shunts, the shunt is at the level of PV branches after its division whereas in the extrahepatic shunts the anastomoses are established between the tributaries of the portal or mesenteric system or main PV and a systemic vein [Figure 1].<sup>[4]</sup>

### Intrahepatic shunts

These are communications between the branches of the PV and inferior vena cava (IVC). The first case was described by Doehner *et al.* in 1956,<sup>[5]</sup> and these were further classified by Park *et al.*<sup>[6]</sup> in 1990, as follows:

- Type 1—Single tube-like vessel connecting the right branch of PV to IVC [Figure 2]
- Type 2—Localized peripheral shunt in which one hepatic segment has communications between the peripheral branches of the PV and the hepatic veins



**Figure 1 (A-E):** Normal portovenous anatomy: (A) Intrahepatic shunt (B). Types of CEPS. Type 1a: Splenic vein and superior mesenteric vein drain directly into the inferior vena cava (IVC) (C). Type 1b: Portal vein drains directly into the IVC (D). Type 2: Shunt between portal vein and IVC (E)

- Type 3—Aneurysmal communication between peripheral PV and hepatic vein
- Type 4—Multiple intrahepatic shunts in both lobes of liver.

### Congenital extrahepatic portosystemic shunts

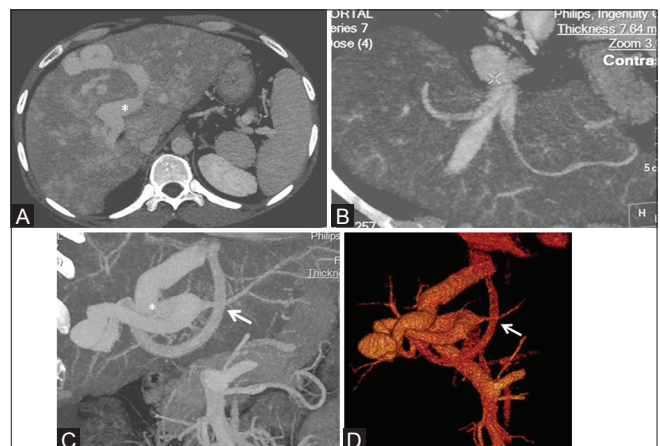
CEPS were classified by Morgan and Superina<sup>[7]</sup> into the following types [Figure 1]:

- Complete—End to side with absent intrahepatic PV branches
  - o SV and SMV drain separately into a systemic vein (type 1a)
  - o SV and SMV join to form a common trunk which drains into a systemic vein (type 1b)
- Incomplete—Intrahepatic PV radicles are present, however, there is partial diversion of the portal blood into a systemic vein through a side-to-side shunt (type 2).

## Embryological Basis of Congenital Extrahepatic Portosystemic Shunts

In the embryo, the right and left vitelline veins emerge from the yolk sac. At approximately 4 weeks, communications develop between the vitelline veins. They anastomose with each other to form a figure of 8 around the developing duodenum. Selective involution of these veins yields the final configuration of the PV.<sup>[8,9]</sup>

As the portal vein is formed by the selective involution of the periintestinal vitelline venous loop, abnormal patterns of involution may result in a preduodenal, prebiliary, or duplicated portal vein. Excessive involution may result in an absent portal vein. The absence of the portal vein thus results due to abnormal development in weeks



**Figure 2 (A-D):** An 8-year-old child presenting with cyanosis, CT angiographic MIP images (A) showing a well-defined large tortuous intrahepatic shunt (\*) between the main portal vein and the middle hepatic vein. The middle hepatic vein is enlarged (B). Reconstructed coronal MIP (C) and VR images (D) showing another shunt between the left portal vein and left hepatic vein (arrow) and the large intrahepatic shunt

4–10 of gestation.<sup>[10,11]</sup> Because the vena cava also has a complex development and is derived from several venous channels including the sinus venosus and a portion of the anastomosis between the right and left vitelline veins in the cranial part of the liver,<sup>[12]</sup> it has been suggested that this may be the embryological basis of development of congenital extrahepatic portosystemic shunts.<sup>[13]</sup>

### Clinical Features of Congenital Extrahepatic Portosystemic Shunts

CEPS may be asymptomatic well into adulthood and many authors have reported seeing adult patients presenting for the first time with clinical manifestations.<sup>[14–16]</sup>

Clinical features of portosystemic shunts may broadly be divided into:

- o Features related to the shunting of portal blood
- o Features secondary to associated congenital abnormalities
- o Features secondary to hepatic lesions.

