



## Original Article

# Congenital extrahepatic portocaval malformation: Rare but potentially treatable cause of pulmonary hypertension



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## ABSTRACT

**Objective:** Abernethy malformation (congenital extrahepatic portosystemic shunt) is a rare anomaly of the splanchnic venous system. Though rare, it is an important cause of pulmonary artery hypertension (PAH) which is often missed. All patients with PAH should be carefully evaluated for presence of Abernethy malformation before labelling them as Idiopathic PAH.

**Methods:** This is a retrospective analysis of prospectively collected data. We reviewed the data of all patients referred to our center for evaluation of PAH. 10 patients were diagnosed to have an extrahepatic portocaval malformation. We reviewed their presentation, diagnosis, catheterization data, intervention and their outcome along with review of literature.

**Results:** 10/104 patients with pulmonary hypertension and no intra or extracardiac shunt were found to have extrahepatic portocaval shunt (EHPCS). 3 patients had EHPCS type 1 and 7 had type 2 EHPCS. 6/7 patient with EHPCS type 2 underwent closure of the shunt. There was no procedure related complication. There was one death 3 months post procedure and one patient who was advised surgical closure was lost to follow up. Closure of the shunt resulted in normalization of the pulmonary artery pressures in 4/5 patients.

**Conclusion:** Congenital portosystemic malformations form an important and potentially treatable cause of pulmonary hypertension.

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## 1. Introduction

Pulmonary artery hypertension (PAH) is a progressive disease with poor long-term outcomes. Detailed evaluation of a patient with PAH can identify potentially treatable causes which could result in better short and long term outcomes.<sup>1</sup> Extrahepatic portocaval shunt (EHPCS) also called as Abernethy malformation (AM) is a rare anomaly of the splanchnic venous circulation. The intestinal and splenic venous blood bypasses the portal and hepatic venous system to drain directly into the systemic vein via an abnormal communication. The communication results in portal

blood directly flowing into the right heart thus bypassing the hepatic capillary system and physiologic hepatic clearance. This loss of hepatic clearance may result in pulmonary hypertension secondary to absence of antiangiogenic factors, endostatin and angiostatin which are involved in normal pulmonary vascular integrity. Complete closure of the EHPCS can result in stabilization or even reduction in pulmonary vascular disease.<sup>2</sup> We describe a single center experience of EHPCS and PAH.

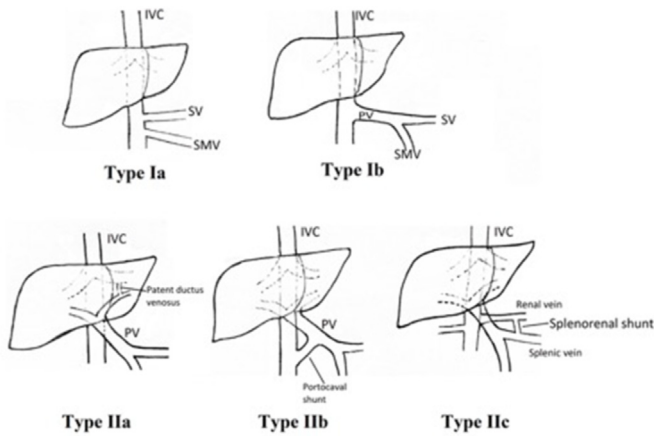
## 2. Materials and methods

### 2.1. Study design

This is a retrospective analysis of prospectively collected data in a single center case with EHPCS and PAH. Institutional ethics

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**Fig. 1.** Classification of Abernathy malformation. Type 1 End to side anastomosis with absent intrahepatic portal venous radicals. Type 1 a: Splenic vein and superior mesenteric vein drain separately into the inferior vena cava. Type 1 b: Splenic vein joins the superior mesenteric vein to form a portal vein which drains into the IVC (end to side). Type 2: Side to side anastomosis: Type 2 a: Porto hepatic shunt or persistent ductus venosus. Type 2 b: Arising from the main portal vein (between splenomesenteric confluence to the portal bifurcation) and draining to the inferior venacava (side to side). Type 2 c: shunts arising from mesenteric, gastric or splenic veins.

committee approval was obtained for the same as part of registry of all patients with pulmonary hypertension (PH).