#### Symptoms related to the shunt

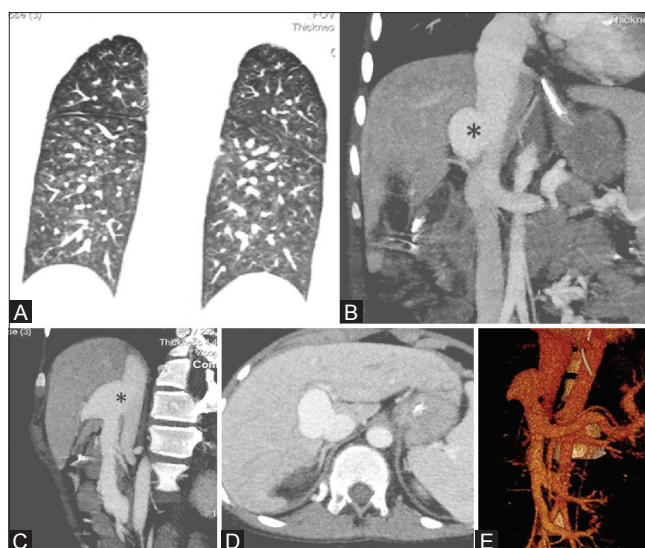
##### *Hepatopulmonary syndrome*

HPS is characterized by the triad of arterial deoxygenation (a widened PA–a O<sub>2</sub> with or without hypoxemia), intrapulmonary vascular dilatation, and liver disease.<sup>[17]</sup> It occurs secondary to diversion of vasoactive mediators into the systemic circulation. There is consequent dilatation of the intrapulmonary vessels and AV shunting with resultant hypoxemia as well as an element of ventilation/perfusion mismatch.<sup>[6,17]</sup>

This syndrome was first described in a patient with Abernethy malformation by Alvarez *et al.*;<sup>[18]</sup> it has subsequently been reported in a number of children with congenital portosystemic shunts.<sup>[2,19,20]</sup> Patients frequently present with cyanosis and digital clubbing and are generally investigated for cardiac and pulmonary shunts. Pediatric patients presenting with structurally normal echocardiograms and unexplained cyanosis should be investigated to rule out the possibility of a CEPS with HPS, even if no previous history is present [Figure 3].

##### *Metabolic dysfunction*

In patients with congenital portovenous shunts, including patent ductus venosus, blood from the mesenteric circulation bypasses the liver and goes directly into the systemic circulation; thus, toxic compounds which are removed in normal subjects by the liver, pass directly into the systemic circulation. These patients often have hyperammonemia and galactosemia.<sup>[2,6,20]</sup> Congenital portovenous shunts are often detected early in countries that screen galactose levels in new-borns.<sup>[21]</sup> Other symptoms related to the shunts/hepatic dysfunction include pulmonary hypertension,<sup>[20,22]</sup> hyperandrogenism, primary amenorrhea, or signs of virilisation.<sup>[23]</sup>



**Figure 3 (A–E):** A 13-year-old child presenting with altered sensorium, hematemesis, and seizures, Coronal reconstructions showing increased pulmonary vascularity seen as increased interstitial markings (A). Coronal MIP images (B) showing enlarged portal vein draining directly into the IVC through a side-to-side shunt (\*). Sagittal MIP image (C) showing the portovenous communication. Axial sections (D) through liver do not reveal any well-defined portal branches. VR image (E) showing the same along with focal prominence of the portal vein

##### *Hepatic encephalopathy*

A number of patients present with neurological symptoms and symptoms due to portosystemic encephalopathy and increased blood ammonia levels.<sup>[2,6,15,20]</sup> These have been recorded as early as 18 months with a mean age of 6 years.<sup>[20]</sup> However, portosystemic encephalopathy is rarely observed in patients who have CEPS with mild hyperammonemia, and CEPS patients remain almost asymptomatic before suddenly developing hepatic encephalopathy.<sup>[24]</sup> A variety of explanations have been put forward for the same, including increasing sensitivity of the brain to ammonia or other toxic metabolites with age.<sup>[25]</sup> It has also been postulated that the shunt ratio may play a role in the occurrence of symptoms.<sup>[26]</sup> High signal intensity has been observed on T1-weighted MRI images in globus pallidus of several children who had CEPS due to deposition of manganese.<sup>[11,27,28]</sup> This has also been reported in other patients with hepatic encephalopathy.

##### **Congenital anomalies associated with congenital extrahepatic portosystemic shunts**

A number of congenital lesions have been reported in patients with CEPS, as tabulated in Table 1. Patients with type 1 shunt have a female preponderance<sup>[13,22]</sup> and often have concomitant congenital anomalies. These anomalies are less common in patients in type 2 shunts.<sup>[5,6,13]</sup> Other anomalies have also been reported in patients with Abernethy malformation which include chromosomal anomalies such as Down's syndrome and structural anomalies of the heart, gastrointestinal, genitourinary, skeletal, and vascular systems.<sup>[2,5,6,13,20,29,30]</sup>

**Table 1: Difference between type 1 and 2 CEPS**

	Type 1	Type 2
Sex predilection	Female preponderance	No sex preponderance
Pathology	Congenital absence of PV	PV supply is partially conserved
Associated anomalies	Concomitant congenital anomalies such as congenital heart disease and renal tract anomalies	Fewer associated malformations
Age at presentation	Younger age	Later in life
Portal vein and its communication	The portal vein typically drains into the retrohepatic IVC anywhere between a point just inferior to the hepatic vein confluence to just inferior to the level of the renal veins	The intrahepatic portal vein may be absent or hypoplastic
Type of anastomosis	End-to-side anastomosis	Side-to-side anastomosis

CEPS: Congenital extrahepatic portosystemic shunts, IVC: Inferior vena cava

### Cardiac anomalies

A number of cardiac anomalies have been reported in patients with CEPS. These are postulated to develop because there is a close relationship between the development of the heart and the vitelline veins in embryonic life, as described above.<sup>[13]</sup> It has been proposed that cardiac development may be affected by the systemic diversion of portal venous flow.<sup>[29]</sup>

The original report by Abernethy<sup>[1]</sup> included findings of right-sided heart and right aortic arch. A number of authors have reported cases of CEPS with associated cardiac anomalies including atrial septal defect (ASD), ventricular septal defect (VSD), atrioventricular septal defect, aortic stenosis, pulmonary stenosis, coarctation of aorta, and patent ductus arteriosus.<sup>[2,5,20,29,30]</sup> [Figure 4].

### Venous anomalies

A number of venous anomalies are seen in patients with CEPS, which include duplicated SVC,<sup>[1]</sup> duplicated IVC,<sup>[31]</sup> left-sided IVC,<sup>[9]</sup> azygous, and hemiazygous continuation of the IVC.<sup>[1,32]</sup>