Study Period: July 2015–January 2020.

**Patient Population:** We run a dedicated pulmonary hypertension clinic. All patients referred for evaluation of PAH undergo a battery of investigations including an ultrasound of the abdomen with portal venous Doppler (USG) (Fig. 2).

**2.2. Diagnosis and treatment**

Patients suspected to have EHPCS on USG underwent CT angiogram of the abdomen with portal venous phase to confirm the same (Fig. 3). Patients were classified as type 1 or type 2 based on the type of anastomosis between the portal venous system and

inferior vena cava (Fig. 1). Consenting patients underwent cardiac catheterization followed by closure of the EHPCS type 2 if feasible.

**2.3. Cardiac catheterization**

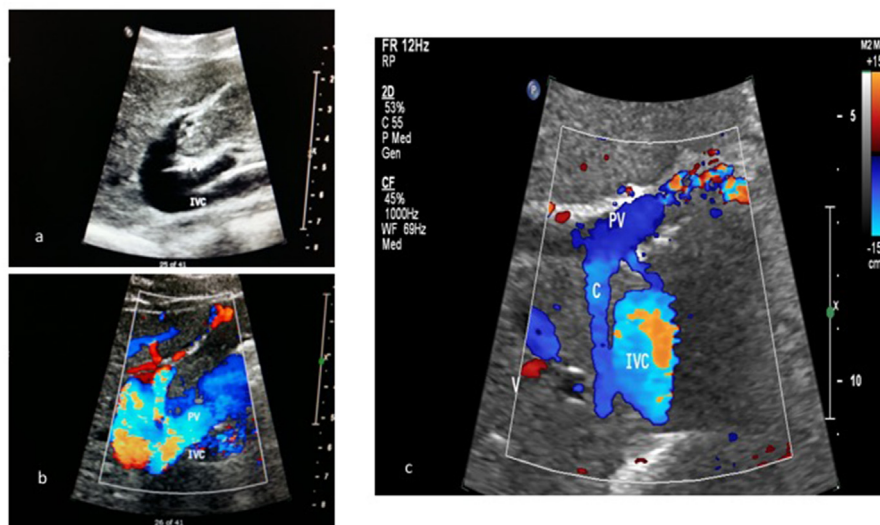
Complete right heart catheterization with hemodynamic data was collected in patients consenting for cardiac catheterization at baseline. EHPCS was identified using digital subtraction angiogram. Portal vein was identified, and portal venous pressures were measured. The shunt was occluded with a suitable sized balloon angioplasty catheter. Distal portal pressures were re-measured after balloon occlusion. Patients with type 2 malformation with an absolute portal pressure less than 25 mm Hg or rise of portal pressures of less than 5 mm Hg after balloon occlusion were chosen for endovascular closure (Fig. 4 &5). Patients not satisfying the above criteria were sent for partial closure by surgery or kept on medical follow up.

**2.4. Shunt closure**

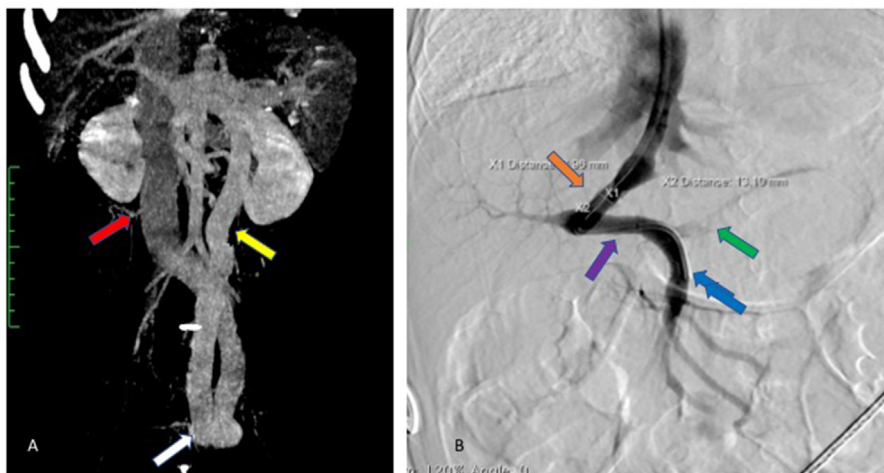
Closure of the shunt was performed under fluoroscopic and ultrasound guidance. Closure was achieved using either vascular plug II or ductal occluder device. Size of the device was 30–50% more than the narrowest portion of the shunt (details in Table 1). Position of the device was confirmed by multiple angiograms and ultrasound. Care was taken not to occlude portal venous flow as well as the inferior vena cava flow. Surgical ligation of the shunt by open laparotomy was performed in 1 patient in whom device closure was thought to be inappropriate due to size of the shunt and possibility of obstruction to main portal vein post deployment.

**2.5. Post closure management**

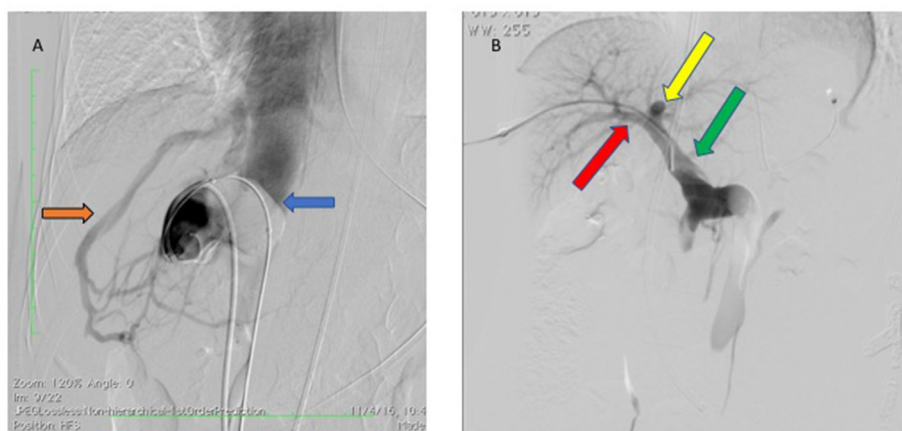
Patients were monitored in the pediatric cardiac intensive care unit. Heparin infusion was started for all patients after achieving hemostasis. Activated partial thrombin time was maintained twice of control. Serum ammonia levels were monitored every 24 h for the first three days. Liver function tests were monitored on post-operative day 1 and 5. Ultrasound abdomen with portal venous Doppler was performed on post-operative day 1 and prior to



**Fig. 2.** Ultrasound abdomen with portal venous Doppler showing end to side anastomosis Type 1 (A and B) and a side to side anastomosis (C). IVC: Inferior venacava, PV: portal vein, SV: Splenic vein, SMV: Superior mesenteric vein.



**Fig. 3.** A: A large communicating vein (yellow arrow) arises from the superior mesenteric vein and joins the right iliac vein. Red arrow shows dilated inferior venacava. B: Portal venogram showing the splenic vein (green arrow), joins the superior mesenteric vein (Blue arrow, to form the portal vein (Purple arrow) which then joins the hepatic vein (orange arrow) most probably a persistent ductus venosus.



**Fig. 4.** Balloon portal venogram done for assessing the suitability for closure of the extrahepatic portal venous connection. A: absent intrahepatic portal radicals with only small communicating channels from the portal vein to the inferior venacava (orange arrow), Blue arrow shallow arrow) branches as well as intrahepatic portal radicals.