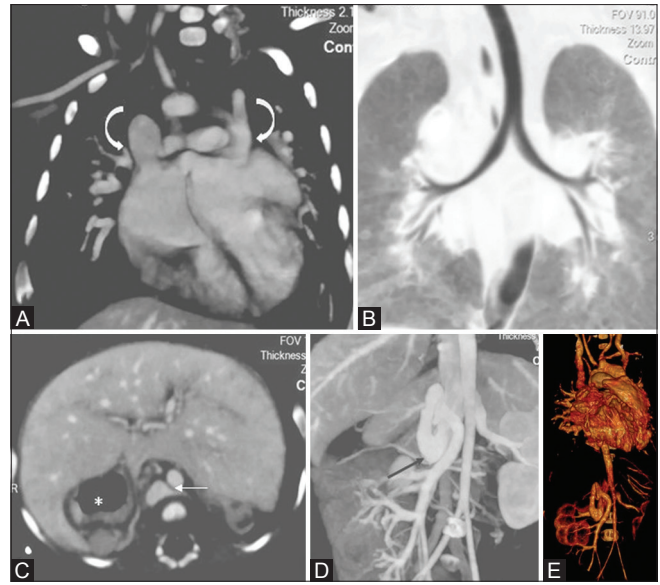
### Visceral arterial anomalies

Patients who have Abernethy malformation have also been reported to have arterial anomalies in the upper abdomen. These include enlarged hepatic arteries,<sup>[33]</sup> which have been postulated to represent a compensatory phenomenon.<sup>[2]</sup>

### Visceral anomalies

A large number of visceral anomalies have been reported in patients with CEPS. All these anomalies with the exception of genitourinary anomalies are more common in patients with type 1 shunts;<sup>[22]</sup> the various anomalies reported include:

- Hepatobiliary—Congenital biliary atresia, choledochal cysts, congenital hepatic fibrosis, malrotation, annular pancreas, and intrahepatic gall bladder.<sup>[2,6,9,13,22,31,34]</sup>
- Genitourinary—Cystic dysplasia of the kidneys,



**Figure 4 (A-E):** A 2-month-old child presenting with severe pulmonary hypertension and cyanosis, Coronal reformatted MIP image (A) showing double SVC (curved arrow) with a small ASD. Coronal MINIP image (B) showing left bronchial isomerism. Axial section through liver (C) shows centrally placed liver with stomach on right side (\*) and interrupted IVC (white arrow). Coronal reformatted MIP image (D) showing drainage of superior mesenteric vein through a well-defined shunt (black arrow) into interrupted IVC/azygous vein. No well-defined intrahepatic portal vein is seen. VR image (E) depicting the same

pelviuretic junction obstruction, crossed fused ectopic kidney, and hypospadias.<sup>[2,6,22,35]</sup>

- Splenic—Polysplenia and splenomegaly with hypersplenism<sup>[1,9,13,36]</sup> [Figure 4].

### Skeletal anomalies

Skeletal anomalies described in CEPS include radial hypoplasia, congenital absence of the first metacarpophalangeal joints, vertebral anomalies, Goldenhars syndrome, maxillary hypoplasia, short fifth fingers.<sup>[2,22,37]</sup>

### Hepatic lesions in patients with congenital extrahepatic portosystemic shunts

Nodular liver lesions have been reported not only in patients with congenitally absent PV but also in many other conditions where patients have disturbances of hepatic circulation.<sup>[38,39]</sup> Most of these lesions are asymptomatic and are either picked up on imaging done for other indications or seen during further evaluation of a patient of CEPS. Rarely a patient may present with an abdominal mass. It has been suggested that approximately half the patients of CEPS have nodular lesions of some sort in the liver.<sup>[6]</sup> The increased incidence of these lesions has been attributed to hepatic ischemia with compensatory increase in arterial flow and lack of growth factors and hormones due to reduced/absent portal flow.<sup>[2,6]</sup>

Nodular hepatic lesions in patients with congenital portosystemic shunts may be single or multiple, and include regenerative nodular hyperplasia,<sup>[20,37,40]</sup> focal nodular hyperplasia,<sup>[20,33,34]</sup> Hepatic adenomas/hepatic adenomatosis<sup>[16,20]</sup> [Figures 5 and 6] and hepatoblastoma.<sup>[41,42]</sup>

Hepatocellular carcinoma has been reported by a number of authors as an association with the Abernethy malformation.<sup>[43-45]</sup> Hepatocellular carcinomas/malignant lesions may develop on follow-up of benign nodular lesions in patients with CEPS or may coexist with other such lesions.