**Table 1**

Characteristics of patients with extrahepatic porto caval shunt (EHPCS). Type 1: End to side with complete absence of intrahepatic portal vein. Type 2: Side to side connection. Patient number 7 expired 4 months after the procedure secondary to an episode of lower respiratory tract infection. M = male, F = female, VP II: vascular plug II, DO 10/8 = Ductal occluder 10 mm/8 mm.

Sr. No	Age (Years)	Gender	Height (cm)	Weight (kg)	Type of EHPCS	Intervention done	Device used for closure	Follow up duration (Months)
1	13	M	128	24	2 B	Surgical closure	–	38
2	11	M	118	17	2 C	Device closure	VPII 14 mm	30
3	15	F	132	27	1 B	Medical follow up	–	36
4	13	M	124	20	2 B	Device closure	VPII 16 mm	17
5	2.5	F	98	8	2 B	Advised partial surgical closure (Lost to follow up)	–	Lost to follow up after 4 months
6	31	F	158	56	1 B	Medical follow up	–	20
7	4	F	100	13	2 C	Device closure	VPII 10	4
8	12	M	109	19	2 B	Device closure	DO 10/8	6
9	0.9	M	68	4.5	2 A	Device closure	VPII 8	18
10	14	F	118	18	1 B	Medical follow up	–	6

discharge to see for unobstructed hepatic venous flow. Oral anti-coagulants were added for all patients and heparin was continued till a stable international normalized ratio (INR) of 2–2.5 was achieved. Dual pulmonary vasodilators (phosphodiesterase 5 inhibitors and endothelin receptor antagonist) were continued for all patients in the immediate post-operative period.

**2.6. Follow up**

All patients were followed up in PAH clinic. Those who underwent a closure of the shunt had follow up USG with portal venous Doppler at 3, 6 and 12-month post procedure. Serial transthoracic echocardiograms were performed in all the patients. Cardiac

catheterization was performed at 12 months post closure of the shunt in consenting patients.

2.7. Results

104 patients with PAH (mean age of 17 ± 15 years, 62 were females) and no intra or extracardiac systemic to pulmonary shunt were referred to the center in the said period. All the patients underwent all the routine investigations to determine the etiology as per recent NICE guidelines.<sup>3</sup> As a part of the same, all the patients underwent USG abdomen with portal venous Doppler. 11/104 patients were suspected to have EHPCS on USG abdomen and portal venous Doppler. Diagnosis of the same was confirmed by CT abdomen with portal venogram in 10/11 patients. One patient suspected to have EHPCS on USG was found to be false positive on CT abdomen. Median age of the patients was 12.5 years (0.9–30 years) and median weight was 18.5 Kg (4.5–56 Kg). 7 patients had EHPCS type 2 and 3 patients had EHPCS type 1. Detailed patient characteristics are mentioned in Table 1. None of the patients had cyanosis on rest or after exercise and a bubble contrast echocardiogram was not suggestive of pulmonary atrioventricular malformation in any of the patients. Liver function tests including serum ammonia levels were within normal limits and there was no evidence of portal hypertension on USG in any patient. 7/7 patients with EHPCS type 2 underwent cardiac catheterization to estimate pulmonary artery pressures and PVRI along with angiography and balloon occlusion of the malformation the details of the cardiac catheterization are as mentioned in Table 2.

Closure of EHPCS: 5/7 patients with type 2 malformation underwent device closure and 1 whose anatomy was unsuitable for device underwent surgical closure of the malformation. One patient with EHPCS type 2 with high portal pressures was advised partial closure of the shunt by surgery, however this patient has been lost to follow up. There was no procedure related complication in any patient.

2.8. Follow up

EHPCS type 1: All patients (3/3) with EHPCS type 1 were on medical follow up. Median follow up duration was 20 months (6–36 months). None of these patients developed signs and symptoms of hepatic encephalopathy or portal hypertension. Dual pulmonary vasodilators with diuretics were continued in these patients. All the patients are in functional class II at last follow up.