Regenerative nodules are usually homogenous with enhancement during arterial phase, on both CT and MRI, however without washout [Figure 6]. "Halo sign" has been described for adenomas where there is a hypodense rim seen surrounding the enhanced lesion. These lesions are usually hyperintense on T1-weighted images.<sup>[6,39]</sup> Hepatocellular adenomatosis has been reported in patients with Abernethy malformation.<sup>[16]</sup>

The imaging findings in patients with Abernethy malformation with Hepatocellular carcinoma do not appear to be typical, that is hypervascularity on the arterial phase images with washout on delayed phase. [Figure 7]. Thus, patients who do not have typical findings of a benign lesion, i.e. lack of arterial enhancement, or arterial enhancement without washout, should be closely followed up or biopsied.

### Imaging of Congenital Extrahepatic Portosystemic Shunts

The cardinal imaging feature of a CEPS is an abnormal communication between the portal venous system and a

systemic vein, either before or after the formation of the PV by union of the SMV and SV.

The first step in the diagnosis of the CEPS is to demonstrate communication between the portal and the systemic venous system. These may be end-to-side shunts where the PV terminates in the IVC (Type I shunts) or side-to-side shunts between the PV and IVC.<sup>[13]</sup>

The second step entails ruling out the acquired causes of nonvisualization of the PV such as portal cavernoma or PV thrombus. An acute PV thrombus is seen on cross-sectional imaging as a hypodense, nonenhancing PV filled with thrombus. As a rule, patients with congenital portosystemic shunts do not have features of portal hypertension,<sup>[6]</sup> such as splenomegaly, varices, and collaterals.

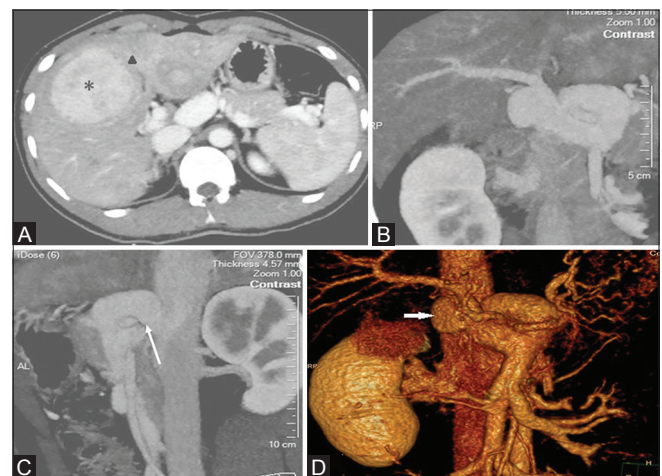
In type I shunts, the PV typically drains into the retrohepatic IVC anywhere between a point just inferior to the hepatic vein confluence<sup>[37]</sup> to just inferior to the level of the renal veins.<sup>[46]</sup> There are, however, descriptions of an abnormal PV ascending posterior to the liver and draining into the suprahepatic IVC<sup>[34]</sup> or into the right atrium.<sup>[9]</sup>

In type 2 shunts, the intrahepatic PV may be absent or hypoplastic, however, even if no PV radicles are seen on imaging, liver biopsy is suggested to confirm the presence or absence of portal venous radicles.<sup>[5,6]</sup>

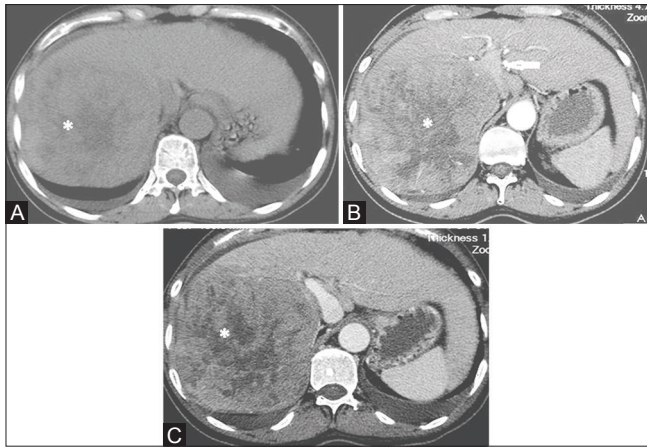
In type 1 shunts, the PV or any of its constituents may drain into any Systemic vein, including the left renal vein,<sup>[22,47]</sup>