EHPCS type 2: Median follow up period for patients with EHPCS type 2 was 16 months (4 month- 38 months). One patient with high portal pressures on cardiac catheterization was lost to follow up.

Table 2

Characteristics at basal cardiac catheterization. Patients serial numbers 3,6,10 who were classified as extrahepatic portocaval shunt type 1 on CT angiogram did not undergo cardiac catheterization. Mean PAP = mean pulmonary artery pressure, Mean AoP: Mean aortic pressure, Mean RAP = mean right atrial pressure CI: cardiac index, PVRI: pulmonary vascular resistance index in Woods units. m<sup>2</sup>, SVRI: systemic vascular resistance index in Woods units.m<sup>2</sup> Rp/Rs: ratio of pulmonary to systemic vascular resistance, basal PV pressure: basal portal venous pressure, PVP after balloon occlusion: Portal venous pressure after balloon occlusion.

Sr No	Mean PAP (mmHg)	Mean Ao P (mmHg)	Mean RAP (mmHg)	CI (L/min/m <sup>2</sup> )	PVRI	SVRI	Rp/Rs	Basal PV pressure (mmHg)	PVP after balloon occlusion (mmHg)
1	41	68	6	4.2	8.3	14.7	0.56	18	20
2	26	68	5	4	5.25	15.75	0.33	21	24
3	–	–	–	–	–	–	–	–	–
4	44	62	8	3.8	9.5	14.2	0.67	16	19
5	55	58	8	4.9	9.6	10.2	0.94	27	32
6	–	–	–	–	–	–	–	–	–
7	35	58	6	5	5.8	10.4	0.56	18	18
8	38	66	6	5.6	4.6	10.7	0.43	17	20
9	26	48	4	4.2	5.23	10.5	0.5	18	21
10	–	–	–	–	–	–	–	–	–

There was one death secondary to lower respiratory tract infection 3 months post closure of shunt. This child continued to have moderate PAH on follow up echocardiogram.

All the patients received pulmonary vasodilators along with anticoagulants and anti-platelet agents. INR was maintained between 2 and 2.5. Anticoagulant (Warfarin) and antiplatelet agent (aspirin) were stopped 6 months post complete closure of the shunt. None of the surviving patients developed portal hypertension or hepatic failure. Repeat USG abdomen and portal venous Doppler revealed complete closure of the shunt in all patients with no obstruction either to the portal venous or the systemic venous flow.

Echocardiogram done at 3,6- and 12-months post procedure revealed normalization of PA pressure in 4/5 patients. Repeat cardiac catheterization performed in 4/5 surviving patients, 12 months post closure of the malformation revealed normal pulmonary artery pressures and PVRI in 3/4 patients, one patient continued to have high PA pressure and PVRI (Table 3). Pulmonary vasodilators were stopped in 3 patients in whom the PA pressures were normal at the cardiac catheterization. One patient with follow up period of 6-month post procedure is still on warfarin and aspirin and is awaiting cardiac catheterization.

2.9. Discussion

Management of patients with pulmonary hypertension without an intra or extracardiac shunt remains challenging with poor medium and long term outcomes.<sup>1</sup> Detailed etiological work up is essential to find a correctable cause of PAH.<sup>4</sup>

Congenital porto-systemic shunts (intra or extra hepatic) although rare are an important and treatable cause of PAH.<sup>2</sup> In severe cases development of PH can occur during early infancy, however most of the patients present later in the first decade or early second decade of life.<sup>5,6</sup> Various classifications have been proposed for evaluation of extrahepatic portosystemic shunts. The one described by Morgan et al was found to be the most practical and has been used in this case series.<sup>7</sup> Anatomically two types of AM have been described, type 1: End to side anastomosis with complete absence of intrahepatic portal vein and type 2: side to side anastomosis with hypoplastic intrahepatic portal veins.<sup>7</sup> Type 2 EHPCS can be further divided into Type 2a: porto-hepatic shunt and ductus venosus, type 2 b: arising from the main portal vein from spleno-mesenteric confluence to portal bifurcation and type 2c: shunts arising from mesenteric, gastric or splenic veins.<sup>8,9</sup> (Fig. 1) Cardiac catheterization with balloon occlusion test has been advocated to accurately assess the presence of intrahepatic portal radicals.<sup>8</sup> The communication results in portal blood directly