**Figure 5 (A-C):** An 8-year-old child, presenting with cyanosis, Axial images (A, B) showing multiple well-defined hypodense lesions showing arterial phase enhancement and becoming isodense on delayed images suggestive of adenomas. Reformatted sagittal MIP image (C) showing fistulous communication of main portal vein with IVC (white arrow). No appreciable intrahepatic portal branches are seen



**Figure 6 (A-D):** A 17-year-old, presenting with fever and loss of appetite, axial MIP image (A) showing multiple arterial phase enhancing lesions (\*) (biopsy proven adenoma), one of them showing halo sign (white arrow head). MIP coronal image (B, C) showing aneurysmal dilatation of proximal portal vein. A tortuous dilated shunt is seen between portal vein and IVC (white arrow). Small intrahepatic portal branches are however seen. VRT image (D) shows the same (white arrow showing the shunt)



**Figure 7 (A-C):** A 40-year-old male, presenting with liver mass, axial sections through liver in plain (A) arterial (B) and venous (C) phases show a large arterial phase enhancing lesion showing washout on delayed phase suggestive of hepatocellular carcinoma (\*) (biopsy proven). There is a large well-defined fistulous communication seen between the portal vein and IVC (white arrow). The intrahepatic branches of MPV are not well seen

the right renal vein,<sup>[22]</sup> and intrathoracic vein [Figure 8].<sup>[48]</sup> Communications have also been reported between the inferior mesenteric vein or its tributaries and left or right internal iliac vein.<sup>[5]</sup>

Once the portosystemic communication has been demonstrated, the major role of imaging is to diagnose the type of shunt because it may have therapeutic implications. Distinguishing between intra and extrahepatic shunts is dependent on the demonstration of anatomical site of communication.

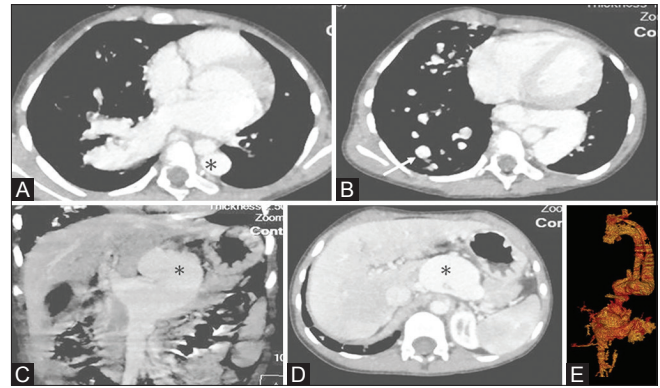
### Imaging Modalities for the Diagnosis of Congenital Extrahepatic Portosystemic Shunts

#### Doppler ultrasonography

Doppler ultrasonography is a safe and noninvasive modality for the diagnosis of the intrahepatic vasculature and may demonstrate the shunt, including the hemodynamics involved such as the magnitude and direction of flow [Figure 9]. It may pick up congenital shunts preoperatively; however, it may not detect associated anomalies and may also be unable to evaluate the retroperitoneum well, particularly in adult patients.<sup>[1,8,49,50]</sup> Thus, smaller shunts, particularly type 1a may not be well picked up. Ultrasound may not fully characterize liver lesions seen in these patients. Associated anomalies and findings particularly lung and cardiac anomalies will not be defined on ultrasound.