**Table 3**

Characteristics at follow up cardiac catheterization. Mean PAP = mean pulmonary artery pressure, Mean AoP: Mean aortic pressure, Mean RAP = mean right atrial pressure CI: cardiac index, PVRI: pulmonary vascular resistance index in Woods units. m<sup>2</sup>, SVRI: systemic vascular resistance index in Woods units.m<sup>2</sup> Rp/Rs: ratio of pulmonary to systemic vascular resistance.

Sr No	Mean PAP (mmHg)	Mean Ao P (mmHg)	Mean RAP (mmHg)	CI (L/min/m <sup>2</sup> )	PVRI	SVRI	Rp/Rs
1	18	58	4	4	2.5	13.5	0.2
2	16	66	6	4.1	2.2	14.7	0.15
4	18	67	4	3.9	2.6	16.2	0.16
9	28	56	8	3.9	5.6	12.3	0.45

flowing into the right heart thus bypassing the hepatic capillary system and physiologic hepatic clearance. Although a similar clinical picture may be observed in patients with intrahepatic portocaval malformation, none of the patients in our series had an intrahepatic malformation. Moreover, unlike extrahepatic malformations majority of intrahepatic malformations close spontaneously by the age of 1 year with resolution of symptoms.<sup>10</sup>

Patients with type 2 EHPCS malformations can benefit from closure of the shunt lesion while those with type 1 malformation would be candidates for liver transplant.<sup>2</sup> In our series 10/104 (9.6%) patients with pulmonary hypertension were diagnosed to have EHPCS. All the patients with type 2 EHPCS and PH should undergo cardiac catheterization with balloon occlusion of the malformation.<sup>11</sup> Presence of intrahepatic portal radicals and a portal pressure of less than 25 have been proposed as some of the criteria to decide regarding complete closure of the malformation. In our series all except one patient had normal portal venous pressures at baseline without significant increase in the portal pressures after balloon occlusion. Successful device closure of the shunt was possible in 5/7 and surgical closure was performed in 1.

Complete closure of EHPCS early in life can result in significant decrease or even normalization of the pulmonary artery pressures.<sup>2</sup> 4/5 patients who underwent closure of the shunt in our series underwent cardiac catheterization 12 months post procedure and revealed normal pulmonary artery pressure and PVRI. One patient with follow up period of less than 12 months revealed normalization of PA pressures on echo, this patient is awaiting cardiac catheterization to be done 12 months post procedure. Pulmonary vasodilators were discontinued in 4/5 surviving patients.

Patients with Type 1 EHPCS need to be kept on close medical follow up. Indication for liver transplant includes hepatic encephalopathy not responding to medical management,<sup>12,13</sup> liver tumor like hepatoblastoma,<sup>5</sup> focal nodular hyperplasia and for associated mal-formations like biliary atresia.<sup>14</sup> None of the patients with EHPCS type 1 in our series developed any of these complications and are on regular medical follow up.

#### 2.10. Limitations of the study: small number of patients with limited follow up

Conclusion: Congenital portosystemic malformations form an important and potentially treatable cause of pulmonary hypertension. Detailed evaluation with balloon occlusion test of the malformation is essential. Closure of the malformation early in the disease process can result in reduction of the PA pressure and pulmonary vascular resistance in selected patients.

#### Funding

None.

#### Ethical approval

Ethical approval was obtained from the institutional ethic committee and waiver of informed consent was obtained.

#### Disclosures

None.

#### Declaration of competing interest

None.

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