#### Multidetector computed tomography angiography

A number of case reports and studies have documented the efficacy of CT in the diagnosis and management of patients with CEPS.<sup>[51]</sup> CT is a fast, noninvasive modality that elegantly demonstrates anatomy and pathology with



**Figure 8 (A-E):** An 8-year-old child presented with cyanosis. Axial MIP images (A, B) of thorax reveals aneurysmal dilatation of pulmonary veins (white arrow) with numerous vascular channels likely pulmonary vascular malformations. Coronal and axial MIP images (C, D) show dilation of splenic vein which unites with superior mesenteric vein and extends into retroperitoneum and then superiorly into the posterior mediastinum and drains into left brachiocephalic vein suggestive of porto systemic shunt (\*). The VRT image (E) showing portal vein draining into left brachiocephalic vein (\*)

high spatial resolution. Though radiation may be a factor in deciding to choose MRI, the newer machines have a highly reduced radiation dose.<sup>[52]</sup> The major advantage of CT is that it clearly displays the portal anomaly and type of shunt and helps decide management. CT evaluates associated anomalies particularly in patients with congenital heart disease who require evaluation of pulmonary vasculature, or patients with suspected hepatopulmonary syndrome who require evaluation of the lungs.

Another major advantage of CT is that it helps to detect and characterize hepatic lesions in these patients. It displays the arterial and venous anatomy, including venous invasion if any, and provides an angiographic road map for surgical resection.

#### Magnetic resonance imaging

MRI has the ability to provide most of the information that CT does, however, it is slower, with need for longer periods of sedation which is a disadvantage in patients with CEPS who may be very young, very hypoxic (due to hepatopulmonary syndrome) or encephalopathic (due to portosystemic shunting). MRI also has lower spatial resolution than CT and may not show small intrahepatic portal venous radicles in type 2 patients.

MRI, however may be superior, particularly with the advent of hepatobiliary contrast agents in the characterization of hepatic nodules [Figure 10].<sup>[39,53]</sup> MRI does not expose the patients to ionizing radiation. MRI should be used for serial follow up of hepatic lesions.

#### Other modalities

*Porto Venography*—Mesenteric portography has an advantage over visceral arteriography. It helps in identifying

the pressure gradient as well as in delineating the portal anatomy and extrahepatic shunts. However, it is an invasive procedure and is usually performed intraoperatively.<sup>[54,55]</sup>

**Scintigraphy**—rectal portal scintigraphy with rectal administration of iodine 123 (<sup>123</sup>I) iodoamphetamine is a noninvasive quantitative method to determine portal hemodynamic and portal collateral circulation.<sup>[56,57]</sup>

#### Management of Patients with congenital extrahepatic portosystemic shunts

A variety of management strategies and therapeutic options are available for patients presenting with CEPS. Alonso-Gamara *et al.*<sup>[4]</sup> suggested a diagnostic algorithm as outlined below.

Asymptomatic patients/mild metabolic abnormalities should be followed-up with ultrasonography and biochemistry. Patients with liver nodules should also be followed up.

Symptomatic patients, that is those with portosystemic encephalopathy, liver dysfunction, or shunt ratio >60%, were divided into two groups according to the type of shunt—those with type 1 shunts should be transplanted, whereas those with type 2 shunts should be offered shunt closure—either interventional embolization or surgical.<sup>[58,59]</sup>

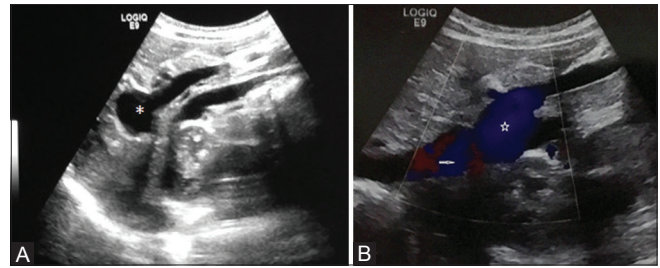
Patients with type 1 shunts may not be offered shunt occlusion because it represents the only route for intestinal and splenic blood drainage. Franchi-Abella *et al.*<sup>[20]</sup> recommended that shunts should definitely be closed whenever patients develop a complication; however, they further suggested that shunts should be closed in asymptomatic patients as well to prevent development of complications at a later date.

There are also other reports that suggest that hypoplastic PV branches are able to expand after the closure of shunt [Figure 11]. Liver transplantation is considered when medical and surgical methods fail especially in patients with complications.

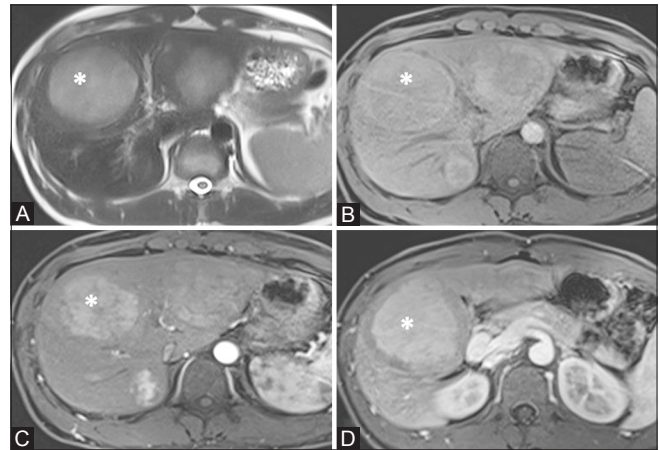
Auxiliary portal orthotopic liver transplant is a recent development where a graft is placed along with native liver. It is useful in reversing fulminant hepatic failure. It is reported to be better than orthotopic liver transplant as lifelong immunosuppression is not required.<sup>[60]</sup>

### Conclusion

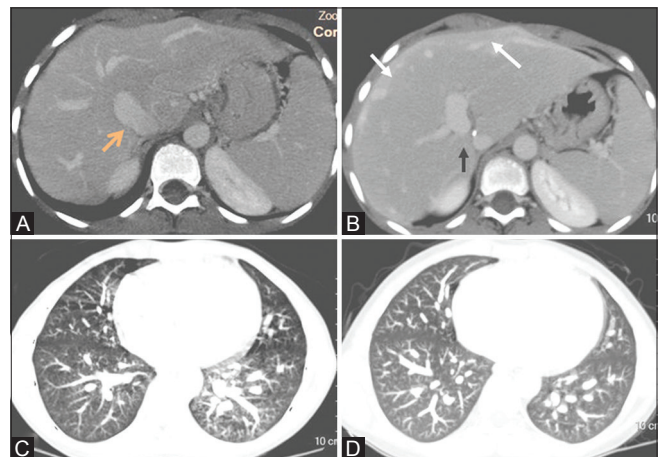
Congenital extrahepatic shunts are being diagnosed with increased frequency as imaging techniques become more and more refined, and many are picked up incidentally. Imaging plays a major role in diagnosis, classification, and treatment of these patients. It is useful in pre and post treatment



**Figure 9 (A and B):** Ultrasound images of a 13-year-old child (same patient in Figure 3), (A) shows bulbous dilatation of portal vein (\*) and direct shunt with IVC (arrow). Color Doppler image (B) showing the direct communication



**Figure 10 (A-D):** MRI of a 17-year-old boy (same patient in Figure 6), Axial imaging in T2WI (A) showing multiple hyperintense lesions and T1WI (B) showing multiple hypointense lesions and post contrast T1 arterial phase image (C) showing arterial enhancement and appearing hyperintense on T1 venous phase image (D) suggestive of multiple hepatic adenomas. Larger one shown as (\*)



**Figure 11 (A-D):** Preoperative axial CT (A) shows well-defined shunt between IVC and portal vein (red arrow). Postoperative axial CT (B) shows a surgical staple (black arrow) at site of portosystemic shunt with numerous collaterals in the periphery of liver (white arrow). Pre and post-op axial sections through lung bases (C, D) showing reduction in vascular congestion

followup imaging as well as imaging of its complications. The radiologist holds a pivotal role in diagnosing the type of

Abernethy malformation and evaluating associated visceral anomalies and other complications.

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### Conflicts of interest

There are no conflicts of interest.

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